Fire and Animal Impact on Vegetation in Tanzania National Parks

DESMOND VESEY-FITZGERALD

Scientific Officer,
Tanzania National Parks,
P. O. Box 3134 Arusha, Tanzania, Africa

IN the northern region National Parks of Tanzania, which have all been gazetted since 1960, the first work undertaken was a biological survey. This comprised an inventory of the species of animals and plants, a description of the vegetation, and an investigation of the dynamics of the environment. Special attention was paid to the nature of plant succession and to disturbances including fire and utilization by indigenous animals. The survey was a necessary prelude to planning a conservation programme in the parks (Interim Reports of the Ecological Unit, T.N.P. 1965–1970).

THE PARKS

In the three northern parks, there had been widespread disruptions of the ecosystem. In all, however, there were mitigating circumstances. In none was the decline of the environment so far advanced that rehabilitation was impossible.

The Arusha National Park had suffered from wild fires in conjunction with deforestation followed by a massive invasion of secondary shrubs and tussock grasses. Wild animals had been virtually

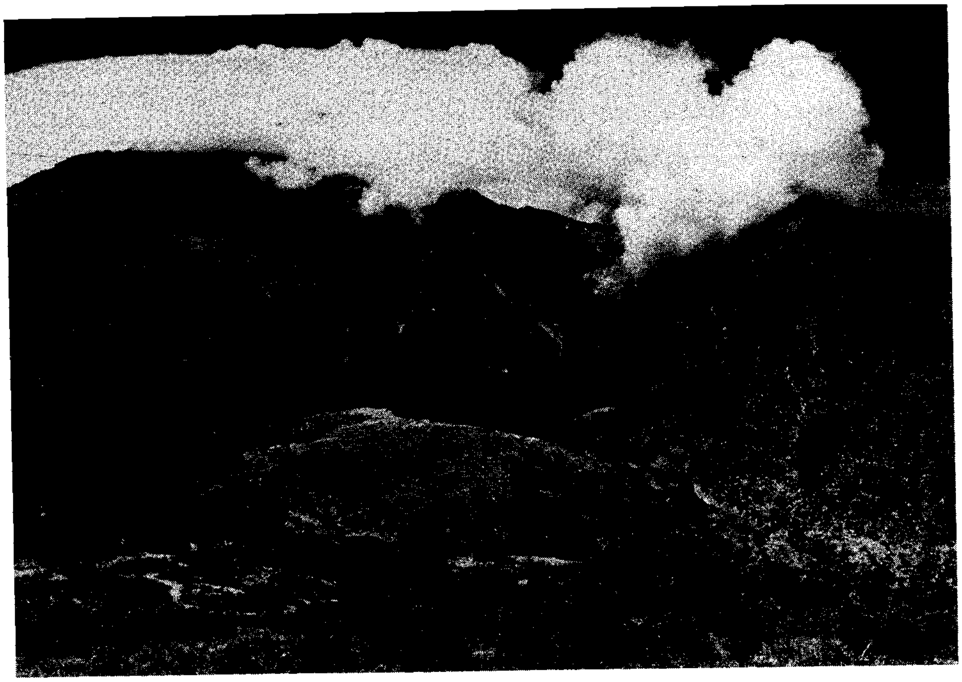

Fig. 1. Mt. Meru, 4,565 m, Arusha National Park. Diversity of vegetation resulting from topography, fire and animal impact. In the background is the precipitous wall of Meru Crater where it is summer everyday and winter every night, and landslides are a daily occurrence. In the middle distance is the conical Cinder-cone and (immediately to the right) a recent lava flow. The vegetation on these young land surfaces has not yet reached a condition of equilibrium with the environment. In the foreground (centre) is a shoulder of derived grassland. The original vegetation was montane forest (immediately to the left). A wild fire destroyed the forest and now large herds of grazing buffalo maintain the grassland as a closed sward. In these circumstances there is no further risk of wild fires eroding the forest.

hunted to extinction in the surrounding countryside. But part of the area had been a private game sanctuary and part forest reserve since the early years of the century (Vesey-FitzGerald, 1967).

Manyara had been a favourite hunting area until 1960. Settlement round about, both African and European, had led to increasing poaching and uncontrolled burning. In recent years the lake has risen to an unprecedented level, and human population pressure has led to excessive erosion all over the highland catchment. The park has consequently become restricted to a narrow slither of land between the lake and the rift wall. But the area is well watered, has excellent riverine and lake shore pastures and adequate browse. So although the former plains game component of the fauna has been flooded out of existence, the elephant and buffalo community has thrived in spite of the restriction of range (Vesey-FitzGerald, 1969).

Tarangire was a game reserve until recently, 1969. It has always

FIG. 2. Lake Manyara National Park. Diversity of vegetation resulting from erosion, fire and animal impact. To the left is the scarp face of the Great Rift Valley, to the right the shallow, saline lake which has no outlet. In the middle of the picture there is a gentle slope of redistributed detritus from the escarpment which is being washed into the lake. Wild fires burnt through the Acacia woodland before the area became a park. Now a heavy population of browsing (elephants) and grazing (buffalo) animals keep the woodland open, so reducing the risk of wild fires and obviating the need for prescribed burning to protect the browse shrubs.

been a dry season concentration area for animals moving in from a wide area in Masailand. Increasingly so in recent years the harrassment of animals in Masailand has been mechanised; yearly wild fires from all directions sweep across the park. The existing situation is therefore one in which there is too much grass (of the wrong sort at the wrong time) for too few animals. But Tarangire was the locus of pioneer wildlife research by Lamprey (the present Director of the Serengeti Research Institute), so there exists a good background of information for future management (Lamprey, 1964).

