

Fire: Its Effect on Grasslands, Including Swamps—Southern, Central and Eastern Africa

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INTRODUCTION

THE aspects of fire described in this paper relate to a very large area. The contents are based on the results from experiments and observations carried out in Southern, Central and Eastern Africa for many years.

Conditions vary greatly, climatically, topographically and in vegetation types and soils. They range from coastal regions with variable grassland–woodland formations to high altitude mountain grassland and woodland associations. There are extensive inland plateaux supporting mixed vegetation communities. There are extensive flood plains associated with large drainage systems. These are subjected to various degrees of inundation. Some flood plain areas are relatively dry while others are under permanent swamp and lagoon.

Due to the extent and complexity of this subject, it is only possible to deal with relatively few aspects.

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Fires are cleansers as well as destroyers. Nature gives of her bounty and if man does not use it to the utmost, he is left with a residue that, in course of time, becomes a hazard.

In most parts of Africa there is no rain for about 8 months of the year. People wait and pray for rain so that crops and pastures may grow.

Growth is rapid during the rainy season. Herbage, surplus to grazing requirements, should be converted into hay and silage while it is still young and nutritious. Tall coarse stemmy grasses lose their nutritional value on maturing and are not readily grazed. Grass of inferior quality, unsuitable for fodder, can be used for bedding, compost or packing.

If it cannot be utilized in any way, what is to happen to it?

Many of the areas under consideration are very sparsely populated and are only used intermittently for grazing or limited arable agriculture.

In the more densely populated areas the question of burning hardly arises because there is seldom anything to burn. Some parts have been so badly denuded that the major problem now is re-establishment of useful vegetation cover to provide some protection to the bare soil surface.

It is neither wise nor desirable to leave excessive quantities of dry stemmy unpalatable grass from season to season.

With sound planning and good management all available herbage on the land should be utilized. If this is done, there would be no burning problem.

People who object to fire under all circumstances do not seem to understand that they oppose the burning of redundant useless dry herbage. They could concern themselves more profitably with the proper utilization of herbage.

BACKGROUND

GENERAL

Reference to burning and its effect on vegetation is made by early travellers and explorers.

In Southern Africa it is mainly during the past half century that

the effects of fire on vegetation has been questioned and investigated. Action was initiated by a few people working on vegetation problems. To mention but a few: Dr. I. B. Pole-Evans, Dr. John Phillips, Dr. E. P. Phillips, Professor J. D. Scott and Mr. R. R. Staples. Increasing numbers of personnel entered the ecological, grassland, wild life and forest management fields. The list of interested people lengthened, at first gradually, and later rapidly.

It is interesting to look at the bibliography list of just one paper: I refer to the paper "Fire—as a Master and Servant: Its Influence in the Bioclimatic Region of Trans-Sahara Africa" by John Phillips, published in the Proceedings of Tall Timbers Fire Ecology Conference, no. 4, 1965, pp. 7–109. Two hundred and ninety references are quoted to articles related to the subject of burning. It unfolds the history of the Southern and Eastern African fire ecology in a few pages.

Rulings based on preconceived ideas and dogmatic action in their application can create gross misunderstanding and confusion. A glaring example is described by Schiff on Administrative travail in his chapter on Forest and Fire 1962.

It demonstrates the embarrassment that can be created if a problem is not liberally and rationally approached with an open mind and with willingness to consider views and findings which might throw new light on old problems.

The most striking and appalling phenomenon is the extensive devastation of woodlands, forests and plantations by fire in America, Canada, Australia and Africa, in spite of rigorous fire exclusion policies. Schiff quotes an example where a 17,000 acre blaze gave impetus to protective burning.

INVESTIGATIONS

One of the earliest descriptions of investigations of the effect of burning on vegetation is by E. P. Phillips in 1920. It is a description of experimental plots at Groenkloof near Pretoria in South Africa.

Professor John Phillips' efforts and deep interest in fire problems from the twenties onwards, in the Knysna area of South Africa, in Tanganyika, later throughout Southern Africa and beyond, contributed greatly to the furtherance of knowledge and the under-

standing of the fire complex. Under his direction and guidance and with the aid of a number of his students, burning trials and fire studies were initiated in most of the major vegetation types in South Africa. Observations were also made on every burnt field that was noticed. Areas which escaped fires were also closely observed to study the effects of exclusion of fire for various periods and the effect of subsequent burning. Interesting examples were located around the perimeters of plantations and fenced fields, where the period of protection could be related to the time when the trees were planted and the areas fenced.

Other investigations were initiated in Southern, Central and East Africa, with different objects in view and with different aspects of bias. It probably depended upon whether such experiments were designed by foresters, wildlife conservationists, grassland workers and agriculturalists. Even where all attempts were made to exclude any bias in the experimental outlay, it is only logical that there would be biased attitudes with respect to various interpretations. It is therefore understandable that a certain amount of confusion is likely to persist and that entire agreement on all aspects of this subject are not always achieved. Being such a complex subject, there are invariably also subsidiary factors which influence the situation under various circumstances.

There existed a determined attitude that fire is bad. In spite of evidence from experimental work, there persisted a tendency to exterminate fire rather than to use it. This attitude basically and theoretically might be desirable but it is not applicable in practice. Hence there is necessity for a better understanding and a compromise until such time as a better standard of vegetation management can be achieved.

