

# Use and Management of Mediterranean Ecosystems in South Africa—Current Problems<sup>1</sup>

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Ecosystems of the mediterranean type in South Africa include Mountain Fynbos, Coastal Fynbos, Coastal Renosterveld and a mesic form of Strandveld. These types extend outside the mediterranean climate into the zone of all-year rainfall but I will include these extensions here. Within this zone are Knysna forest, occurring where moisture regimes are unusually favourable (Specht and Moll, in press), and various Karoo formations, in areas with rainfall less than about 200 mm/yr; the dynamic relationships between these and the mediterranean-type formations can be strongly influenced by management. These ecosystems have been described in general terms by Adamson (1938), Taylor (1978), Kruger (1979) and Day and others (1979).

The ecology and management of Mountain Fynbos ecosystems were discussed at a previous conference (Bands 1977, Kruger 1977a). A broader view will be presented here, before returning to current problems in Mountain Fynbos.

## PATTERNS AND TRENDS IN LAND-USE AND MANAGEMENT

### History

Changes by man to Cape mediterranean-type ecosystems during the pre-settlement era appear to have been less than in Chile, California and the Mediterranean Basin (Aschmann 1973, Aschmann and Bahre 1977), especially in view of the absence of cultivation, late arrival of domestic stock, and absence of mining, and despite the longest history of occupation (more than 250 000 yr--Klein 1977). For example, available evidence suggests that major changes in extent of forest in the Holocene correlate with climatic change rather than human influence (Deacon in press). Also, the advent of pastoralism, about 2 000 B.P., seems to have had relatively little ecological effect overall because

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Abstract--This paper summarises patterns of land-use and management in mediterranean-type ecosystems of South Africa and, in greater detail, aspects of current management of fynbos mountain catchments. The managed fire regime and how it is likely to affect ecosystems is outlined. Controversial questions about the effect of fire frequency on species diversity and on catchment nutrient and water balance, and about the ecological effects of unseasonal burning, indicate priorities for research. The biology of invasive plants needs more thorough study. Techniques of applying fire need development to allow more flexible management.

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seasonal migration "... on a regular beat ..." relieved pressure on the vegetation, and stock was confined largely to the coastal forelands (Wilson 1969).

The changes that followed European settlement, real or inferred, influence present attitudes and policy toward land management. For example, much is made of destruction of the native evergreen forest and for the past century there have been continual pleas for reconstitution (e.g. Brown 1887, Phillips 1931, McKenzie and others 1976). However, one may infer from accounts in Katzen (1969) and elsewhere rather that forests were confined originally to locally favourable habitats; Acocks' (1953) implied much wider extent of forest is deceptive. Exploitation and destruction of forests caused degrade and local decline but no major landscape changes (see accounts in Brown 1887). For Coastal Renosterveld, major, widespread modification by new grazing practices, from a grassy shrubland, to the present rather low, open shrub formation,, is the usual inference (Acocks 1953, Taylor 1978, Boucher and Moll 1981) and this is often supported by historical evidence (Wilson 1969) though the extent of such change is not documented. Replacement of fynbos on clay soil by Elytropappus is often reported (Taylor 1978; see also below). An evident effect of settlement on the biota in general was the local extermination of nine or more species of larger mammal, and perhaps as much as 60 species of plant (Bigalke 1969) - a surprisingly small proportion of a flora of possibly 8 500 species.

There appears to be little evidence of change in the structure and composition of fynbos on low-nutrient soils, except for the great transformations locally that followed the introduction and spread of exotic trees and shrubs (see below).

### Present patterns

Cook<sup>1</sup> has determined the broad patterns in modern land-use in each of the mediterranean-type

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<sup>1</sup>Cook, G. Department of Geography, University of Cape Town. Unpublished report of the Fynbos Biome Project. 1980

Table 1--Approximate extent of different forms of land-uses or cover types in the major Veld Types of the mediterranean-climate zone of South Africa. (Veld types according to Acocks 1953.)