Arusha (45 square miles) is a mountainous and forested park (Vesey-FitzGerald, in preparation); Manyara (30 square miles) comprises an alkaline lake and acacia woodland (Greenway and Vesey-FitzGerald, 1970). Tarangire (1,000 square miles) is a semi-arid area of grassland and wooded grassland; (Lamprey, 1963). The management programme for each park is fundamentally similar. The object is to restore a state of naturalness and ecological tranquility. The

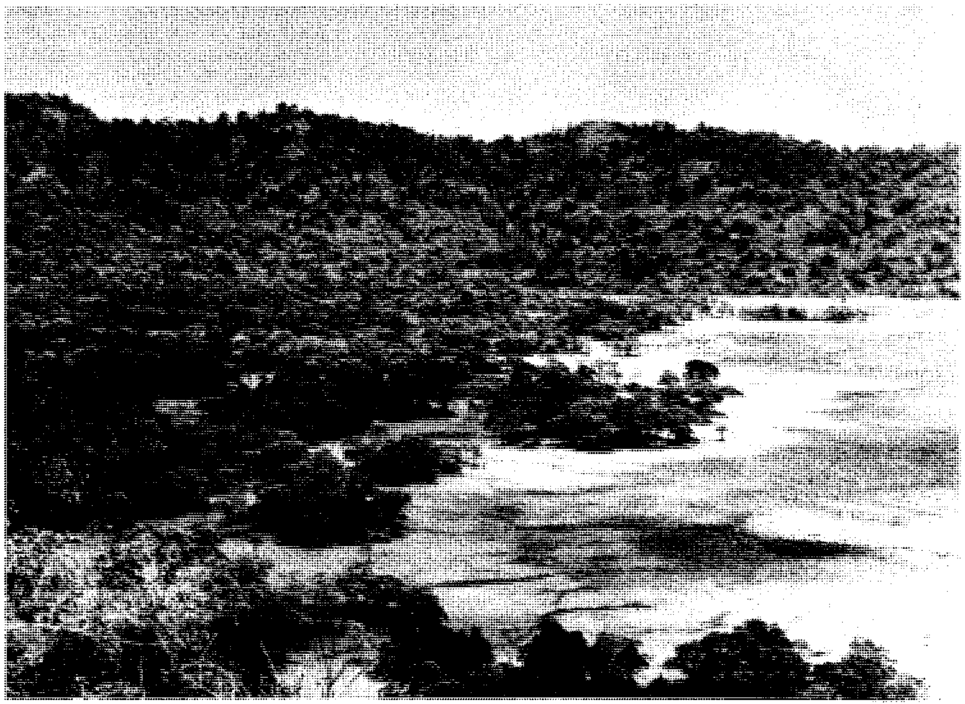

FIG. 3. Ngurdoto Crater, Arusha National Park. Diversity of vegetation in this picture results from edaphic (soil and drainage), former burning and present grazing conditions. In the background, the rim of the crater is covered with forest which however shows "fire-scars" dating from occupancy by Masai herdsmen a century ago. To the left (foreground) forest is established on well drained rocky ground. To the right there is badly drained high water-table grassland and swamp on alluvial soils. The grass sward is maintained like a lawn all the year round by herds of grazing buffaloes and other animals. There is no evidence of there having been any fires in the crater during the present century.

method is to encourage the animals themselves to ameliorate their own environment. Meanwhile the changes are monitored as the natural balance swings (Russell, 1968).

FIRE, ANIMALS, AND SUCCESSION

Three basic realities are involved, the animal impact, the impact of fire, and the natural course of plant succession. The investigation and possible manipulation of these fundamentals is our present interest. Expected bonuses are conservation of the environment, survival of animal communities and preservation of amenities.

The fire impact and animal impact on vegetation are largely supplementary. An excess of both is expected to throw the course of succession into a state of decline. One or the other balanced to growth is likely to preserve stability and maintain diversity (Darling, 1960).

Fig. 4. Edaphic forest glade, Arusha National Park. The sharp contact between closed canopy forest and lawn-like grass results from drainage and animal occupancy. Hollows of closed drainage are a feature of volcanic landscapes. During the rains they fill up and become a habitat for aquatic plants and water fowl. During dry periods grasses colonise the basins where the drainage conditions are unsuitable for trees. Heavy grazing by many animals eliminates any risk of fire, either natural (lightning) or man induced, eroding the standing forest.

Batchelder (1967) mapped burning in relation to climate and vegetation throughout the tropics. He emphasises that fire has a long history in the tropics but that combustible vegetation was relatively restricted in early times. More recently the increasing fire impact has resulted in an "ecological disequilibrium," shortages of food and deterioration of land values, in many areas of tropical Africa. Only very recently has "ecological rehabilitation" been considered.

Handley (1969) notes that the evolution of grasslands and grazing mammals were intimately related. Komarek (1965) notes that grassland animals create conditions that either change the vegetation or modify the effects of fire. In East Africa grazing lessens the fire hazard in grasslands and thereby maintains the diversity initiated by grazing. This has a double advantage in ameliorating the impact of fire, first on the plant and then on the animal environment.

Komarek (1967) records the role of lightning in causing a mosaic of seral vegetation. He points out that such fire environments, and the animals that go with them, are intimately connected with the origin of man in Africa. However, in Pleistocene Africa it is probable that grazing constituted a more important impact than fire on the natural grasslands at that time existing. There is indeed evidence that grazing animals and grasslands evolved together a considerable time before the ancestors of man left their trees to raise fire on the open plains (Ardrey, 1961).

Phillips (1965) treats the contemporary fire impact upon biotic communities and their habitats within the major bioclimatic regions of Africa south of the Sahara. Our present interest is to consider more particularly certain seral stages and states of naturalness represented by open grasslands and wooded grasslands.

Clearly an East African landscape dominated by mature grass is subject to wild fires during the dry season. Such fires by burning out the brush set back the course of succession and cause an extension of secondary grassland. Evidently if there exist extensive areas of long grass at the end of the growth period the grazing pressure has not been sufficient to reduce the fire hazard. An imbalance therefore exists in which there is too much grass for too few animals; firestorms naturally become more prevalent and the imbalance increases.

