WASTE PRODUCTS IN NATURAL VEGETATION

By J. S. Henkel

For many years the writer has studied South African plant ecology, and in his classifications of vegetation types relied on the more conspicuous woody plants. Grasslands were treated as whole units, and scant attention was given to grass species. The reason, of course, being that it is easier, at any time of the year, to identify woody plants.

As the grass consummates play an important part in South African ecology, the writer has, in recent years, made a special study of the vegetative organs of the various species, mainly with the object of preparing a key to the species for field use.

Since the grasses, apart from being dominants in grassland, are distributed among all the vegetative types in the various climatic zones, problems for their preservation and maintenance in competition with themselves, as well as with other groups of plants, attracted the writer's attention and led him to make some investigations into the whole problem of the stability of existing plant communities.

South Africa is said to be a very old land surface. If this is so, then all the natural vegetation found in any locality must be in equilibrium with all the factors, including biological ones, and so long as the factors remain the same the various existing communities will maintain themselves indefinitely. All South African plant communities are closed. These communities are made up of many species of plants, often in layers, each species claiming a place in the "sun" or in the "shade."

In South Africa there are summer and winter rainfall areas, with corresponding dry seasons when plants are dormant. In each of these localities the plants are adapted to the environment. All plants during the process of growth yield waste products in the form of annual or periodic leaf-fall, the shedding of bark, mature fruits, twigs and branches resulting from competition or suppression; deaths at maturity, unseasonable frosts, periodic severe droughts or excessive rains leading to water-logging; defoliation by insects, such as locusts, caterpillars, beetles, etc.

The disposal of the continually increasing undecomposed dead material is a natural problem and the means of disposal of these waste products determines the character of the community.

As is well known, the South African climate is an erratic one, wet cycles alternate with dry cycles so that there is no absolute stability. Since European and Bantu occupation a new series of disturbing factors were brought into being.

Europeans decimated the wild animals. With this reduction of a biological factor, i.e. the restraining influence of browsing and grazing animals, particularly in communities with light-demanding vegetation, another factor, namely fire, became of greater importance. Later this factor was partly neutralised by the increase in the number of domestic animals often leading to overstocking and change in the grass flora. This is not all. In places faulty agricultural practice led to soil erosion and development of gullies and consequent reduction in the producing capacity of the land.

For the purpose of this paper all species of plants may be placed in one of two classes, namely:

1. Plants which are light-demanding, i.e. those which do not thrive unless their crown of foliage is freely exposed to sunlight and air. To this class belong the grasslands and the various savannah and sclerophyll associations.

2. Plants which are shade-enduring or shade-bearers, i.e. those which can grow and thrive without being exposed to full intensity of sunlight. Plants belonging to this class are aggregated in evergreen closed forests having a dense canopy and sharply defined perimeters.

Waste material in these two classes break down into simpler compounds by different processes.

In areas occupied by light-demanding plants waste products of aerial parts, shed annually, accumulate on the soil surface and do not readily decompose to form humus. Various causes are responsible for this, such as low air humidity, extremes of day and night temperatures, lack of sufficient moisture to favour bacterial or fungal action in the mass of accumulated dead material. This surface accumulation of dead matter forms a blanket preventing vegetative growth or regeneration by seed.

In their response to the factors, it should be remembered that grasses are monocotyledons. Growth takes place at the leaf base; injury from cropping as well as from fire. Repeated cropping leads to the development of auxillary leaves at the closely-spaced nodes at or just below the soil surface. On the other hand, trees and shrubs are dicotyledons, leaves, buds and twigs more easily injured by browsing animals.

The manner of disposal of waste products plays an important part in the continued existence of the various species. The accumulated dead material becomes inflammable and is liable to destruction by fire, which may originate from lightning, rolling stones or through ignition by man. Hence the greater the accumulation of dead material the greater will be the injury caused by fire, or if fire is absent by suppression of vegetative growth and the prevention of seedling regeneration. Other influences are also at work. Earthworms and moles, by their castings, cover up some of the material. Ants and termites dispose of some of the dead material. Elephants, wild pigs, antelopes and spring hares do a certain amount of soil cultivation. Wild animals or domestic stock by trampling flatten out the dead material. Notwithstanding these biotic factors, there is an ever-present menace from fire.

