RANGE DEGRADATION IN BOTSWANA: MYTH OR REALITY?

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ABSTRACT

The widely-held notion that Botswana's communally-managed rangelands are degraded plays a significant role in determining rural development policy. Under the pretext of stopping range degradation and increasing livestock productivity the Government of Botswana is determined to transfer the control over vast tracts of land from communities to individuals. Because of the high social cost of this trend, the notion that the country's rangelands are degraded is being questioned. A recent paper (White 1992) argues that Botswana's rangelands show no symptoms of degradation at all.

I wrote this paper in an attempt to dispel some of the confusion surrounding the application of the range degradation concept in Botswana. To accomplish this I pursued three objectives. First, to present the current thinking of range ecologists vis-a-vis range degradation. Second, to dismiss recent arguments that range degradation in Botswana is insignificant. Third, to present an argument linking the livestock industry to ecosystem level degradation of the Kalahari.

INTRODUCTION

The view that Botswana's rangelands are severely degraded has been expressed by several authors over the past few decades (Campbell and Child 1971, van Rensberg 1971, van Vegten 1981, Arntzen and Veenendaal 1986, Ringrose and Matheson 1986). This perception, coupled with the theoretical link that exists between range degradation and communal land ownership as proposed by Hardin (1968), is an important determinant of the Government of Botswana's livestock development policies (Devitt 1982, White 1992, Mannathoko 1992). For example, the recently elaborated National Policy on Agricultural Development (Government of Botswana/Ministry of Agriculture 1991) uses the degradation of communally-held grazing areas and low livestock productivity as reasons to increase the control by individuals over range resources. This move from communal towards private ownership is to be achieved by fencing areas around privately or group-controlled boreholes.

Because of the potentially serious sociological and ecological implications of fencing and *de facto* privatization of Botswana's rangelands, the National Policy on Agricultural Development (NPAD) has attracted criticisms from different quarters. Of these, White's (1992) paper has been widely quoted in Botswana's media.

White's justified attack on the NPAD focuses on undermining NPAD's biological and socio-economic assumptions. Of particular importance is his categorical dismissal of the notion that Botswana's rangelands are degraded. He maintains that there is little scientific evidence to support this supposed rangeland degradation and states that:

> The most telling argument against degradation is that productivity, in terms of meat output per animal, has not declined. It has increased. While dressed carcass mass at slaughter, calving and off-take rates have not changed since 1966, the average age of cattle at slaughter has declined from seven years of age in 1966 to four years of age in 1990 (Setshawelo pers. comm.). If degradation had occurred since 1966 we would expect to see lower calving rates, lower off-take rates, lower dressed carcass mass and greater age at slaughter. We see nothing of the sort (p.45).

White goes a step further and makes the unqualified assertion that:

> ...research has shown that lowering the stocking rate raises productivity per animal, but it does so at the price of reducing productivity per hectare (p.46).

The categorical acceptance by policy makers of White's unqualified affirmations, namely, that there is no range degradation in Botswana, and that high stocking rates result in higher yields of animal products per unit area, may have serious ecological ramifications. After all, if high stocking rates represent greater output per unit area than low stocking rates, *and* do not result in range degradation, Botswana's livestock development policies should aim to maximize the number of livestock per unit area. Unfortunately this argument is based on a poor understanding of the range degradation concept and incomplete representation of the relationship between livestock productivity and stocking rate.

In this paper I aim to clarify the confusion that surrounds the application of the concept of range degradation in Botswana.

- First, I outline the theoretical framework used in conventional approaches to range condition assessment, and delimit the degradation concept in light of the latest model of rangeland dynamics.

- Second, I present a few examples to illustrate the relevancy of this emerging range dynamics paradigm to the Southern African region.

- Third, I underscore the flaws in the argument that range degradation in Botswana is virtually non-existent.

- Fourth, I use ecological data to support the notion that Botswana's livestock industry has undermined the integrity of the Central Kalahari ecosystem by seriously damaging a fundamental ecological process.

THE RANGE DEGRADATION CONCEPT

What is range degradation?

