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IMPACT OF HUMAN ACTIVITIES ON NATURAL ECOSYSTEMS IN AFRICA

Edited

by

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IMPACT OF OVERGRAZING ON AGRICULTURAL AND RANGELANDS

*A. O. Isichei**

I. INTRODUCTION

Herbivory is the consumption of living plant tissues by herbivores and the term includes grazing, browsing, defloration, seed predation, parasitism and disease (Louda *et al.*, 1990). Grazing is used in the same sense as herbivory in popular literature but is usually restricted to consumption of living herbage by ruminant livestock.

The present report deals with the relationship between the grazing animals and their environment. Practically all vegetation types have grazing animals in them but what matters is the concentration of animals and the corresponding intensity of grazing. The suitability of the vegetation type for providing readily accessible forage and climatic and other related constraints, including land-use economics and pests affect animal abundance. Generally, forest vegetation unless specially converted is not suitable as grazing land and could be more profitably used for cultivation. Most grazing lands are for the above reasons concentrated in subhumid, semi-arid and arid ecologies especially in the tropics. Such lands are also referred to as ragelands and at times in a restricted sense, pastures.

1. Agricultural and Grazinglands

All lands where agricultural activity including pastoralism and related activities is carried out are agricultural land.

Tropical grazing lands are found in savanna, shrubland or steppe and grassland vegetations and the soils usually associated with them include entisoles, inceptisols, vertisols, aridisols and alfisols. One unifying feature of grazing lands is the relative openness of their top canopies and the dominance of herbaceous vegetation, usually graminoids in the lower stratum (see Sanford and Isichei 1986 for definition of savanna and UNESCO 1979 for other grazing land vegetation types). Such vegetation types occupy 944

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million hectares in Africa, Latin America, India and Pakistan (UNESCO 1979). Whilst other land uses such as hunting and gathering and, in the less arid areas, crop cultivation are possible, livestock production is their principal use. Grazing animals have extended the areas of grazing lands and may have been responsible for their creation. UNESCO (1979) states that grazing land ecosystems are characterized by the fundamental role of man as a controller of domesticated herbivorous mammals.

The domestic herbivores of Africa comprise cattle, sheep, goats, donkeys, horses and camels (Cumming 1982). Cumming observes that all but the donkey which was domesticated in Egypt were introduced from domestication centres in southwestern Asia from about 7000 BC from which time much of the northern savanna and the Sudanese and Somali arid zones have been subjected to pastoral influences. Recent estimates of the numbers of domestic animals in Africa south of the Sahara indicate a population approaching 400 million head (Cumming 1982). Increases in human populations in the arid and semi-arid zones lead to corresponding increases in livestock holdings and range detoriation (Cumming 1982). Gillet (1986), for example, reports that the number of cattle in the Sahel doubled between 1955 and 1970. Total bovine population of India is estimated at 239.09 million excluding sheep, goats, camels, donkeys and horses whose population is estimated at about 100 million (Yadava and Singh 1977).

2. The Role of Grazing in Ecosystems

The effects of grazing are summarized in Figure 1. Cumming (1982) lists the influence of herbivores on plants and plant cover as (a) major effects resulting in conspicuous changes to plant community structure and composition; (b) interactions resulting in stable subclimaxes and (c) co-evolutionary relationships such as evolution of plant defense systems, irregular fruiting in some plants etc. Grazing animals also have influences on local geomorphology in that large herbivores tend to follow particular routes between feeding grounds and watering points. Such paths can form the focal points for headward gully erosion which may affect local drainage and engender a change in woody plants to herbaceous plants ratios (Cumming 1982). Trampling and loss of nutrients through defaecation and excretion (see Woodmansee 1978) are other ways by which animals influence rangeland ecosystems.

