# Fire in South African ecosystems: an annotated bibliography

G U Schirge and A H Penderis

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

SOUTH AFRICAN NATIONAL SCIENTIFIC PROGRAMMES REPORT NO

33

OCTOBER 1978

Issued by
Cooperative Scientific Programmes
Council for Scientific and Industrial Research
P O Box 395
PRETORIA
0001
from whom copies of reports in this series are available on request.

Printed 1978 in the Republic of South Africa
by the Graphic Arts Division of the CSIR

ISBN 0 7988 1416 0

Compilers' address -
Gudrun U Schirge and A H Penderis
Cooperative Scientific Programmes
CSIR
P O Box 395
PRETORIA
0001

## PREFACE

The Scientific Committee on Problems of the Environment (SCOPE) was set up in 1970 by the International Council of Scientific Unions to act as a focus of non-governmental international scientific effort in the environmental field. The principal aim of SCOPE projects is the review and synthesis of knowledge in various environmental problems and concepts. South African activities within the SCOPE programme are administered by the National Committee for Environmental Sciences, a cooperative undertaking of scientists and scientific institutions concerned with research related to environmental problems.

The Terrestrial Ecosystems Section of the National Programme for Environmental Sciences concerns itself with environmental problems related to terrestrial ecosystems. Its current activities include several major long-term investigations into the structure and functioning of representative ecosystems of South African biomes and a series of short-term review and synthesis projects. As far as possible, participating organizations finance their own research within these projects. The research of participating universities and museums is financed from a central fund administered by the National Committee for Environmental Sciences and contributed largely by the Department of Planning and the Environment.

The programme on the "Ecological effects of fire" is one of the current review and synthesis activities. As its first objective, the Working Group for Fire Ecology has sought to bring together fire ecologists at scientific workshop meetings on the one hand and to bring knowledge together in a comprehensive review on the other. The present bibliography is seen as a first approximation to the latter goal.

## ACKNOWLEDGEMENTS

Sincere thanks are expressed to all who assisted in the compilation of this bibliography by the contribution of abstracts or literature references, in particular : Mrs L Davidson (University of the Witwatersrand), Dr R L Davidson (CSIRO, Australia), Dr P J Edwards (Department of Agricultural Technical Services), Mr O Kerfoot (University of the Witwatersrand), Mr F J Kruger (Department of Forestry), Dr C J Loedolff (Department of Nature and Environmental Conservation, Cape Provincial Administration), Mr I A W McDonald (Natal Parks, Game and Fish Preservation Board), Dr J W Morris (Department of Agricultural Technical Services), Professor J F V Phillips (Hekpoort, Transvaal), Mr E R Robinson (University of the Witwatersrand), Dr J C Scheepers (Department of Agricultural Technical Services), Professor J D Scott (Pietermaritzburg, Natal),Mr H C Taylor (Department of Agricultural Technical Services), Mr W S W Trollope (University of Fort Hare), Dr P van der Merwe (Department of Nature and Environmental Conservation, Cape Provincial Administration), Mr D W van der Zel (Department of Forestry), Dr H J van Rensburg (Natal Parks, Game and Fish Preservation Board) and Dr O West (Plettenberg Bay, Cape).

## ABSTRACT

References to 258 publications are presented together with summaries, keyword listings and a keyword index. This bibliography forms part of the South African contribution to the SCOPE project "The ecological effects of fire", 1977-1980.



## SAMEVATTING

Die bibliografie bevat verwysings na 258 publikasies met opsommings, sleutelwoordlyste en 'n sleutelwoordindeks. Dit vorm deel van die Suid-Afrikaanse bydrae tot die SCOPE-projek "Die ekologiese uitwerking van vuur", 1977-1980.

TABLE OF CONTENTS

# INTRODUCTION

The role of fire as a major factor in southern African ecology has long been recognized and research in this field has an extended history in the Republic. Published research results are scattered through a wide range of local and overseas journals, while a considerable volume of unpublished information remains in inaccessible departmental files. The present bibliography attempts to bring together all papers published in the open literature, in theses and in formal departmental bulletins. Brief reports in periodicals, newspapers and pamphlets have usually been omitted.

The bibliography includes research, review and discussion papers dealing with problems relating to fire in the Republic of South Africa and the recently independent territories within its geographic limits.

References are listed alphabetically by author name. Abstracts are provided for all documents which could be obtained. Certain early accounts of fire are included for their historical interest but few of these are abstracted, although page references are provided where possible. The abstracts were drawn either directly from the published article, supplied by authors or written by the compilers or by Mr B J Huntley (CSIR).

Keywords have been provided for all references. The choice of keywords includes geographic regions in the Republic, biomes, factors relating to fire effects, study procedures and so forth.

## BIBLIOGRAPHY

1. Ackerman D P 1976. Control of water catchments by the Department of Forestry. South African Forestry Journal 98, 24-27.

A brief account of the role played by the Department of Forestry in the conservation and management of private and state land is given.

The Mountain Catchment Areas Act, 1970, by which responsibility for the conservation of all mountain catchment areas, public or private, is taken over by the Department of Forestry is discussed in some detail. The Act provides for the preparation of management and fire protection plans for all defined catchment areas and for putting these plans into effect either by employees of the Department or through the agency of fire protection committees.

The Department of Forestry has direct control over some 1 500 000 ha of land - 250 000 ha of plantation, 32 000 ha of drift sand and the balance of nearly 1 000 000 ha is mountain catchment. All these areas are covered by the term "State Forest" and are managed under the provisions of the Forest Act, 1968, and management is aimed at satisfying a primary objective. Examples of such primary objectives are establishing plantations, conservation of indigenous forests, conservation of water, proclamation of wilderness areas, etc.

CATCHMENT, CONSERVATION, LEGISLATION, MANAGEMENT, WATER YIELD

2. Adamson R S 1927. The plant communities of Table Mountain : preliminary account. Journal of Ecology 15, 278-309.

The three main types of vegetation of Table Mountain are briefly considered in regard to their relations to one another and to the vegetation of other regions.

The vegetation has often been destroyed by fire. Many of the resulting communities and successions are described.

CAPE, FYNBOS, SUCCESSION

3. Adamson R S 1935. The plant communities of Table Mountain. III. A six years' study of regeneration after burning. Journal of Ecology 23, 44-55.

The regeneration of a climax community after destruction by fire is traced through a period of six years. At the end of this period the vegetation had returned to a condition similar to but not identical with the original. In the early stages the shrubs regenerated partly from shoots and partly from seed. Temporary dominance was assumed by Euryops abrotanifolius after three years. After five years the plant was

rapidly reduced in quantity. The number of species showed a progressive increase, being larger than the original number at the end of the period.

Salient features of the community at yearly intervals are described. The relations of the prevalent life forms are dealt with. In the early stages there was a distinct increase in geophytes and a small increase in annuals. Chamaephytes showed a progressive increase. Immediately after the fire there was an increase in the ratio of nanophyllous to leptophyllous Nanophanerophytes owing to the fact that many of the former sprout freely from the base after burning while the latter regenerate only from seed. Grass-like hemicryptophytes increased and relatively broad-leaved hemicryptophytes decreased in percentage after burning, giving a more xeromorphic facies to the vegetation.

General comparisons are made with other sclerophyll types. Those of the southern hemisphere are poor in annuals as compared with northern examples. All show the initial increase in geophytes and temporary large increase of one or more shrubby plants.

CAPE, FYNBOS, SUCCESSION, VEGETATION STRUCTURE

4. Adamson R S 1938. Notes on the vegetation of the Kamiesberg. Memoirs of the Botanical Survey of South Africa 18, 1-25.

Brief notes on the effects of fire in various communities are presented. Leucospermum and Erica appear to be deleteriously affected while Elytropappus regenerates rapidly after fire.

CAPE, ELYTROPAPPUS, ERICA, FYNBOS, LEUCOSPERMUM, SUCCESSION

5. Andrag R H 1977. Studies in die Sederberge oor (i) die status van die Clanwilliam seder Widdringtonia cedarbergensis Marsh (ii) buitelugontspanning (Studies in the Cedarberg on (i) the status of the Clanwilliam cedar Widdringtonia cedarbergensis Marsh (ii) outdoor recreation). MSc thesis, University of Stellenbosch. 141 pp.

A short description of the physiography, geology, climate, vegetation, animal life and history of the Cedarberg State Forest is given.

The present status of Widdringtonia cedarbergensis Marsh was investigated inter alia by studying 40 one-hectare cedar tree sample plots. Some of these plots were burnt after the initial survey and on these the effects of the fire on cedar populations were determined.

CAPE, FYNBOS, VEGETATION DYNAMICS, WIDDRINGTONIA

6. Anon 1931. Grass burning and erosion. Farming in South Africa 5, 570.

The disastrous effect of grass burning is discussed from the point of view of erosion.

SOIL EROSION, TRANSVAAL

7. Anon 1933. Judicious veld burning. Farming in South Africa 8, 247-248.

Advice is provided to farmers on the type of veld to be burnt and the season of burning. They are urged to study their veld and discover the effect of burning by means of small experiments.

BURNING SEASON, FIRE REGIME, MANAGEMENT

8. Anon 1934. Journal of the Mountain Club of South Africa 37, 8.

An account is given of unsuccessful attempts to induce ignition of various vegetation types at Tokai by spreading broken bottles through the fuel. The theory that fires are often started by the magnification of sunlight through broken bottles is unsupported by this experiment.

CAPE, FOREST, FYNBOS

9. Anon 1956. Veld burning - devastation or a blessing. The opinion of experts. Farming in South Africa 32(5), 14-20.

Experts from the Karoo, Stellenbosch, the Little Karoo and the Transvaal highveld were approached and questioned on fire management. This article deals with their opinions. For each of the respective regions the types of veld which may be burnt or burnt with advantage, the types of veld that should never be burnt, the precautionary measures which should be taken in burning of the veld, the unavoidable disadvantages of veld burning and the specific advantages of veld burning are given.

FIRE REGIME, FYNBOS, GRASSLAND, GRAZING, KAROO, MANAGEMENT

10. Anon 1959. Burn veld judiciously. Farming in South Africa 35(4), 5; 13.

The different reasons for veld burning are discussed.

Advantages and disadvantages of burning karroid scrub, sourveld areas, mixed veld and sweetveld are discussed.

KAROO, MANAGEMENT, SAVANNA

11. Anon 1961. Veld burning in the Karoo mountains with special reference to sour grassveld areas. Farming in South Africa 37(5), 36-37.

The Veld Burning Investigation Committee of the Karoo Region concludes that veld burning is justified when its purpose is to restore useless densely overgrown sour grassveld to a useful condition. This article deals with the recommendations made by the Committee for the burning treatment and management of "suurpol" veld Danthonia disticha, "koperdraad" veld Elyonurus argenteus and "gwashu" mountain veld Festuca costata. General recommendations for management are also given.

KAROO, MANAGEMENT

12. Anon 1968. Incalculable damage through untimely veld fires. Farming in South Africa 44(3), 5.

Damage done by accidental veld fires to the veld and to the cover of the catchment areas with subsequent soil erosion is discussed. The financial loss to farmers is stressed. Timely burning of fire breaks is urged.

CATCHMENT, FIRE BREAKS, MANAGEMENT, SOIL EROSION

13. Atcherley R J 1879. A trip to Boerland. R Bentley and Son, London. 267 pp.

Early historical reference - see inter alia pp 40, 48, 61, 71, 74.

HISTORICAL ACCOUNT

14. Backhouse J 1844. A narrative of a visit to the Mauritius and South Africa. Hamilton, Adams and Co, London. 648 pp.

Early historical reference - see inter alia pg 741.

HISTORICAL ACCOUNT

15. Bagshawe-Smith L 1937. Rhenoster bush in the district of Albany. South African Journal of Science 33, 355.

The use of fire in the control of rhenoster bush Elytropappus rhinocerotis in the Grahamstown area is advocated. A 50% reduction in carrying capacity due to rhenoster bush infestation is reported.

ANIMAL PRODUCTION, CAPE, ELYTROPAPPUS, FIRE REGIME, GRASSLAND, GRAZING

16. Bands D P 1977. Prescribed burning in Cape fynbos. Proceedings of the Symposium on Environmental Consequences of Fire and Fuel Management in Mediterranean Ecosystems. USDA Forest Service. General Technical Report WO-3. pp 245-256.

Water supplies from fynbos mountain catchments are of prime importance to the regional economy of the south-western Cape. Conservation of these mountain ecosystems as water source areas and because of the scientific, aesthetic and economic importance of the natural communities, is actively pursued. Prescribed burning is a management tool central to conservation of fynbos.

This paper reviews the history of land-use and conservation practice in these ecosystems, and the evolution of present policies. Current practice is briefly described and assessed.

CAPE, CATCHMENT, CONSERVATION, FYNBOS, MANAGEMENT

17. Banks C H 1964. Further notes on the effect of autumnal veld burning on stormflow in the Abdolskloof catchment, Jonkershoek. Forestry in South Africa 4, 79-84.

The results of an investigation (Rycroft 1947) on the immediate effects of autumnal veld burning on rate of stormflow during May to July in the Abdolskloof catchment from 1943 to 1945 are presented, and compared with results obtained in 1946.

An analysis of these data show that the rate of stormflow increased significantly during the three months after burning the vegetation, and that a year after the fire the rate of stormflow had returned to pre-burn level.

CAPE, FYNBOS, VEGETATION STRUCTURE, WATER YIELD

18. Banks C H and C Kromhout 1963. The effect of afforestation with Pinus radiata on summer base-flow and total annual discharge from Jonkershoek catchment. Forestry in South Africa 3, 43-65.

Streamflow data from two afforested and four unafforested experimental catchments at the Jonkershoek Forest Research Station are used in a covariance analysis to determine the effect on summer base-flow and total annual discharge of replacing the natural scrub cover by afforestation with Pinus radiata.

The results show a significant, progressive decrease in the stream discharge from the afforested catchments. The decrease occurs from the fourth to twelfth year after afforestation, and subsequently the flow remains relatively constant but at lower level than prior to afforestation. There is also some evidence that complete protection of unafforested catchments may lead to a change in their streamflow regime.

The conclusions support the general hypothesis that the hydrological effect of vegetation is proportional to its density.

AFFORESTATION, CAPE, CATCHMENT, FYNBOS, PINUS, VEGETATION STRUCTURE, WATER YIELD

19. Barrow J 1806. Travels into the interior of South Africa. Vol 1. T Cadell and W Davies, London. 427 pp.

Early historical reference - see inter alia pg 137.

HISTORICAL ACCOUNT

20. Bartlett H H 1955. Fire in relation to primitive agriculture and grazing in the tropics : annotated bibliography. Vol I. Department of Botany, University of Michigan. 568 pp.

An annotated bibliography bearing on primitive agriculture and fire is presented. The bibliography is not complete and is confined mainly to the tropics. Ten references pertaining to South Africa are included.

BIBLIOGRAPHY, HISTORICAL ACCOUNT

21. Bartlett H H 1957. Fire in relation to primitive agriculture and grazing in the tropics : annotated bibliography. Vol II. Department of Botany, University of Michigan. 873 pp.

The annotated bibliography on primitive agriculture and fire presented in Volume II, was intended to serve as a supplement to Volume I with no segregation by area, presenting all reviews and abstracts in a single sequence, alphabetically according to the name of the author. However due to the mass of material accumulated, Volume II is of mixed contents. It presents articles and books for author names from A through G and is completed by literature pertaining only to southern Asia and the Pacific for author names from H through J. Twelve South African references are commented upon in the first section.

It was the author's intention to publish three further volumes, Volume III containing remaining reviews on southern Asia and the Pacific, Volume IV to deal exclusively with Africa and Volume V with the Americas. Only Volumes I to III were completed at the time of the death of the author.

BIBLIOGRAPHY, HISTORICAL ACCOUNT.

22. Bayer A W 1943. The thornveld tree : a note on plant adaptation. South African Journal of Science 39, 44-55.

South Africa is considered a favourable country for studies in plant adaptation. The thornveld environment is described,

particularly with respect to rainfall, temperature extremes, long winter drought and the occurrence of veld fires. A discussion follows of thornveld plant characters which may possess adaptive value. Physiological investigations of water relations are summarized, and emphasis is placed on economic and theoretical value of studies of plant adaptation.

ACACIA, ADAPTIVE RESPONSE, VEGETATION DYNAMICS

23. Bayer A W 1955. The ecology of grasslands. In : The grasses and pastures of South Africa. D Meredith (ed). Central News Agency, Johannesburg. pp 539-550.

Principles of plant ecology are dealt with in general terms. South African grassland ecology is discussed in some detail from primary succession to climax situations. Effects of burning on grassland succesion are discussed, especially the return to Themeda grassland by Cymbopogon miscanthidium grassland and the inability of natural forests to spread due to continual burning of surrounding grassland.

The effect of fire on associated grassland plants is mentioned both in terms of vernal and autumnal aspect plants. Spring aspect plants commence growth earlier when the soil surface has been exposed to sunlight and can withstand limited seasons of spring shading only. The persistence of these plants would indicate that they are adapted to and have evolved under conditions of short grass in spring which could only have arisen as a result of fires caused by lightning. Autumnal aspect plants are not resistant to grass fires and burning would then prevent the natural succession going beyond the grassland stage to scrub and forest.

The effects of man on grassland are discussed, particularly the effects of overgrazing and burning at the wrong time on Themeda triandra grassland. An appeal for better veld management and spring burning only when necessary is made.

AFFORESTATION, BURNING SEASON, CONSERVATION, FIRE REGIME, GRASSLAND, GRAZING, MANAGEMENT, SUCCESSION, THEMEDA, VEGETATION DYNAMICS

24. Bean P A 1962. An enquiry into the effect of veld fires on certain geophytes. MSc thesis, University of Cape Town. 104 pp.

Hybrid watsonias flower very profusely after being burnt. The increase in the number of spikes and flowers per unit area is threefold, and of fruits twofold.

In artificial bush fires watsonias can survive temperatures up to 90°C, the soil at two to three inches (51 to 76 mm) can be heated to temperatures between 37°C and 51°C while the surface temperatures recorded varied between 102°C and 370°C.

The corms of 22 genera and 61 species of Iridaceae were found to lie within the first three inches (76 mm) of the soil in all but eight species, on the evidence of herbarium specimens. Heat-treatment of dormant corms of a variety of Iridaceous genera failed to produce any considerable increases in the number of flowers, or earliness of flowering.

Soil analyses after fire revealed very variable concentrations of nitrogen, phosphorus and potassium. Sandy soil at Bain's Kloof, very low in potassium, regenerated much more slowly than loam at Durbanville. There is evidence in some cases that potassium and phosphorus levels are higher in burnt than in unburnt soil.

When the apical buds of Watsonia varieties were removed, there was an increase in spike production, but this was not always accompanied by an increase in flowers. There was an increase in the number of flowers in Watsonia x meriana when the corms were planted in previously burnt areas. There was a slight increase in the number of flowers following the application of phosphoric fertilizer. There is a likelihood that the flowering of geophytes after a fire is regulated by the sum of interactions of many different factors, as for example, the heating of soil and corms by fire, and increased availability of phosphorus and/or other minerals.

ADAPTIVE RESPONSE, CAPE, FYNBOS, SOIL CHEMISTRY, WATSONIA

25. Beard J S and G D Darby 1951. An experiment on burning in wattle silviculture. Journal of the South African Forestry Association 20, 53-77.

The history of an experiment initiated in 1928 and continued until the time of writing is described. Wattle production was determined in three plots, alternately burnt and not burnt at the time of re-establishment. The second cycle of production was concluded early in 1950, when measurements of the mature crop disclosed no effective difference between treatments. It is concluded that burning as a silvicultural practice has no effect on the quality or productivity of wattles.

In order to determine whether any degradation of soil fertility is liable to occur as a result of burning wattle brushwood and litter, soil samples from burnt and unburnt experimental plots were investigated for humus content, water holding capacity, hygroscopic moisture and pH. The results are discussed and, since no differences were found in the first three and the difference in pH was too small to warrant consideration, it is concluded that there is no loss of fertility as a result of burning wattle brushwood.

Some properties of samples of virgin veld and neighbouring wattle soils were also investigated and the results are discussed.

The indications are that, although some of the soil properties had altered, there was no loss of soil fertility due to wattle plantations.

ACACIA, AFFORESTATION, BURNING TRIAL, FOREST, HERBAGE YIELD, NATAL, SOIL CHEMISTRY

26. Beard J S 1961. Further evidence on burning versus non-burning in wattle silviculture. Journal of the South African Forestry Association 38, 7-10.

The results of a continuation and extention to five sites of a trial begun in 1951 (Beard & Darby 1951) are reported. Regeneration is effected by either burning or hoeing and in addition, the effect of the mineral value of the ash is tested by either applying ash (in unburnt plots) or removing ash in burnt plots. It is concluded that the method of regeneration by burning or otherwise has no effect upon performance unless the ash of the burn is lost as it might be by wind erosion in autumn and winter or by rain-wash on steep slopes after a summer burn.

ACACIA, AFFORESTATION, BURNING TRIAL, HERBAGE YIELD, NATAL, SOIL CHEMISTRY

27. Bews J W 1918. Grasses and grasslands of South Africa. P Davis and Sons, Pietermaritzburg. pp 141-143.

A general discussion of the effects of grass burning according to the type of veld and the stage in the succession of that veld is presented. Time of burning of grassland is discussed as are the occurrence of soil erosion and the encouragement of flowering plants other than grasses by exposure of the soil surface.

ARISTIDA, BURNING SEASON, ERAGROSTIS, SOIL EROSION, SUCCESSION, THEMEDA, VEGETATION DYNAMICS, VEGETATION STRUCTURE

28. Bews J W 1926. The study of forest vegetation in South Africa. In : Aims and methods in the study of vegetation. A G Tansley and T F Chipp (eds). British Empire Vegetation Committee and the Crown Agents for the Colonies, London. pp 314-317.

This is a study of the replacement of grassland by woody vegetation, sometimes by thorn-bush of the type Bews calls tree-veld dominated by thorny species of Acacia and Gymnosporia or by a semi-open type of savanna forest. The effects of grass fires in preventing the establishment of woody vegetation is mentioned.

ACACIA, GRASSLAND, SAVANNA, SUCCESSION

29. Booysen P de V, N M Tainton and J D Scott 1963. Shoot-apex development in grasses and its importance in grassland management. Herbage Abstracts 33, 209-213.

The importance to grassland management of studies on morphological development of the shoot apex in perennial grasses is demonstrated. Special mention is made of Hyparrhenia hirta, Tristachya hispida and Themeda triandra, important tufted veld grasses.

In view of the differences in morphogenic features of these grasses, the proportion of the tillers which are killed by grazing or burning at different times and the effect thereof on plant recovery and seed production is likely to vary widely. Such differences should therefore be taken into consideration in the design of management programmes for veld containing these species.

GRASSLAND, GRAZING, HYPARRHENIA, MANAGEMENT, THEMEDA

30. Botha C G 1924. Note on early veld burning in the Cape Colony. South African Journal of Science 21, 351-352.

A historical review contributed to the South African symposium on veld burning (see also Pillans 1924, Marloth 1924, Levyns 1924). Kolbe, in his Beskryving van de Kaap de Goede Hoop (1727), reported that Cape farmers took over the practice of burning from the Hottentots. Laws against veld burning preceded 1687. In that year an uncontrolled fire destroyed a great quantity of stored grain, and a new law established scourging as the penalty for a first offence and death by hanging for the second. No attention was paid to the law, which was re-enacted in 1740 and 1741. It was a dead letter, probably always, and certainly by the time the British assumed administration in 1806.

CAPE, HISTORICAL ACCOUNT, LEGISLATION

31. Botha J P 1945a. The burning of veld. Farming in South Africa 20, 404-409.

The advantages and disadvantages of veld burning are enumerated and discussed.

The time of the year when veld is burnt is of greatest importance, least damage being caused if the veld is burnt in spring after the first rains. The harm done by autumn and winter burning is discussed.

Alternatives to veld burning for different types of veld are given. Recommendations for better veld management are made.

BURNING SEASON, FIRE REGIME, GRAZING, MANAGEMENT

32. Botha J P 1945b. Veld management in the eastern Transvaal. Farming in South Africa 20, 537-541.

The article deals with the sour, semi-sour and sweeter pastures occurring in the districts of Wakkerstroom, Piet Retief, Ermelo, Middelburg, Carolina, Machadodorp and Lydenburg. The veld utilization by farmers is described. Sheep farming is most important followed by cattle farming. In order to provide for grazing throughout the year, the sourveld is burnt in winter from the beginning of July until the beginning of September and thatch-grass veld is often burnt in summer. As a result of the prevailing methods of overgrazing and burning, the sourveld has been greatly encroached upon by weeds and increasing erosion has taken place.

Results of experiments conducted over seven years in sourveld areas which can judiciously be introduced into the above farming system are described.

BURNING SEASON, BURNING TRIAL, FIRE REGIME, GRASSLAND, MANAGEMENT, TRANSVAAL

33. Botha J P 1953. Veldbeheerstudies op die suurveld van Oos-Transvaal (Veld control studies on the sourveld of the eastern Transvaal). DSc thesis, University of Pretoria. 375 pp.

Chapter 6 of this study, deals with the influence of annual burns on a continuously grazed system. In these studies it was shown that an annual burn had no disadvantageous effect on the liveweight production of cattle over a period of 13 years. In those cases where grazing commenced annually in early spring, veld burning appeared to have a detrimental effect on plant coverage.

A yearly burn plus spring rest is probably not more detrimental than the spring rest alone. Burning the veld probably influences the botanical composition of the veld and seems to be responsible for the increase of Digitaria tricholaenoides.

ANIMAL PRODUCTION, BURNING TRIAL, FIRE REGIME, MANAGEMENT, SAVANNA, TRANSVAAL

34. Brooks H 1876. Natal, a history and description of the Colony. L Reeve and Co, London. 336 pp.

Early historical reference - see inter alia pp 281-283.

HISTORICAL ACCOUNT

35. Brown J C 1875. Hydrology of South Africa. Henry King and Co, London. 260 pp.

Early historical reference - see inter alia pp 175-194.

HISTORICAL ACCOUNT

36. Brown J C 1887. Management of Crown Forests at the Cape of Good Hope under the old regime and under the new. Oliver and Boyd, Edinburgh; Simpkin, Marshall and Co, London. 352 pp.

Early historical reference - see inter alia pp 84-113, 220-222, 249, 324-327.

HISTORICAL ACCOUNT

37. Brynard A M 1964. The influence of veld burning on the vegetation and game of the Kruger National Park. In : Ecological studies in southern Africa. D H S Davis (ed). Junk, The Hague. pp 371-393.

See Brynard 1972.

ANIMAL INFLUENCE, BURNING FREQUENCY, BURNING SEASON, GRASSLAND, GRAZING, HISTORICAL ACCOUNT, KRUGER NATIONAL PARK, TRANSVAAL

38. Brynard A M 1972. Controlled burning in the Kruger National Park - history and development of a veld burning policy. In : Fire in Africa. Proceedings Annual Tall Timbers Fire Ecology Conference 11, 219-231.

