# 7TH ANNUAL RESEARCH MEETING OF THE FYNBOS BIOME PROJECT

FRUIT & FRUIT TECHNOLOGY RESEARCH INSTITUTE,
STELLENBOSCH,
29TH AND 30TH JULY 1985

## RESEARCH FOR RESOURCE MANAGEMENT

# 7DE JAARLIKSE NAVORSINGSVERGADERING VAN DIE FYNBOSBIOOM PROJEK

NAVORSINGSINSTITUUT VIR VRUGTE EN VRUGTE-TEGNOLOGIE, STELLENBOSCH,
29 EN 30 JULIE 1985

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ORGANIZING COMMITTEE

Mrs M L Jarman (Convener), CSIR
Professor W R Siegfried, University of Cape Town
Professor E J Moll, University of Cape Town
Dr R M Cowling, University of Port Elizabeth
Mr F J Kruger, South African Forestry Research Institute
Mr B J Huntley, CSIR
Mrs P van Helsdingen) Secretariat, CSIR
Ms E Mantle )

Research meeting convened by the National Programme for Ecosystem Research of the CSIR.

## INTRODUCTION

The Fynbos Biome Project of the National Programme for Ecosystem Research is one of several national scientific programmes administered by the CSIR. The National Programme is a co-operative undertaking of scientific bodies 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 the Scientific Committee on Problems of the Environment (SCOPE), the body set up in 1969 by the International Council of Scientific Unions (ICSU) to act as a focus of non-governmental international scientific effort in the environmental field.

The Fynbos Biome Project forms part of the activities of the Committee for Terrestrial Ecosystems of the National Programme for Ecosystem Research. It aims to provide the fundamental knowledge needed for the optimum use of natural communities by man. It is a joint undertaking of scientists from the Department of Agriculture and Water Affairs, the Cape Provincial Administration, the CSIR, the Department of Environment Affairs and the three western Cape universities. As far as possible, participating organizations finance their own research within the project. University research is financed from a central fund administered by the National Committee for Ecosystem Research and contributed largely by the Department of Environment Affairs.

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.** At the outset of the project it was intended that the objective would 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 would be used to predict the effects of land management practices.

The research programme of the Fynbos Biome Project was divided into three phases: Phase I - baseline studies of the fynbos biome; Phase II - comparative studies of component ecosystem structure and functioning; Phase III - validation studies or testing of Phase II hypotheses and models.

Formal coordination at an inter-organizational level has been provided by the Steering Committee while informal contact between field workers has been maintained through workshop meetings, seminars, etc. As the project developed, annual research meetings became a major mechanism for bringing all parties together for an exchange of progress reports, research plans and the review of programme goals. The seventh such meeting is planned for Monday, 29 and Tuesday, 30 July 1985 at the conference facilities of the Fruit and Fruit Technology Research Institute, Stellenbosch.

The theme of the two day meeting is **Research for Resource Management.** The meeting consists of invited keynote reviews, interspersed with invited verbal discussion papers and contributed poster papers from a number of project participants on the following topics:

- conservation management of fynbos ecosystems;
- alien vegetation control;
- water-shed management and
- the wildflower industry.



**SYMPOSIUM PROGRAMME**

MONDAY - 29 JULY 1985

| | | |
|---|---|---|
| 08h00-09h00 | | Registration and Coffee |
| **SESSION I : WELCOME AND INTRODUCTION** | | |
| Chairman: | | Mr F J Kruger, Director, South African Research Institute (Chairman: Fynbos Biome Project Steering Committee) |
| 09h00 | | Welcome: Dr R R Arndt, Deputy President, CSIR |
| 09h15 | | Opening Address: The Hon J W E Wiley MP, Minister of Environment Affairs and Tourism |
| 09h45 | | Setting the scene: the palaeohistory and history of settlement of the fynbos biome<br>Professor H J Deacon, University of Stellenbosch |
| 10h15 | | TEA |
| **SESSION II : HABITAT CONSERVATION** | | |
| Chairman: | | Dr J H Neethling, Deputy Director, Cape Department of Nature and Environmental Conservation |
| 10h45 | 1 | Current strategy for the conservation of fynbos ecosystems<br>Mr C J Burgers, Cape Department of Nature and Environmental Conservation |
| 11h15 | 2 | Identifying conservation priorities in lowland regions of the fynbos biome<br>Mrs M L Jarman, CSIR |
| 11h45 | 3 | Case study: the role of farmers in conserving threatened habitats<br>Mr C McDowell, University of Cape Town |
| 12h15 | | Discussion |
| 12h45 | | Introduction to poster session<br>Professor E J Moll, University of Cape Town |
| 13h00 | | LUNCH |
| **SESSION III : POSTERS : HABITAT CONSERVATION AND INVASIVE BIOTA** | | |
| 14h00 | | Poster session |
| 15h00 | | TEA |
| **SESSION IV : INVASIVE PLANTS AND ANIMALS** | | |
| Chairman: | | Mr M C Walters, Deputy Director: Research, Winter Rainfall Region, Department of Agriculture and Water Supply |
| 15h30 | 4 | Understanding aliens in the fynbos biome<br>Mr I A W Macdonald, University of Cape Town |
| 16h00 | 5 | Feasible management goals and strategies for control of invasives<br>Mr P A S Wilson, Department of Environment Affairs |
| 16h30 | 6 | Case study: Hakea in the southern Cape<br>Mr G J Breytenbach, Saasveld Forestry Research Centre |
| 17h00 | | Discussion |
| 18h30 | | RECEPTION: Weltevreden Farm |

TUESDAY - 30 JULY 1985

SESSION V : CATCHMENT MANAGEMENT

Chairman: Mr J A Fenn, Regional Director of Forestry: Western Cape, Department of Environment Affairs

| | | |
|---|---|---|
| 09h00 | 7 | Planning and problems in catchment management<br>Mr F J Kruger, Director, South African Forestry Research Institute |
| 09h30 | 8 | The role of fire in the management and conservation of mountain catchments<br>Mr B W van Wilgen, Jonkershoek Forestry Research Centre |
| 10h00 | 9 | Case Study: Monitoring mountain catchments<br>Dr J M King, University of Cape Town |
| 10h30 | | TEA |
| 11h00 | 10 | Grazing impacts and their potential influence<br>Dr R M Cowling, University of Port Elizabeth and<br>Mr G J Breytenbach, Saasveld Forestry Research Centre |
| 11h30 | | Discussion |

SESSION VI : POSTERS : CATCHMENT MANAGEMENT AND THE CAPE FLOWER INDUSTRY

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|---|---|
| 12h00 | Introduction to poster session<br>Mr D B Versfeld, Jonkershoek Forestry Research Centre |
| 12h15 | Poster session |
| 13h00 | LUNCH |

SESSION VII : THE CAPE FLOWER INDUSTRY

Chairman: Mr W J Middelmann, Honorary Life President
South African Protea Producers and Exporters Association

| | | |
|---|---|---|
| 14h00 | 11 | The nature and development of the industry<br>Mr G Davis, Department of Agriculture and Water Supply |
| 14h30 | 12 | Ecological factors influencing the development and maintenance of the industry<br>Mr A Rebelo, University of Cape Town |
| 15h00 | 13 | Case Study: the adaptive significance of serotiny in the Proteaceae<br>Mr J Midgley, Saasveld Forestry Research Centre |
| 15h20 | | Discussion |
| 15h35 | | TEA |

SESSION VIII : PANEL DISCUSSION AND CONCLUSION

Chairman: Professor W R Siegfried, Director, Percy FitzPatrick Institute of African Ornithology, University of Cape Town

| | |
|---|---|
| 16h00 | Discussion: Management priorities for the next five years of the Fynbos Biome Project<br>Panel: Dr J H Neethling, Mr J A Fenn and Mr M C Walters |
| 16h30 | Closing remarks: Has the Fynbos Biome Project contributed to the solution of management problems in the biome?<br>Professor W R Siegfried, Director, Percy FitzPatrick Institute of African Ornithology, University of Cape Town |



Poster.

ABSTRACTS OF ~~VERBAL~~ PAPERS

SESSION II : HABITAT CONSERVATION

1. CURRENT STRATEGY FOR THE CONSERVATION OF FYNBOS ECOSYSTEMS

C J Burgers
Cape Department of Nature and Environmental Conservation, Private Bag 5014, STELLENBOSCH, 7600

As one of the richest and most distinctive floristic regions of the world, the fynbos biome is of international conservation significance. Exceptional measures are therefore justified to ensure the conservation of the diverse ecosystems and biota of this unique natural heritge. This objective will only be achieved by a combination of approaches, including land use planning and the development of scientific management systems which will allow a measure of reconciliation between development and conservation. However, the mainstay of any successful conservation strategy must be the establishment of a viable network of conservation areas which will serve to maintain, in perpetuity, adequate samples of the ecosystems and biota.

An outline is given of progress with the development and implementation of conservation strategies towards the attainment of these objectives. It is concluded that significant progress has been made towards improving the conservation of montane environments in the biome through the establishment of nature reserves and wilderness areas mainly by the Department of Environment Affairs (Directorate of Forestry) and by the proclamation of private land as mountain catchment areas. The greater portion of extant mountain fynbos ecosystems has thereby been placed under scientific management which has resulted in a significant reduction in the major threats to the integrity of these environments.

However, many major ecosystem types are as yet poorly conserved, particularly in the lowlands of the south-western Cape, which appears to be the centre of greater floristic richness and endemism in the biome. This is also the part of the biome where the greatest loss of natural ecosystems has occurred and where very few conserved areas have been established with the result that exceptional numbers of plants are threatened with extinction in this region. The development and implementation of an adequate and effective conservation strategy for this region presents severe problems as most of this land is in private ownership, remaining natural ecosystems are fragented and because of high land values. Innovative conservation measures are therefore required and, in this respect, acquisition of land for the establishment of nature reserves will have to be supplemented by conservation measures which will allow land to be retained in private ownership. The proclamation of large areas of the most valuable remaining portions of the lowlands as Nature Areas is therefore receiving high priority. The South African Natural Heritage Programme will also provide a vehicle for encouraging landowners to protect valuable natural sites on their properties. Furthermore, attempts to integrate conservation with development should be greatly facilitated by the National Atlas of Critical Environmental Components (NACEC), which seeks to document and disseminate information on the location and significance of sites and features of special conservation importance.

Recently, considerable progress has been made with the identification of priority areas for conservation by working groups under the auspices of the Foundation of Research Development. Evaluation of these proposals by working groups under the auspices of the NAKOR National Plan for Nature Conservation will result in recommendations for appropriate measures to conserve these sites.

However, it is concluded that progress with the implementation of measures to conserve the diversity of fynbos ecosystems is totally inadequate, particularly in the lowlands of the south-western Cape. A concerted effort is also urgently required in order to expedite the identification of areas which are of key conservation importance by more systematic and comprehensive studies.

## 2. IDENTIFYING CONSERVATION PRIORITIES IN LOWLAND REGIONS OF THE FYNBOS BIOME

M L Jarman
FRD, CSIR, c/o Department of Organic Chemistry, University of Cape Town, Private Bag, RONDEBOSCH, 7700

Concern about the survival of fynbos vegetation types has been expressed from time-to-time since the early 1900's. This concern reached a new pitch in the 1970's with more explicit descriptions beginning to appear as to the extent to which the unique flora has been fragmented and reduced. Attention was specifically focussed on the problem in the lowland regions at a "symposium on coastal lowlands of the western Cape' held at the University of the Western Cape in March 1981. Natural vegetation in the lowlands region of the fynbos biome has been transformed by land use practices to a patchwork of small remnants. At a meeting of the Fynbos Biome Project Steering Committee in August 1981, it was recommended that a plan should be drawn up to initiate immediate action to conserve what remains of lowland vegetation communities. In the absence of an objective basis for the selection of priority sites for conservation out of hundreds of remnant patches working groups were established in five regions within the fynbos biome to:

- identify and map remnant areas in the survey region worthy of designation as protected areas;
- list other details relevant to the protection of each area;
- arrange selected areas into a rough priority order.

This undertaking was embarked upon in the assumption that is is a predominant purpose of nature conservation to preserve representative examples of these reduced plant communities and thus to minimize further extinction of species. Basic to this exercise therefore was the production of an acceptable break-down of fynbos vegetation types. It was generally accepted that Acocks' Veld Types (used in all previous assessments of the conservation status of the fynbos biome) would have to be sub-divided in order to ensure adequate representation of the component ecosystems.

The production of the map of the vegetation of the fynbos biome in 1983, and a description of the categories mapped and statistics concerning the extent of each in 1984, identified 23 categories of vegetation in the fynbos biome of which 15 are lowland categories and eight are mountain categories. The lowland categories, together with some of the mountain categories in the eastern regions and the inland valleys of the biome, were used as the basis for assessing lowland conservation priorities.



A system was developed for identifying sites of conservation merit and ordering them by means of numerical rating. The principle factor contributing to the value of the rating is the current rarity of the vegetation types of each site. A second level of factors comprises habitat diversity, plant species richness and the existence of rare and threatened species. Level three criteria include; size of the site; its shape; the degree of invasion by alien woody plants; and the degree of other forms of 'abuse', such as over grazing, road-building and quarrying. Finally a small bonus score is added to any site having a special attribute, such as proximity to any other conservation remnant. Scores for 153 sites were developed, and conservation priorities recommended in each of the five lowland regions of the study area.

## 3. CASE STUDY : THE ROLE OF FARMERS IN CONSERVING THREATENED HABITATS

C McDowell
Department of Environmental and Geographical Sciences, University of Cape Town, Private Bag, RONDEBOSCH, 7700

Reasons are given for chosing West Coast Renosterveld (sensu Acocks 1953, Moll et al 1984) as a research baseline. Previous crop expansion has reduced the area of renosterveld more than any other local habitat, to an archipelago of small refuges covering six per cent of its previous distribution. The one fifth of extant renosterveld that is under public ownership, has both poor conservation status and low conservation priority. Private landowners thus represent key ecological elements in future conservation or degradation of the remainder. Analysis of conservation motivation by a sample of landowners controlling high conservation priority renosterveld, forms a vital basis in formulating mechanisms for improving conservation behaviour of landowners as a whole. Fifty-two parameters (together with 'conservation behaviour' as a dependent variable) included under 'census-type', 'land use', 'attitude / personality' and 'conservation expense' categories are rated for landowners. An original methodology is used to measure the 32 'less-tangible' parameters for incorporation into the data base.

