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LAND DEGRADATION, STOCKING RATES AND CONSERVATION POLICIES IN THE COMMUNAL RANGELANDS OF BOTSWANA AND ZIMBABWE

by

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LAND DEGRADATION, STOCKING RATES AND CONSERVATION POLICIES IN THE COMMUNAL RANGELANDS OF BOTSWANA AND ZIMBABWE

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ABSTRACT

Communal rangeland management policies in Botswana and Zimbabwe are based on incorrect technical assumptions about the stability of semiarid rangeland, the nature of rangeland degradation, and the benefits of destocking. Consequently, inappropriate policies, stressing the need to destock and stabilise the rangelands, are pursued. Acknowledgement of the great instability but intrinsic resilience of rangeland would encourage the Governments to more favourably regard the opportunistic stocking strategies of the agro-pastoralists of the Communal Areas. However, degradation of rangelands is occurring, although at varying rates. This justifies the promotion of a 'tracking strategy', in which livestock densities are encouraged to follow, more closely that at present, variations in rainfall.

The establishment of grazing territories controlled by specific 'communities' may be a prerequisite for the promotion of the tracking strategy, and for communal rangeland management and improvement. However, the establishment of such territories must take into account social equity, institutional problems and transaction costs, as well as spatial and temporal variation in rangeland resources.

KEY WORDS Communal rangeland management Rangeland policy Stability of semiarid rangeland Rangeland degradation Stocking strategies

INTRODUCTION

This paper arose from a comparative study of the management of communal rangelands in Zimbabwe and Botswana (Abel and Blaikie, 1988). It draws upon the work of Abel *et al.* (1987) for case material on Botswana. This paper focusses upon the technical basis of current rangeland policy, with only passing reference to the complex socio-economic and political issues. It is set in the context of the current debate on 'sustainability' of rangeland (Scoones, 1988a; Glantz and Orlovsky, 1983; Warren and Agnew, 1988), and calls upon range scientists and policy-makers to re-assess their views, for:

> '... the experts must be wrong, are destined to be wrong, unless they make explicit provision for reversing their plans and hedging their bets ... Perhaps ... we ought to have institutional protection against being carried away by temporary enthusiasms.'
> (Frankel, 1976, 111–112).

The rangelands in question are situated within the 'Communal Areas' of the two countries. Here 'traditional' agropastoralism provides a partial living for peasant households. In both countries much concern has been shown by Governments and outside agencies over a perceived problem of rangeland degradation. The Governments have, based on a particular explanation of causes, responded with fairly similar policies. The purpose of this paper is to question that explanation and offer others. It is not our aim to evaluate policy itself, but as we conclude that some of the assumptions behind policy are incorrect, we do suggest in the final section policy changes compatible with these alternative explanations.

This paper is organized as follows. After this section there is an examination of the Zimbabwean and Botswana Governments' interpretations of the rangeland degradation problem. This is followed by a description of their policy responses, and an assessment of the validity of the assumptions on which policies have been based. The paper ends with a discussion of policy changes arising from changed assumptions about rangeland degradation.

GOVERNMENTS' PERCEPTIONS OF RANGELAND DEGRADATION

In both Botswana and Zimbabwe Governments have based rangeland policies on similar, conventional interpretations of rangeland degradation (Stoddart, *et al.*, 1975). This holds that overstocking causes degradation, or 'desertification' (Warren and Agnew, 1988). The components of degradation are thought to include:

(i) *soil erosion* — the loss of mineral particles, organic matter and nutrients;
(ii) *changes in soil structure* — in particular those affecting available water capacity;
(iii) *decreases in palatable and nutritious plant species, and increases in unpalatable and non-nutritious ones*;
(iv) *decreases in perennial grasses, and increases in annuals*;
(v) *shrub encroachment;*
(vi) *decline in the quality and quantity of forage;*
(vii) *decline in the primary and secondary productivity of rangeland*;
(viii) *decline in the welfare of herd-owners.*

In Botswana these views are expressed in Campbell and Child, 1971; van Rensberg, 1971; van Vegten, 1981; Cooke, 1981; Arntzen and Veenendaal, 1986; Ringrose and Matheson, 1986.

The official Zimbabwean view is shown by this extract from the National Conservation Strategy (Ministy of Natural Resources and Tourism, 1987: 27).

> 'The most important aspect of livestock production which is occupying the mind of Government is the accumulated and continuing deleterious effects of over-stocking and overgrazing in communal lands which are causing severe and potentially irreversible ecological degradation ... A comprehensive national programme that focusses on these problems will be implemented ... Such a programme will include stock control, better land management and destocking where necessary'.

The conventional explanation of rangeland degradation assumes that an essentially stable system has been perturbed by mismanagement — overstocking, and untimely utilisation of forage. Cook (1970), for example, defines ecological succession as an orderly progression of community development that terminates in a state of equilibrium, until disturbed by man or some natural catastrophe. Strange (1980: 167) says, therefore, that an '... important management objective is ... to establish a stable sub-climax at the most favourable seral stage for stock production ... '.

Both Governments hold that the reason for overstocking and poor pasture management is because communally-held rangeland is grazed by privately-owned livestock. Thus a 'tragedy of the commons' (Hardin, 1968) ensues, in which individual herders increase their herds because the individual gains all the marginal benefit (extra stock) while sharing the marginal cost (range degradation and reduced grazing) with other herders. These interpretations have led logically to the policy responses described and assessed below.

LAND TENURE POLICY AND PROBLEMS OF RANGELAND VARIATION IN TIME AND SPACE

One logical outcome of the 'tragedy of the commons' explanation is allocation of grazing territories to specific groups of people, so that the 'owners' bear all the costs of overstocking, thereby removing the rationality of overstocking. Colonial and subsequent attempts to influence communal range management in Botswana and Zimbabwe are reported in Abel and Blaikie (1988). In Botswana, with the exception of spontaneous local construction of drift fences to exclude livestock from arable areas during the growing season, there has been no successful communal grazing scheme (Willett, 1981). Abel, *et al.* (1987) ascribe this to a political–economic environment in which traditional communal institutions are weak, decision-making is uncoordinated and individualistic, and access to waged work has made the high transaction costs of participation in communal management schemes very unattractive.

Zimbabwe has a long history of colonial and post-colonial attempts by Government to intervene in the management of communal range: 'centralisation', was an early approach, in which arable and grazing activities were zoned into discrete blocks of land; compulsory destocking followed in the 1940s; and stock control was again attempted with the granting of grazing licences under the Native Land Husbandry Act (NLHA), 1951. The harshness of the NLHA roused much African opposition to the settler regime, and in the mid-1960s a gentler 'community development' approach was tried. This included the introduction of communal grazing schemes, subsidised and technically supported by Government. These were to manage the communal summer (rainy season) pastures. A particular community was identified and the boundaries of its grazing scheme demarcated for its exclusive use. The area was normally fenced and subjected to a regime of short-duration grazing (Froude, 1971).

Schemes established under the settler regime were mainly abandoned during the war of independence (Sandford, 1982). After Independence in 1980 the policy was renewed, the schemes are again being promoted, and some were examined by the present authors in 1987 (Abel and Blaikie, 1988). As before, the basis of the scheme is the demarcation of a grazing territory with rights of exclusion. The main technical problem resulting from this tenure policy concerns rangeland variation in time and space.