An overgrazed (or overbrowsed) landscape is in many respects the antithesis of the fire situation. In this case utilization has been too prolonged on too restricted an area. There remains no feed, no fuel, and no cover to protect the soil. Although the fire hazard is low, the course of succession becomes disrupted by attendant circumstances such as erosion and increased aridity. An imbalance therefore now exists in which there are or have been too many animals for too little feed, and so both the animal community and the environment is likely to fall into a state of decline.

A balanced situation is one in which there is evidence that the prevailing animal impact and inevitable fire impact is more nearly matched to the existing course and stages of succession.

An animal impact is manifest in various ways. First of all consideration needs to be given to the grazing mosaic. A grazing mosaic develops as a result of utilization. It comprises a diversity of well used short grass lawns interspersed with ungrazed mature grass stands.

The component grass species may be the same in both areas. This is because the stage of growth is more often a more important characteristic of palatability than the species of grass. Most species of grasses are palatable during their young and growing stages. Grazing, like mowing, retards maturation and promotes growth. And so growth favours utilization. Maturation on the other hand tends to cause neglect and finally actual avoidance of many grass species by grazing animals.

Hence the grazing mosaic becomes a measure of occupancy and utilization. The degree of development of the mosaic, which can be measured, is therefore a function of the animal impact which can be recorded. If the short grass lawns are small in relation to the long grass stands, evidently there is under utilization. At the other extreme if the whole natural pasture is reduced to a short grass sward, then there is optimum utilization.

Optimum utilization can be confused with overgrazing. They are clearly distinct, however, because the former recovers following a period of rest, whereas the latter degrades the course of succession. The prevailing situation at any site can be monitored. First of all, the botanical composition of the pasture can be assessed from time to time, and any induced changes in the flora can be ascertained. Meanwhile, the current effects of grazing can be ascertained by measuring the leaftable height (a measure of growth and grazing), the culm height (a measure of species composition and maturity) and the ground cover (a measure of the over-all grazing impact). Metre square exclusion frames set out on the pasture provide a convenient method for demonstrating the overall utilization.

From the botanical record, any reduction of palatable species, or an increase of grazing resistant ones, becomes evident. The leaf-table and culm height measurements, inside and outside exclusion frames, give evidence of use, or abuse, of the pasture during the period of occupancy. The ground cover assessment will indicate any undue exposure of soil that might lead to erosion. Thus optimum utilization or overgrazing can be recognized, and the extent by which the fire hazard is reduced can be ascertained.

Optimum utilization is a beneficial process. The development of a grazing mosaic keeps the pasture in a state of productivity while

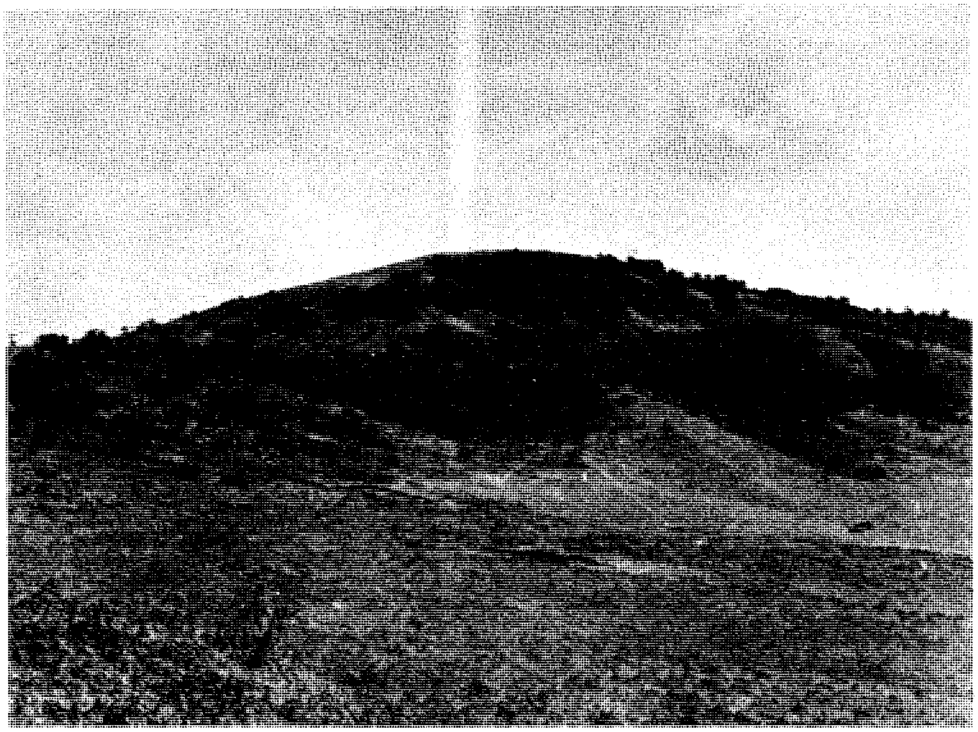

FIG. 5. On rim of Ngorongoro Crater. Diversity of vegetation induced by deforestation, fire and grazing by Masai stock. The distribution of relict forest, secondary shrubs and derived grassland shows no conformity to the vegetation-soil catena. There is no ecotone existing between the several secondary plant formations. Fire erosion and grazing pressure are degrading this vegetation from natural montane forest to secondary upland grassland.

portions are rested and portions are used. Fire-storms are prevented and a fire mosaic promoted by the existence of short grass lawns and long grass stands. Controlled burning (if considered necessary to remove unpalatable rough or induce a flush) is likewise facilitated and diversity can be maintained.

GRASSLANDS

At this point it is necessary to establish the fact that in the management of natural pastures there are different types of grasslands to consider. These different types can be categorised by their distribution (in relation to the vegetation catena), by a botanical analysis (species composition), by their phenological development (season of growth and flowering), and by their expected status in the course of plant succession.