The following transformations are derived to illustrate patterns of relationship between subjects and parameters: scatterplots of 'conservation behaviour' versus each of the parameters; a dendrogram illustrating similarity between parameters based on a regression matrix; a prediction model involving an equation with 12 variables obtained through multiple regression techniques; a dendrogram illustrating similarity between the subjects based on the Euclidean Distance Matrix (with 52 parameters as 'dimensions') and an Underhill Bi-plot displaying relationships between subjects and key parameters on two dimensions. The value of the models in determining reasons for, and present patterns in, 'conservation behaviour' by landowners are critically reviewed.

This quantitative data, qualitatively supported with case studies, rules of thumb, quotes, etc, is used to explore the feasibility of creating favourable conservation attitude/behaviour shifts in landowners through 'persuasive techniques' alone; ie excluding 'coercive disincentives' or 'material incentives'. Persuasive techniques include effective liaison, official recognition literature remittance; coercive disincentives include legislation affecting crop expansion limitation, management controls; and material incentives include financial subsidies, tax rebates for conservation. (Minor emphasis is given to the supporting role the former two policy categories have on enhancing landowner conservation behaviour.)

SESSION IV : INVASIVE PLANTS AND ANIMALS

## 4. UNDERSTANDING ALIENS IN THE FYNBOS BIOME

I A W Macdonald
Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Private Bag, RONDEBOSCH, 7700

Increases in our understanding of invasive alien organisms in the fynbos biome are summarized for the period 1979 to 1985.

### Problem identificatiion

Research on rare and endangered plant species has shown that alien woody plants are currently the most frequent factor threatening plants with extinction in the south-western Cape (approximately 50% of threatened taxa affected). This has served to further emphasize that alien woody plants are a major environmental problem in the biome. Recent research has also re-emphasized the problem status of the Argentine Ant Iridomyrmex humilis and European Starling Sternus vulgaris. By contrast, following detailed analyses, two organisms previously considered alien to the biome, the fungus Phytophthora cinnamomi and the Red-eyed Turtle Dove Streptopelia semitorquata, are now considered indigenous. The American Grey Squirrel Sciurus carolinensis and African Honeybee Apis mellifera adansonii have both been shown to pose little danger to untransformed areas within the biome.

### Quantifying the extent of the problem

Several recent studies have helped quantify the extent of alien woody plant invasions of the biome. Depending on the definition of the term "infested" and the alien species and area being studied, estimates of infestation range from 25 to 100%. In all cases where time series have been studied infestations were increasing.

Three alien bird species, the Helmeted Guineafowl Numida meleagris, European Starling and House Sparrow Passer domesticus have been shown to be present in every quarter by quarter degree area in the western portion of the biome.

The Argentine Ant was found to be present at 42% of 83 disturbed fynbos sites surveyed during 1983/84.

### Understanding the invasion process

Recent research has documented high rates of seed production for a range of successful alien plant invaders. In some cases this has resulted in very large seedbanks being present. Although high rates of predation of this seed have been recorded the number surviving have been sufficient to maintain or increase the infestation. Several woody aliens have been found to be dispersed by birds and their fruit displays have, in general, been shown to be as effective as those of the most successful indigenous fruiting species. Phenological studies indicate that an earlier start to their growing season might impart a competitive advantage to invasive alien plant species.

Several studies have indicated the importance of man-induced disturbance in increasing the competitive ability of aliens. Similarly, the phenomenon of "ecological release", in which the absence of predators and pathogens in the country of introduction imparts an advantage to the alien, has been well documented in several recent studies. The emergence of "new" predators and



pathogens that attack aliens in their introduced range and the introduction of such organisms from their native habitats into their introduced range, have both been shown to reduce the alien's competitive ability.

### Quantifying alien impacts

Little work has been carried out on this aspect. The impacts of the Argentine Ant on indigenous ant communities and consequently on the regeneration of myrmecochorous fynbos plants has been well documented. Additional information has been provided on the effects of woody aliens on indigenous plant communities; in general a loss of species richness occurs. Their impact on faunal communities is different with species richness remaining unchanged but density decreasing. The intensity of the interactions between the fauna and the surviving indigenous flora change considerably.

The impacts of woody aliens on ecosystem functioning have been little researched: areas of impact identified to date are those of sediment dynamics, geochemical cycling and fire regime characteristics. One study has been initiated on the impacts of an invasive alien grass species. Its impacts are apparently high. There is an urgent need for research into the impacts of faunal invaders.

## 5. FEASIBLE MANAGEMENT GOALS AND STRATEGIES FOR CONTROL OF INVASIVES IN THE FYNBOS BIOME

P A S Wilson
Department of Environment Affairs, Private Bag X9005, CAPE TOWN, 8000

The problem of invasive plants in the fynbos biome has been recognized for many years. Very little is known or has been recorded on invasive fauna. This paper deals largely with the control of invasive plants. The history of control of invasives from 1940 to the present day is sketched.

As control of invasives is a conservation practice competing for limited funds there is a need to quantify the economic value and to state clearly in laymans terms the ecological and botanic value of the biome.

Feasible management goals have been limited to two broad aspects: prevention of further invasion of the biome by flora and fauna; and restriction of invaders to levels that can easily be controlled, preferably by biological techniques.

Management strategies aimed at prevention of further invasion of the biome include: identification of potential invader flora and fauna already present in the area which may constitute a threat - in the veld, nurseries, refuse dumps; and improvement of the existing regulations governing the import of plants and animals into the country. In both these aspects special attention must be paid to flora and fauna from climatically compatible areas and plants that are adapted to fire. In addition, systematic monitoring to detect invasions and mapping on a degree grid, concentrating on disturbed areas, river banks and the fringes of intact areas is essential.

The invasive fauna identified to date in the fynbos biome, the Himalayan Thar (Heritragus jemlahicus), the European starling (Sternus vulgaris) and the

Argentine ant (Iridomyrmex humilis) have a widely differing extent and method of invasion. Control of these, and future faunal invaders will be specific to each species and will depend on the life cycle of each species.

Management strategies aimed at restriction of further levels of invasion by floral elements presuppose a clear understanding of the process of invasion and the characteristics which make invader plants successful. Phenological studies of invader plants are required.

Considerable progress has been made in two fields of control: large scale clearing of invader species using manual clearing in conjunction with burning and more recently the use of herbicides; and advances in the field of biological control, especially in reducing seed production and the seed store. The manager now has at his disposal a number of alternatives and combinations of alternatives. The challenge to the manager is therefore to select the method or combination of methods that is effective, causes the least disturbance to the biome, and is cost effective.

Control methods currently in use or on a trial basis are the following:

- Fell manually in the season least favouring regeneration, burn when regeneration completed, follow up clearing manually or using herbicide, eg Hakea, Pinus or Acacia species.
- Fell manually, allow sufficient period for seed predation, follow up clearing, eg Hakea sericea.
- Fell manually, burn, fell regeneration manually, burn, eg Acacia species where use of herbicide undesirable.
- Burn invader standing, follow up clearing manually, using herbicide or biological control: Hakea sericea, Acacia species.
- Introduce biological control agents, eg Hakea sericea.
- Introduce biological control agents to reduce the seed load and then apply burning and follow up methods eg Acacia longifolia.
- Apply herbicide to freshly cut stumps or inject herbicide to standing trees for species which coppice eg Acacia saligna, trees on stream banks.
- Ringbark isolated trees, eg Pinus species.

The basic strategy of control recommended is: to define and map the extent of the invasion and species involved; rank invasion in order of priority of control of the area to be cleared; draw up a programme of control according to manpower, funds and control methods; be strict in keeping to the programme - follow up is as important as initial clearing; and monitor the effectiveness of the control method (and adjust if necessary) and the effect on the resource.

Control of invader plants in the fynbos biome is feasible but requires coordinated and intelligent action by landowners, adequate and regular funding and a readiness to apply new methods of control. Research input is required in: identifying potential invasive species; evaluating the effect of control treatments on the biome; studying recognized invasive species; and increasing the input into biological control for invasive plants.



## 6. CASE STUDY : HAKEA SERICEA IN THE SOUTHERN CAPE

G J Breytenbach
Saasveld Forestry Research Centre, South African Forestry Research Institute, Private Bag X6515, GEORGE, 6530

Research on invasive species has concentrated on either the species itself, ie how does it grow and reproduce, or on control measures. Considerable effort has thus been spent without considering whether there is a certain stage during the invasion when the indigenous plant and animal communities have been impacted to the extent that recovery, even after the invasive species have been eradicated, is not possible.

If such a point does exist, consideration should then be given to use cheaper control measures that may have severe impacts on pristine fynbos, but will allow us to get rid of the alien, eg short rotation burning in the case of Hakea. The funds saved on control could then be invested on fynbos reclamation.

Our work has therefore been aimed at determining the degree of impact on community structure and function, given different levels of invasion. The major aim being to establish whether processes such as pollination and herbivory (both grazing/browsing and seed predation) have been impacted beyond redemption.

Communities are impacted as follows:

- alpha diversity of plant communities decreased considerably;
- small mammal communities showed virtually no response;
- arthropod densities stayed fairly constant but diversity and community structure changed completely. (It is worrysome that ant community structure changed considerably. The implication for myrmecochory is unknown);
- seed set (pollination?) was influenced;
- seed predation increased;
- leaf predation also changed.

Previous research has also failed to assess whether control measures have any impact on communities. Our results indicate that under certain conditions present control measures have a severe impact on biotic communities, eg:

- annihilation of Isoptera communities was recorded under certain conditions;
- resprouting plant densities decreased;
- ant community richness decreased considerably;
- seed banks were severely depleted.

It is therefore obvious that more research is required to identify:

- under which conditions funds should be spent on control measures;
- under which conditions cheap control measures should be used and the saved funds rather be spent on re-establishment;
- where control should start. Do we concentrate on dense, medium or lightly infested sites?

SESSION V. CATCHMENT MANAGEMENT

## 7. PLANNING AND PROBLEMS IN CATCHMENT MANAGEMENT

F J Kruger
South African Forestry Research Institute, P O Box 727, PRETORIA, 0001

This paper includes an analysis of the importance of mountain fynbos ecosystems as water source areas for the economy centred on the region of the fynbos biome. The history of policy, practice and research in catchment management is sketched briefly, and evidently important research questions are discussed.

The water from streams arising from mountain catchments dominates the available surface water resource picture for the region, not only because rainfall is high in the mountains but also because of the very high ratios of runoff to rainfall. Water from mountain catchments has exceptionally good quality, and is especially important for amelioration of down-stream water resources, where quality is and has been deteriorating. Quality problems do arise, however, because of high acidity and unacceptable colour in certain instances.

Formal catchment conservation has a history extending from the promulgation of the Colonial Forest and Herbage Act of 1859, and evolved through different stages of preservation policy to the present approach, based on active ecological management. Present policies are determined largely by the Forest and the Mountain Catchment Areas Acts. The premise underlying practice is that the most cost-effective measures are those which aim to maintain the natural fynbos vegetation as catchment cover. This requires the use of fire.

The effects of fire per se and of changes in the fire regime on streamflow from fynbos catchments are controversial. First principles and some empirical results indicate that fire should be followed by substantial streamflow increases and that vegetation maintained with a low biomass by frequent burning should favour higher average water yields than otherwise. This is contradicted by certain experiments. A basis for robust prediction of fire effects may lie in the relationship between leaf area index and evapotranspiration but the hydrological role of catchment physiography may require further study to allow the necessary understanding. Regarding floods, the experimental work indicates that rainfall volumes and antecedent catchment conditions are dominant determinants of volumes and peak rates and that opportunities for their control through vegetation management are limited if not negligible.

The biogeochemistry of the catchments is dominated by precipitation. The effects of burning of natural fynbos on water quality are therefore seldom of any consequence. Limited opportunity exists for amelioration of acidity and perhaps colour. The major threats to water quality lie in wildfires in thickets of hakea and other invasive species and in operations involved in the control of invasive species, but these have yet to be determined. Any development involving road or track construction holds the potential for increased sediment yield, especially given the periodic incidence of extreme rainstorms. Quality in streams, issuing from mountain catchments is immediately degraded by pollution from sources at points such as dwellings and by irrigation return flows; any developments within mountain catchments are likely to have the same consequences.



Possible trade-offs between nature and catchment conservation which may arise from contrasting burning regimes required by different objectives are discussed briefly. The potential hazards to catchment condition of the short-rotation burning scheme which could arise from water yield objectives are speculated upon.

## 8. THE ROLE OF FIRE IN THE MANAGEMENT AND CONSERVATION OF MOUNTAIN CATCHMENTS

B W van Wilgen
Jonkershoek Forestry Research Centre, South African Forestry Research Institute, Private Bag X5011, STELLENBOSCH, 7600

Significant advances in the understanding of the effects of fire on fynbos ecosystems have been made since the inception of the Fynbos Biome Project. This paper reviews the role of fire in the management and conservation of mountain catchments in the light of recent advances in knowledge. Fire should be reviewed in terms of the fire regime, and current understanding of the effects of fire frequency, fire season and fire intensity are presented. The main aims of prescribed burning in mountain catchments are: to reduce fire hazard; to enhance water yield; to rejuvenate fire adapted vegetation and to control woody weed species.

Fire is used to reduce fire hazard through reducing fuel loads and creating a mosaic of different aged blocks of veld. Before the use of prescribed burning began in the 1970's, wildfires accounted for all the area burnt. Wildfires are still currently important, and have accounted for about 60% of the total area burnt over the past three years, but blocks of recently burnt veld have proved useful in combating wildfires. Case histories from the Cederberg and Hottentots-Holland catchment areas are given.

Early studies predicted that prescribed burning would increase water yield by about 3000 $m^3$ $ha^{-1}$, based on data from one protected catchment in Jonkershoek. Further analyses with more data showed that this increase was only around 900 $m^3$ $ha^{-1}$, and that yields from other catchments showed little change with burning. However, management should aim to conserve ecosystem qualities responsible for the existing, seemingly efficient water yield from catchments and for maintaining high water quality by using fire, rather than attempting to increase water yield *per se*.