In the evergreen closed forests dead vegetable matter is continually being resolved into simpler compounds through bacterial and fungal action. This is favoured by the suitable moisture and temperature conditions. The product of the decomposition is humus—a black or brown amorphous substance in which organic cell structure is completely destroyed. Within the closed forests there is a green non-inflammable floor cover. Earthworms and burrowing insects aid in mixing humus with the soil. The rapidity of humus production varies with the temperature, being rapid in warm situations. Termites are absent from closed forests. In closed forests fires do not occur unless the canopy and margin has been interrupted by hurricanes or careless utilization of timber by man, leaving excessive amounts of waste timber littering the soil.

In South Africa the light-demanding communities may be conveniently classified into three groups, namely:

(a) Grassland. Areas in which numerous species of perennial tufted grasses are dominant. These areas are chiefly confined to localities with summer rainfall.

(b) Savannah. Areas with trees and shrubs in open woods with ground herbage of grasses—chiefly in summer rainfall localities.

(c) Sclerophyll. Areas with evergreen leathery-leaved shrubs, sometimes with a few trees and scattered xerophytic grasses, confined to winter rainfall areas, and crests of mountains in summer rainfall areas.

All the areas occupied by these communities are subject to fire, either annual or periodic. Additional particulars are given for each of the communities.

Semi-desert areas with thin stocking of plants are omitted, for generally speaking there is no fire menace. Winds scatter what little waste products are produced.

GRASSLAND.

Grassland occupies considerable areas in the summer rainfall zone. There are many perennial tufted species in the community. The height growth of individual species varies within wide limits. The grasses usually have shallow root systems. Various methods of classification have been adopted, such as the one used by Pentz, i.e. tall grassland, highland sourveld and mountain veld. For others, R. S. Adamson, in Vegetation of South Africa and Henkel, who simply divides them into mountain, plateau and vlei grasslands. The margins of grasslands are sharply defined in the case of vlei types or where they adjoin closed forests. In other cases the grasslands merge into savanna.
and sclerophyll associations without any great change in the component species. In grassland the top soil in many localities is porous through the agglomeration of soil particles into crumb-like groups which are resistant to erosive action. This feature may be noted along road or railway cuttings or the margins of gullies and dongas. Below the depth normally occupied by grass roots there is no colloidal action, and consequently when the top soil is removed the subsoil erodes rapidly. This is well shown in the excellent photographs in Botanical Survey of South Africa Memoir No. 19, by J. A. Pentz.7

Every year there is a fresh flush of leaves, which become fibrous when normal height growth has been attained, and in late autumn the leaves die or are killed by frost. Before death salts are withdrawn to the rhizomes. If cropping is not excessive or absent, the dead material forms a mantle of undecomposed matter. If this is not removed it accumulates, and in the course of a few years by suppression kills the producing species and prevents regeneration by seed. These areas are then invaded by non-grasses or by savanna or closed forest species if seed-bearers are in the neighbourhood.

Bews' in his book on Grasses and Grasslands of South Africa (1918), states that at Nottingham Road, Natal, on the farm of Mr. James King, there is an area of over 60 acres which has been protected from grass fires by fire-breaks for over 35 years. The result has been to change the area from pure grassland to closed forest.

The writer also noted this effect, and instances are given in his paper on Forest Progress in the Drakensberg.8

The elimination of light-demanding grasses following protection from fire provides a simple method of establishing closed forests by planting tree seedlings in pits dug in the grassland.

On the other hand, grassland areas are maintained in full vigour by regular burning of the waste vegetable matter. This is typically seen along the fenced strips of grassland bordering the railway tracks. Here the grasses are burned annually during late summer and autumn as soon as they are inflammable. This practice by railway officials has been continuous since the building of the railways. It is in these annually-burned strips that grasses show their best growth. In State forest reserves wide fire-breaks are burned annually along the perimeters of closed forests. These areas are cropped by domestic stock, yet the burning plus the cropping has not led to the deterioration of the grasses or the formation of gullies or dongas. It is not contended that the burning of the grasses as practised by railway or forest officials gives the best results for pastoralists, but it is positive evidence of the use of fire in maintaining grassland.

It is clear from the evidence submitted that grasses, if not heavily cropped, perish in areas from which fire is excluded, and in areas annually burned-out they persist and maintain themselves vigorously.

It is clear also that the annual removal by burning of the aerial undecomposed waste products cannot produce humus, which is the product of decomposed organic matter.

It is, however, evident that some colloidal substance is present in the top soil binding the soil particles into crumb-like masses which do not break down when immersed in water. This colloidal effect may result from the decay of grass roots, or perhaps from the decay of the layer of dead organic matter in immediate contact with the soil surface.

In general, it would seem that the consuming of aerial undecomposed organic matter by fire is nature's method of maintaining grasslands.

