Fire and Wildlife Grazing on an African Plateau

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MAN'S use of fires dates from well over 50,000 years ago, in Neolithic times in north or sub-Saharan Africa (Clark, 1964). In fact, intentional burning of grassland or woodland may have been man's first land management tool. Upon only brief reflection, primitive human beings may have noticed the congestion of wild grazing animals upon a recently burned area. If we go to mythology, it is written that the Nordic giant *Surtur* defied the gods by using fire as a weapon! So also might primitive man have done.

Natural fires start from lightning (Schaefer, 1958), rolling stones, or lava flows (Komarek, 1965). Once a natural source of fire occurs it is easy to visualize burning a significantly large area, especially if conditions are dry and a fresh breeze whips the fire along. Though the reasons for improved grazing will be developed later, it suffices for the moment to state that both wild and domestic animals are strongly attracted to the clean and vigorous new growth that springs forth in a few days of favorable weather after a fire (Sweeney, 1956; Brynard, 1965; and Batchelder, 1967).

AREA OF INVESTIGATION

As any ecologist or forester knows, it is important to specify the climate and geography of an area before attempting a suggestion for intentional use of fire. Whether fire is helpful or harmful depends upon myriad considerations such as evolutionary history, past and present climate, principal economic resources, means of fire control, cultural patterns, and environmental characteristics.

The present discussion is based upon a year's research initiated by the Government of Malawi.* The primary location, the Nyika Plateau is centered at about 10° 30′ South Latitude and 33° 45′ East of Greenwich (Fig. 1). The area, a rolling grassland plateau, contains over 750 square miles at elevations of 4,000 to over 8,000 feet above sea level (Fig. 2). The Nyika Plateau has "always" been thinly settled for it is considered too cold for the usual preference of Africans. The mean annual temperature of the Chelinda Rest Houses is 13°C. (55°F.) and rainfall is about 115 cm. (45 ± inches), reaching 175 cm. along the eastern escarpment.

ENVIRONMENT AND EVOLUTION

On the Nyika Plateau there is a cool 5-month dry season and a warm 7-month rainy season (May to November). If we may assume that periodic fire was a long time feature of the environment, then all other portions of the ecosystem are powerfully conditioned thereby. The plateau consists of broad, gently rounded ridges, mildly cut by drainages which are often marshy or well-grassed. The erosion cycle is at a very early stage and the soil has been long in place and parent materials are well disintegrated. Subsoils are of deep clay composition tending toward the acid.

Such conditions might well be expected to produce a tropical broad-leaved evergreen forest. A number of former colonial officers stated that I should expect forest growth on the Nyika Plateau "under *normal* conditions." However, there is strong biological evidence against the possibility of extensive broad-leaved evergreen forests. Particularly, one must take account of the significant number of endemic plant and animal species which appear to have evolved and adapted to existing climatic, soil, and fire occurrence patterns