Woody weed species are removed from catchment areas for both nature conservation and water conservation purposes. Woody weeds may also increase fire hazard under certain circumstances. Fire has proved useful in controlling serotinous species such as *Hakea sericea* and *Pinus pinaster*, but species with long-lived, hard-coated, soil-stored seeds (for example Australian *Acacia* species) are not easily controlled by fire. Some problems occur when fires burn cleared areas under intense conditions and the effects of clearing, combined with fire, on the indigenous fynbos vegetation need to be determined.

Fire is necessary for species conservation in the fynbos. Research results on the effects of fire season have precipitated changes in the fire management approach. For example, there has been a considerable shift in the season of prescribed burns from predominantly late autumn and spring to early autumn burns. The original proposals for a fire cycle of around 12-15 years have been upheld by research findings.

The safe practical application of fire is still a major problem facing catchment managers. The optimum ecological fire season coincides with the period of highest fire hazard. Research into the adoption of a fire hazard and fire behaviour prediction system has shown promising preliminary results. The system can be used in predicting rates of spread and fire intensities required to achieve desired aims. The implications for management of the use of these systems is discussed.

9. CASE STUDY : MONITORING MOUNTAIN CATCHMENTS

J M King
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Mountain catchments in South Africa are widely managed for their water resources. While management practices often involve manipulating the vegetal cover of catchments to increase their water yield, little attention has been paid to the streams that actually carry the water. It is known that their waters are of very high quality, but in order to manage them successfully in the long term, we need to know how they function as living systems. Members of the Freshwater Research Group at the University of Cape Town have monitored three mountainous sub-catchments of the Eerste River (south-western Cape) during the last 18 months. Baseline information has been collected on a wide variety of stream characteristics, and details of the parameters measured and the techniques used will be discussed in the talk. The knowledge gained to date is already being used in the design of more advanced experimental work.

Whilst establishing the background information, we sought for clues as to the ways in which the streams function. Primary producers - the usual beginning of food chains - are very scarce in the water, and leaves fallen from riparian trees form the most obvious organic material present. Much of this material is retained within the system as benthic detritus, leaf packs and interstitial organic particles. These accumulations are the basis of the food web for the stream fauna: whole leaves and large fragments, fine particles in suspension and in the sediments, and the film of organic material on rocks are all potential sources of food for these detritivore-dominated communities. All of the above aspects are receiving attention, including some that have not been studied by stream ecologists before.

The stream ecosystems are interesting in that, although inherently very poor in nutrients and organic carbon, they are continuously losing any inputs of these, through downstream drift. Yet they must be delicately in balance with their surrounding catchments, because the stream communities are stable and predictable. Some of the questions we are facing now are 'How stable are the stream communities?', 'What disturbances in the catchments can detrimentally affect them?' and 'How long does recovery from disturbances take?' These questions have relevance to managers because though the water yielded by these streams is of very high quality, this is not entirely due to the nature of the catchments. Stream biota are a vital part of the self-purification processes that characterize all running waters, and they must have an important, but as yet unquantified, role in the maintenance of high-quality waters in these mountain streams.



10. GRAZING IMPACTS AND THEIR POTENTIAL INFLUENCE

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Fynbos grazing is of very low nutritive value and the production of domestic livestock from the veld is not widespread in the biome. Only in the coastal forelands and lower mountain slopes of the south east Cape is there a noticeable grazing impact on Cape Fynbos Shrublands (sensu Moll et al 1984). Here more fertile soils and a higher proportion of summer rain than elsewhere in the biome, results in a high cover of $C_4$ grasses (Themeda, Trachypogon, Heteropogon and Tristachya). These fynbos communities, which have strong affinities with the Afromontane grasslands of the eastern Cape and Natal, are termed Grassy Fynbos (Moll et al 1984).

This paper reports on the impacts of grazing on two Grassy Fynbos communities, one on the coastal forelands of the Humansdorp district, the other in the Baviaanskloof Mountains. Impact was assessed in terms of the management goals of the maintenance of community structure and functioning, and water catchment conservation.

In the Humansdorp district the Erica-Trachypogon community occurred in two stable cover states, easily differentiated by the presence of overstorey reseeding proteoid species. The grazed cover state is burnt on a 4,5 year rotation and is moderately to heavily grazed by large- and small-stock; the ungrazed cover state is burnt on a 12-15 year rotation and is not grazed by domestic livestock. Species richness was significantly lower in the ungrazed state. However, when species were collapsed into guilds, there were significantly more reseeders (especially Ericaceae and serotinous species) and succulents, and significantly fewer sprouters in the ungrazed than the grazed state. There were also fewer herbs and more myrmecochorous reseeders in the ungrazed state. Species which were apparently eliminated as a result of short fire frequency and grazing included many local and regional endemics as well as conspicuous proteoids such as Protea neriifolia and P. repens. In terms of overall richness, the loss of these species was compensated for by the immigration, into grazed fynbos, of weedy herbs and shrubs such as Piloselloides hirsuta, Arctopus echinatus, Senecio illicifolia and Helichrysum species.

In the Baviaanskloof community there was significantly higher rock and bare soil cover and significantly lower plant cover in grazed sites. This deterioration of catchment condition resulted in an estimated soil loss of 100 tons per hectare per year. Ungrazed sites supported fewer species than grazed sites but had a higher alpha diversity ($S/4m^2$). There were significantly lower numbers of reseeders and ant- bird- and insect-pollinated species in the grazed sites.

These results show that grazing, especially in association with a short fire frequency, can have a major impact on Grassy Fynbos. Community structure was profoundly and irreversibly altered. There was a loss of species (many rare) within certain guilds, a collapse of dispersal and pollination syndromes, and a gross alteration in community physiognomy. Grazing resulted in serious degradation of mountain catchments. The utilization of Grassy Fynbos for domestic livestock production must, out of economic necessity, continue on the

privately-owned lowland regions. This form of land use is at least compatible with the conservation of Grassy Fynbos in a semi-natural state. However, in mountain catchments, whether privately or state-owned, grazing should be disallowed. Here the long-term goal of high quality water production must override the short term economic benefits derived from sustained or occasional grazing.

## SESSION VII. THE CAPE FLOWER INDUSTRY

### 11. THE NATURE AND DEVELOPMENT OF THE INDUSTRY

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The wildflower industry of the Cape constitutes a major portion of the South African cut and dried flower trade, which on the export market currently earns upward of R8 million annually. Merchandise is broadly divisible into the three categories - fresh cut flowers, fresh foliage ('greens'), and dried material - exports of which are well monitored on a monthly basis by the Department of Customs and Excise. Being one of the few human activities which relies directly on fynbos vegetation as a resource, the industry is of special interest to planners attempting to construct an ecologically sound strategy for management of natural vegetation in the region. Producers themselves are optimistic about long-term prospects for a stable industry, and many are therefore willing to cooperate with research where results might assist in determining the patterns and levels of harvesting compatible with sustained yields from commercially viable species.

Although horticultural research over the past three decades has led to the successful cultivation of many exportable and economically valuable variants - nearly all within the Proteaceae - an estimated 75% to 85% of all produce is still harvested directly from the veld. From its beginnings as a street-vending trade approximately a century ago, the industry has been developed for the most part by small enterprises in laissez-faire fashion, resulting in a complex array of routes for the movement of produce between its innumerable sources and the market place. This complexity has hampered the construction by conservation authorities of a control mechanism capable of accurately monitoring the commercial flow of material from the veld. In the branch of the industry concerned with export to overseas markets however, the patterns of handling are simpler, and work in progress at present promises to provide some detailed insight into the commercial utilization of the fynbos flora.

During the 1970's boom conditions were experienced in the industry, primarily as a result of the development of efficient export channels to the lucrative European market. Some areas of fynbos which had previously been protected by their unsuitability to conventional agriculture, were annexed during this period of expansion for the establishment of plantations. Unlike the cultivated areas already established by pioneering producers in the previous decade-and-a-half, these marginal plantations faced a new set of horticultural and ecological problems, many of which still require considerable research.



It is clear that if an effective management plan strategy is to be developed in order to provide an unequivocal rationale and a definitive set of guidelines for commercial producers, then an accurate knowledge of the relationship between the industry and its resource is required. Various research bodies are currently investigating diverse aspects of the system, and hopes are for a scheme to evolve which will protect a large proportion of the surviving fynbos as both an economic resource, and an ecological refugium.

### 12. ECOLOGICAL FACTORS INFLUENCING THE DEVELOPMENT AND MAINTENANCE OF THE INDUSTRY

A G Rebelo
Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Private Bag, RONDEBOSCH, 7700

The protea industry realizes over R2,7 m in exports of fresh material and a further R2 m in dried material while the local market is valued at over R1,5 m per year. Only 20% of the fresh material currently exported is cultivated, the remainder being picked from uncultivated natural veld. The effect of this exploitation, with its lack of legal control and inordinately light penalties, on the future of the industry is largely unknown. Already some species (eg Leucadendron salicifolium) are declining in abundance to be low economical levels of exploitation due to over-exploitation coupled with agricultural encroachment. Specific avenues where research is desperately needed include the effect of flower harvesting on pollinator abundance and the resultant effects of pollination on seed set. While the industry maintains that picking is undertaken to enhance the regrowth of a new crop of flowers, the correct pruning techniques for many of the species exploited in the natural veld are unknown, and known techniques are not enforced when picking outside of cultivated orchards. While many producers collect seeds from cut plants, especially bradysporus species utilized for the dried flower market, little is known about the efficient storage, protection, longevity and sowing of many of the important economic species. Fire will become very important as a tool in the management of exploited veld. The effects of many small blocks of different aged veld on the pollinator and parasite populations and on the spread of disease in organisms are unknown. Under natural conditions parasites and diseases would have been limited by the lack of suitable hosts during the years following the large scale natural fires. Many of these problems are also pertinent to the cultivation of flowers for the industry, and it is in the interests of the industry to ensure that research on these topics will be undertaken.

### 13. A CASE STUDY. THE ADAPTIVE SIGNIFICANCE OF SEROTINY IN THE PROTEACEAE (AND THE HUNTING OF THE SNARK)

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Serotiny (canopy stored seed; about 105 species or 32% of fynbos Proteaceae) is one of three seed storage alternatives; the other two being myrmecochory (175 species, 54%) and passive soil stored seed (45 species, 14%).

It is important to understand the adaptive significance of serotiny because presently most of the fynbos biome is being managed in terms of the response to fire by serotinous species. This is because the serotiny strategy is displayed

by species which are the most conspicuous and important component in terms of cover abundance for much of the landscape. Yet, there are more non-serotinous than serotinous species of Cape Proteaceae. Based on a detailed investigation of serotiny and other fire survival traits in the genus Leucadendron, the following points have emerged.

- Serotinous species dominate mesic fynbos and are less important at the arid end of the spectrum.
- They usually have thinner seed coats and thus weaker dormancy than non-serotinous species.
- Their seeds have similar phosphate concentrations to non-serotinous species.
- There does not appear to be nutrient cycling from older to younger serotinous seeds.
- Serotinous seeds are eaten by small mammals, but so are non-serotinous seeds.
- These species are usually taller than non-serotinous species. The tallest fynbos Proteaceae are usually serotinous.
- Serotiny is poorly developed in the Proteaceae from more frequently burned biomes (eg grasslands). Serotiny is favoured by an intermediate fire-frequency.
- Serotiny represents a cost to the plant for producing the woody cones and maintaining the vascular connections.
- The relative contribution of the last two years of seeds to the total seed store of serotinous species is far greater than the sum of the rest of the seeds.
- It is a relatively derived (recent trait); passive soil stored seeds being the postulated ancestral condition.

The question arises "what is the advantage (or reason) to plants for being serotinous as opposed to being non-serotinous"? (Where or what is a Snark?). The following are views from the literature. Serotiny (and myrmecochory) are considered as small mammal predation avoidance mechanisms; but there are non-serotinous non-myrmecochorous fynbos species and the seeds of species of this guild are consumed by small mammals. Serotiny is considered a precisely cued release of seed onto the post fire seed bed; but this depends on fires occuring in summer to late autumn. Serotinous seeds usually do not have dormancy and therefore this guild is sensitive to fires at certain times of the year. Serotiny is considered to be a mechanism to buffer erratic seed production; but this is not particular to serotiny. None of the above points explain why serotiny is restricted to mesic habitats.

I suggest that serotiny evolved historically during a moist but fire-prone phase during which fires would have been restricted to the driest (summer-autumn) times. In moist fynbos types, inter-fire establishment would (and is) not be possible due to the density and height of the vegetation, dormancy would not have any strong selective advantage and fungal or rodent attack may be greater for these seeds lying on the soil surface. Serotiny restricts seed release to the post-fire environment, the only chance for establishment. Because a trait like serotiny is part of a syndrome and syndromes are parts of organisms it is difficult to determine the exact adaptive significance of the trait. (The Snark was a Boojum, you see!). Nevertheless, research into serotiny has provided a framework for the conservation of such species.



**ABSTRACTS OF POSTER PAPERS**

SESSION III - HABITAT CONSERVATION

1. PALMIET PUMPED STORAGE SCHEME - ENVIRONMENTAL CONSIDERATIONS

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The Palmiet Scheme, in the Hottentots Holland mountains near Grabouw, is located in a geographically young landscape where topsoil is sparse and the nutrient status low. Climatically it is a harsh environment causing considerable leaching in soil. The Cape fynbos - indigenous to the Cape's south western region and the smallest of the six floristic kingdoms of the world, is specifically adapted to this environment. The Cape fynbos occurs only in South Africa and comprises a very rich variety of species.

Joint project developers, Escom and the Department of Water Affairs, have been giving attention to environmental aspects during the construction of the Palmiet Pumped Storage Scheme; a project that will not only add 400 MW of peaking power to the National grid, but will also augment the Cape Metropolitan area's water supply by a much needed 30 million $m^3$ annually.

Before this scheme could be developed in the Hottentots Holland mountains, with its fragile fynbos vegetation, a number of environmental factors had to be carefully considered. Initially the Palmiet Environmental Committee was appointed to determine both the beneficial and adverse effects of the scheme and to look into the alternatives.

In line with Escom's environmental policy to minimize the negative impact of its activities on the environment, an independant consultant was appointed prior to construction, to carefully analyze and survey this sensitive environment. Natural aspects such as the fauna, flora, geology and climate of the area were studied and socio-economic and historical aspects were also given due consideration. A working document "The Environmental Impact Control Plan" was drawn up to incorporate construction impact control guidelines into all construction activities. These include guidelines relevant to the protection of historical and archeological sites, the fencing of work areas to limit access, water pollution control measures, topsoil and the stockpiling thereof, borrowing pits, material storage, refuse control and sign-posting.