The rangelands of Botswana and Zimbabwe are spatially heterogeneous (Abel, *et al.*, 1987; Scoones, 1988a). Abel, *et al.* (1987) have demonstrated correlations between rock-type and the quality of forage, so that the quality of rangeland can be crudely stratified on the basis of rock-type (Figure 1). Sekwale (1983) has also demonstrated variation in ground water resources in relation to rock type (Figure 2). Geomorphological processes have produced soils which vary at a finer-scale than the geological variation. Variations in soil texture and depth have determined fine-scale variations in the physiognomy of the vegetation (Figure 3) and the cover and biomass of grass (Figure 4). Thus rangeland offers livestock a set of forage and water resources which vary in quality and quantity at different spatial scales. Comparison of Figures 1–4 illustrates the difficulty for cattle of finding the resources they need in a small area, for while groundwater and grass biomass are positively correlated, both are negatively correlated with forage quality and browse plants.

If a communal grazing scheme is to be self-sufficient it must include within it the necessary amount and quality of forage and water. The qualitative aspects are crucial: at what spatial scale can a herd obtain the mix of digestible crude protein, digestible energy, minerals and water it requires? It may obtain nearly all the resources it requires within a small grazing orbit, but if just one factor — say a trace element — is missing, the herd may need to leave the small territory periodically in order to balance its nutritional requirements. Peacock (1984) found that for Maasai smallstock, animals constrained in their movements by belonging to a group ranch were obtaining a diet with a lower digestibility than animals moving greater distances in the traditional way.

The critical size of a grazing territory will vary according to the patterns of spatial variation of the resources within it, but in both Botswana and Zimbabwe, even in a moderately dry year, a self-sufficient scheme would be large—say the size of a commercial ranch (ca. 6000 ha). However, such a large unit would encompass a considerable and heterogeneous human population, with the attendant problems of conflicting production strategies and objectives, and high transaction costs (Abel and Blaikie, 1988). In Botswana the unsuccessful Communal Grazing Cells were in fact 2340 ha (Sweet, 1986). In Zimbabwe communal grazing schemes are small, eight schemes examined by Abel and Blaikie (1988) ranged from 88 to 651 ha, (the mean was 263 ha). They were intended to provide only rainy season grazing, and could never be self-sufficient.

Even if a scheme were large enough to be self-sufficient in some years, during drought no scheme could produce sufficient forage and water, and livestock would need to be moved. Figure 5 shows the seasonal

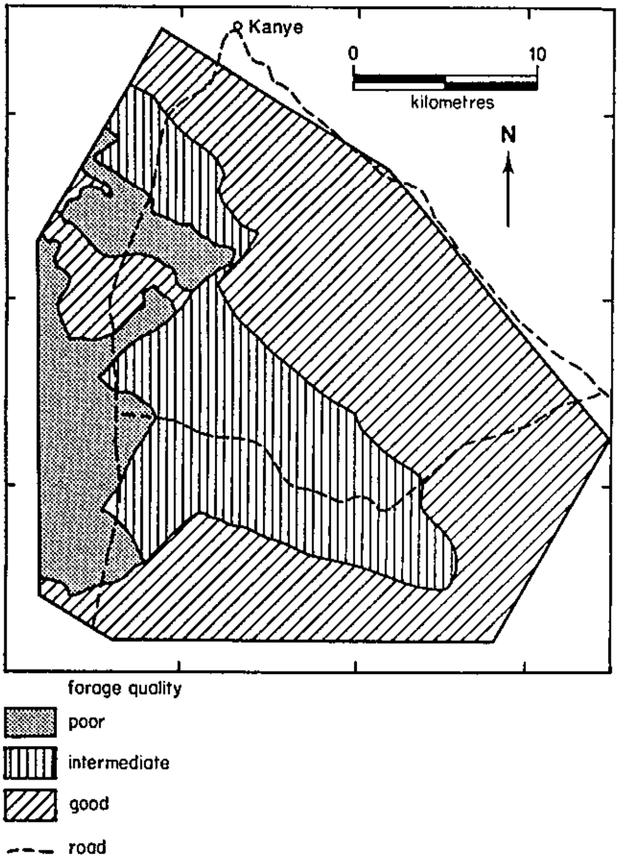

Figure 1. Forage quality zones of communal rangeland in SE Botswana, based on rock-type (Source : Abel, *et al.*, 1987). *Note*: Indicators of forage quality are: % crude protein,fibre, and lignin; and ppm of calcium, phosphorus and magnesium

distributions of twelve cattle herds in a 700 km^2 study area in SE Botswana in a non-drought year. Movements of the herds are very small. The next year this pattern was disrupted by drought, and many of the herds left the study area entirely for distant water points in the Kalahari, to the north and west. A viable policy which relies on territoriality must therefore accept one, both or all of these non-exclusive options:

(i) *stock reduction during drought*, requiring marketing facilities, abattoirs, and price incentives. Each of these is costly,

(ii) *long distance movements of livestock*, with attendant problems of disease spread, and the need for complex reciprocal arrangements among groups controlling grazing territories. In Botswana

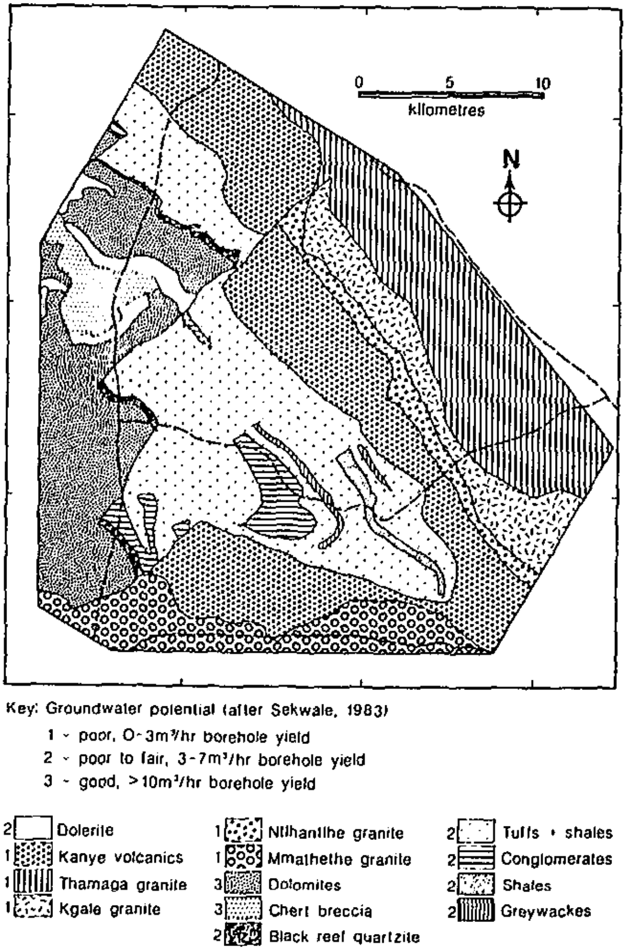

Figure 2. Rock-type and groundwater potential of communal rangeland in SE Botswana (source: Sekwale, 1983)

arrangements are already made between borehole owners in the Kalahari, and communal area herders. In Zimbabwe they are sometimes made between private ranchers and the herders;

(iii) *very high mortality of cattle*, as in the last and earlier droughts. This was a massive national and private loss of capital, but this opportunistic approach is, we shall argue, a rational strategy under unreliable rainfall.