Land-use or cover type	Mountain Fynbos				Coastal Fynbos		Coastal Renosterveld		Total	
	Veld type		Veld type 70		(Veld type 49)		(Veld type 46)			
	Area,		Area,		Area,		Area,		Area,	
	sq. km	Pct	sq. km	Pct	sq. km	Pct	sq. km	Pct	sq. km	Pct
Agriculture (cultivated fields, orchards, etc.)	3,150	15.8	1,600	600	620	2,620	10,140	76.4	17,500	27.7
Urban development	120	0.6	72	72	260	260	80	0.6	530	0.8
Timber plantations	290	0.5	140	140	16	16	23	0.2	470	0.8
Water bodies and wetlands	105	0.5	21	21	220	220	58	0.4	400	0.6
Natural and semi-natural vegetation	16,200	81.6	18,400	400	640	6,640	2,980	22.5	44,300	70.1
TOTAL:	19,900	100	20,300	300	750	9,750	13,200	100	63,200	100

veld types, as shown on standard topographic maps. Her data are summarized in table 1. Agricultural development accounts for most landscape transformation. Overall, nearly 30 per cent of the land has been transformed from the natural state (Hall, 1978, estimated 60 per cent). But the relatively fertile Coastal Renosterveld is disproportionately affected; Coastal Fynbos, though readily accessible, has just about one-third under agriculture and Mountain Fynbos has lost 10 to 15 per cent to development. Topography, climate and soil severely limit the use of Mountain Fynbos. For example, no more than a further 150 sq. km is seen as afforestable. Reservoir construction and similar intensive developments create acute but strictly local problems. Thus we see that problems of management of mediterranean-type ecosystems in South Africa turn largely on questions concerning the use and management of wildlands or veld in the natural condition.

#### Use of wildlands

##### Public lands

Public lands that include wildlands in are small. Of Strandveld, around one per cent is publicly owned; of Coastal Renosterveld, about the same; Coastal Fynbos, 2-3 per cent, and Mountain fynbos, about 18 per cent (Edwards 1974). These are mainly reserves, either Provincial Nature Reserves or State Forests.

Some public land was used for pasturage on a lease system until the middle of this century but these lands are now held for nature conservation or catchment protection, usually both. Bands (1977) has described the background to this system and the evolution of the methods of managing State Forests.

##### Lands in private ownership

There is little published information on how wildlands in private ownership are used. What follows is based on personal observation and communication with various colleagues.

Pasturage--The relatively small remaining area of renosterveld is used as rough pasturage, on the basis of seasonal grazing and patch-burning (see Bands 1977 for a discussion of patch-burning). Injudicious combinations of grazing and burning leads rapidly to domination of the sward by *Elytropappus*; Taylor (1978) and Boucher and Moll (1981) discuss this problem. Coastal Fynbos is apparently still extensively grazed, also on a patch-burning system. There is a trend to integrate this use with flower harvesting (see below). There are no reports of marked degrade in this type.

Grazing of Mountain Fynbos, previously rather widespread, has declined generally in response to improved ley pastures in the renosterveld wheatlands (Wasserman 1979) and changing cultural and economic factors (Bands 1977). Nevertheless, the old practices do survive in many areas and present a problem in the control of land-use in water catchments, especially in remoter rural areas with relatively poor economies.

Harvesting of wildflowers--Of increasing importance is a wildflower industry which has grown over a decade to a business that brings in foreign exchange of around R6 million/yr. Much of this produce comes from the veld but the extent of the area used in this way is still unknown. Various products are harvested, from fresh blooms of Proteaceae and other shrub taxa available mainly from mature vegetation, through various kinds of dried

material including Proteaceae capitula but also shoots of Restionaceae and Cyperaceae, optimally available from vegetation regenerating post-fire, as well as post-fire "everlastings", inflorescences of Helichrysum spp.

Much of this use tends to be exploitative. The markets and the industry are new, many of the harvesters lease the right to do so and many in the business no doubt see it as ephemeral. No consensus on sustained-yield management has yet emerged. Many practitioners do not presently allow fire, but fail to consider regeneration requirements. The established, organized industry tries to promote secure markets for quality products from orchards, but this seems to have had little impact on use of wildlands. Flower harvesting complicates management of Mountain and Coastal Fynbos; requirements for sustained yield management compatible with conservation of other resources must be determined and included in general policy.

Recreational development--In many cases, land is held simply for its tourist and recreation potential. A growing trend in the mountains toward resort development and for schemes for second homes is now discernible, but the extent and consequences of this have yet to be appreciated.