Dr. Shantz (1958) published some very interesting photographic comparisons of vegetation changes in Southern, Central and East Africa over a period of 37 years. These ranged from arid situations, to medium rainfall areas with woodland and tall grass, to high rainfall areas with tropical rain forest. The major factors of influence were a combination of settlement, grazing and fire.

In general, there is a tendency for woody plants, notably thorny species and succulents, to increase, particularly in arid areas. In

many situations this is due to the exclusion of fire to an increasing extent due to heavy continuous grazing. Shantz concludes, however, that succulent trees and forbs become dominant where fires are excessive. Buechner in a note on the causes of vegetational changes on Butiaba flats and the adjacent escarpment, in the same paper, concludes that the thickening up of a woody vegetation in that part of Uganda seems to have resulted from elephant browsing and the elimination of fire. The increase in *Acacia hockii* he considers resulted primarily from a change in fire pattern to one of early burning.

Vogl describes the effects of spring burning on forage yields in North Western Wisconsin in 1965:

“Spring burning of brush prairie savanna produced more than 1,000 pounds per acre increase in green herbage, with a three-fold increase in grass and forb yield. Green herbage was more productive, palatable and desirable to herbivores when burning increased the water content. The removal of dead herbage stimulated earlier and more vigorous growth and made forage more accessible to herbivores.

Dead herbage comprised about 90 percent of the total yield of stands unburned for 25 years.

Periodic burning prevents prairie savanna from becoming decadent, helps maintain maximum productivity and is important in retarding woody growth”.

Shepherd in a Range and Pasture Management report, F. A. O. TA 2468 1968, considers that: “learning how to use fire effectively and beneficially presents a challenge to range management and research.”

Progressively there has been a growing appreciation that fire should be utilized to dispose of unused herbage. A great deal of light has been thrown on the adaptation of the use of fire to serve various situations under different conditions.

During the thirties investigations on burning were vastly extended throughout Southern, Central and East Africa, the United States of America and in other countries. The objects of most experiments centered around the effect of fire on plants to assess

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whether burning was detrimental or not and the time of burning, to establish whether burning would be more detrimental to plant growth at certain times than at others.

West, (1965) analyzed the reasons for using fire in the management of natural pastures. He mentions that in South Africa, Scott (1947), gave four reasons for the use of fire in veld management:

- 1) To burn off the unpalatable growth left over from previous seasons growth which would not be touched by livestock and which, if not removed, would tend to become moribund and die out.
- 2) To stimulate growth during seasons when there is little green grazing and thus provide green food for stock at a time when it does not occur naturally.
- 3) To destroy parasites such as ticks which carry and transmit stock diseases.
- 4) To control the encroachment of undesirable plants.

In the United States of America Campbell (1960) endorsed these reasons and added six others:

- 5) To aid in better distribution of animals on the range. Livestock tend to concentrate on favourite areas. Judicious burning of outlying areas attracts the herds and promotes even distribution of grazing over the range as a whole.
- 6) To remove the fire hazard of accumulated old grass.
- 7) To establish fire breaks in developing a system of protection from wild fire.
- 8) To prepare a seed-bed for natural or artificial seeding of desired forage species.
- 9) To stimulate range or pasture grasses to produce seed.
- 10) To encourage the growth of native legumes for forage and soil improvement.

It is pointed out that the relative importance of these reasons varies with the type of pasture and its successional status. The effects of fire are modified by grazing and a strong interaction exists between the intensity of grazing and the efficiency of fires in controlling the encroachment of woody species.

TIME OF BURNING

Grass burning trials initiated by Staples in Southern Tanganyika in 1931 were summarized by the author in 1952. The objects of the investigations were to study the effects of burning on the quality of the pasture, to determine the optimum frequency and best time of the year for burning. It was evident that it would be impossible to eliminate burning except with closer settlement and heavy stocking. It was considered desirable to burn to obtain palatable young grass and to destroy parasites.

It was found that complete protection from burning and grazing for 24 years rendered the pasture most unattractive. It resulted in an accumulation of dead herbage which smothered fresh growth and caused deterioration to the crowns of grasses. Burning of areas protected for a number of years cause much damage to the vegetal cover by killing off the plant tussocks and leaving large bare spaces. Pastures which are not mown or closely grazed should therefore be burnt periodically to maintain their vigour, palatability and nutritive properties.

LATE DRY SEASON BURNING

The late dry season seemed to be the optimum time to burn. The plots burnt in October (Fig. 1) every year or every second year produced the densest, tallest and most vigorous grass growth. With grazing, the effectiveness of burning would depend upon the amount of herbage left ungrazed (Fig. 2) and this factor would determine the frequency of burning. The results from burning experiments throughout Southern Africa have repeatedly confirmed these findings. Scott strongly advocates burning immediately after the first rains, a method which seems to have merit, but it is sometimes difficult to apply in practice due to the time factor and weather conditions.