Contractors are legally obliged to observe impact control specifications, thereby inflicting the minimum amount of damage on the environment during and after construction and thus reducing any resulting rehabilitation. Because of the extreme difficulty expected with the rehabilitation of fynbos, conservation of seed is vital. The richest source of seed, other than the plant, is the topsoil, and so extensive measures have been taken to ensure conservation of this resource. Topsoil removal and stockpiling on demarcated areas, prior to construction activities, was conducted on an extensive scale. Access roads were tarred at a very early stage to prevent erosion. Dressings from the topsoil stockpile are placed on distribution areas, such as road embankments, for rehabilitation purposes. This process is supplemented by the application of a fynbos mulch, which serves as an additional seed source and creates a micro-environment which is more conducive to germination.

In nature, the germination of fynbos seeds is aided by an indigenous variety of ant. An exotic ant, the more aggressive Argentinian ant, may usurp this local ant variety with devastating consequences for the Cape fynbos vegetation. Measures to control the introduction of this exotic ant onto the site are effected by ensuring demarcated eating areas for labourers, waste disposal areas and prompt refuse removal.

Attention is also paid to the socio-economic implications of Palmiet, which, like any large installation, has significant effects on the local infrastructure and lifestyles. Local farmers were concerned that labour would be attracted away from the farms to the new project. To prevent this, the recruitment of labour was done from outside the area. Local candidates, however, were considered if they could prove that they were unemployed.

In conclusion, Palmiet has clearly shown the financial justification and benefits of incorporating environmental planning procedures during the initial stages of a project. Curing environmental ailments can be a costly process - prevention is therefore better than cure. At Palmiet, all preliminary investigation and current rehabilitation works will add not more than two percent to the total cost of the project.

2. FIRE AND MAMMAL COMMUNITY CONSERVATION

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3. THE ECOLOGICAL CORRELATION OF RARE PLANT DISTRIBUTION

S A Brown
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The objective of this survey is to identify any unifying ecological parameters which might affect species rarity and be of specific use in conservation management. The family Proteaceae, a typical Cape family with 320 species found within the fynbos biome of which 123 are rare or endangered, has been selected as a representative sample. Of the 123 rares, three are already extinct. One, Sorocephalus tenuifolius, has recently been annihilated from its unique locality of less than 50 $m^2$ on the Klein Palmiet River. This could have been avoided by the creation of a small nature reserve. A system of small nature reserves would be of immense value in preserving the Cape Flora which is characterized by many very restricted, local endemics. Of the 123 rare Proteaceae, 40 are restricted to single populations and 24 to two populations. Not only is the number of populations small but also the linear distribution is very limited. 65 of the rare Proteaceae have distributions of less than five kilometres. Such single population species are extremely vulnerable to sudden total extermination.



4. AN ASSESSMENT OF THE CONSERVATION STATUS OF LOCALLY ENDEMIC AND THREATENED PLANTS BETWEEN BREDASDORP/AGULHAS AND INFANTA WITH SPECIAL REFERENCE TO THE DE HOOP NATURE RESERVE AND THE OVERBERG MISSILE TESTING RANGE

C J Burgers
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A survey was undertaken to determine the status and distribution of 108 locally endemic (±50 taxa) and nationally threatened plants which occur in the area between Bredasdorp/Agulhas and Infanta. This survey has revealed that about 80% of these taxa occur in the De Hoop Nature Reserve and the Overberg Missile Testing Range but that as many as 42% of these ca 85 taxa may be 'Vulnerable' or 'Endangered' in this area due to critically small populations, very localized distributions or occurrence in areas which may be subjected to adverse impacts and development. The majority of ca 21 locally endemic and threatened taxa which occur in the study area but which have not been found in the De Hoop Nature Reserve or Overberg Missile Testing Range, are also represented by critically small populations and occur in areas which are threatened by development on private land.

This high proportion of species which require special conservation attention in the study area was found to be mainly due to the large number of threatened plants which occur in renosterveld and communities which are transitional between renosterveld and fynbos. These habitat types have been largely destroyed by agricultural development in this area and only small degraded remnants occur in the De Hoop Nature Reserve and the Overberg Missile Testing Range.

Conservation proposals include the registration of the critical habitats of threatened plants on private land as South African Natural Heritage Sites and the creation of nature reserves. Indications are that the critical habitats of the majority of the Vulnerable and Endangered Taxa in the De Hoop Nature Reserve and Overberg Missile Testing Range could be protected against development and adverse impacts.

The poster presents a summary of available information on the distribution and status of locally endemic and threatened plants in the study area. The location of the known critical habitats of Endangered and Vulnerable plants and proposed South African Heritage Sites are indicated.

5. THE NACEC PROJECT : A PROPOSED APPROACH FOR THE INITIATION OF A PILOT STUDY IN THE SOUTH-WESTERN CAPE

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The National Atlas of Critical Environmental Components (NACEC) project has been initiated by the Department of Environment Affairs. The main objectives of the "atlas" are to provide a central data base of information for environmental planning on the location of sites and features of special conservation importance and sensitive areas as well as a referral system to primary sources of information which are relevant to environmental planning.

The "atlas" is designed for use at a scale of 1:250 000; which was considered most appropriate for planning at the national and regional levels. More details on the objectives, format and content of NACEC will be provided in a poster by Liz Marrao of the Department of Environment Affairs.

An area in the south-western Cape, which will include the area covered by the 1:250 000 scale map sheets 3318 Cape Town and 3319 Worcester, has been selected for undertaking a pilot study for completion by January 1986. In order to ensure the most complete coverage of the area and features of conservation importance, the following procedure will be followed:

- A map of all remaining natural and semi-natural habitats will be drawn at a scale of 1:250 000 from LANDSAT imagery supplemented by aerial photographic interpretation.
- All areas which are known to be of special conservation significance will be indicated on the base map.
- This map will be circulated to knowledgeable persons for comment and proposals for additional sites will be obtained.
- Contributors will be sought to obtain the required information for threatened biota, representative or rare examples of natural ecosystems and sensitive habitats as well as other features of special conservation concern.

The information which will be obtained for the pilot study will be handled by means of the SIEMENS SICAD geographical information system. This system will allow very flexible storage, retrieval, analysis and graphical representation of the data.

The poster presents a map of remaining natural and semi-natural habitats in this area, existing conservation areas and a provisional indication of sites of special conservation importance.

The objective is to give participants at the meeting the opportunity to indicate additional sites of special conservation importance and to provide other relevant information.

6. LATE CAINOZOIC VEGETATION AND CLIMATIC CHANGE IN THE SOUTH-WESTERN CAPE

J A Coetzee
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Fossil pollen evidence has shown that subtropical Rainforest, common to Madagascar, Africa, South America and Antarctica during the Cretaceous, existed in the Miocene of the Cape. It was exterminated at the end of this period as a result of the maximum glaciation of Antarctica and the consequent cooling of the Southern Ocean. This led to the spread of fynbos from the early Pliocene and to progressive aridity in southern Africa.



7. REVEGETATION OF COASTAL DUNES AT WILDERNESS

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The widening of the national road through Wilderness has caused much of the vegetation on the primary dunes at the Touws River mouth and secondary dunes between Wilderness and Kleinkrans to be destroyed. A long-term revegetation programme is underway to re-establish indigenous vegetation on these dunes by a combination of methods. These include hydroseeding, the transplanting of individual plants rescued from the road reserve, mulching with chipped fynbos and seeding with seed harvested from adjacent areas.

8. BIOLOGY OF SMALL POPULATIONS

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9. NATIONAL ATLAS OF CRITICAL ENVIRONMENTAL COMPONENTS

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10. RED DATA LIZARD SPECIES IN THE SOUTH-WESTERN CAPE: FACT OR FICTION?

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A provisional list of threatened lizard species (red data species) was compiled by McLachlan in 1978 for South Africa (South African National Scientific Programmes Report No 23). The following species occurring in the area south of 32°30' and west of 19°30' have been listed: Phyllodactylus microlepidotus (small-scale leaf toed gecko), Lacerta australis (Cape Mountain lizard), Cordylus cataphractus (Armadillo lizard) and Scelotes gronovii (Gronovi's monodactyle skink).

Up to 1978 P. microlepidotus was known from only two specimens collected at Pakhuis Pass near Clanwilliam, while only one specimen of L. australis was known from Matroosberg, south-east of Ceres. Both species were accordingly placed by McLachlan in the "rare" category, ie taxa with small populations that are not at present endangered or vulnerable, but are at risk. Extensive fieldwork done during the last three years extended the ranges of these two species dramatically. It has now been established that P. microlepidotus occurs along the Cape Fold Mountains from Pakhuis Pass in the north southwards to Ceres, being quite common at many places within its range. L. australis was demonstrated to have roughly the same distribution, from the Hexriver Mountains immediately south of Ceres, to the Cederberg Mountains in the north. It is, however, nowhere very common, probably because of its secretive nature. With more fieldwork further extension of the ranges of these two species is likely. Both species are exclusively montane. Owing to the great diversity in agriculturally useless montane situations present in their range, these forms should be considered as fairly safe from any possible human disturbance.

C. cataphractus occurs only peripherally in the study area and recent fieldwork extended its range slightly southwards to the Piketberg Mountains and Olifantsriver Mountains in the west and the Swartruggens Mountains in the east. It was found to be quite common in these areas, but as McLachlan stated, it could be vulnerable owing to its charm and hence its popularity as a pet.

We were not able to extend the range of S. gronovii, but can report that it occurs quite commonly from Langebaan to Stompneusbaai and also on Dassen Island. A few specimens were found in recently ploughed fields indicating that farming activities probably have little influence on them.

The extensive fieldwork of the last three years led to the discovery of two new, well-defined species in the south-western Cape. A new Afroedura species was discovered in the Hawekwa Mountains near Paarl and it was subsequently found also in Bainskloof. This large, attractive gecko should, as a precaution, be listed as a red data species, until more is known about it. A second new form, a Cordylus species, was discovered in the Koue Bokkeveld and it is at present only known from the type-locality. Because of its apparently restricted distribution it should also be added to the red data list.

The discovery of the two new species and the dramatic extension of the ranges of P. microlepidotus and L. australis indicates our ignorance of the distribution of many of our lizards and stresses the need for continued thorough fieldwork to establish accurate distribution patterns for all the species. All the abovementioned species will then most probably be removed from the red data list.

## 11. PREHISTORIC PASTORALISM IN WEST COAST STRANDVELD

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From the archaeological record it appears that sheep and cattle have been present in the south-western Cape for about 2000 years. Bones of domestic stock have been recovered from a number of sites, but the quantities recovered are generally too small to tell us anything about herd management techniques of these early stock-keeping people. It is in the records of sixteenth century explorers that we find information on Khoi stock and pasture management. From the absence/presence of the Khoi at various places along the coast as recorded by these early travellers, patterns of pastoralist movements across the landscape can be deduced. In the dry environment of the west coast pastoralists would have been continually on the move, searching for fresh pastures and water. The coastal lowlands of the south-western Cape include three main veld-types, differing in composition and growth patterns; thereby offering a range of natural pastures to be utilized.

Based on the records of the early explorers, Smith (1984) has put forward a pattern of transhumance for the Cochoqua (who lived in the coastal lowlands between Table Bay and the Berg River) as follows:

> In winter stock was kept on the Vredenburg Peninsula, moving off as the summer approached and heading inland somewhere to the south-east to utilize the richer pastures of the renosterveld, returning to the Vredenburg/ Saldanha area along the Berg River.



There is no archaeological evidence to support this but some environmental factors seem to suggest that this pattern makes sense. Brock (1959) found that pastures in the Vredenburg area were deficient in some critical nutrients in the summer, whereas those of the renosterveld showed only marginal deficiencies. A serious shortage of copper occurs in the former area, exacerbated by high levels of molybdenum. Sheep would not have survived if grazed in the area all year round. In other parts of the coastal vegetation (strandveld) to the north and south of Saldanha, these deficiencies are non-existent or not serious. Whether or not these areas supported all year grazing would have depended on the availability of water.

Since not all of the strandveld vegetation is alike as a pasture resource, more data are required in order to begin to understand the nature of the pasture resource and how it could be utilized. This project aims to expand on existing data on the nutrient status of the pastures, as well as gather data on available biomass, effects of burning and grazing pressure, seasonal processes in the vegetation, grazing and browse selectivity of cattle and sheep and water availability. Two areas have been tentatively selected for study, one south of Saldanha and one to the north. With these data it is hoped to propose a model of strandveld natural pasture utilization by the Khoi, and to speculate on the effects of pastoralism on the vegetation and the nature of any changes that may have occurred in the past 2000 years.

## 12. THE CONSERVATION OF HEUWELTJIES

B G Lovegrove
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W R Siegfried
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Recent surveying and mapping of the patterned topography formed by uniform distributions of raised earth mounds known as "heuweltjies" or "kraaltjies" in the south-western Cape, has raised many questions and hypotheses which need to be addressed by a variety of scientific disciplines, particularly those involved in the Fynbos Biome Project. For instance, heuweltjies support very distinctive plant communities, and may contribute significantly to species diversity over small areas. As such, it is important that consideration be given to the conservation of areas of pristine heuweltjie topography in the different vegetation communities of the biome, if for no other reason than to provide for future research programmes.

Heuweltjies occur in association with at least five vegetation types occuring in and adjacent to the fynbos biome (Moll et al 1984), namely: Karroid Shrublands, Central Mountain Renosterveld, Sand Plain Fynbos, Dry Mountain Fynbos, and West Coast Strandveld. Whereas some existing reserves do inadvertently conserve heuweltjies occurring in association with some of the above vegetation types eg heuweltjies on Karroid Shrublands in the Vrolijkheid reserve near Robertson, a multi-disciplinary survey is required to ensure that heuweltjies in association with the remaining vegetation types, particularly the Dry Mountain Fynbos south-west of Clanwilliam, are being adequately conserved.

13. THE CLANWILLIAM CEDAR

P T Manders
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The Clanwilliam cedar (Widdringtonia cedarbergensis Marsh) is an endangered tree species endemic to the Cederberg range of mountains in the south-western Cape Province.

