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GRAZING SYSTEMS IN THE NORTHERN COMMUNAL AREAS OF NAMIBIA

A Summary of NOLIDEP Socio-economic Research on Range Management

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It is widely rumoured that important people do not read long reports. This report is brief. It compresses into 10 pages the results of NOLIDEP research on the social, economic and institutional aspects of livestock production and rangeland management north of the veterinary cordon fence. For readers who require more detail or substantiation, Annexes 1 and 3 of the report discuss policy issues that effect all NOLIDEP regions and are critical for an informed appraisal of the project's range management programme. Annex 2 presents a region-by-region summary of the field studies conducted for or in association with the project. Work reported here was conducted in 1996 and 1997 by project staff, consultants, and affiliated institutions working with NOLIDEP in eight of the nine regions of Namibia's Northern Communal Areas (NCAs).

Background

NOLIDEP is a combined livestock development and rangeland management project. This means that the project must serve several purposes that are potentially antithetical. Under its mandate to develop livestock production, the project should promote increases in livestock output to improve the economic welfare of herd owners. Under its 'sustainable rangeland management' component, the project must fulfil these economic objectives in a way that is consistent with maintaining or improving long-term environmental conditions in the NCAs.

The original NOLIDEP project design assumed that the best method for meeting these objectives was the replication in communal areas of range management practices found on Namibia's commercial ranches, and the project at inception was directed to set up 200 semi-commercial ranch units. It was also assumed that the project's beneficiaries - local stock owners - would support the creation of ranches and that the project could be 'participatory' despite promoting a standardised package of interventions. These assumptions were unfounded. Regional project staff quickly discovered that most small- and medium-scale livestock owners were disinterested or actively opposed to fencing open rangelands.

In 1996-7 the original project blueprint was abandoned (Behnke 1996). It was also clear that the best methods for managing Namibia's communal rangelands were unknown, that solutions were likely to be locally variable, and that there was insufficient information available to predict how project activities would either be received by local communities or would affect the environment.

NOLIDEP has, in effect, become a large-scale, open-air experiment in participatory resource management. The outcome of this experiment remains in doubt. The research reported here is part of the project's attempt to assess the effectiveness of its programmes and to use this information to identify procedures for balancing environmental concerns and the economic interests of small-scale livestock owners.

NOLIDEP's range management work in the NCAs has concentrated on the development of livestock water supplies. Water development was a suitable entry point for the project. It is the most important factor influencing resource management that the project can manipulate, it is actively sought after by rural communities, and it is expensive and can absorb the large amounts of outside funding that the project is obliged to dispense.

NOLIDEP's water programme is participatory in the sense that local communities set their own water development priorities and are expected to maintain the facilities after construction. More controversially, the programme requires rural communities to share construction costs with the project. This report assesses the likely future impact of this cost-sharing policy.

Some observers think that NOLIDEP's range management programme should move beyond water development into the implementation of schemes of grazing rest and rotation and the control of livestock numbers. This report argues that both rotational schemes and stocking controls modelled on commercial ranching practices are unacceptable to small-holder livestock owners, and - in at least some cases - insufficiently justified on scientific grounds to warrant imposition. In many instances, work summarised here documents the existence of indigenous grazing rotation systems and methods of either controlling stock numbers or adjusting to their increase. It is these practices - rather than the imposition of exotic techniques - that the project should attempt to strengthen or modify in light of environmental concerns.

Communal stock owners - like commercial ranchers - make rational decisions about their stocking rates and patterns of herd movement. Until producers face new constraints and incentives, these husbandry practices will not change. Improving security of tenure is one way government can assist rural communities to adopt and enforce their own programmes of restrained resource use. The legal status of community land rights is currently under discussion in Namibia as new legislation is drafted for land tenure in the communal areas. The importance of this legislation and the nature of indigenous land tenure are also discussed.

The inter-regional diversity of grazing systems in the NCAs

Very different circumstances and livestock husbandry practices prevail in the different regions of the NOLIDEP's project area. NOLIDEP must therefore work with a multitude of distinctive grazing systems for which there is no single development blueprint.