The rainy season commences between September and November, but in some areas it is very erratic and most precarious. During some seasons the rain begins exceptionally early while in other years it is delayed until the end of December. There are also big variations in the amount of rain and the distribution. It is therefore difficult to lay down an exact time table. October may be adopted as a



FIG. 1. Burning of vegetation. A vigorous growth of grass after burning in October every second year in grass burning trials on the Morale pasture research station near Mahalapye. The pasture is open underneath the bushes and trees. The grass is readily accessible to stock. The grasses include *Cenchrus ciliaris*, *Digitaria eriantha*, *Eragrostis rigidior*, *E. superba*, *Schmidtia pappophoroides*, and *Brachiaria nigropedata*. The woody species include: *Acacia tortilis*, *Acacia fleckii*, *Acacia nigrescens*, *Boscia albitrunca*, and *Dichrostachys cinerea*.

general guide but the exact choice of time will have to be decided on the spot, taking into consideration local conditions and circumstances.

MID DRY SEASON BURNING

Burning at this time of the year, June to September, must be strongly condemned. In the first instance grazing animals are deprived of their fodder supply at the crucial time of the year. The plants start growing and then die back due to lack of adequate moisture or they are defoliated. Their reserves are depleted and they are weakened. Furthermore, the burnt tussocks and the surrounding bare ground are exposed to the sun, wind and frost prior to the onset of the rains.



FIG. 2. Burning of vegetation. A control plot protected against burning and grazing since 1959, in grass burning trials on the Morale pasture research station near Mahalapye. The grass is old coarse and decaying. A large proportion of the pasture is covered by thorn bushes and inaccessible to livestock. The condition of the grass and the basal cover are poorer than on the burnt plots. After 11 years protection the grazing has largely been lost.

The grasses include: *Brachiaria nigropedata*, *Cenchrus ciliaris*, *Digitaria eriantha*, *Eragrostis rigidior* and *Eragrostis superba*.

The woody species include: *Acacia mellifera*, *Acacia fleckii*, *Acacia tortilis*, *Combretum apiculatum* and *Dichrostachys cinerea*.

EARLY DRY SEASON BURNING

Burning at this time of the year, April–May has been advocated by Forestry Departments. It generally results in a slow patchy burn that is not as devastating to woody plants as burning later in the dry season. It affords a certain amount of protection and makes it easier to control fires later in the season. This measure has met with various degrees of success or failure, depending upon interpretation. In areas where it was associated with grazing, there was encroachment of woody species until eventually the grasses were eliminated. This resulted in the exclusion of fire and sometimes in the develop-

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ment of bush thicket unsuitable for grazing and equally useless for profitable forestry utilization.

Examples of this type of habitat deterioration in Botswana are described by Child in an F. A. O. Ecological Survey report of Northeastern Botswana, 1968 with excellent illustrations of the deterioration of woodland and grassland associations until they degenerate into useless impenetrable thorny bush thickets and bare ground.

This situation is also described by Tinley (1966).

There are specialized conditions under which early dry season burning is recommended. In swamp grassland or tussock grassland, in areas where the rainfall is high or where moisture relations are favourable, early burning produces a considerable amount of regrowth suitable for dry season grazing. This situation occurs for example in the Kafue National Park in Zambia. Poachers have cashed in on this situation and by burning outside the park boundaries they have attracted the game away from the park for slaughter at their convenience.

A planned burning and improvement programme on selected areas inside the park would counteract this process to a large extent. It would not only save the animals, but would also enhance tourism by having the game on show within easy reach of the game camps.

Burning experiments within the park boundaries have indicated the benefits which can be derived from controlled burning and have demonstrated the effects of accumulation of unused coarse dry herbage protected against burning for several years.

Some of these aspects were described in an article on the effect of fire on vegetation, 1969.

THE EFFECT OF BURNING ON DIFFERENT VEGETATION TYPES

FOREST AND PLANTATIONS

Fire should be excluded from rain forests and from plantations. Adequate precautionary control measures and strict management practices have to be applied to minimize risks of careless accidents.

UPLAND WOODLANDS AND GRASSLANDS

These are most variable in composition and nature ranging from valley tall hyparrhenia–andropogon valley grasslands and woodlands to short, dense mountain grassland with *Themeda triandra* and other species. The various areas are all differently affected by climatic conditions: rainfall, drought periods and frost. To a very large extent the burning pattern is of an accidental nature and most irregular.

The important aspect is the utilization pattern and it is only with the aid of a utilization plan that a suitable burning programme can be designed.

FLOOD PLAIN AND SWAMP

The flood regime of the Okavango swamps in north western Botswana is similar in some respects to that of the Kafue River basin in Zambia. Maximum flooding, in both cases, takes place in the middle of the dry season. The flood waters originate from remote catchment areas and from extensive natural storage systems.

A regime of this nature would have many advantages if flood water control and systems of land development were co-ordinated to achieve improved systems of land use. Under prevailing conditions there is much wastage in the midst of potential plenty.

It is a characteristic feature that many swamp grasses and sedges are rhizomatous. The rhizomes or underground stems are magnificent storage organs. They are located safely underground or underwater and cannot be easily damaged by fire. It is therefore not surprising that these plants can withstand fire and produce valuable out of season pastures. They can produce early or late growth depending upon the time of burning, because they are stimulated by burning, and moisture is not generally a limiting factor in their favourable environment.