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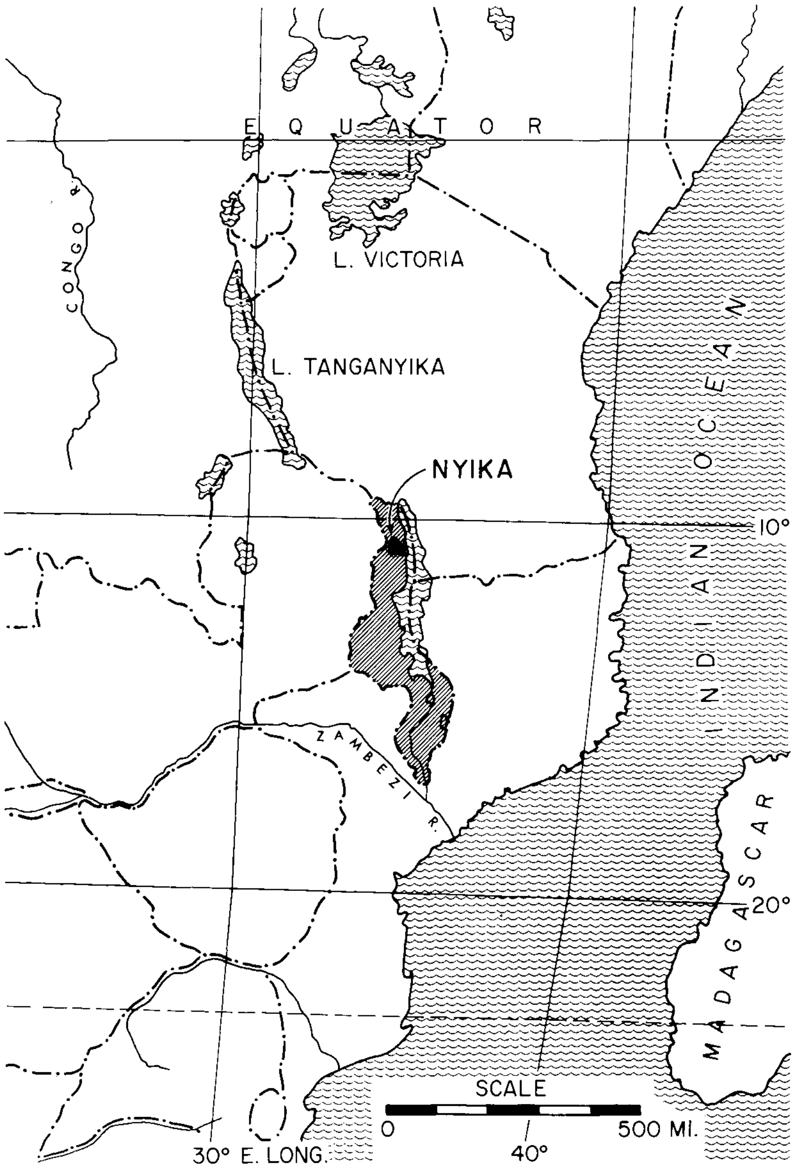

FIG. 1. Malawi (diagonal hatch), Africa, and adjoining areas along the lower east coast.