- In Kunene study community, specialised livestock keepers have adjusted to low and erratic rainfall by creating sophisticated systems of seasonal transhumance involving numerous distinct grazing areas. The grazing system is managed through intact local institutions, livestock owners produce a marketable surplus for sale, and are prepared to invest in communally owned water facilities. **In this case improved range management rests on the development of a restrained, community-based water development programme that will strengthen current husbandry practices.**

- In Kavango, stock owners are supported by diversified livelihood systems in which livestock production is constrained by non-pastoral concerns. Households are dependent upon cash incomes, but herd sizes are small, few animals are sold and residents are unwilling to invest their own money in developing communal stock watering facilities. Environmental conditions are relatively benign and overall land pressure is low. As a consequence, forage is plentiful, the interior of the region is lightly stocked, and seasonal herd movement involves little more than keeping herds away from the fields when crops are standing. **Veterinary issues and water development in the interior of the region are high priorities, and any systems of improved forage management must be cheap and simple.**

- In North Central Division land pressure is high and agro-pastoral production systems are changing more quickly than in any other part of the NCAs. In the central Cuvelai drainage, these changes are accompanied by small-scale peasant-based range enclosure, as customary transhumance patterns collapse under the weight of more people and animals. Outside the heavily populated Cuvelai, change is being driven by urban capital in the hands of politicians, businessmen and civil servants who are enclosing ranches of thousands of hectares. **In heavily populated areas, NOLIDEP sponsored research on cultivated forages is more relevant than its range management programme. In the lightly populated forest periphery, appropriate land tenure legislation to protect the interests of small-holders must precede any programme of environmentally sustainable technical intervention.**

- In Caprivi, land pressure is lower than in NCD and privatisation of resources is driven by commercial concerns rather than land pressure. To a greater extent than in any other region, Caprivi agro-pastoralism is dependent upon the use of seasonally inundated floodplain pastures which are not susceptible to improvement using normal rest and rotation systems. Changes in river levels and flooding patterns replace erratic rainfall as a major environmental challenge to livestock owners. **In upland areas which are not flooded, water development rather than forage management will produce the most dramatic changes in livestock numbers and output. On the floodplains, forage management is a dry-season activity based on rotational pasture use and controlled burning.**

Grazing rotation

All communities studied here practice some form of rotational pasture use by season. Indigenous systems of seasonally deferred pasture use were described in the Kunene case study area, long-distance transhumance in Oshikoto Region, the seasonal oscillation of animals between cropped and un-cropped areas in Kavango and between uplands and floodplains in Caprivi. In all these systems there exist heavily used sacrifice zones around water points and settlements. Year-long or multi-year resting of these sacrifice zones occurs, but on an unplanned basis when water points fail, when there is insufficient rainfall in a area to support livestock, when there are decade-long shifts in regional hydrology, or an area is burned or (in the past) insecure. In our case studies we discovered no enthusiasm by NCA livestock owners for the planned, long-term resting and rehabilitation of these areas through periodic voluntary destocking.

Herders recognise that sacrifice zones are excessively used from the point of view of forage production, which is insufficient in the immediate vicinity. Instead of rehabilitating these areas they have devised strategies for obtaining low-cost animal feed in other ways or from other places, and the sacrifice zones remain heavily used because they provide valuable benefits aside from forage, typically field sites and stock water.

This means that introducing exotic grazing schemes will not be as easy as planners and outside consultants often assume. Themselves ignorant of the rationale behind village-level management practices, outsiders frequently assume that improved management schemes are simply filling a 'management void'. All that is needed is to educate the locals, free them from the shackles of custom and get local communities properly organised. In reality, improved management schemes are competing against established husbandry and resource use systems and must out-perform these systems by providing more benefits or lower costs.

The benefits of formal rotational systems are often so subtle that they cannot be statistically demonstrated by long-term, controlled experimentation. Why, producers may reasonably ask, are they being asked to abandon grazing systems that work for them in favour of unproved theoretical benefits, when the returns to better veterinary coverage or water development are immediately obvious? That these changes are needed 'for conservation' or 'for the good of future generations' are not compelling responses; it has been demonstrated that resource conservation in rural Africa must pay real and immediate dividends if farmers of modest means are to adopt programmes requiring more cash or labour.