Damage is only caused to a limited extent in relatively dry situations or where fire is excluded for very long periods when the rhizomes may be destroyed and the plants damaged.

Rhizomatous swamp and swamp edge species include: *Acroceras macrum*, *Cynodon dactylon*, *Cyperus papyrus*, *Oryza longistaminata*, *Panicum repens*, *Phragmites mauritianus*, and *Typha latifolia*.

Herbage utilization is very poor due to the flooding pattern. Under these circumstances, maximum benefit cannot be derived from favourable moisture conditions and fertile soil which produces prolific seasonal herbage growth. Frequently the herbage is of poor quality after flooding. Much of it is coarse and dry or covered with mud and in a state of decay.

Utilization is also complicated due to the occurrence of tsetse fly in some areas.

Okavango Swamps:—The Okavango swamp and flood plain complex situated in north western Botswana covers approximately 6,000 square miles. The Okavango river is fed from the Angolan highlands. The flood water that enters the Okavango system from about February reaches Maun and Lake Ngami about June and the Rakops-Mopipi area, adjacent to the southern fringe of the Makarikari depression, about July.

Apparently the river systems in this region previously discharged across the African continent in southern and south-easterly directions, into what now seems to be largely fossil rivers feeding into the Orange River and into the Shashe-Limpopo complexes. These southerly and south-easterly flows were deprived and cut off by changes in the drainage pattern caused by geological faulting in the central area. This disturbance resulted in much of the water being blocked and trapped in the Okavango swamps. When the swamps fill, dry season outflow takes place to Lake Ngami and down the Boteti River to Lake Xau and the Makarikari depression.

Burning follows the sequence of drying up of vegetation along the different zones of elevation. Fires burn locally with clouds of smoke billowing out over the incineration centres, a process which continues for months. Due to the dense smoke, the fires can be seen miles away.

An attempt seems to be made to burn the flood plain vegetation along some of the swamp margins before the dry season flood water inundate the low-lying areas for about three months. Much burning was in progress in this area during June–July 1970 as the increasing volume of water from the Okavango swamps was moving down to fill the dry river beds and inundate the flood plain margins.

Lake Ngami:—Apart from the immediate lake edge, the vicinity of Lake Ngami is completely denuded of pasture.

The Okavango swamps nearby to the north produces flood plain and swamp vegetation in profusion. In the southern sector the herbage is grazed but further north it is inaccessible due to tsetse fly and it is burnt.

Kafue River Flood Plain, Zambia:—Gross wastefulness is the most striking feature. Vast quantities of herbage grow prolifically year after year, on moisture-laden fertile extensive flood plains. Most of this is burnt year after year. Even in the most extensively used areas only a small portion of the annual herbage growth is utilized by stock and only a small amount is consumed by game.

On most of the flood plains the picture is dismal. During flooding the herbage is submerged. By the time the water recedes the grasses are stemmy and coarse. The herbage is covered with a layer of mud and is in a partial state of decay. The tall aquatic grasses collapse when the water recedes. They are covered with mud, trampled, spoilt and wasted for grazing.

Oryza longistaminata, *Echinochloa stagnina*, and *Leersia hexandra*, on drying, cover the ground with a thick mat of coarse straw which is unpalatable and of poor feeding quality.

Cattle have been observed to move some of this straw with their horns and mouths to reach young grass shoots underneath (Fig. 3).

Fires sometimes spread over large areas of flood plain before the grass is dry. This results in incomplete patchy burns. The leaves are singed but coarse stems of large tussock grasses remain standing. These include species such as *Setaria avettae*, *Echinochloa pyramidalis*, and *Vetiveria nigriflora*. After burning, fresh green shoots develop, and some grazing becomes available for livestock and game but the animals have to extract young shoots from among the coarse charred stems of the large tussocks.

Along the river banks and lagoons grazing conditions are generally good. Cattle wade into the water to graze. Partly submerged stems and foliage of prostrate floating grasses such as *Vossia cuspidata* and *Echinochloa stagnina* are intermingled with tussock grasses such as *Vetiveria nigriflora* and *Echinochloa pyramidalis*.