Lack of self-sufficiency of grazing schemes means that animals must sometimes get forage and water from outside the scheme. It is highly likely that communities which have obtained a fenced grazing territory by having a Government-sponsored grazing scheme will use their fence and territorial rights to

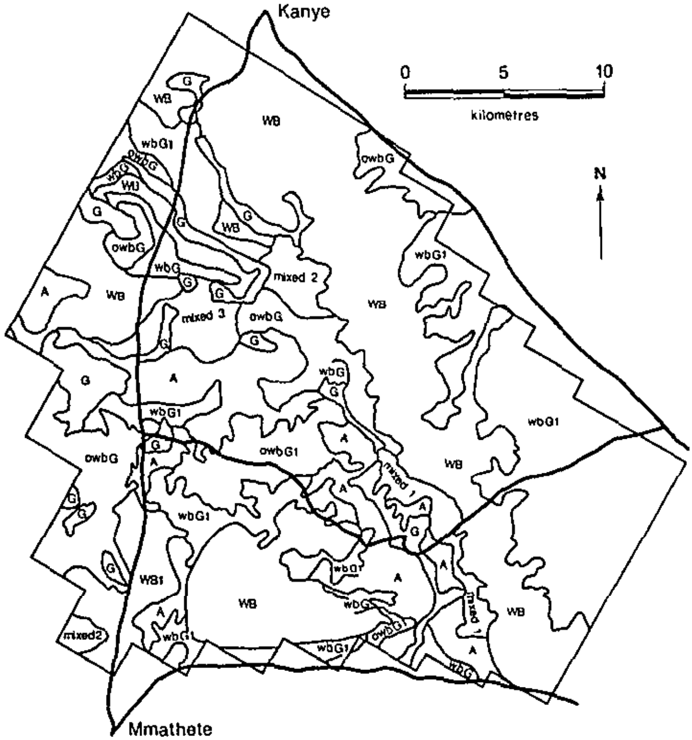

Figure 3. Vegetation structure of communal rangeland in SE Botswana

Key:

o = open
b = bush—shrubs present
w = wooded—trees present
G = grassland (bush or tree canopy cover <2%)
B = bushland (bush canopy cover > 20%)
W = woodland (tree canopy cover > 20%)
A = arable, including plough and fallow
WB = shrubs and trees mixed (woody canopy cover > 20%)
WB1 = WB with scattered fields (both plough and fallow)
owbG = shrubs and trees mixed (woody canopy cover >2 < 10%)
owbG1 = owbG with scattered fields (both plough and fallow)
wbG = shrubs and trees mixed (woody canopy cover > 10 < 20%)
wbG1 = wbG with scattered fields (both plough and fallow)
mixed 1 = owbG and wbG mixed
mixed 2 = owbG, wbG and the WB mixed
mixed 3 = A, owbG, wbG and WB mixed

——— Road

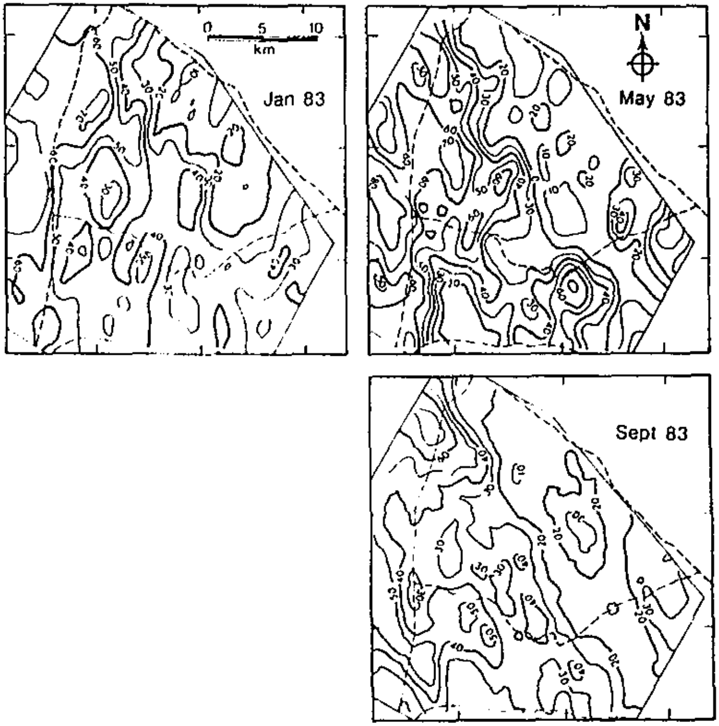

Figure 4. Grass cover of communal rangeland in SE Botswana, January, May, September, 1983 (per cent) (source: Abel, *et al.*, 1987)

protect their grazing against outsiders, while moving their cattle onto the unprotected pastures of these same outsiders (Cousins, 1987). An evaluation of such a scheme might well show improvements in the conditions of cattle and livestock, but might fail to show that these had been gained at the expense of the surrounding non-scheme areas.

GRAZING SYSTEMS POLICY AND RANGELAND CONSERVATION

Grazing systems are intrinsic to the technical design of communal grazing schemes in both countries. They are designed to regulate the timing, intensity and duration of grazing to suit the physiological needs of rangeland plants for rest and defoliation. All such systems rely on deferred or rotational grazing with rest periods. Fenced paddocks are usually but not always required. Advocates of grazing sysems argue that livestock productivity increases under a rotational or deferred system compared with continuous grazing. Savory (1983) has claimed that under short-duration grazing range condition can improve even with increased stocking rates.

In Botswana grazing systems for Communal Areas were implemented in the form of the World Bank/Animal Production Research Unit 'Grazing Cells'. These were run mainly as demonstrations by Government staff, and were not adopted by farmers. In Zimbabwe a simplified Savory Short Duration

Figure 5. Distribution of twelve cattle herds in 1983 on communal rangeland in SE Botswana (source : Abel, *et al.*, 1987).
Notes;
(1) Herds were followed on foot over a period of one year, and locations plotted on aerial photographs; one occurrence means one herd entered one survey grid cell on one occasion during one sub-season.
(2) Early rainy season: December – February
Late rainy season: March – May
Early dry season: June – August
Late dry season: September and October

Grazing System was promoted by the settler and the present Government, and has been adopted by farmers, although it is not always managed formally (Cousins, 1987).

Trials in Zimbabwe have examined the effects of varying the duration, frequency and stocking rates of steers on rangeland, from which Gammon (1984) concluded that in general only small increases in stocking rate above those appropriate to continuous grazing can be achieved. However, he felt that when the starting point is seriously degraded range:

'SDG (short duration grazing), can effect very great increases in carrying capacity through veld improvement, the degree of increase depending on the initial degree of degradation'. (1984: 63).

It is hard to deduce from the evidence he offered how this last conclusion was reached, but SDG is recommended for all Zimbabwean Communal Grazing Schemes, and our own study of communal schemes in Masvingo Province, Zimbabwe in March/April 1987, did to some extent support his views. We compared conditions inside and outside two schemes with known and relatively long histories of good management—Razi, in Chibi Communal Area, and Tagwirei in Gutu Communal Area. In addition, Ndambani Scheme, which is well established and managed, was compared with neighbouring Mabachi, which was not then fully operational.

The research hypotheses tested in the rangeland assessments were:

(i) the percentage of bare ground would be less on the grazing schemes than outside;
(ii) the frequency of perennial grasses, both rooted frequency and canopy cover, would be greater within the schemes than outside, contributing to better cover and increased fodder;
(iii) the frequency of better quality and more palatable grass species on the schemes would be greater relative to the occurrence of less-desirable species;
(iv) livestock would be in better condition on the schemes than on the surrounding open range.