A brief description of the situation, topography, rainfall, animal life and vegetation of the Kruger National Park is followed by a history of veld burning.

An initial policy of burning less often than every fifth year (1949) was followed, after disastrous accidental fires, by an interim policy of burning long grass every third year in spring after the first rains (1954). Since then certain areas are excluded from this policy inter alia to protect the flora. The results of this policy are discussed.

ANIMAL INFLUENCE, BURNING FREQUENCY, BURNING SEASON, GRASSLAND, GRAZING, HISTORICAL ACCOUNT, KRUGER NATIONAL PARK, TRANSVAAL

39. Brynard A M and U de V Pienaar 1960. Annual report of the biologist, Kruger National Park 1958/1959. Veld burning. Koedoe 3, 173-194.

Annual, biennial and triennial veld burning experiments in Mopani veld, Knobthorn-Marula veld, Combretum veld and large-leaved deciduous woodland with tall grass are described. Pre-

liminary observations on the ease of burning, temperature of burn, vegetation affected by burn and grazing activity after burn are reported for each plot burnt at different times ie February, April, August, October and December. Recommendations in connection with the triennial rotation burning policy are summarized.

ANIMAL INFLUENCE, BURNING SEASON, CONSERVATION, FIRE BREAKS, FIRE REGIME, GRASSLAND, GRAZING, KRUGER NATIONAL PARK, MANAGEMENT, SAVANNA, TRANSVAAL, VEGETATION STRUCTURE

40. Burchell W J 1822. Travels in the interior of southern Africa. Vol 1. Longman, Hurst, Rees, Orme and Brown, London. 582 pp.

Early historical reference - see inter alia pp 116-117, 419.

HISTORICAL ACCOUNT

41. Carlquist S 1977. A revision of Grubbiaceae. Journal of South African Botany 43, 115-128.

On pp 127-128 the effect of fire on the growth form of members of the family Grubbiaceae is discussed. Grubbia tomentosa forms large populations on slopes subject to fire and drought and its resistance to fire by means of lignotubers seems a better long-term strategy for survival than resistance in the form of fire-resistant seeds. G rourkei is relatively uniform morphologically to G tomentosa but lacks a lignotuber. The scarcity of G rourkei may be related to the fact that although plants occupy moist slopes, these slopes are open and thus dry out and burn during the hottest portions of the year. G rosmarinifolia, being restricted to streams and seeps is less frequently burnt and minimally subject to drought.

ADAPTIVE RESPONSE, CAPE, FIRE REGIME, FYNBOS, GRUBBIA

42. Coetzee P J S 1942. Fire and veld management. Veld burning as an agent in the "ngongoni" sourveld. Farming in South Africa 17, 107-116; 131.

The effect of fire on the vegetation depends, amongst other things, on the type of grassland, the plant succession within that particular type of veld, the time of burning, the grazing intensity, rainfall, etc. The beneficial effect of an occasional burn is generally acknowledged. In the ngongoni Aristida junciformis sourveld burning once every second or third year can be recommended. Burning during the dormant period encourages the dominance of Themeda triandra and causes the vegetal cover to thicken considerably. Burning during the period of active growth resulted in total destruction of T triandra, its replacement by ngongoni and a reduction in the density of the cover.

Leaving the veld unburnt and ungrazed for any length of time resulted in the gradual destruction of the softer and more palatable grasses, whilst continuous summer grazing resulted in the destruction of T triandra.

It is doubtful whether mowing can take the place of burning in the ngongoni sourveld. Grasses with narrow wiry leaves tend to predominate in veld that is only mown or only mown and grazed but not burnt.

ARISTIDA, GRASSLAND, MANAGEMENT, NATAL, THEMEDA

43. Cohen C 1937. Stoebe vulgaris Levyns. MSc thesis, University of the Witwatersrand. 118 pp.

Fire as one of the means of eradicating Stoebe vulgaris is investigated. Results of these experiments are presented on pp 92-95.

FRANKENWALD, STOEBE, TRANSVAAL

44. Cohen C 1949. The occurrence of fungi in the soil after different grazing and burning treatments of the veld. Part I. South African Journal of Science 46, 260-265.

The aims of the Frankenwald experiments are to make the first survey of soil fungi in South Africa and to determine whether or not the long continued burning and grazing treatments, or lack of them, had resulted in the establishment of distinct soil fungal floras.

Of the veld treatments surveyed, burning and light grazing produced a richer flora as regards number of species, and was better balanced as regards the three main fungal groups than the other plots, and its flora was the most actively spore-producing. In burning but no grazing, the plots were apparently sterile when assayed by the usual microbiological methods, but in actual fact were only dormant. The control plot seemed to possess a markedly poorer flora but was more actively spore-producing than burning and heavy grazing, and burning but no grazing treatments.

FRANKENWALD, GRASSLAND, SOIL MICRO-ORGANISMS, TRANSVAAL

45. Compton R H 1926. Veld burning and veld deterioration. South African Journal of Natural History 6, 5-19.

An extended discussion is given on the damage associated with veld fires, especially at the Cape. Areas of future research are elucidated and the effects of fire on the mineral and nutrient balances in nature are discussed. The farmer, particularly, is blamed for injudicious firing of the veld and deterioration thereof as a result of overstocking. The ultimate cost

to the country in terms of loss of natural wealth as a result of veld fires is discussed.

ANIMAL PRODUCTION, CONSERVATION, FYNBOS, GRASSLAND, GRAZING, NUTRIENTS, SUCCESSION

46. Compton R H 1934. The results of veld burning. The Education Gazette, Department of Public Education, Cape of Good Hope 33, 644-655.

This article is written for the guidance of teachers who are asked to deal with the problem of veld burning "in their nature study lessons and to do their utmost to impress upon pupils, and through them upon parents, the necessity for putting an end to the practice of veld burning".

The practice of veld burning is condemned and its adverse effects discussed. Reasons for the burning of veld are mentioned. Successional changes, the increased occurrence of erosion and the loss of humus as a result of fire are explained.

CAPE, CONSERVATION, SOIL EROSION, SUCCESSION

47. Cook Lynette 1938a. A digest of available literature on the burning of vegetation. BSc (Hons) thesis, Department of Botany and Microbiology, University of the Witwatersrand. 97 pp.

An attempt is made to summarize all available South African publications which deal with the burning of vegetation. Summaries of scientific publications are given, quotations from correspondence on the subject of fire in scientific journals are presented and in the case of publications dealing with a wider topic, the section dealing with fire is either quoted or summarized.

The digest is divided into sections dealing with the burning of grasslands and the burning of forests and plantations. Comments on the desirability of veld burning in these different biomes are made.

BIBLIOGRAPHY, FOREST, GRASSLAND, REVIEW

48. Cook Lynette 1938b. Some experiments and observations on veld burning. BSc (Hons) thesis, Department of Botany and Microbiology, University of the Witwatersrand. 42 pp.

A description of seasonal burn experiments carried out at Frankenwald and issues arising from observations viz phenological changes which are taking place, temperature of burns, growth on the various plots and amount of shooting in spring are discussed.

Descriptions of grazing and burning experiments at Frankenwald and of the seasonal burn experiments at Drylands are presented. General observations and conclusions are discussed.

ADAPTIVE RESPONSE, BURNING SEASON, BURNING TRIAL, FIRE REGIME, FRANKENWALD, GRASSLAND, GRAZING, TRANSVAAL

49. Cook Lynette 1939a. A contribution to our information on grass burning. MSc thesis, University of the Witwatersrand. 43 pp.

Experimental work is described on soil erosion, run-off and soil analysis at a site at Crescent Creek, Milner Park, Johannesburg; seasonal burning at Frankenwald; burning and grazing at Frankenwald and burning at Drylands, Groenkloof, Pretoria.

Conclusions drawn from six years' experimental work are that burning improves the grass cover, the best time for burning in the highveld is late June or July and that burning should not be on an annual basis if grazing occurs. The benefit derived from burning namely good or improved pasturage outweighed the losses.

General observations on experiments at Frankenwald are included as well as a comprehensive literature review and discussion on the controversy of burning.

ANIMAL INFLUENCE, BURNING TRIAL, CONSERVATION, FIRE REGIME, FRANKENWALD, GRASSLAND, GRAZING, MANAGEMENT, REVIEW, SOIL CHEMISTRY, SOIL EROSION, SUCCESSION, TRANSVAAL

50. Cook Lynette 1939b. A contribution to our information on grass burning. South African Journal of Science 36, 270-282.

From the Crescent Creek (Milner Park, Johannesburg) experiment it has been shown that the plot which was not burnt has deteriorated in grazing quality. The plot burnt every other year has remained in the same condition, and the plot burnt every year has improved in quality. From these observations and the phenological records of all the experimental plots, it appears that burning improves the veld, and that the best time for burning in the highveld areas is late in June or July, but if grazing is being carried out, burning should not take place annually.

Analyses of the soil showed that firing over a period of six years did not prove extremely detrimental with respect to the amount of organic matter, nitrogen, total soluble salts, hydrogen ion, and the maximum water retaining capacity of the soil, and that the benefits derived from burning resulting in good or improved pasturage outweighs the losses caused by fires in deterioration of soil composition. The amount of water lost from burnt areas during rain is greater than that on unburnt areas, and the unburnt areas conserve the water for a greater length of time.

The actual temperature of the burn does little harm if the fire takes place during winter. It is the following months of exposure to the sun which cause the greatest amount of damage.

There is often a great difference in the growth of certain grasses in the control plots and the burnt plots. The growth in the control being far more luxuriant, but unfortunately unattainable owing to the hamper of dry leaves.

From statistical analyses of the amount of shooting in spring, it appears that there is very little difference between burnt areas, and areas which are burnt frequently but are unburnt at the time of analysis, but that there is more shooting on both these areas than on areas which have been protected from fire for several years.

BURNING TRIAL, GRASSLAND, HERBAGE YIELD, MANAGEMENT, RUN-OFF, SOIL CHEMISTRY, SOIL STRUCTURE, TRANSVAAL

51. Coutts J R H 1945. Effect of veld burning on the base exchange capacity of a soil. South African Journal of Science 41, 218-224.

Laboratory experiments show that the base exchange capacity of a soil is scarcely altered by heating the soil temperatures up to about 250°C, but exposure to temperatures between 250°C and 500°C causes a moderate reduction (of the order of 20%) in buffering capacity.

The influence upon base exchange capacity of veld burning under field conditions is very small and probably transitory.

SOIL CHEMISTRY.

52. Daitz J 1953a. Some measurements of the $CO_2$ produced by micro-organisms in soil collected from a veld burning experiment. BSc (Hons) thesis, Department of Botany and Microbiology, University of the Witwatersrand. 12 pp.

This paper reports some preliminary experiments on the $CO_2$ production of micro-organisms in the heavy black clay soil collected from the seasonal burning experimental plots at Naudesfontein in the Bethal district. The objective of the investigation was to determine the output of $CO_2$ by the micro-organisms in the soil collected at Naudesfontein and to try and correlate this index of their activity with the effects of burning the veld at different seasons of the year.

Unfortunately the experiments were not carried out under standard conditions. It is concluded that the effect of seasonal burning on the soil micro-organisms cannot be assessed from the data available.

BURNING SEASON, BURNING TRIAL, FRANKENWALD, GRASSLAND, SOIL CHEMISTRY, SOIL MICRO-ORGANISMS, TRANSVAAL

53. Daitz J 1953b. A further report on the seasonal burn experiment at Bethal. Annual Report for 1953 of the Frankenwald Field Research Station. University of the Witwatersrand, Johannesburg. pp 33-34.

The layout and conduct of this experiment is described by Davidson (1950, 1951a). In this report herbage yields are recorded. In February, August and October plots Themeda triandra and Setaria nigrirostris were harvested separately from all other herbage.

The total herbage yield from the control plots is significantly greater than that from any other treatment; similarly for grasses and sedges. There are no significant differences for yield of grasses and sedges between any of the five plots under fire treatment. The separate yields of Themeda, Setaria and other grasses from the February, August and October plots indicate the decrease of T triandra and increase of S nigrirostris in the October burns and to a lesser extent in the February burns.

Themeda plants were collected during 1952 and 1953 for an investigation into the seasonal variation of carbohydrate root reserves under the influence of fire. The results are presented by Daitz (1954).

BURNING SEASON, BURNING TRIAL, FRANKENWALD, GRASSLAND, HERBAGE YIELD, THEMEDA, TRANSVAAL

54. Daitz J 1954. Available carbohydrate reserves in the roots of Themeda triandra from a seasonal burn experiment at Bethal. Annual Report for 1954 of the Frankenwald Field Research Station. University of the Witwatersrand, Johannesburg. pp 27-29.

This report is primarily concerned with the estimation of total available carbohydrate in the roots of Themeda triandra from the experimental plots described by Davidson (1950, 1951a, 1952b). Interest in the root reserves arose from the observation that T triandra had almost completely disappeared from the October burn plots. The results show that irrespective of the time of fire, the percentage carbohydrate reserves follow the same curve for all plots and it is concluded that fluctuations in percentage carbohydrate in the roots cannot explain the disappearance of T triandra from the October burn plots.

BURNING TRIAL, FRANKENWALD, GRASSLAND, THEMEDA, TRANSVAAL, VEGETATION DYNAMICS

55. Darnell B H 1973. The great forest and veld fire of 1869. Looking Back 13(2), 43-44.

This is the text of a letter about this fire written by Mr Darnell, who was Member of the Legislative Assembly for Caledon, Victoria East and Queenstown at different times

between 1854 and 1870, and was living at Knysna at the time. The editor's comment is that this was the greatest veld fire in South Africa and devastated the whole area from Riversdale to Uitenhage.

CAPE, HISTORICAL ACCOUNT

56. Davidson R L 1950. Veld burning experiments at Bethal. Annual report for 1950 of the Frankenwald Field Research Station. University of the Witwatersrand, Johannesburg. pp 21-26.

Two long-term experiments which were set up on the farm Naudesfontein in the Bethal district in 1938 and extended in 1940 are described. Phenological observations recorded since the inception of the experiment are summarized. Results for point quadrat analyses to determine the botanical composition in each of the subplots and clipped quadrat data to determine herbage yield are presented.

The influence of fire at different times of the year was investigated and the conclusions drawn after 10 to 12 years are :

- complete protection of the veld results in deteriorated pasture with significantly less Themeda triandra and more Setaria nigrirostris after 12 years
- there are no significant differences in cover, yield or percentage composition between June and August burns
- February and April burns are strikingly similar in all respects and both are significantly better than the October burns in respect of total yield and percentage of T triandra in basal cover and herbage
- although the basal cover of the October plots is not significantly less than that of the others, the total herbage yield and the percentage of T triandra in cover and yield are significantly lower than in any other plot
- comparing the results of point quadrats alone, there are no significant differences between the mown, lightly grazed veld and the June and August burns.

From the results of these experiments which do not include grazing and trampling factors, it would appear that the time of burning in the dormant season was not important but that a burn in October led to deterioration of the veld.

BURNING SEASON, BURNING TRIAL, FRANKENWALD, GRASSLAND, THEMEDA, TRANSVAAL, VEGETATION STRUCTURE

57. Davidson R L 1951a. Further analysis of a veld burning experiment at Bethal. Annual Report for 1951 of the Frankenwald Field Research Station. University of the Witwatersrand, Johannesburg. pp 39-46.

One of the two long-term experiments described by Davidson (1950) was terminated during the period reported. In the remaining veld burning experiment in Themeda triandra veld there are 12 plots, two of which are controls and are never burnt. Of the rest two are burnt in each of the months August, October, February, April and June. The plots are never grazed. For comparison with these burnt plots, analyses have been done in closely grazed unburnt veld and in unburnt veld which is mown in winter and grazed very lightly in summer.

Statistical analysis of point quadrat data has shown that the June plot burns have a significantly higher basal cover than the October plots but that the difference between the basal cover of the other plots is less than 1,5%. The species composition of the veld has changed considerably. In general, burning in the winter months tends to increase the basal cover of T triandra, while burning in the growing season tends to decrease T triandra. Setaria nigrirostris appears to be increased in the October and February burns.

Clipped quadrat data to determine herbage yield are also presented and general conclusions are summarized.

BURNING SEASON, BURNING TRIAL, FRANKENWALD, GRASSLAND, THEMEDA, TRANSVAAL, VEGETATION DYNAMICS

58. Davidson R L 1951b. A long-term seasonal burn experiment near Standerton. Annual Report for 1951 of the Frankenwald Field Research Station. University of the Witwatersrand, Johannesburg. pp 47-55.

A seasonal burn experiment laid out in veld dominated by Themeda triandra at Bankies Farm in the Standerton district in 1938 is described. Two subplots were burnt each month from April to November and two were protected from fire.

Point quadrat data and herbage yields from clipped quadrats taken in May 1951 are presented. Conclusions drawn from the analysis of basal cover and herbage yields are summarized. In general these experiments confirm the conclusions drawn from the Bethal experiments (Davidson 1950, 1951a). The June burn proved to be the best treatment, followed by the May burn. The trend of the results from the August to November and April burns is towards a poorer veld the later the burn.

It is pointed out that the conclusions conflict with those drawn by Scott (1949) from experiments in Natal sourveld and

that further long-term experimentation was necessary before drawing hasty conclusions.

BURNING SEASON, BURNING TRIAL, FRANKENWALD, GRASSLAND, HERBAGE YIELD, THEMEDA, TRANSVAAL, VEGETATION STRUCTURE

59. Davidson R L 1952a. Herbage yield from a seasonal burn experiment near Standerton. Annual Report for 1952 of the Frankenwald Field Research Station. University of the Witwatersrand, Johannesburg. pp 30-31.

The seasonal burn experiment conducted near Standerton (see Davidson 1951b) was extended in December 1951 to include veld which had been lightly grazed since 1938 but not burnt.

Total herbage yields as well as yields for grasses and sedges, and for other monocotelydons and dicotyledons are presented for the various treatments (protected, grazed unburnt, April to October burns). The method of sampling developed, whereby clipped quadrats may be taken over the same period in each treatment, has shown significant differences which partly conflict with the data presented for the previous season.

It is proposed to continue sampling these plots to determine the yields of the treatments during seasons of higher rainfall.

BURNING TRIAL, FRANKENWALD, GRASSLAND, GRAZING, HERBAGE YIELD, TECHNIQUE, TRANSVAAL

60. Davidson R L 1952b. Herbage yields from a seasonal burn experiment at Bethal. Annual Report for 1952 of the Frankenwald Field Research Station. University of the Witwatersrand, Johannesburg. pp 32-34.

This report gives further results of the veld burning experiment reported by Davidson (1950, 1951a). Statistical analysis of point quadrat data has shown that the June burns have a significantly higher basal cover than the October burns, but the difference between the other burns is less than 1,5%. It was also found that firing in winter tended to increase the basal cover of Themeda triandra while firing in the growing season tends to decrease T triandra. Setaria nigrirostris appears to be increased by October and February burns.

The method of sampling of herbage used is described and a discussion of the preliminary results of the trial follows.

BURNING SEASON, BURNING TRIAL, FRANKENWALD, GRASSLAND, THEMEDA, TRANSVAAL

61. Davidson R L 1953. A seasonal burn experiment in sour/mixed bushveld. Annual Report for 1953 of the Frankenwald Field Research Station. University of the Witwatersrand, Johannesburg. pp 29-32.

A seasonal burn experiment was set up in Sourish Mixed Bushveld in the Pretoria North district in 1939. Subplots were burnt at different frequencies in each of the months February, August, October and November during the period 1939 to 1952. There were two control plots and none of the plots had been grazed since 1939.

Basal cover and species composition of the sward were determined by the point quadrat method and results for the different treatments are presented. Herbage yields taken over a complete growing season are given.

The tentative conclusion which required verification, was that August, October and February burns gave the highest yield together with the highest proportion of palatable grasses. The November plots gave a high yield but this herbage was mainly unpalatable Elyonurus and Schizachyrium species.

It is not known what the results will be under grazing conditions.

BURNING SEASON, BURNING TRIAL, FRANKENWALD, GRASSLAND, HERBAGE YIELD, TRANSVAAL, VEGETATION STRUCTURE

62. Davidson R L 1954. Further herbage yields from a seasonal burn experiment near Standerton. Annual Report for 1954 of the Frankenwald Field Research Station. University of the Witwatersrand, Johannesburg. pp 25-27.

This burning experiment near Standerton is described by Davidson (1951b). In an extension to the experiment undertaken in 1951 (Davidson 1952a) two mown subplots and two subplots to be burnt after the first half inch (12,7 mm) of rain were included. A third season of herbage yields were taken from this experiment. These are presented and compared with the results of previous years.

The marked difference in species composition of the sward resulting from the various treatments is mentioned.

BURNING TRIAL, FRANKENWALD, GRASSLAND, HERBAGE YIELD, TRANSVAAL, VEGETATION STRUCTURE

63. Davidson R L 1964. An experimental study of succession in the Transvaal highveld. In : Ecological studies in southern Africa. D H S Davis (ed). Junk, The Hague. pp 113-125.

It is suggested that one of the factors retarding the establishment of scrub forest, the probable climax stage, in the grass-

land subclimax on the highveld is that fire causes a high mortality of seedlings.

Successional changes are investigated at Frankenwald in the Fallows Fertility Experiment, where the effect of soil fertility on the nature of secondary succession is determined. Treatments of a fallow land were O, P, PN, and $PN_2$ and since 1951, phenological observations, basal cover determinations and specific herbage yield measurements were done.

A discussion of the factors influencing succession is included.

FERTILIZATION, FRANKENWALD, GRASSLAND, HERBAGE YIELD, SUCCESSION, TRANSVAAL

64. Davidson R L, A M Brynard, P Gillard, G Lecatsas and J Leigh 1961. Veld burning (c) Calibration of the belt transect method in Combretum woodland in the Kruger National Park. Koedoe 4, 31-44.

The belt transect method to determine the frequency of the woody species in the veld for monitoring the effects of fire is examined. Various transect lengths and widths are statistically tested. A 200 ft (60,96 m) transect 5 ft (1,52 m) wide appears to provide a satisfactory sample if all trees and shrubs are to be treated together. When it is desired to compare the density of individual species, it is necessary to double the area of the belt transect. Statistical analysis of belt transects cannot differentiate between trees and coppices and this problem becomes very important where the effect of fire is to reduce trees to coppices.

COMBRETUM, KRUGER NATIONAL PARK, SAVANNA, TECHNIQUE, TRANSVAAL, VEGETATION DYNAMICS

65. D'ewes D 1960. Three centuries of veld fires. Journal of the Botanical Society of South Africa 46, 6-7.

The first recorded veld fire which occurred on 5 February 1661 is described. The author suggests that although fires are a natural feature of the south-western Cape vegetation, they have been instrumental in the spread, especially during the last 50 years, of invasive Hakea and Acacia species. Ways in which fire has induced this spread are discussed. Suggestions are made regarding fire management.

CAPE, FYNBOS, HISTORICAL ACCOUNT, MANAGEMENT, SUCCESSION, VEGETATION DYNAMICS

66. Donaldson C H and J W C Mostert 1958. Alarming encroachment of bitterbos in the Orange Free State. Farming in South Africa 34(9), 53-55.

An experiment was conducted in the western Orange Free State on the control of bitterbos Chrysocoma tenuifolia. The treat-

ments applied to the veld were burning in spring, mowing in spring, mowing in summer, mowing in autumn and winter mowing. The results revealed that burning in spring or mowing veld once only during any season of the year resulted in a significant decrease in the bitterbos. Burning in sweetveld can only be recommended under certain conditions.

KAROO, MANAGEMENT, ORANGE FREE STATE, VEGETATION STRUCTURE

67. Donaldson C H 1966. Control of blackthorn in the Molopo area with special reference to fire. Proceedings of the Grassland Society of southern Africa 1, 57-62.

Numerous studies were conducted on the effects of different types of fire on individual plants of blackthorn Acacia mellifera spp detinens. It was evident from these studies that burning of the basal stems of blackthorn with dung, sawdust or wood fires proved to be highly effective in producing total root kills of this plant. Burns obtained from dry grass fires were effective only in killing the aerial growth of the plant.

ACACIA, BURNING TRIAL, MANAGEMENT, SAVANNA, TRANSVAAL, VEGETATION STRUCTURE

68. Donaldson C H 1967. Further findings on the effects of fire on blackthorn. Proceedings of the Grassland Society of southern Africa 2, 59-61.

Numerous investigations into the effects of different types of fire on blackthorn were conducted. The basal stems of blackthorn were burnt with a gas flame at soil level and 12 inches (305 mm) above soil level for periods of one, three and six minutes respectively. An illustration of a "flame girdling" apparatus which was especially constructed for these investigations and a description of its operation are presented. A total root kill of blackthorn was obtained by burning the lower basal stems of the plant for periods of three and six minutes respectively. All other burn treatments resulted in the development of coppice shoots. A fire-mechanical method for eradicating blackthorn is suggested.

ACACIA, BURNING TRIAL, MANAGEMENT, SAVANNA, TRANSVAAL, VEGETATION STRUCTURE

69. Downing B H 1974. Reactions of grass communities to grazing and fire in the sub-humid lowlands of Zululand. Proceedings of the Grassland Society of southern Africa 9, 33-37.

A stratified sample of 350 plots was used to record grass species presence, the physical conditions of grasses and forbs, and to assess grazing usage. Normal association analysis of the sample data identified and characterized the grass communities present which, on a plant successional basis, were found

to be part of a retrogressive sequence induced by increasing grazing usage and the elimination of veld fires.

BURNING TRIAL, GRAZING, NATAL, SUCCESSION, VEGETATION STRUCTURE

70. Downing B H, E R Robinson, W S W Trollope and J W Morris 1978 (in press). The effects of macchia eradication techniques on botanical composition of grasses in the Döhne Sourveld of the Amatole mountains. Proceedings of the Grassland Society of southern Africa.

Grass communities determined through association analysis were used for determining the effects of several methods for eradicating and controlling macchia. Follow-up burns at three frequencies applied over a ten-year period to control macchia were found to have masked most differences in species composition of the grass sward which may have arisen as a result of eradication treatments of burning, spraying and cutting. However, Elyonurus argenteus and Harpechloa falx were absent only from stumped plots. Themeda triandra and Tristachya hispida survived in a vegetative state in unburnt control plots for about 20 years in spite of competition from a dense, bushy growth of macchia (Cliffortia paucistaminea, C linearifolia and Erica brownleeae). Themeda triandra was best adapted to withstand frequent burning while Heteropogon contortus was suppressed by this treatment. Certain other grasses may have survived entirely below the soil with no evidence of aerial portions in moribund veld. Basal cover was used for recommendations on veld burning management, whether for purposes of water production or for grazing.