We conclude that NOLIDEP would be wise to abandon any lingering nostalgia for commercial systems of grazing rest and rotation, and instead build on existing indigenous systems of resource use. This would involve meeting the perceived needs of rural producers, e.g. with work on fire-break construction on the Zambezi floodplains in Caprivi, by deepening pans in Kavango inland communities, through research on improved forages for small grazing exclosures in NCD, or through water development and support for community institutions in Kunene. None of these innovations will make the communal areas look like commercial farms. So what?

Stocking rates

It is widely stated that the NCAs are overstocked. The logical confusion that sustains many of these assessments is discussed in Annex 3. Available evidence on conditions in the NCAs is also equivocal:

- Sacrifice zones are visual eyesores, but provide only anecdotal evidence of widespread overstocking. How extensive are the sacrifice zones? Are they spreading? Is their impact localised or does it ramify throughout the regional ecosystem? And what is being sacrificed; aesthetic values, the conservation ethic of European urbanites, or hard cash and material benefits in the pockets of local residents?

- Periodic livestock die-offs in droughts are evidence of temporary livestock feed supply-demand imbalances. But wild herbivores in semi-arid areas experience these population fluctuations, which are unlikely to permanently damage vegetation and provide long-term limits to herbivore population growth.

- Stock densities are high in the central Cuvelai, but herd owners are already adapting to these problems by intensifying both their arable and pastoral production systems and by shifting to private forms of rangeland tenure. Evolutionary changes of this kind are documented both world-wide and in semi-arid Africa, and have produced conservation benefits in the long run (Boserup 1965;; Pingali et al. 1987; Tiffen et al. 1994; McIntire et al. 1989). It may be more practical for NOLIDEP to support the intensification of these farming systems than to struggle in vain to suppress livestock numbers.

- Only in Caprivi have stock numbers expanded quickly in the last decade, and the causes and consequences of this expansion are unclear. Caprivi wildlife has undoubtedly suffered, but it is much less certain that domestic stock numbers have grown to the point that aggregate livestock output is in decline or threatened by environmental collapse. Preservation of wildlife may be best promoted through programmes that permit rural residents to profit from its preservation and exploitation, rather than by direct attempts to limit herd growth. This is current MET policy through its wildlife conservancy programme.

- Much the same can be said about Kavango timber resources and pastoral expansion into the interior of the region. At present, rural residents profit from further herd growth but may loose subsistence forest products. They loose little from the destruction of marketable timber reserves, which are controlled and profitably exploited by a combination of civil servants and commercial firms. If Kavango farmers could profit from timber sales, they would be more inclined to weigh the benefits of forest preservation against the costs of further herd growth.

- Stocking rate and carrying capacity estimates based on Namibian commercial ranches are misleading and irrelevant to the production objectives of most NCA livestock owners.

We conclude that draconian stocking controls are insufficiently justified on scientific grounds to be recommended for the NCAs. It is further evident that the Namibian Government, like most independent African governments, lacks the will and means to implement such controls, should they be recommended. Finally, there are more practical means of addressing the issue of long-term herd growth. These include:

- **NOLIDEP supported research into improved cultivated forage production;**
- **Policy changes that will allow rural people to internalise the benefits from forest or wildlife resources threatened by herd expansion;**
- **The removal of government fodder and water subsidies that encourage cost-free expansion of herd numbers (see below);**
- **Improved marketing opportunities that encourage offtake through both the formal and informal sectors[1];**
- **Secure tenure rights for rural residents which would empower communities to enforce stocking rate decisions that are locally meaningful (see below).**

Land tenure

Responsible community-based natural resource management requires security of tenure. Without secure rights rural residents have diminished incentives to exploit resources on a sustainable basis and no means to limit exploitation by excluding outside users. But there is little security of tenure in rural areas over resources critical to livestock production.

In all but one of the communities studied by NOLIDEP, privatisation of pastoral resources by individuals is occurring as people invest cash incomes back into the pastoral sector and larger herd operators move towards commercial production. The problem is most acute in eastern Oshikoto and Ohangwena Regions where there exists a well-capitalised enclosure movement involving national politicians, civil servants, urban-based wage earners and businessmen, and the customary authorities.

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[1] NOLIDEP efforts to improve formal marketing include support for the construction and rehabilitation of crush and auction pens, labour-based rehabilitation of rural roads, and efforts to inform producers about Meatco's grading procedures. A year-long NOLIDEP-funded study on informal marketing has been initiated, but results are not yet available.