SAVANNA.

Savanna in Africa covers vast areas. The community is found in many forms. In some localities the trees and shrubs are widely spaced, in others simulating closed forests. The trees and shrubs may be deciduous or evergreen or a mixture of both. The annual or periodic shedding of leaves, twigs, bark, branches and the death of plants adds inflammable material to that of the grasses.

The constant presence of adaptations among trees and shrubs to resist injury from fire is ample proof that the fire factor has prevailed for thousands of years. Thick fissured, corky or flaky bark, together with abundant dormant buds and vigorous coppice or sucker growth, are noted among woody plants in all savanna areas. In the case of *Uapaca kirkiana* the large leaves on young seedlings or coppice growing amidst grasses have their bases deeply cut so as to deflect the flames from the main shoot. This the writer proved by experiment in the field as well as noting the results following grass fires.

Termites are abundant in savanna, and termite-mounds of huge dimensions are frequently a feature in the landscape.6 Termites devour dead or moribund organic matter. King6 (figs. 21 and 22) illustrates some termite-mounds in his book South African Scenery.

### SCLEROPHYLL.

This is the chief association in localities of winter rainfall. For the most part trees and shrubs are represented. The shrubs, in areas of high rainfall, form thickets, while in drier parts their wide spacing leaves much of the ground bare except for annuals. Most of the woody plants have protective devices against destruction by fire. Perennial grasses are thinly scattered among the shrubs and grasses. As in the case of grassland and savanna, there is the annual or period leaf-fall which accumulates and remains undecomposed. Grasslike plants such as species of *Festuca* are common. The mountain areas in the south-western districts are masses of quartzite or sandstone yielding poor, acid soils. In these areas during the hot dry summers bush fires are not uncommon. Termites are not numerous, and their termite-mounds never reach the size of those in summer rainfall areas. Peat occurs in wet localities. There is no surface production of humus. Frequent burning of the litter tends to foster grass growth—most of the hard-leaved evergreen plants are unpalatable to browsing animals, and because of the sparse grass growth afford poor pasture for domestic stock.

### EVERGREEN CLOSED FORESTS OF SHADEBEARING PLANTS.

The closed forests are not extensive. In South Africa they occur along the eastern escarpment, and from Natal extend along the coast and coastal escarpments to the Cape Peninsula. The component species vary with the climatic factors. Their best development is where geographic precipitations are most abundant. These forests are complete units, having a layered canopy which extends to ground level along sharply-defined perimeters. Within these forests humid conditions prevail and there is small diurnal range of temperature. Frost does not occur. Waste organic products in the form of fallen leaves, fruits, twigs, branches and dead stems soon decompose as the result of bacterial and fungal action to form humus. These closed forests are not subject to fire. Earthworms, often attaining to lengths of 4 feet or more, are common, as also are many kinds of burrowing insects. Termites are absent. In former years a certain amount of cultivation was brought about by wild pigs.

The outstanding distinction between savanna open woods, where no humus is formed, and the closed forest is the amazing volume of solid wood accumulated in the trees and shrubs. Some of the dominant trees attain to heights of 200 feet and up to 50 feet in girth, while many subdominant species also attain to a large size. It is difficult for a person acquainted only with the accessible "cut out" forests to imagine the dense stocking of these primeval forests before they were ruthlessly robbed by European sawyers, or in some cases deliberately destroyed by Natives to grow food crops. Fortunately there still exist a few of these primeval forests, which are being preserved as national monuments.

Though in some places complete destruction has taken place and the areas are now occupied by grasses, the writer cannot recall any case of erosion leading to donga formation. In the heavily "cut out" forests drag paths are soon clothed with plants and regeneration is everywhere taking place and, if not interfered with by man, will, in course of time, reproduce their pristine glory. In his long experience as a forester, the writer has discovered no decadent species.

### DISCUSSION.

It has been shown that on the old land surface of South Africa there are many different plant communities which are in equilibrium with all the factors of the environment. The division of these plant communities into light-demanding and shade-bearing species is a useful method of studying nature's way of dealing with waste vegetative products and ensuring the main-
tenance of all species in a community. The evidence yielded by the plants which grow in light-demanding communities shows that fire is a biotic factor of considerable importance and aids in the maintenance of species. In the case of the closed forests fire is not a biotic factor. In areas occupied by light-demanding species, chiefly owing to unfavourable climatic conditions, waste organic matter accumulates and remains undecomposed or tardily breaks down without forming humus. In the closed forests with favourable moisture and temperature conditions, humification of waste organic products is a continuous process.