Two techniques were used: condition-scoring of oxen, and step-point transects.

Condition-scoring of oxen

Nicholson and Butterworth (1985) have discussed the use of subjective condition–scoring of cattle as an indirect way of predicting herd productivity. The method has been validated by Abel, *et al.* (1987): Elliot (1964): Harwin, *et al.* (1967), Steenkamp, *et al.* (1975) and van Niekerk (1982). Fleshing (muscle) and finish (fat deposition) were the main criteria used with some weighting for the condition of the coat and general alertness (Abel, *et al.*, 1987). Only oxen were scored so as to reduce variations, caused by sex, age and reproductive status. Sixty-three animals were sampled. A nine-point scale was used, but classes were pooled to form three levels of condition–average, above–average, and below–average.

Analysis of a contingency table showed no significant difference in condition between CGS and non-CGS cattle.

Step-point transects

This technique was adapted from Evans and Love (1957). Each transect comprised 100 point samples. Transects were located subjectively to represent conditions inside the scheme. For every transect inside a scheme, another was run outside on similar slope and soil type, and with similar vegetation structure. Once the starting point and orientation of a transect was decided, it was placed in a straight line aided by a compass.

Sampling points along the transect were defined by a 2 mm notch cut into the toe of one of the surveyor's shoes. At each alternate pace the point under and above the notch was examined and these factors recorded if 'hit':

* bare ground: no litter nor canopy cover;
* litter;
* rooted bases of herbaceous plants: recorded separately as perennial grass, annual grass or forb. Species of grasses were recorded;
* canopy of herbaceous plants vertically above the point: recorded as perennial grass, annual grass or forb. Species of grasses were recorded;
* canopy of shrubs or trees vertically above the point: species were recorded.

Except for bare ground and litter, the categories were not mutually exclusive.

A total of thirty transects was recorded, 3,000 points, half inside schemes and a matched set outside (Table I). These results support the hypothesis that range condition 'improves' under short duration

Table I. Step-point transects—cover assessments

	% herbaceous basal cover				% herbaceous canopy cover				% woody canopy cover				% soil cover	
	perenn. grass	ann. grass	forb	total	perenn. grass	ann. grass	forb	total	shrub	tree	total	litter[3]	bare ground[1]	effective cover[2]
Operational grazing schemes														
Ndambani	12·8	1·8	0	14·8	54·8	1·0	0·8	56·8	2·0	0	2·0	61·3	11·0	89·0
Razi	2·0	1·0	0·2	3·2	6·2	0·2	1·0	7·6	5·4	23·2	28·6	41·0	45·6	54·4
Tagwirei	4·2	0·8	0	5·0	20·5	3·3	2·5	26·3	0·7	0·7	1·5	30·7	47·7	52·3
Mean (weighted)	5·8	1·1	0·1	7·0	24·9	1·7	1·5	28·2	2·6	8·0	10·7	42·3	37·2	62·8
Non-grazing schemes														
Mabachi	10·8	1·5	0	12·3	38·0	1·5	0	39·5	1·0	0	1·0	53·5	23·8	76·2
Outside Razi	1·2	0·2	0	1·4	3·8	1·0	1·4	6·2	7·4	18·2	25·6	31·4	54·6	45·4
Outside Tagwirei	6·3	0·5	1·2	8·0	27·5	2·5	2·8	32·8	4·8	0	4·8	23·8	44·8	55·2
Mean (weighted)	5·8	0·7	0·5	6·9	22·4	1·7	1·6	25·7	4·7	6·1	10·7	34·3	42·5	57·5
Difference CGS/non-CGS	0	0·4	0·4	0·1	2·5	0	0·1	2·5	2·1	1·9	0	8·0	5·3	5·3

Notes: [1] No litter, no herbaceous cover, no woody canopy.

[2] 100–*l*. The difference in effective cover between Ndambani and Mabachi is statistically significant ($p < 0{\cdot}001$) and between Razi and the communal grazing outside ($p < 0{\cdot}01$), but not between Tagwirei and its surrounds. For all transects combined the difference is also significant ($p < 0{\cdot}01$).

[3] The difference in litter cover between every pair of scheme and non-scheme samples is statistically significant ($p < 0{\cdot}05$). For all transects combined, the difference between scheme and non-scheme transects is more significant ($p < 0{\cdot}001$).

grazing. The biggest differences are in litter cover 8 per cent and bare ground (5.3 per cent), both in favour of the schemes. It is clear, however, that no spectacular changes in vegetation condition have so far resulted.

Table II shows grass species encountered, and table III shows differences in the frequency of 'indicator species' of grasses along the transects. It suggests the CGS are, in terms of species composition of grasses, in 'better' condition than the pastures outside because of the higher frequency of 'decreasers' and lower occurrence of 'increasers' and 'invaders' on the schemes ($P < 0.005$).

In economic terms the 'indicator species' concept is supposed to reflect the loss of palatable and nutritious species and the spread of unpalatable ones. However, Kelly (1973) compared the percentage crude protein, crude fibre and phosphorous contents of herbaceous vegetation on unused, and on

Table II. Grass species recorded along step-point transects[1,2]

Aristida congesta
Aristida rhiniochloa
Aristida spp.
Brachiria sp.
Cynodon dactylon
Digitaria milanjiana
Digitaria sp.
Eragrostis spp.
Heteropogon contortus
Hyparrhenia filipendula
Loudetia simplex
Paspalum, sp.
Perotis patens
Pogonarthria squarrosa
Rhyncelytrum repens
Sporobolus pyramidalis
Sporobolus sp.
Stereochlaena cameronii
Trichoneura grandiglumis

Notes: [1] These species were recorded by basal or aerial frequency.
[2] Most annual grasses and a few perennials could not be identified because of heavy grazing following poor growth after low rainfall in 1986/7.

Table III. Range condition inside and outside communal grazing schemes (CGS) based on indicator species of perennial grasses

	frequency of occurrence on step-point transects[1]		
	inside CGS	outside CGS	
Decreasers[2]	74	57	131
Increasers & Invaders[2]	54	101	155
	128	158	286

$\chi^2 = 13.46, p < 0.005$

Notes: [1] Frequency was the sum of rooted frequency and aerial canopy cover frequency.
[2] Classification was based on Rattray (1960). The habit, distribution, habitat, forage value and veld indicator value of the commoner rhodesian grasses, *Rhodesian Agricultural Journal*, 57(5) p. 424.

lightly–, moderately– and heavily–used sites in SE Zimbabwe. The heavily–used sites carried superior quality forage in terms of these criteria. The heavily–used sites were in communal range; moderately–used sites were on commercial ranchland; the lightly–used sites were under wildlife, and the 'unused' sites in a tse tse control area. These results were obtained during the rains, and given that annual grasses made up much more of the herbaceous biomass on the communal sites than on the others, it is likely that quality would fall more in the dry season on communal sites than on the others. Yet the ability of cattle to survive on browse is well established (Walker, 1980), and besides decline in condition of cattle during the dry season due to lack of feed is usually balanced by compensatory growth during the next rainy season (King, 1983). Thus there is not necessarily a clear link between change in grassland species composition and livestock productivity (Abel, *et al.*, 1987).