The search for the solution to the question of how to conserve this species appears to have reached an impasse by the late 1970's. A policy of actively protecting the cedar areas proved impractical, and the mortality in the intense wild fires which did occur was very high. The alternative was prevention of intense wild fires by reducing fuel loads with cool burns in winter or spring. This alternative also proved unacceptable in that although mortality was far lower, there was insufficient regeneration to replace the trees killed.

Burns in winter or spring are not conducive to successful regeneration for a number of reasons:

- Seeds released from trees killed in the fire may be exposed to granivory for the entire summer before conditions suitable for germination occur.
- Those seeds which do germinate are unlikely to produce seedlings which are sufficiently well developed to survive the drought by the onset of summer.
- The negative effects persist for a number of years after the burn. Fires in this season appear to adversely affect most large seeded species which occur in this area. Subsequent crops of cedar therefore form a disproportionally large contribution to the food available to granivores, and granivory is excessive.

Fire intensity is not determined by the season of the burn, but rather the conditions under which the burn is carried out. It should be possible, therefore, to achieve low mortalities comparable to those resulting from winter or spring burns by burning cedar areas in late summer or autumn.

14. FYNBOS RECLAMATION

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The development of South Africa's infrastructure is essential for its growth. Road building results in road cuttings, quarries and borrow pits. The consequences are scars to the environment, erosion, and the loss of habitats. Methods of restoring these areas are being sought for various reasons: to check erosion, revegetate scarred areas, and to protect high priority habitats. To this end two experiments have been set up on a gravel quarry near Caledon. One compares different techniques of introducing a seed source to the disturbed area, while the other deals with the use of fertilizers to ameliorate the sub-soil when top-soil is absent. Forthcoming results will aid the revegetation and management of artificially disturbed areas.



15. ECOLOGICALLY DIAGNOSTIC XYLEM ANALYSIS (EDXA): DIAGNOSING THE ECOLOGICAL STATUS OF A VEGETATION, PAST AND PRESENT BY QUANTATIVE ANALYSIS OF WOOD ANATOMY

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The rationale and methodology of this approach has been developed during analysis of fossil charcoal assemblages, but is a development of approaches used elsewhere to study the relationships that exist between wood anatomical and ecological variables. The computer based methodology which has been developed has been applied in the analysis of nine stratigraphically and temporally distinct fossil charcoal assemblages from Boomplaas Cave, Cango Valley. The time span covered is the last ca 60 000 years and changes in the values of the 13 EDXA variables have been used to diagnose changes in several climatic variables during this time. Together with other forms of charcoal analysis, the results have provided a relatively detailed reconstruction of climates and climatic change in the southern Cape during the late Pleistocene and Holocene.

The approach consists in the quantitative analysis of the wood anatomy of branch wood of selected diameters. Aspects of wood anatomy such as maximum and mean vessel diameters, vessel size range, total vessel and ray areas, number of vessels per mm and relative volume flow per mm are obtained for samples of sets of wood types represented in the charcoal assemblages. These sorts of basic variables are used independantly, but also to construct indices such as 'vulnerability' (mean vessel diameter/no of vessels per mm). Specific ranges of these variables and indices are known to characterize vegetation associated with specific climatic regimes. Thus these values 'provenance' the assemblage on an ecological gradient and can therefore be used to diagnose past climates.

An innovation in the present study was to obtain measures of the relative abundance of vessels in each of 50 diameter size classes to characterize a charcoal assemblage (or the woody component of a vegetation type). These profiles provide much data on climatic variables such as total annual precipitation and the operation of various factors limiting to growth, but also provide information on the diversity of the environment and on the habit of woody plants. The occurrence of 'growth rings' has also been quantified to provide a relative measure of the operation of factors limiting to growth.
The approach may be applied in the analysis of the wood anatomy of single 'plastic' or 'generalist' species or in the analysis of a set of representative woody taxa and the changes may be studied through time or spatially, across ecological gradients. The present study has focussed on change through time, but it is from EDXA measurements of the xylem morphology of extant woody species and vegetation types that refined correlations between climatic and wood anatomical variables can be established. This is the present challenge.

16. ALIEN ACACIA CYCLOPS AND A. SALIGNA SEED BANKS

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Annual seed falls under mature stands have been measured to be 1 197 seeds $m^{-2}$ for A. cyclops and 5 443 seeds $m^{-2}$ for A. saligna. Both results represent approximately half the annual seed production measured (Milton and Hall 1981).

Furthermore, seed banks were measured to be 2 031 seeds $m^{-2}$ and 11 920 seeds $m^{-2}$ respectively, ie representing less than twice the annual input for A. cyclops and more than twice the annual input for A. saligna. This data suggests species differences in dispersal behaviour and predation pressure.

At the Pella Research Site, soil cores taken parallel to a fence line confirmed bird dispersal of A. cyclops seed and also indicated bird-dispersal of the non-arillate A. saligna seed. Soil stored seed decreased with increasing distance from the fence. Seed sampled within one metre of the fence represented seed banks of 31 seeds $m^{-2}$ for A. cyclops and 18 seeds $m^{-2}$ for A. saligna.

An investigation into the distribution of seed from the parent canopy indicated that in both species, most seed falls vertically below the canopy. Outside the canopy edge there is a directional influence, with most seed falling to the northern side.

The immediate and long-term effects of clearing method on acacia seed banks is currently under investigation. A comparison of clearing with clearing plus burning in A. cyclops and A. saligna stands (Milton and Hall 1981) is being followed-up by resampling the same sites. Preliminary results show that although clearing plus burning has the greater initial effect in reducing the seed banks, the numbers of seeds remaining after several years are still sufficiently large to potentially form new thickets.

Reference

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17. CONSERVATION OF PROTEA ODORATA : CATTLE GRAZING AND ALIEN ENCROACHMENT

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Protea odorata is an endangered Protea growing on the ecotone between Sand Plain Lowland Fynbos and West Coast Renosterveld (sensu Moll et al 1984), specifically confined to Klipheuwel sands. The largest population occurs on a farm near Malmesbury where two aggregations together numbering ca 350 plants have been fenced off, ostensibly for protection from grazing by cattle. The impacts of grazing and alien encroachment were assessed by measuring seed set and current year growth inside and outside the enclosures, and in Acacia stands of different densities.

18. DIE VERSPREIDING VAN DIE ARGENTYNSE MIER IN DIE FYNBOS VAN DIE WES-KAAP STREEK

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Die uitheemse Argentynse mier (Iridomyrmex humilis) se indringing in die natuurlike fynbos wek ernstige kommer onder ekoloë. Die rede hiervoor is dat



mirmekochorie, dit wil sê saadverspreiding en berging deur die inheemse mierspesies, deur die Argentynse mier bedreig word. In gebiede waaruit die inheemse mierspesies, veral die Anoplolepis-spp verdryf word, word plantsade blootgestel aan brande, sonuitdroging en saadpredasie deur veral kleinsoogdiere. As gevolg hiervan bestaan die moontlikheid dan dat indringing van die Argentynse mier uiteindelik, na regenerasie, die samestelling van fynbos-gemeenskappe mag beïnvloed, deurdat mirmekochore plante relatief mag afneem of geëlimineer word.

Voordat of beheermaatreëls, of voorkomende stappe beplan kan word, moet die omvang van die probleem bepaal word. 'n Argentynse mieropname is gevolglik vanaf November 1983 tot April 1984 in die Wes-Kaapse fynbosgebiede onderneem met die doel om allereers te bepaal waar die Argentynse mier reeds in die fynbos gevestig is en wat die omvang van die besmetting is. Verder was die doel van die ondersoek om te bepaal watter fynbosgebiede nog vry is van hierdie indringerspesie sodat sorg gedra kan word dat hierdie gebiede sover moontlik skoon gehou word. Daar moes ook vasgestel word watter faktore verband hou met die vestiging van hierdie indringerspesie.

Daar is vervolgens by 83 persele in of aangrensend aan 'n fynbosgebied, waar versteuring vermoed is, vir Argentynse miere bemonster. Hierdie persele is verspreid oor 'n groot gebied wat in die noorde begrens word deur die Pakhuispas, in die weste en suide deur die kusgebied vanaf die Weskus tot by De Hoop, en in die ooste deur die Langeberge van die Riversdalse distrik. Daar is vir die teenwoordigheid van sowel die Argentynse mier as die inheemse mierfauna bemonster.

Die aas-metode, met vetlose beesvleis as aas, is gebruik omdat dit 'n relatief-vinnige manier is om vas te stel of die indringermier wel by 'n spesifieke plek voorkom. Die aas is volgens 'n sirkelpatroon met behulp van 'n kompas en maatbande uitgeplaas sodat 'n presiese beeld van die miermosaiek verkry kon word. By elke versamelpunt is daar oor 'n sirkel met 'n radius van ten minste 100 m bemonster.

Omdat die bogrondse-aktiwiteitspeil van die miere maksimaal is in die midsomer, is die grootste gedeelte van die opname vanaf die einde van November 1983 tot die begin van Februarie 1984 uitgevoer. Hierna is die versamelde miere gesorteer en tot spesie-vlak geïdentifiseer met behulp van Dr A J Prins van die Suid-Afrikaanse Museum in Kaapstad.

By 35 van die 83 bemonsteringspersele is Argentynse miere gevind. Hierdie Iridomyrmex-besmettings was almal by, of naby, piekniek of kampeerplekke, woongebiede, vuilgoedhope of dierstalle. Dit is duidelik die makliker-bereikbare gebiede wat reeds deur hierdie miersoort ingeneem is, want dit is by verskeie plekke in die Hermanus-Steenbras-Botrivier-gebied, die Grootvadersbos-Swellendam-gebied, die Bain's Kloof-Mitchell's Pass-gebied en in Jonkershoek gevind. Daarteenoor is geen Argentynse miere by enigeen van die bemonsteringspunte in die Sandveld of die Cederberge of die De-Hoop-gebied gevind nie. Hierdie laasgenoemde gebiede is geografies meer afgeleë en het nie sulke goeie padverbindings en so 'n hoë verkeersvloei soos die besmette gebiede nie.

'n Ontleding van die data met inagneming van die volgende faktore is gedoen: die arbitrêre streek, natuurlike plantegroei, indringerplante, versteuring, hoogte, huidige voertuig-toegang, historiese voertuig-toegang en die bereikbaarheid d m v 'n goeie padverbinding. Vir die data-ontleding is

gebruik gemaak van die G-toets (log-waarskynlikheidsverhouding) van gebeurlikheidstabelle. Die faktore wat hoogs-betekenisvol-gekorreleerd is met Argentynse mier-tenwoordigheid hou almal verband met die toeganklikheid van 'n gebied vir motorvoertuie en vir bewoning. Dit was veral baie duidelik dat die Argentynse mier deur middel van die mens se vervoermiddels na nuwe gebiede versprei word en nie deur voetgangers nie.

Vanuit hierdie slotsom is dit duidelik dat voertuigtoegang tot skoon fynbosgebiede sover as moontlik verbied of vermy moet word. Verder moet bestuurspersoneel, sowel as die publiek, bewus gemaak word van die bedreiging wat die Argentynse mier vir ons fynbos-ekologie inhou. Riglyne behoort neergelê te word om die verspreiding van hierdie miere te beperk. So behoort die storting van huishoudelike or ander vuilgoed in 'n ongeskonde fynbosgebied nooit toegelaat te word nie.

Wat die beheer of uitroei van hierdie indringerspesie betref, is die data nog onvoldoende. Dus word navorsing nou beplan om vas te stel of hierdie spesie, by gebiede waar die besmettingspunt nog klein genoeg is, uitgeroei kan word.

19. EFFECTS OF BURNING AND ALIEN PLANTS ON BIRD COMMUNITIES IN MOUNTAIN FYNBOS OF THE CAPE OF GOOD HOPE NATURE RESERVE

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This project aims to investigate the effects of two man-induced perturbations - burning regime and invasion by alien woody plants - on the avian community structure of mountain fynbos. The study is being carried out at the Cape of Good Hope Nature Reserve where block-burning as part of management has resulted in areas of known age vegetation. Extensive alien invasion, by Acacia cyclops in particular, has also taken place. Within the study area the mountain fynbos communities - Upland Mixed Fynbos ("upland"), Restionaceous Plateau ("plateau") and Restionaceous Tussock Marsh ("marsh") (Taylor 19??) - occur in the ratio of 5:3:2.

Line transects and plot censuses have been employed to determine avian density, biomass and species richness in the three mountain fynbos communities in the immediate pre- and post burn years and in 1,5, 5,5 and older than 15 year old blocks.

The generally depauperate nature of the habitat was displayed by the low avian abundance and biomass recorded. A maximum of 16 species was present in pre-burn "upland" where density was 2,7 birds $ha^{-1}$ and biomass 54 g $ha^{-1}$. These values were all greater than those in "plateau" or "marsh". Nectarivores predominated in "upland", whereas "plateau" supported largely insectivores and "marsh" supported insectivores and one granivorous species. In the year immediately following a May burn, bird density dropped by half although biomass altered little in the area as a whole. "Upland" continued to support the greatest biomass of the three communities. Species composition changed markedly with the advent of typically open country birds at the expense of those which had previously occupied the dense vegetation.



After 1,5 years biomass rose steeply as more of the relatively large bodied opportunist species, notably Crowned Plover Vanellus coronatus moved in. Species composition of 5,5 year old veld more closely resembled that of mature mountain fynbos than that of the 1,5 year old, but it supported less than both in terms of avian density, biomass and species number. In this transition phase pioneer species characteristic of the newly burnt veld were absent, as were the nectarivores which were a major component of 15 year old fynbos.

Three study plots covered 10%, 40% and 75% infestation by alien Acacia cyclops. The most striking vegetational difference was the suppression of indigenous species, including important food plants such as Erica species and Leucaspermum conocarpodendron. Accordingly, a decline in nectarivorous species was recorded with increasing alien infestation. However, the numbers of frugivores and insectivores also declined indicating that the A. cyclops did not support or serve as viable alternative food source. Biomass declined from 221 g $ha^{-1}$ in 10% infestation to 124 g $ha^{-1}$ in 75%. Density also declined (from 6,1 birds $ha^{-1}$ in both 10% and 40% infestation to 3,9 birds $ha^{-1}$ in 75% infestation) and species composition did not differ greatly between plots, underlining a tendency towards species suppression rather than replacement.