In the one case no great improvement in soil condition is apparent, while in the other soil improvement resulting from humus production is shown by the continued production of immense volumes of solid wood.

It is only as we understand nature's methods and apply them that it is possible to propagate and utilise vegetative products to the best advantage.

SUMMARY.

It has been shown that the vegetation of South Africa consists of plant communities adapted to environmental conditions, and that the maintenance of any community largely depends on nature's method of disposing of waste vegetative products of growth.

To appreciate the problem, all species of plants, as they occur in their natural environment, are grouped into two classes, namely, (a) light-demanding communities and (b) shade-enduring communities. In the former class, waste products of aerial parts accumulate on the soil surface and do not readily decompose and form humus. The biotic factor of fire is used by nature to remove the encumbrance which, if not removed, inhibits the growth and maintenance of many species. In the latter class all waste products are converted by a continuous process of humification leading to enrichment of the soil. Fire plays no part in this process. To support the contention, light-demanding communities are divided into three groups, namely, Grassland, Savanna and Sclerophyll. Short accounts are given of the three communities. In the case of grassland it is shown by examples that if areas are not burned annually or periodically grasses perish. The judicious use of fire maintains them. The same principle is in force in savanna areas, but in addition there is the added termination of some species.

In sclerophyll areas, where grasses are sparsely represented, the accumulated leaf-fall and lateral spread of the woody species is the suppressing factor, and if not removed leads to the termination of some species.

In the evergreen closed forests of shade-bearing plants all waste products are converted into humus. There is no fire menace unless the areas are injudiciously managed by man.

References.
1 Adamson, R. S. (1938) : Vegetation of South Africa. British Empire Vegetation Committee, London.

Mr. ROBERTSHAW said that this paper was of interest to him. In almost every part of the country tracts of land were found which were not particularly suitable for cash crops, and the possibility of these areas being used to confine them to afforestation or to grasslands. Mr. Stevens, the Conservator of Forests, was of the opinion that unless afforestation was likely to prove profitable, it would be better to have grass and to carry out properly controlled farming.

Mr. SCOTT agreed with Dr. Henkel on the necessity of burning areas where the mower could not be used. If that were not done the vegetation would die out. The time of burning was, however, most important, and he had to disagree with the author that the autumn was the best season. His example of grass burned along the railway enclosures was not a good one, because there was no grazing on these reserves. The speaker maintained that the plant cover in autumn-burnt veld was only thirty per cent. of what it would be if burnt in the spring. Along the fringes of forest reserves autumn burning was necessary, but it resulted in the deterioration of the veld, and his opinion had been sought as to whether grazing in those areas should be stopped.

Dr. HENKEL, in reply, referred to a paper by Professor Hector in the South African Journal for the Advancement of Science, 1934, in which the results of burning veld for fifty years were given. Some areas were burnt in winter, some in November and December, and the rest in January and February. All those areas were, of course, carefully looked after and the areas burnt during the months of January and February maintained all the stock, consisting of 200 head of cattle, 4,000 sheep and 30 horses, during the winter months. Yet there was no soil erosion and the cattle were in good condition. As Forest Officer, Dr. Henkel had burned grass year after year with good results. In recent years, however, overstocking in certain areas such as the Transkei often resulted in the most appalling destruction. That damage could hardly, however, be attributed to burning.

Mr. DODDS wanted to know whether there were any indications in this country that the rainfall had altered materially as a result of changes in the distribution of forests. As far as our very scanty rainfall records in the sugar-growing belt went back, there was no evidence of such changes.

Dr. HENKEL stated that the South African mainland was one of the oldest in the world. Its climate was affected by the cold Arctic current in the west and the warm current from the Indian Ocean in the east. The rainfall depended on the prevailing winds from the east, and had nothing to do with forests and vegetation. He thought the rainfall had been constant, and we could not alter it, but the conservation of the water was quite a different matter. He gave a number of instances where overstocking or faulty management had led to soil erosion and a lowering of the water-table. The problem was really to conserve the water, and it was in this direction that Mr. Scott and others were doing very valuable work.

In reply to Dr. Fisher, Dr. Henkel said that he would not advise the Durban Corporation to plant trees in their catchment areas. These areas were under grass and it was best to keep them under grass.

Soil erosion often took place as a result of the drying-out of soil following drought periods. Subsurface cracks developed as a consequence of soil shrinkage, and when followed by severe summer storms these cracks were widened, leading to underground channels which usually collapsed and formed pronounced dongas.