#### Invasive plants

Hall (1979) has estimated that about a quarter of the wildlands is occupied by exotic woody plants, to a greater or lesser degree. This problem has been thoroughly described elsewhere (Taylor 1978, Hall 1979). The most important invaders are Hakea sericea, Pinus pinaster and Acacia spp. Several costs arise from these invasions (Kruger 1977b). First, water yields from mountain catchments decline significantly. Second, the aesthetic, scientific, educational, recreational and other indirect values of the land are diminished. Third, problems and costs of management, especially of fire control, are greatly aggravated. There are few or no benefits, aside from firewood harvested from accessible infestations in the lowlands.

Though biological control is seen as a means to long-term control, removal or eradication of present infestations requires other means. An effective programme of control is now applied to hakea and pines in mountain catchment areas. First, measures are written into long-term management plans (see below). Second, control in any management unit is effected by (a) felling adult trees and shrubs (b) burning the slash with the natural vegetation within 12 months to kill seed and seedlings and (c) biennial surveys to detect and remove any escapees. This system reduces populations by several orders of magnitude over large areas (Fenn 1980), and has the prospect with biological agents of ensuring long-term control (not eradication) of these species. This programme critically determines many aspects of ecosystem management, and disqualifies laissez faire management because, for example, unplanned fires cause invaders to proliferate.

## RESILIENCE OF SOUTH AFRICAN MEDITERRANEAN-TYPE ECOSYSTEMS

These ecosystems appear to vary significantly in their capacity to recover after disturbance. Such resilience seems to correlate with climate, soil and the nature of disturbance. Under a "normal" fire regime, any biotic community appears to recover more or less fully in structure and composition (e.g. references in Kruger 1979, Van Wilgen and Kruger 1981). Fynbos on low-nutrient soils appears to persist despite in the face of many forms of disturbance. For example, Coastal Fynbos appears highly stable under a grazing regime with patch-burning. Where fynbos on infertile soils has been deforested or cleared of weeds, most of the original species return. By contrast, fynbos on more fertile sandy loams or loams, especially where rainfall is less than about 1 000 mm/yr, is easily changed by disturbance. There, Elytropappus invades readily with overgrazing (Adamson 1938). Recovery after clearing of exotics is incomplete at best, and the regeneration is dominated by exotic, especially Mediterranean herbs. The same applies to Coastal Renosterveld. In the east, where summer rainfall is significant and grasses prominent, fynbos shrubs are a labile component of the vegetation and are reduced or exterminated by very frequent burning (Kruger and Bigalke in press). In the west, only a small proportion of the shrub flora is eliminated by the most frequent burning practical (Van Wilgen 1981b). These differences in the capacity to recover and their implications for management appear to need close attention in research for the development of management systems.

#### PROBLEMS WITH POLICY AND PRACTICE IN MOUNTAIN CATCHMENT AREAS

Approximately 4 000 sq. km of private land in fynbos ecosystems has been proclaimed Mountain Catchment Area; ultimately, nearly 20 000 sq. km of private and State land will be managed integrally for water conservation. Three goals dominate policy for Mountain Fynbos ecosystems: (a) management to sustain yields of silt-free water in streams - this on all lands, whether public or private; on public lands (b) nature conservation and (c) a secondary goal, recreation opportunity of a kind compatible with the primary goals. Fire control is a general goal.

Experience over the past 10 yr in applying this policy has revealed certain pressing questions.

#### Present policy

Policy for mountain catchment areas includes the following (Bands 1977). Prescribed burning is an acknowledged management tool and is to be applied in any management compartment (500 - 2 000 ha in extent) at intervals of about 12 yr and preferably in the late summer though, in the initial phases of management when extensive areas of old vegetation are encountered, burning at safer times is permissible. Control of invasive plants is a prerequisite. Management of any given zone is based on

a five-year plan which prescribes the measures to be applied to each compartment, in a manner that should optimally fulfill the goals for the area. It embodies principles established in a policy memorandum, in turn based on the findings of an inventory of resources.

#### The prescribed fire regime in practice

Policy memoranda have been approved, or are in advanced stages of review, for 18 management plans. Burning rotations agreed to range from 9 yr through 12 yr for most areas, to 15-20 yr for dry north slopes. In certain areas, "natural" burning regimes are to be allowed on an experimental basis: fires that occur in any given compartment will be allowed to burn while confined to the compartment. These areas are usually in dry zones (rainfall less than about 600 mm/yr on average) with low fuel accumulations and infrequent fires in the past.