STOCKING RATE POLICY

Stocking rate is the main determinant of the productivity of cattle, and the species composition and grass cover of rangeland (Butterworth, 1985). The Governments of Botswana and Zimbabwe are therefore justified in focussing on animal densities as a key issue. As grass cover decreases, erosion rate rises and the output per head of cattle falls as stocking rate increases. Destocking would, it was therefore assumed, not only conserve range but also bring increased benefits to herders through improved livestock productivity. Destocking has never been implemented in Botswana, and not since the 1960s in Zimbabwe. However, in both countries the legislation is still 'on the books'.

The rangeland of Botswana and Zimbabwe receive highly–variable rainfall. In these circumstances it is difficult to devise a stocking rate which does not result in overgrazing in a dry year, under-utilisation in a good one. Policy has, following the conventional wisdom of range science (Strange, 1980), set recommended stocking densities to fairly low levels, a conservative strategy intended to avoid overgrazing (Field, 1978). These levels can only be maintained by high rates of offtake, so that a conservative stocking policy is fully compatible with the economic policies, a feature of both countries, promoting beef production from the Communal Areas.

The key issue to consider here is that both Governments have assumed that over-stocking causes degradation, and that destocking can improve welfare in the medium– and long–term through increases in livestock productivity. The assumption is therefore that destocking carries its own reward, and that if individuals could provide 'mutual assurance' (Runge, 1986) through an appropriate institution, de-stocking could become individually and collectively rational because the productivity increase would provide the necessary incentive.

STOCKING RATE AND RANGE PRODUCTIVITY

In Botswana the Range and Livestock Management Project initiated the myth, assumed to be correct in the Tribal Grazing Lands Policy, that startling increases in the productivity of livestock in the Communal Areas were possible if the socio-political aspects of production could be reconciled with technical innovations. Rennie, *et al.* (1977) quantified this assumption by claiming to show that productivity per cow under the commercial ranch system of management can be twice that under the 'traditional' cattle-post system. Behnke (1985), however, pointed-out that the comparisons were made between experimental, not commercial ranches and cattle-posts. Experimental ranches are run for scientific, not financial purposes and apply uneconomically high intensities of management. Hubbard (1982) found that if true commercial ranches were compared with cattle-posts, livestock productivity *was* higher on the former but with a modest margin.

De Ridder and Wagenaar (1984) accepted Rennie's ranch data at face value, but they included milk for human consumption and draught-power for ploughing, and changed the productivity criterion from annual output per animal to output per hectare. The traditional system emerged as twice as technically productive as the experimental ranch. The main reason is the higher stocking rates under traditional systems—commonly 6 ha per livestock unit (l.u.), compared with 12·5 ha per l.u. on ranches. APRU

(1980) has demonstrated experimentally that as stocking rate increases, output per head declines while output per hectare increases, and continues to increase up to very dense stocking rates. At Morapedi Ranch in SE Botswana, a stocking rate of 4 ha per l.u. gave a higher livemass gain per ha (15·7 kg/yr) than an 8 ha per l.u. treatment (12·9 kg/ha/yr).

As in Botswana, stocking rate in Zimbabwe is more important than the choice of grazing system in determining the productivity of animals and the secondary productivity of land. Barnes (1965) has shown how animal productivity declines, while the secondary productivity of land increases with stocking rate. Carew (1976) working at Matopos found that maximum livemass gain per steer was achieved at 3·8 ha per l.u., and maximum livemass gain per ha at 2·8 ha per l.u.

The implication is that destocking would reduce the number of people the land could carry despite the expected increase in output per animal. However, governments' attitude to stocking rates is still based on the wrong notion that productivty increases per beast will more than compensate for losses caused by reduced density.

The threat that the misconception about the stocking rate/productivity relationship poses for incomes of the many Batswana and Zimbabweans who already have insufficient animals for their needs (Flint, 1986; Sandford, 1982) is compounded by official carrying capacity figures (Field, 1978). These give the impression of a fixed, ideal, narrow range of stocking rate densities for each rangeland type. In fact, of course, carrying capacity varies enormously from year to year, and is correlated with rainfall. The annual average rainfall at Kanye (SE Botswana) has varied between 100 mm and nearly 1000 mm between 1926/27 and 1982/83. The present strategy in the Communal Areas of Botswana and Zimbabwe is to encourage animal numbers to build up between droughts in the knowledge that they will crash when a severe drought occurs. Herds rebuild from the survivors. This strategy is termed 'opportunistic' by Sandford (1983) who contrasts it with 'conservative' strategies which reduce drought mortality by maintaining lower densities in good years. The benefits of conservatism are those espoused by governments and commercial ranchers—high rates of animal productivity, early slaughter, premium prices for beef, exportable carcasses, good returns to capital, lower drought-risks and less risk of rangeland degradation. The costs are failure to realise potential production in the best years, when the stocking rate is below carrying capacity, and low output per unit area.

Opportunistic stocking as Sandford (1983) has shown, gives a higher output over time than the conservative strategy when carrying capacity varies. The higher the variation the greater is the advantage of opportunism over conservatism. The costs are very high mortality during drought, low productivity per animal (but high output per hectare over time), low prices for the poor quality carcasses which are not usually suitable for export. A potential cost is land degradation, which is more likely under an opportunistic strategy, and it is on this issue which the Governments' policies hinge.

STOCKING RATE AND RANGELAND DEGRADATION

Given the importance of land degradation as a political issue and the weight of policy it has had to bear, surprisingly little research has been carried out to establish its nature, rates and importance (Stocking and Peake, 1985). The issue has, in addition, been clouded by poor definition. By range degradation we mean an *effectively permanent* decline in the rate at which the land yields livestock products under a given system of management. 'Effectively' means that natural processes will not rehabilitate the land within a timescale relevant to humans, and that capital or labour invested in rehabilitation are not justified. As Warren and Agnew (1988) point out, this definition may be hard to apply in practice, but as a working concept we find it useful. This definition of degradation excludes *reversible* vegegation changes even if these lead to temporary declines in secondary productivity. It includes effectively irreversible changes in both soils and vegetation.

The reversibility of vegetation change, and the normality of great fluctuations over time in rainfall and herbivore numbers conflict with concepts of ecosystem stability as a desirable range mangement goal (cf. Strange, 1980). It has been pointed out in the previous section that annual rainfall in SE Botswana varied between 100 mm and nearly 1000 mm over 36 years. Walker and Noy-Meir (1982) have stressed, not the stability of savanna ecosystems, but their great instability. No system perturbed by a highly variable extrinsic force could be stable in the way Strange (1980) envisages. However, a property of unstable systems is resilience—the ability to recover from perturbation (Holling, 1973). Wide variation in rainfall (in particular), fire and herbivore numbers has promoted the evolution in grazing systems of mechanisms which confer resilience. At the level of the plant these include adaptations for tolerating defoliation (underground storage of food reserves, protected buds, rapid regrowth, persistant seeds), or resisting it (fibrous leaves, toxins, digestion-inhibitors). Walker, *et al.* (1981: 495) preferred to define resilience as the '... ability to adapt to change by exploiting instabilities ...'. If by intensive management temporal variation can be reduced, it has been argued that resilience declines: Walker, *et al.* (1981) suggest that a ranch managed for high and stable output of meat through the maintenance of a moderate and fixed stocking rate becomes dominated by palatable but graze-sensitive grasses at the expense of the 'ungrazeable grass refuge' of unpalatable species. In severe drought such a system is prone to denudation to an extent that a more heavily-grazed system, replete with unpalatable plants, is not. The ranch has lost resilience because it has been managed for stability. In this sense instability leads to resilience.