BURNING TRIAL, CAPE, FYNBOS, GRASSLAND, MANAGEMENT, VEGETATION DYNAMICS

71. Drought Investigation Commission 1923. Final Report October 1923. Cape Times Limited, Government Printer. pp 62-64.

With regard to veld burning, the Commission finds that :

- veld burning is still too prevalent and should be discouraged
- paddocking will tend to reduce veld burning
- much of the veld, at present used for grazing and which can be kept usable for this purpose only by frequent burning, would be far better under timber
- it cannot recommend direct legislation against veld burning, because this could not be enforced
- State action to prevent or reduce grass burning must therefore generally be along the lines of education, of encouraging fencing, and of tree planting

- where the right to graze is taken away, the desire to burn automatically ceases

- in the case of certain mountain catchments particularly valuable to irrigators below, immediate action should be taken

- this action should consist in legislation prohibiting the use of certain mountain catchments for grazing.

CATCHMENT, FOREST, GRAZING, LEGISLATION

72. Du Toit P F 1972. Acacia karroo intrusion : The effect of burning and sparing. Proceedings of the Grassland Society of southern Africa 7, 23-27.

An investigation was conducted in the eastern Cape sweetveld to determine the effect of frequency of burning, extended sparing and controlled grazing on the establishment of seedlings of Acacia karroo. After eradication of a mature A karroo stand, seedling establishment in the area concerned was recorded annually in permanent transects on paddocks neither grazed nor burnt, burnt annually, burnt biennially and burnt triennially. Grazing and resting treatments were superimposed on the burning treatment. After seven years reinfestation of A karroo was determined on all paddocks and population height was sampled for evidence of layering.

Some of the treatments proved effective in preventing seedling establishment and there was no difference between treatments, seedling establishment being directly correlated to the original thorn tree density. Despite severe drought conditions there was a continuous establishment of seedlings, and at the termination of the trial no layering was evident in the community. Fire, while not preventing establishment, did retard seedling development.

ACACIA, BURNING TRIAL, CAPE, MANAGEMENT, SAVANNA, VEGETATION STRUCTURE

73. Dyer R A 1932. Control of Selago corymbosa. Farming in South Africa 6, 511-512; 518.

Experiments to determine the effect of various veld management practices on the control of Selago corymbosa in the Grahamstown district are described.

Of the five inferences made from the experiments, the one relating to burning treatment is as follows :
Resting the grassveld and burning during winter results in the eradication of both S corymbosa and Helichrysum anomalum. During the first two years of the experiment nearly all the

foreign growth, including the Selago was replaced by a 90% stand of excellent redgrass Themeda triandra in the burnt area.

BURNING TRIAL, CAPE, GRASSLAND, MANAGEMENT, SELAGO, THEMEDA, VEGETATION STRUCTURE

74. Edwards P J 1961. Studies in veld burning and mowing in the Tall Grassveld of Natal. MSc thesis, University of Natal, Pietermaritzburg. 240 pp.

Effects of 20 years treatment with different times and frequencies of veld burning and of mowing on the basal cover, species composition, physical characteristics of the soil surface and on run-off and soil loss are discussed. Four facets of plant cover were considered : living basal, dead rooted, litter and canopy. Multiple correlations between the vegetation and soil factors and run-off and soil loss were evaluated. Complete protection resulted in a decline in living basal cover as compared with mowing and burning and there was more of this fraction of cover on the mown than on the burnt plots. Burning after the first spring rains resulted in superior cover compared with autumn burning. The composition of the two major components of the sward Themeda triandra and Tristachya hispida varied considerably with treatment.

BURNING TRIAL, GRASSLAND, MANAGEMENT, NATAL, RUN-OFF, SOIL EROSION, VEGETATION STRUCTURE

75. Edwards P J 1968. The long-term effects of burning and mowing on the basal cover of two veld types in Natal. South African Journal of Agricultural Science 11, 131-140.

Veld burning is a common occurence in all the higher rainfall areas of South Africa. Two experiments are described in which the long-term effects of mowing and of burning at different seasons of the year and at varying intervals between treatments were examined. One experiment was conducted on a mixed veld and the other on a sourveld.

After 20 years of treatment marked differences were recorded in the amount of rooted basal cover present on the various treatments in both veld types. Complete protection of the veld resulted in a decline of basal cover in comparison with mown veld and burnt veld in both veld types. This decline in basal cover was noticeable in the palatable grass species in the Tall Grassveld, and in both palatable and unpalatable grass species in the Highland Sourveld. On the average burning of veld resulted in a poorer basal cover than did mowing the veld. In both veld types, annual and biennial burns gave, on average, a greater basal cover than did triennial burns.

BURNING TRIAL, GRASSLAND, MANAGEMENT, NATAL, VEGETATION STRUCTURE

76. Edwards P J 1969. Veld burning in the Giant's Castle Game Reserve. Lammergeyer 10, 64-67.

The effect of 14 different times and frequencies of veld burning on the basal cover and species composition of grassland in the Giant's Castle Game Reserve (altitude 2 000 m) after five years of treatment is reported. A good basal cover occurred under biennial and triennial spring burns, annual and triennial winter burns and mowing. Poor basal cover resulted from no burning or mowing and alternate autumn and winter burns. Palatable species were encouraged on mown plots, biennial spring and annual winter burns while they were discouraged with no burning or mowing and the alternate autumn and winter burn. Effects of the treatments on unpalatable grass species and non-grass species are also discussed as are recommendations for a burning programme in this situation.

BURNING TRIAL, DRAKENSBERG, GRASSLAND, MANAGEMENT, NATAL, VEGETATION STRUCTURE

77. Esterhuysen Elsie E 1936. Regeneration after clearing at Kirstenbosch. Journal of South African Botany 2, 177-185.

An area that had been under Pinus pinaster for about 30 years was cleared by felling of the pines and burning of the debris in sections over a two-year period. This paper records the plant species occurring there about one year after clearing.

Colonization of the area was observed to have taken place from plants present before clearing, from a strip of subclimax association adjoining the clearing and from more distant associations. On areas burnt during the clearing operations no pine seedlings appeared, whereas on unburnt sections an abundance of pine seedlings occurred.

CAPE, DEFORESTATION, FYNBOS, PINUS, SUCCESSION, VEGETATION DYNAMICS

78. Fair P 1969. A preliminary investigation into the effect of firing on the metabolism of two highveld grasses. BSc (Hons) thesis, Department of Botany and Microbiology, University of the Witwatersrand. 32 pp.

No literature directly relating to firing and its effect on metabolising of a plant was found. Thus literature indirectly related to the problems is reviewed, with a view to indicating possible lines of research.

The experimental approach and method is discussed with reasons given for the method adopted in each case. Procedures for the culturing of the seedlings and the manometric measurement of the respiratory rate are given.

Results are discussed individually and in relation to the literature reviewed. No definite conclusions are reached. However, the indications are that firing of the grasses studied has no direct metabolic response but rather an indirect ecological effect.

GRASSLAND, METABOLISM, REVIEW, TRANSVAAL

79. Fantham H B 1924. Some Protozoa found in certain South African soils - IV. South African Journal of Science 21, 445-479.

Preliminary observations on the effect of veld burning on soil Protozoa are recorded on pp 474-475 of this report.

The experiments were conducted in the University grounds, Milner Park, Johannesburg. It was found that during the first 40 days of culture, 11 species of Protozoa appeared in cultures taken before veld burning as compared with nine from soil taken after veld burning. Seven species were common to both sets of soils. A culture of soil taken after veld burning yielded almost exactly double the number of Protozoa as that taken before veld burning. Further differences could be found later as many Protozoa were very slow in developing in culture.

BURNING TRIAL, GRASSLAND, SOIL MICRO-ORGANISMS, TRANSVAAL

80. Galpin E E 1926. Botanical survey of the Springbok Flats. Memoirs of the Botanical Survey of South Africa 12, 1-100.

The author suggests that the Springbok Flats was in the process of being transformed from open grassy plains with abundant springbok and other antelope to a closed Acacia woodland or thicket due to the cessation of annual burning. The maintenance of annual burning of plant communities on basalt rock and turf was recommended but fire should be excluded from sandveld areas.

BURNING FREQUENCY, MANAGEMENT, TRANSVAAL, VEGETATION DYNAMICS

81. Gill G A 1936. Veld burning experiments. Farming in South Africa 2, 134.

Burning experiments on sourveld commenced at the Cedara School of Agriculture in 1921 and relative stability has been attained in the reaction of the veld to treatment applied. Results show that burning during the dormant period of growth from May till early September, has a beneficial effect on composition and quality of the grazing. Burning is best done before the early spring rains and is recommended once every second year to minimize soil erosion.

Burning is detrimental when conducted during the phase of active growth of grass, maximum damage being suffered in mid-

summer. Allowing the veld to remain unburnt for longer than two years also leads to veld deterioration due to accumulation of litter. Mowing may delay the necessity for burning. If the veld is not burnt and mown only, or mown and grazed only, grasses with narrow wiry leaves tend to predominate.

BURNING TRIAL, GRASSLAND, MANAGEMENT, NATAL, SOIL EROSION, VEGETATION STRUCTURE

82. Glover P E and H J van Rensburg 1938. A contribution to the ecology of the highveld grassland at Frankenwald in relation to grazing and burning. South African Journal of Science 35, 274-279.

Experiments were conducted over a five-year period between 1933 and 1938 on 18 small plots, each approximately 188 $m^2$, to determine the effects of burning, grazing and trampling on undisturbed veld for periods ranging from one to five years. The work was done at Frankenwald, the Botanical Research Station of the University of the Witwatersrand.

Annual burning without grazing and complete protection from both burning and grazing favoured the development of tussock grasses such as Tristachya hispida and Trachypogon spicatus and neither were they adversely affected by moderate grazing. Burning alone and complete protection however, were most detrimental to Digitaria tricholaenoides, the root stocks of which are partially above the surface of the ground, but this grass was favoured by moderate grazing.

The plot subjected to trampling for five years in succession showed the most pronounced vegetational change with replacement of most of the original grasses by Cynodon dactylon while there were also bare patches where all the grass had been trodden out. There was however an increase in total basal cover on the quadrats due to the spread of Cynodon dactylon.

Under complete protection against burning and grazing, Eragrostis chalcantha, Brachiaria serrata, Themeda triandra and Heteropogon contortus also decreased at the expense of Tristachya hispida and Trachypogon spicatus.

BURNING TRIAL, FRANKENWALD, GRASSLAND, GRAZING, TRANSVAAL, VEGETATION DYNAMICS, VEGETATION STRUCTURE

83. Granger J E 1976. The vegetation changes, some related factors and changes in the water balance following 20 years of fire exclusion in Catchment IX, Cathedral Peak Forestry Research Station. PhD thesis, University of Natal, Pietermaritzburg. 615 pp.

This study is a resurvey of the status of the vegetation in Catchment IX following 20 years of almost total protection from fire.

The history of the area and of the research station is discussed. The influence of a number of environmental factors, namely climate, physiography, geology and soils were examined. Of the climatic factors particular attention was paid to rainfall and radiation and these factors have in turn been related to gauged streamflow and potential evapotranspiration losses.

Changes in the vegetation have been assessed by comparing the two maps compiled in this resurvey using the techniques of tacheometry and photogrammetry against the primary survey map of Killick drawn in 1953 (and included in Killick 1963).

A more detailed quantitative-qualitative study of the vegetation has been made by way of sampling along transects and subjecting the data to the objective techniques of Normal Association Analysis and Principal Components Analysis. This latter technique has also been applied to various soil factors. The results of these analyses have been related to various environmental factors.

From these investigations it is concluded that the exclusion of fire from an area that was predominated in 1953 by large communities of Themeda triandra and Pteridium aquilinum has resulted in the development of more mesic environment. This change is illustrated most clearly on the steep south-facing slopes of Catchment IX where there has been considerable invasion by such woody species as Philippia evansii and Leucosidea sericea.

CATCHMENT, DRAKENSBERG, FOREST, NATAL, REVIEW, SUCCESSION, THEMEDA, VEGETATION DYNAMICS

84. Grobbelaar W S 1960. Controlled veld burning is essential. Farming in South Africa 36(8), 46-48.

Veld fires have always been a regular occurrence in the Outeniqua area because of the very dry summer conditions and the presence of dry grass and fynbos which burn very easily.

Summer fires have resulted in the almost complete destruction of useful grasses such as Themeda triandra, because these fires burn the grass seed and the burnt veld is grazed before the grass can run to seed.

CAPE, FYNBOS, MANAGEMENT, THEMEDA

85. Grout L 1861. Zululand; or, Life among the Zulu kafirs of Natal and Zululand. New Impression 1970. African Publication Society, London. 351 pp.

Early historical reference - see inter alia pp 34, 36, 45.

HISTORICAL ACCOUNT

86. Guilloteau J 1957. The problem of bush fire and burns in land development and soil conservation in Africa south of the Sahara. African Soils 4(2), 64-102.

A general review of the topic is presented, based mainly on evidence from francophone and southern Africa.

CONSERVATION, REVIEW

87. Hall A V 1959. Observations on the distribution and ecology of Orchidaceae in the Muizenberg Mountains, Cape Peninsula. Journal of South African Botany 25, 265-278.

Distribution patterns of 44 species of the family Orchidaceae were examined in a five square mile tract of mountains on the Cape Peninsula, South Africa.

Relationships between the distribution patterns and various ecological factors were examined and included an examination of post-burning periods in the area in relation to distribution. A marked increase in numbers of flowering individuals of certain species was noted after fire. In addition, results are presented of five years of observations on a stretch of burnt fire break and an adjacent unburnt area. The implications of these results are discussed.

CAPE, FYNBOS, ORCHIDACEAE, VEGETATION DYNAMICS

88. Hall T D 1934. South African pastures : retrospective and prospective. South African Journal of Science 31, 59-97.

Discussion is centred on droughts, rainfall, overstocking and overgrazing, fencing and rotational grazing, veld fires, game and pastures, locusts, mineral deficiencies and fertility, soil fertility, sweet and sourveld, lamsiekte and improved pastures.

The section on veld fires (pp 71-74) deals with a historical review of literature concerning veld fires, mainly of the nineteenth century.

GRASSLAND, GRAZING, MANAGEMENT, REVIEW

89. Hubbard C S 1937. Observations on the distribution and rate of growth of Clanwilliam cedar Widdringtonia juniperoides Endl. South African Journal of Science 33, 572-586.

The history of the reckless exploitation of the cedar area, by the burning of trees and the destruction of seedlings by sheep and goats, is related. The present distribution of cedars is described and possibility of their earlier occurrence in the plateau areas is considered. The effect of fire damage on their distribution pattern is discussed.

Some aspects relating to the silviculture of cedars are described, and the data relating to the measurement of a number of trees and plots are presented and discussed.

CAPE, FYNBOS, HISTORICAL ACCOUNT, WIDDRINGTONIA

90. Huntley B J 1972. Aspects of grassland production and utilization on a northern Transvaal nature reserve. Journal of South African Wildlife Management Association 2, 24-28.

The seasonal and spatial variation in the production and utilization of the herbaceous component of grassland and savanna communities on Percy Fyfe Nature Reserve, northern Transvaal, was investigated over a three-year period. Periodic estimates of standing crop inside and outside 14 game proof exclosures provided the basic information, indicating large variations in all parameters measured according to plant community, rainfall, burning regime and food preferences of the herbivore population.

BURNING TRIAL, HERBAGE YIELD, MANAGEMENT, SAVANNA, TRANSVAAL

91. I'ons J H 1960. Studies on veld burning. MSc thesis, University of Natal, Pietermaritzburg. 242 pp.

The study was conducted in two parts. The first involved a field experiment near Pietermaritzburg to determine the effects of burning and mowing of veld for the removal of old material, and different times of mowing for hay on herbage production, botanical composition of the sward, protein content of the herbage and infiltration rates and moisture content of the soil. A study of the effects of different times of burning (autumn, winter and spring) on root growth of Themeda triandra in glass-sided boxes, was conducted in conjunction with the veld burning and mowing field experiment.

The second part of the series of investigations was conducted in Swaziland, where a survey of veld burning practices and their effects (in terms of botanical composition of the sward) was carried out. It was found that a system of biennial autumn burning, in order to provide winter grazing for sheep moved in from outside areas, is of great importance in the sourveld areas of Swaziland. Beyond this and a certain amount of annual and biennial winter burning however, little other regular burning was found to have taken place.

Little precise information could be obtained on grazing management of the areas analyzed botanically, thus introducing an unknown factor of some importance which makes it impossible to extract precise data on the effects of different burning treatments from the survey.

BURNING FREQUENCY, BURNING SEASON, BURNING TRIAL, GRASSLAND, HERBAGE QUALITY, NATAL, SOIL CHEMISTRY, THEMEDA, VEGETATION DYNAMICS, VEGETATION STRUCTURE

92. Irvine L O F 1943. Bush encroachment in the northern Transvaal. Farming in South Africa 18, 725-729.

The view is held that bush encroachment in the bushveld of the northern Transvaal is a phenomenon of the present century and its causes and effects are discussed.

Combating bush encroachment is seen in two distinct phases; firstly eradication or thinning-out of the bush and secondly prevention of encroachment or re-encroachment. Methods of thinning-out are described.

Practical methods for the prevention of encroachment are seen as periodic effective veld burning or periodic artificial destruction of unwanted bush. Both methods are described and approximate costs involved per morgen are given.

ACACIA, MANAGEMENT, SAVANNA, TRANSVAAL, VEGETATION STRUCTURE

93. Jackson W P U 1976. Fire and flora on Constantia Ridge, Table Mountain. Veld and Flora 62(1), 24-27.

An account is given of the rejuvenation of the veld after a fire in January 1972 and is followed by a discussion and listing of the vegetation appearing on the mountain after this fire.

CAPE, FYNBOS, SUCCESSION, VEGETATION STRUCTURE

94. Jansen P J 1959a. A study of Margarodes on grasses of the Trachypogon - other species grassland at Frankenwald. BSc (Hons) thesis, Department of Botany and Microbiology, University of the Witwatersrand. 8 pp.

The classification and life cycle of the genus Margarodes is presented. Experiments were designed to determine whether burning during the past years had any direct or indirect influence on the population of Margarodes in the different seasonal burn treatments conducted in the experimental burn plots (Block XI) which had been laid out in 1938 at Frankenwald in undisturbed "purple veld". Results are presented and discussed. Owing to the lack of knowledge on the life and habits of the genus Margarodes it was difficult to draw definite conclusions from the experimental data. It would appear that burning during February and August controls the population of Margarodes.

BURNING SEASON, BURNING TRIAL, FRANKENWALD, TRANSVAAL

95. Jansen P J 1959b. The influence of burning on grasses and soil structure of Trachypogon - other species veld. BSc (Hons) thesis, Department of Botany and Microbiology, University of the Witwatersrand. 27 pp.

The effects of burning "purple veld" at different times of the year at Frankenwald are investigated in terms of a growth study and root analysis and a soil moisture and run-off investigation. Results for the three co-dominant grass species indicate that in terms of carbohydrate root reserves, spring burns are least detrimental while in terms of nitrogen reserves, summer burns are least detrimental. Winter burn plots showed the greatest water and soil run-off and the slowest rate of percolation. The percentage moisture in the soil at about one metre depth was not influenced by treatment whereas at about 250 mm depth during the dry months this was lowest in the winter burn treatments. It is concluded that burning in autumn is particularly harmful and recommended that this veld be burnt before grass begins to shoot in the spring regardless of the first spring rains.

BURNING FREQUENCY, BURNING SEASON, BURNING TRIAL, FRANKENWALD, GRASSLAND, NUTRIENTS, RUN-OFF, SOIL EROSION, TRANSVAAL, WATER YIELD

96. Jordaan P G 1949a. Gemeenskapsontwikkeling en veldbeheer (Community development and veld control). Tydskrif vir Wetenskap en Kuns 9(2), 204-214.

Plant succession on wet and dry rock, on sand, on ploughed lands and in burnt areas is discussed briefly with reference to the winter rainfall area of South Africa. Plant succession in burnt areas is very diverse. Retrogressive plant succession results if succession is obstructed.

The importance of the flora and vegetation of the winter rainfall area is discussed from an aesthetic point of view as well as its significance as a tourist attraction. The necessity of controlling the vegetation in catchment areas and the management of veld to control its inflammability are stressed.

CAPE, CATCHMENT, FYNBOS, MANAGEMENT, SUCCESSION

97. Jordaan P G 1949b. Aantekeninge oor die voortplanting en brandperiodes van Protea mellifera Thunb (Notes on the propagation and fire period of Protea mellifera Thunb). Journal of South African Botany 15, 121-125.

The life cycle of P mellifera is described and discussed. Different periods are evident in the life cycle of the species - a period of floral development, a flowering period, developmental period of the embryo, the fruiting period, germination period

and youth period. These periods overlap so that at any time during the year more than one period is to be found.

From data it is inferred that, as far as sexual reproduction is concerned, January to March is a safe, April to June an unfavourable and July to December an unsafe fire period for the species. The interval between successive safe fires is determined by the youth period and is about eight years for P mellifera.

If there is a safe and unsafe period and a definite fire frequency for P mellifera, it is to be expected that the same will be true for other species of plants.

ADAPTIVE RESPONSE, BURNING FREQUENCY, CAPE, FYNBOS, PROTEA

98. Jordaan P G 1965. Die invloed van 'n winterbrand op die voortplanting van vier soorte van die Proteaceae (The influence of a winter burn on the propagation of four species of the Proteaceae). Tydskrif vir Natuurwetenskappe 5, 27-31.

Results of a fire in June in the winter rainfall area of South Africa are presented. All plants and seeds of Protea mellifera and P pulchella were destroyed; plants of Leucadendron plumosum were totally killed but a few seeds survived to regenerate the species; all seeds of L adscendens were killed but the plants sprouted from buds protected in or near the ground; the seeds of Anthospermum aethiopicum (Rubiaceae) survived and the species increased its cover and density to such an extent that it became dominant.

The results are advanced as further proof of the hypothesis that species which are dependent on seed for regeneration, have both safe and dangerous fire periods.

ADAPTIVE RESPONSE, BURNING SEASON, CAPE, FYNBOS, LEUCADENDRON, PROTEA, VEGETATION DYNAMICS

99. Joubert D M 1977. Ecological effects of fire : an overview. South African Journal of Science 73, 166-169.

Fire, both controlled and natural, can have a profound effect on the floral and faunal composition of a region. An understanding of the mechanisms involved is therefore of considerable practical importance to conservationists and agriculturists alike. Hence the role of fire in the disturbance of natural balances or the creation of new equilibria in nature is traced from the first record of such occurrences at the southern tip of Africa to the present day. Though by no means complete, the review includes references to many major contributions on the subject and provides a starting point for participation by South African scientists in an international research programme

under the aegis of the Scientific Committee on Problems of the Environment (SCOPE).

FIRE REGIME, HISTORICAL ACCOUNT, REVIEW

100. Kanthack F E 1907. Sluits : their evil and prevention. Agricultural Journal of the Cape of Good Hope 31, 574-589.

Views expressed in answer to a memorandum published in 1904 are summarized. The extent, causes, effects and methods of prevention and treatment of sluiting (gully erosion) in the Cape Colony are discussed. Grass burning as a management tool is admitted as being one of the causes of sluiting and this practice is condemned in the strongest terms.

CAPE, CONSERVATION, MANAGEMENT

101. Keet J D M 1952. The veld and forest fire law of the Union of South Africa. Government Printer, Pretoria. 18 pp.

This is a compilation of the provisions of the Union Law (since superceded by more recent legislation) relating to veld burning and to the protection of veld and forests from fire.

FIRE BREAKS, FOREST, LEGISLATION

102. Kern N G 1978. The influence of fire on populations of small mammals of the Kruger National Park. MSc thesis, University of Pretoria. 79 pp.

A total of 16 000 trap nights was employed over 11 months to examine the influence of burning on small mammal populations in two major veld types of the Kruger National Park. Four burning treatments (control, annual August, triennial August and April burning) were examined in detail and the following parameters determined : small mammal species composition, population density, biomass and species diversity. The control treatment had a high, stable small mammal density, biomass and diversity; the annual burning treatment had a low diversity and was dominated by Tatera leucogaster. The triennial burning treatments showed a cycle of species composition from domination by T leucogaster following burning, through domination by other rodent species to domination by Crocidura hirta at the end of the cycle. The distributions and movements of the small mammals can be explained in terms of cover and litter preferences.

BURNING TRIAL, FAUNAL STRUCTURE, KRUGER NATIONAL PARK, SAVANNA, SUCCESSION, TRANSVAAL

103. Killick D J B 1959. An account of the plant ecology of the Table Mountain area of Pietermaritzburg, Natal. Memoirs of the Botanical Survey of South Africa 32, 1-119.

A short section of this memoir deals with the occurrence and effects of grass fires in this area. It is considered that fire may have contributed to the retrogression of the grassveld succession to Aristida junciformis.

ARISTIDA, BURNING SEASON, GRASSLAND, NATAL, SUCCESSION

104. Killick D J B 1963. An account of the plant ecology of the Cathedral Peak area of the Natal Drakensberg. Memoirs of the Botanical Survey of South Africa 34, 1-146.

The survey includes a short section on the occurrence of, reason for, and effects of fire in mountains.

DRAKENSBERG, GRASSLAND, NATAL, SUCCESSION, THEMEDA

105. King J A 1957. Meteorological aspects of forest fire danger rating. Journal of the South African Forestry Association 29, 31-38.

The effect of past weather conditions on inflammability and the influence of weather on fire behaviour are discussed. Using a method of deriving inflammability from rainfall, temperature and humidity data, the frequency of days of high inflammability in January, February and March in the Cape over eight years is derived and shows a maximum in mid-February. With the use of a burning index meter daily values of fire danger rating at the Cape for the same months in 1953 to 1955 are derived. Attention is called to the advantages of an objective method of forest fire danger rating and the role meteorological forecasts can play in fire protection.

CAPE, FIRE DANGER RATING

106. Komarek E V Sr 1972. Lightning and fire ecology in Africa. In : Fire in Africa. Proceedings Annual Tall Timbers Fire Ecology Conference 11, 473-509.

This paper discusses lightning in ancient and modern times. The climatological patterns of Africa and particularly South Africa are shown to be especially conducive to thunderstorms and lightning while the rainfall pattern of South Africa almost invariably produces an abundance of dry, easily ignitable vegetation. The activities of man are shown to have an effect on the volume of such material.

Information is presented to show that over the 13-year period

prior to 1970 more than 11% of fires in forest plantations in South Africa were started by lightning.

The adaptation of plants to a fire environment is briefly discussed. Fire ecology in Africa is discussed at length and an appeal is made for the recording of knowledge of the fire uses of native peoples, the necessity of obtaining knowledge of the ecology of the important bush and tree species and their relation to the fire-cycle, and for further study focused on the interactions of the grazing or browsing habits of wild animals on vegetation and their relationship to fire.