The rotations laid down in policy memoranda are guidelines; vegetation is not necessarily burnt at that age, especially where fire has been excluded in the past. In the Kogelberg, on the eastern shores of False Bay, vegetation had been protected since an extensive wild fire in 1945, and burning was begun in 1967 to rehabilitate a rare species of Proteaceae, Orothamnus zeyheri (Boucher and McCann 1975). Three compartments, amounting to about 12 per cent of the area, are still protected, to allow forest succession, or as long-term reference areas. A classification by age at time of burning during the first planning cycle shows that more than 80 per cent of vegetation was burnt at an age of 20 yr or more in the first cycle, and 50 per cent at over 25 yr. Information for most other areas covered by plans indicates the same pattern: most vegetation is or will be older than prescribed at the time of burning in the first cycle. By the second cycle, however, the age-class distribution would have normalized around the prescribed age, barring wild-fires and other accident. According to prescriptions, nearly 80 per cent of the area will be burnt at ages between 10 and 15 yr in the second cycle in the Kogelberg. A major shift in regime is therefore under way.

In the Kogelberg, nearly 50 per cent of the area has been burnt in spring, and over 30 per cent in winter; Van Wilgen (in press) shows that this pattern is general. Initially, spring burning was encouraged as being less hazardous with regard to erosion; now, burning between the end of April and the end of August is strongly discouraged. Burning between the end of February and the end of April is recommended and the intention is to limit spring burns only to cases where safety and the work load make them unavoidable.

The tendency to burn in spring reflects the managers' experience. Although prescribed burning was not extensive before 1967, firebreaks have been prepared by controlled burns since the institution of fire control in the Cedarberg around 1900 and more extensive protection of native rain forests and coniferous plantations in the Tsitsikamma area

from about 1880 (Brown 1887). Official instructions have naturally prohibited burning without special authority during the hazardous season. Managers are therefore not accustomed to nor prepared for burning with any safety during the ecologically desirable season.

No data are available on actual fire intensities, the third component of fire regime.

#### Issues in management of Mountain Fynbos

##### Rotation (frequency) of burning

Moll and others (1980) have argued that frequent fires have eliminated trees from the fynbos and further that the presence in the flora of certain Proteaceae and other small trees and shrubs which have long youth periods indicates that prescribed burning regimes should have long intervals - 40 years and more - between fires. However, available data indicates that most fynbos shrubs are precocious, and the few species with youth periods of 8-10 yr and more tend to occur in special habitats infrequently burnt - cliffs, perennially cool-humid sites, arid sites with sparse vegetation - or, like Leucadendron argenteum, tend to survive as adults protected by insulating bark (Kruger and Bigalke in press). Further Bond (1980) and Van Wilgen (1981a, b) have shown how certain Proteaceae tend to enter senescence at ages of 30-45 yr. Bond (1980) found regeneration from seed after fire among Proteaceae that store seed in the canopy and among dicotyledons generally to be much reduced in senescent stands, relative to mature stands. Both suggest that fires at intervals greater than 20 yr could lead to changes in fynbos, including decreased plant species diversity, lower densities of Proteaceae, and possibly less effective catchment cover.

The effects of fire frequency, and fire per se, on catchment water and nutrient balances are still controversial. Van der Zel and Kruger (1975) reported substantial decreases in flow with advancing age of vegetation in a catchment at Jonkershoek, however, analysis of new data tend to confirm earlier reports showing that streamflow response to fire are relatively small and short-lived (Kruger and Bigalke in press). Regarding nutrient dynamics, Van Wyk (in these proceedings) adduces data to show that, at least in the cases he has studied, erosion losses are small after fire, changes in streamflow chemistry are short-lived and, even at rotations of 6-12 yr, there is no evident net loss of nutrients from the flush after fire. Patterns of hydrological response in relation to biomass and rainfall regime need to be examined to establish the general rule.

##### Season of burn

The present seasonal pattern of the managed fire regime, if maintained, is likely to degrade fynbos. For example, Jordaan (1949, 1965) predicted and demonstrated how a winter burn eliminated or severely reduced certain Proteaceae.

