Fire and Conservation of the Habitat in Kenya

P. M. OLINDO

Director, Kenya National Parks,
Nairobi, Kenya

INTRODUCTION

Using the words of Phillips, "despite the dread danger of burning when it is feckless, wanton, casual or accidental, there are great possibilities for its use as a tool in the management of the savanna regions of Africa and these possibilities require much more study in the future, particularly the timing and frequency of burning in local environments."

THE EFFECTS OF FIRE AND OTHER INFLUENCES ON THE HABITAT

A great deal of research has been conducted in the past 50 years in the vast areas of savanna country in Africa south of the Sahara, both from the agricultural and pastoral aspects. Reference to the UNESCO vegetation map of Africa gives some idea of the extent of savanna in this continent.

Fire, shifting cultivation, and grazing are the major factors responsible for the formation and maintenance of savanna country. Bush fires have exerted a profound influence on the vegetation of Africa (Fig. 1) for so long that fire has become an important limiting factor, of almost equal importance in its effect to topography and climate.

The prolonged effects of fire upon the savanna habitat have

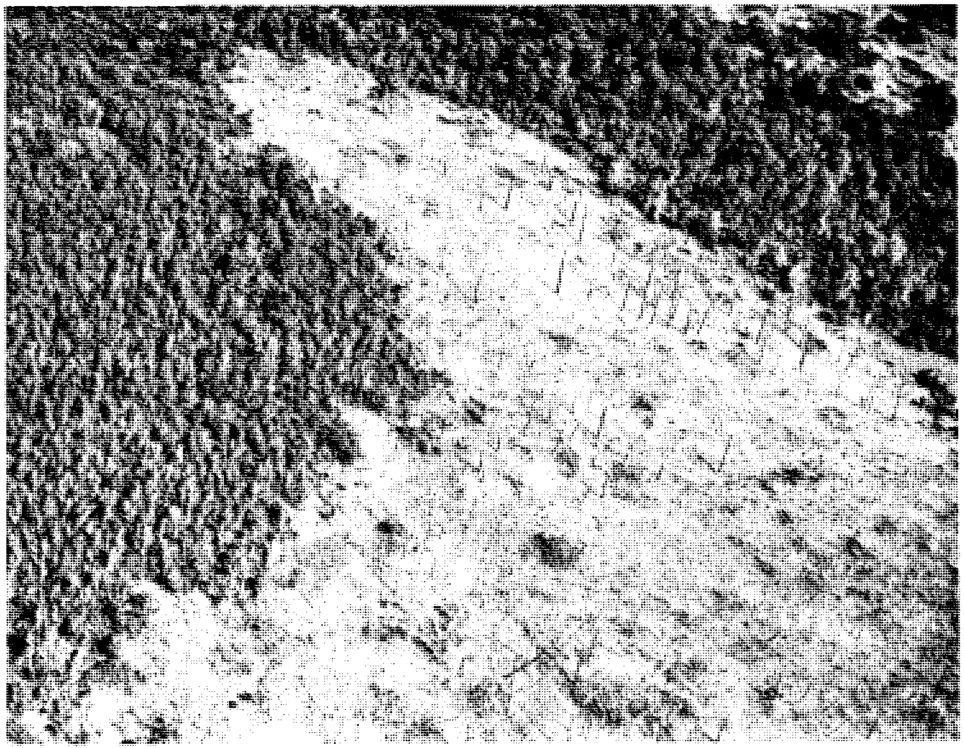

Fig. 1. Fire encroachment in the Mau Forest.

resulted in the development of special fire-resistant communities of plants and animals which are dependent on periodic burning for their existence (Fig. 2). Examples of these communities are the open grassy plains and woodlands of tropical and sub-tropical Africa which were inhabited by vast herds of plains game such as zebra (*Equus* spp.), wildebeest (*Connochaetes taurinus* (Burchell)), Thomson's gazelle, (*Gazelle thomsonii* Günther), kongoni (*Alcelaphus-buselaphus* Pallas), topi (*Damaliscus korrigum* (Ogilby)), etc. These in turn supported large numbers of predators such as lions (*Panthera leo* (L.)), hyaenas (*Crocuta crocuta* and *Hyaena* spp.) and jackals (*Canis* spp.), birds of prey such as hawks and eagles, and scavengers such as vultures, only a century ago. Today, however, larger numbers of plains animals can be seen only inside National Parks and Game Reserves. Nevertheless, they are an integral part of the savanna community and exert their influence in maintaining it as such.