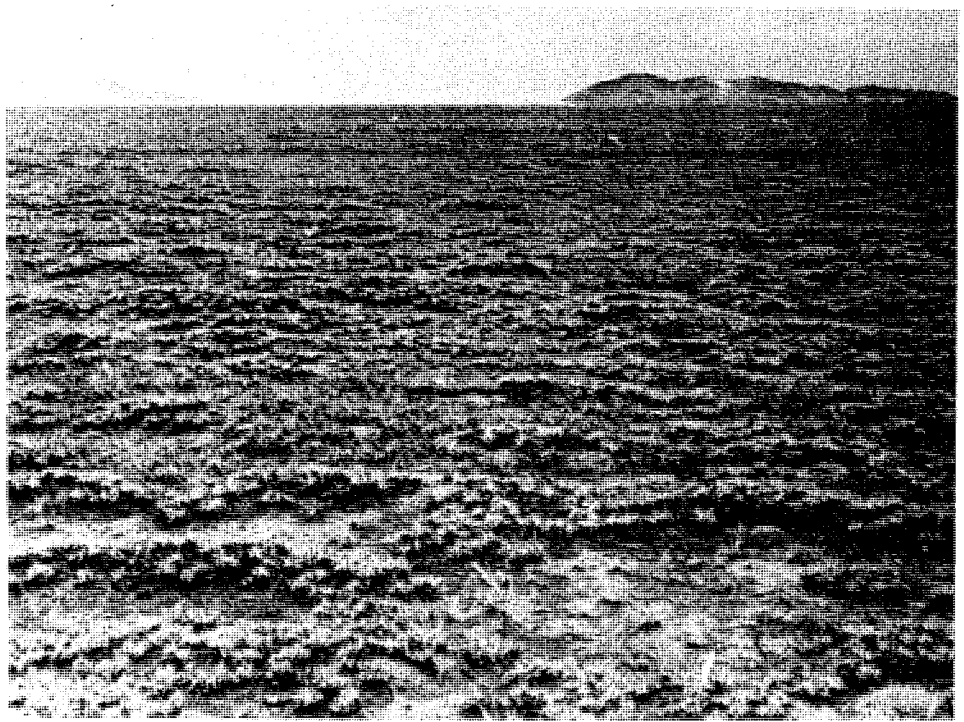

FIG. 6. Serengeti plains. The monotony of this treeless landscape is natural. The very low and highly seasonal rainfall, level land surface, shallow ash-soil overlying a hard-pan base and undeveloped drainage combine to exclude trees and favour a few adapted species of indigenous grasses. Fire plays no part in the development of this "climatic-edaphic" grassland. Heavy utilization by indigenous animals—wildebeest, zebra and other species, during the rains produces the "micro diversity" seen in the foreground. The clumps of closely cropped cushion-grasses are separated by trampled lanes of dusty soil which is wind eroded during the dry months. Water from showers is dammed in the hollows and irrigates the "cushions" to produce an early bite.

The south American term savanna has unnecessarily crept into African ecological literature and caused considerable confusion (Blydenstein, 1968). As the word is not used in the present discourse, a brief explanation of our own terms is given. The several types of grassland recognised in East Africa have been described by Vesey-FitzGerald (1963). They are based on their seral status or state of naturalness; the meaning of grassland is also extended to include certain wooded formations with a uniform grassy field layer. Grasslands as here understood are characterised by both grasses and sedges (Cyperaceae); there are three main categories:

1) Natural grasslands are under edaphic or climatic control. They occur prevalently where the drainage or under drainage is impeded or seasonal. Swamps, bogs, river valleys, flood plains and other sites in

the lower part of the catena are characteristic of their distribution, (Vesey-FitzGerald, 1970). Seasonally arid flat plains with shallow soils also support natural grasslands. The component species and associations are relatively few and often exhibit a zoned or mosaic form of distribution (Vesey-FitzGerald, 1955). These natural grasslands are modified by both burning and grazing but remain as grasslands whether such disturbances occur or not.

2) Secondary grasslands by contrast are seral. The majority are induced and maintained by fire. In the event of fire being eliminated, the course of succession proceeds to a woody sere. A large variety of species occurs, and they tend to have a random distribution. But in certain circumstances where a degree of stability becomes established, a few species may occur as dominants or co-dominants.

3) Derived grasslands are a special type of secondary grassland. They more or less permanently replace a previously existing type of vegetation as a result of attendant changes occurring in the environment at the time when the original vegetation was replaced. They may conform to the catena because the original vegetation did so. They may also alternate with relict stands of the pre-existing vegetation. Examples are upland grassland and montane grassland.

In a sense derived vegetation fills an ecological hiatus. The species occurring are varied and are themselves derived from a variety of habitats, their abundance varying from place to place and from season to season. Derived grasslands are frequently maintained by grazing if there is an animal community available to occupy them.

Wooded grasslands must also be considered. They are usually defined as a wooded formation with a grassy field layer, the canopy cover being less than about 20 percent (Gillman, 1949). There are two categories. First there are the edaphic wooded grasslands which are controlled by soil and drainage conditions; these conform to the catena. They can be recognised by their botanical composition. The woody element tends to have a grouped distribution.

Secondly there are the derived woody grasslands which occur as a result of disturbance, usually fire; these do not conform to the catena. They are in reality woodland in decline. Usually in their case the course of succession can be re-established by removing the modifying factor.

NATURAL MANAGEMENT OF GRASSLANDS

It is clear, therefore that all types of edaphic grasslands exist in harmony with soil and drainage conditions. They are related to the plant catena. They are not seral. Their composition or state may be modified by fire, but fire exclusion will not cause the grassland formation to be replaced by a woody formation.