The new Communal Land Act currently under discussion may address these problems, but the legislators who will consider the Act are among those individuals who profit privately from large-scale fenced holdings in the communal areas. The danger exists that these legislators will pass a law that is consistent with their personal interests but inconsistent with the equitable distribution and use of communal resources. Such a law would undermine the basis for communal rangeland management even in areas where private enclosure is not now a problem.

At all study sites there exist territorial boundaries between and often within communities, and either individuals or local authorities attempt to control access to critical resources. The nature and degree of control varies widely by community and according to the kind of resource. Community members can readily identify territorial boundaries, but these boundaries are not comparable to the boarder fences of commercial ranches. They instead reflect the closeness of social relations between individuals and the historical connections between communities, mapping social space and social distance rather than the hard and fast territorial divisions of a cadastral survey. As a consequence, almost all these boundaries are permeable upon occasion, access by outsiders is subject to negotiation, and the degree of exclusion is variable.

In almost all instances, critical water resources are more closely managed and tightly controlled than surrounding grazing areas, which are difficult to police and of relatively low value per hectare. The investment of labour or cash in developing a resource such as a field site or a water point generally enhances the rights of those who have invested in it. Free goods - either natural, unimproved resources or facilities donated by outside agencies or government - are the most difficult for local communities to maintain control over. In sum, communities or individuals tend to control critical or key resources, water points in particular, rather than extensive grazing areas. NOLIDEP's cost sharing approach to water development - discussed below - is designed to reinforce these controls.

Water development

The supply of improved stock watering facilities decisively alters livestock production possibilities in most NCA communities. No other technical input has such dramatic impact, and none is so popular. Indeed, it may be too popular; many observers worry that water development will promote unsustainable increases in livestock numbers.

In the NCAs sufficient data is generally unavailable to conclusively address this question. With international funding at its disposal, NOLIDEP could conceivably collect information about the environmental impact of some facilities in a small number of pilot communities. This would have suited the immediate needs of the project and its donors, but an intensive data gathering and planning exercise is beyond the present capacity of MAWRD and does not provide a realistic model for future GRN water development policy in the NCAs as a whole.

NOLIDEP adopted a different approach based on its mandate to undertake participatory development: it asked rural communities to set their own priorities. This is not an approach that would appear to have much chance of success. This is because many rural dwellers view water development as something of a lottery. You make as many demands as possible, as frequently and loudly as possible, and wait to see if anything happens. Usually nothing happens, but occasionally - and often for no apparent reason - the government authorities give you an extremely valuable installation for free.

Sensible, community-based water development is impossible if local participation amounts to little more than a gamble backed up by begging, demanding and cajoling. To break this cycle, NOLIDEP has required participating communities to share in the costs of water point construction and reduce their demands to levels that they can help pay for, in exchange for assured delivery of promised inputs by the project.

It is too early to judge the results of this programme. The construction of new water points on a cost-sharing basis began in North Central Division, Caprivi and Kavango Regions in the second year of the project, and new installations were not operational when the field studies summarised here were conducted.[2] It is, however, possible to comment upon the feasibility and probable pitfalls of a cost-sharing policy:

- Community cash contributions should be collected prior to construction. NOLIDEP's water development programme was delayed in 1997 because of policy debates over the principle of cost sharing. Because of these delays, tendering for water projects often preceded the full collection of the community portion of construction costs. Field staff now anticipate some problems in collecting this money, since the project has no way to sanction non-payment except to refuse to undertake further work in uncooperative communities.

- Problems of getting communities to comply with their contractual obligations are most acute when NOLIDEP develops water points adjacent to areas that are receiving new water installations free of charge from government or other projects. If NOLIDEP procedures are workable and beneficial, it is essential that they be adopted as a consistent government policy as soon as possible in order to minimise these conflicts.

- The same applies to NOLIDEP's community-based approach to the siting of new facilities. The project's restrained approach to water development is largely theoretical as long as other agencies are free to construct additional installations with little or no community consultation. Because of their desperate desire to see any form of water development, it is possible to extract agreement for new facilities of almost any kind from almost any community. The best way to insure that communities are genuinely and carefully consulted is to require outside agencies to receive substantial material support from communities before work is begun.