An area of 10% mixed alien infestation, comprising largely A. saligna, supported almost ten times the avian biomass of the 75% A. cyclops plot due particularly to the presence of a number of high mass granivorous species. At 6,3 birds $ha^{-1}$ the density was also greater in the mixed alien plot. An area of alien-free coastal thicket supported more birds in all respects than both the 75% A. cyclops and the mixed alien plots (which it most resembled in terms of vegetation structure). Here 27 species were recorded at a density of 19,3 birds $ha^{-1}$ and a biomass of 1 540 $ha^{-1}$. The biomass of birds in 15 year old "upland" mountain fynbos was only one percent that of coastal thicket.

Present work is directed at detailed monitoring of resource availability within the different aged vegetation communities and the sites of alien infestation. The feeding ecology of frugivores occurring within the study area will also be studied, particularly where pertaining to the potential dispersal of alien seeds.

20. HACK GROUPS - WHAT DO THEY CONTRIBUTE?

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The major contribution from 'Hack Groups' is awareness of the problem; the problem being defined as the extensive presence of alien invasive weeds on public and state owned lands, coupled to a lack of knowledge and interest, mainly in the public sector.

To date action initiated by 'Hack groups' has amounted to small groups of concerned people working in isolation on specific areas, usually indicated to them by the landowner. The physical input is extensive. However, achievements have been limited. Finance is often limited to donations and local efforts at fund raising.

One solution to the impasse in the Cape Peninsula has been the formation of Captrust plant protection committee, which coordinates all local Hack Groups.

Positive results of this coordination have been: greater visability through mass media; improved credibility; benefits of collective pressure; greater cooperation with local authorities; the possibility of group action in sensitive areas indicated by professionals; school and social activity groups becoming involved with their own local natural environment, following field trips combining careful instruction in clearing and cutting techniques; the possibility of distribution of biological control agents to combat invasive weeds in more remote areas by mountaineers and hikers; improved education in learning to discriminate between invasive and indigenous plant species; and local authorities accepting our cooperation. Education plus publicity results in greater awareness, in turn creating intelligent concern and producing collective action.

21. SEED DISPERSAL OF ALIEN ACACIAS BY THE BLACK KORHAAN

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A small study was carried out on the seed-dispersal of two Australian wattles, Acacia cyclops and Acacia saligna by the Black Korhaan Eupodotis afra. The study was carried out in order to demonstrate that significant seed-dispersal may be accomplished by bird species that are not wholly or even predominantly frugivorous. The arillate seeds of Acacia cyclops and the vestigal arillate seeds of Acacia saligna appear to be seasonally important in the diet of the Black Korhaan, a species which is generally considered granivorous. An investigation was undertaken into the amount and viability of Acacia cyclops and Acacia saligna seeds found in the faeces of these birds. Up to 800 seeds could be found in a single faecal sample, with approximately 80% of the seeds being A. cyclops. Almost all of the seeds found in the faecal samples were viable. The viability of Black Korhaan dispersed seeds which had been left in the field for six months was also tested. It was found that almost all A. saligna seeds were viable, whereas almost 60% of Acacia cyclops were inviable. Of the remaining Acacia cyclops seeds, most had already germinated, whereas no Acacia saligna seeds had germinated naturally. After the bird-dispersal of seeds it appears that Acacia cyclops needs to germinate quickly, but Acacia saligna may need further scarification of the seed coat to promote germination.

22. ATTRIBUTES OF SEED-DISPERSAL AT DIFFERENT FYNBOS SITES IN RELATION TO THE PRESENCE OF ALIENS

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In this study the patterns of seed-dispersal in five vegetation types in the south-western Cape were compared. The importance of different dispersal agents within each vegetation type was determined at both a species and an abundance level.

Preliminary results indicate that the predominance of bird-dispersal within forests is the most significant difference between any of the five vegetation types. At an abundance level over 80% of the forest plants are dispersed by



birds. At sites within strandveld vegetation about half of the plants appear to have adaptations for bird-dispersal. Within renosterveld and mountain fynbos sites approximately half of the plants rely on ants for the dispersal of their seed. These results, are compared to the presence and the importance of introduced species present at the various sites. The results are interpreted in terms of the need to have a knowledge of plant dispersal for the management of natural vegetation. The emphasis of this study will be on the management of plant communities dominated by bird-dispersed species and the predicted ecological perturbations that may occur with a large-scale invasion of alien plants.

23. A STUDY OF THE ALIEN PLANT INFESTATION LEVELS AND HISTORICAL LAND USE PRACTICES ON THE DE HOOP NATURE RESERVE AND OVERBERG MISSILE TESTING RANGE

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The aim of this study is to investigate the extent of alien plant infestations on the Overberg Missile Testing range and the De Hoop Provincial Nature Reserve. This information is necessary for the planning of a control programme and the long-term monitoring of the rate of spread as well as the effectiveness of control operations.

The approach adopted will be three-faceted:

- alien plant cover will be estimated from aerial photographs and estimations will be checked for accuracy with ground surveys. Each infestation will be plotted and placed into one of six cover classes (adapted from Braun-Blanquet Cover Abundance Scales);
- using the above data, a correlation can be made by comparing the level of infestation with previous land use practices, past control efforts, history of fires and stocking rates (domestic stock) in each of the major habitat types present; and
- study areas will then be selected for the long-term monitoring of the effectiveness of control and control methods.

The poster depicts the various cover classes as estimated from 1981 aerial photographs and separate maps showing past control efforts, history of fires, stocking rates and the major habitats.

24. EFFECTS OF EXOTICS ON THE COASTAL DUNE FUNBOS AT HUISKLIP ON THE TSITSIKAMMA COAST

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Recent studies of the coastal Dune Fynbos (sensu Moll et al 1984) have revealed that in the last fifty years the introduction of Acacia cyclops and Ammophila arenaria have had a profound effect on the stabilization of drift sands in the Huisklip area. In the 1920s marram grass was used to stabilize the large coastal foredunes. Studies of a series of aerial photographs since 1935 and field observations show that this has resulted in an increase in the stabilization of blow-out areas behind the foredunes by Dune Fynbos species,

principally Passerina rigida and Metalasia muricata. The extent of the spread of natural fynbos can be seen in the latest airphotos. A negative effect, however, is the spread of Acacia cyclops, Rooikrans, which is invading large drift sands to the interior and also the blow-out areas along the coast.

25. WHAT INFLUENCES ACACIA INVASIONS AT PELLA?

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Total enumerations by size classes of the alien woody plants invading the 270 ha Pella Fynbos Research Site (3332S 1832E) were carried out by 2 ha grids during 1984 (Beeston in press). Information on the site's history, as determined by retrospective aerial photographic analyses (Brownlie 1982) and recorded by the site manager (Pickard, personal communication), was recorded according to the 1 ha grid system (Macdonald et al in preparation). the current paper presents the results of some preliminary analyses (Kruskal-Wallis H-tests) of the variations in density of the two main invading species Acacia cyclops and A. saligna.

In an analysis of the influence of distance from the boundary both species showed the same trend of highest densities near the boundary and lowest densities in the centre of the site. However, due to high variance in the data these trends were not statistically significant. Both species showed highly significant (P less than 0,01%) differences in density between areas burnt once, twice or thrice since records began (A. cyclops had mean densities of 151, 2 and 1 plants/ha respectively while those for A. saligna were 305, 688 and 3845). Both species also showed highly significant differences between areas having different frequencies of occurrence of bare ground. A. cyclops was most dense on areas bared frequently (363 plant/ha) and least dense on areas never bared (2 plants/ha) while A. saligna was densest on sites bared once (1564 plants/ha) and least dense on areas bared frequently (24 plants/ha).

Areas that had been bushcut in the past had highly significantly reduced densities of A. saligna (309 plants/ha) as compared to areas that had never been cut (872 plants/ha). A. cyclops showed a similar trend (30 plants/ha as compared to 62 plants/ha) but the statistical significance of the difference was less (P = 8%). The differences in density between areas subjected to manual clearing operations between 1980 and 1983 and those where no clearing was undertaken were also highly significant. However, these differences appear to be the result of non-random choice of target areas rather than any response to clearing operations themselves.

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26. AVIFAUNAL RESPONSES TO THE SPREAD OF ALIEN TREES IN THE FYNBOS BIOME

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Historical analysis of the distributions of the Hadeda Ibis Bostrychia hagedash and the Pied Barbet Lybius leucomelas show both to have been absent from the fynbos biome at the start of the twentieth century. Distributional data have been assembled from published and unpublished sources which show a progressive expansion of the distributions of both species within the biome (Macdonald in press, Macdonald et al in preparation).

Maps are presented illustrating these range expansions.

Both species are shown to be using alien trees as their major nesting substrate within the biome. These trees are also important for roosting.

Other species which are thought to have shown similar range expansions within the biome are listed.

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27. THE INFLUENCE OF WIND ON THE DISPERSAL PATTERN OF ACACIA SALIGNA SEEDS

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Soil cores were collected around lone Acacia saligna trees in the south-western Cape. The highest concentration of seed occurred within 0,5 m of the stem. Seed concentration decreased with increased distance from the stem. Cores collected in the north-easterly quadrant contained significantly more A. saligna seeds than the other three quadrants. The data can be correlated with the direction of the prevailing south-westerly winds that occur during the time of seed fall.

28. SELECTING METHODS FOR CONTROL OF INVADER VEGETATION

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SESSION VI : CATCHMENT MANAGEMENT

29. MIST INTERCEPTION BY THREE SPECIES OF MOUNTAIN FYNBOS

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The objective of the present study was to investigate mist interception by Mountain Fynbos under non-rainfall conditions. Quantitative measurements and qualitative observations of plant-drip and stem-flow from selected plant species were recorded at five experimental sites on the Back Table of Table Mountain, Cape Province. Plant-drip and stem-flow catching devices were designed and installed in order to collect the moisture intercepted by plants. The results indicated that mist interception by the vegetation was influenced by wind speed, density of mist and by the morphological characteristics of the plants. Greater interception occurred when dense mist was accompanied by high wind speeds. The interception ability was found to increase with plant size. Interception efficiency depended on the leaf morphology of the plants. Narrow-sclerophylls (eg Psoralea pinnata) were found to be more effective in intercepting mist droplets than broad-sclerophylls (eg Leucadendron salignum). The portioning of intercepted water into plant-drip and stem-flow was largely influenced by the shape of the plant. The mean rate of water yields per plant observed during five periods of rainfree, misty conditions, was 71 ml $hr^{-1}$.

Rainfall is, therefore, not the sole source of moisture contributing to the water balance. The additional moisture intercepted by vegetation should, therefore, be taken into consideration in studies of water balance and hydrology.

30. FYNBOS VEGETATION : THE CAUSE OF BLACK WATER LAKELETS?

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In general, blackwaters are thought to originate through draining vegetation which is stressed by low nutrient levels. Due to the paucity of available inorganic nutrients in the soils, the plants produce considerable amounts of secondary compounds as a defence, partly toxic, against herbivory and bacterial attack. During plant decomposition these compounds, including a large phenolic fraction, become incorporated into humic/fulvic compounds, thus forming polyphenols. As a result of leaching, the compounds leave the soil horizons where formation occurred and make up much of the dissolved organic fraction of lake waters. It is these dark-coloured organic compounds that generally cause black and acid waters.

In the low, sclerophyllous fynbos vegetation of the south-western Cape, the black waters are expected to reflect low-nutrient soils and nutrient-stressed vegetation. The low pH of some waters reflects both the acid soils, which they drain and the acid nature of the organic compounds leaching from those soils.

This study involves a comparison of lakes which vary in degree of colour, pH, the degree of association of water with fynbos and with fynbos decomposition, as well as in their plankton communities. The relationship between water



colour, pH, polyphenols, major cations and anions, and nutrients are being examined in an attempt to understand the basic chemistries of the different lakes. By relating the aquatic fauna to the physico-chemical environment, the major types of lake in the fynbos region may be derived.

Water colour and, thus, dissolved organic compound concentration, certainly appears to be affected by the extent to which the waters are associated with fynbos and with the soils. The character of dissolved organic compounds is also determined in this manner and the chemical composition of lake water is closely related to the levels of humic/fulvic compounds present, since these readily complex metal ions, major anions and nutrients. pH further reflects, fairly closely, the levels of humic/fulvic compounds, due to the interaction between inorganic species and these compounds, as well as to their acidic nature.

Zooplankton and phytoplankton communities differ in composition and diversity in lakes of different colour (humic/fulvic compounds) and pH. Generally, the low coloured, alkaline lake waters are rich in phytoplankton with a high zooplankton species diversity, while dark, acid lakes are poor in phytoplankton and low in terms of zooplankton species diversity, but nonetheless, often support dense zooplankton populations.

31. THE FACTS OF LIFE IN A MOUNTAIN STREAM IN THE FYNBOS BIOME

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For stream invertebrates the normal food chain does not exist. Green plants are rare on the stream bed because of low nutrient and light levels and the scouring action of moving boulders. Phytoplankton are even more scarce, for any that occur are swept away by the current. The most obvious organic material in streams is leaves of riparian trees and, logically, many stream invertebrates are detritivores. Peak leaf-fall of the trees is in summer, and the amount of leaves on the stream-bed closely follows the pattern of leaf-fall, being abundant in summer and scarce in winter. Submerged leaves decompose quickly, both because of fragmentation by the turbulent waters and because of the feeding activities of detritivores. By mid-winter, most leaves have been reduced to fragments of little nutritive value.

The aquatic community is composed almost entirely of insects. The turn-over time of the community is one year, as is shown clearly in successive years by the mass appearance of early instars of many species. Each community must be on 'short rations' during winter and early spring, and thus for a significant portion of its life-span. Indeed, the animals in the streams grow more slowly and mature as smaller adults than do those in more nutrient-enriched waters downstream.

It is concluded that the input of leaves from riparian trees is vitally important to the functioning of the high-altitude stream ecosystems. We believe that because of the low levels of productivity and the long turn-over times of the biota, recovery of the systems from disturbances will be very slow. This hypothesis will be tested for a common disturbance, when the Swartboskloof sub-catchment is burnt in 1987.