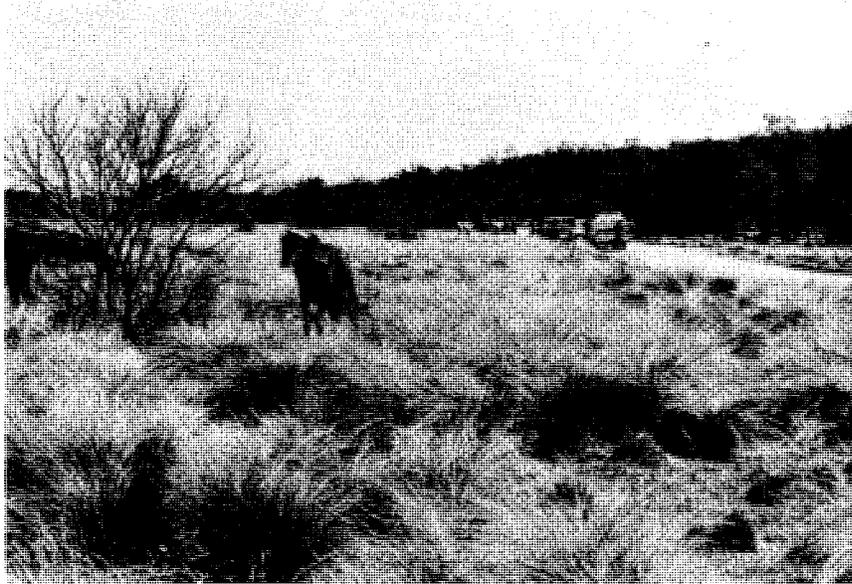


FIG. 3. Grassland in need of burning—Manyana, Eastern Botswana. Dry coarse, unpalatable *Aristida junciformis* on poor leached sandy soil along quartzite ridges. Note the poor condition of the cattle trying to reach green shoots of what remains of more palatable species such as *Digitaria milanjana* and *Cynodon dactylon* at the bottom of the dry tussocks. In a case like this burning in April–May to encourage green growth might have been justifiable. The pasture would greatly benefit from burning in October–November to dispose of the old dry tussocks. The trees include *Peltophorum africanum*, *Terminalia sericea*, and *Burkea africana*.

Burning of flood plain and swamp vegetation generally follows the topographical sequence and takes place in belts, more or less following the contours or elevation zones, which frequently determines the rate of dessication. It commences on high lying ground with shallow soil and in wooded grassland which dries out rapidly at the end of the rains. As each succeeding belt of soil and vegetation towards the flood plain, and on the flood plain, dries out, the zones of burning are extended. The pattern is irregular due to surface irregularity, variable soil, and vegetation types. If the seasonal rainfall is high or if the rains continue until late, burning is delayed compared with dry years. The extent of a burn also depends upon wind

velocity, wind direction, time of day, dryness of grass, location of area, and other factors. The dates of previous burns and the amount of dry inflammable herbage that accumulated are also important influencing factors.

In places where there is no grazing and where fires do not occur for several seasons, dry grass accumulates to such an extent that subsequent burning may take place at any time, even during dry spells in the rainy season. Along swamp edges and riverbanks and on flood plains, accumulated dry herbage burns above the water surface. It leaves an unfinished messy burn. Burning of dry grass above the surface of standing water is a common phenomenon on the Kafue flats. This forms a marked contrast with fierce dry season burns when combustion is complete, and a mass of loose deep ash remains on the ground.

SUMMARY AND CONCLUSIONS

APPLICATION OF FIRE

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 (Fig. 4). 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 (Figs. 5-7).

Utilization of flood plain and swamp (Figs. 8-9) grassland is

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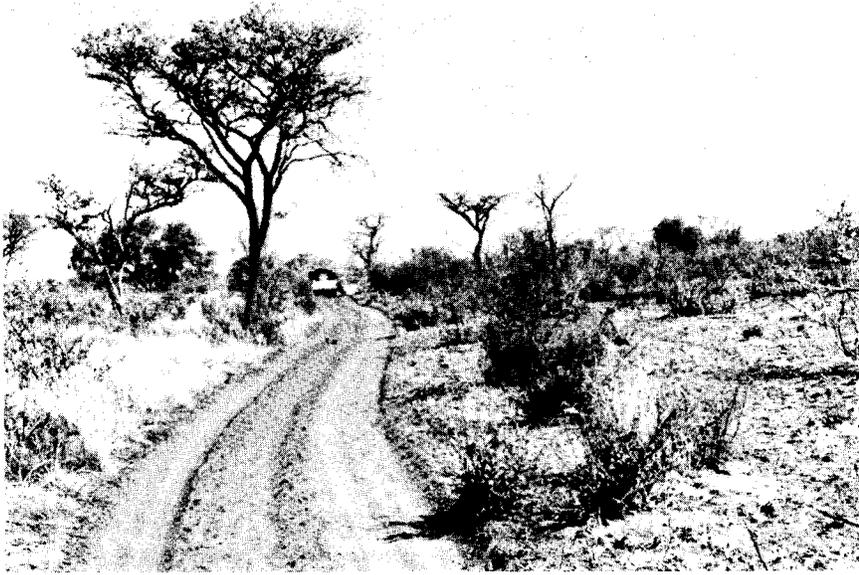
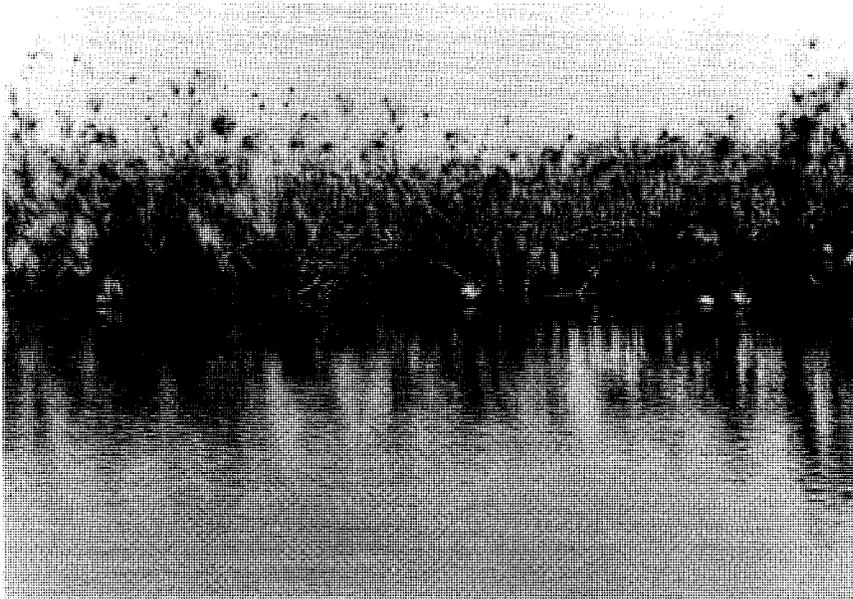