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[2] Work began in Kunene in the first year of project operation, but the partially completed dam in the Kunene study community of Etanga did not fill because of low rainfall. A pan excavated during the 1997 dry season by the Kavango pilot community of Fumbe was also empty at the time of the field study, early in the rains in 1997. Work on cost-shared facilities was in progress at the time of the NCD field study, and at the planning stage when research was carried out in Caprivi. The impact of these installations on livestock movements and numbers is therefore unknown, and will likely become clear only after a number of years.

- Restricted access is the basis of community control over and management of local resources. Community cash and labour contributions to water point development are likely to be cited by contributing communities as a justification for restricting access by outsiders. How this will change existing pattern of resource use is unclear at this point. In some communities - such as the Etanga DA in Kunene - negotiated access by outsiders to locally constructed and financed water points is already the norm, and NOLIDEP activities constitute no challenge to prevailing practice. Around the Kavango pilot community of Fumbe, on the other hand, pans used for watering stock in the wet season are open to surrounding settlements. Some of Fumbe's neighbours contributed to the labour-based excavation of a pan with NOLIDEP assistance near Fumbe, while others did not, and it is unclear if non-contributors will continue to have free access to this site. In Oshikoto, boreholes constructed by government and never fully controlled by communities have been enclosed and privatised. Finally, in Caprivi NOLIDEP has constructed dams both free-of-change and on a cost sharing basis. The different patterns of use and control that may emerge around these two kinds of installations should be a focus of continued NOLIDEP study.

- The greatest challenge to NOLIDEP's cost-sharing policy comes from Kavango where water development in the interior is important for Regional development, but communities are small, poor in animals, and disinclined to sell those that they have. Also, in Kavango - unlike the rest of the project area - communities form **after** a water point has been constructed and, hence, are difficult initially to define and negotiate with or receive contributions from. Furthermore, the larger herd owners who could co-finance construction are disinclined to do so unless they receive exclusive private control of the installation, which is incompatible with NOLIDEP's mandate.

Outstanding issues

The field studies summarised here were carried out in the second year of project operation before the construction of most community-NOLIDEP co-financed water development. Our evaluation of this critical component of project activity is therefore preliminary. Below we note some outstanding issues and information gaps that NOLIDEP should in future attempt to close.

- The Kunene study site was extraordinary demanding - in terms of it large territorial size, high human and livestock numbers, the complexity of husbandry practices, and time required for study. As a consequence, field research was carried out in only one Kunene Himba pilot community. There is an urgent need to carry out further work in Kunene in one of the two NOLIDEP pilot development areas occupied predominately by Hereros.

- In NCD the study programme uncovered but could not focus on a peasant-based enclosure movement taking place in communities experiencing high land pressure. These tenure innovations and associated changes in husbandry practices have important practical implications for the design of NOLIDEP's adaptive research programme on cultivated forage, and deserve closer scrutiny.

- In Kavango, NOLIDEP and DART are carrying out important research on controlling parasite infestation in large and small stock. When available, the results of this work bear close scrutiny and possible extension by NOLIDEP or through other programmes in Kavango to communities in which NOLIDEP does not now operate. Monitoring the adoption or rejection by farmers of any 'package' of parasite control measures should be a high priority.

- In Caprivi, work is being initiated by NOLIDEP on the controlled burning of floodplain pastures through the construction of firebreaks by communities. The results of this programme should be documented.

- Across all regions, NOLIDEP has constructed or rehabilitated water points on a cost sharing basis with local communities. The management and use of these facilities must now be monitored. The situation is particularly interesting in Caprivi where the project has constructed or improved water points both free of charge (in year 1) and with community contributions (in year two). Comparison of the management of these two kinds of water points should provide valuable insights on the impact of cost sharing on patterns of resource use and control, and provide guidance for the DWA as it begins to implement the government's cost-sharing policy.

- Careful consideration should be given to concentrating NOLIDEP's adaptive forage research programme in NCD, where farmers are interested and prepared to grow cultivated forages. Interest in agricultural intensification is low to non-existent in other parts of the project area.