There are few topics in range ecology that are more polemic and emotionally charged than rangeland degradation. The lack of agreement on the meaning of range degradation has given rise to a multitude of often contradictory definitions (Behnke and Scoones 1991). Therefore, it is not without trepidation that I broach the subject.

Land degradation may be regarded from two points of view: i) the ability of the land resource to produce a commodity; and ii) the basic processes that permit an ecosystem to regenerate itself (Leopold 1968).

The points of reference and indicators used to assess its severity are largely determined by which of these lines of thought is followed. If, for example, degradation is measured in terms of the ability of the range to yield beef, then the point of reference used to assess the degradation's severity is the potential natural community that has the highest grazing value to beef cattle. On the other hand, if range degradation is defined with respect to ecosystem processes, the reference community is chosen with respect to its ability to cycle nutrients, process energy and conserve the soil.

Assessing range degradation: the conventional approach

The rationale that underlay conventional approaches to range condition monitoring in Australia (Wilson 1984), the United States (Smith 1978, 1989) and South Africa (Tainton et al. 1980) espoused the Clementsian model of vegetation succession. Briefly, this model of vegetation dynamics views vegetation change as a deterministic series of vegetation types leading to a 'climax' community that may fluctuate in composition but remains relatively unchanged over long periods of time. The degree of deviation in species composition from this ecological point of reference was used to rank the condition of the range.

The usefulness of the Clementsian model of succession as a basis for assessing range condition has been questioned for over a decade (Smith 1978, Westoby et al. 1989). There are several reservations concerning the general utility of the model in a range monitoring framework, and a growing body of knowledge that indicates that the model is not applicable to semi-arid and arid rangeland situations (Friedel 1991, Laycock 1991, Westoby et al. 1989). The range profession is on the verge of a major paradigm shift in the way it views rangeland dynamics, and the related concept of range degradation.

The state-and-transition model

The model of rangeland dynamics likely to supplant the Clementsian model of succession as a basis for assessing range condition is presently referred to as the ‘state-and-transition’ model (Westoby et al. 1989). This view allows for a number of relatively stable vegetation states at a particular site instead of a linear and deterministic progression culminating in a stable ‘climax’ end-point. Shifts from one stable state to another occur relatively fast when the range is stressed beyond a threshold by a combination of factors (Friedel 1991). In this framework, the desirability of any one vegetation type becomes a function of the management objectives, provided the basic ecosystem processes such as nutrient cycling and energy flow are not damaged. Thus, a patch of rangeland that is in good condition for goat production may be in poor condition from the viewpoint of cattle production.

It follows from the above that the usefulness of the term ‘degradation’ has no meaning unless the context in which it is used is clearly outlined. In fact, there is a consensus emerging among range ecologists that the term ‘degradation’ should be reserved for irreversible ecosystem changes. In other words, degradation entails a management-induced impact which damages basic ecosystem processes and compromises the ecosystems’s ability to regenerate itself of its own accord. Changes that are confined to reversible shifts in vegetation structure and plant species composition are better referred to as ‘desirable’ or ‘undesirable’, depending on management objectives.

To reconcile range inventory and monitoring procedures with the emerging ‘state-and-transition’ model of vegetation dynamics, the Task Group on Unity in Concepts and Terminology of the Society for Range Management (SRM 1991) recently proposed a set of guidelines for the assessment of rangelands. These guidelines were designed to accommodate the dual objectives of rangeland management, namely, to meet management objectives and to conserve long-term environmental options. Two of these guidelines presented below in an abbreviated form serve to summarize current thinking *vis-à-vis* range condition monitoring and conclude this section.

1. Management objectives should be defined in terms of a Desired Plant Community (DPC) for each ecological site, and a Vegetation Management Status should be reported in terms of similarity to and trend away from the DPC. The DPC is defined as: one of the plant communities that may occupy a site, and that has been identified to best meet the objectives of the management plan for the site. Rangeland management plans should encompass two basic objectives: i) to conserve to the extent practicable the long-term potential of the site to produce vegetation; and (ii) to produce in the shorter term those combinations of goods and services desired in the management of the land. The DPC should meet both of these objectives.