FIG. 4. The effect of fire on vegetation: Mahalapye—Lephephe, Botswana. Fairly open grassland maintained through relatively light stocking, due to distance from water, and periodic fire. The grass is dominantly *Aristida stipitata* with *Digitaria milanjiana* and *Schmidtia pappophoroides*. Trees and woody growth include *Acacia giraffae*, *Peltophorum africanum*, *Terminalia sericea*, *Ozoroa paniculata*, *Acacia fleckii*, *Combretum hereroense*, *Boscia albitrunca*, *Elephantorrhiza elephantina*, *Tarchonanthus camphoratus*, and *Maytenis tenuispina*.

FIG. 5. The effect of fire on vegetation: Untimely burning. Moyabana, Eastern Botswana. An April burn in *Terminalia sericea* woodland on sand, 14 miles north west of Kalamare. Burning of semi-arid areas at this time of the year is detrimental to grass growth. Prevalent species include *Aristida stipitata*, *Eragrostis cilianensis*, *Schmidtia pappohoroides* and *Digitaria milanjiana*, *Dichrostachys cinerea*, *Bauhinia macrantha*, *Strychnos pungens*, *Ziziphus mucronata* and *Clerodendrum lanceolatum*. Some *Burkea africana* trees were damaged and killed.

FIG. 6. The effect of fire on vegetation: Mahalapye—Lephephe, Botswana. Early dry season burning in these areas is not advisable. Burning in *Terminalia sericea* woodland on sand, 48 miles west of Mahalapye. Area on left unburnt, area on right burnt in January 1970 in tussock grassland with *Aristida stipitata*, *Eragrostis rigidior* and *Schmidtia pappophoroides*. The tall tree on the left is *Burkea africana*. Other species include *Acacia fleckii*, *Commiphora pyracanthoides*, *Ochna pulchra*, *Grewia flava* and *Peltophorum africanum*.

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FIG. 7. The effect of fire on vegetation: Untimely burning, Artesia, Eastern Botswana. A May burn-in *Terminalia sericea* woodland on sand. Burning at this time of the year, in semi-arid areas, is most detrimental to pasture. The burnt stubble is exposed throughout the very long dry season, May to November, to cold frosty weather followed by scorching heat later. The grass tussocks are weakened and killed. In cases where fire is required to remove ungrazed coarse grass, burning should be delayed until October–November.

Peltophorum africanum on left, *Grewia flava* in foreground and a relatively large *Acacia giraffae* on the right. The grasses include *Digitaria milanjiana*, *Antheophora pubescens*, *Stipagrostis uniplumis* and *Eragrostis pallens*.

FIG. 8. The effect of fire on swamp vegetation: Okavango River, Botswana. River channel between Saronga and Boro junction with partly burnt *Cyperus papyrus*. A fairly recent burn. Due to its strong rhizomatous growth and wet habitat, periodic burns are not detrimental to papyrus but a burn following the exclusion of fire for a long period would damage the rhizomes in places which are relatively dry.

FIG. 9. Burning of Swamp and Riverine vegetation. Cattle grazing in the Boteti river at Motopi where the water is receding. The riverine vegetation includes *Typha latifolia*, *Pycneus mundtii*, *Cyperus articulatus*, *Cyprus esculentus* and other sedges. *Panicum repens*, *Cynodon dactylon* and other grasses are abundant along the river banks and provide excellent grazing.

The swamp vegetation along the river was burnt in June just prior to the arrival of the flood water from the Okavango swamps. This encouraged fresh herbage growth along the Boteti River.

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complicated due to unmanageable growth during inundation (Figs. 10–12). The fertile soil supports a number of valuable pastures species and when the floods recede soil moisture conditions are favourable for growth. The useful grazing season can be considerably extended under suitable management. The productivity of such grasslands can be greatly improved by planned burning to obtain better utilization of herbage.

Burning experiments conducted over a long period in many different places have provided many valuable basic data. It is now possible to place much of this information in perspective and to relate it to specific problems, applicable to different conditions and circumstances.