ANNEX 1

FOUR OUTSTANDING POLICY ISSUES

Improving range management in the NCAs is a speculative undertaking. According to the Ministry of Agriculture's senior range management professional, 'No rangeland management trials were conducted in the communal areas of Namibia' (Bester nd: 8). In other words, there exists no experimental evidence specific to the production systems and natural environments of northern Namibia upon which NOLIDEP can base its range management programme. Work must instead be guided by descriptions of conditions in the NCAs, first principles, and experience in neighbouring countries and similar environments. This is a dangerous procedure. An eminent range ecologist recently summarised the state of rangeland science in the following terms:

> There have been some exciting development in the rangelands over the past decade, with more to come in the near future....A review of why past paradigms have failed points to a major underlying problem: ideas from one rangeland (or non-rangeland) environment have repeatedly been imposed across others, without due regard for the differences among systems (Stafford Smith 1995: 19).

Despite scientific caution, NOLIDEP's international managers are definite about what the project should do. The lead recommendation made by the last IFAD/UNOPS project supervision mission (on 30/07/97) demanded that:

> All regions should have finalised biological and socio.-economic surveys and subsequent recommendations for implementation of improved range management including the development of rotational grazing practices, stocking rates (*sic*) and provision of appropriate addition (*sic*) water development (UNOPS 1997: 19).

It would appear that the project's donor's have suppressed their enthusiasm for fences, but have lost little of their enthusiasm for the standard management practices - control of livestock movement and numbers - that are sustained by fencing on private ranches.[3]

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[3] IFAD/UNOPS are not alone in this assessment. Technical questions about how to develop Namibia's communal rangelands are widely discussed within Namibia, and some authorities favour the extension of commercial range management practices into communal areas. A draft handbook on livestock marketing prepared by the Meat Board of Namibia contains a brief section devoted to grazing principles. It states:

> It is very important that the producer should control his livestock numbers and only keep numbers of livestock suitable to be carried by the land. The producer should also control the grazing pattern of his livestock (Meat Board 1997: section 2.1).

The draft of a DART extension manual on Sanga cattle is more specific:

> To be able to rest veld. it is necessary to apply a rotational grazing strategy. It would be appropriate at this stage to mention that fencing is not a goal, but only a means to reach a

Two other issues - community cost-sharing on the construction of water points, and GRN communal land tenure policy - were extensively discussed among project staff, MAWRD authorities and IFAD representatives at the time of project reformulation.

This annex reviews the main implications for NOLIDEP's range management programme of scientific and policy debates on grazing systems, stocking rates and carrying capacities, pastoral land tenure, and water development policy. We will be asking whether the objectives of NOLIDEP are technically sound, consistent with the interests of local land users, susceptible to participatory implementation and supported by overall government policy. Annex 2 presents case study material on NOLIDEP's pilot communities in an attempt to resolve some of these issues.

Rotational grazing

The theoretical benefits of rotational grazing are supported by theories of plant growth; attempts to demonstrate the practical virtues of rotational systems have been less successful.

Rotational grazing systems were invented and have been extensively researched in the western United States. Despite the long history of American work on the topic, an authoritative range management textbook concluded:

> From the data at hand it cannot be categorically stated that a rotational-grazing system will invariably improve the range or give grater livestock production than moderate, continuous seasonal grazing. Existing evidence is contradictory (Stoddart et al, 1975: 297).

Closer to Namibia, a comprehensive review of experimental data from southern Africa demonstrated that the effects of rotation varied by soil type and plant community, according to rainfall levels in different years, and according to the criteria used to measure success - e.g., livestock output versus changes in plant composition or cover. The reviewer concluded:

> It is also notable that grazing system trials have shown no significant effect on composition over a wide range of savanna types...even though many of these studies compared continuous grazing and some form of rotational grazing.

> goal. That is, to graze and rest he range correctly. With a bit of organisation, and co-operation with-in communities this is also possible without fences (Els et al 1997: 35).
>
> It is recommendable that a portion of the range be rested regularly for the full growing season, so that the root system and root reserves can be restored, seeds be produced and new plants establish Continues [continuous] over-grazing, especially during the active growing season, results in a gradual exhaustion of the root reserves, plants become smaller and eventually die of starvation (Els et al. 1997: 34).