ADAPTIVE RESPONSES, CONSERVATION, FOREST, LIGHTNING, REVIEW

107. Kruger F J 1977a. A preliminary account of aerial plant biomass in fynbos communities of the mediterranean-type climate zone of the Cape Province. Bothalia 12, 301-307.

Aerial plant biomass has been sampled by harvesting on several sites in fynbos communities of the south-western Cape Province. Biomass in stands of about two years old ranged from about 2 200 kg per ha to about 7 500 kg per ha. Mature stands comprised about 11 000 to 15 000 kg per ha in heaths and 15 000 to 26 000 kg per ha in sclerophyllous shrub. The data indicate a maximum annual growth rate of 1 000 to 4 000 kg per ha early in the development of a stand, but growth rates appear to decline rapidly as communities age.

Young stands are dominated by hemicryptophytes which comprise about 2 000 to 6 000 kg per ha, or about 60% to 75% of the biomass in stands of about four years old. Shrubs become prominent later, but the hemicryptophytes persist.

The data indicate that the biomass, growth rates and the shape of the growth curves of fynbos communities are on the whole similar to those of analogous vegetation in other zones of mediterranean type climate. However, there are important structural differences in that analogues of the northern hemisphere (garrigue, chaparral) do not have a significant component of persistent hemicryptophytes. Although Australian heath communities do have this feature, the hemicryptophytes are not as prominent as in fynbos.

CAPE, FYNBOS, HERBAGE YIELD, SUCCESSION, VEGETATION STRUCTURE

108. Kruger F J 1977b. Ecology of Cape fynbos in relation to fire. Proceedings of the Symposium on Environmental Consequences of Fire and Fuel Management in Mediterranean Ecosystems. USDA Forest Service. General Technical Report WO-3. pp 230-244.

Conservation of Cape fynbos (sclerophyllous shrublands), a biome-type with unique biogeographic features, includes habitat

management by means of prescribed burning. This practice is based principally on the observation that community diversity is dependent on periodic fire. These communities respond much like those of other mediterranean type and related ecosystems, but are possibly unique in that most include a comprehensive range of responses. Initial observations confirm the obvious view that community response to fire regime varies according to community type, and season and frequency of burning. The nature of these responses and the underlying factors responsible for their manifestation require further inquiry, particularly to permit more refined management.

CAPE, CONSERVATION, FYNBOS, MANAGEMENT, SUCCESSION

109. Kruger J A and I B J Smit 1974. Die invloed van winterbrand en sny op die seisoenshooiproduksie van Eragrostis curvula (Schrad) Nees (The effect of winter burning and mowing on seasonal herbage yield of Eragrostis curvula (Schrad) Nees). Proceedings of the Grassland Society of southern Africa 9, 117-122.

The response of Eragrostis curvula in Ermelo to three levels of fertilizer (no N or P, 53 kg N + 16 kg P per ha, and 106 kg N + 32 kg P per ha), three times of removing unutilized herbage (July, August and September) and three methods of herbage removal (annual mowing, annual burning, and burning and mowing in alternate years) was measured over six years in a 3x3x3 factorial experiment.

Each experiment of fertilizer produced an increase ($P < 0,01$) in DM yield, nitrogen and fibre percentage and crude protein and fibre production per hectare. But time of defoliation had no effect on any of these variables. Plots cut annually produced more dry matter ($P < 0,01$) than those burnt annually or those subjected to alternate burning and mowing. The last treatment gave better yields ($P < 0,01$) than annual burning.

BURNING TRIAL, ERAGROSTIS, GRASSLAND, HERBAGE YIELD, MANAGEMENT, TRANSVAAL

110. Krupko Irena and R L Davidson 1954. Stoebe vulgaris control experiments U3 and U5. Annual Report for 1954 of the Frankenwald Field Research Station. University of the Witwatersrand, Johannesburg. pp 29-33.

Nine subplots, 20 yards (18,29m) square, were set up in duplicate blocks U3 and U5 in 1937 in Trachypogon - other species grassland at Frankenwald to investigate the effect of various kinds of treatments (burning annually in August, hoeing, poisoning with sodium chlorate, heavy grazing, various combinations of these treatments and complete protection) on the control of Stoebe vulgaris. Botanical analyses were done in 1937, 1941 and 1954 in U3 and in 1939, 1941 and 1954 in U5.

The results of the botanical analysis are presented and discussed.

It is concluded that methods of eradication such as poisoning and hoeing are only temporarily effective unless conditions are made unsuitable for reinvasion. Furthermore, burning in August appears to prevent invasion after poisoning and to result in better control in the burn plots than in the complete protection plots. It is suggested that the curtailment of veld burning in the highveld generally during the past 20 years may be partly responsible for the general increase of S vulgaris in the veld in this region. Finally protection is not effective in either eradicating S vulgaris or keeping it out once it has been removed by poisoning or hoeing. The complete protection plots and the hoeing and poisoning plots suggest that the underlying causes of the encroachment of S vulgaris go deeper than mere overgrazing.

BURNING TRIAL, FRANKENWALD, STOEBE, TRANSVAAL

111. Krupko Irena and R L Davidson 1961. An experimental study of Stoebe vulgaris in relation to grazing and burning. Empire Journal of Experimental Agriculture 29, 175-180.

Experiments described are part of a long-term study of the ecology of Stoebe vulgaris, a bushy ericoid perennial weed in South African pastures, which has increased on the sandy soils of the highveld, where burning and heavy grazing have been discouraged over the past 25 years. The experiments have shown that the establishment of S vulgaris can be prevented by spring burning of grassland, which otherwise becomes heavily infested. Once established, S vulgaris is not killed by spring burning, but over a period of 10 to 15 years annual burning at this time of year leads to a gradual reduction of S vulgaris. It is presumed that this results from the senescence of established plants and the prevention of ecesis of seedlings by fire.

Heavy grazing without burning has reduced the amount of S vulgaris, and heavy grazing together with burning have eliminated it. Both these treatments have led to changes in grass species similar to the botanical changes resulting from the application of nitrogen and phosphorus in this region.

The eradication of S vulgaris with sodium chlorate and by hoeing was found to be temporarily effective. The reinvasion of these plots by S vulgaris where fire has been withheld has shown clearly that on certain soils carrying natural grassland the encroachment of S vulgaris is not caused by overgrazing or fire. It is clear that chemical or mechanical means of control are not effective unless they are followed by burning or heavy grazing.

BURNING TRIAL, FRANKENWALD, GRASSLAND, GRAZING, MANAGEMENT, STOEBE, TRANSVAAL

112. Lecatsas G 1961. Some aspects of the ecology of Stoebe vulgaris. MSc thesis, University of the Witwatersrand. 100 pp.

Various aspects of the ecology of Stoebe vulgaris have been investigated with a view to elucidating the conditions necessary for its establishment on sandy soils of the highveld and controlling its spread by means of burning and hoeing.

The effect of temperature pre-treatment of seeds has been studied with a view to determining optimum conditions for germination. Low temperatures have been found to stimulate germination ability. Limited experiments on dormancy indicate no apparent dormant period for S vulgaris seed. Ecesis of seedlings has been studied in relation to light intensity, soil aeration and low temperature tolerance. Significant results have been obtained in all investigations.

Vegetative growth has been extensively investigated. Burning and mowing of adult plants was compared as well as intensity of burning necessary for eradication. Physiological studies in shoots produced after burning in November have provided some basis for advocating November burning as a means of control. The significance of adventitious buds found on the stem basis of adult plants has been established and hoeing (in relation to vegetative reproduction) as a means of eradication has been substantiated.

The sensitivity of seedlings and adults to nitrogen has been established and the hypothesis that the position of S vulgaris in the highveld subsere and its disappearance in heavily grazed veld is dependent on soil fertility in terms of nitrogen, seems to be well established.

FRANKENWALD, GRASSLAND, MANAGEMENT, SOIL CHEMISTRY, STOEBE, TRANSVAAL

113. Lecatsas G 1962. The effect of mowing and burning on the vegetative growth of Stoebe vulgaris. South African Journal of Science 58, 301-304.

Stoebe vulgaris is a pasture weed on the highveld. Its ecology has been studied by various workers at the Frankenwald Field Research Station with a view to establishing a method of control. Veld burning in November has been found to be the most practical means of control and the present investigation seems to establish these findings.

This paper deals with the results of investigations carried out to determine the effect of burning on the plant in comparison to the effect of mowing, whether new shoots produced after burning have toxic properties and whether chemical differences exist between shoots produced after mowing and shoots produced after burning.

The sensitivity of S vulgaris to nitrogen in comparison to highveld climax grasses is significant and seems to be correlated with the observed difference in nitrogen content of new growth after mowing and burning. A general disturbance in nitrogen metabolism in the plant seems quite probable.

BURNING TRIAL, FRANKENWALD, GRASSLAND, MANAGEMENT, SOIL CHEMISTRY, STOEBE, TRANSVAAL

114. Le Roux Anneliese and J W Morris 1977. Effects of certain burning and cutting treatments and fluctuating annual rainfall on seasonal variation in grassland basal cover. Proceedings of the Grassland Society of southern Africa 12, 55-58.

The variation in total basal cover from one time of year to another was investigated by means of the bridge- and wheel-point methods over a period of seven years. Treatments were : a control plot, one cut annually in winter and one in spring; a fourth plot was burnt and a fifth burnt and cut, alternately, in spring.

Statistically significant increases and decreases in total basal cover were found between a number of consecutive surveys. Maximum basal cover was usually recorded between April and July and the minimum basal cover between July and October, although exceptions to both ranges were found. Winter and spring basal covers were significantly correlated ($p = 0,001$ and $0,01$ respectively) with the rainfall of the preceding season on the control plot, but no correlation with rainfall was found on the treated plots. The cover of Trachypogon spicatus and Eragrostis curvula increased and decreased, respectively, with or without cutting and burning treatments, over the period of study. Themeda triandra increased in basal cover with treatments, while cover of Setaria perennis decreased. The cover of Heteropogon contortus remained fairly constant, but decreased when no treatments were applied. The various treatments gave similar results, but usually differed from those of the control. It was concluded that the best time for making an annual survey of basal cover by means of a point method is between May and June. At this time the plants may be easily identified and basal cover is at its highest.

BURNING TRIAL, GRASSLAND, TRANSVAAL, VEGETATION STRUCTURE

115. Le Roux H H 1966. Veldbestuur in die wateropvanggebied van die winterreënstreek van Suidwes-Kaapland (Veld management in the catchment areas of the winter rainfall region of the south-western Cape). Forestry in South Africa 6, 1-32.

The management of the vegetation of the water catchment areas of the mountains of the south-western Cape Province is dealt with as a background to the current policy of protection of the

mountain veld of the south-western Cape. A historical sketch of veld burning in the past is given and the opposition against burning and measures to prevent fires are sketched.

The current policy in respect of the protection of the mountain catchments by the State, by public bodies and by private owners and the results attained are discussed. The implications of the past and present treatment of the mountain veld are discussed from the viewpoint of the possible effect on the vegetation and soil, on water conservation and on wildlife.

In regard to vegetation and soil, the merits of total protection as against burning are discussed and the possible effects of uncontrolled and repeated burning as opposed to controlled and periodic burning are treated in the light of research results. Attention is given to the burning season and veld burning in combination with grazing.

In the discussion of the possible effect of vegetation on the water supplies of a catchment area, it is indicated to what extent a vegetal cover may influence infiltration of precipitation, cause interception and evaporation, reduce soil moisture through transpiration, control the discharge of water from the catchment and contribute towards conservation of the soil. In dealing with veld treatment in its relationship to wildlife conservation, special stress is laid on the value of the catchment areas as places of recreation.

CAPE, CONSERVATION, FYNBOS, MANAGEMENT, SOIL EROSION, WATER YIELD

116. Le Roux P J 1969. Brandbestryding in Suid-Kaapland met spesiale verwysing na chemiese metodes van beheer (Fire preventative measures in the southern Cape with special reference to chemical methods of control). MSc thesis, University of Stellenbosch. 157 pp.

The historical development of the protection of plantations against fire is reviewed for the period from 1910 to the present. The climatic conditions which affect fire risk and the effect which these factors have on the size of the plantation fire are discussed. The effect of the natural vegetation on fire risk and the influence of fire in the vegetation at different times of the year are indicated. Plants which enhance fire risk are mentioned. An analysis of fire reports over a period of 50 years is given. The necessity of statistical analysis of this material is stressed.

The effectiveness of fire breaks and the cost involved in the different methods of establishing breaks are discussed. Testing a variety of herbicides in order to obtain the desired percentage death of the vegetation for effective establishment of guide breaks is discussed.

The requirements for and use of fire extinguishing chemicals and problems encountered when using these are mentioned. An exposition on the use of helicopters in fire fighting is given.

CAPE, FIRE BREAKS, FYNBOS, MANAGEMENT, REVIEW

117. Levyns Margaret R 1924. Some observations on the effects of bush fires on the vegetation of the Cape Peninsula. South African Journal of Science 21, 346-347.

The Cape Peninsula is subjected to deliberate periodic fires during summer months and in three cases detailed records were kept of the vegetation during the period of its recovery. The areas studied were on the slopes of Signal Hill and near Kalk Bay. The processes of recovery in these areas were different due to differences in the soil and are considered separately.

The adverse effects of fire in the Signal Hill area included the extensive spread of the rhenoster bush Elytropappus rhinocerotis and soil erosion. In the Kalk Bay area the recovery was much slower and two years after the fire the original balance in the vegetation had not yet been restored. Erosion of the loose soil in these sandy areas by winter rains also occurred.

CAPE, ELYTROPAPPUS, FYNBOS, SOIL EROSION, SUCCESSION, VEGETATION DYNAMICS

118. Levyns Margaret R 1927. A preliminary note on the rhenoster bush Elytropappus rhinocerotis and the germination of its seed. Transactions of the Royal Society of South Africa 14, 383-388.

A short discussion on the various species of Elytropappus is given.

Field experiments were carried out at Ida's Valley where it became apparent that burning acted as a stimulus to seedling development. Laboratory experiments were carried out on the germination of the seed. The first set of experiments showed no definite results due to the fact that the seeds only germinate well after the second year, but they did indicate that burning straw over the seed pans and deep sowing of the seed tend to lower the percentage of germination. From a second set of tests it was shown that while fire is detrimental to the germination of fresh seed, this is not so in the case of seed a year old.

Results are also presented relating to further growth of the seedlings.

ADAPTIVE RESPONSE, BURNING TRIAL, CAPE, ELYTROPAPPUS, FYNBOS, GERMINATION

119. Levyns Margaret R 1929a. The problem of the rhenoster bush. South African Journal of Science 26, 166-169.

Research has shown that the common practice by farmers of burning Elytropappus rhinocerotis in order to induce a temporary growth of other plants suitable for grazing, is a short-sighted policy that only serves to perpetuate the rhenoster bush. The occurrence and distribution of rhenoster bush is discussed and results of recent research is mentioned.

Germination tests show that the fresh seed has a low germination rate, increasing to the third year of age and then decreasing, while the germination period is a protracted one. Preliminary results of burning of seedlings indicate that winter burning as opposed to summer burning may be successful in eradicating rhenoster bush. Burning, particularly in summer, is probably responsible for the spread of rhenoster bush, as this practice tends to keep the plant community at this particular stage in the succession.

ADAPTIVE RESPONSE, ELYTROPAPPUS, GERMINATION, MANAGEMENT, SUCCESSION

120. Levyns Margaret R 1929b. Veld burning experiments at Ida's Valley, Stellenbosch. Transactions of the Royal Society of South Africa 17, 61-92.

The experiments described extended over a period of two years.

Rhenosterveld is not a stable type of plant community, and evidence is brought forward to show that it must be a stage, although probably a protracted stage, in succession. Burning leads to rapid increase of the rhenoster bush and certain other plants. Burning also induces vigorous growth among the petaloid monocotyledons and some other plants. This vigour is of a temporary nature. Clearing does not favour the rapid increase of the rhenoster bush. In this case vigorous growth is more apparent among the grasses than among the petaloid monocotyledons.

The effect of various conditions on the germination and growth of the more important constituents of the vegetation is described. Determinations of soil moisture, specific acidity and soil temperature are given.

BURNING TRIAL, CAPE, ELYTROPAPPUS, FYNBOS, SOIL CHEMISTRY, SUCCESSION, VEGETATION STRUCTURE

121. Levyns Margaret R 1935. Veld burning experiments at Oakdale, Riversdale. Transactions of the Royal Society of South Africa 23, 231-244.

Experiments in burning and clearing rhenosterveld at Riversdale

were carried out. The results of burning differ from those obtained in rhenosterveld at Stellenbosch where an immediate return to rhenosterveld was demonstrated. Here the vegetation undergoes a series of successional changes and it takes several years for rhenosterveld to be established once more. The results of clearing are similar to those obtained at Stellenbosch. Grasses appear in greater abundance than usual. The successional changes noted after burning are not apparent in this case.

A comparison is made between the results of these experiments and those made some years ago at Stellenbosch.

BURNING TRIAL, CAPE, ELYTROPAPPUS, FYNBOS, SUCCESSION, VEGETATION STRUCTURE

122. Levyns Margaret R 1956. Notes on the biology and distribution of the rhenoster bush. South African Journal of Science 52, 141-143.

Elytropappus rhinocerotis occurs throughout the area of the Cape flora. Two distinct forms occur. The fruit is immature when shed and very few germinations occur at this time. Fruits from one to four years old germinate reasonably well but after that deterioration sets in. Under natural conditions burning acts as a stimulus to germination, whereas heating the seed before sowing has no effect on germination. Seedlings are drought sensitive and cease growing when shaded. The distribution of this plant is discussed in view of its seeding habits and water requirements. The periodicity of its life cycle is in disharmony with the climate of much of the area in which it grows today.

ADAPTIVE RESPONSE, CAPE, ELYTROPAPPUS, FYNBOS, GERMINATION

123. Levyns Margaret R 1966. Haemanthus canaliculatus, a new fire-lily from the western Cape Province. Journal of South African Botany 32, 73-75.

A disastrous fire swept through an area from Betty's Bay to Rooi Els during the latter part of December 1960. Two months after the fire, in places where the soil was sufficiently moist, some brilliant red inflorescences of Haemanthus appeared, at first taken to be a marsh form of the common Haemanthus rotundifolius. Closer examination and a second visit to the site towards the end of June after the leaves had appeared showed that this was a new species H canaliculatus, which had only been collected once before, also after a fire. It seems likely that fire is needed to stimulate flowering.

A description of the species is given.

ADAPTIVE RESPONSE, CAPE, FYNBOS, HAEMANTHUS

124. Lichtenstein H 1812. Travels in southern Africa, in the years 1803, 1804, 1805 and 1806. Vol 1. Henry Colburn, London. 470 pp.

Early historical reference - see inter alia pg 229.

HISTORICAL ACCOUNT

125. Liebenberg L C C 1934a. Veld burning. How it affects the farmer as well as the country. Farming in South Africa 9, 213-215.

Changes and developments in vegetation that follow veld burning are discussed. Reasons for the practice of veld burning are enumerated. The harmful influence and effects of fire are discussed with emphasis on soil erosion and its concomitant evils.

MANAGEMENT, SOIL EROSION, SUCCESSION

126. Liebenberg L C C 1934b. Veld burning. II. Its influence on various types of vegetation. Farming in South Africa 9, 265-266; 278.

The harmful influences and effects of veld burning on the vegetation types, fynbos, karoo and grassland are given. Farmers are advised on the treatment of their veld.

FYNBOS, GRASSLAND, KAROO, MANAGEMENT

127. Livingstone D 1905. Travels and researches in South Africa. The Amalgamated Press Ltd, London. 656 pp.

Livingstone in his travels (1849-1856) through the Kalahari, Rhodesia, Angola and other areas mentions the practice of burning.

HISTORICAL ACCOUNT

128. Lowes J J 1963. A preliminary investigation into the relative merits of pre-rain and post-rain burning of sourveld in the spring. MSc thesis, University of the Witwatersrand. 100 pp.

It is standard practice for farmers in the highveld to wait until after the first good spring rains have fallen before burning the dead aftermath from their ungrazed sourveld and so to ensure continued new growth and replenishment of the root reserves. This investigation was conducted to see whether in certain years, waiting for the first spring rains could perhaps result in the destruction of fresh green growth (hidden under the aftermath) which had resulted from a soil moisture carry-over from the previous autumn.

Different soil moisture contents were induced in plots on the Bankenveld (near Pretoria) by irrigating some of them in April, others in June and others in July. Half of these were burnt on 1 August and the rest on 1 September after a 25 mm irrigation simulating a good spring rain.

It was found that where the moisture carry-over in the subsoil is sufficiently high, burning in August will result in increased herbage yields over burning after the rain, despite moisture contents in the region of wilting point in the top 225 mm of soil.

The possibility is discussed of farmers knowing in advance that in certain years it will be safe, indeed advisable, to burn before the first spring rains, and that they must burn before a certain date, determined by taking weekly soil temperatures, to avoid destruction of fresh young growth.

BURNING SEASON, BURNING TRIAL, GRASSLAND, HERBAGE YIELD, TRANSVAAL

129. Lückhoff H A 1954. The establishment and regeneration of Eucalyptus saligna plantations in the coastal belt of Zululand. Journal of the South African Forestry Association 25, 1-20.

The history and development of the short rotation eucalyptus growing industry in South Africa is briefly dealt with. Today this industry covers over 81 000 ha, mainly consisting of Eucalyptus saligna, and is concentrated in the eastern and northern Transvaal and along the subtropical coastal belt of Zululand where over 20 000 ha have already been planted to this species. Experimental work on the establishment of E saligna plantations is described and the early results recorded.

E saligna is very intolerant of weed competition in the early stages and in afforestation complete soil preparation should always be used. For the best results seed should not be sown before the beginning of April and young plants are generally ready for planting out into the field after two to three months. Seedlings are very sensitive and if good results are to be obtained in the nursery it is necessary to enrich the poor sandy soil with liberal quantities of compost and manure. Afforestation is best carried out with plants about four inches (102 mm) high and during the cooler winter months. Watering after planting is also always advisable. The use of superphosphate fertilizer in the establishment of plantations was tried and not found to be of value. Where bad grass competition occurs one clean weeding during the first summer after establishment significantly improves growth and is recommended. The early results of coppice regeneration experiments, with and without the burning of brushwood after clear felling, are given and discussed.

AFFORESTATION, EUCALYPTUS, FOREST, MANAGEMENT, NATAL

130. Lückhoff H A 1971. The Clanwilliam cedar Widdringtonia cedarbergensis Marsh : its past history and present status. Journal of the Botanical Society of South Africa 57, 17-23.

A historical account of the Clanwilliam cedar is given.

The devastating effect of fire on Widdringtonia cedarbergensis is discussed. Despite the Department of Forestry's policy of complete fire protection in the cedar-bearing areas in the past, more than 80 accidental fires have been recorded in the Cedarberg in the present century of which 75% could be traced to human agency, 8% to lightning, 5% to rock fall while 12% are of unknown origin.

Due to the decline in status of the Clanwilliam cedar a long-term research programme was initiated in 1965 to determine the cause of mortality of the cedars, the best method of veld management to protect surviving trees and to encourage natural regeneration, and the best and most economical method of re-establishing cedars in areas where very few trees are left or where they have completely disappeared. Preliminary results revealed that an average of 75% of the standing trees on the five study areas were dead, and that 84% of the living trees were in a moribund state with bad fire scars. There was no doubt that fire, supplemented by periodic drought losses, was by far the most important cause of mortality.

The effect of rodents and dassies in the cedar re-establishment trials is also discussed.

The future policy in the conservation of the Clanwilliam cedar is outlined. A suitable burning experiment has been designed for the implementation of frequent light burns which would largely eliminate the destructive, uncontrolled conflagrations which occurred during total fire protection.

CAPE, FYNBOS, HISTORICAL ACCOUNT, MANAGEMENT, WIDDRINGTONIA

131. Macnae M M 1960. Fire on Melville Koppies. Trees in South Africa 12, 33-36.

A fire swept through Melville Koppies, a proclaimed nature reserve within the confines of the City of Johannesburg, on 9 June 1960 and at least one third of the area was burnt out.

The article describes the regeneration of the flora after the fire. The main concern is the spread of perennial grasses with a concomitant diminishing of the indigenous trees and shrubs. In order to preserve what remains of the existing woody flora it will be necessary to extend the existing system of fire breaks to prevent accidental fires.

FIRE BREAKS, SAVANNA, SUCCESSION, TRANSVAAL, VEGETATION DYNAMICS

132. Marloth R 1924. Notes on the question of veld burning. South African Journal of Science 21, 342-345.

The question of veld burning, particularly in the western Cape, is discussed in the light of the observations that the vegetation of large areas of the country has deteriorated without positive proof that this may be due to a decrease in rainfall. It is held that the damage which the practice of mountain veld burning has done to the country is the extinction of plant species, increased run-off of winter rain and consequent diminished supply for the streams in summer, and reduced power of the mountains to capture the moisture brought in by clouds. These aspects are discussed and the opinion expressed that putting an end to all further burning of the mountain veld will solve these problems.

CAPE, CATCHMENT, CONSERVATION, FYNBOS, RUN-OFF, VEGETATION DYNAMICS, WATER YIELD

133. Martin A R H 1966. The plant ecology of the Grahamstown Nature Reserve. II. Some effects of burning. Journal of South African Botany 32, 1-39.

A study of the vegetation in the reserve was undertaken over an extended period (1948-1965), with various uncontrolled fires occurring as well as controlled burning experiments. Prolific flowering after heath fires is mostly due to subterranean parts of surviving herbaceous plants while annual plants do not play an important role. Flowering in months following fire is in a definite order while the same type of response is produced following clearing. It is thought that the changed rhythm of soil temperature following the fire stimulus, is the reason for the flowering of "fire lilies" after a fire. Geoxylic shrubs survive fires and become temporarily dominant, whereas aeroxylic shrubs are destroyed by fire. Repeated burning of heath at short intervals leads to a "grass-heath complex", with geoxylic shrubs predominating, while irregular occurrence of fires appears to be essential to the maintenance of a diversified flora. Controlled burning of heath at average intervals between 8 and 20 years will maintain all components of the present flora.

ADAPTIVE RESPONSE, BURNING FREQUENCY, CAPE, CONSERVATION, FIRE REGIME, FYNBOS, SUCCESSION, TEMPERATURE PROFILE, VEGETATION DYNAMICS

134. McLachlan D and E J Moll 1976. A report on fire and vegetation on Table Mountain. South African Forestry Journal 99, 7-12.

The effect of fire on fynbos vegetation is discussed with special reference to two recent fires in the Nursery and Apostles area. The rate of regeneration of the vegetation is dependent upon the age of the community and local environmental

conditions. Too frequent burning causes severe degradation of fynbos and leads to soil erosion, and if the vegetation is protected from fire for too long, extremely fierce fires result which can be extremely destructive. A 12- to 15-year fire interval on Table Mountain appears to be the most acceptable regime.