2. Vegetation communities should be evaluated as to their effectiveness in protecting a site from accelerated erosion. The point at which erosion accelerates due to management influences would be called the Site Conservation Threshold (SCT). The SCT may be estimated using one or more parameters of the vegetation such as canopy cover, basal area, density, species composition, etc. Each vegetation community that can occur on a site would be evaluated in relation to the SCT for that site. Those communities that protect the site would be assigned a site conservation rating of 'sustainable'; all others would be deemed unsustainable.

Is the state-and-transition model applicable to Botswana?

A definitive answer to this question will have to await well-designed long-term vegetation dynamics studies, and the re-implementation of a range monitoring program. Nonetheless, preliminary inferences may be drawn from recent studies in South Africa and the analyses of data gathered in Botswana from 1974 through 1981 by the now defunct range monitoring program, and in 1989 as part of a joint project between the Department of Environmental Science of the University of Botswana and the Range Ecology Unit of the Ministry of Agriculture.

Fuls (1992) studied the influence of sustained heavy grazing pressure on patches of a semi-arid (600-650mm average rainfall per annum) rangeland in South Africa in an area of medium-textured soils. His results show that when utilization of the vegetation surpasses a threshold, an abrupt decline in basal cover and changes in soil surface characteristics occur. He describes this change in range attributes as a shift to another 'domain of attraction' (Friedel 1991). As a result of the decrease in basal cover and the disruption of soil surface structure, the heavily-grazed patches experienced a 55% decrease in rainfall infiltration relative to the patches that did not undergo a shift in states. Furthermore, in a companion study Fuls and Bosch (1991) compared the effects of drought in the absence of grazing on patches that had different grazing pressure histories. They found that patches that had a history of light grazing and high basal cover of tufted perennial grasses withstood the dry period without significant changes in vegetation. In contrast, patches that had a history of heavy grazing pressure and low cover of perennial grasses in vegetation composition, experienced a further decrease in total basal cover of up to 94% over the dry period. This continual movement away from the previous perennial grass-dominated state was associated with a decrease in rainfall effectiveness within the heavily-grazed patches.

The results of Fuls and Bosch's studies strongly indicate that at least in some southern African rangelands, heavy grazing pressures may trigger a shift between vegetation states. This supports the relevancy of the state-and-transition model of vegetation change to southern African rangelands. Furthermore, the significant decrease in rainfall effectiveness within heavily-grazed patches indicates that the shift from one state to another is accompanied by a change in soil climate. Finally, the heavily grazed-patches failed to respond to the removal of grazing.

Between 1973 and 1982, the Range Ecology Unit of the Ministry of Agriculture collected vegetation data throughout Botswana as part of a range monitoring program. Five of these monitoring sites were re-sampled under close supervision in 1989 by the same crew that last sampled the sites in 1982.

Results of preliminary analyses of vegetation data collected in Matlolakgang, a beef cattle ranch managed by the Animal Production Research Unit in Botswana's sandveld, are summarized in Fig. 1. The 'clusters' portrayed correspond to different sampling areas located at increasing distances from a water point. Thus, cluster 1 located at approximately one km from the borehole experienced the heaviest, and cluster 3 at three km from the borehole the lightest grazing pressure.

When juxtaposed with rainfall for Gaborone (Fig. 1), some association between relative cover of grasses, precipitation, and grazing pressure becomes apparent. For example, in 1974 cluster 1 (heavily-grazed) had a low relative cover of perennial grasses in comparison with clusters 2 and 3 (lightly grazed). This appears to be related to the combination of low rainfall and heavy grazing in 1973 which triggered the reduction in the proportion of perennial grasses in the community in favor of annual grasses and forbs. During the good rainfall years of 1975 through 1978 all three clusters had similar proportions of perennial grasses. The influence of the good rainfall years appear to carry through to the low rainfall year of 1979. The low cover of perennial grasses in 1980 for all three clusters may reflect the effects of the low rainfall in 1979, interacting with heavier grazing pressure on the lower levels of available forage. Meaningful interpretation of the data for 1981 is made difficult because of the abnormally early date of sampling that year. Additionally, the ranch staff indicated that a large fire swept the ranch in the dry season of 1980, but they were not sure whether the three sampling sites had been affected.