Herbivores have major effects on the plants they consume and the character of these effects depends on many factors including feeding preferences, refuges, differential growth rates, differential recruitement rates and competition among co-occuring plants (Louda *et al.*, 1990). Compétition, within limits set by a variety of environmental/biotic constraints, plays a major role in structuring pasture communities (Turkington and Mehroff 1990). According to Louda *et al.*, (1990), herbivory might influence competitive

interactions by (a) changing a plants relative ability to acquire limited resources or (b) eliminating the plant as a competitor.

Herbivory that kills plants decreases their density and selective herbivory contributes to local spatial variation in density. Herbivory can also change ecosystems by altering the nature of the component plants. Grime (1970) observes that under conditions in which productive vegetation is subject to frequent mowing or grazing, the effect of repeated defoliation is to stimulate the development of a very large number of small tillers with the result that a dense and rapidly repaired leaf canopy is formed close to the ground surface. McNaughton (1979) has listed the conditions that lead to such stimulation of growth and compensation for plant parts grazed.

Grazing lands are usually highly stressed environments with water as a major limiting factor to productivity. Grime (1979) observes that plants growing in stressed environments grow slowly and will be prone to damage by herbivores during their slow recovery from defoliation. Plants growing in grazing lands have therefore evolved resistance to palatability by the use of physical and chemical deterrents. Such deterrents include spines, leathery texture and coarsely siliceous leaves, and chemical defenses which are well documented in the literature (see Grime op. cit., p. 37).

II. THE EFFECT OF OVERGRAZING

1. Overgrazing as a Stress on Grazing Land Ecosystems

Overgrazing or excessive herbivory puts stress on the plant being consumed and its habitat. The effects of overgrazing could be assessed from the point of view of it being a stress on both the plant and its surrounding environment. Barret (1981) defined stress as a perturbation that is applied to a system by a stressor which is foreign to that system or which is natural to it but in the instance concerned, is applied at an excessive level. Stress pushes the functioning of a critical subsystem beyond its ability to restore homeostatis. The dramatic effects of stress are observed after certain thresholds of tolerance are exceeded and system recovery is difficult or problematic (Auerbach 1981).

Grazing could also be viewed as a disturbance, Frost *et al.*, (1985) define disturbance as an aperiodic event, such as flood, a severe storm, a prolonged drought, excessive herbivory or other activities that partially or completely disrupt the structure and functioning of a system, either directly by damaging or causing mortality of individuals, or indirectly through altering the physical environment. 'Perturbation" could be used in the same sense as disturbance. Having put overgrazing in ecological perspective we may now assess its role in the ecosystem and at the level of the plant.

Weaver and Clements (1938) describe the deterioration of rangelands through overgrazing as follow: "The more palatable species are eaten down, thus rendering the uneaten ones more conspicuous. This quickly throws the advantage in competition to the side of the latter. Because of more water and light, their growth is greatllly increased. They are enabled to store more food in their propagative organs as well as to produce seed. The grazed species are correspondingly handicapped in all these respects by the increase of the less palatable species and the grasses are further weakened by trampling as stock wander about in search of food. Soon bare spots appear that are colonized by weeds or weedlike species. These weeds reproduce vigorously and sooner or later come to occupy most of the space between the fragments of the original vegetation. Before this condition is reached, usually the stock are forced to eat the less palatable species and these begin to yield to the competition of annuals. If grazing is sufficiently severe, these too may disappear unless they are woody, wholly unpalatable or protected by spines".

2. The Ecophysiological Basis of Vegetation Response to Overgrazing

Louda *et al.*, (1990) have observed that chronic herbivory modifies the growth rate, the form or developmental timing of plants, and so changes plants traits that appear critical in resource acquisition. In fact, they further observe, the characteristics that determine competitive ability either to deplete resources or to tolerate low resource levels are the traits most often modified by herbivores. Herbivory may also change internal allocation of resources, root: shoot ratios, nutrient turnover rates and litter accumulation rates.