CAPE, CONSERVATION, FIRE REGIME, FYNBOS, MANAGEMENT, SUCCESSION

135. Mentis M T 1973. A comparative ecological study of greywing and redwing francolins in the Natal Drakensberg. MSc thesis, University of Stellenbosch. 112 pp.

The study was conducted in Giant's Castle Game Reserve and on an adjoining farm, situated on the Natal Drakensberg. The geology and physiography, climate, soils, fire regimes and vegetation of the study area are briefly described.

Both francolins occurred almost exclusively in grassy habitats, but redwing were more widely distributed than greywing which were virtually confined to igneous substrates. Recently and cleanly burnt expanses of grassland, and areas where fire had been absent for a long time and where grass had become rank were detrimental to both francolins. It was concluded that a fine-scale mosaic of burnt and unburnt grassland would be optimal for the francolin.

Recommendations are made for managing habitat for greywing and redwing in forest, game and nature reserves in midland and highland Natal. These recommendations concern controlled use of fire. Management recommendations for redwing on farmland are also made, and concern controlled use of fire and providing food and cover on specially selected small areas.

CONSERVATION, DRAKENSBERG, FAUNAL STRUCTURE, FIRE REGIME, FRANCOLINUS, GRASSLAND, MANAGEMENT, NATAL

136. Mentis M T, M J Meiklejohn and J S B Scotcher 1974. Veld burning in the Giant's Castle Game Reserve, Natal Drakensberg. Proceedings of the Grassland Society of southern Africa 9, 26-31.

The basic aim in the management of a wildlife reserve is to maintain ecological diversity. In the Giant's Castle Game Reserve the vegetation is largely composed of fire subclimax grasslands. Under the natural fire regime, before man influenced the system much, fires probably occurred at any time of the year, but mostly in summer. At present there are acute problems in controlling wild fires which occur mostly in late winter when there is an extreme fire hazard. Most of the Natal Drakensberg is now burnt by wild fires in late winter and deliberate fires in early spring. The ecological effect of the

natural and present fire regimes are discussed, and a burning plan for Giant's Castle is outlined.

CONSERVATION, DRAKENSBERG, FIRE REGIME, GRASSLAND, MANAGEMENT, NATAL

137. Mes M G 1958. The influence of veld burning and mowing on the water, nitrogen and ash content of grasses. South African Journal of Science 54, 83-86.

When Hyparrhenia hirta, Themeda triandra, Eragrostis aberstonei and Hyparrhenia schimperi plants were cut or burnt in August/early September, the new leaves had a higher water, nitrogen and generally a higher ash content than new leaves on undisturbed plants.

In searching for an explanation of these results, the effects of shading had to be considered, since in undisturbed plants the new leaves are shaded by old dead leaves. In an experiment where the new growth of cut plants was shaded by detached dead leaves, a higher water and ash content was found than in the leaves of unshaded cut plants. Thus the differences in the composition of the new growth of cut or burnt plants as compared with undisturbed plants are not due to shading in the latter. Two possible reasons for the differences in composition are firstly, that the partly dead stems and leaves in undisturbed plants may still compete with the new leaves for water and nutrients and secondly, that the more vigorous leaf growth in the burnt or cut plants may promote root growth and consequently promote an increase in water and nutrient uptake.

BURNING TRIAL, ERAGROSTIS, GRASSLAND, HERBAGE QUALITY, HYPARRHENIA, THEMEDA, TRANSVAAL

138. Michell Margaret R 1922. Some observations on the effects of a bush fire on the vegetation of Signal Hill. Transactions of the Royal Society of South Africa 10, 213-232.

The bush fire, the effects of which are recorded, broke out on 5 February 1919 and burnt for two days, killing all the aerial parts of plants on the slope. About three weeks later considerable growth had taken place in Asparagus capensis and Andropogon hirtus. Shortly afterwards Haemanthus coccineus and a few other less notable plants were in flower. Various species of Rhus were putting up shoots. The early winter and spring flowering periods were characterized by an abundance of vigorous flowering shoots. In the majority of cases these plants possess underground storage organs. Progressive decrease in numbers and vigour of plants flowering during these periods was noted in 1920 and 1921. Suggestions are made to account for the phenomenon.

The northern, shaded slopes of the valleys showed a conspicuously different plant population from the southern exposed slopes during the winter months. In the summer months the contrast was not as sharply marked. This is attributed largely to the fact that in winter the sun shines on the northern slopes only for a short period of the day, while the southern slopes get most of the available sunlight.

During 1920 the shrubs were divided into two classes : those where the underground parts had survived the fire and from which new shoots arose, and those which were killed by the fire and which reproduced themselves by seed. The rhenoster bush falls into the second class, and is clearly favoured by burning.

The removal of the vegetation by the fire helped the process of soil erosion. This process was also aided by man and cattle. The area is shown to be deficient in several typical south-western families, but to what extent this may be attributed to the influence of repeated fires is not clear, and the view is brought forward that soil may be the determining factor in this case.

ADAPTIVE RESPONSE, CAPE, FYNBOS, SOIL EROSION, SUCCESSION

139. Mogg A O D 1918. Some preliminary observations on unseasonal veld burning, and its possible relation to some stock diseases. South African Journal of Science 15, 653.

Investigations of some stock diseases definitely known to be caused by plants necessitated a detailed botanical study of the veld, and the causes producing veld change.

Ecological surveys throughout one season, of the various paddocks of a single farm followed by a comparison of the results, elicited most astonishing and interesting results. These results were accentuated when several farms in one district, similarly treated, were compared. Further, when the farms of entirely different and widely separated districts, carrying the same disease, were compared, the facts concerning the powerful effect of veld burning in producing veld change became of a graver nature.

These facts elicited have led the writer to the conviction that at least in the case of Dunziekte ("grass staggers") in horses, a disease associated with a geological formation, all veld in a Dunziekte district are only potentially so, but may become actively so by extensive veld burning at unseasonable times, particularly if the farm is overstocked. The annual loss of horses due to this disease amounts to several hundreds.

It was also indicated how a sweetveld on some physiological formations be made sour in a comparatively short time by indiscri-

minate burning, particularly spring and summer burning.

ANIMAL PRODUCTION, BURNING SEASON, GRAZING, STOCK DISEASES, SUCCESSION, VEGETATION DYNAMICS

140. Moll E J, B McKenzie and D McLachlan 1977. Present management problems and strategies on Table Mountain, South Africa. Proceedings of the Symposium on Environmental Consequences of Fire and Fire Management in Mediterranean Ecosystems. USDA Forest Service. General Technical Report WO-3. pp 470-475.

The unique flora of Table Mountain is under considerable human pressure because it is surrounded by a major metropolitan area. A vegetation survey from aerial photographs and ground checks to ascertain the impact of humans, fire and alien plants and animals indicated a poor conservation status. Consolidation of ownership and detailed ecological research are essential for coordinated management.

CAPE, FYNBOS, MANAGEMENT

141. Morris J W and P J Müller 1970. Seasonal variation of grassland basal cover. Proceedings of the Grassland Society of southern Africa 5, 145-152.

Preliminary results of a long-term study of seasonal variation in grassland basal cover are presented. Seasonal stability appears to have been taken for granted but has not yet been shown experimentally.

The vegetation cover of the experimental area in Pretoria is an open, bunch grassland. The construction of a portable bridge for establishing 1 000 relocatable points is described. Basal cover, measured by wheel-point and bridge-point methods, showed a statistically significant seasonal increase through summer and a decrease again after the rainfall began decreasing with the onset of winter. An initial small rise and fall in basal cover at the beginning of spring was shown by the wheel-point survey only. Inspection of individual species behaviour showed that the seasonal changes in basal cover are a result of small changes in basal cover of many species. The influence of defoliation by both cutting and burning on the seasonal variation of basal cover is discussed. Possible sources of error in the application of the point technique which were revealed during the study are given.

GRASSLAND, TECHNIQUE, TRANSVAAL

142. Mostert J W C and C H Donaldson 1956. Veld burning : observations in the central Orange Free State. Farming in South Africa 32(6), 34-39.

The effects of annual winter burns combined with light sheep

grazing on the botanical composition of Themeda veld were observed at the Glen College of Agriculture. Winter burning resulted in the deterioration of the grass cover and the presence of bare patches in the veld. It was concluded that regular winter burns had a harmful effect on Themeda triandra veld in the central Orange Free State.

BURNING SEASON, GRASSLAND, GRAZING, ORANGE FREE STATE, THEMEDA

143. Nänni U W 1956. Forest hydrological research at the Cathedral Peak Research Station. Journal of the South African Forestry Association 27, 2-35.

The Cathedral Peak Forest Influences Research Station was established in Natal in 1938 to determine the effect of exotic conifer plantations on water supplies.

The major investigation is the planting to within one chain (20,12 m) of any streams, of six catchments with Pinus patula at eight-year intervals. One catchment is to be protected from burning and grazing for an indefinite period to determine the trend of plant succession and the effect on water supplies of the various stages of the succession. An eighth catchment is to be grazed intermittently for five years followed by complete afforestation. The ninth catchment is to be completely planted to Pinus patula and no margins will be left open next to streams. Discharge from all experimental catchments is continuously recorded by means of clockwork instruments.

The situation, topography, geology, soils, vegetation and climate of the area are described and mention is made of the nature of the streams and the more important characteristics of the catchments. The technique favoured is that of "whole catchment research" whereby streamflow variables from comparable catchments are correlated. Subsidiary investigations planned to elucidate special hydrological processes such as infiltration, evaporation-transpiration losses and interception will be undertaken.

The results of experiments conducted at Cathedral Peak will determine to what extent plantations of exotic conifers in the summer rainfall area of South Africa influence water supplies.

AFFORESTATION, CATCHMENT, DRAKENSBERG, GRASSLAND, GRAZING, NATAL, PINUS, RUN-OFF, SUCCESSION

144. Nänni U W 1960. The immediate effects of veld burning on streamflow in Cathedral Peak catchments. Journal of the South African Forestry Association 34, 7-12.

There is no evidence that burning of the natural mountain grassland at the Cathedral Peak Forest Influences Research Station

has an immediate detrimental effect on the ground-water discharge or base-flow.

CATCHMENT, DRAKENSBERG, GRASSLAND, NATAL, WATER YIELD

145. Nänni U W 1969. Veld management in the Natal Drakensberg. South African Forestry Journal 68, 5-15.

The annual extreme fire hazard in the Natal Drakensberg will limit forestry and the rugged topography and vulnerability of the soil discourage use of the area for grazing.

Judicious patch-burning alternatively in spring and in autumn will reduce costs of fire protection and is expected to keep the veld stable. Quality and quantity of run-off is expected to be as favourable as possible in this very important catchment area.

The area is especially suited for a nature and recreation reserve. The burning system proposed above is wholly compatible with management for water yield and nature conservation.

CATCHMENT, CONSERVATION, DRAKENSBERG, GRASSLAND, MANAGEMENT, NATAL, RUN-OFF

146. Nursey W R E and A H G Kruger 1973. The effect of spring mowing and burning on seed and dry matter production of Anthephora pubescens Nees. Proceedings of the Grassland Society of southern Africa 8, 123-127.

The inability of farmers of the northern Cape to obtain adequate seed supplies of Anthephora pubescens is hampering their attempts to use this grass for veld reclamation. At the Vaalharts Agricultural Research Station it was found that, by intensive defoliation of the tufts at the start of the growing season, greater numbers of reproductive culms were produced earlier in the season than on the control plots, resulting in a shorter harvest period. Percentage live seed content was also increased so that the total live seed production was nearly trebled. Seed production could be a remunerative undertaking for irrigation farmers whilst the herbage could be profitably used for fattening oxen.

BURNING TRIAL, CAPE, HERBAGE YIELD, MANAGEMENT, SAVANNA

147. Oates F 1889. Matabele Land and the Victoria Falls. Kegan Paul, Trench & Co, London. 433 pp.

Early historical reference - see inter alia pg 9.

HISTORICAL ACCOUNT

148. Orange Free State (Province) 1969. Nature Conservation Ordinance No 8 of 1969. Provincial Administration of the Orange Free State. 46 pp.

Two sections are important in terms of veld and forest fire laws, namely :

Section 30 - Protected plants, see particularly Section 30(3)(c)

Section 32 - Picking of indigenous plants on or near public road.

LEGISLATION, ORANGE FREE STATE

149. Penzhorn K E W 1942. Burning veld out of season. Farming in South Africa 17, 453-454.

Veld deterioration and soil erosion caused by untimely burning late in winter or in the spring before good rains have set in are discussed. Advantages ascribed to veld burning during spring before the first rains have fallen are questioned. General principles relating to veld burning which may be applied in sourveld or semi-sourveld areas are outlined.

BURNING SEASON, GRASSLAND, MANAGEMENT, SOIL EROSION

150. Phillips E P 1919. A preliminary report on the veld burning experiments at Groenkloof, Pretoria. South African Journal of Science 16, 285-299.

Results are presented of research conducted on five plots laid out on the experimental farm at Groenkloof. Three plots were burnt, one unburnt but mown, and one controlled.

Burning of the veld and denuding the soil of its protective vegetation tends to encourage the flowering of many plants, particularly hemicryptophytes, by allowing access of light and warmth. In the development of the succession on the burnt portion there appears to be a definite life history, and the formation of vernal aspect societies. At first Anthistiria imberbis is the dominant grass, but later there is an invasion of Trachypogon polymorphus and Andropogon spp, and on portions left unburnt for several years the latter species tend to replace the Anthistiria imberbis.

On bare soil the temperature during the day is considerably higher than on soil covered with vegetation, and the same at night, but, taking the daily maximum and minimum temperatures, soil protected by a covering of vegetation has a more even temperature, and does not exhibit such extremes of heat and cold.

Soil denuded of its vegetation absorbs more water after rain than does soil covered with vegetation, but also loses it more quickly by evaporation. Soil with a protective covering of vegetation, while not absorbing the same amount of water after a rainfall, loses its water more slowly, and consequently does not fluctuate between a very high and very low moisture content, but is more stable in this respect.

The few observations made during the latter part of 1918 at Groenkloof are the beginning of a series of experiments carried out there by the Division of Botany. Data relating to the mechanical and chemical examination of soils are given.

BURNING TRIAL, RUN-OFF, SOIL CHEMISTRY, SUCCESSION, TEMPERATURE PROFILE, TRANSVAAL

151. Phillips E P 1920. Veld burning experiments at Groenkloof : second report. Science Bulletin 17. Department of Agriculture, Union of South Africa. 7 pp.

The area of the previous experiment (described in Phillips 1919) was extended and subdivided into 15 plots. Of these, ten plots were burnt annually at six week intervals from May through November, one was ploughed, two were grazed, one mown but neither burnt nor grazed, and one was a control plot.

The object of the experiment was to determine the effects of veld fire on the vegetation at different seasons. The article presents a summary of the observations made on the various plots. The author concludes that the later the veld is burnt, the greater the number of shrubs in the resulting vegetation.

Preliminary results from the grazing experiment showed that sheep could be supported for longer periods of the winter season on unburnt veld than on burnt veld.

ANIMAL INFLUENCE, BURNING SEASON, BURNING TRIAL, GRASSLAND, GRAZING, TRANSVAAL

152. Phillips J F V 1930. Fire : its influence on biotic communities and physical factors in South and East Africa. South African Journal of Science 27, 352-367.

The biological and economic importance of burning vegetation is discussed. The need to augment scientific information is stressed. An attempt is made to outline the most important changes in vegetation following firing. It is plain to see that vast areas of southern and eastern Africa have their vegetation kept in a non-climax condition by periodic fires. It is held that fire in the tree and grass savannas has played a part in the development of certain growth forms in plants.

Firing in the savanna regions also has a profound effect upon the animals associated with the vegetation.

Suggestions regarding probable lines for future research are made. In reviewing the state of our knowledge as to the influences of firing, it is held that neither those who consider firing as having no evil effects nor those who state it to have no merits are correct. Controlled firing is a useful and often necessary agent in veld management.

ANIMAL INFLUENCE, ANIMAL PRODUCTION, BURNING FREQUENCY, BURNING SEASON, FIRE REGIME, GRASSLAND, GRAZING, MANAGEMENT, REVIEW, SAVANNA, SUCCESSION, VEGETATION DYNAMICS

153. Phillips J F V 1931a. Forest succession and ecology in the Knysna region. Memoirs of the Botanical Survey of South Africa 14, 1-327.

A brief review of the influence of fire on soil condition is presented. Preliminary results of a study of fire effects in fynbos include decreased surface soil pH, increased subsurface and surface temperatures. Increased rainfall run-off and greater soil compaction was found in burnt sites. Fire destroyed soil animal populations, litter and humus.

The effects of ground and crown fires in forest, and the post-fire succession are briefly described.

CAPE, FOREST, FYNBOS, RUN-OFF, SOIL CHEMISTRY, SOIL EROSION, SOIL MICRO-ORGANISMS, SOIL STRUCTURE, SUCCESSION

154. Phillips J F V 1931b. The biotic community. Journal of Ecology 19, 1-24.

Man is one of the more profoundly effective ecological determinants especially through the agency of annual grass fires and should thus be included in the biotic community. The effects of veld fire on animals and plant succession are discussed and special mention is made of the occurrence of tripanosomiasis, carried by the tsetse fly, in man and beast and the influence of vegetation type thereon.

ANIMAL INFLUENCE, ANIMAL PRODUCTION, GRASSLAND, SAVANNA, STOCK DISEASES, SUCCESSION

155. Phillips J F V 1936. Fire in vegetation : a bad master, a good servant and a national problem. Journal of South African Botany 2, 35-45.

The influence of fire in vegetation is discussed on account of the renewed interest shown in the matter, since the adoption by Government of a policy of veld improvement.

An attempt is made to indicate both the harmful and the beneficial influences of fire. Certainly destructive when uncontrolled, fire may be turned to good utility when regulated according to objects of management, season, frequency and locality.

An outline is given of the procedure considered to be necessary before adequate control of fire could be possible. A special Conservation Commission is suggested and some of its principal duties are discussed briefly.

BURNING FREQUENCY, BURNING SEASON, FIRE BREAKS, GRASSLAND, MANAGEMENT

156. Phillips J F V 1938. Deterioration in the vegetation of the Union of South Africa and how this may be controlled. South African Journal of Science 35, 476-484.

A discussion of the extent and causes of the obvious deterioration in the natural vegetation of South Africa is presented. Among the causes mentioned is the extent of bush encroachment as a result of fewer and cooler veld burns where heavy grazing has denuded the veld. A warning is sounded that "our country's most precious material possessions, its vegetation, its soils, its water, are being taken from us by three national foes - deterioration, ignorance and procrastination". Eight possible lines of action likely to lead to a solution to this problem are given.

CONSERVATION, SOIL EROSION, SUCCESSION, VEGETATION STRUCTURE

157. Phillips J F V 1965. Fire - as master and servant : its influence in the bioclimatic regions of Trans-Saharan Africa. Proceedings of the Fourth Annual Tall Timbers Fire Ecology Conference 4, 7-109.

This is an extensive paper dealing with fire ecology in all its numerous facets. It includes a voluminous bibliography and discusses inter alia the following : effects of fire upon biotic communities and their habitats within the major bioclimatic regions (wherein a summary of the effects of seasonal burning on pasturage and forestry potential in each community is tabulated), effects of fire upon animal associates, effects of fire upon the soil, effects of fire upon the welfare of man, the future of fire research and the use of fire in agriculture and forestry.

ANIMAL PRODUCTION, BURNING FREQUENCY, BURNING SEASON, FOREST, GRASSLAND, HISTORICAL ACCOUNT, MANAGEMENT, REVIEW, SUCCESSION

158. Phillips J F V 1968. The influence of fire in Trans-Saharan Africa. Acta Phytogeographica Suecica 54, 13-20.

A very brief general review is presented with a condensed, tabulated survey of the gross influence of fire on the major ecosystems in terms of reduction of their area, soil chemical and physical properties, crop, pasture, forest and wildlife potentials and aesthetic values. It is concluded that fire plays a highly significant role in wooded savanna, open grassland, fynbos and forest ecosystems.

FOREST, FYNBOS, GRASSLAND, REVIEW, SAVANNA

159. Phillips J F V 1974. Effects of fire in forest and savanna ecosystems of sub-Saharan Africa. In : Fire and ecosystems. T T Kozlowski and C E Ahlgren (eds). Academic Press, New York. pp 435-481.

A general review of the subject is presented with extensive literature citations of work conducted during the first half of the present century. The cause of natural fires, kinds of fires, flammability and potential combustibility of various fuels are discussed.

FOREST, REVIEW, SAVANNA

160. Pienaar A J 1959. Bush encroachment not controlled by veld burning alone. Farming in South Africa 35(9), 16-17.

The burning of sweetveld which is well-utilized can reduce a farm's carrying capacity by as much as 20%. Bush encroachment in these areas may be regarded as one of the most important reasons for the increased use of veld burning. Observations made by various research workers indicating that veld burning does not solve, but often aggravates the problem of bush encroachment, are presented.

DE-BUSHING, MANAGEMENT, SAVANNA, VEGETATION STRUCTURE

161. Pienaar U de V 1968. The use of fire as a tool in wildlife management in the Kruger National Park. In : A practical guide to the study of the productivity of large herbivores. F B Golley and H K Buechner (eds). IBP Handbook No 7, Blackwell Scientific Publications, Oxford and Edinburgh. pp 274-280.

Although the Kruger National Park has been in existence as a protected area for more than 60 years, much of its vegetation is not "climax" in the edaphic or climatic sense, but is fire-induced.

A brief history is provided of the fire regime in this area since its proclamation until an organized system of fire management was introduced.

Since 1950, considerable strides were made in establishing an efficient system of fire breaks throughout the Park. A provisional policy of rotational veld burning was adopted in 1954 and is still in operation albeit in a modified form.

Modifications of the original veld burning plan were dictated by the results of an extensive series of veld burning experiments initiated in all the different vegetation types and which were monitored and interpreted by skilled personnel.

Veld burning experiments have not been concluded but obvious trends have become evident and it is now possible to manipulate particular vegetation types according to the dictates of particular herbivore's habitat selection, food preferences, seasonal migrations and the preservation of unique floristic areas or physiognomic aspects.

In areas where a veld management policy involving rotational burning on an annual, biennial, triennial or longer schedule has been instituted, burning is executed at different times of the year according to the effect desired and accidental fires in all other areas are combated by trained fire-fighting crews.

It is deemed necessary that all interim veld management policies involving the use of fire should be substantiated by a proper series of controlled veld burning experiments to measure the ecological effects of the particular fire regime.

ANIMAL INFLUENCE, BURNING TRIAL, KRUGER NATIONAL PARK, MANAGEMENT, SAVANNA, TRANSVAAL

162. Pillans N S 1924. Destruction of indigenous vegetation by burning in the Cape Peninsula. South African Journal of Science 21, 348-350.

A discussion on the causes, frequency, distribution and effects of veld fires in the Cape Peninsula area is given. Vegetative changes as a result of frequent fires are explained and it is suggested that legislation be introduced to curb the indiscriminate burning of land with suitable rates of compensation being fixed.

CAPE, CONSERVATION, FYNBOS, LEGISLATION, VEGETATION DYNAMICS

163. Plathe D J R and D W van der Zel 1969. 'n Veldbrandeksperiment op meervoudige opvanggebiede in Jakkalsrivier, Lebanon (A veld burning experiment in multiple catchment areas at Jakkalsrivier, Lebanon). Forestry in South Africa 10, 63-71.

This paper describes the veld burning experiment which has been

laid out on the Jakkalsrivier mountain catchment near Grabouw to determine the effects of controlled burning of the mountain heath vegetation (fynbos) on interflow and erosion. The first controlled burns on some of the nine subcatchments were applied in 1969. Glass fibre H-flumes are used to measure run-off, while it is planned to use glass fibre silt traps in the measurement of soil loss. Readings from a meteorological station and eight scattered rain gauges are available since March 1967.

BURNING TRIAL, CAPE, CATCHMENT, FYNBOS, RUN-OFF, SOIL EROSION

164. Pons J E 1955. Veld burning. Farming in South Africa 30, 312; 328.

The veld types in the Transvaal region - sourveld, mixed veld and sweet and sour bushveld, are discussed in terms of their location, the prevailing climatic conditions and nutritive value.

The pros and cons of winter veld burning are discussed and recommendations are made regarding the use of fire in the management of the different types of veld.

In view of the danger of accidental fires, the public is requested to extinguish camp fires. The useful service of fire protection committees in certain districts is mentioned.

BURNING SEASON, GRASSLAND, MANAGEMENT, SAVANNA, TRANSVAAL

165. Potgieter H J 1976. The Forest Act 1968, as a means of preserving our green heritage. Pamphlet 122, Department of Forestry, Republic of South Africa. 9 pp.

An analysis and elucidation of the provisions of the Forest Act (Act 72 of 1968) are presented.

FIRE BREAKS, FOREST, LEGISLATION

166. Republic of South Africa 1963. Rural Coloured Areas Act, 1963 (Act No 24 of 1963). Statutes of the Republic of South Africa 1963. Government Printer, Pretoria. pp 204-268.

Certain provisions in the Rural Coloured Areas Act, 1963, relate to forest and veld fires, inter alia the following :

Section 28 - Power of board of management to make regulations, in particular see Section 28(28).

LEGISLATION

167. Republic of South Africa 1968. Forest Act, 1968 (Act No 72 of 1968). Government Gazette Extraordinary, 3 July 1968, No 2116. Government Printer, Pretoria. 16 pp.

Certain provisions in the Forest Act, 1968, relate to veld and forest fires, inter alia the following :

Section 13 - Clearing of fire belts on common boundaries of properties

Section 14 - Clearing of fire belts by fire protection committees

Section 15 - Procedure in regard to extinguishing fires

Section 16 - Agreement for reciprocal assistance

Section 21 - Offences, in particular see Section 21(1)(a)(iii),Section 21(1)(b), Section 21(1)(c), Section 21(2)(e) and Section 21(4)

Section 23 - Negligence presumed.

General regulations under the Forest Act, 1968 as amended. No R1591, 8 September 1972. Government Gazette, 8 September 1972, No 3645. Government Printer, Pretoria. 14 pp.

Section 16 dealing with the clearing of fire belts and planting of trees, is of particular importance with regard to veld and forest fire laws.

FIRE BREAKS, FOREST, LEGISLATION

168. Republic of South Africa 1969. Soil Conservation Act, 1969 (Act No 76 of 1969). Government Gazette, 18 June 1969, No 2437. Government Printer, Pretoria. 10 pp.

Certain provisions in the Soil Conservation Act, 1969, relate to veld and forest fires, inter alia the following :

Part IV

Section 12 - Declaration and establishment of fire protection areas and committees

Section 13 - Fire protection schemes

Section 14 - Minister may amend fire protection schemes

Section 15 - Minister may render financial assistance to fire protection committee

Part V

Section 20 - Regulations, in particular see Section 20(1)(c)

Section 21 - Penalties, in particular see Section 21(1)(e)(ii).