The possible use of fire in the management of edaphic pastures can be summarised briefly as follows. Because the grasses occurring are perennial, and in the circumstances of the water-table being high (edaphic valley grasslands), controlled burning will usually produce a flush even in the absence of rain. But the burn must be controlled and not over done. Long grass fires which get out of control can cause serious damage to adjacent (wooded) formations thereby setting back the course of succession and initiating an imbalance between the quantity of grass and the animals in need of it. If too extensive an area of grass is burnt, the young grass will grow away from the animals and there will be a waste of pasture. Later in the dry season this pasture might be needed.

In park management practice it is rather difficult to visualise circumstances in which setting fire to edaphic grasslands might be beneficial. If the grazing animals are few in relation to the extent of the pasture, clearly a flush is not likely to be necessary. The natural development of the grazing mosaic should satisfy the requirements of the animals; the unused grass will rest and form a reserve that might be needed at some future time. If the animals are many in relation to the available pasture, then this is surely an indication that the population has increased to the capacity of the range. In these circumstances it could be argued that any flush induced by burning might tend to over burden the range and so delay adjustment of the natural balance.

Utilization of edaphic grasslands by an indigenous community of grazing animals, presupposes an understanding of grazing succession (Vesey-FitzGerald, 1960). Briefly this is a sequence of utilization by a spectrum of species. Heavy animals work down the long grass stands so that lighter animals can later use the short grass lawns of the grazing mosaic. In the course of this process the fire hazard is reduced; indeed even for prescribed burns fuel will be at a premium.

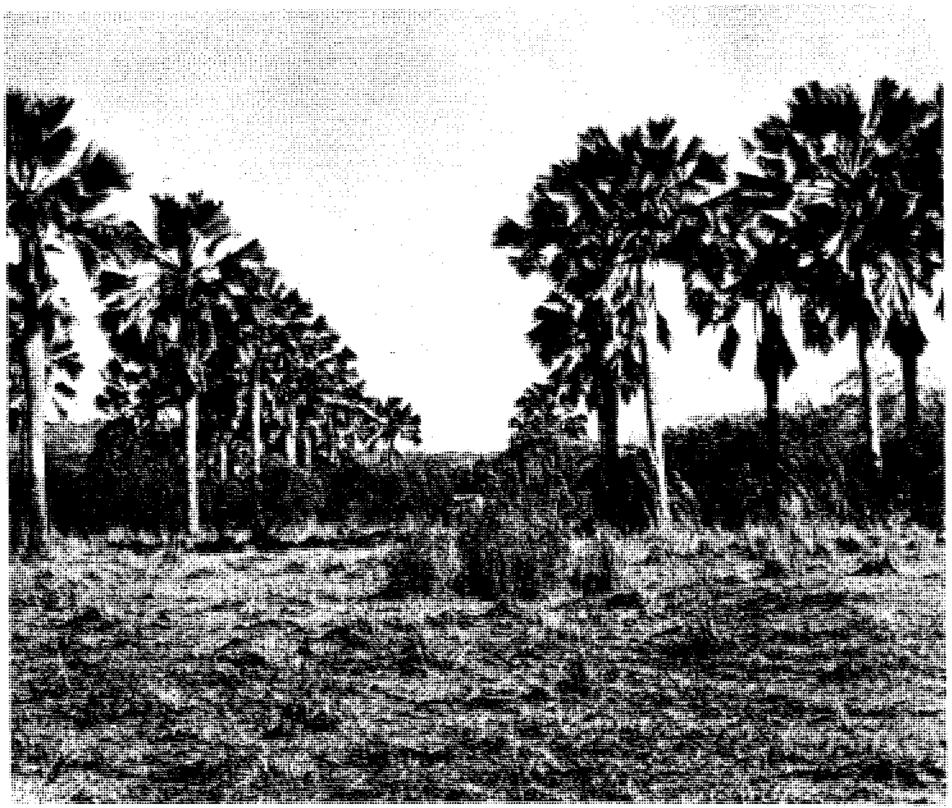

FIG. 7. Palm-stand valley grassland or "wet savanna," Ruaha National Park. The animal impact on this indigenous vegetation is marked. In the foreground there is a well developed grazing mosaic induced by buffalo followed by hartebeest. The standing clumps of long grass, *Hyparrhenia sp.*, indicate the former stature of this long grass. The shrub layer is heavily browsed by elephants. The palm grove, *Borassus aethiopum*, originated from seeds in elephant droppings; elephants feed avidly on the fallen fruit the stout palms resisting breakage when the animals shake them. The closely grazed grass provides a natural fire break protecting the clumps of browse shrubs.

Grazing succession as a natural function emphasises a difference between managing a national park and a ranch. On a ranch, fire may well be a useful tool with which to increase carrying capacity; in a park, the better tool is surely the animal community in a state of balance with its environment.

Fire subclimax grasslands are not necessarily related to either the drainage or the plant catena. They are however seral in the sense that if the prevailing fire impact is prevented, the course of succession will proceed through wooded to a woodland or forest formation. The animal impact is seldom evident on secondary grasslands; a grazing mosaic is seldom well developed. This is because at the onset of the rains when the new grass grows and is palatable, there is likely