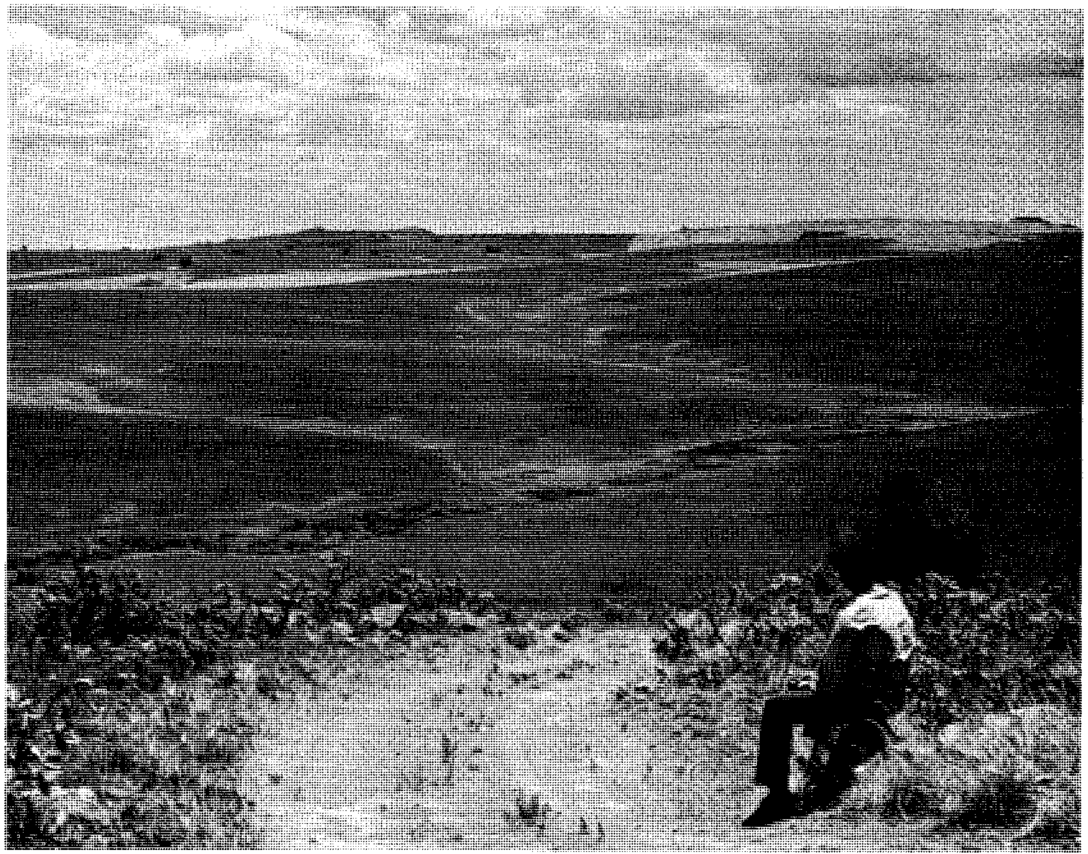

Fig. 2. Burned grasslands of the Nyika Plateau, early in the dry season (May or June).

(Lemon, 1964a and b). Although additional study would doubtless alter the following list, it represents our present understanding of endemic forms resident on the Nyika Plateau:

(1) Crawshay's zebra, *Equus burchelli crawshayi* de Winton is cited by Sweeney (1959) and others

(2) Four species of birds, as determined by Benson (1953)

(3) Three amphibians, see Stewart (1967)

(4) Two species of lizards, according to Stewart and Wilson (1966)

(5) Two seed plant species, according to Lemon (1964a).

Further, there are four bird and two plant species that are quite far removed from any similar natural community. (*Note.* The "Nyika" of Tanzania is neither continuous nor contiguous with our Nyika Plateau, nor does it have any similarity in elevation or ecological characteristics.) The tendency to produce and maintain endemic species represents strong evidence for assuming habitat and ecosystem stability over a long period of time.

NUTRITIONAL BASIS OF LIFE

It can be said either poetically or scientifically that the soil provides a source of strength to all creatures that dwell upon it. For animal life, especially, the nitrogen cycle is an environmental factor of basic importance. When first arriving in Africa, we were told that any lack in the minor elements might induce extensive annual migrations of the animals. Consequently, care was taken to check all possible evidence to guard against overlooking a micro-nutrient deficiency. Soil analyses were made on both macro- and micro-nutrients for 20 samples taken from the central plateau. So far as is known, this is the first time that any chemical analyses have been reported for collections of wild forage from the Nyika Plateau.

The results for soil nitrogen content analyses generally varied between the values 0.11 and 0.40 percent. Some scientists feel that a more meaningful measure of quality, in terms of availability of soil nitrogen to plants, is the carbon/nitrogen ratio. The range in C/N ratios proved to be from 9.1/1 to 19.0/1, averaging 11.0/1. This average value implies rather favorable release of usable nitrogen in behalf of protein accumulation by the forage plants.

It is much better to make direct analysis of forage plants than to limit our data to nutritional analysis of soils. Ten selected samples were gathered, five grass collections and five of legumes known to be cropped by eland and roan antelope. A certain coarseness of this type of forage is shown by the crude fibre content, which varied from 30.4 to 42.7 percent. The protein content of Nyika grasses was usually lower than that of the legumes. Two grass samples taken from land protected from fire for 11 and 3 years, respectively, had 7.8 and 8.7 percent crude protein. Analyses of crude protein on samples taken from burned land showed higher values, while a specimen collected five weeks after a late season burning (31 December 1963) contained 16 percent protein. The legumes contained from 12.7 to 17.4 percent crude protein and there was no clear distinction between protein values from burned or unburned land. Common high values for the Nyika samples were from 14 to 16 percent. One could safely say that the better kinds of forage plants on the Nyika Plateau are *neither very good nor very poor*. The forage, then, is of acceptable quality for wildlife but would be considered below the standards of good pasturage for domestic livestock.