Bond (1980, and personal communication) has reported similar results from the Swartberg, east of Jordaan's study area.

Effects of season or burn on catchment condition are hypothetically important. Burns before the winter rains expose the soil to erosion and ashed nutrients to leaching. Van Wyk's work does not clearly show such effects, because rains after the experimental fires were small. Nevertheless, field observers report apparently increased wash, and deflation by berg winds, following late autumn and winter fires (Bands, Bond, pers. comm.).

#### Fire intensity

No experimental information is available on the effect of different fire intensities on subsequent regeneration and development of fynbos communities, nor of the spectrum of intensities encountered in the normal range of prescribed and wild fires. In view of results reported elsewhere (e.g. Warcup 1981), a shift in mean fire intensity is likely to alter vegetation composition; managed fires may have important effects of this kind.

#### Size of burn

Current evidence indicates that most fynbos plant species do not disperse seed any great distance, and dispersal is apparently effective mainly in securing safe-sites locally (e.g. Bond 1980). Seed and plant predators take a heavy toll, especially where old vegetation offers shelter (Bond 1980). Predation is much reduced, or eliminated, in burns depending on the proximity of shelter, mainly in the form of unburnt vegetation. This interaction between predation and fire may have crucial effects on plant species populations, as in Widdringtonia cedarbergensis (Luckhoff 1971), and the effect will in a large measure be mediated by size of burn. Size of burn is also important where local animal migrations occur. Size of prescribed burn corresponds with compartment size, which is determined by practical considerations (time to complete the job) and economy, as well as inferred ecological arguments.

### CONCLUSION - RESEARCH REQUIREMENTS IN CATCHMENT MANAGEMENT AND NATURE CONSERVATION

#### General requirements - understanding the basics

No consensus on appropriate land-use zoning and land management practices will develop without studies that allow a proper depth of understanding of past and present ecosystem structure and functioning. The general requirements may be classified as follows:

- (a) Palaeobiological and historical studies; clarify essential features of past ecosystem dynamics, especially regarding the influence of man.
- (b) Biogeography: comprehensive biogeographic studies of the complex patterns of fynbos

are required as a basis for planning conservation systems, predicting the consequences of land-use patterns, and accommodating ecological heterogeneity in management systems.

- (c) The physiological ecology of plants and animals in the special conditions of climate and nutrition of these ecosystems need study to the point that the inherent tolerances to management may be understood.
- (d) Patterns and trends in land-use are poorly perceived, have a marked effect on management, and must be clarified to allow rational policy.

#### The ecological effects of fire

There are inherent conflicts in goals of management, for example between fire control and nature conservation, each of which tends to influence the choice of prescribed regime in one direction or another. What is required is the knowledge to predict and evaluate, in ecological and other terms, the outcome of a shift in regime one way or another, as well as that of a choice between a variable regime as opposed to a relatively rigid one, and of the pattern and scale of burning. This will need additional information in the following fields.

Hydrological and mineral cycles--Modelling, and additional experiments for validation; specifically a much better understanding of the dynamics of nutrients in the plant-litter-soil system is needed.

Plant demography--Predicting the interactions between the fire regime and vegetation dynamics needs much better understanding of plant life-cycles. Patterns in the distribution of species with unusual life-cycles, especially long youth-periods, need investigation.

Plant-animal interactions--Vertebrates and invertebrates appear to play a key role in the functioning of especially fynbos plant communities, through predation on seed and seedlings, pollination and dispersal. The fundamental aspects of plant-animal interactions must be determined before fire regimes can be managed with any confidence.

Fire technology--Means of predicting fire behaviour, in the form of fire danger-rating models, need to be developed urgently to allow more flexible management, and especially the techniques to burn in the ecologically desirable season.

#### Ecology of invasions

Increased efficiency of present control measures depends on a better understanding of the biology of the target species. Long-term management of the complex of pest-plants will require understanding

of the invasion process as such. Among the many questions requiring attention, for example, is Shaughnessey's (1980) hypothesis, that most "invasion" is owing to past propagation by man: whether or not this is valid for a given species will fundamentally determine approaches to management of the problem. What, therefore, are the actual processes of invasion and what characters of demography and ecophysiology especially fit an invasive species for success in this environment, especially where nutrients are apparently limiting? Is disturbance a prerequisite for invasion, and if so, what nature of disturbance?

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