According to Frost *et al.*, (1985) the effects of herbivory depend on (i) the plant parts removed, (ii) the intensity, frequency and season of grazing; (iii) the growth stage of the plant; (iv) soil type and moisture conditions; and (v) the history of the plant particularly the time since a previous defoliation by other herbivores or fire. Since recovery from defoliation is not instanteneous, future events such as heavy rainfall, drought or further defoliation by herbivores, and fire can influence the eventual outcome.

Kelly and Walker (1976) working in a semi-arid region in south eastern Rhodesia (now Zimbabwe) reported that a large percentage of perennial grass tufts in areas of intensive utilization were in the small category and it would seem either that continual grazing was detrimental to growth above this size or that intensity of grazing was causing them to die prematurely. Only 32% of tufts in these areas were alive and the trend was apparently toward complete domination by annual grasses. In perennial grasses the underground parts are used for storage of reserves; the most important being carbohydrates manufactured by the aerial parts in excess of current requirement. These together with nitrogen and mineral elements are translocated during maturation to root and rhizomes where they are stored over the dry season to be re-utilized by the plant in the following growth

season for the productivity of new top growth (Weinmann 1949). Underground development in grasses is often most active at the time of the season when herbage growth is at a minimum. So vital are these factors in plant growth that even after they become well established plants may be killed by being grazed too closely-either when growth starts or later in the growing season or during the time when they should be storing food for the next year's growth (Semple, 1970). This results in reduced vigour and herbage growth and in extreme cases, in the death of the plant. On a large scale this manifests itself in undesirable changes in the botanical composition of the range and in a decrease in vegetative cover paving the way for soil detoriation and erosion.

While decrease in the biomass of grasses by overgrazing is accompanied by an increase in that of woody vegetation (Gupta and Saxena 1971; Walker *et al.*, 1981) which are generally less palatable and less nutritions, trees and shrubs also face much greater danger when the herbaceous vegetation is overgrazed and the animals are forced to browse on tree seedlings and leave the soil under the trees bare and unprotected from rain (Semple 1970).

3. Overgrazing and Soil Degradation

The vegetation cover of soil in areas with permanent animal routes are normally denuded by the mechanical effect of animal hoofs' trampling by movement of herds over the years. The annuals which succeed perennials in overgrazed areas are largely consumed by animals and only a very small percentage of the crop becomes litter. In addition, annual grasses have on inherently low basal cover and their foliage provides little protection to the soil surface (Kelly and Walker, 1979).

The compaction of the surface soil and breakdown of soil aggregate through trampling under these conditions increases bulk density and reduces the rate at which rain water percolates into the soil and the water-holding capacity of the soil (Frost *et al.*, 1985). It also increases the amount of run-off and erosion and usually the loss of surface soil. The bareness created by vegetation removal increases the exposure of the soil surface to raindrop impact, sun and wind and leads to more extreme soil surface temperatures, higher evaporation rates and ultimately, to the structural collapse and deflation of the soil surface (Frost *et al.*, 1985). Impermeable surface seals are often formed resulting in a cycle of degradation, of reduced infiltration rates, increased run-off, lower seedling establishment, less plant production and further exposure of the soil surface (Kelly and Walker 1976; Macdonald, 1978; Bridges *et al.*, 1983). Seed germination and survival are handicapped by a harsh microclimate at the soil surface so that eroded spots, even through not subject to continuing displacement, remain bare for long period (Ellison 1949).

4. Other Effects of Overgrazing

Savanna offers a grazing resource based on the herbaceous layer (Johnson and Tothill, 1985). Overgrazing removes grass biomass which acts as fuel for savanna fires thereby reducing the intensity of annual savanna fires. Fire exerts a control on build-up of woody species. Frequency of burning and relative use of browse and herbaceous species by grazing animals are factors which act in maintaining the savanna boundary (Johnson and Tothill, 1985).