32. LIVES OF STREAM INVERTEBRATES - SYNCHRONIZED WITH WHAT?

J M King
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Limnologists in the northern hemisphere hypothesise that the life cycles of much of the biota of heterotrophic mountain streams have become synchronized with the major energy input, which occurs primarily as autumnal leaf fall from riparian trees. Mountain streams in the fynbos biome of the south-western Cape also appear to be heterotrophic, but the major organic litter input occurs in early summer rather than in autumn. If the above hypothesis is correct, then the life cycles of aquatic invertebrates of fynbos streams should be synchronized with the summer input, and therefore be out of phase with those animals in systems which receive mainly autumnal input.

The Eerste River catchment is within the fynbos biome and lies completely within the winter rainfall area. The invertebrate community of its mountain stream has annual life histories, with most species first appearing as very small individuals (1 mm) in late autumn, and growing for a short period before almost ceasing growth for the bulk of the winter. Growth rates increase slightly in spring and very small adults emerge in summer. This type of life cycle - autumn start, and including the following summer - is one of the most common in streams of the northern hemisphere. Thus, aquatic invertebrates of western Cape systems do not appear to have life cycles which are out of phase with their northern hemisphere counterparts. The hypothesis appears to be of questionable accuracy.

Are the life cycles of our fynbos stream invertebrates actually synchronized with food inputs anyway? Those of the western Cape do not appear to be, for leaves are abundant on the river bed in autumn (40 g dry mass $m^{-2}$), while the animals are very small, and then leaf packs are swept away, from late autumn onwards, as current speeds increase. Thus, animals halfway through their growth, requiring ever increasing amounts of food, are forced to compete for a rapidly dwindling resource as winter levels of detritus fall below 5 g dry mass $m^{-2}$. Growth rates pick up again in spring as leaf debris increase again, and slow winter growth appears to be linked to food supply rather than to temperature, for experimental work has shown that low temperatures do not inhibit growth when food is plentiful.

If life cycles are not synchronized to food input, then what could influence their timing? When compared to individuals of the same species occurring downstream in the same system, mountain stream animals do not reach their full productive potential (eg they do not grow as quickly or as big, they do not bear as many eggs and their life cycles are twice the length), so whatever controls the timing of their life cycles must outweigh the disadvantages of poor winter growth and low production. At present, the most likely factor appears to be high summer temperatures; a large number of species tend to 'avoid summer', but the importance of temperature remains to be proven in this case. If the high temperatures of summer have to be avoided by mountain stream invertebrate communities in the fynbos biome, then this would explain why the major energy input to these streams appears to be largely unexploited.



33. PHOTOSYNTHETIC LIGHT RESPONSES OF FYNBOS PLANTS

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IRGA measurements of three representative species of the proteiod, restioid and ericoid elements of fynbos indicate different carbon fixation responses for each group to light intensity. All these show C-3 photosynthetic characteristics, but Erica pinea shows a much higher light saturation point (1000 uE $m^{-2}$ $sec^{-1}$) than either Leucadendron argenteum or Elegia fenestrata (600-800 uE $m^{-2}$ $sec^{-1}$). The maximum carbon fixation rates for E. pinea, L. argenteum and E. fenestrata are 3, 13 and 10 mg $CO_2$ $dm^{-2}$ $h^{-1}$ respectively, the low rate of E. pinea being a reflection of its compact leaf growth form. These rates are lower than for comparable Chaparral plants.

34. THE EFFECTS OF VELD BURNING ON WATER YIELD

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ABSTRACT

Hydrologic records from three sub-catchments in the Zachariashoek research area, near Paarl in the western Cape, were analyzed to determine the effects of burning natural fynbos vegetation on streamflow volumes. Treatments consisted of late spring (November) burns on six and 12 year rotations.

Results indicate that burning six year old vegetation significantly influenced streamflow. The most marked changes were evident during the 12 month period immediately following the two consecutive burning operations in the same catchment - one in 1971 and one in 1977. Streamflow increased by an average of 7,6 mm per month (20,8% of the average monthly discharge) after the 1971 burn, and by an average of 7,3 mm per month (11% of average discharge) following the 1977 burn. These increases were followed by brief reductions in flow before the system stabilized to pre-burn conditions.

Burning 12 year old vegetation did not produce any significant increase in streamflow, but led to a 13% reduction in average monthly streamflow during the second year following the burn.

The effects of burning fynbos on streamflow are comparatively short-lived, and appear to be influenced by the rate of vegetation recovery. Changes in streamflow occurred mainly during the wet season.

35. PROTEACEAE - BEAUTIFUL BUT FRAGILE

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A broad survey of inflorescence form in the Proteaceae in environments where fire is a regular but stochastic factor shows that they have certain common features. The Australian large shrub species, mainly in the genus Banksia,

appear to have more complex mechanisms for retaining seed in their inflorescences than the South African species, in the genera Protea and Leucadendron. I suggest that the present flower form was essentially the same before the advent of fire as a relatively frequent factor (10-50 year cycle?). The traits we observe today and label loosely "fire adaptations" are a product of different processes. The species we see are those that have managed to survive and to see them as being adapted in the sense of "optimally suited" is short-sighted. Myrmecochory is also, at first sight a "fire adaptation" but is apparently equally vulnerable to manipulations of the fire regime. I suggest that the major reason that there are seasonal fluctuations in recruitment is because the species are in fact struggling to survive and are not buffered against man's manipulation of the fire regime, particularly for low intensity fires.

36. DOES THE CAPE FYNBOS SYSTEM LEAK MORE NUTRIENTS THAN ITS WESTERN AUSTRALIAN COUNTERPART?

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Recent studies on deep acid sands in typical climax Sand Plain Lowland Fynbos (sensu Moll et al 1984) (western Cape) and Kwongan heath (south-western Australia) communities indicate a higher soil nutrient status, and possibly availability, in the former. The structure and functioning of Kwongan heath reflects a system where nutrient supply is limited and seasonal moisture stress may be marked.

Compared with Protea repens - dominated Sand Plain Lowland Fynbos, the Banksia - dominated Kwongan heath displays better-developed strategies which may enhance nutrient uptake and conservation. These include an extremely well-developed proteoid root-mat, most effective vertical and horizontal exploitation of the soil profile and slow rates of litter drop and decomposition. In addition the wide B horizon acts as a nutrient trap/exchange site due to the presence of sesquioxide coatings on the soil particles. Extremely high C/N and C/P ratios in the topsoil point to microbial immobilization of these nutrients and this may signify a strong conservation rather than competitive mechanism.

We propose that the Cape system is poorly protected against irreversible nutrient losses due to relatively low efficiency in appropriate structural and functional characteristics. We further suggest that this system may be considered "leaky" in terms of nutrient movements, and that the frequent veld-burning of recent times is exacerbating this leakiness. Atmospheric replenishment of nutrients is relatively insignificant. In addition the low importance of legumes in Sand Plain Lowland Fynbos (prominent in Kwongan heath) indicates that loss of nitrogen may be critical as this element is easily volatilized and lost during burning.

Our argument may be extended to frequently burnt Cape mountain fynbos areas where soils are generally skeletal and depauperate in colloids (low nutrient retention). Here irreversible nutrient losses are accentuated by uplifted topography (steep slopes) and overall good drainage.



37. WHICH RESEARCH RESULTS HAVE BEEN APPLIED BY MANAGERS?

T S Newby
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Since the inception of the Fynbos Biome Project many research results have been published in literature.

Not all these results were intended for direct management application, others that were may have been lost to managers in the sea of literature. This poster paper attempts to illustrate some of the research results that have been applied by managers and points out the probable flow path by which these results reached the managers.

38. REMOTE SENSING AS AN AID IN MANAGEMENT

T S Newby
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This poster paper attempts to illustrate some of the potential applications of Satellite imagery and digital image processing in the management of fynbos biome areas. The use of Vegetation Index Numbers (VIN) in the assessment of above-ground biomass is suggested and the use of Digital Terrain Modelling in combination with Vegetation Index Numbers in a Fire Danger Rating Model is proposed.

39. SEED DYNAMICS OF ERICOIDS IN SOUTH COAST DUNE FYNBOS

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In order to manage fynbos communities, an understanding of the species population changes and their causes (ie demography) is necessary. This study, initiated in January 1985, aims to determine selected stages representing population changes in six selected ericoid species in south coast Dune Fynbos (sensu Moll et al 1984). This vegetation is the most threatened of fynbos biome types: destroyed by coastal development, infested by aliens and frequently burnt by farmers to promote grazing. Preliminary studies cover: community size structure, cover and density in mature stands; variations in annual seed production; size of soil-stored seed banks; seed dispersal (myrmecochory); seed predation and deterioration; fate of seedlings; youth period and fecundity schedules. The effects of different disturbances (bush cutting; litter clearing; fire) in both spring and autumn seasons are being monitored. Results will be used in a submodel to predict effects of fire interval and season on recruitment, and also in identifying possible environmental germination triggers. At a later stage these will be investigated in detail on seed collected from the study site. These germination experiments will provide useful data for the model and also in the propagation and management of populations of rare and endangered species, and in dune revegetation programmes.

## 40. STOCKING DENSITY OF LARGE HERBIVORES IN FYNBOS OF THE CAPE OF GOOD HOPE NATURE RESERVE, IN RELATION TO VELD AGE

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The Cape of Good Hope Nature Reserve comprises one of the few areas of fynbos supporting a diverse large herbivore population. Since 1975 management of the reserve has involved sequential burning of different blocks of vegetation, each of ca 1000 ha, every second year. Burns were conducted in May of 1975, 1977, 1979, 1981 and 1983. The present study focussed on the manner in which the seven largest species of herbivore present, the Eland Taurotragus oryx, Mountain Zebra Equus zebra, Red Hartebeest Alcelaphus buselaphus, Ostrich Struthio camelus, Bontebok Damaliscus dorcas, Springbok Antidorcas marsupialis and Grey Rhebok Pelea capreolus distributed themselves in relation to veld age.

Between August 1982 and February 1983 a complete census of the reserve was conducted by a team of rangers on one day in each month. Estimated mean census efficiency (% total individuals present found) was 76%. Similar censuses were repeated between August 1984 and March 1985, during which period estimated mean census efficiency was 69%. Every animal seen was mapped in relation to the age of veld in which it was found, with animals in firebreaks or in disturbed areas being noted separately. Data for all species were then converted to Animal Units (A U), a domestic beast of 456 kg being taken as unity. The following conversion factors were used: Eland (0,88), Zebra (0,57), Hartebeest (0,50), Ostrich (0,24), Bontebok (0,20), Springbok (0,12), Rhebok (0,10). Overall results, expressed in terms of A U observed/100 ha/census for each period, are given in Table 1.

Results demonstrate disproportionately high observed stocking densities on the most recently burned veld and on fire breaks/disturbed areas, and disproportionately low stocking densities on veld burned over 4 years previously, with veld aged 2-3 years being intermediate. Systematic decreases in stocking density on the 1979 and 1981 burns between the two periods indicate veld age rather than intrinsic difference between vegetation blocks as the key factor influencing observed stocking density.

Table 1.

| Year of burn | A U/100 ha/census 1982-83 | A U/100 ha/census 1984-85 |
|---|---|---|
| Pre 1970 | 0,28 | 0,45 |
| 1975 | 0,04 | 0,14 |
| 1977 | 0,04 | 0,35 |
| 1979 | 1,85 | 0,18 |
| 1981 | 4,14 | 1,98 |
| 1983 | (see old veld) | 2,45 |
| Firebreaks/ disturbed areas | 4,97 | 15,94 |
| Overall average: | 0,93 | 1,06 |



## 41. DETERMINANTS OF FYNBOS INSECT COMMUNITY STRUCTURE AND DISTRIBUTION

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The role of polyphenols, sclerophylly, leaf surface area and leaf water content as potential defences against phytophagous insects in the fynbos, a mediterranean-climate vegetation occurring on oligotrophic soils in the south-western Cape, South Africa, was studied. The plant species Passerina vulgaris, Metalasia cephalotes, Cliffortia ruscifolia, Protea repens, Virgilia oroboides, Erica species and Restio species were sampled in a single plant community for phytophagous insects. In addition P. vulgaris was sampled in two distinct plant communities to test for the influence of the biotic environment in which a plant occurs on the insect community associated with it. A new descriptive method, the Entomosociological Table, is proposed for studies concerning the distribution of and interrelationships between folivorous insect communities. Insect communities on each plant species were distinct. Diversity of phytophagous insect species correlated positively with leaf tannin levels for all plant species sampled within a habitat. It is hypothesized that these unexpected results may be associated with insect-transmitted microbial plant pathogens. Data from two populations of P. vulgaris in different plant commnities did not fit this regression line. No relationship was demonstrated between insect communities and leaf water content, leaf surface area or sclerophylly. It is concluded that the evidence does not support the hypothesis that low palatability of fynbos leaves is a result of coevolution with herbivores.

## 42. WHY ARE GRANIVORES SCARCE IN MOUNTAIN FYNBOS?

A G Rebelo
Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Private Bag, RONDEBOSCH, 7700

Avian granivore biomass in mountain fynbos is limited by the inaccessibility of seed resources, which is primarily due to the adaptations of plants growing under nutrient poor conditions for storing seeds safely in a fire prone environment. These adaptations include serotiny and myrmecochory which effectively reduce the time seeds are available to predation in the post-fire environment and the time seeds are exposed, respectively. While avian biomass is lower than that of comparable ecosystems, avian species richness remains high, with a fine level of resource partitioning, probably due to the variety of seed types, sizes and seed dispersal strategies present. It appears that this hypothesis may equally well apply to non-avian granivores.

## 43. THE BIOGEOGRAPHY OF THE PROTEACEAE

A G Rebelo
Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Private Bag, RONDEBOSCH, 7700 and
J P Rourke
Compton Herbarium, Kirstenbosch National Botanical Gardens, Claremont, 7700

The patterns of distribution and species richness of the 353 species of Proteaceae in the fynbos biome have been investigated. The highest species diversity is centered at Houwhoek, with Koegelberg, and Kleinriviersberg having

slightly less species. Most mountain ranges are discernible as units, although the mountain ranges in the east (Outeniqua, Tsitsikama and Kouga) are not distinct. In addition to the Phytogeographical Centres identified by Weimark, we recognize the Bredasdorp Coastal Flats as a region distinct from the Langeberg Range, and the Witteberg Range as distinct from the Swartberg Range. Regarding endemism, the highest endemism occurs in the Houwhoek area (Kogelberg, Kleinriviersberge and Groenlandberge) where endemism accounts for about 50% of the total species richness, and endemic species outnumber the total species richness of most other areas. In contrast the Franshoek area (Du Toits, Slanghoek and associated ranges) have a very low endemism (less than five percent) although it has a high species richness. These patterns suggest that local endemism is largely confined to the extremes of the biome where peninsula effects are greatest.