It is possible that in the past, large elephant populations had a profound effect on the formation of savanna country by destroying the woody vegetation as they have done recently in the Murchison and Tsavo National Parks. (Fig. 3 and 4).

FIG. 2. A Masai "manyatta" on the Mau moorland.

Similarly, large hippopotamus (*Hippopotamus amphibius* L.) populations appear to have effected the grasslands in a similar way in the Queen Elizabeth Park in Uganda.

Although bush fires encourage the formation of grasslands, untimely burning exposes the soil to desiccations and erosion, the results of which are all too evident in the Guinea zones of West Africa and the plains and woodlands of East Africa.

Before man learned to use fire as a tool, burning of the vegetation must have occurred only occasionally as a result of lightning or spontaneous combustion in places where large amounts of dry, organic matter had accumulated. (Fig. 5).

In the past two thousand years, however, the social development of human communities and recently the invention of the safety match have accelerated the effects of fire upon the African landscape, devastating the fire-tender forest edge and dry bushland. This process has in turn been assisted by shifting cultivation accentuated by a sudden rise in the human population and, in many places, the near extermination of savanna animals as has happened in Northern Nigeria (Petrides, 1965).

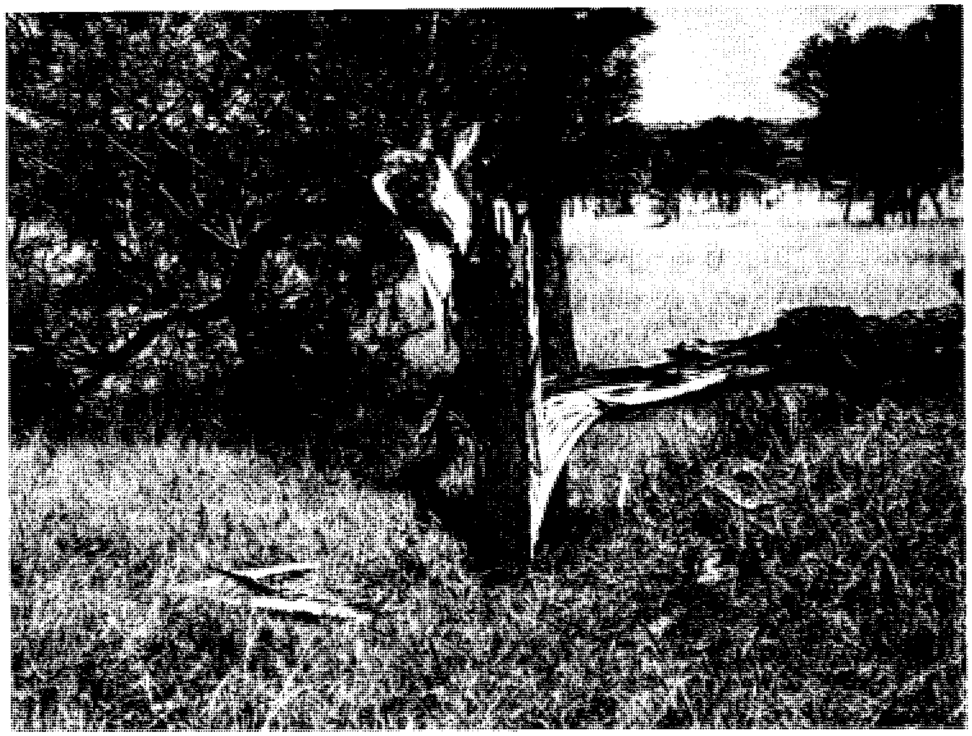

FIG. 3. Elephant damage to *Acacia gerrardii* in the Mara area of Masailand.

Phillips' (1965) exhaustive review of the effects of fire on the bioclimatic regions of Trans-Saharan Africa highlights the influence and importance of fire on the habitat.

DEFLECTED SUB-CLIMAX COMMUNITIES

The savanna regions of Africa are made up of communities of plants and animals which have been "deflected" from their normal course of ecological succession by the influences of cultivation, fire, grazing, and browsing, exerted individually or combined. Thus, savanna communities dependent on these factors for their existence can hold the position of "deflected sub-climax associations" or "associes" (Weaver and Clements, 1938) without further deterioration. (Fig. 6).