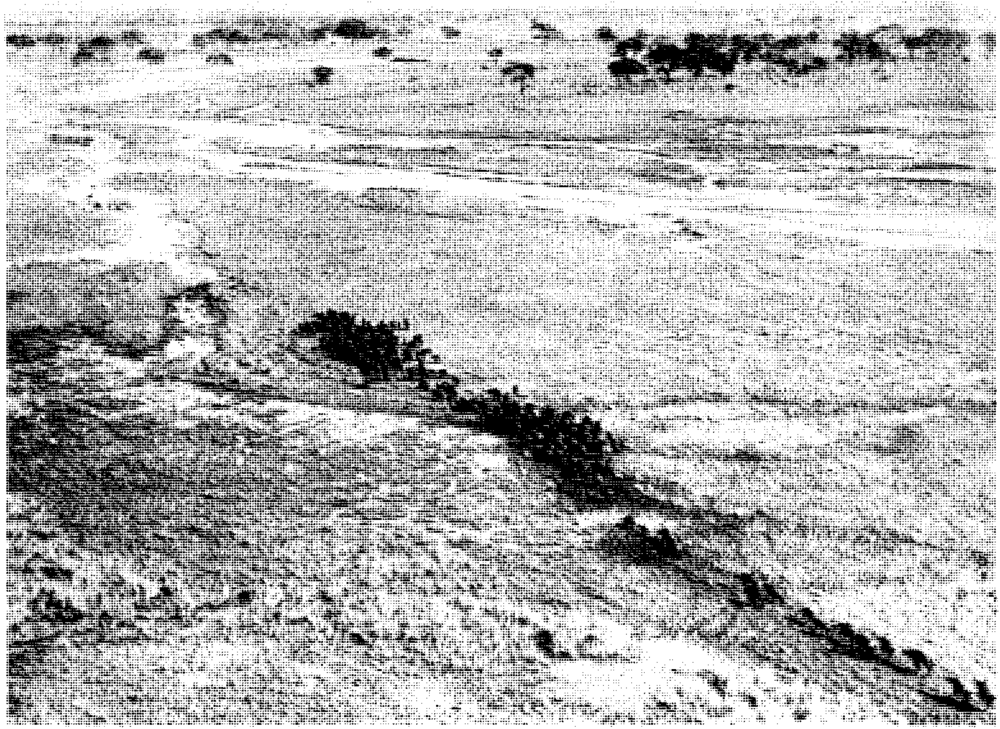

FIG. 8. Lake Rukwa flood plain part of the Great Rift Valley. The vast expanse of valley grassland results from the impeded drainage and black clay soil. The scattered groups and lines of trees exist where the soil is sandy and drainage better. The exceptional productivity of the valley grassland formation supports large concentrations of many species of grazing animals, the heavy ones preceeding the light ones as the dry season advances. The grazing pressure reduces the risk of fire storms in the long grass and so protects the growth of browse shrubs and trees on the sandy islands.

to be too much of it for too few animals. When the grasses mature they usually become fibrous and unpalatable and so are neglected, and other parts of the range will then be frequented. The dynamics of fire subclimax grasslands are being investigated particularly in the Tarangire National Park.

There, as elsewhere, it has been ascertained that secondary grasslands are composed of a variety of perennial species. The course of succession is truncated and maintained as a grassland formation by annual dry season fires. Frequently there is no animal community available to utilize the extensive fire subclimax grasslands that have been caused by overburning.

Clearly fire is an important tool in the management of fire subclimax grasslands as pasture. But prescribed burning must always be under control if the imbalance arising from too much grass and too few animals is to be redressed. Ideally just enough grassland, of the right sort, must be burned in order to satisfy the current requirements of the animal community. Both the plan and purpose are therefore essential considerations in prescribed burns. The cost of carrying out a burning programme efficiently is, therefore, likely to be far more than the price of a box of matches.

Prescribed burning in fire subclimax grasslands is a not unusual management practice on a ranch, the object being to retard bush encroachment by using a hot fire late in the dry season. In a national park, however, burning has a different purpose.

The purpose in park management should be to restore the course of plant succession, not to retard it. To achieve this purpose the accumulation of fuel must always be kept so low that fire-storms are prevented. Conventional firebreaks seldom suit either the ecology or the economy of a national park. The alternative is to establish a fire mosaic by ecological means. This is perfectly feasible and should become progressively more efficient as the programme proceeds and succeeds.

In practice there are several promising ways of setting about this task. A common method is early burning, whereby a cool fire of limited extent causes minimum damage to woody plants and regeneration. There are times and places when this type of prescribed burning can even be extended into the rainy season. In all cases the object is to reduce the hazard of wild fires getting out of control and so setting back the course of succession.

Ecological burning is a newer idea and has been less used. An understanding of the plant catena in relation to the drainage is necessary, and a vegetation map of the area is required to plan effective ecological burning. Use is made of the differential drying out of the different formations and stages of succession. Usually it is possible to burn the more elevated parts of the plant catena before the lower lying areas. For example, the ecotone forming the perimeter zones of valley grasslands can usually be burnt before the valley grassland formation is dry enough to burn.

By this method a differential fire impact can be established and the different zones of vegetation can be protected from fire storms. Furthermore, the chances of dry season fires spreading from one zone to another are reduced by the establishment of a fire mosaic. Ideally the needs of both grazing and browsing animals are served and the imbalance caused by too much grass for too few grazing animals to use is redressed.

This statement becomes especially meaningful when the derived grasslands are considered. Derived vegetation, it will be recalled, is vegetation that has replaced pre-existing vegetation that has been eliminated through some cause or other. Derived formations may exist in a degree of harmony with the altered environment. Such derived vegetation may therefore conform to the plant catena but may also represent a stage in the truncated course of plant succession.

For practical purposes, grazing maintained derived grasslands are pertinent to park management practices. They are being studied in the Arusha National Park where they provide the main pastures at the present time for the existing grazing animals.

Derived grasslands are especially characteristic of mountain areas. They can often be recognised because they alternate with a different formation, often the one from which they are themselves derived. The line of contact is usually sharp, unrelated to drainage features and not marked by an ecotone. The juxtaposition of upland grassland and relict forest blocks is one example, of tussock grassland and moorland another. The botanical composition of derived vegetation is itself derived from a variety of sources. The component species may be regarded as invaders. A period of interspecific competition may have been passed through until a degree of stability was attained with the changed environment.

Derived grasslands may be modified by extraneous circumstances such as fire and grazing, but they are controlled by the altered environmental conditions such as alterations to the soil or increased exposure and aridity. These attendant circumstances need to be considered therefore when planning the managment of derived grasslands.

Derived grasslands may be invaded by either grazing animals or fire; the one modifying the impact of the other. In the event of a fire invasion, there is a probability that the surviving original vegetation will be eroded, and the alternate derived vegetation will be extended. Invasion by animals is likely to cause a mellower impact.