44. CHANGES IN THE COMPOSITION OF FYNBOS VEGETATION FOLLOWING 35 YEARS OF SUPPRESSION BY PINES AT JONKERSHOEK, STELLENBOSCH

D M Richardson
Jonkershoek Forestry Research Centre, South African Forestry Research Institute, Private Bag X5011, STELLENBOSCH, 7600

The fynbos vegetation of Biesievlei Catchment, Jonkershoek, was surveyed and described in 1945. In 1948 the catchment was afforested with Pinus radiata. This poster presents results of a reassessment of the vegetation in 1984 using the same methods used in 1945. Afforestation has reduced the cover of natural vegetation from 74,73 to 19,70% and reduced the total number of species from 292 to 126 (at least 190 species found in 1945 were not found in 1984 and at least 18 new species were added to the list). The most important families in the impoverished flora are Oxalidaceae, Poaceae and Asteraceae. Briza maxima (Poaceae) and Hypochoeris radicata (Asteraceae), both cosmopolitan weeds, have become important species in the understorey vegetation. The mean plant density was reduced from 260 to 78 plants/$m^2$. The spectrum of life forms was changed by a reduction of chamaephytes and an increase in hemicryptophytes. The results are used to show that the stability of the ecosystem may have been severely affected by afforestation. Hypotheses on the possible recovery of the vegetation after clearing are proposed.

45. THE INFLUENCE OF VEGETATION ON STREAM FLOW

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This poster reports results of a multiple catchment experiment in south-western Cape Province where the influence of afforestation with Pinus radiata and total protection of natural vegetation (fynbos) on stream flow was monitored from 1940-1980.

Both afforestation and protection of some of the fynbos catchment resulted in reduced stream flow. In a 98% pine afforestation catchment the stream flow decreased by an average of 313 mm from an initial 663 mm. Stream flow decreases stabilized after about 14 years in this case. In a 57% afforested catchment inflow decreased by 197 mm from an initial 593 mm. Here stream flow decreases stabilized after about 19 years. Percentage of area afforested, total biomass and mean rainfall appeared to have influenced the magnitude of



deductions. In a fynbos covered catchment protected from fire for 38 years there was an average decrease in stream flow of 185 mm from an initial flow of 1603 mm. Stream flow decreases stabilized at this level after about 22 years in this catchment. Two protected fynbos catchments receiving less than 1400 mm rainfall per annum showed no reduction in stream flow related to post-fire age.

This study indicates that fynbos does not reduce stream flow to the extent postulated in an earlier paper but confirms previous estimates of the effect of afforestation with pines on stream flow.

46. WHETHER CLIMATE IN SWARTBOSCHKLOOF?

D Versfeld and E Prinsloo
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What is the role and the potential role of a network of climate stations within the Swartboschkloof valley? A network of raingauges has been installed and the siting of three automatic weather stations is weighed against user-requirements. Data will serve as background to all research fields and monitoring may extend to limited-scale microclimate studies. Researchers in Swartboschkloof are invited to add their views.

47. MICROBIAL ATP, $CO_2$ EVOLUTION, NITRIFYING, NITRATE-REDUCING AND DENITRIFYING MICROORGANISMS IN TWO SWARTBOSCHKLOOF SOILS

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Microbiological studies have been conducted with Clovelly and Glenrosa soil (derived from sandstone and granite, respectively) from beneath Protea neriifolia on similar sites in Swartboschkloof (from March 1984 to May 1985). Microbial ATP was consistently higher in the Glenrosa than in the Clovelly soil; in both soils ATP peaks were recorded in the winter and early summer, with low values in the late summer to autumn and in the spring. Evolution of $CO_2$ from sieved soil incubated in the laboratory was also consistently higher in the Glenrosa soil, but did not follow the same trends with season as the ATP, peaking in spring and showing minima in November 1984 and February 1985. Populations (MPN) of nitrate-reducing microorganisms in the Glenrosa soil showed the same trends with time as the microbial ATP; the trends were often but not always similar in the case of the usually lower populations of the Clovelly soil. Populations (MPN) of denitrifying bacteria showed less agreement with the ATP trends, but the populations in the Glenrosa soil were usually the higher. When the medium pH was decreased to pH 5,0, no denitrification occurred, but nitrate reduction was sometimes evident. No autotrophic nitrifying bacteria have been detected in any samples. A nitrogen cycle lacking nitrification and denitrification in these acid (pH 4,61-5,16) soils would be advantageous for conserving limited nitrogen reserves. Soil temperature, moisture and nutrient studies will attempt to explain the seasonal trends and differences between soils in microbial ATP and $CO_2$ production, nitrate-reducing and denitrifying microbial populations.

48. PRELIMINARY RESULTS OF THE EFFECTS OF FERTILIZERS ON NUTRIENT UPTAKE AND GROWTH OF THAMNOCHORTUS PUNCTATUS PILL. (RESTIONACEAE) AT PELLA

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Plots (thirty six 10 x 5 m) have been laid out in Sand Plain Lowland Fynbos (sensu Moll et al 1984) Fynbos growing on Clovelly soil at Pella and were fertilized with combinations of nitrogen, phosphorus and balanced nutrients (-N & P) during September 1984. Soil ammonium, nitrate, total nitrogen and phosphorus, available phosphorus (both resin-extractable and Bray No 2), organic matter and pH were determined before and after the applications. Plants of one-to-two year-old Thamnochortus punctatus were harvested during February/March 1985 and the shoots, roots and rhizomes were analyzed for total nitrogen and phosphorus. In those plots ammended with nitrogen as ammonium nitrate, soil ammonium and nitrate levels decreased rapidly after fertilization but still remained higher than the levels in the unfertilized control plots after eight months. The addition of phosphorus as calcium phosphate resulted in a constant elevation of available phosphorus in the soil over the same period. Higher tissue concentrations of nitrogen and phosphorus have been measured in T. punctatus plants growing in nitrogen and phosphorus fertilized plots respectively and changes in their growth and nutrient allocation patterns have occurred.

## SESSION VI : THE CAPE FLOWER INDUSTRY

49. INSECTS ON PROTEAS: BOON OR BANE?

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Proteas are some of the few plants that are grown as a commercial crop in the areas where they occur naturally. They are therefore well adapted to the local soil and climatic conditions. However, all their natural insect pests and diseases are also present. Therefore it is a big challenge for a protea producer to market a product that is free from insects or their damage. In this respect it is necessary to distinguish between producers who pick flowers in the veld and those that harvest them from cultivated plantations. The former not only poses a threat to the fynbos, but also finds it extremely difficult to obtain insect free flowers. The latter stands a better chance of controlling pests, because of the dense stands and smaller areas involved. Ideally he should use integrated control programmes in which chemical insecticides play a subsidiary role.

From the producers point of view, pest insects are a bane, uncontrollable in the veld and costly and difficult to control. From the conservationist point of view, however, they are a boon, because the damage to proteas in the natural veld will force producers to concentrate on cultivation in plantations and thus save the plant in the veld from over-exploitation.



50. MODELLING THE LEVELS OF UTILIZATION BY FLOWER PICKERS IN THE FYNBOS BIOME - A PRELIMINARY LOOK

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The fynbos vegetation has served as a resource for the wildflower industry in the Cape for over a century and even with today's advanced horticultural techniques, an estimated 75% to 85% of produce harvested by the trade comes directly from the veld. Human activities such as public works projects, timber plantation expansion and housing developments are transforming much of the remaining fynbos with the result that the natural vegetation will become increasingly valuable as a source of supply for (amongst other things) the floricultural industry. This in turn suggests that if the industry is to conserve its resource, a rigorous and effective management scheme needs to be developed in the very near future. From a preservational perspective it will become even more critical to identify the species which could be exposed to extreme utilization pressure, with the consequent threat of extinction.

The work represented by this poster is a theoretical exploration of the relationship between the fynbos veld and the consumer market, assisted by a computer-based simulation of the selective removal of material from the veld. The process is mediated by a hypothetical entrepreneur who attempts, with conservational concern, to optimize profits under given conditions of market behaviour and the seasonal availability of saleable material (= 'flowers'). In assuming the size of the enterprise to be fixed - representing a commitment to a certain level of operation determined by factors such as the number of permanent workers employed, and an investment in capital equipment - the business will be sub-optimal whenever demand exceeds supply. The model identifies these periods and matches them to the condition of the veld. In the real-world situation it is at such times that species in a phenological phase suitable for commercial harvesting must be assumed to be in danger of over-utilization.

The algorithms employed by the simulation are written into a PASCAL programme which is executed on a microcomputer. Input data representing the seasonal demand of the market, and those describing the relevant phenology of the utilized species are derived from existing information, while the relationship of the entrepreneur to the resource is determined by the assignment of random values to descriptive parameters. Random number generators are also employed to select the 'fynbos-characters' of the set of hypothetical species which serve as the basis for the trader's livelihood. Output data consists of weekly synopses of market and supply status, and lists the species flowering at times when excessive demand would pose a threat to their conservation if our protagonist were to suffer an opportunistic lapse. It is suggested that a sophistication of this approach, when linked to accurate data, could constitute a viable management tool in fynbos conservation.

51. INSECT POLLINATION IN SELECTED ERICA SPECIES IN SWARTBOSCHKLOOF, STELLENBOSCH

D B MacGillivray and J H Giliomee
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Erica is a very important floristic element in the fynbos, being the largest genus contributing to the fynbos vegetation. In the south-western Cape the majority (about 80%) of Erica species appear to be insect pollinated emphasizing the need for this study which will supplement Rebelo's work on the ornithophilous Erica species.

To date studies have been conducted on six Erica species in Swartboschkloof, Jonkershoek that were found flowering during February/May. These are E. sphaeroidea; E. curvirostris; E. grandiflora (ornithophilous); E. parviflora; E. nudiflora and E. articularis. Blaeria dumosa (Ericaceae) has also been selected for study, since flower size, shape and colour is very similar to that of E. nudiflora. In the next flowering season, E. plukeneti, E. corifolia and other Erica species still to be located, will be studied.

The method of study involves weekly visits to Swartboschkloof during the flowering season of ericas under study. Observations on a 15 minute/hour basis are conducted on each Erica species, the major pollinators being collected and their relative abundance noted; pollinators are distinguished from nectar robbers and accidental visitors. Exclusion experiments involving the exclusion of flowers from insects are to be conducted to determine the relative importance of insects in pollination of these ericas. Microscopic brushing off of pollen from insects caught and the resultant identifiction of the pollen and comparison with that of the Erica species on which it was caught will hopefully yield answers regarding the flower constancy of the pollinators.

Preliminary studies indicate that hymenopterans dominate as pollinators of the ericas in Swartboschkloof. A much smaller component of dipterans and still fewer lepidopterans are also present. It seems as if Apis mellifera, the Cape honeybee, has a wide range as a pollinator. It was observed to fly from Blaeria dumosa to E. nudiflora, actively pollinating both. The average visiting time is about 10 minutes/plant, in which time the bee moves actively from flower to flower. Since the flowering times of these sympatric species coincide, there may be competition for pollinators - an aspect to be investigated. Surprisingly E. grandiflora, essentially an ornithophilous species, was found to have many insect visitors, some being nectar robbers, but the majority enter the flower from the stigmatal area and could therefore pollinate the flower. Dissection of the flowers revealed the presence of thrips which must be considered as possible pollinators. Experiments will be conducted to assess the importance of thrips. The question arises: "How important are insect pollinators in essentially ornithophilous Erica species?"

52. COLOUR AND SIZE OF FLOWERS IN RELATION TO POLLINATION OF ERICA SPECIES

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Data on flower colour polymorphism were recorded for 341 of some 426 species of Erica occurring in the south-western Cape. Thirty eight per cent of these Erica species are colour polymorphic, the incidence of colour polymorphism



being greater than expected in the genus for ornithophilous species, and lower than expected for anemophilous species. Both altitude and season of flowering are correlated with the incidence of colour polymorphism, with most polymorphs occurring in species which have relatively large altitudinal ranges and extended flowering periods. We suggest that the patterns of colour polymorphism, because of their relationships with the behaviour of pollinators, may reflect patterns of speciation in the genus. We hypothesize that entomophilous Erica species have tended to speciate in accord with differential pollinator visitation to different colour morphs. In contrast, we propose that ornithophilous species did not speciate due to the indiscriminate visitation of only one avian pollinator, the Orange-breasted sunbird Nectarinia violacea. Instead they tend to form either tightly knit species-complexes (eg E. coccinea, E. mammosa) or by extensive backcrossing of incipient races have resulted in closely associated hybrids (E. longifolia).

53. SURVEY OF INDIGENOUS FLORA UTILIZED BY THE WILDFLOWER INDUSTRY: CHARACTERISTICS OF PROTEACEOUS SPECIES WHICH MAY RESULT IN EXPLOITATION BY THE WILDFLOWER INDUSTRY

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Increasing concern over the effect of the Wildflower Industry (WFI) on natural vegetation has resulted in the recent initiation of a project by the Cape Department of Nature and Environmental Conservation, which will investigate the species utilized by the WFI and possible threats to these species in areas where they are removed from the veld.

The trade in wildflowers is heavily reliant on the overseas demand and the choice of favoured species is influenced greatly by the everchanging trends of fashion. Most species remain firm favourites, but a considerable number vary with the whims of fashion, depending on their colour, shape or texture. This makes it difficult to compile a checklist, as not only do additional species appear every season, but some are removed from the list as they lose favour in the flower trade.

The major factors which decide the desirability of a species within the WFI have been identified (eg colour, stem length and flowering season), and an attempt to categorize these factors is shown on the poster. the characteristics of a species will be rated within these categories and the level of vulnerability to exploitation (by the WFI) will be determined. Species will be dealt with in families and some categories will vary, depending on the salient features of the species within each family, eg the cones of some Leucadendron species are more attractive than others, which is an important characteristic, but there are few, if any, non-proteaceous species which bear cones.

The family Proteaceae, heavily favoured by the WFI, lends itself to a pilot study in this direction, since many studies on this family have resulted in a wealth of valuable and readily available information. Some species from the Proteaceae have been chosen as examples for this poster.