In the savanna plant communities, as in all living societies, there is perpetual competition for survival between individuals and evolution towards a more highly organized type of association in which the components are in equilibrium with one another under similar climatic and soil conditions; however, this equilibrium can be maintained in a deflected sub-climax association only so long as the

FIG. 4. Elephant damage grassland replacing acacia-commiphora bushland, Tsavo.

deflecting influences (fire, etc.) continue to be exerted to an optimal degree. When these factors cease to operate, development is resumed towards the normal, more stable, climatic climax—be it thicket or forest (Lester, 1950).

When the deflecting factors exceed the adaptive powers of the organisms concerned, deterioration sets in, resulting in lower and more primitive types of biotic communities and eventually complete destruction of the habitat. Therefore, fire alone, or coupled with grazing, can be a most devastating influence or a very valuable tool in managing woody regrowth in the grasslands and open woodlands which form Africa's most important National Parks, rangelands and stock-producing areas.

Even as early as 1936, Swynnerton showed that in Tanganyika the exclusion of fire from a block of country for 10 years caused a thickening of the vegetation and the disappearance of the tsetse fly *Glossina swynnertoni* Austen (a savanna species related to *G. morsitans* Westwood which inhabits large areas of savanna country in tropical and subtropical Africa), but encroachment of *G. pallidipes* Austen, a thicket fly in that area, took place when this happened.

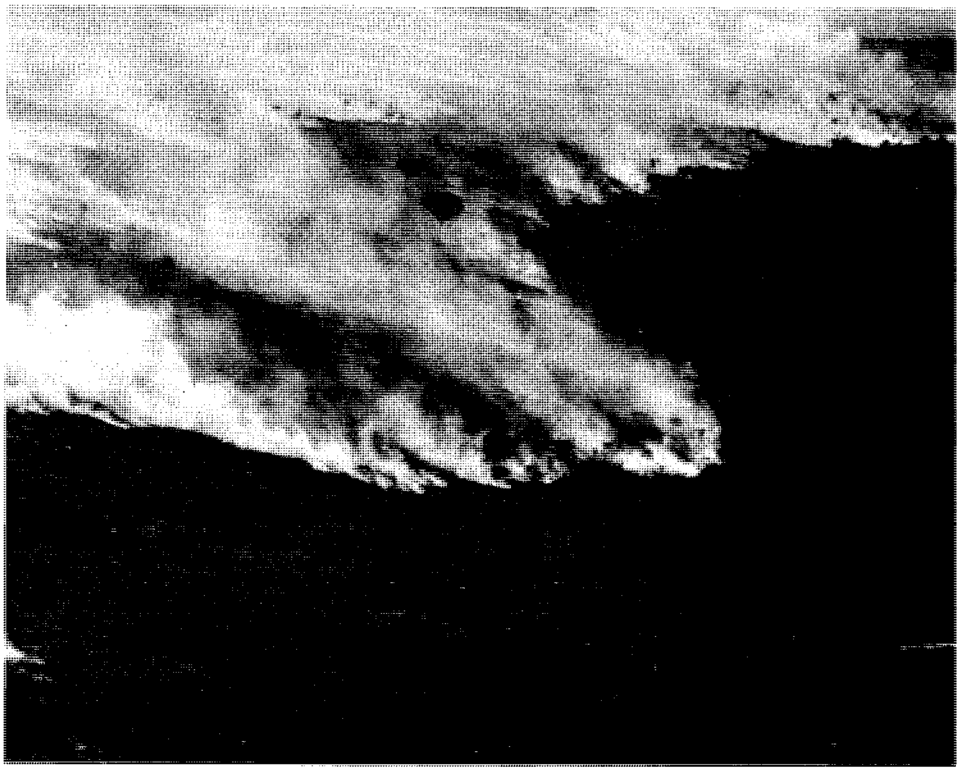

Fig. 5. A Grass fire approaching thicket in the Mara area.

Swynnerton's findings have been clearly confirmed many times.

Another good example was that of a forest reserve near Kaduna in Northern Nigeria where several blocks of isoberlinia woodland received various degrees of protection from fire for more than 20 years. In the section which had been completely protected from fire for the entire period there was a general thickening of the vegetation, and patches of bush with numerous creepers had developed. The block that had been burnt every year at the end of the dry season was almost completely open, tufted perennial grasses were dominant and only a few fire-resistant trees with blackened trunks remained; dead, charred stumps were numerous (Keay, 1958).

A classical example of the misuse of fire can be seen in the south-eastern region of Kenya today where charcoal is made for export to Arabia. Vast areas in the Coast hinterland and the country between Voi and the Tanzania border are being decimated of their hardwood tree cover. Roads of access are cut into the bush to permit vehicles to transport the charcoal to the railheads at Buchuma and Mackinnon where large quantities are constantly being railed away to

FIG. 6. *Themeda* grassland in the Suswa area of the Rift Valley, Kenya.