The results for 1989 are of particular interest to this discussion because they give us an indication of the effects of heavy grazing superimposed on a series of low rainfall years. Where grazing pressure was light (clusters 2 and 3), two years of above average rainfall (1988, 1989) nullified the effects, if any, of the drought on vegetation composition. In cluster 1, where heavy grazing and drought coincided, the perennial grass component experienced a catastrophic reduction and was unable to recover following two wet years. Therefore, the data suggest that heavy grazing coupled with a protracted drought is capable of effecting profound and relatively fast changes in vegetation composition. How permanent these changes are is not known but the results show that in

Fig. 1. Relative cover of perennial grasses from 1974 through 1981 and 1989 in Matlolakgang ranch in Botswana's sandveld and annual

Botswana's sandveld the potential for rapid grazing-induced changes in vegetation composition from perennial grasses to annual grasses and forbs is real.

In summary, the preliminary indications of studies conducted in South Africa and information derived from range monitoring data suggest that the state-and-transition model of vegetation dynamics is applicable to Botswana conditions. The combination of drought with heavy grazing appears to be effective in drastically altering vegetation composition over a relatively short time. Some of these changes in areas of medium-textured soils may be accompanied by a shift in soil climate towards greater aridity, a clear manifestation of irreversible degradation.

ARE BOTSWANA'S RANGELANDS DEGRADED?

The case against the existence of degradation

As stated at the outset White (1992) concluded that range degradation in Botswana is more myth than fact. Because of the important implications to rural development policies in Botswana and the attention his claim attracted, the robustness of this assertion needs to be appraised. A reasonable starting point is to assess the validity of the evidence he presented to support his argument against the existence of range degradation.

First, White down-played the link between soil erosion and heavy grazing pressure. To achieve this he used estimates derived from a model developed by Biot (1990) where the decrease in the ability of a given soil to produce forage, as a result of soil erosion, is related to stocking rate. Although a worthwhile attempt at quantifying the relationship between grazing, soil erosion, and long-term decreases in biomass productivity, the model suffers from some fundamental weaknesses. Chief among them is the assumption that soil morphology was taken to be uniform from the surface downward.

In Botswana's hardveld area where Biot's model was calibrated, the soils are characterized by a subsurface horizon of clay accumulation within the top 50cm of the profile. Erosion of the surface layer and exposure of the subsurface horizon would be accompanied by a drastic reduction in infiltration rates and rainfall effectiveness as measured by Fuls and Bosch (1991).

The prediction of Biot's model is, to a great extent, dependent on available water-holding capacity and does not take into account changes in infiltration rate. Since water has to find its way into the soil before it becomes available to plants, forage production can be significantly reduced by a decrease in infiltration rates even when soil erosion is slight. Therefore, the statement advanced by White (1992) that under heavy grazing the ability of soils to produce forage would not be significantly affected for 400 years is questionable.

Second, White (1992) maintains that degradation has not occurred in Botswana because productivity in terms of meat output per animal has increased from 1966 to 1990. This argument is riddled with weaknesses. For the sake of brevity only the more obvious ones are discussed.

White did not take into account differences in stocking rates between the two dates. In Kgalagadi District despite the increase in cattle population from 36 500 to 62 400 between 1960 and 1990, there was a reduction in stocking rate from 0.47 to 0.51 km^2 per livestock unit (White 1992). This occurred because of the increase in the number of water points and area accessible to grazing by domestic livestock. As he correctly argues in the same manuscript, the output per head should increase with a reduction in stocking rate.

There are many variables apart from the condition of the range and stocking rate that affect the yield of livestock products from rangelands. In the case of beef output these include rainfall, the availability of veterinary services, and the marketing infrastructure.

The provision of veterinary care and livestock marketing facilities between 1966 and 1990 improved dramatically in response to the Government of Botswana's tremendous investment in the livestock industry (White 1992). This being the case, it is indeed remarkable that average dressed carcass weight did not increase between the two dates. Instead of undermining it, White's argument actually supports the notion that the ability of Botswana's rangelands to produce livestock products could have decreased since 1966.