There have been a number of expressions of informal opinion or speculation on the worth of the Nyika for pasturage (e.g., by domesticated animals), but it must be emphasized that this grassland community is mainly composed of harsh and sometimes rather rank species. *Andropogon*-like grasses are predominant.

Since the Nyika area is definitely not agricultural land, many have wondered whether mineral nutrients are adequate to supply the animals grazing on it. For this reason forage collections were subjected to careful analyses to determine the mineral content. Considerable variation was found between samples, probably as a result of the different species of grass and legumes included and the different sites that were represented.

It should be noted that the specimens taken were intended to approximate the dietary preferences of eland. At the time of making collections the forage plants were at their mature stage, which is to say they were neither "spring growth" nor old, dry foliage. The findings are summarized in Table 1.

TABLE 1. MINERAL CONTENT OF FORAGE SAMPLES FROM NYIKA PLATEAU

Mineral Element	Extreme Values (10 Samples) Percent D.M.B.*
Calcium	0.22–0.73
Magnesium	0.07–0.49
Phosphorus (Total)	0.12–0.31
Phosphorus (Water Soluble)	0.09–0.15
Potassium	0.56–1.88
Total Ash**	3.70–8.60

* D.M.B. is dry matter basis, abbreviated.

** Separately determined, *not* by simple addition (therefore includes other ash constituents than the four here detailed).

One might expect that old soils developed from kaolinitic clay and disintegrating granite would contain a good variety of micro-nutrients (Fried and Broeshart, 1967). To make certain, though, a complete analysis of minor elements found in forage plants was undertaken, the results of which are presented in Table 2.

TABLE 2. MICRO-NUTRIENT OR TRACE ELEMENT CONTENT OF FORAGE SAMPLES COLLECTED ON THE NYIKA PLATEAU

Sampling Site	Aluminum	Boron	Copper	Iron**	Manganese	Zinc
Unburned Area (for 11 years)	72*	16	21	100	420	21
Unburned Area (for 3 years)	50	16	32	59	352	25
Annually Burned (early in season)	98	14	24	107	384	16
Biennially Burned (late in season)	62	4	29	74	784	18

* All values in table represent parts per million, dry matter basis.

** Unwashed foliage may carry dust contamination and consequently yield inflated values for routine iron analysis.

Neither Table 1 nor 2 reveals any serious defect in the mineral content of the Nyika forage plants. Calcium is near the limit for acceptable levels but cannot be called clearly deficient. No other element is low enough to cause serious concern. Actually, the available physiological data on wild animals are scanty and hard to use (Taylor and Lyman, 1967). The larger research establishments should continue and even increase their investigations of this sort. Although most of the minerals were about the same on burned and unburned areas, both potassium and manganese showed some increase on the burned land. This could be due to release of ash materials after burning or the result of greater vigor in the new growth (over about one month's time).

In a word, the analyses of forage samples showed satisfactory quantities of protein and the mineral nutrients. The latter included both major nutrients and the rare micro-nutrients. While these values are too low for agricultural exploitation, they are adequate for the normal health and reproduction of wildlife. In addition to the author, other observers asserted that the animals, as viewed in the field, gave every appearance of being in good condition. One of the more encouraging things was the result of very thorough studies in the effect of burning upon a low, herbaceous legume: "phunga," or *Aeschynomene oligophylla* Harms. Three totally different methods of census indicated (Lemon, 1968) that an occasional fire improved its vigor and production. Beyond this, *A. oligophylla* appears to be a definite favorite of eland (Pellew, 1967).