The development of the grazing mosaic in derived grassland is a measure of the grazing impact. The short grass lawns are maintained as pasture and the long grass stands (tussock grasses) form a reserve until needed by the increasing animal population. The risk of firestorms is progressively reduced as the grazing impact increases and finally the grassland may become grazing maintained as a pasture without the influence of fire.

It is likely that an animal invasion will consist of a single species which becomes the dominant grazer; it is rather unlikely that there will be a sufficiently varied assortment to establish grazing succession. For this reason prescribed burning may have a useful purpose as a management practice.

The welfare of the dominant grazer can be expected to pass through three phases. Arrival and survival, a period of increase and then a state of stability in relation to the capacity of the environment. The animal impact in relation to the maintenance of the derived grassland can be observed and monitored throughout the year by the establishment of grazing exclusion frames as already mentioned. Consecutive measurements of the leaf-table, culm height and ground cover, inside and outside the frame provide a running record of both the qualitative and quantitative aspects of utilization.

In all types of naturally occurring grassland (edaphic, secondary, and derived) optimum utilization depends on suitable and sufficient pastures for the use of the animal community throughout the year. Clearly the carrying capacity of the range is a function of the pasture available at the time of greatest shortage. It is essential therefore to work out the "grazing calendar" that is available when planning a conservation programme in a national park (Vesey-FitzGerald, 1969).

The grazing calendar was certainly not thought about when the northern parks were demarcated. In the smaller ones restriction of range is a considerable problem. Nevertheless, indigenous animals show adaptability to circumstance in working out their own grazing calendar. This is achieved by a degree of nomadism (Vesey-FitzGerald, 1965). Consideration has therefore to be given to the effect of both the animal impact and the fire impact on the available grasslands, and on the course of plant succession, in modifying the grazing calendar within the range.

In the larger parks the relative freedom of movement allows the animal community to adjust itself to the variations of season and grazing. In smaller parks the effect of grazing pressure in maintaining the pasture in a productive state is of considerable importance. The satisfactory maintenance of a thriving community of animals in a healthy environment therefore largely depends on the factor of optimum utilization of existing pastures, and not very much on artificially increasing the productivity of the range by the use of fire. Clearly the animal impact influences the environment. Equally, it is postulated, the environment influences the animal population. In this way diversity is maintained, and what amounts to a mosaic of territories is maintained throughout the range.

BROWSE

So far this dissertation has only considered grazing. The question of browsing must now be introduced. Browse studies necessitate a comprehension of plant taxonomy, vegetation dynamics, the impact of the dominant browser and of fire on succession and regeneration. These matters are presently under investigation in Lake Manyara National Park.

Data are obtained by application of the point-centred quarter method of survey. This comprises setting down an X-shaped frame at random intervals throughout the plant formation that is being examined. The nearest plant to the center point in each quarter of the frame is identified. A number of attributes are recorded namely, the distance (a measure of distribution), height (a measure of maturity and coverage) and evidence of a browse or fire impact. Each of the last two being categorised into degrees of severity.

The browse and fire impact is categorised into a) an impact immediately replacable by growth, b) an impact more or less disfiguring a plant and possibly affecting its chances of survival, c) an impact likely to alter the course of succession. This standardised method of monitoring the contemporary situation has proved to be economical in time and efficient in practice. From these figures information is obtained on the relative and absolute density of each species of woody plant, together with the height, age and coverage class to which each belongs. Data on utilization species by species and from season to season, and on the overall effect of browsing and burning on the dynamics of the vegetation, are also made available. From these data the stage of succession, signs of regression and the regeneration potential of canopy trees can be ascertained.

It is generally accepted that browsing preceded grazing in the geological time scale. It was not until the early Miocene that grazing mammals began to flourish. Apparently about this time grasslands became an important element of the vegetation. It appears that the evolution of grasslands and grazing animals were intimately related.

Elephants (Proboscidae) are a more ancient group than the typical grazing animals (Bovidae). In competition with the latter, which have flourished, the former have declined. The bodily structure of elephants proclaims the creatures as breakers of branches and consumers of coarse herbage, and of giraffes (*Giraffa camelopardalis*) as nippers of high level twigs. The survival of the African elephant (*Loxodonta africana*) is undoubtedly connected with the fact that the species has become an efficient grazer.

In the seasonally dry tropics bush encroachment is a problem on ranches. This is generally because grazing reduces the grass cover, and therefore fuel for a hot late season burn. Hence the course of succession is not impeded and the vegetation naturally proceeds through a shrub dominated stage to tree regeneration, and eventually to the reestablishment of woodland.

Keeping a ranch clear of bush is an expensive and continual process. Fire is largely used because it is more effective and easier than such alternatives as hand or mechanical clearing, or using poison and herbicides. Effective burning is however not as cheap as is often supposed. A third to a quarter of the ranch must be rested from grazing so as to insure sufficient fuel for a hot burn. The vagrancies of climate make it difficult to plan ahead. Strict precautions are always necessary inorder to avoid fires starting at the wrong time in the wrong place and causing damage to pasture and fences.

In a national park the situation is different. A wide spectrum of both grazing and browsing animals has to be catered for. Conservation of the environment requires that the course of succession should be restored as a natural process. In East Africa at the present time succession has usually been increasingly impeded or even totally inhibited by wild fires and attendant changes such as increased aridity followed by soil erosion may also have occurred.

MONITORING THE ECOSYSTEM

The existing situation has therefore to be assessed and artificial disturbances brought under control. Once the course of succession has been restored future progress is likely to be a naturally progressive process. Management then becomes a matter of monitoring the changes and where possible correcting imbalances, especially those caused by over abundant animals and too frequent fires.