The concept of resilience requires us to rethink definitions of degradation. Changes that occur as an adjustment to perturbation are reversible, provided the system is not pressed beyond its bounds of resilience, in which case it would be unable to return to its former state. Rangeland systems respond rather readily to perturbations such as increases in stocking rate. Whereas many observers have classified such responses as 'degradation', we are arguing that this term should apply only to changes which are effectively irreversible because the system has been forced beyond its bounds of resilience. In the Communal Areas of Botswana the main vegetation changes are bush-encroachment and changes in the species composition of grasses (Carl Bro International, 1982; Cooke, 1981; van Vegten, 1981; Abel, *et al.*, 1987). Bush encroachment *can* become effectively irreversible in circumstances where grass cover is so reduced that rates of water infiltration cannot support a recovery of the herbaceous layer (Walker and Noy Meir, 1982). In general, however, changes in the balance between woody and herbaceous components of the range are dynamic and reversible. Besides, the rate and severity of bush encroachment is *not* directly correlated with stocking rate: in SE Botswana at least encroachment is more severe on commercial land than on the nearby Communal Area.

Changes in the species composition of the vegetation have occurred in the Communal Areas. These are likely to be reversible provided soils have not been greatly changed. Abel, *et al.* (1987) found in a heavily-stocked study area in SE Botswana that the herbaceous layer of all range types was dominated by palatable and nutritious grasses; although species composition probably *had* changed with increasing animal densities, the shift was towards low-growing graze-tolerant but palatable perennials. Kelly (1973) demonstrated the improved rainy season quality of the herbaceous layer on heavily-stocked communal rangeland compared with more lightly-stocked sites in Zimbabwe.

Changes in rangeland such as species composition, reversible or otherwise, will not matter to land users provided the output of livestock products is not reduced. Since stocking rates have been *increasing* in the Communal Areas, it is highly probably that the output of livestock products has also increased, given the established relationship between stocking rate and weight gain/ha (Butterworth, 1985). In these circumstances changes in species composition do not matter to present users, whereas degradation of soil, being effectively irreversible, *would* affect posterity.

SOIL EROSION AND RANGELAND DEGRADATION

Little work has been done to relate erosion to land productivity in Zimbabwe, Botswana or elsewhere (Stocking and Peak, 1985). Also missing from governments' research response to overgrazing is a set of studies on the relationships among land use, land tenure, land degradation and primary and secondary production. Kelly's (1973) excellent thesis is the only such study we have found, but this was not concerned with secondary production, and so is limited in its ability to comment on degradation (Sandford, 1982). Kelly worked in the dry south-east of Zimbabwe, comparing sites which were similar except for the intensity of grazing and browsing. One was ungrazed within a tsetse control corridor, one lightly used by wildlife, one moderately-grazed by commercial ranch cattle, and the last intensively-grazed and browsed by cattle and goats in a Communal Area. He argued that the Communal Area was degraded in relation to the other sites because:

—in the heavily used area there were more dead and dying perennial grass tufts, and insufficient replacements;
—annual species were more abundant. These are inferior to perennials in promoting infiltration, and they provide poor dry-season feed;
—rates of infiltration are much lower;
—annual production from the herbage layer varies greatly between years as summarised in Table IV.

In a dry year, when rainfall accounted for most of the variation in production in the samples, the Communal Area sites produced very little compared to the ranched sites. During a better season, when rainfall accounted for very little of the variation in production, herbaceous yields were very similar. Kelly accounts for the difference mainly in terms of the large contribution of annual grasses to herbaceous biomass on the Communal Area sites. These grow well in a good year and very poorly in a dry one. Perennial grasses are much less susceptible to rainfall variation.

Sandford (1982) has argued that these findings do not constitute evidence of degradation. We support Sandford's objections to the extent that:

a. the change from perennial to annual grasses would be reversible provided changed soil conditions do not prevent it;
b. although infiltration capacity is reduced on the Communal Area sites, Kelly accounts for variation in infiltration capacity mainly in terms of litter cover; this is closely correlated with stocking rate, and to an extent at least is therefore reversible;
c. for human purposes land degradation should be defined in terms of declining output of livestock products per ha of land. Kelly offers no evidence that such a decline has occurred.

Where Kelly may be correct in claiming degradation is through identifying the link between soil depth and herbaceous production. Abel and Blaikie (1988) took Kelly's samples from areas with less than 22 500 m^3/ha of woody canopy, and found a positive linear relationship between soil depth and herbaceous biomass. Extrapolation shows near-zero production at zero soil depth. The seriousness of degradation will depend on *net* rate of soil loss in relation to rate of soil formation. These data are not in the thesis, which cannot therefore answer questions on rates of degradation. However, some relevant investigations have been carried out in Botswana.

Abel and Stocking (1987) have estimated that the net annual rate of soil loss from an undulating rangeland type in a Communal Area in SE Botswana was 1·2 tonnes/ha. These rates do not represent an 'ecological crisis', although Abel, *et al.* (1987) argued that slow degradation *was* occurring. Meanwhile, Biot (1988) has been modelling rates of land degradation in a very heavily used and (for Botswana) steeply-sloping landscape within the Communal Areas. Comparing sites with similar geology and soils,

Table IV. Herbaceous production and rainfall in commercial ranching and Communal Areas

land use	season	on-site rainfall (mm)	herbaceous production (kg/ha)*
Commercial ranching	1970/71	303–311	1005
	1971/72	518–565	1322
Communal Area	1970/71	275–337	200
	1971/72	524–578	1204

*harvested in April from protected plots.
Source: Kelly, 1973.

but at different erosional stages, he found that the main soil factor affecting herbaceous production was soil depth. He estimated net rates of soil-loss, and concluded from the predicted rate at which depth was declining that any decrease in herbaceous production would only start to affect the ability of the land to sustain present cattle densities from about 400 to 500 years from now. (c.f. Arntzen and Veenendaal, 1986).

VARIATION IN THE SUSCEPTIBILITY OF RANGELAND TO EROSION

Biot (1988) did not attempt to extrapolate from his model to form general conclusions about rates of degradation under different rainfall regimes and in other soil types. Under very heavy stocking rates at Matapos in Zimbabwe, Carew (1976) found that range condition 'collapsed'. However, at stocking rates of one steer per 5·7 ha, one per 4·1 ha, and one per 2·4 ha at Marondera, Barnes (1965) found no significant changes in grass species composition. He concluded that the Marondera sandveld remains unchanged under very heavy stocking rates for up to 15 years. Thus rangeland varies in its ability to tolerate grazing, a view substantiated by the work of Stocking and Elwell (1973) on erosion hazard mapping.

Stocking and Elwell's work has shown how the erodibility of land and the erosivity of rainfall vary within Zimbabwe to produce varying rates of geological erosion. The Communal Areas are generally in regions where erosion hazard is greater than in the Commercial Areas. Here human and livestock populations are very much denser than in the Commercial Areas, so that greater actual rates of erosion can be expected. Whitlow (*undated*) has confirmed in a national survey using aerial photography that gullying, sheetwash, rilling and streambank erosion were all more severe in the Communal Areas than in the country as a whole. We should bear in mind that even with uniform distribution of livestock and people these areas should show more erosion than the national average.