EXTENSIVE CONTROL OF ANIMALS

In the western ranges of the United States of America the traditional cattleman keeps his cattle in certain areas by such methods as: (a) fences, (b) cowboys on horseback, (c) salting places, and (d) water holes or tanks (Humphrey, 1962). These methods are unsuited to large antelopes and zebra on the Nyika Plateau although there still may be practical ways to influence animal movements. It must first be insisted, of course, that there will not be poaching or daytime, exposed shooting. If harvesting later becomes necessary it should be done by shooting on the flanks of the plateau or by night hunting by professionals. In any case, these are negative influences. By way of positive influences, two attractants can be considered: salt or mineral stations, and prescribed burning. Drinking water is abundant on the Nyika Plateau almost year long, so it can not be considered a factor. Previous sketchy experience with salting is inconclusive and awaits more careful investigation. Probably experiments should be carried out as soon as it can be arranged for sufficient observation of the results. This leaves but one clear possibility for positive attraction, namely, prescribed use of fire.

Intensive behavioral studies were attempted in order to learn about herd structure and daily and annual movements. It was especially important to see whether weather, forage, or nutritional factors stimulated migration. Secondarily, data were gathered on mortality by disease, predation, and poaching. Initial observations showed that eland (*Taurotragus orxy livingstonei*), roan antelope *Hippotragus equinus*), Crawshay's zebra (*Equus burchelli crawshayi*), and reedbuck (*Redunca arundinum*) were the most abundant large herbivores. Preliminary computations of carrying capacity have been attempted. Eland, roan antelope, and Crawshay's zebra were made equivalent to cattle, with reference to food requirement. The allowance, as calculated, worked out to be four hectares per animal month, or nearly 50 hectares (125 acres) per annum. The smaller herbivores, duiker (*Silvicapra grimmia*), reedbuck, and wart hog (*Phacochoerus aethiopicus*), had been computed at the rate of half the nutritional requirement of a cow. Thus figured, the range under study certainly received light utilization.

It soon became evident that grazing animals were attracted to recently burned grass for a number of reasons. New, clean foliage can be taken quickly and in large quantity. This is an advantage mid-period or late in the 6- or 7-month dry season. An advantage in nutrient content has often been reported (Lemon, 1946; Humphrey, 1962), and indeed, on the Nyika Plateau grass samples from recently burned areas showed 75 to 100 percent higher crude protein content than green leaves from areas long unburned. Surprisingly, though, foliage from leguminous herbs had approximately the same protein content whether from burned or unburned range.

There are also some other points to consider with respect to the attracting power of burned range. On cold, clear days the charcoal which blackens the ground causes noticeably more heat to be absorbed than on straw-colored areas. It is certainly easier to walk through a clear area than the tangled litter such as that on many unburned areas (Lemon, 1946). However, we should avoid making only one contrast: newly burned vs. unburned range. Actually, areas that have been burned within 1 to 3 years still retain some of their advantages for grazing ungulates. Many recently burned areas have good vegetative vigor, not too much dead mulch material, and may possess a fair variety of forage species.

The apparent abundance of wildlife at different times of the year is of interest. Figure 3 gives the estimates for the four leading species throughout the year 1962, as observed by Game Guards. At or slightly before rains begin (about October) the eland herds, especially, are large, composed of from 80 to 125 animals. Roan antelope may occur in groups of 15 to 30 or more. Zebra occur commonly in parties of five to eight (or multiples of these) and do not vary seasonally as much as the large antelopes. Reedbuck are found singly or in groups of three's or four's all year. By contrast, eland herds drop to small bands of 12 to 30 during the dry months of July and August. At this time they seem to frequent brushy patches or the edges of evergreen forests. Their diet appears to shift to more woody plants (in extreme cases, it is said they dig fleshy roots with their hooves or horns). Possibly the ebb in abundance of forage, coupled with lower temperature, causes the eland to break up into smaller bands and diffuse widely. More study of seasonal behavior patterns is urgently needed.