As was the case for grazing, it has been shown that browsing begets growth and growth begets browsing. Just as there is a tendency for grazing animals to maintain their pastures, so browsing animals maintain their browse-table of pruned and sprouting tips. Optimum browsing occurs in the shrub stage of succession. There is a tendancy for browse pressure to maintain this stage. Under-utilization would tend to allow the course of succession to advance to a tree stage, over-utilization to induce a state of decline of the shrub layer towards grassland.

Climax vegetation (closed canopy forest) offers relatively little pasture or browse. In secondary or seral vegetation, including both woodlands in decline and edaphic wooded grasslands, both pasture and browse may be available, the one interdigitating with the other. In this event browsing and grazing are mutually advantageous to both browsing and grazing animals. Browsing reduces overhead cover thus permitting growth of grass. Grazing reduces the fire hazard thus promoting the growth of browse. Diversity is thus maintained by both the browsing and grazing impact.

Diversity is seemingly a very important ecological phenomenon; evidently nature abhors a monoculture. All our work in the Tanzania National Parks brings us to the same conclusion. Maintaining ecological diversity then must be the objective of our plan and the purpose of our practices.

In the narrow field that has been investigated it has become apparent that fire-storms have degraded the environment largely by destroying the natural state of diversity. Yet the judicious use of fire, by preventing an accumulation of fuel and thus reducing the fire hazard, tends to establish a fire mosaic in which both the browsing and grazing potential is good. Prescribed burning under strict control may therefore become a useful tool with which to improve the pasture, protect the browse and foster the course of succession.

There is ample evidence in East Africa that overgrazing and overbrowsing resulting from prolonged occupancy of a restricted area by a few kinds of animals is causing increasing degradation, aridity, and erosion of the environment. Yet a mixed community of animals of comparable mass is able to thrive without damaging the environment. This is seemingly so because of the diverse effects of grazing, browsing and burning on the varied types of vegetation and stages of succession in a well balanced environment.

In practice, therefore, the first necessity of management in our National Parks must be to monitor the impacts of animals and fire on the course of succession so as to ascertain when imbalances occur as the balance of nature swings. In this way a state of harmony will be assured between the animal and fire impact and the course of plant succession.

SUMMARY

Following a biological survey in the Arusha, Manyara and Tarangire National Parks of Tanzania, the dynamics of the environments were investigated as a preliminary to planning a conservation plan.

In each park there had been man induced disturbances of the ecosystem. But rehabilitation is shown to be possible by manipulating such natural variables as the impact of animals and the impact of fire in relation to the plant succession. Imbalances arising as a result of over burning and over grazing need correcting so that both can be channelled towards a state of harmony with the naturally occurring course of succession in different types of vegetation.

Varying degrees of treatment may be required for the different types of grassland that occur, namely edaphic, secondary (fire subclimax) and derived grasslands. Both browsing and grazing animals need to be catered for in a national park, and so both wooded and

treeless grasslands and both the grassy and woody stages of succession need to be considered.

Methods whereby management practices may be carried out, and ways of monitoring the results obtained are mentioned. It is emphasized that the differential effects of grazing, browsing and burning on the course of succession all tend to create a state of diversity. Maintaining such a state of diversity is stressed as being the proper purpose in managing a National Park in East Africa.

LITERATURE CITED

Ardrey, R. 1969. African genesis. Collins.

Batchelder, R. B. 1967. Special and temporal patterns of fire in the tropical World. Proc. Tall Timbers Fire Ecol. Conf. no. 6, pp. 171–190.

Blydenstein, J. 1968. Burning and tropical American savannas. Proc. Tall Timbers Fire Ecol. Conf. no. 8, pp. 1–14.

Darling, F. Fraser 1960. Wild life in an African territory. Oxford Univ. Press, London.

Gillman, C. 1949. A vegetation types map of Tanganyika Territory. Geogr. Rev., New York, 39:7–37.

Greenway, P. J. & Vesey-Fitzgerald, D. F. 1970. The vegetation of Lake Manyara National Park. J. Ecol. 57:127–149.

Handley, C. O. 1969. Fire and mammals. Proc. Tall Timbers Fire Ecol. Conf. no. 9, pp. 151–159.

Komarek, E. V. 1965. Fire ecology—grasslands and man. Proc. Tall Timbers Fire Ecology Conf. no. 4, pp. 169–220, bibliography.

———. 1967. Fire and the ecology of man. Tall Timbers Fire Ecology Conf. no. 6, pp. 143–170.

Lamprey, H. F. 1963. Ecological separation of the large mammal species in the Tarangire Game Reserve, Tanganyika. East Africa Wildl. J. 1:63–92.

———. 1964. Estimation of the large mammal densities, biomass and energy exchange in the Tarangire Game Reserve and the Masai Steppe in Tanganyika. East Africa Wildl. J. 2:1–46.

Philips J. 1965. Fire—as master and servant: its influence in the bioclimatic regions of trans-Saharan Africa. Proc. Tall Timbers Fire Ecology Conf. no. 4, pp. 7–109, illustrations, maps, bibliography.

Russell, E. W. 1968. Management policy in the Tanzania National Parks. T.N.P. publication 1–24.

Vesey-FitzGerald, D. F. 1955. The vegetation of the outbreak areas of the red locust (*Nomadacris septemfasciata* Serve.) in Tanganyika and Northern Rhodesia. Anti Locust Bull. 20 London. 1–31.

———. 1960. Grazing succession among East African game animals. J. Mammal, 41 (2): 161–172.

———. 1963. Central African grasslands, J. Ecol. 51:243–274.

———. 1965. The utilization of natural pastures by wild animals in the Rukwa Valley, Tanganyika. East Africa Wildl. J. 3:38–48.

———. 1967. A glimpse of Eden. Africana 3 (3): 11–16.

———. 1969. Utilization of the habitat by buffalo in the Lake Manyara National Park. East Africa Wildl. J. 7:131–145.

———. 1970. The origin and distribution of valley grasslands in East Africa. J. Ecol. 58: 51–75.