LEGISLATION

169. Republic of South Africa 1970. Mountain Catchment Areas Act, 1970 (Act No 63 of 1970). Government Gazette, 7 October 1970, No 2858. Government Printer, Pretoria. 6 pp.

Certain provisions in the Mountain Catchment Areas Act, 1970, relate to veld and forest fires, inter alia the following :

Section 8 - Fire protection plans

Section 9 - Secretary may amend fire protection plans

Section 11 - Right of entry on or way over land

Section 14 - Penalties, in particular see Section 14(d) and Section 14(e)

Section 19 - Application of Act to South West Africa.

Regulations under the Mountain Catchment Areas Act, 1970, No R1606, 17 September 1971. Government Gazette, 17 September 1971, No 3255. Government Printer, Pretoria. 8 pp.

Of particular importance with regard to veld and forest fire laws are :

Section 2 - Fire protection committees

Section 5 - Notice to owners of land.

LEGISLATION

170. Rourke J P 1972. Taxonomic studies on Leucospermum. Journal of South African Botany Supplementary 8, 172-176.

Fire has played a significant role in the development of different life forms in the vegetation of South Africa and fire resistance is one of the most important biological attributes any plant occurring in southern Africa can possess. The effect of fire on different species of Leucospermum is explained and the ability of species to recover from the effects of fire is discussed.

ADAPTIVE RESPONSE, BURNING FREQUENCY, LEUCOSPERMUM

171. Roux E 1969. Grass, a story of Frankenwald. Oxford University Press, Cape Town. 212 pp.

Chapter 7 of this book deals with fire, its effect on succession, palatability, erosion, etc, and discusses the work done in this field at Frankenwald as well as work done outside of this area by researchers from Frankenwald. Research at Bethal showed that rooigras Themeda triandra is retained by regular burning in June, July or August. It is shown how stable "purple veld" is in relation to fire while being rejuvenated by burning.

BURNING SEASON, FRANKENWALD, REVIEW, SUCCESSION, THEMEDA, TRANSVAAL, VEGETATION DYNAMICS, VEGETATION STRUCTURE

172. Rycroft H B 1947. A note on the immediate effects of veld burning on stormflow in a Jonkershoek stream catchment. Journal of the South African Forestry Association 15, 80-88.

An investigation into the effects of autumnal veld burning on stream behaviour in a Jonkershoek stream catchment showed that during the winter following the fire there was a highly significant increase in the rate of stormflow, a rise in flood heights, an increase in the volume of stormflow and an increase in stream discharge. These conclusions indicate that there is a serious danger of flooding and erosion if the protective vegetation is removed by late autumn burning (see Banks 1964).

BURNING SEASON, BURNING TRIAL, CAPE, CATCHMENT, FYNBOS, RUN-OFF, SOIL EROSION

173. Schelpe E A C L E 1976. Veld burning and veld and flora conservation. Veld and Flora 62(2), 24-25.

Reasons for veld burning by farmers are discussed as well as effects on the vegetation of such burning. Species of plants that only flower after burning are mentioned. Senescence of fire-susceptible woody species of fynbos when protected from fire for an extended length of time is discussed together with the spread of exotics as a result of fire.

ADAPTIVE RESPONSE, CAPE, FYNBOS, VEGETATION DYNAMICS

174. Schönland S 1927. On the reclamation of ruined pasturage on the Amatolas, near Keiskama Hoek. Science Bulletin 55. Department of Agriculture, Union of South Africa. 15 pp.

An experiment conducted between 1922 and 1926 on ten acres of pasturage, badly infested with Helichrysum argyrophyllum, is described. The conclusions of the experiment may be summarized as follows :

- the areas on the Amatolas, now more or less covered by H argyrophyllum, a plant useless as stock feed, can be restored to their original condition (pasture ground covered chiefly by rooigras Themeda triandra) within a period of 18 months

- when well established, H argyrophyllum can be destroyed at the end of winter by burning. This method of destruction should be supplemented by weeding out plants that have not been burnt

- after the eradication of H argyrophyllum, grazing should be regulated

- further observations are required on very steep parts and on incipient erosion channels before advice can be given to prevent erosion of the soil

- paddocking of the pastures on the Amatolas will probably be necessary if the present consequences of overstocking are to be avoided.

ANIMAL INFLUENCE, CAPE, GRASSLAND, GRAZING, HELICHRYSUM, SOIL EROSION

175. Schütte K H 1960. Trace element deficiencies in Cape vegetation. Journal of South African Botany 26, 45-49.

Observations of trace element deficiencies in vegetation of the Muizenberg mountains and in Bain's Kloof, Cape are presented.

These deficiencies may throw some light onto the changes that are taking place in the Cape vegetation at the present time. Amongst other factors, the impoverishing effect on soil by burning is discussed in this context.

CAPE, FYNBOS, HERBAGE QUALITY, NUTRIENTS, SOIL CHEMISTRY

176. Scott J D 1947. Veld management in South Africa. Bulletin 278. Department of Agriculture, Union of South Africa. 40 pp.

Throughout all the areas of South Africa in which veld management systems have been applied, it is apparent that the veld will respond to good management. Not only is there an improvement in cover and composition of the veld, but stock also does much better and with the improvement of the veld, an increase in the carrying capacity is also noticeable. In all veld management systems there are certain principles which have emerged, and which if applied generally, will make a great difference to the productivity of the land. These may briefly be summarized as :

- definite resting periods during the growing season, whether for part or whole of the season depending on the veld type

- application of correct farming systems to avoid misuse of veld, eg cattle and not sheep farming in tall grass areas

- use of the mower wherever possible for conserving feed or controlling the accumulation of old grass

- elimination of veld burning as far as possible, except where old grass accumulates and it is impossible to mow and where encroaching undesirable plants must be controlled.

In both these cases, burning at the correct season followed by sound veld management, is essential.

BURNING SEASON, GRASSLAND, MANAGEMENT

177. Scott J D 1949. A contribution to the study of the problems of the Drakensberg Conservation Area. DSc thesis, University of the Witwatersrand. 297 pp.

See Scott 1952b.

BURNING SEASON, CONSERVATION, GRASSLAND, MANAGEMENT, RUN-OFF, SAVANNA

178. Scott J D 1951. Conservation of vegetation in South Africa. In : Management and conservation of vegetation in Africa. Commonwealth Bureau of Pastures and Field Crops. Bulletin 41. Penglais, Aberystwyth, Wales. pp 9-27.

The history of the early colonization of South Africa indicates that the natural vegetation has been largely destroyed or damaged in the course of one century. Since the days of early settlement there have been those who realized the danger of the destruction of the vegetation, particularly with reference to the forests and attempts were made to protect the vegetation. Later, the inauguration of the Botanical Survey led to a knowledge of the distribution of the vegetation and its resources as well as the damage it was suffering. The establishment of grassland research stations produced results on the effects of veld burning, veld management and conservation farming which, today, act as a basis for most conservation farming.

Planned land utilization, based on ecological conditions, with a view to eliminating land-use which causes erosion and the destruction of vegetation, is indicated as the proper basis for all conservation of soil and vegetation.

The problems of soil and vegetation conservation in the native areas are bound up with primitive customs and beliefs and, un-

less natives are educated beyond these beliefs and customs, no conservation measures can succeed.

Recent legislation allows for the tackling of vegetation and soil conservation on a nation-wide scale.

CONSERVATION, FOREST, GRASSLAND, HISTORICAL ACCOUNT, MANAGEMENT, REVIEW

179. Scott J D 1952a. Management of range lands (veld) in Africa. Proceedings of the Sixth International Grassland Conference 1, 477-483.

A discussion of the principles of veld management and of burning and mowing of veld is presented. The use of fire in controlling bush encroachment and in improving the palatability of grasses is mentioned. The importance of the correct time of burning, burning frequency and management of the veld after burning is stressed.

ACACIA, BURNING FREQUENCY, BURNING SEASON, DE-BUSHING, MANAGEMENT

180. Scott J D 1952b. A contribution to the study of the problems of the Drakensberg Conservation Area. Science Bulletin 324. Department of Agriculture, Union of South Africa. 145 pp.

Events leading up to the selection of the area for special work are described together with the vegetation, soils and climate of the Drakensberg Conservation Area. The area is divided into three main veld types - Thornveld, Tall Grassveld and Highland Sourveld - with differing conditions. The rainfall of the different veld types is discussed.

Farming conditions, past and present, in the main veld types are discussed and a survey of the problems facing those interested in soil conservation and agricultural production is given. The approach to these problems on the research station is also discussed. The approach is based on the study of the ecological conditions within each veld type to determine what type of land utilization should be employed.

Experiments in the Thornveld on veld management, veld restoration, thorn scrub eradication and control and the breeding of beef are described and discussed.

In the Tall Grassveld, experiments on veld burning, fodder conservation, veld management and the production of compost are outlined and analyzed. The successful growing out of beef on the veld supplemented by a minimum of arable land is also described.

The veld burning experiments showed that it was necessary to remove old grass, left from previous seasons. The best method of removal was by mowing but, if that was impracticable it was necessary to burn. However the only time burning could be done without damage was in spring after rains. Autumn burning and burning before the spring rains was shown to be most harmful. Removal of old grass by mowing was found to produce earlier grazing and higher hay yields than any burning practice. Greatest run-off of water was found under conditions of complete protection of vegetation against fire, cutting or grazing.

Experiments in the Highland Sourveld include work on veld burning, veld management, fodder conservation, production of compost, cultivated pastures and soil fertility studies. Experiments on veld burning here confirmed the results obtained in the Tall Grassveld.

Results of the experiments in the different areas are discussed in relation to their application by the farming community. It is shown that quite a number of farmers are applying the results of research on their farms today. Next, the time lag usually found between the publication of results and their application by the farmers is discussed and it is indicated that this time lag can be enormously reduced in a Conservation Area by including the results in the individual schemes for each farm, planned under the Soil Conservation Scheme.

BURNING SEASON, CONSERVATION, DRAKENSBERG, GRASSLAND, MANAGEMENT, RUN-OFF, SAVANNA

181. Scott J D 1955. Principles of pasture management. In : The grasses and pastures of South Africa. D Meredith (ed). Central News Agency, Johannesburg. pp 601-623.

The development of the grass plant is rather different from that of other plants and it has certain critical stages of growth which must be considered in any system of management.

Veld types in South Africa are divided into three main groups - sweetveld which is palatable to livestock throughout the year, sourveld which is palatable and nutritious for only the first part of the growing season until it reaches maturity, and mixed veld which is intermediate with an admixture of the types of grass found in the other two types. The main constituents of the three veld types are listed and systems of veld management which have been successfully applied in each are described.

The effect of burning at different seasons shows that, in the thorn and sweetveld types, it should not be necessary to burn except for the express purpose of controlling development of seedlings of undesirable thorn scrub. Otherwise burning should be used to remove old grass left from grazing in previous seasons but time and frequency of burning is important.

Burning after the first spring rains causes least damage and frequency of burning should depend on the amount of old grass to be removed. Where practicable, mowing of old grass instead of burning is a better practice.

There are numerous practical considerations to be borne in mind when practising veld management such as fencing, gates, water, shade and size of camp and herd, carrying capacity and suitable yards for winter feeding when this is practised.

BURNING FREQUENCY, BURNING SEASON, GRASSLAND, GRAZING, MANAGEMENT

182. Scott J D 1966. Veld burning in South Africa. African Wild Life 20, 93-102.

Veld burning is a very controversial subject and many who condemn the practice are arm-chair critics who tend to generalize without taking into account the many variations in veld, soil and climatic conditions.

When examining the problem, one should investigate its various aspects which can be divided into three groups :

- the effects of fires on forests

- the effects of fire on conservation areas which are regarded as sources of water supplies and

- the effects on grazing land for domestic and wild animals.

Fire can be regarded as detrimental in forest areas and on forest margins.

Where areas have been protected for water conservation purposes it has been found that the protected grass plants become moribund and the grass dies out and the run-off is greater than with a healthy grass cover. It is thus wiser to burn such areas at intervals to maintain a healthy and dense grass cover.

Under grazing conditions there should be no need to burn in sweetveld except to control the seedlings of encroaching undesirable plants. In sourveld and mixed veld burning is necessary to remove old grass from previous seasons if it is not practicable to mow.

In the grazing management of our natural veld, fire is a tool of utmost importance provided it is used at the correct time of the year. It must be emphasized however, that any burning is likely to be harmful unless it is done in conjunction with sound veld utilization. Harmful results often attributed to veld burning are usually caused by bad management which, even

without fire, would have ruined the veld in the long run.

ANIMAL PRODUCTION, CONSERVATION, GRASSLAND, GRAZING, MANAGEMENT, SAVANNA

183. Scott J D 1970. Pros and cons of eliminating veld burning. Proceedings of the Grassland Society of southern Africa 5, 23-26.

Fire has been a factor of the environment in Africa since time immemorial and it is often caused by natural agencies such as lightning. It is maintained that there is much prejudice against veld burning, often ill-founded. Fire has caused and maintained most of the world's grassland. When fire has been prevented plant succession has resulted in bush encroachment in the savanna and surrounding areas or in fynbos encroachment in others. Fire results in much old grass being wasted but, if this is not removed in some manner, the grazing deteriorates. Old grass can be removed by fire, mowing, or grazing using high protein supplements. The consequences of the different methods of removal, other than mowing, may be equally deleterious.

CONSERVATION, FYNBOS, GRASSLAND, MANAGEMENT, SAVANNA, SUCCESSION

184. Scott J D 1972. Veld burning in Natal. In : Fire in Africa. Proceedings Annual Tall Timbers Fire Ecology Conference 11, 33-51.

Preliminary work was carried out in the Natal Thornveld and critical experiments were laid out in the Tall Grassveld and Highland Sourveld to determine the effects of fire in these three different veld types.

Veld burning though not a common practice in the Thornveld could be used successfully to prevent bush encroachment if carried out at the right time of the year and in conjunction with good veld management.

In the Tall Grassveld burning is a common practice. Under conditions of complete protection from burning or defoliation the grass cover dies out. If there is a source of seed, the succession may proceed to a shrub stage but this is very slow. Run-off is high between the dead tufts of grass which form very good protection for rodents against predators. The best treatments for the maintenance of a good cover of good species is mowing in the spring or burning in the spring after rain.

In the Highland Sourveld complete protection leads to the replacement of the grass sward by forest margin grasses and shrubs. Mowing of the old grass instead of burning maintains the best cover while there is much damage done by leaving too long a period between burns. The generally recommended practice is burning biennially in spring after rain.

Under grazing conditions, some method of removing old grass must be used if the veld is not to deteriorate. Burning in spring after rain is the commonest practice to achieve this. Removing old grass by mowing gives the best results. The new practice of feeding high protein supplements is being studied.

BURNING SEASON, GRASSLAND, MANAGEMENT, NATAL, SAVANNA, SOIL EROSION, SUCCESSION

185. Scott J D 1975. Pasture research in southern Africa in retrospect and prospect. Rhodesia Agricultural Journal 72, 23-27.

A review of some aspects of pasture research and pasture management practices in southern Africa, including veld burning, bush eradication methods and non-selective grazing is presented.

The reasons commonly given for the necessity to burn veld are noted, while veld burning practices are discussed. Preliminary burning trials did not include grazing treatments but later work showed that the accumulation of litter as a result of not burning or as a result of no grazing or, in sourveld areas particularly, as a result of selective grazing could lead to detrimental changes in species composition.

It would appear from research work that fire is very often a necessary tool in pasture management in that it can prevent litter accumulation which may be undesirable and can be used to check bush encroachment.

Work done on the time and frequency of burning is reviewed. It would appear that in many situations fire cannot be dispensed with but should then be used correctly so that fire-caused deterioration of the sward does not occur.

ANIMAL PRODUCTION, BURNING FREQUENCY, BURNING SEASON, CONSERVATION, FIRE REGIME, GRASSLAND, GRAZING, HERBAGE YIELD, MANAGEMENT, REVIEW, SUCCESSION

186. Scriba J H 1976. The effects of fire on Widdringtonia nodiflora (L) Powrie on Mariepskop. South African Forestry Journal 97, 12-17.

During October 1964 and October 1970, fires occurred on the summit of Mariepskop in the eastern Transvaal and damaged, among other mountain vegetation, Widdringtonia nodiflora (L) Powrie trees. It is the purpose of this brief report to describe the damage done and to supply some data on the regenerative capacity of this mountain cedar.

ADAPTIVE RESPONSE, TRANSVAAL, WIDDRINGTONIA

187. Shantz H L and B L Turner 1958. Photographic documentation of vegetational changes in Africa over a third of a century. University of Arizona, College of Agriculture. Report 169. 158 pp.

This is a photographic documentation of changes in vegetation cover of specific sites throughout Africa with discussions on possible causes of the differences noted. Alarming changes in cover and species composition in South African veld have taken place as both a direct result (eg roadways, railways, urban development, etc) and an indirect result (eg increase in occurrence of fires, overgrazing, etc) of the rapid increase in the human population over the period of the study.

DEFORESTATION, GRASSLAND, SUCCESSION, VEGETATION DYNAMICS

188. Sim T R 1907. The forests and forest flora of the Colony of the Cape of Good Hope. Taylor and Henderson, Aberdeen. 361 pp.

Early historical reference - see inter alia pp 6, 9, 41, 42, 43, 44, 46, 59.

HISTORICAL ACCOUNT

189. Sim J T R 1943. Mountain fires. Farming in South Africa 18, 283-286.

Accidental and intentionally lighted fires in the mountains of the western Cape are deplored. The function of the mountain vegetation in ensuring regular water supplies is discussed. The damage caused by floods which result from the protective plant cover being damaged by fire or overgrazing is described.

Prompt action to save the mountain vegetation and water supplies is urged. Various protective measures against mountain fires are described.

CAPE, CATCHMENT, CONSERVATION, FOREST, SOIL EROSION

190. Smit I B J 1954. Some notes on the effects of burning on two veld types at Frankenwald. Annual Report for 1953 of the Frankenwald Field Research Station. University of the Witwatersrand, Johannesburg. pp 35-36.

Seasonal burn experiments were set out during 1938 in two camps - X1, in the purple veld at Frankenwald dominated by Trachypogon plumosus, Tristachya hispida and Elyonurus argenteus, and X2 on a fallow with Cynodon dactylon dominating. A floristic survey of each plot in both camps showed that fire had no great effect on species composition of X1 after 15 years but from the X2 experiment it appears that the time of burning influences the successional development.

Herbage yields for each treatment are presented. The effect of seasonal burning on Stoebe vulgaris is also discussed.

BURNING TRIAL, FRANKENWALD, GRASSLAND, HERBAGE YIELD, STOEBE, TRANSVAAL, VEGETATION DYNAMICS, VEGETATION STRUCTURE

191. Sonntag A E 1960. The protection of veld and forest against fire. African Wild Life 14, 117-123.

Damages caused by fire in forest grassland and savanna are discussed briefly. The author lists the main causes of fire. These are pyromania, negligence on the part of persons burning veld or refuse, lightning, railway locomotives, etc. He regards human negligence as the most important cause.

Directions to serve as a general guide for the prevention of fire are enumerated and discussed. These precautionary measures include fire breaks, regular fire patrols, fire protection committees, ensuring that adequate labour is available during a burn, education of employees regarding fire and propaganda to make the public protection-conscious, careful choice of suitable climatic conditions for the fire, etc.

CONSERVATION, FIRE BREAKS, FOREST, LIGHTNING, MANAGEMENT

192. Southern African Regional Committee for the Conservation and Utilization of the Soil (SARCCUS) 1956. Regional Conference on Pastures and Water Supplies. SARCCUS, Pretoria. 17 pp.

The report on bush encroachment (Section III) makes it clear that this is a most serious problem, especially in the more tropical areas and that there is little doubt that open bushland is essentially a fire subclimax. Recommendations are made for the establishment of protection plots to study this problem. Major causes of bush encroachment, ie exclusion of fire, overgrazing, lack of browsers, the distribution of seed of invader species by animals, shifting cultivation as practised by Africans and the injudicious cutting of timber are discussed. Recommendations are made for the control of bush encroachment.

The report of Section IV on grass and bush fires considers fire a factor which has a definite place in veld management, but that knowledge on this topic is still lacking and a recommendation is made for a comprehensive programme of research on veld burning.

DE-BUSHING, GRASSLAND, MANAGEMENT, SAVANNA

193. Sparrman A 1786. A voyage to the Cape of Good Hope. Vol 1. Second Edition. G G J and J Robinson, London. 368 pp.

Early historical reference - see inter alia pg 254.

HISTORICAL ACCOUNT

194. Staples R R 1926. Experiments in veld management. First report. Science Bulletin 49. Department of Agriculture, Union of South Africa. 30 pp.

Preliminary data are reported in this paper on certain investigations in veld management conducted by the School of Agriculture, Cedara, since June 1921.

The effects of various burning and grazing treatments on the dominance of Themeda triandra are described in detail.

BURNING TRIAL, GRASSLAND, MANAGEMENT, NATAL, THEMEDA, VEGETATION STRUCTURE

195. Staples R R 1930. Studies in veld management. A second report on certain veld burning and grazing experiments. Science Bulletin 91. Department of Agriculture, Union of South Africa. 31 pp.

An account of certain veld experiments in progress at the School of Agriculture, Cedara, to determine the effects of burning, grazing and mowing on veld pasture is presented.

Effects on the vegetation of burning during the winter months are discussed in detail. The experiments have shown that burning at any time when the vegetation is in a dormant condition (winter months) encourages the dominance of Themeda triandra. Effects of light grazing without burning, heavy grazing without burning, and mowing but not burning are given. Burning every second year was found to be sufficient in this area and the reasons why farmers burn their veld is discussed.

Effects on the vegetation of burning during the summer months are undesirable. The density of the cover is markedly reduced, the percentage of T triandra decreases and less palatable species increases. The greater the intensity of the heat of the burn the more damage is done.

BURNING TRIAL, GRASSLAND, MANAGEMENT, NATAL, THEMEDA, VEGETATION STRUCTURE

196. Steinke T D and L O Nel 1967. The growth of veld in response to defoliation by various means in late winter and spring. Proceedings of the Grassland Society of southern Africa 2, 113-117.

An experiment was conducted on Döhne Sourveld to determine the

effect of mowing and burning during the late winter and spring on subsequent herbage yields. Mowing in spring and burning in late winter before rain gave the highest and lowest yields respectively. There was no difference between burning after the late winter and the spring rains. Mowing both before and after the late winter rains yielded less material than the previous two burning treatments. Reasons for these results are suggested and their implications discussed. Growth curves revealed that at no time did late winter burning before rain stimulate earlier grazing than mowing or burning after rain.

BURNING TRIAL, CAPE, GRASSLAND, HERBAGE YIELD, MANAGEMENT

197. Story R 1951. A botanical survey of the Keiskammahoek district. Memoirs of the Botanical Survey of South Africa 27, 1-184.

The invasion of grasslands by Acacia karroo woodland was ascribed to the elimination of annual fires in this area. The influence of fire was tested on established A karroo seedlings grown for the purpose and it was found that only seedlings of less than 355 mm in height were readily killed by burning. Fire will cause a sudden abundance of seedlings but will decrease rather than increase final germination figures.

Fynbos spread was also related to the reduced incidence of veld fires. Cliffortia linearifolia and Erica brownleeae are killed by a hot fire, but regeneration from seed or coppice, but not suckers, will occur after mild fires. Cliffortia paucistaminea, also killed by hot fires, regenerates from seed, coppice or suckers after a mild fire. It is concluded that it is impossible to maintain a grass sward in the highlands without the occasional use of fire.

ACACIA, CAPE, CLIFFORTIA, ERICA, FYNBOS, GERMINATION, GRASSLAND

198. Tainton N M 1963. Burning or mowing - which is more profitable? Farming in South Africa 39(8), 24-25.

Recovery in spring of Natal Tall Grassveld mown at monthly intervals from April to November was always better than recovery from burning. Greatest recovery growth rates followed mowing or burning immediately after the first effective rains (33 mm) in spring. Recovery was poor when the veld was burnt either a month before or a month after these rains. The detrimental effects of early burning have often been stressed in the past; it is important that the equally bad effects of late burning be similarly appreciated.

BURNING SEASON, BURNING TRIAL, GRASSLAND, MANAGEMENT, NATAL

199. Tainton N M 1978 (in press). Fire in the management of humid grasslands in South Africa. Proceedings of the First International Rangeland Congress.

The humid grasslands of South Africa are fire-climax communities in which the grasslands become moribund, and are replaced by woodland or forest, if the top-growth is not removed at regular intervals. Grazing is seldom sufficiently controlled to ensure a uniform removal of this top-growth, and so fire is usually essential to the maintenance of the grasslands. Fire is also widely used in agricultural practice today to stimulate out of season growth by burning in autumn or winter and to provide high quality spring grazing free of contamination by low quality residual material.

In the role of stimulating out of season growth, fire is generally harmful, largely because of the heavy grazing to which the recovery growth is subjected. Spring burning is therefore generally recommended, provided it is applied before the veld has commenced active spring growth. Summer burning may however be successfully used to reduce the full load, and so the danger of unscheduled fires, where forest regeneration is being encouraged.

BURNING FREQUENCY, BURNING SEASON, GRASSLAND

200. Tainton N M and P de V Booysen 1963. The effects of management on apical bud development and seeding in Themeda triandra and Tristachya hispida. South African Journal of Agricultural Science 6, 21-30.

The apical buds of spring-initiated tillers of Themeda triandra are elevated some distance above the soil surface in mid-summer but develop into flowers only during the following spring. These buds are therefore susceptible to removal by defoliation for a considerable length of time prior to inflorescence maturity. Burning and grazing treatments applied during the period of bud elevation, by removing these apical buds, reduce the degree of flowering of T triandra and consequently result in a reduction in the number of seeds produced in this grass. At the same time, the removal of the apical meristematic region stimulates the initiation of secondary tillers from basal nodes.

As opposed to the developmental behaviour of the apical buds of T triandra tillers, those of spring-initiated Tristachya hispida tillers remain at or near the soil surface until immediately prior to infloresecence maturity. These buds are consequently well protected against removal by grazing animals and by mowing operations for the greater part of their developmental period. While spring burning treatments do not destroy the developing buds, the heat emitted by the fire may damage the buds to the

extent of reducing floret formation and decreasing seed viability.

ADAPTIVE RESPONSE, BURNING TRIAL, GRAZING, HERBAGE YIELD, MANAGEMENT, THEMEDA

201. Tainton N M and P de V Booysen 1965a. Growth and development in perennial veld grasses. I. Themeda triandra tillers under various systems of defoliation. South African Journal of Agricultural Science 8, 93-110.