THE COSTS AND BENEFITS OF DESTOCKING

Destocking is advocated as a means of reducing or preventing rangeland degradation. What level of destocking is required to reduce rates of erosion? We examined this question using the Soil Loss Estimation Model for Southern Africa (SLEMSA) devised by Elwell and Stocking (1982), and applied to rangeland by Abel and Stocking (1987). The model estimates gross soil loss from rill and sheet erosion from sites of specified slope length. The results is an index of relative rates of soil loss, and not a measure of actual net loss of soil.

Figure 6 summarises the relationships between estimated gross soil loss (tonnes/ha/yr) and effective vegetation cover (herbaceous, woody and litter cover) for two Communal Area study sites, in Gutu and Chibi, Zimbabwe. In calculating vegetation cover the herbaceous contribution includes either basal cover or canopy, but without double-counting. Tree canopy is included as if it were as effective as herbacious vegetation. This is not strictly correct, since woody plants intercept less rainfall energy than herbaceous vegetation (Young, 1986). Biot (*pers. comm.*) has assumed that a tree canopy only intercepts about 30 per cent of rainfall energy. This makes little difference to our soil loss calculations since total woody canopy covers only 21 per cent in the Chibi and four per cent in the Gutu study area.

The difference in vegetation cover between grazing scheme and non-scheme transects was around five per cent (57·5 per cent compared with 62·8 per cent) (see Table I). This difference would result, if applied to the whole of the two study areas, in a negligible decline in rate of gross soil loss. The reason is the negative exponential form of the soil loss curve (Figure 6). For the same reason improvements in cover on sparsely vegetated rangeland produce substantial reductions in soil loss. For example, if we accept that the establishment of the communal grazing scheme at Razi has resulted in a real increase in cover of nine per cent from 45·4 per cent to 54·4 per cent (Table I), this would result in a decrease in gross soil loss of around 0·4 tonnes/ha/yr, or 18 per cent of the rate of loss at 45·5 per cent cover. Small improvements in vegetative cover make very little difference to rates of erosion unless rangeland is already sparsely covered.

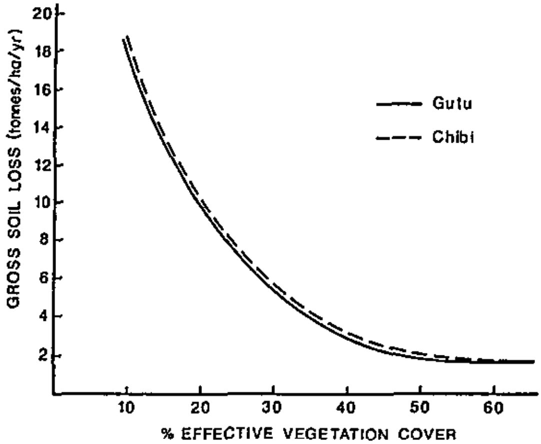

Figure 6. Predicted effect of vegetation cover on soil loss for two study areas in Zimbabwe's Communal Areas
Note: Vegetation cover is 'effective cover', and includes aerial and rooted herbaceous plant parts, litter and tree canopy. Woody canopy covers only 21 per cent of the Chibi and 4 per cent of the Gutu study areas

Abel, *et al.* (1987) estimated a relationship between herbaceous cover measured on step-point transects, and herbacous biomass of grasslands in SE Botswana on 'hardveld' receiving 517 mm mean annual rainfall. The equation is:

$$y = -64{\cdot}1 + 19{\cdot}4 \ln x$$

where: y = herbaceous cover per cent
x = herbaceous biomass, kg/ha
$R^2 = 0{\cdot}72$

The relationship can be used to make a crude assessment of the opportunity cost of destocking to conserve soil if we assume a static and short-term relationship between stocking rate and herbaceous cover: to improve vegetation cover by a given percentage we remove the number of animals which would have eaten the biomass of grass corresponding with that increase in cover. Other assumptions are listed in Table V. This table is not intended to give the misleading impression that a site with a 10 per cent herbaceous vegetation cover and a stocking rate of 0·0075 l.u./ha/yr (133 ha per l.u.) can be transformed to one with 55 per cent cover and 0·0762 l.u./ha/yr (13 ha per l.u.) by a destocking programme. It is rather intended to indicate for various levels of herbage cover and biomass—as determined by annual rainfall, soil type, topography and past use for example—what the incremental cost might be for a small decrease in soil erosion. Cost is expressed in terms of numbers of l.u. removed from the range.

The stocking rate-cover-erosion rate relationships in Table V and Figure 7 determine that the stocking rate reduction needed to effect each five per cent herbaceous cover increment is 49 per cent of the current stocking rate—a heavy cost. Furthermore, as the status of the range improves, each increment of herbaceous cover is bought at increasing cost in terms of number of animals removed to effect the cover increase.

The relationship between herbaceous cover and erosion rate shows that the soil erosion component of range degradation is a *continuous* process. Even light stocking rates may cause soil to erode faster than it

Table V. Destocking, herbaceous cover and biomass, and soil loss

1/ current herbaceous cover (%)	2/ current herbaceous biomass (kg/ha)	3/ current stocking rate (l.u./ha/yr)	4/ desired increase in herbaceous cover (%) from – to	5/ increase in herbaceous biomass associated with increased cover (kg/ha)	6/ decrease in stocking rate (l.u./ha/yr) needed to effect cover and biomass increases	7/ decrease in gross soil erosion rate (tonnes/ha/yr) due to cover increase (Chibi data)	8/ l.u. destocked per tonne of soil saved by destocking
10	45·6	0·0075	10 – 15	13·4	0·0037	4·78	0·0077
15	59·0	0·0097	15 – 20	17·3	0·0047	3·51	0·0013
20	76·3	0·0125	20 – 25	22·5	0·0062	2·55	0·0024
25	98·8	0·0162	25 – 30	29·0	0·0079	1·75	0·0045
30	127·8	0·0210	30 – 35	37·6	0·0103	1·44	0·0072
35	165·4	0·0272	35 – 40	48·6	0·0132	1·28	0·0103
40	214·0	0·0352	40 – 45	62·9	0·0172	0·64	0·0269
45	276·9	0·0455	45 – 50	81·4	0·0223	0·32	0·0697
50	358·3	0·0589	50 – 55	105·4	0·0289	0·16	0·1806
55	463·7	0·0762	55 – 60	136·3	0·0373	0·16	0·2331

Notes: (see text for limitations)

1/, 2/ Relationship of herbaceous cover (α, per cent) to biomass (y, kg/ha) is based on Abel *et al.*, 1987: $y = -64{\cdot}1 + 19{\cdot}41x$ ($R^2 = 0{\cdot}72$).

3/ Current stocking rate is based on assumptions that: column 2/ represents annual forage production, 60 per cent of which is consumed; one livestock unit (l.u.) = 500 kg, which consumes two per cent of its bodymass daily, or 3,650 kg/yr; current stocking rate = (column 2/ × 0·6) ÷ 3650.

4/ 'Desired increase in herbaceous cover' is set out in increments of five per cent, each associated with a decrease in stocking rate—based on annual consumption rate of 3650 kg/l.u./yr (column 6/); and a decrease in gross soil erosion rate (7/) based on SLEMSA—see Figure 6 for two study areas. SLEMSA is the Soil Loss Estimation Model for Southern Africa—see earlier ('The Costs and Benefits of Destocking').