The case for the existence of livestock-induced rangeland degradation in the Kalahari

As I previously explained, rangeland degradation may be viewed with respect to the ability of an ecosystem to produce a set of commodities, or from the point of view of ecosystem processes. In his paper, White (1992) attempted to show that Botswana's rangelands were not degraded from the standpoint of livestock producers. Below I use ecological data to argue that Botswana's livestock industry is culpable of ecosystem level degradation of the Kalahari because it is responsible for the virtual collapse of a fundamental ecosystem process.

Pan and fossil valleys are topographic depressions that occur throughout Botswana's sand-covered Central Kalahari desert. These landscape units differ from the surrounding areas in terms of soils and vegetation, and are believed to be crucially important to the maintenance of viable wildlife populations and biological diversity in the region (Parris 1976, DHV 1980c, Milton et al. 1992), even though they only occupy around 10% of the land surface. Recent work undertaken by Miriam van Heist and myself in Khutse Game Reserve in the Central Kalahari showed that the available phosphorus content of most pan and some fossil valley soils is well above levels necessary for crop production in well-watered regions. As depicted in Fig. 2, this contrasts sharply with the generally low available phosphorus content of the sandy soils that dominate the region.

The high phosphorus content of pan and fossil valley soils is associated with higher amounts of this element in grasses growing within these landforms. For

Fig. 2. Frequency histogram showing the distribution of available phosphorus in the surface horizon of upland and depression soils.

example, in Khutse Game Reserve van Heist and I found that the mean phosphorus content of grass plants growing in pans (.124 ppm) was significantly ($t=2.76$; $p<.05$; $df=30$) higher than the mean phosphorus content (.096 ppm) of grass plants growing in surrounding upland areas. This link between high soil fertility and nutritive value of plants was invoked by Milton et al. (1992) to explain the strong preference of springbok (*Antidorca marsupialis)* for pans in the arid regions of the Cape Province in South Africa.

The occurrence of phosphorus-rich pockets in what is otherwise a phosphorus-poor environment is intriguing and a possible explanation is given below, linking Botswana's livestock industry with the degradation of the Kalahari rangeland ecosystem.

The relatively high nutritive value of the vegetation growing within pans and fossil valleys is only one of a number of reasons rendering these landforms focal points to wild ungulates. Mineral licks are found in pan and fossil valleys that are not found in the upland areas (Parris 1976, DHV 1980). Furthermore, the low growing vegetation and firm footing allow wild ungulates to detect and escape predators (Parris 1976, DHV 1980) while during the rainy season many pans host imperfectly drained depressions that accumulate water (DHV 1980). Additionally, the concentration of wild ungulates itself attracts predators and scavengers.

The regular congregation of wild animals within these relatively small topographic depressions is associated with the concentration of animal faeces and urine. This is illustrated in Fig. 3, where the density of animal pellets as determined by Parris (1976) is related to landscape position at increasing distances from the center of pans in the Kalahari. Analogous results were recently reported by Milton et al. (1992) for three different pans in South Africa.

The concentration of wildlife excreta within pans offers a very plausible explanation for the high nutrient status of pan and fossil valley soils. In Utah, Jurinak and Griffin (1973) found that rabbit droppings contained as much as 3750 ppm of phosphorus. In East Africa, high levels of nutrients under trees were partly attributed to excreta from birds and large mammals that tended to congregate in and under the canopies (Belsky et al. 1989, Belsky 1992).

Based on the above, I propose that the high levels of phosphorus and other nutrients found in pan and fossil valley soils result from the concentration of faeces and urine by wildlife over long periods of time. In other words, pans and fossil valleys serve as nutrient sinks with wildlife acting as the conduit for elements from the surrounding sandy areas. The creation and maintenance of these fertile patches increases the heterogeneity of what would otherwise be a homogeneously dystrophic landscape. A rupture of this wildlife-mediated nutrient transport process would undermine the integrity of the Kalahari ecosystem and result in a loss of its capacity to support biological diversity.