Mombasa and replenished from all around. Bare blackened patches which look like pock-marks from the air are dotted over the country side. Add to this thousands of acres of bushland devastated by perennial wildfires and some idea of the destructive powers of misused fire can be gained.

FIRE-SENSITIVENESS

Fire-sensitive plants are those which have not developed a resistance to burning (Thomas and Pratt, 1967). In most instances, the reason is that they are members of plant communities which are not normally affected by fire because of their density or lack of undergrowth, or because these plants belong to humid forest communities where burning can make little headway unassisted by man. The most vulnerable plants are those in the marginal rainfall areas where thicket and scrub are the dominant climax vegetation types with sparse perennial and dense annual grass cover of the types found in the drier bushlands of Africa, such as those in the Tsavo National Park in Kenya and the Sudan zone of Northern Nigeria.

Fire-Resistance

A number of terms have been coined for the ability of some plants to withstand the effects of bushfires such as: "fire tolerance", "fire-loving", "pyrophytic" etc. but fire-resistance seems to be the closest approach to an adequate word for the purpose.

Through natural selection, many plants have developed a permanent resistance to fire over thousands and perhaps millions of years. Good examples of these are "geophytes" which have large underground storage organs but only slender ephemeral aerial parts. Geophytes are most conspicuous in full flower or fresh green flush after the grass has been burnt and the ground appears to be otherwise bare or carpeted only with short shoots of perennial grasses.

Two examples of geophytic fire-resistant plants are *Cochlospermum tinctorium* A. Rich. in Northern Nigeria and other parts of West Africa, and *Courbonia glauca* (Klotsch.) Gilg and Benedict, which is common on parts of the plains of the Mara and Serengeti areas of East Africa. In the woodlands of southern Tanzania, *Cryptosepalum* spp. appear as perennial herbs only a few centimetres high, but below ground there is a stout rootstock like the trunk of a small tree with widely spreading branches; only the tips of these appear above the surface. In this same woodland there are also dwarf species of *Combretum*, *Gardenia* and several other plants which have taken to a geophytic habit apparently as a defence against perennial grass fires.

In addition, there are intermediate stages shown by many savanna trees which are able to assume a geophytic form, maintaining only a small stem above the ground which is often mistaken for a seedling, but having a stout rootstock beneath the surface with numerous fire scars on it. The writer has counted as many as 75 growth rings from a rootstock of this type which had no more than a stem 6–10 cm high with two leaves showing above the ground in brachystegia—isoberlinia woodland south of Tabora in Tanzania.

In the Abercorn district of Northern Rhodesia, in brachystegia woodland in which grass was burnt perennially, Glover, et al. (1955) found that more than 65 percent of the potential tree population was up to 1 m (0–3 feet) high, there was markedly fewer plants in the 1–2 m (3–6 feet) and 2–4 m (6–12 feet) height groups and little difference in the numbers in the 4–8–16 m (12–25–50 feet) height groups, indicating that plants 1–4 m (3–12 feet) in height are most vulnerable to grass fires. Most of the plants less than 1 m (3 feet) high had stout rootstocks at ground level or just below, showing numerous fire scars. Very few true seedlings were found.

Later Glover (1965), working in Tanzania in the Serengeti National Park, found that of 5,777 plants of various trees species counted in a series of ten belt transects 5 miles apart in the 50 miles between Seronera and Kline's Camp, 71 percent were less than 1 m (3 feet) tall; about 8 percent were 1–2 m (3–6 feet) high; about 10 percent 2–4 m (6–12 feet) high; about 9 percent 4–8 m (12–25 feet) high and only about 2 percent were taller than 8 m (25 feet).*

Here also many of the trees in the 0–1 m (0 to 3 feet) group had stout rootstocks at ground level showing signs of repeated burning, and there were very few seedlings. This emphasises the point that most of the small plants in these areas which appear to be seedlings are not, but merely regrowth from underground fire-resistant stems.

These investigations indicate that although fire can have a most destructive effect upon woody vegetation, some plants have acquired a temporary geophytic phase which permits them to survive for many years inspite of having their aerial parts scorched off repeatedly. Eventually however, because of drought suppressing the grass growth, overgrazing, or both combined, there comes a period of 2–3 years with no fierce grass fires when these plants are able to grow to a height of more than 2 m (6 feet) and become big enough to be safe from burning. Many of them also then develop thick corky bark as a further protection against fire.