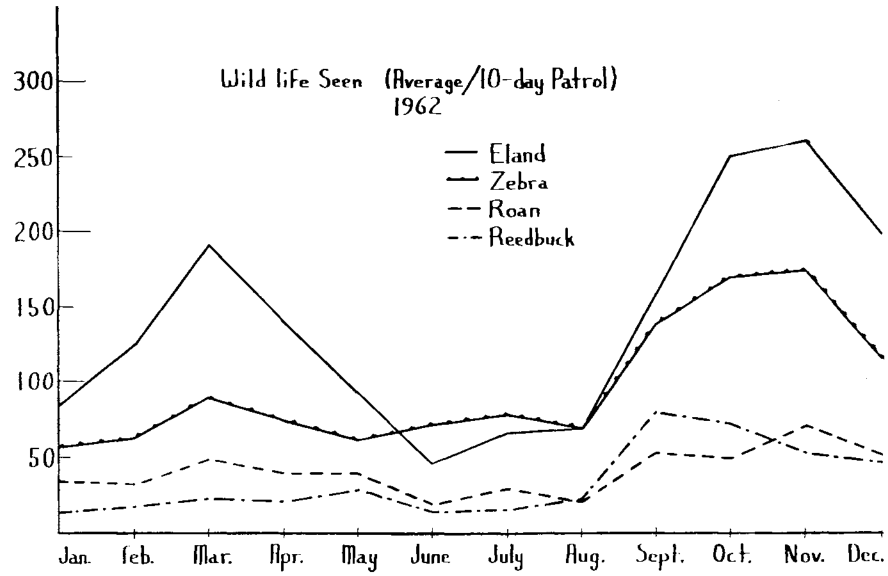

FIG. 3. General indication of seasonal abundance of the four leading ungulates during 1962.

Some attention was given to predation as a controlling factor. There are doubtful reports of hyena (*Crocuta crocuta*), occasionally a few wild dogs (*Lycaon pictus*), and many side-striped jackals (*Canis adustus*). Small cats such as caracal, serval, genet, and mongoose occur in low numbers or infrequently. On the other hand, the larger cats are regularly present and probably serve the constructive roles of light or normal predation. Leopard (*Panthera pardus*) may be very effective at the margins of the plateau, working in *miombo* or forest patches. They have not been observed in the central grassland. However, lion (*Panthera leo*) and cheetah (*Acinonyx jubatus*) do occur and probably take some prey. The so-called short grass does not provide good stalking cover for lion. Only three prides have been reported and most usually only one group of three to four lions is commonly seen. This pride harasses the cattle used for construction and recently took one African. This kind of behavior might indicate that their usual hunting practices are not easy.

All available information indicates, then, that the predator toll is light. A carcass or group of vultures is rarely found on the plateau grassland. Smaller antelopes such as duiker and reedbuck may provide better prey for lion or cheetah than the larger antelope or zebra.

If it be assumed that the animals of the land are desirable, then fire seems to play a significant role. Undoubtedly, intermittent burning has occurred over many thousands of years. Since this extensive plateau presents a distinctive environment, the whole situation seems to have allowed a number of species of organisms to evolve, as local endemics. The vegetation has become suited to survive fire, through a variety of specific structural and physiological adaptations. In many parts of the tropics laterization can be a by-product of regular burning. In such cases the soil loses its water-absorbing and water-retaining powers and the vegetation becomes more xeric. However, on the Nyika Plateau, where mean monthly temperatures are from 10° to 15°C. (50 to 60°F.) all year, laterization is not expected. This cool climate, with rainfall of about 115 cm. (45 inches) per year, may fully maintain soil fertility and productivity under a regime of mild firing. Planned or prescribed burning may help to provide desirable forage which acts as a great drawing power for herbivores (See also Lemon, 1964b; Dwyer, 1967; and Box *et al.*, 1967). This is a much needed agency of control, toward the goal of keeping animals from wandering off the central grasslands during the dry season, into areas where they will surely be subject to poaching.