In the late seventies, hartebeest and wildebeest – the two most numerous and largely migratory ungulate species in the central Kalahari – numbered an

Fig. 3. **Average for 6 pans of pellet group density at different positions on the landscape.**

PC corresponds to bare pan center;
GS corresponds to grassy strip that surrounds the pan center;
PR corresponds to shrub dominated perimeter of pan complex;
S1 and S2 correspond to sites on the sandveld at 1.6 and 3.2 Km from the pan edge.

estimated 280 000 and 262 000 (DHV 1980). By 1991 the population of hartebeest had decreased to around 33 000 and that of wildebeest to 16 000 (Craig 1992). This drastic reduction in wildlife numbers has been convincingly linked to the veterinary cordon fences that criss-cross Botswana and interfere with migratory movements, especially in drought periods (Childs 1972, DHV 1980, Rosenblum and Williamson 1987, Pearce 1992, Parry 1987, Harris 1992). If, as I proposed above, wild animals were responsible for concentrating nutrients within pans and fossil valleys, this catastrophic reduction of the

Kalahari's wild ungulate population drastically changed an important nutrient cycling pathway and must be viewed as degradation of the Kalahari ecosystem.

The above notwithstanding, some may propose that the flow of nutrients between different landscape units in the Kalahari may be re-established by the introduction of cattle to areas previously reserved for wildlife. However, unlike wild ungulates, cattle – the dominant livestock type in Botswana – tend to linger in the vicinity of watering points unless coaxed into seeking other areas.

Thus, in Botswana where herding is uncommon, the efficiency of livestock as nutrient transfer agents is restricted to small areas around watering points.

SUMMARY AND CONCLUSIONS

The widely-held notion that Botswana's communally-managed rangelands are degraded plays a significant role in determining rural development policy. Under the pretext of stopping range degradation and increasing livestock productivity the Government of Botswana is determined to transfer the control over vast tracts of land from communities to individuals. Because of the high social cost of this trend, the notion that the country's rangelands are degraded is being questioned. A recent paper (White 1992) argues that Botswana's rangelands show no symptoms of degradation at all.

The emerging paradigm of ecosystem dynamics refutes the assumption that there is only one potential vegetation community capable of maintaining the ecological integrity of a site. Instead, various relatively stable communities are viewed as being ecologically acceptable provided that their existence preserves the ability of the ecosystem to regenerate itself. Therefore, the concept of range degradation can be viewed from two angles: i) with respect to the output of a set of management-defined commodities, and ii) with respect to ecosystem processes.

The argument that range degradation does not exist in Botswana was advanced primarily from the point of view of beef cattle production. It was based primarily on the fact that average carcass weights in 1966 and 1990 were the same. This in isolation would undermine the contention that the range has degraded over time. However, average stocking rate declined over the same period, animal health improved through better veterinary services, and access to markets was greatly facilitated over the 24 years from 1966 to 1990. Given the changes in those other variables, the slaughter and off-take rates presented by White (1992) could have no bearing on any shift in range condition. Therefore, from the standpoint of beef cattle production there is no support for the argument that Botswana's rangelands are not degraded.

In building the case for the existence of landscape level degradation of the Central Kalahari, I presented ecological data that suggest that ecologically important pockets of fertility in the region were maintained by the concentration of wild ungulate excreta within topographic depressions. Since veterinary cordon fences have been linked to the decimation of the Kalahari's wild ungulates, I reasoned that Botswana's livestock industry is responsible for the virtual cessation of the transfer of nutrients from the uplands to these pockets of fertility. This rupture of a fundamental ecosystem process should be viewed as range degradation at the landscape level.

The evidence I provided to support the hypothesis that Botswana's rangelands are ecologically degraded is preliminary. In other words, I did not prove that there is *de facto* degradation. As Bateson (1979) stated, science does not prove, it probes.

Nonetheless, management decisions are invariably made in the absence of a complete and irrefutable body of knowledge. This is particularly true of ecosystem management. The assumption that all is well and nothing needs to be done about the ecological degradation of Botswana's rangelands has serious long-term consequences.

White (1992) is justified in attacking the logic that attaches range degradation to communal land ownership. Privatization of the Kalahari would not reverse the ecologically unsustainable trend assailing the Central Kalahari. To restore the region's ecological integrity, it is necessary to re-establish migration routes and allow the wild ungulate populations to recover to numbers commensurate with their ecological role and economic utilization. Only then will the Central Kalahari be able to play a significant role in ensuring that Botswana's development is sustainable.

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