This ability of woody plants to survive underground and regenerate quickly in savanna regions when given respite from grass fires for a few years is one of the reasons why regrowth is so difficult to control in over-grazed country, tsetse clearings and areas of grassland protected from fire.

SUGGESTIONS FOR FUTURE RESEARCH

It has been mentioned previously that much knowledge on the management of the savanna regions of Africa has been acquired in

* This work was described in detail by Lamprey, et al. (1967).

the past 50 years, so much, in fact, that if no further progress were made, there is enough information available on fire control and other forms of range management to deal with any rangeland problems that might arise, if proper control can be achieved!

More than 30 years' experience in Africa led Glover to believe that all the future research in the world could be of no avail without the disciplined co-operation of the local people, encouraged and supported by their leaders, politicians and heads of state. Control of the habitat, including man's influence upon it, is the vital factor on which the future of true development depends.

Bearing these facts in mind, a few suggestions for some of the more obvious topics which require further research in the savanna zones are put forward:

(1) Prolonged investigations on the effects of fire, grazing, and browsing of all types of savanna country ranging from freshly felled forest land being prepared for cultivation to open, long-established grasslands.

Cook (in Phillips, 1965) giving a brief description of some grassland burning experiments carried out at Frankenwald, the University of Witwatersrand experimental farm in the Transvaal of South Africa, stated that after 30 years the greatest alteration in the composition and quality of the vegetation was in the control plot which had been protected from fire. There was more bare ground between the tussocks and there were more dicotyledons present. In the plots that had been burnt annually, there was practically no change, indicating that annual burning had kept these plots in a stable condition.

(2) In order to gain a better understanding of the reactions of the plants themselves to the different disturbance factors mentioned above, more intensive work on their root systems and soil moisture relationships are required.

A great deal has been done on the root system of plants in America (Weaver and Clements, 1938) but very little has been carried out in tropical Africa beyond the work of Glover (1950–51) in the Somaliland Protectorate and more recently in Kenya by officers of the East African Agriculture and Forestry Organization (unpublished). It has been found that various plants have different types of root systems adapted to the needs of their particular niche in the environment.

Some are deep-rooted, others have shallow roots with a wide lateral development, and yet others have both deep roots and widely developed lateral ones.

According to Gwynne (in Davies and Skidmore, 1966), a careful study into the degree of grass root activity within the top four feet of soil is urgently needed and into the role of the deeper roots under conditions of adequate water supply and in times of drought. Research workers of the East African Agriculture and Forestry Research Organization have also demonstrated that the presence of plants influences the penetration of rain water into the soil (Glover, et al., 1962).

Further, the importance of variability of soil depth and the rooting habits of grassland plants in determining the species composition of these plant communities is just beginning to be realized.

In addition, Gwynne says that more work on the physiology of growth of tropical grasses with particular reference to root development and the effects of water stress should be a high research priority.

(3) Studies on the nutritive value of different plants. Dougall and Glover (1964) made chemical analysis of *Themeda triandra* Forsk. and *Cynodon dactylon* (L.) Pers. at different stages of growth after burning and mowing and demonstrated that the green leaves of *T. triandra* are a better source of protein, calcium or phosphorus than either the older or bulked foliage of that plant. This is one of the reasons why both wild ungulates and stock prefer to graze freshly shooting grass after it has been burnt rather than that in the taller, more mature sward, which is less palatable and has less nutriment in it.

Therefore the study of the nutritive value of important grazing and browse plants in different stages of growth could be a very profitable field for further research.

(4) Another aspect which requires closer investigation is the problem of permitting subsistence agriculture such as the cultivation of millet and maize on land that could be put to better use as rangeland for the production of meat and milk. The problem is especially acute when the land lies bare and unprotected for months under a hot, desiccating sun, and then suffers flash floods and severe erosion, after which it is used to grow only a subsistence crop of millet.

(5) The possibilities of using all suitable parts of the savanna regions to the best advantage should be investigated in detail:

a) By mapping vegetation and soils.

b) By selecting and locating grazing areas.

c) By working out a general policy for the proper use and conservation of grazing land, including wet and dry season alternation of grazing and the use of swamps for both pastoral and arable purposes. Research into traditional tribal movements might be rewarding in this context based on trial and error experienced over countless years.

d) By introducing methods of pasture improvement and management with special reference to stock-carrying capacities in different conditions of climate and soil.

e) By investigating and improving water resources and requirements when these are necessary.

f) By investigating the possibilities of integrated pastoral and arable land use in areas where it seems feasible (Maclennan, in Glover and Aitchison, 1966).