PRESCRIBED BURNING TECHNIQUES

It was my recommendation that about 33 percent of the Nyika grassland be burned each year. In my judgment this should be done during a 5- or 6-month period, beginning in May. The main part of the task should be finished by the middle of July. Use of a small crew, with beneficial returns accruing from practice, is cheaper and better than an ungainly group of amateurs. Skillful use of barriers, such as streams, roads, or previously burned areas, reduces the task of hoeing fire breaks. In fact, a knowledge of wind, fuel, moisture and fire behavior allows doing a good job in burning large areas of land on schedule.

Figure 4 illustrates the procedure of burning relatively narrow streaks along roads by rapidly-moving, downwind burning. Figures 5 and 6 represent rather broad burned areas. Note that this was mainly done during a time when fires followed ridges and stopped on major creeks. Though they spread in width as they travelled, the length downwind was several times the average width. Ordinarily it is wiser to attempt to break large blocks into much smaller subdivisions. Dashed lines show where controlled burnings could easily be made to cut off sub-areas for either later burning or protection until another season. The short strips could be installed by watching for a favorable wind or beating out one side of a fire that is slowly spread by technicians. One can often work against the wind or a topographic limit such as a flowing stream, to stop further spreading of a fire. The dashed lines on Fig. 5 suggest blocks of grassland that could be readily isolated in this fashion.

Once these subdivisions are cut off by barriers one can burn large areas with safety. In fact, this is necessary in view of our knowledge of the grazing habits of large herbivores. If even a small herd encounters a spot of newly burned land the tendency is to graze it very closely. This is so much the case that valuable forage plants may be damaged or eliminated. Contrarily, if sizable burns are carried out the grazing pressure will be more evenly distributed and cropping of individual plants will probably be milder.

It could be asked whether plant growth, stimulated by fire during an "unnatural" time, might be harmful; that is, perhaps it would expend plant food reserves at a "wrong season." More study should be undertaken, but this possible ill effect does not seem to be a major danger. First, it is felt that the dominant grasses are fire-adapted and thus little inconvenienced. Second, the burden of fire