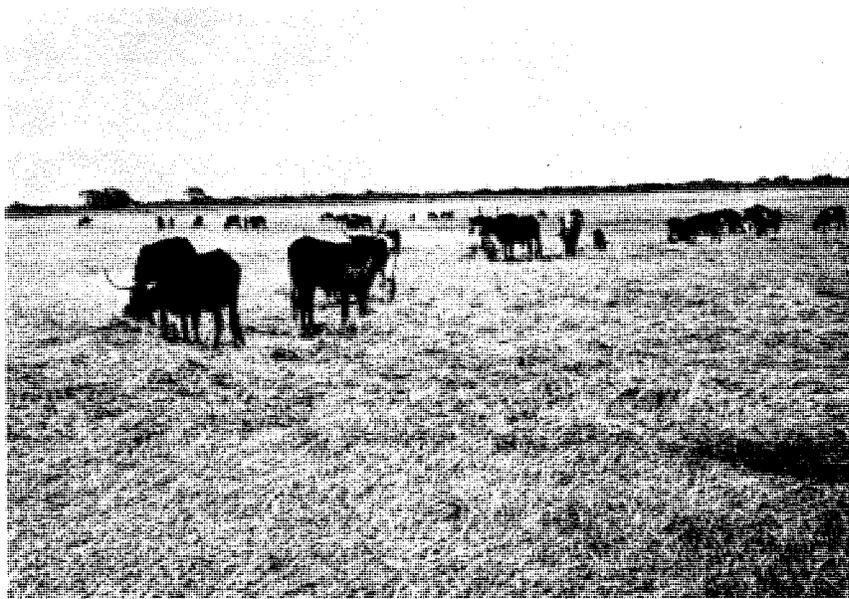


FIG. 10. Burning flood plain grassland, Baunza and Kafue River Junction, Namwala, Zambia. Massive *Oryza longistaminata*, *Echinochloa stagnina* and *Vossia cuspidata* herbage collapses after the receding floods. The coarse dry herbage is unpalatable to stock. They borrow down with their heads to find green shoots.

Fierce fires sweep across these plains during the dry season.



FIG. 11. Burning flood plain grassland, along the Namwala arm of the Kafue River, Zambia. Cattle grazing on regrowth soon after burning. The grasses include *Oryza longistaminata*, *Acroceras macrum* and *Echinochloa pyramidalis*. *Vossia cuspidata* and *Echinochloa stagnina* grow along the river banks and lagoons. The trees growing along the river bank in the back ground are *Acacia albida*.

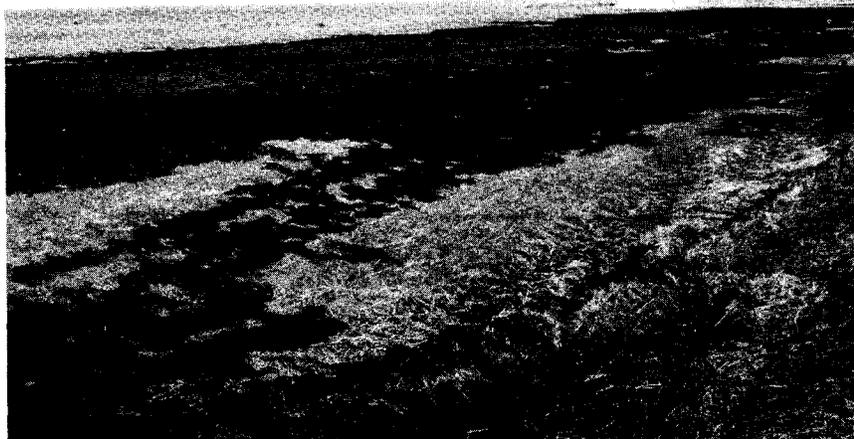


FIG. 12. Burning flood plain grassland, Itebe, between the Magoye and Kafue rivers. Burning of *Oryza longistaminata* flood plain grassland takes place, progressively, in irregular belts as the grass dries out. If there is accumulated dry grass from previous seasons, burning frequently takes place above the surface of the water before the plains are dry.



FIG. 13. Grassland in need of burning: Mahalapye-Tobela, Eastern Botswana. Dry grass at the end of the dry season. Inadequate grazing pressure and the exclusion of fire for several years has resulted in an accumulation of old grass, no longer acceptable to stock. It is advisable to burn such areas in October–November to improve the quality of the herbage for future use.

The grasses include *Cymbopogon excavatus*, *Heteropogon contortus*, *Eragrostis rigidior*, *Themeda triandra*, *Urochloa trichopus*, *Panicum maximum* and *Digitaria eriantha*.

LIST OF PLANTS

- | | |
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| <i>Acacia albida</i> Del., Mokosho | <i>Albizia anthelmintica</i> (A. Rich.) A. |
| <i>Acacia fleckii</i> Schinz, Mhahu | Brongn., Monoga |
| <i>Acacia gerrardii</i> Benth., Mokgwelekgwele | <i>Albizia harveyi</i> Fourn., Mmola |
| <i>Acacia giraffae</i> Willd., Mogotlho | <i>Albizia versicolor</i> Oliv. |
| <i>Acacia hockii</i> De Wild | <i>Andropogon gayanus</i> Kunth |
| <i>Acacia mellifera</i> (Vahl) Benth., Mongana | <i>Antheophora pubescens</i> Nees |
| <i>Acacia nigrescens</i> Oliv., Mokoba | <i>Aristida junciformis</i> Trin. and Rupr. |
| <i>Acacia nilotica</i> (L.) Del., Mokhi | <i>Aristida stipitata</i> Hack., Seloka |
| <i>Acacia polyacantha</i> Willd. | <i>Bauhinia macrantha</i> Oliv.—Mokoshi |
| <i>Acacia seyal</i> Del. | <i>Berchemia discolor</i> (Klotzsch) Heml., Motsintsila |
| <i>Acacia sieberana</i> DC., White thorn | <i>Boscia albitrunca</i> (Burch.) Gilg and Ben., Motlope |
| <i>Acacia tortilis</i> (Forsk.) Hayne, Mosu | <i>Brachiaria nigropedata</i> (Munro) Stapf |
| <i>Acroceras macrum</i> Stapf, Nile grass | <i>Brachystegia specifformis</i> Benth. |