Clipping twice (once in spring and once in summer), compared with no clipping, reduced by 14% the mass of primary tillers of Themeda triandra at maturity in the following summer. Two additional clipping treatments, one applied in autumn and one in winter, decreased the mass of mature tillers by 65%. Similar results were shown by the individual components of the primary tiller.

Clipping delayed the onset of stem elongation in primary tillers from mid-summer, when elongation commenced in unclipped tillers, to the following spring. Clipped tillers possessed fewer culm nodes and more basal nodes than did unclipped tillers.

The number of culm secondary tillers which developed on primary tillers was decreased by clipping, but basal secondary tiller development was more pronounced in clipped than in unclipped tillers in the season of treatment application. This difference did not persist beyond late spring of the following season.

The number of living roots on unclipped tillers which were burnt in spring decreased considerably within a short period of time following the burn. Burning did, however, result in the development of a large number of basal secondary tillers, many of which died during early summer.

BURNING TRIAL, GRASSLAND, HERBAGE YIELD, THEMEDA

202. Tainton N M and P de V Booysen 1965b. Growth and development in perennial veld grasses. II. Hyparrhenia hirta tillers under various systems of defoliation. South African Journal of Agricultural Science 8, 745-760.

Clipping twice (once in spring and once in summer), compared with no clipping, reduced by 9% the mass of primary tillers of Hyparrhenia hirta at maturity in mid-winter. Two additional clipping treatments, applied in autumn and winter, decreased the mass of mature tillers by 66,5%. Similar results were shown by the individual components of the primary tiller.

Clipping had no effect on the time at which stem elongation commenced, so that clippings applied after the commencement of stem elongation in mid-summer removed the stem apices of primary tillers and so greatly reduced flower formation.

The number of culm secondary tillers which developed on primary tillers was decreased by clipping, but basal secondary tiller development was more pronounced in clipped than in unclipped tillers. Burning also resulted in an increase in basal secondary tiller development. These differences persisted in both clipping and burning treatment to the end of the recording period.

BURNING TRIAL, GRASSLAND, HERBAGE YIELD, HYPARRHENIA

203. Tainton N M, R H Groves and R C Nash 1977. Time of mowing and burning veld : short-term effects on production and tiller development. Proceedings of the Grassland Society of southern Africa 12, 59-64.

In a comparison of mowing and burning as removal treatments in the Natal Tall Grassveld, mowing proved to be superior to burning in terms of sward productivity in the season following the removal treatment, but burning was responsible for a sward of higher protein content, at least during the early part of the season. Varying time of either mowing or burning between 1 August and 16 October had little effect on recovery growth but harvesting of the recovery growth of burnt veld in the early season in particular, reduced total yields considerably. This yield reduction brought about by early harvesting of regrowth emphasized the need to provide adequate rests after burning before burnt veld is grazed in the spring.

BURNING TRIAL, GRASSLAND, HERBAGE QUALITY, HERBAGE YIELD, MANAGEMENT, NATAL

204. Tainton N M, P de V Booysen, D I Bransby and R C Nash 1978 (in press). Long-term effects of burning and mowing on Tall Grassveld in Natal : dry matter production. Proceedings of the Grassland Society of southern Africa.

Veld burning treatments applied annually, biennially or triennially during the first week of August or after the first substantial spring rains considerably reduced herbage yields during the season which followed the burn, but had no long-term effect on the productivity of the veld. Long-term effects did however result from differences in summer utilization. Where veld was not cut for hay in summer, it developed a potential to produce higher yields than veld which was cut during the summer season. This increased production potential is, however, ac-

companied by changes in the nature of the sward which in many respects are undesirable.

BURNING FREQUENCY, BURNING TRIAL, GRASSLAND, HERBAGE YIELD, NATAL, VEGETATION DYNAMICS

205. Taylor H C 1972. Notes on the vegetation of the Cape Flats. Bothalia 10, 637-646.

Though the Cape Flats, adjoining Cape Town, were among the first explored parts of South Africa, their vegetation, rapidly being altered by encroachment of alien plants, has not been described before. In these notes, five inland and four coastal plant communities, delineated by habitat, are described; their relationships with one another and with coast-flats vegetation elsewhere are suggested.

Observations on means of regeneration after fire show that the woody, tropical-derived element regenerates rapidly from coppice, while the fynbos or temperate scleropyll element contains many seed-regenerating species. Succession in the fynbos is thus more complex and prolonged.

ADAPTIVE RESPONSE, CAPE, FYNBOS, SUCCESSION, VEGETATION STRUCTURE

206. Taylor H C 1973. Fire in fynbos. Veld and Flora 3(1), 18-19.

The effect of fire on fynbos and the necessity of fire to maintain fynbos are discussed. However, the uncontrolled use of fire is warned against, especially since pestplants may be encouraged by such practices.

CAPE, FYNBOS, MANAGEMENT

207. Taylor H C 1977a. Aspects of the ecology of the Cape of Good Hope Nature Reserve in relation to fire and conservation. Proceedings of the Symposium on Environmental Consequences of Fire and Fire Management in Mediterranean Ecosystems. USDA Forest Service. General Technical Report WO-3. pp 483-487.

The three landscape types in the Reserve are described and the rare species list examined to show that conservation management must ensure survival of the following endangered or fragile elements : members of typical or endemic families of the Cape flora; seed - regenerating species; and rare habitats. Fire regeneration strategies of three taxa are compared to show that fire is an essential tool in such management, both to maintain the Cape flora and to reduce the invasive alien species that are replacing fynbos vegetation.

ADAPTIVE RESPONSE, CAPE, CONSERVATION, FYNBOS, MANAGEMENT, VEGETATION STRUCTURE

208. Taylor H C 1977b. The Cape floral kingdom : an ecological review. In : Proceedings of the Second National Weeds Conference of South Africa. A A Balkema, Cape Town and Rotterdam. pp 19-33.

Primitive man may have started fires in fynbos up to 100 000 years ago, and natural fires probably occurred for as long as the fynbos climate, topography and vegetation have existed. Fynbos species have evolved "fire life forms" to enable them to survive fire either as individuals through vegetative regrowth, or as populations through seed production. The diverse and specialized physiognomy of fynbos is largely a result of these adaptations of fire, and many fynbos shrubs are dependent upon not too frequent fires for their perpetuation in the community.

ADAPTIVE RESPONSE, BURNING FREQUENCY, CAPE, FYNBOS, VEGETATION DYNAMICS

209. Taylor H C 1978. Capensis. In : Biogeography and ecology of southern Africa. M J A Werger (ed). Junk, The Hague. pp 171-229.

On pp 206-211 the literature on fire in fynbos is briefly reviewed and the means of fire survival discussed. The part played by fire in the cyclical succession of fynbos is explained and the importance of season of burn in the fire-management of fynbos is stressed.

On pg 217 the behaviour of renosterbos Elytropappus rhinocerotis when subjected to burning is summarized.

ADAPTIVE RESPONSE, BURNING SEASON, CAPE, ELYTROPAPPUS, FYNBOS, MANAGEMENT, REVIEW, SUCCESSION

210. Taylor H C and F J Kruger 1978. A first attempt to measure temperatures of fire in fynbos. Bothalia 12, 551-553.

An investigation of the temperatures of fire in the Cape fynbos (sclerophyll scrub) by means of heat sensitive pellets is described, and the results are briefly discussed. The pellets proved unsatisfactory for this purpose and chromatic thermometers are suggested as an alternative.

CAPE, FIRE BEHAVIOUR, FYNBOS, TECHNIQUE, TEMPERATURE PROFILE

211. Theron G C 1932. Veld burning in the western Transvaal. Farming in South Africa 7, 244; 254.

Results of an experiment, aimed at studying the effect of burning on veld grasses started in 1928 at Potchefstroom are discussed. Half the camps were burnt in May each year and the other half in September each year and then rested, ie the veld

was neither cut nor grazed. This camp was compared with adjacent plots which were grazed or cut but not burnt.

No change has taken place in the grass populations, Themeda triandra still being the dominant grass, but in the burnt plots the grass appears less vigorous and stunted. Burnt plots also appeared to be more prone to drought than plots that were grazed, as well as displaying a certain amount of erosion.

BURNING SEASON, BURNING TRIAL, GRASSLAND, THEMEDA, TRANSVAAL, VEGETATION DYNAMICS, VEGETATION STRUCTURE

212. Theron G C 1937. Veld management investigations at the School of Agriculture, Potchefstroom. Preliminary report. Bulletin 166. Department of Agriculture, Union of South Africa. 23 pp.

A series of veld management experiments was commenced at Potchefstroom on typical western Transvaal grassland in 1927, and this report gives the results obtained up to 1934.

Annual burning in spring and in autumn continued over a number of years almost killed off Themeda triandra while Aristida congesta was encouraged. The most alarming result of this practice was the increase of bare ground. This was almost negligible at the beginning of the experiment, but after five years comprised more than half of the surface of the plots, and thus provided favourable conditions for soil erosion.

ARISTIDA, BURNING TRIAL, GRASSLAND, MANAGEMENT, SOIL EROSION, THEMEDA, TRANSVAAL

213. Theron G C 1946. Research in connection with veld control at the Potchefstroom College of Agriculture. Science Bulletin 266. Department of Agriculture. Union of South Africa. 14 pp.

In 1927 a series of experiments was commenced at Potchefstroom in connection with veld control on typical western Transvaal grassland. The interim report appeared in 1937 (Theron 1937) and the present report reflects the results obtained until 1946.

Veld was burnt during four periods of the year viz spring, summer, autumn and winter. Spring burning causes the least damage and summer burning the most, the latter apparently being very undesirable. Certain camps were burnt every year, every second year and every third year, usually towards the end of winter. In the long run annual burning is very injurious to the veld, but burning every third year causes comparatively little damage and the results obtained in the latter case compare favourably with those of an unburnt camp receiving the same further treatment. Annual burning towards the end of winter followed by spring grazing is harmful to the veld in the long run.

A good but slow way of restoring Aristida congesta veld is to rest it completely during spring and summer and grazing it down in winter. The treatment must not be applied uninterruptedly on good veld for a number of years since this may cause the veld to deteriorate. Complete resting of the veld, especially over a number of years, is very detrimental.

Summer grazing and spring resting give better results in the long run than spring grazing and summer resting. Heavy summer grazing for short periods gives better results than light grazing for longer periods. The difference is not significant.

ARISTIDA, BURNING TRIAL, GRASSLAND, MANAGEMENT, SOIL EROSION, THEMEDA, TRANSVAAL

214. Thompson W R 1937. Veld burning, its history and importance in South Africa. Publications of the University of Pretoria. Series No 1 : Agriculture No 31. 19 pp.

The author gives a fairly comprehensive account of earlier records of veld burning in South Africa. Burning as practised at present is compared with earlier times. Early views and modern opinion regarding the effects of burning are discussed.

The experiment in progress at the University of Pretoria experimental farm during the last four years with the object of measuring run-off and soil erosion from different veld treatments is described. Results obtained are presented. A comparison of the run-off from differently managed plots show conclusively that burning of the veld encourages run-off. Soil erosion was negligible except during the high rainfall season 1933-1934 when almost four tons of soil per morgen (3,12 t/ha) eroded from the burnt plot. Burning also influenced the composition of the sward.

Arguments for and against veld burning are presented and the influence of the time of burning is also dicussed.

BURNING SEASON, GRASSLAND, HISTORICAL ACCOUNT, MANAGEMENT, REVIEW, RUN-OFF, SOIL EROSION, TRANSVAAL

215. Thunberg C P 1793. Travels in Europe, Africa and Asia. W Richardson and J Egerton, London. Vol 1. 317 pp.

Early historical reference - see inter alia pg 179.

HISTORICAL ACCOUNT

216. Transvaal (Province) 1967. Nature Conservation Ordinance No 17 of 1967. Government Printer, Pretoria. 118 pp.

Two sections are important in terms of forest and veld fire laws, namely :

Section 77 - Picking of protected plants, in particular see Section 77(1)(c)

Section 80 - Picking of indigenous plants near public roads, in particular see Section 80(1)(c).

LEGISLATION, TRANSVAAL

217. Trollope W S W 1970. A consideration of macchia (fynbos) encroachment in South Africa and an investigation into methods of macchia eradication in the Amatole mountains. MSc thesis, University of Natal, Pietermaritzburg. 357 pp.

In extensive areas of South Africa, macchia (fynbos) vegetation has tended to become dominant at the expense of grassland. This has been in response to incorrect veld management, the most important factor being the elimination of critical fire regimes. Macchia vegetation is a natural component of the South African flora and comprises such typical genera as Protea, Erica and Leucospermum. Botanical evidence suggests that macchia was the dominant vegetation in South Africa during Gondwanaland times. However, with the change in climate that occurred with the fragmentation of Gondwanaland into the different continents, macchia retreated to the temperate areas of South Africa viz south-western Cape, coastal and inland mountain ranges. The recent movement of macchia out of these regions includes the encroachment of Elytropappus rhinocerotis, Euryops spp, Stoebe vulgaris, Athanasia acerosa and the Amatole macchia, all of which constitute serious agricultural problems.

A research programme was conducted in the Amatole mountains to investigate different methods of controlling the encroachment of the macchia species Cliffortia linearifolia, C paucistaminea and Erica brownleeae. The experiments comprised the application of burning, stumping, cutting and spraying with 2-4-5 T weedicide treatments to mature stands of macchia. It was concluded from the results that burning was the most practical and effective method of eradicating the macchia vegetation and re-establishing a vigorous grass sward.

BURNING TRIAL, CAPE, CLIFFORTIA, DE-BUSHING, ERICA, FYNBOS, GRASSLAND, MANAGEMENT, SUCCESSION, VEGETATION STRUCTURE

218. Trollope W S W 1972. Fire as a method of eradicating macchia vegetation in the Amatole mountains of South Africa - experimental and field scale results. In : Fire in Africa. Proceedings Annual Tall Timbers Fire Ecology Conference 11, 99-120.

Stumping and to a lesser extent burning, were the two most effective methods of eradicating the lowland macchia. Burning was the most effective method of eradicating the highland macchia.

Burning was a most effective follow-up treatment for reducing the regrowth of both the lowland and highland macchia communities after any form of eradication. Burning resulted in an improvement in the grass sward to varying degrees in all cases.

BURNING TRIAL, CAPE, DE-BUSHING, FYNBOS, MANAGEMENT, SUCCESSION, VEGETATION STRUCTURE

219. Trollope W S W 1973. Fire as a method of controlling macchia (fynbos) vegetation on the Amatole mountains of the eastern Cape. Proceedings of the Grassland Society of southern Africa 8, 35-41.

Earlier research on eradicating macchia (fynbos) vegetation on the Amatole mountains showed that both the lowland and highland macchia communities were re-established from coppice growth and seedlings. Follow-up burning treatments were therefore applied following eradication. In the lowland macchia, burning two years after destroying a dense stand of Cliffortia linearifolia, followed by another burn one year later, virtually eliminated the species and caused a complete recovery in the grass sward. In the highland macchia, burning two, three or four years after the original treatments was equally effective in reducing the regrowth of Erica brownleeae and Cliffortia paucistaminea to negligible proportions. However, the hotter the burn, the more adversely affected was the grass sward. This effect became more pronounced as the interval increased between the original eradication treatment and the follow-up burn.

BURNING TRIAL, CAPE, CLIFFORTIA, DE-BUSHING, ERICA, FYNBOS, GRASSLAND, MANAGEMENT, SUCCESSION, VEGETATION STRUCTURE

220. Trollope W S W 1974. Role of fire in preventing bush encroachment in the eastern Cape. Proceedings of the Grassland Society of southern Africa 9, 67-72.

A serious bush encroachment problem has developed in the eastern Cape and it has been suggested that this is partly the result of the elimination of regular, fierce veld fires. The author is of the opinion that it was rather the interaction of burning and wild browsing animals that played the major role in maintaining the original grasslands and preventing the encroachment of bush in the past.

After a controlled burn had been applied to an area of dense, sweet grassveld, moderately encroached by Acacia karroo and other bush species, most of the bushes suffered a kill of stems and branches but coppiced from the base of the stem. Stocking lightly with goats controlled this coppice growth with no detrimental effect on the grass. These results indicate that a sys-

tem of burning and browsing could be used in combating bush encroachment in certain situations.

ADAPTIVE RESPONSE, ANIMAL INFLUENCE, BURNING TRIAL, CAPE, DE-BUSHING, GRASSLAND, MANAGEMENT, SAVANNA, SUCCESSION, VEGETATION STRUCTURE

221. Trollope W S W 1978a (in press). Fire behaviour - a preliminary study. Proceedings of the Grassland Society of southern Africa.

There is a serious deficiency in knowledge concerning the behaviour of fires in South Africa. Arising from this, an investigation was initiated to characterize the behaviour of head and back fires under a variety of environmental conditions.

The results showed that head fires had a significantly greater rate of spread, length of flame and overall intensity than back fires. However at ground level, back fires were more intense which had a significant depressing effect on the recovery of the grass resulting in lower yields. These results demonstrate the value of knowledge about fire behaviour in veld management and it is recommended that fire behaviour and its effect on vegetation always be taken cognizance of in any future research on fire in relation to vegetation.

FIRE BEHAVIOUR, HERBAGE YIELD

222. Trollope W S W 1978b (in press). Fire - a rangeland tool in southern Africa. Proceedings of the First International Rangeland Congress.

Results from burning experiments over the last half century have led to the development of fire as a practical and economic tool for rangeland management in southern Africa. Burning is used to maintain grassland in a vigorous and acceptable state for livestock and for controlling the encroachment of undesirable vegetation. Burning to remove moribund grass material is largely confined to the humid areas of the southern coastal strip and eastern portion of the subcontinent.

The encroachment of trees and shrubs, macchia, karoo and herbaceous species poses a serious threat to rangeland and burning programmes designed to re-establish a vigorous and productive grassland sward are presented. Fire has the economic advantage of being an indirect cost technique making it an attractive alternative to other methods like mechanical and chemical control of brush. This gives it great applicability in solving rangeland problems in developing countries.

DE-BUSHING, MANAGEMENT, REVIEW

223. Trollope W S W and P de V Booysen 1971. The eradication of the macchia (fynbos) vegetation on the Amatole mountains of the eastern Cape. Proceedings of the Grassland Society of southern Africa 6, 28-38.

On the Amatole mountains of the eastern Cape Province extensive tracts of grassveld have been invaded by macchia (fynbos) vegetation and rendered agriculturally unproductive. Two distinct macchia communities occur, namely the lowland macchia dominated by Cliffortia linearifolia and the highland macchia dominated by Erica brownleeae and Cliffortia paucistaminea.

A similar experiment was laid out on each community to determine the most effective method of eradicating the macchia and replacing it with a grass sward. A wide range of treatments, comprising spraying with 2-4-5 T weedicide, burning, cutting, and stumping were applied. Stumping and burning most effectively eradicated C linearifolia, whereas burning and, to a slightly lesser degree cutting and spraying, were very effective in eradicating E brownleeae and C paucistaminea.

BURNING TRIAL, CAPE, CLIFFORTIA, DE-BUSHING, ERICA, FYNBOS, GRASSLAND, MANAGEMENT, SUCCESSION, VEGETATION STRUCTURE

224. Trollope W S W and P G F Coetzee 1975. Vegetation and veld management. In : The Agricultural Potential of the Ciskei - a preliminary report. Faculty of Agriculture, University of Fort Hare. pp 71-124.

An account of the dynamics of the region's vegetation, particularly in response to changing conditions of grazing, browsing and fire, is presented as background to detailed proposals for veld utilization and reclamation. Judicious use of fire following adequate resting for macchia control in savanna areas is recommended.

CONSERVATION, DE-BUSHING, FYNBOS, GRAZING, MANAGEMENT, VEGETATION DYNAMICS

225. Van der Merwe N J 1962. The position of nature conservation in South Africa. Koedoe 5, 1-122.

A comprehensive list is presented of all work being done in the field of nature conservation in South Africa and the organizations, divisions and departments concerned. Recommendations regarding veld burning in the Kruger National Park are summarized.

CONSERVATION, FIRE REGIME, KRUGER NATIONAL PARK, MANAGEMENT, SAVANNA, TRANSVAAL

226. Van der Merwe P 1966. Die flora van Swartboskloof, Stellenbosch en die herstel van die soorte na 'n brand (The flora of Swartboskloof, Stellenbosch and the methods of recovery of flora after a fire). Annale Universiteit van Stellenbosch 41 Serie A (14), 691-736.

A floristic survey of Swartboskloof, Stellenbosch including a survey of the methods of survival of the flora was made from 23 to 35 months after a fire which occurred on 2 February 1958. The survey yielded 448 species of flowering plants. Of these 298 species survived the fire vegetatively and 150 species survived only in the form of seed. No indications of immigration were found.

Soils in the area are derived from Table Mountain sandstone and granite. Seven soil types were identified. The variation in floristic composition on these soil types was such as to justify division of the flora into seven plant communities, of which two were forest communities and five fynbos communities.

Life forms, fire life forms and flowering periods of the various species were noted. The flora consists mainly of geophytes, hemicryptophytes, chamaephytes and nanophanerophytes. The majority of species flower during September, which is two months after the height of the rainfall period.

ADAPTIVE RESPONSE, BURNING TRIAL, CAPE, FYNBOS, SUCCESSION, VEGETATION DYNAMICS, VEGETATION STRUCTURE

227. Van der Merwe P 1969. Datering van veldbrande met behulp van Protea mellifera Thunb (The dating of veld fires with the aid of Protea mellifera Thunb). Tydskrif vir Natuurwetenskappe 9, 251-254.

Branching and phenological characteristics are used to determine the age of Protea repens (= P mellifera). P repens survives a veld fire only in the form of seeds of which the majority first germinate the following growing season. The age of the P repens plants will then be an indication of the age of the regenerated veld and it is therefore possible to calculate the date of the last fire and by implication also the duration of the last fire-free period.

It is also possible to determine the age of burnt P repens plants and to calculate the date of the second last fire and the duration of the previous fire-free interval.

ADAPTIVE RESPONSE, CAPE, FYNBOS, PROTEA

228. Van der Merwe P and Dorothy van der Merwe 1968. Fire in Swartboskloof Nature Reserve. African Wild Life 22, 147-157.

Fynbos and forest plant communities were surveyed 35 months

after a February fire which occurred after a 15-year fire-free period.

This February fire was found to be beneficial to Protea repens (= P mellifera) and P neriifolia. The number of burnt individuals, compared with the number of seedlings showed a marked increase of individuals in both species.

Of the flowering plants in the surveyed area, 33% were totally dependent on seed for regeneration after the fire and were termed fire therophytes (fire therophytes include annuals which would normally be classed as therophytes). Climax forest communities contained 11-22% fire therophytes, as opposed to 27-42% of the fynbos communities. The high percentage of fire therophytes in the fynbos communities can be regarded as an indication of a subclimax stage maintained by fire.

The period of optimum seed production is November when conditions become driest and most inflammable.

ADAPTIVE RESPONSE, CAPE, FOREST, FYNBOS, PROTEA

229. Van der Schijff H P 1958. Inleidende verslag oor veldbrandnavorsing in die Nasionale Krugerwildtuin (Introductory report on veld burning research in the Kruger National Park). Koedoe 1, 60-93.

Fire has been a natural factor of the environment of the vegetation of the Kruger National Park since time immemorial. Before the advent of man, fire was probably one of the principal factors responsible for the maintenance of the typical bushveld flora of this area. Confronted with the controversial opinions of laymen and scientists and the absolute lack of factual and experimental knowledge regarding veld burning in a wildlife sanctuary such as the Kruger National Park, the National Parks Board of South Africa decided in 1954 to undertake its own research into this vital and much discussed ecological problem.

For the purpose of management, the vegetation of the Park is classified into six main veld types. An account of these main veld types is given with special reference to their location and dominant trees, shrubs and grasses.

The major pasture problems of the Park, namely overgrazing and undergrazing, bush encroachment, uncontrolled veld fires and game movements over the western boundary are evaluated and the urgent necessity for research into veld burning with regard to these problems is stressed.

The experimental layout and procedure of research in connection with veld burning in the Kruger Park is sketched. Experiments have been laid out in the four most important veld types with 12 burning treatments in each. The size of the

plots for each treatment is 40 yards by 200 yards (36,6 x 182,9 m). The 12 plots are laid out together in one block and each block is replicated four times in different localities within the same veld type.

The effect of fire on the natural communities will be evaluated by means of botanical surveys, photographic records and regular observations. Due consideration will also be given to other aspects such as soil fertility, erosion, insect and animal populations, etc.

Botanical analysis of trees and shrubs in each plot has been done according to a belt transect method and the composition and basal cover of the grasses and herbs by means of a point quadrat.

Preliminary observations not only indicate that different veld types are affected differently by fire but also that the time of the year in which the veld is burnt is of the utmost importance.

BURNING TRIAL, CONSERVATION, KRUGER NATIONAL PARK, MANAGEMENT, SAVANNA, TRANSVAAL

230. Van der Schijff H P 1959. Weidingsmoontlikhede en weidingsprobleme in die Nasionale Krugerwildtuin (Grazing possibilities and problems in the Kruger National Park). Koedoe 2, 96-127.

The role of fire in the fight against bush encroachment is discussed and literature on the subject reviewed. A list of the most common encroachment species in the Park is included. The need for research into the problem of bush encroachment is stressed.

DE-BUSHING, GRASSLAND, KRUGER NATIONAL PARK, SAVANNA, TRANSVAAL

231. Van der Schijff H P 1964. 'n Hervaluasie van die probleem van bosindringing in Suid-Afrika (A re-evaluation of the bush encroachment problem in South Africa). Tydskrif vir Natuurwetenskappe 4, 67-80.

The extent and economic significance of bush encroachment in South Africa is described and a list of plant species which tend to encroach on natural veld is given.

The morphological and ecological differences between shrubs and grasses are discussed and the differences in their ecological adaptations and requirements are elucidated. The bush encroachment problem is stressed. Ecologist and pasture research workers will have to decide on the eradication of undesirable scrub and bush, whether this represents a natural climax or is due to bush encroachment.

Several hypotheses on the underlying causes of bush encroachment are discussed. It is concluded however, that in this respect basic information is still lacking. Bush encroachment is probably the result of an interaction of a number of factors.

Research into bush control and eradication in South Africa is summarized and evaluated. It is clear however that a satisfactory economical method for the control of bush in natural pastures has not yet been developed.

The need for fundamental research into the cause and control of bush encroachment is stressed.

MANAGEMENT, REVIEW, SAVANNA, SUCCESSION, VEGETATION STRUCTURE

232. Van der Schijff H P 1969a. Weidingsprobleme en natuurbewaring. Deel I (Pasture problems and nature conservation. Part I). African Wild Life 23, 25-36.

See Van der Schijff 1969b.

CONSERVATION, MANAGEMENT, REVIEW, SAVANNA, SUCCESSION, TRANSVAAL, VEGETATION STRUCTURE

233. Van der Schijff H P 1969b. Weidingsprobleme en natuurbewaring. Deel II. (Pasture problems and nature conservation. Part II). African Wild Life 23, 105-128.