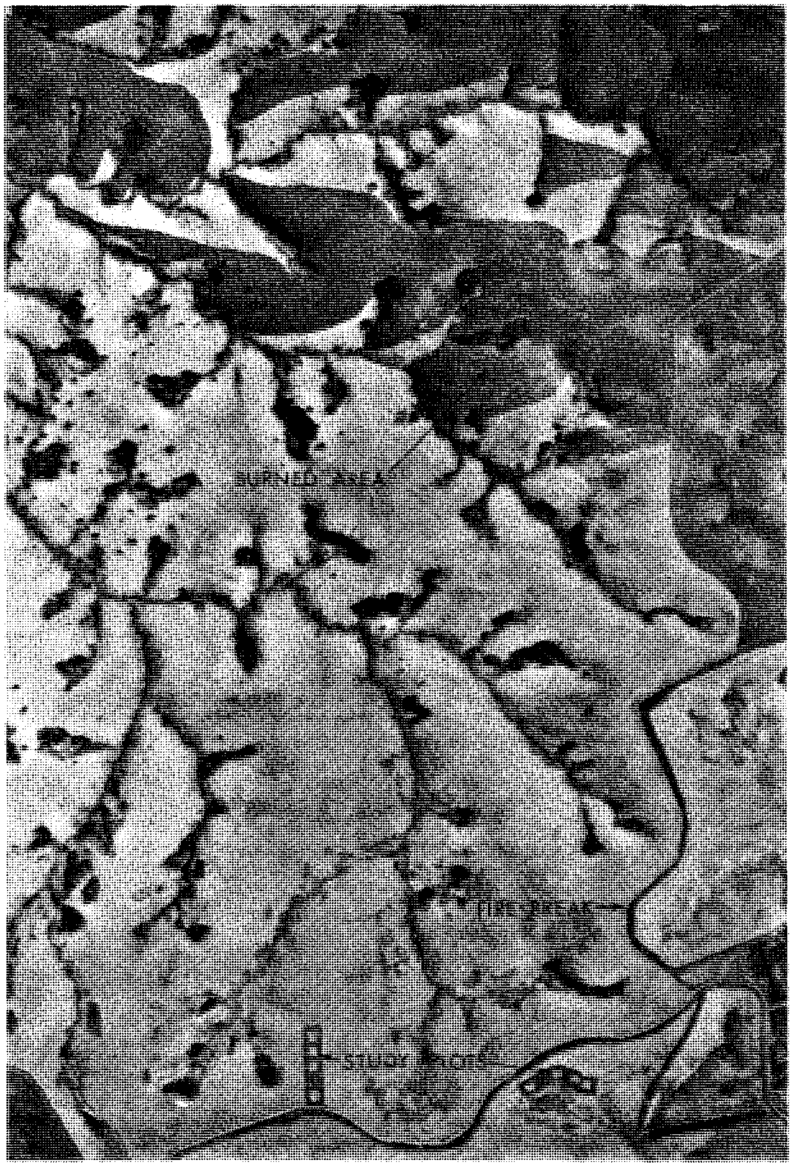

FIG. 4. Central part of the Nyika Plateau showing fire study plots (½ a. each), fire breaks, and typical burns.

Fig. 5. Fire behavior patterns; note suggested connecting breaks to isolate large blocks.

FIG. 6. Fire behavior patterns showing how strong wind and moderately moist fuels make elongate burns on ridges.

and heavy grazing cannot occur repeatedly on the same area. Fire does not spread unless a quantity of fuel accumulates on the ground. After moderate grazing a fire most likely will not recur for 18 months or more. Thus, planned distribution of burning over time and space will achieve the following important advantages:

(1) Forage availability as an attraction for the large grazing animals,

(2) Avoidance of destructive wildfire which could spread over large areas on a dry, windy day, and

(3) Protection of the evergreen forest patches.

These investigations suggest that an ecological community long free of artificial disturbances tends toward maximum efficiency or maximum gross productivity. The main reason is that diversity of animal and plant life allows fuller utilization of the assets of the habitat than is the case with single (or few) species of domesticated organisms.

SUMMARY AND CONCLUSIONS

While the old figure of speech, "playing with fire," still retains its literal implications, ecologists are gradually learning to *work* with fire as a constructive tool for land management. Studies on a high, temperate African grassland appear to demonstrate the following:

(1) In Africa, as in parts of the United States and other places, there are certain *fire-adapted communities* where the processes of evolution have helped plants and animals to become geared to periodic burning as a normal feature of the environment.

(2) Carefully planned use of fire can provide grazing animals with a nutritive food source upon a sustained basis.

(3) Practically any burned grassland area will act as a powerful attractant for wildlife, after a few days of good growing conditions.

(4) On the Nyika Plateau, prescribed burning can be used to help hold wildlife on the grasslands during the dry season when otherwise the animals tend to diffuse widely, becoming more liable to various kinds of mortality (including poaching).

(5) The tracts or patches to be burned should be large enough to avoid excessive bunching and overgrazing by the animals.

(6) An informal rotation of burning should be carried out so that approximately a 2- or 3-year rotation is followed for any particular area.

(7) On the Nyika Plateau, a comprehensive plan is needed so that pressure of burning and grazing will allow sustained vigor of desirable forage plants. Eland, reedbuck, roan antelope, and zebra populations must be held to the proper carrying capacity of the land. Good plant indicators may be "phunga" (*Aeschynomene oligophylla*), in addition to the dominant grasses such as russet grass (*Loudetia simplex*) and grey beard grass (*Trachypogon spicatus*).

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