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- Burkea africana* Hook., Monato
Cenchrus ciliaris L., Mosekangwetsi
Chloris gayana Kunth, Rhodes grass
Clerodendrum lanceolatum Gürke, Log-onyana
Colophospermum mopane (Kirk ex Benth.) Kirk ex J. Leon., Mopane
Combretum apiculatum Sond., Mohudiri
Combretum gbasalense Engl. and Diels.
Combretum hereroense Schinz, Mokabi
Combretum imberbe Wawra, Motswere
Combretum molle R. Br. ex G. Don, Moduba
Commiphora mollis (Oliv.) Engl., Seroka
Commiphora pyracanthoides Engl., seroka
Cymbopogon excavatus (Hochst.) Stapf, Turpentine grass
Cynodon dactylon (L.) Pers., Motlho
Cyperus articulatus L.
Cyperus esculentus L.
Cyperus papyrus L., Koma
Dichrostachys cinerea (L.) Wight and Arn., Moselesele
Digitaria eriantha Steud. Moseka
Digitaria milaniana (Rendle) Stapf, Namele
Diplorhynchus condylocarpon (Muell. Arg.) Pichon, Molya
Dombeya rotundifolia (Hochst.) Planch.
Echinochloa pyramidalis (Lam.) Hitchc. and Chase
Echinochloa stagnina (Retz.) Beauv.
Elephantorrhiza elephantina (Burch.) Skeels., Mositsane
Eragrostis cilianensis (All.) Lutati
Eragrostis pallens Hack., Motsikiri
Eragrostis rigidior Pilg., Rathathe
Eragrostis superba Peyr., Mogamapudi
Euphorbia candelabrum Trem. ex Kotschy
Ficus sycamorus L., Mochaba
Garcinia livingstonei T. Anders., Motosaudi
Grewia bicolor Juss., Mogwana
Grewia flava DC., Moretlwa
Hemarthria altissima Stapf and C. E. Hubb.
Heteropogon contortus (L.) Beauv., Seloka
Hyparrhenia filipendula (Hochst.) Stapf, Thatch grass
Hyparrhenia rufa (Nees) Stapf, Thatch grass
Hyperthelia dissoluta (Nees ex Steud.) Clayton, Thatch grass
Hyphaene ventricosa Kirk, Makulwane
Indigofera daleoides Benth.
Indigofera flavicans Bak.
Jardinia sp.
Julbernardia paniculata (Benth.) Troupin
Leersia hexandra Sw., Mokanja
Lonchocarpus capassa Rolfe, Mhata
Londetia simplex (Nees) C. E. Hubb.
Maytenis tenuispina (Sond.) Marais, Mherehere
Miscanthidium teretifolium (Stapf) Stapf, Moxa
Nymphaea caerulea Sav., Tsui
Ochna pulchra Hook., Monyele n yele
Oryza longistaminata Chev. and Roehr., Mokao
Otoptera burchellii D C., Mosihapo
Ozoroa paniculosa (Sond.) R. and A. Fernandes, Monokune
Panicum coloratum L.
Panicum maximum Jacq., Mhaha
Panicum repens L.
Parinari capensis Harv.
Peltoporum africanum Sond., Mosetlha
Phoenix reclinata Jacq., Tsaro
Phragmites mauritianus Kunth, Lotlhaka
Pterocarpus angolensis DC., Mokwa
Pycreus mundtii Nees
Sansevieria aethiopica Thunb., Mosokelatsebeng
Schmidtia pappophoroides Steud., Tshwang
Sesbania bispinosa (Jacq.) W. F. Wright, Mositanokana
Setaria avettae Pir.
Setaria ciliolata Stapf and C. E. Hubb.
Setaria sphacelata (Schumach.) Stapf and C. E. Hubb. ex M. B. Moss, Motawaphesa
Stipagrostis uniplumis (Licht.) De Wint., Tsikitsane
Strychnos pungens Solered., Mogwagwa
Syzygium quineense (Willd.) DC., Isane
Tarchonanthus camphoratus L., Mohatlha
Terminalia sericea Burch. ex DC., Mogonono
Themeda triandra Forsk.

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<i>Tristachya superba</i> (De Not) Schweinf. and Aschers.	<i>Urochloa trichopus</i> (Hochst.) Stapf, Puka
<i>Tylosema fassoglensis</i> (Kotschy ex Schweinf.) Torre and Hillcoat, Morama	<i>Vetiveria nigritana</i> (Benth.) Stapf
<i>Typha latifolia</i> L., Bulrush	<i>Vossia cuspidata</i> Griff., Hippo grass
	<i>Ziziphus mucronata</i> (Willd.), Mokgalo

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