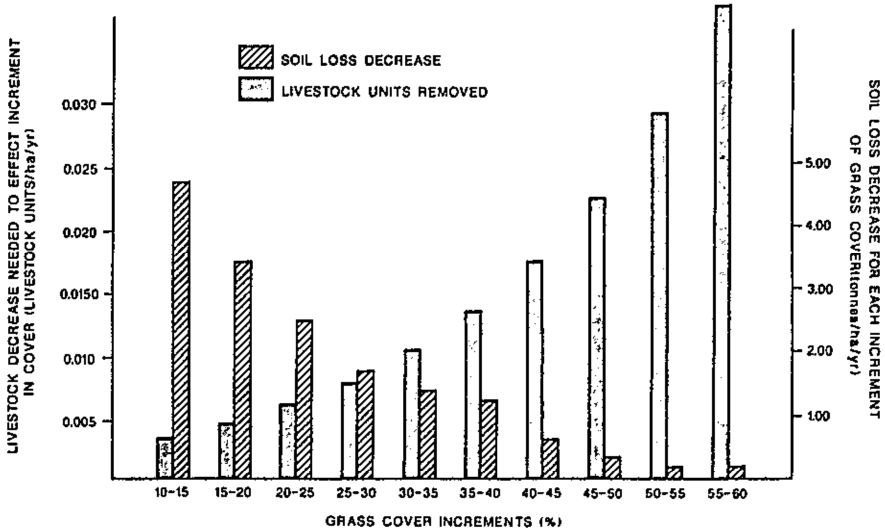

Figure 7. Vegetation cover, stocking rate and soil loss (see Table V)

forms. Range degradation does not, therefore, begin or cease on either side of some arbitrary 'carrying capacity' threshold. Policy should aim, therefore, at determining socially-acceptable rates of range degradation assessed in terms of trade-offs in welfare between present and future generations (Seckler, 1987). Figure 6 suggests that a socially-acceptable stocking rate might be determined by the level of grass cover below which soil erosion rates rise steeply—in our model, at around 30–35 per cent cover. The *principle* that the inflexion in the curve may indicate acceptable stocking rate may be generalisable, the 30–35 per cent is not. Stocking rate should not, however, be fixed since under the variable rainfall if the rangeland carrying capacity is itself highly variable.

The simplistic relationship which our model assumes between stocking rate reduction, herbaceous cover increase and reduction in erosion may be approximately correct over a brief period under constant rainfall, in that material not removed by livestock can remain to protect the land. In reality and in the longer-term the response would be complicated by rainfall variation and changes in rooted frequency, species composition and physiognomy of plants. However, two principles which the model illustrates—that each improvement in herbaceous cover is costly to rangeland users, and that this cost rises as cover increases—are believed to be correct.

CONCLUSIONS AND IMPLICATIONS FOR RANGELAND POLICY IN THE COMMUNAL AREAS

Conclusions

These conclusions stem from our paper:

(i) the two Governments are rightly concerned about stocking rate on communal rangeland, since this is the main determinant of secondary productivity. They are wrong, however, in assuming that destocking leads to a greater annual output of livestock products in the short and medium term.

They are correct in the long term, in that rates of soil loss and therefore degradation rise with stocking rate. How long depends on rates of degradation, which varies between land types;

(ii) destocking would, in the short- and medium-term, be a great cost to agro-pastoral households. The amount of benefit it would bring in *terms of reduction in rate of soil loss*, depends on the present level of herbaceous cover: the greater the cover, the smaller the reduction in erosion resulting from destocking;

(iii) rangeland degradation is a continuous process which does not begin or cease on either side of some 'safe' threshold. Policy makers should therefore seek a socially acceptable trade-off between the interests of present and future generations;

(iv) rangeland is intrinsically unstable because it is adapted to varying rainfall. Management should be an adaptation to this variation, not an (infeasible) attempt to control it;

(v) because it is unstable, rangeland is also intrinsically 'resilient' compared with more 'stable' ecosystems. Degradation occurs when rangeland is perturbed beyond its ability to recover. Resilience varies with land type;

(vi) grazing territories can never be large enough for long-term self-sufficiency, and it is difficult to include within a territory all the qualitatively necessary forage resources;

(vii) our work lends tentative technical support to the promotion of grazing systems for communal rangeland management. However, rangeland resources do not follow fencelines, and the arbitrary demarcation of paddocks is likely to reduce the ability of animals to obtain their nutritional requirements;

(viii) rangeland varies in its erodibility, and better rangeland management should take this into account.

Two main policy issues proceed from these conclusions. They are discussed below.

Stocking rate policy

In neither country can uncompensated destocking be a realistic measure, since most households already have too few cattle (Abel, *et al.*, 1987; Flint, 1986; Sandford, 1982), and reductions would reduce the number of people the land can carry. Research along the lines of Biot (1988) should be used to establish the rate and seriousness of current rates of degradation, before deciding whether a policy of *compensated* destocking should be promoted.

Target stocking rates should be variable, and determined by variations in carrying capacity. Sandford (1977) argued the need for a 'tracking strategy'. Abel, *et al.* (1987) proposed these measures to encourage livestock numbers to vary with carrying capacity:

(a) the establishment of locally managed grazing territories in which a management fee per animal is charged. The fee is inversely related to the previous season's rainfall, so that it is expensive to keep cattle after a dry season, and cheap after a wet one;

(b) a subsidised market price, also inversely related to rainfall, so that after a dry season the price is high, in a good year, low;

(c) improved marketing, trekking and abbatoir facilities, so that stock can be removed from the range and slaughtered quickly;

(d) subsidised drought assurance schemes, partly funded by Government, partly from the mangement fees;

(e) improved drought recovery measures, such as access to tractors for ploughing in the absence of oxen, heifers for rebuilding herds, and goats, which breed quickly.

The system is intended to encourage sales of cattle in poor years, and accumulation in good seasons. The drought assurance (d) and recovery (e) components enable farmers to do with fewer animals in dry years.

The scheme is unlikely to be self-financing, since poor animals would be bought for high prices in dry years, and few animals would be sold in good years. Its main benefits are expected to be: reduced hardship during and quicker recovery after drought; and rangeland conservation, since fewer animals are on the range to remove the remnants of vegetation cover during the drought.

Grazing territories and systems

The establishment of grazing territories is fraught with socio–political problems concerning equity, the formation of institutions, transaction costs, land tenure and so on (Cousins, 1987; Scoones, 1988b; Abel and Blaikie, 1988). The demarcation of territories needs to take into account the social and ecological reasons for pre-existing patterns of grazing. Our view is, nevertheless, in agreement with both Governments that territorial control by specific groups of people is a prerequisitie for rangeland conservation because it internalizes costs and benefits. However, range varies in resilience, and in the quality and quantity of forage and water in time and space. Therefore, territories should be established with a knowledge of this spatial and temporal variation, perhaps using 'ecological fencing' to separate land types with differing resiliences and resource endowments. Moreover, groups must be enabled to negotiate reciprocal, paid-for grazing arrangements to cope with spatial variation in rainfall.

Grazing systems, including deferred and rotational grazing may well form a useful part of rangeland management policy. However, the partitioning of land should be based on ecological variation, and the timing and duration of grazing be worked out separately for each land type and for each grazing territory: blanket recommendations such as 'two weeks graze, two weeks rest' cannot be suited to the variation of soils and vegetation characteristic of rangelands in the two countries.

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