The problems of grazing management in relation to nature conservation should be seen against the background of our interpretation of concepts such as nature conservation and nature utilization, nature reserve and nature park, and grazing management. Only when the nature-lover understands clearly what is meant by these concepts can the problem of maintaining natural pastures be seen in perspective, approached in a sensible way and tackled in a practical manner.

Problems of undergrazing, overgrazing, provision of water, bush encroachment, and veld burning are discussed shortly and evaluated, and the causes and results examined. Increasing tourist traffic, the management of a reserve and an increasing elephant population are also regarded as problems involving grazing management because they are so closely associated with either the distribution of game or the available grazing. Elephants have already created serious problems with regard to their habitat which can be corrected only by reducing their numbers.

CONSERVATION, MANAGEMENT, REVIEW, SAVANNA, SUCCESSION, TRANSVAAL, VEGETATION STRUCTURE

234. Van der Walt J L 1961. Veld burning in the Sneeuberg Range, with special reference to scrub veld. Farming in South Africa 37(5), 33-35.

A special committee of officers from the Karoo Region was appointed to investigate the burning of veld and its implications and to make recommendations in this regard following the extensive fires which had occurred in the Sneeuberg range. The findings of the committee are presented in this article. The main dangers of veld burning, including denudation of the soil surface, the intrusion of less desirable plants, destruction of humus and change of veld type are discussed.

The cases where veld burning in the Sneeuberg range is justified are described and recommendations are made regarding time of burn, period of rest, and other management aspects.

BURNING FREQUENCY, BURNING SEASON, CAPE, KAROO, MANAGEMENT, VEGETATION DYNAMICS

235. Van der Wijk-Verkerk J A A 1973. Seasonal grass burning experiments at Frankenwald Research Station, University of the Witwatersrand. BSc (Hons) thesis, Department of Botany and Microbiology, University of the Witwatersrand. 86 pp.

At Frankenwald Research Station, University of the Witwatersrand, seasonal burning experiments were started in 1934 in plot F 11, an area consisting of approximately 6 500 $m^2$. The purpose of the experiment was to study the effect of fire at different times of the season in Trachypogon - other species grassland ("purple veld").

Nine subplots were laid out, some differing widely in dimensions. These plots have since been burnt every year between the 20th and 25th of a certain month - May, July, August, September, October (one plot each month) and June (three plots). There was one control plot.

Fixed metre quadrats were staked out, three quadrats in two of the three June burnt plots and two quadrats in each of the other plots. In 1934 and in 1937 the species in the fixed quadrats were identified and listed and their basal area was measured or estimated. Except for some phenological observations, no other data were collected.

In 1971 when the experiments had to be rounded off, only six of the 20 fixed quadrats could be recovered, in 1972 one other quadrat was found. Lack of comparative quantitative data which can be tested statistically has impeded the evaluation of the eventual changes of the grassland after almost 40 years of regular veld burning.

By the grid method and the assessment of randomized samples as well as the use of the concept of the minimal area, an attempt is made to verify whether the grasslands have undergone change.

BURNING SEASON, BURNING TRIAL, FRANKENWALD, GRASSLAND, SUCCESSION, TRANSVAAL

236. Van der Zel D W 1974. Catchment research at Zachariashoek. Forestry in South Africa 15, 23-30.

Five Zachariashoek research catchments, situated in the Klein Drakenstein Mountains of the south-western Cape, are described. Preliminary rainfall figures are included and the topography, geology, vegetation and hydrography are described. Treatments consist of periodic burning of catchment areas of about 250 ha each on rotations of 4 and 12 years.

Water quantity, regime and quality are regularly measured. Vegetation composition is regularly observed in 50 $m^2$ quadrats and phytomass yields are estimated. Research results should be applicable to a considerable area of mountain catchments in the south-western Cape.

CAPE, CATCHMENT, FYNBOS, HERBAGE YIELD, VEGETATION STRUCTURE, WATER YIELD

237. Van der Zel D W and F J Kruger 1975. Results of the multiple catchment experiments at the Jonkershoek Research Station, South Africa. 2. Influence of protection of fynbos on stream discharge in Langriver. Forestry in South Africa 16, 13-18.

Protection of an upland fynbos catchment in the winter rainfall region of South Africa resulted in a one percent decrease in streamflow per year of protection. Annual streamflow declined about 500 mm during the 25 years after an accidental fire in December 1942. The decrease can be ascribed entirely to diminution in streamflow during the months April to November. No change was detected in dry-season flow. The decrease in streamflow is ascribed to increased transpiration and interception losses arising from increases in phytomass. The decline is substantial and points to the need for scientific management of South African mountain catchments to provide a higher constant water yield.

CAPE, CATCHMENT, FYNBOS, MANAGEMENT, VEGETATION STRUCTURE, WATER YIELD

238. Van Rensburg H J 1972. Fire : its effect on grasslands, including swamps - southern, central and eastern Africa. In : Fire in Africa. Proceedings Annual Tall Timbers Fire Ecology Conference 11, 175-199.

Herbage should be utilized for forage, bedding, compost,

packing or other useful purposes. If it cannot be utilized purposefully, redundant herbage should be disposed of by controlled burning at the most propitious time. The reasons for burning have been clearly stated : controlled burning of redundant herbage at the correct time has a most desirable effect. It disposes of unpalatable old herbage, controls encroachment of undesirable woody plants, destroys parasites, and produces a fresh healthy sward. It also aids better distribution of animals, reduces fire hazards, stimulates seeding and helps to prepare a favourable natural seed bed.

The time of burning is very important. In southern, central and eastern Africa the best time for burning to promote vigorous grass growth is at the end of the dry season, about October. There is, however, considerable variation in seasonal rainfall.

Early dry season and mid-dry season burning encourages bush encroachment at the expense of grasses and causes exposure that is likely to damage and weaken the sward.

Utilization of flood plain and swamp grassland is complicated due to unmanageable growth during inundation.

ANIMAL INFLUENCE, BURNING SEASON, BURNING TRIAL, GRASSLAND, REVIEW

239. Van Rensburg W L J 1962. Die aandeel van grasse in veldtipes rondom Stellenbosch (The role of grasses in veld types of the Stellenbosch area). MSc thesis, University of Stellenbosch. 182 pp.

Samples were taken in stands of representative and disturbed vegetation in five veld types in the vicinity of Stellenbosch in the winter rainfall area of South Africa to study the part played by grasses in these veld types. A sample consisted of the species touching a thin rod placed vertically at points spaced at one metre intervals.

It was found that on burnt areas with loamy soil in Veld Types no 43 (Mountain Rhenosterbosveld) and no 46 (Coastal Rhenosterbosveld) and on burnt areas with loamy soil in Veld Type no 69 (Macchia) the frequency of the grasses was higher than on unburnt areas and that on such areas there were always one or a few species with a high frequency. In burnt areas on sandstone in Veld Type no 69 the frequency of grasses was lower than on unburnt areas.

It is suggested that grass communities in Veld Types nos 43, 46 and on loamy soil in Veld Type no 69 can be produced and stabilized by fire if it is known when and how often the vegetation must be burnt.

CAPE, FYNBOS, MANAGEMENT, VEGETATION STRUCTURE

240. Van Wyk P 1972. Veld burning in the Kruger National Park, an interim report of some aspects of research. In : Fire in Africa. Proceedings Annual Tall Timbers Fire Ecology Conference 11, 9-31.

The importance of fire in maintaining the status quo of the Kruger National Park is stressed.

It appears that the withdrawal of the fire factor initially leads to a deterioration of grazing conditions and eventually to encroachment by the woody stratum and the exclusion of grasses. Excessive burning ultimately leads to deterioration of the entire plant community. After 15 years of burning, the damage is apparently still limited to the grass stratum, but in time the tree and shrub stratum may also be affected in such a way that the entire physiognomy of the community will be changed, especially in the presence of browsing species like elephant.

Available data suggests that there is no reason for a change in the present general veld burning policy followed in the Kruger National Park. There seem to be very little or no qualitative or quantitative changes in the grass stratum in the case of triennially burnt plots. Advantageous tendencies with regard to the woody stratum are also more pronounced on the triennially burnt plots.

BURNING TRIAL, KRUGER NATIONAL PARK, MANAGEMENT, SAVANNA, TRANSVAAL

241. Van Wyk P and V A Wager 1968. The problems of fire in the Kruger Park. African Wild Life 22, 269-280.

Brief discussion of the vegetation, geology, topography and climate of the Kruger National Park and the known detrimental and advantageous effects of veld fires are presented. The history of fire control and the causes, extent of and methods employed in combating accidental fires are discussed.

The paper deals mainly with the existing policy of controlled burning in the Park which involves burning of roughly 50% of the area on a triennial or biennial rotational basis and temporary or permanent protection of the remainder.

BURNING FREQUENCY, BURNING SEASON, KRUGER NATIONAL PARK, MANAGEMENT, SAVANNA, TRANSVAAL

242. Vowinckel E 1958. Fire-danger rating. Journal of the South African Forestry Association 31, 58-73.

With the aid of experiments and the known properties of timber and combustion, an objective fire danger rating system is

developed, where each contributing factor can be expressed by a numerical value.

FIRE DANGER RATING, FOREST

243. West O 1943. The vegetation of Weenen Country - an ecological account of the vegetation of the Estcourt and Weenen districts. DSc thesis, University of the Witwatersrand. 267 pp.

This study deals inter alia with the influence of man on the vegetation of the area, the climax associations and a survey of the different vegetation types. The reaction of the grassbuds to burning is discussed with reference to research work at Tabamhlope Research Station (altitude 2 000 m), where it was found that Themeda triandra has remained dominant in quadrats burnt during the winter and protected from grazing. When protected from both grazing and burning, T triandra rapidly disappears. The grasses that disappear when veld is protected from both grazing and burning are listed as are those which persist. It is almost certain that the existing grassland is a fire maintained subclimax. The necessity of burning grasslands to maintain palatability is discussed. The effect of burning on soil erosion is mentioned.

ANIMAL PRODUCTION, BURNING FREQUENCY, BURNING SEASON, BURNING TRIAL, GRASSLAND, GRAZING, HERBAGE QUALITY, HERBAGE YIELD, HISTORICAL ACCOUNT, MANAGEMENT, NATAL, SOIL EROSION, SUCCESSION, THEMEDA, VEGETATION STRUCTURE

244. West O 1951. The vegetation of Weenen Country, Natal. Memoirs of the Botanical Survey of South Africa 23, 1-160.

See West 1943.

ANIMAL PRODUCTION, BURNING FREQUENCY, BURNING SEASON, BURNING TRIAL, GRASSLAND, GRAZING, HERBAGE QUALITY, HISTORICAL ACCOUNT, MANAGEMENT, NATAL, SOIL EROSION, SUCCESSION, THEMEDA, VEGETATION STRUCTURE

245. West O 1952. Plant succession and veld burning considered particularly in relation to the management of bushveld grazing. In : Veld Gold. National Veld Trust, Johannesburg. pp 65-80.

Bushveld is regarded as a stage in the plant succession where two competing communities, the bush and the perennial grassland, exist together in a delicate state of balance. Experimental results show that management systems designed to achieve and maintain a favourable balance between bush and grass should incorporate inter alia controlled burning at intervals of four

years to suppress bush encroachment and to "even up" the pasture.

DE-BUSHING, GRASSLAND, GRAZING, MANAGEMENT, SAVANNA, SUCCESSION

246. West O 1955. Veld management in the dry, summer-rainfall bushveld. In : The grasses and pastures of South Africa. D Meredith (ed). Central News Agency, Cape Town. pp 624-636.

The aim of veld management is to produce and to maintain that particular stage in plant succession best fitted both for utilization by domestic animals and as a protective cover for the soil under grazing.

From this viewpoint, veld management is discussed under the headings of plant succession, the effect of fire on the plant succession, plant succession and veld burning in grazing management, the essential requirements of veld management and practical systems for the management of bushveld grazing. Burning procedures to control bush encroachment are explained and subsequent management is discussed.

ANIMAL PRODUCTION, BURNING FREQUENCY, BURNING SEASON, DE-BUSHING, FIRE REGIME, GRASSLAND, GRAZING, HERBAGE QUALITY, MANAGEMENT, SAVANNA, SUCCESSION, TRANSVAAL

247. West O 1958. Bush encroachment, veld burning and grazing management. Rhodesia Agricultural Journal 55, 407-425.

This is a general discussion on the problem of bush encroachment into areas where the farming is based on cattle run extensively on veld grazing. Succession and the ecology of bush encroachment as well as the effects of fire on succession are dealt with. The fire regime and fire management to deal with bush encroachment problems are discussed and specific recommendations made.

DE-BUSHING, FIRE REGIME, GRASSLAND, GRAZING, MANAGEMENT, SOIL EROSION, SUCCESSION

248. West O 1962. Report of the sub-committee on bush and bush encroachment. A report to the eighth ordinary meeting of SARCCUS. African Soils 7(3), 301-312.

From answers to a questionnaire, it is clear that the Republic of South Africa views the problem of bush encroachment as a minor one. The opinion is that the general magnitude of the threat of bush encroachment has diminished considerably over the past 14 years as a result of improved farming methods.

The effects of bush encroachment, especially the effect on the carrying capacity of veld and the benefits derived from the ability to control bush are discussed. Progress made towards a solution of the bush problem is dealt with under headings of the correct farming system, management and measures which assist the effect of management such as the use of browsing animals, weeding, selective clearing, ring barking, poisoning, fire, mechanical clearing and the use of arboricides. The need for the establishment of coordinated research programmes is stressed.

ANIMAL INFLUENCE, DE-BUSHING, MANAGEMENT

249. West O 1964. Report of the sub-committee on bush control. Proceedings of the Ninth Ordinary Meeting of SARCCUS. pp 37-49.

The findings of the Regional Conference of SARCCUS were that in South Africa bush encroachment is a very serious problem particularly in the bushveld area and that insufficient information on the eradication and control of the invading bush species is available. It was recommended inter alia that research should be encouraged and further research initiated into the use of fire to control bush encroachment as well as the encroachment of undesirable shrubs, notably Elytropappus rhinocerotis and other. A report on the progress of research into veld management in the four provinces is submitted.

DE-BUSHING, ELYTROPAPPUS, MANAGEMENT

250. West O 1965. Fire in vegetation and its use in pasture management with special reference to tropical and subtropical Africa. Commonwealth Bureau of Pastures and Field Crops. Hurley, Berkshire. 53 pp.

The literature on early records of fire in tropical and subtropical Africa is reviewed. Observations by early travellers on the effects of fire on vegetation are recorded. Burning experiments conducted in South Africa, West Africa and East Africa are reviewed.

The experimental results of the effects of fire on air and soil temperature, on plants, on flowering and leaf growth, on chemical composition of herbage, on run-off and erosion, on water content of the soil, on organic matter and on chemical content of the soil are discussed.

The official attitude towards the use of fire in managing vegetation is outlined. Reasons for using fire in the management of natural pastures are given. Burning as a management practice is discussed in terms of resting, season of burning, fre-

quency of burning, paddocking, etc. The need for research into the technique of burning and controlling fires is stressed.

GRASSLAND, HERBAGE QUALITY, HISTORICAL ACCOUNT, MANAGEMENT, REVIEW, RUN-OFF, SAVANNA, SOIL CHEMISTRY, SOIL EROSION

251. White R E and D Grossman 1972. The effect of prolonged seasonal burning on soil fertility under Trachypogon - other species grassland at Frankenwald. South African Journal of Science 68, 234-239.

The chemical fertility of soil under a Trachypogon - other species grassland, after 38 years of seasonal burning, was compared with that of an unburnt control. Losses of organic carbon and total nitrogen in the burnt plots were unexpectedly small, but losses of exchangeable bases (Ca, Mg, K and Na) in the plant ash were large. The decrease in base saturation of the soil was greater after a spring burn, when rain fell in greater amounts and more intensely, than after a winter burn. Although erosional losses from a burnt area may affect an undisturbed part of the ecosystem, such losses will generally lead to a real decline in fertility, through the removal of nutrients in surface run-off into the drainage system.

BURNING TRIAL, FRANKENWALD, GRASSLAND, SOIL CHEMISTRY, SOIL EROSION, TRANSVAAL

252. Wicht C L 1948a. Hydrological research in South African forestry. Journal of the South African Forestry Association 16, 4-22.

Progress made at the Jonkershoek Forest Influences Research Station in the Cape Province, the establishment of which was recommended by the Empire Forestry Conference in 1935, is described. A second research station, being established at Cathedral Peak in Natal, is briefly referred to. Surveys of site factors, technique of observations on rainfall, streamflow, net rainfall under forest canopies, infiltration, evaporation and transpiration, treatments being investigated (including afforestation, veld-protection, broadcast burning with and without grazing) and design and interpretation of streamflow experiments, are discussed.

The importance of streamflow investigations is specially stressed, and it is recommended that such research should be greatly extended, not only to test the effects of various forms of land management, but also to provide essential data on water supplies.

AFFORESTATION, CAPE, CATCHMENT, CONSERVATION, FOREST, NATAL, RUN-OFF, WATER YIELD

253. Wicht C L 1948b. A statistically designed experiment to test the effects of burning on a sclerophyll scrub community. I. Preliminary account. Transactions of the Royal Society of South Africa 31, 479-501.

After an introductory discussion of the application of statistical methods in plant ecological research, a statistically planned experiment to test burning of sclerophyll scrub vegetation in spring, summer and autumn months at the Jonkershoek Forest Research Station, Stellenbosch, Cape Province, is described. Preliminary analyses show the variability of the vegetation on the experimental site and give an advance indication of the sensitivity of the experiment.

Results of burning carried during January to April, as observed in the succeeding winter and spring, are presented and discussed. It is proposed to publish further accounts of experimental results from time to time. The description of the experiment indicates some of the ways in which statistics can be used in order to advance the study of South African vegetation from the descriptive to the analytical stage.

BURNING SEASON, BURNING TRIAL, CAPE, FYNBOS, VEGETATION STRUCTURE

254. Wicht C L 1959. The management of water catchments. African Soils 4(3), 20-51.

The report, prepared for the fifth meeting of the Southern African Regional Committee for Conservation and Utilization of the Soil (SARCCUS), held in Windhoek, South West Africa in 1957, refers to the need for the application of hydrology in the management and conservation of water catchments. The importance of the holistic approach, treating catchments as ecosystems is emphasized. Practical catchment management measures including fire management are listed with indications of the objects of management they serve. The paucity of hydrological data is mentioned and the need for more biohydrological research is stressed. A procedure for achieving efficient water catchment management within a region is outlined.

CATCHMENT, CONSERVATION, MANAGEMENT, WATER YIELD

255. Wicht C L and C H Banks 1963. Die invloed van beheerde brand en bebossing op die wateropbrengs van bergopvanggebiede in die winterreënstreek (The influence of controlled burning and afforestation on the water yield of mountain catchment areas in the winter rainfall area). South African Geographer 2(2), 23-29.

The hypothesis that the magnitude of the hydrological influence of vegetation is directly proportional to the density thereof

is tested in the light of three possible management regimes on catchment areas not used for agricultural purposes, viz complete protection, controlled burning without grazing and afforestation. Results of research in the winter rainfall areas having a bearing on this subject are briefly reviewed.

Complete protection of fynbos in the mountains against fire, which would then be an unnatural situation, will lead to dense climax associations and ultimately forest in high rainfall areas. Such protection will cause the greatest moisture losses to the atmosphere and greatest retention of moisture in the catchments. This management method must be considered the most important flood control mechanism.

Controlled burning without grazing controls plant succession and in that way could increase total run-off and may be necessary for the most efficient control of water yield. Afforestation has a similar effect to that of complete protection while also having a possible economic advantage.

AFFORESTATION, BURNING TRIAL, CAPE, CATCHMENT, CONSERVATION, FYNBOS, MANAGEMENT, REVIEW, RUN-OFF, SUCCESSION, WATER YIELD

256. Wicht C L and F J Kruger 1973. Die ontwikkeling van bergveldbestuur in Suid-Afrika (The development of mountain veld management in South Africa). South African Forestry Journal 86, 1-17.

The development of vegetation management in the humid mountain catchments of South Africa is described. The vegetation comprises grass and fynbos veld types with scattered forest remnants and is of little agricultural value.

The role of fire in influencing official policy and legislation and determining the conservation measures applied in mountain veld is discussed.

The historical development of management in catchment areas is discussed. Management of mountain veld as prescribed in official policies was ecologically negative and aimed chiefly at protection against fire and grazing.

Experience gained in applying extensive, total fire protection, favoured by the fire protection committees, indicated a need to change the policy. This was supported by observations of the effects of fire in fynbos and the results of pasture research in grassland. Controlled burning was approved by the Department of Forestry in 1948 in the southern Cape, though mainly as a measure for protection of forests and plantations. Fire has since been used tentatively as a measure for rehabilitation of rare fire-adapted plant species. A policy of controlled burning could not be fully implemented because of uncertainty

about burning rotation and season, but such a policy was formally adopted by the Department in 1968 and guidelines on where, when and how frequently to burn were laid down.

Future management plans for mountain veld to be implemented by the Department of Forestry are discussed.

CAPE, CATCHMENT, CONSERVATION, FYNBOS, LEGISLATION, MANAGEMENT

257. Wicht C L and Y R de Villiers 1963. Weerstoestande en brandgevaar by Hermanus (Weather conditions and fire danger at Hermanus). South African Geographer 2(3), 25-36.

A brief account is given of publications dealing with deductions of objective forest fire danger rating in South Africa from meteorological observations.

In this article an attempt is made to deduce from information available from Hermanus which weather conditions contribute to fire danger and to determine to which degree the knowledge about local weather phenomena can be used in the planning of precautionary measures against the start and spread of fires.

An account is given of metereological observations made at Hermanus. Climate, rainfall, temperature, sunshine, dry or rainless periods and wind are discussed in some detail.

An account of recorded disastrous fires at Hermanus is given. Conclusions of an analysis of the weather phenomena which reigned during these fires are :

- a dry period of ten days is a warning that fire hazard weather is developing
- a dry period of 15 days or longer indicates acute fire hazard weather
- a decrease in humidity and pressure, without the occurrence of rain, indicates the coming of a berg wind and that fire hazard weather is developing
- an increase in wind speed from the north and north-west without accompanying rain creates serious berg-wind fire hazard weather.

The authors suggest that these local investigations should be undertaken in other areas.

CAPE, FIRE BEHAVIOUR, FIRE DANGER RATING, FYNBOS, HISTORICAL ACCOUNT

258. Wroughton F H 1948. To burn or not to burn. Journal of the South African Forestry Association 16, 76-78.

An account is given of the adverse effects of fire exclusion on the natural regeneration of teak in the mixed forests of Burma. In view of these facts it is suggested that under certain conditions fire might be beneficial in South African forests.

Examples are given of the ways in which complete exclusion of fire in open areas may be harmful. Instead of attempting to eliminate fires completely, a technique for the controlling of the harmful effects of fire is suggested.

FOREST, MANAGEMENT

# KEYWORD INDEX

## TITLES IN THIS SERIES

1. *A description of the Savanna Ecosystem Project, Nylsvley, South Africa. December 1975. 24 pp.

2. *Sensitivity analysis of a simple linear model of a savanna ecosystem at Nylsvley. W M Getz and A M Starfield. December 1975. 18 pp.

3. *Savanna Ecosystem Project - Progress report 1974/1975. S M Hirst. December 1975. 27 pp.

4. Solid wastes research in South Africa. R G Noble. June 1976. 13 pp.

5. *Bibliography on marine pollution in South Africa. D A Darracott and C E Cloete. June 1976. 131 pp.

6. *Recycling and disposal of plastics waste in South Africa. R H Nurse, N C Symington, G R de V Brooks and L J Heyl. June 1976. 35 pp.

7. South African Red Data Book - Aves. W R Siegfried, P G H Frost, J Cooper and A C Kemp. June 1976. 108 pp.

8. South African marine pollution survey report 1974-1975. C E Cloete and W D Oliff (editors). September 1976. 60 pp.

9. Modelling of the flow of stable air over a complex region. M T Scholtz and C J Brouckaert. September 1976. 42 pp.

10. Methods and machinery for pulverising solid wastes. M J Simpkins. October 1976. 29 pp.

11. South African Red Data Book - Small mammals. J A J Meester. November 1976. 59 pp.

12. Savanna Ecosystem Project - Progress report 1975/1976. B J Huntley. March 1977. 41 pp.

13. Disposal and recovery of waste paper in South Africa. G R de V Brooks. April 1977. 35 pp.

14. South African Red Data Book - Fishes. P H Skelton. July 1977. 39 pp.

15. A checklist of the birds of the Nylsvley Nature Reserve. W R Tarboton. September 1977. 14 pp.

16. Grondsoorte van die Nylsvley-natuurreservaat. H J von M Harmse. September 1977. 64 pp.

17. Description and manual for the use of DRIVER - an interactive modelling aid. P R Furniss. September 1977. 23 pp.

18. South African Red Data Book - Large mammals. J D Skinner, N Fairall and J du P Bothma. November 1977. 29 pp.

19. Introducing you to satellite operated Data Collection Platforms (DCP's). C C Stavropoulos. September 1977. 9 pp.

20. A phytosociological classification of the Nylsvley Nature Reserve. B J Coetzee, F van der Meulen, S Zwanziger, P Gonsalves and P J Weisser. December 1977. 31 pp.

21. An annotated checklist of the amphibians, reptiles and mammals of the Nylsvley Nature Reserve. N H G Jacobsen. December 1977. 65 pp.

22. Cooperative National Oceanographic Programme. SANCOR. January 1978. 19 pp.

23. South African Red Data Book - Reptiles and amphibians. G R McLachlan. February 1978. 53 pp.

24. Guidelines for the disposal of dangerous and toxic wastes so as to minimize or prevent environmental and water pollution. R T Rudd. January 1978. 12 pp.

25. Richards Bay mesometeorological data. Vertical profiles of air temperature and wind velocity and surface wind statistics. M T Scholtz, E T Woodburn, C J Brouckaert and M Mulholland. March 1978. 104 pp.

26. Studies of mineralization in South African rivers. G C Hall and A H M Görgens (editors). March 1978. 24 pp.

27. Nylsvley - A South African Savanna Ecosystem Project : objectives, organization and research programme. March 1978. 37 pp.

28. A description of the Fynbos Biome Project. June 1978. 25 pp.

29. Savanna Ecosystem Project - Phase I summary and Phase II progress. B J Huntley and J W Morris. July 1978. 52 pp.

30. Review of Coastal Currents in South African Waters. T F W Harris. August 1978. 106 pp.

31. Report of the Task Group on Fermentation Technology. R J Andrews, J A de Villiers, P M Lategan, F G Neytzell-de Wilde and J P van der Walt. September 1978. 16 pp.

32. South African programme for the SCOPE mid-term project on the ecological effects of fire. September 1978. 36 pp.