Also in this regard Walker (1985) reported that there are two major direct influences of herbivores. First is the conversion of woodland to grassland by elephants and of tall grassland with high basal cover to eroded, bare plain by large concentrations of grazers. Less obviously, vegetation structure and species composition in most African Savannas are maintained by herbivores in a state which is different from that which would develop in the absence of these herbivores.

III. SOME CASE STUDIES OF OVERGRAZING

The transition from normally grazed to overgrazed rangeland may be difficult to discern. Often, overgrazed lands reach advanced stages of deterioration before this is realized. What may be regarded as grazed and overgrazed may depend on time scale because some systems are more stable (more resistant to change under perturbation) than others while others are more resilient (signs of change but bouncing back to the original state after some time). It has, however, been demonstrated in some cases in real life and ecological models that vegetation and soil deterioration have occurred over time.

Gornitz (1985) in a survey of anthropogenic changes in vegetation in West Africa during a century (1880-1980), based on changes in albedo observed two major areas of maximum albedo increase in the region. These were the Forest Zone (4°-8°B), and the Savanna-Southern Sahel Zone (10°-12°N). That livestock activity contributed to the increased albedo in the Savanna is shown by the difference observed in albedo values between a protected ranch in Niger Republic and the overgrazed terrain outside the ranch. The protected ranch had an albedo value of 34.2% compared 42.3% in the overgrazed range outside. Gornitz observes that albedo increase in West Africa over the study period was 0,4% but that 80% of the increase must have occurred within the last century.

Also in the Sahel, Gillet (1986) reports that Le Houerou *et al.*, examined aerial photographs of the Sahel taken between 1952 and 1975 and concluded that the percentage of surface soil not stabilized by vegetation rose from 4 to 26 % over the period. In East Africa McNaughton (1983) reported that over-utilization by native ungulates was converting a perennial grassland in the Serengeti plains into an annual grassland. Yadava and Singh (1977)

report that many areas, especially the high altitude pastures and the arid and semi-arid grasslands of India suffer from a seasonal grazing stress by migratory livestock. Okaeme *et al.*, (1988) give a similar report for the sub-humid savanna of northwestern Nigeria. UNESCO (1979) report that in Indonesia and Viet-Nam overgrazing is referred to as a cause of soil erosion.

The Integrated Project in Arid Lands (IPAL) was set up by UNESCO's Man and Biosphere Programme in the Semi-Arid Marsabit District of Kenya to study the problems facing nomadic pastoralists and the ecosystems in which they were the dominant element (UNESCO-MAB 1988). The study found that overgrazing and over-use of wood, coupled with the impact of rapidly changing socio-economic conditions were the prime cause of pasture and soil deterioration and, in the worst cases desertification in the arid and semi-arid lands.

Noy-Meir (1982) concluded from his plant-herbivore model that the dynamics, stability and resilience of savanna ecosystems can be significantly affected by herbivores (see also Van Dyne, 1981).

IV. CONCLUSIONS AND RECOMMENDATIONS

The natural grazing lands of the tropics occupy an intermediate environment, between the arid deserts and the relatively wet forests. They have been in use for centuries for raising livestock but are now under threat due to rising human and animal populations. Overgrazing has extended into marginal areas that cannot withstand such stress. What has resulted in many areas is range deterioration and in some cases, desertification.

The transition from grazing to overgrazing with the implied environmental degradation is not easily noticed. What is required is scientific management of grazing lands where a suite of quantificable community criteria is monitored for assessment of range quality. This will allow for early detection of deterioration.

Scientific management of ranges requires the maximization of available resources without reduction of carrying capacities. In the tropical grazing lands this will necessitate maximal use of excess wet season fodder for dry season feeding thereby reducing dry season livestock movement with its attendant ecological impacts.

Overgrazing has adverse effects on the environment but the relative importance of consumption of plants and trampling has not been assessed. Studies to assess the combined effects of these factors and of each factor acting alone are needed.

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