6) The conservation and use of wild life resources must be studied as an integral part of savanna research. This work must include management plans for national parks and game reserves to ensure the preservation of variety in the habitat by controlling bush fires and regulating the numbers of different species of animals to the carrying capacities of the regions concerned. In some national parks, such as Tsavo in Kenya and Murchison in Uganda, overstocking of elephant (*Loxodonta africana* (Blumenbach)) coupled with uncontrolled fire has caused marked changes in the habitat. The same is starting in the Serengeti in Tanzania (Lamprey, et al, 1967). The causes of such situations and possible remedial measures require urgent investigation.

The control and proper use of existing wild life resources is perhaps one of the most pressing problems facing Africa today: —Before the introduction of domestic stock and the intensified agricultural activity that followed, the semi-arid areas of Africa were comparatively stable ecologically although they supported large herds of wild ungulates, but because of extreme fluctuations in rainfall distribution, high temperatures and sparse distribution of water, these arid areas are vulnerable to desolation by desiccation and erosion under continued, in contrast to periodic, shifting stocking.

Sir Julian Huxley, writing in 1961 on Central Africa, observed that a large proportion, probably over a third of the country, consists of marginal land that constitutes an ecologically "brittle" habitat which readily deteriorates and loses productivity under cultivation or the least degree of overgrazing.

Fraser Darling (1960) and Ledger (1964) have demonstrated that wild animals under "natural" conditions are normally in a state of comparative balance with their habitat because they have a wide range of feeding and other habits, so that among the different species each one fits into its own "niche". Further, Ledger (1963) showed that the carcass composition of wild animals has advantages over that of domestic stock because wild animals have a larger proportion of red meat per unit of carcass.

Dasmann (1963) studied the commercial production of game meat and income in Rhodesia and elsewhere and found it both feasible and profitable. This information indicates that wild animals must be studied, not only in relation to their scientific and aesthetic interest and their impact on agricultural activities, but from the point of view of red meat production as an economic asset to the community.

Indeed, the conservation and management of wild life are inextricably linked, because the equilibrium of the habitat is fundamentally dependent on the natural fauna and flora and they must be preserved at all costs even in the face of increasing human population pressure and the continuous economic competition caused by so-called "development".

The subjects upon which future research should be based must enable administrators to enforce the knowledge available, supported by propaganda and education to convince the people concerned of the evils of mismanagement.

"My Government will establish a Land Use Commission to determine how best the many ecological units in this country may be utilized." H. E. Mzee Jonce Kenyatta (1969), President of Kenya.

This statement was made on the occasion of the opening of parliament, and it leads one to believe that the message is getting through to the right authorities and with this sympathetic consideration of the ecological approach in development and in solving problems of our environment, may increasingly be expected.

In the new approach to proper land use, education should be on three levels: (1) that of the the people of the land; (2) that of the upper administrative officials, and (3) that of the leaders and heads of state.

To be effective, this approach must be carried out by example and demonstration in the field as well as in the classroom.

Finally, a more enlightened understanding of game-stock management is urgently required, and a new veterinary approach is needed, to recognize the great potential that lies at hand if it is properly used —despite the protests of the "old guard" of veterinarians, some of whom still claim that the only good wild animal is a dead one, and, if wild ungulates have to be preserved, they must be kept behind a barbed wire entanglement with a ditch in front of it.

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I wish to thank Dr. Philip E. Glover, Head of the Kenya National Parks research activities in Tsavo Park with whom I have worked for the last 3 years, and with whom I have discussed in great detail, contents of this paper.

The work with fire and the observations of many East Africans has been put on record through the opportunity given to me by the Komareks (Ed, Betty, and Roy) to present a paper to the 11th Fire Ecology Conference. I wish therefore, to give due credit to the Masai people from whom I have learned that fire is an effective tool in the conservation of what one may call the "ecosystem". The hunting communities in East Africa have lived by the fact that animals are always attracted to burned areas. Their careful burning rotations as a means of successful hunting deserves special mention.

To the staff of the Kenya National Parks on whom the responsibility of implementing rotational fire programs in the respective areas under our charge rests, (Bill Woodley, David Sheldnick, Hassan Said, Ted Goss, and others) deserve special mention also. The same goes to the millions who have used and will continue to

use fire as a servant and not as a master, and to our many friends around the world.

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