SARDEP, long a source of unconventional thinking on rangeland issues, has recently de-emphasised technical issues in favour of work on national policy and the strengthening of community-based organisations and support services for communal farmers.

> Furthermore, there is no evidence that controlled selective grazing has any influence on botanical trends (O'Connor 1985: 42).

Rotational grazing schemes implemented in the communal areas of South Africa have, on occasion, yielded perverse results: resting an area can encourage both bush encroachment and the overgrazing of preferred grass species when undesirable species escape gazing, mature and become unpalatable (Forbes and Trollope 1991).

Finally, between 1975 and 1990 the Botswana Ministry of Agriculture carried out a series of long-term grazing trials comparing continuous grazing, 3-paddock, and several multi-camp systems. The results were inconclusive, as chronicled below:

> 1978: 'After 3 years of operation there is still very little difference between treatments' (APRU 1978: 46).
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> 1979: 'Unless the difference between short rotation and the continuous grazing increases over time it is difficult to see how the cost of the extra fencing involved in the former system can be justified' (APRU 1979: 42).
>
> 1980: 'The effects of grazing systems on animal performance are not entirely clear since there are not as yet any consistent trends' (APRU 1980: 43).
>
> 1984: 'At Makhi continuous grazing has only once in four years been surpassed by rotational grazing in terms of animal performance, and at Morapedi only once in six years' (APRU 1984: 82, 83).
>
> 1986: '[A figure] summarises the monthly liveweights and shows no indication of superiority of any one grazing system over another. The 1985 data indicated that continuous grazing persistently remained above other systems.... [Another figure] shows mean liveweight gains for three two-year periods. In the first two periods the continuous grazing system was superior...however this superiority did not persist in the third period when grazing conditions were generally poor.' (APRU 1986: 108).
>
> 1990: 'Initial studies conducted in the 1975-79 period have shown relatively small differences between systems in animal performance, botanical composition and basal cover. Greater advantages are required from the multi-paddock systems to justify the fencing costs. A new trial was started in 1979....This project however did not bring about the expected outcome....' (APRU 1990: 18).

In sum, while they are theoretically plausible, the advantages of deferred, rotational and multi-paddock grazing systems have not been consistently demonstrated despite considerable efforts to do so. Often the advantages from these systems are so modest as to be difficult to discern statistically even in carefully controlled experiments. Given the probable costs of adoption and the major fluctuations in pasture and livestock output associated with variations in rainfall, Namibian small holders are unlikely to realise from these systems the

obvious benefits needed to promote their voluntary acceptance. Scientific ambivalence regarding the advantages of rotational grazing offers no encouragement for authoritarian measures to force these systems on rural communities.

Stocking rates

'Stocking rate is the most important management variable affecting productivity and stability in rangelands' (Ash et al. 1996: 216). Unfortunately, current opinion is divided on how to estimate and enforce appropriate stocking rates, especially on communal rangelands subject to erratic rainfall. Annex 3 of this report reviews the logical problems that beset the carrying capacity concept. Some conclusions important for NOLIDEP stocking rate policy in the NCAs are given below:

- *Ecological versus economic carrying capacities.* Current work suggests that the correct stocking rate for a grazing system cannot be set except in relation to the production strategy and the social and economic circumstances of the rangeland user - there is no single optimum density. Small-scale African producers do not share the production objectives of large scale commercial ranchers. Hence, carrying capacity estimates and estimation techniques appropriate in a ranching context are irrelevant to any meaningful assessment of the stocking rates of indigenous rangeland users (Annex 3).

- *Measurement error.* Errors in estimating carrying capacity can also be due to problems of measuring critical biological parameters. First, carrying capacity estimates are routinely based on assumptions about how much of total vegetative production is available for consumption by animals and can be safely consumed without causing rangeland deterioration in subsequent years. This 'proper use' factor - which routinely varies from abut 30% to 45% - is little more than an educated guess, since little is known abut the carryover effects of grazing between years. Secondly, rainfall-based carrying capacity estimates of biomass production rarely take into account landscape heterogeneity and variability in productivity. Thirdly, carrying capacity estimates assume fixed boundaries, but mobility of stock means that these assessments are artificial. Fourthly, estimation of the amount and kind of forage needed by an animal is not straightforward, especially when several herd species with different feeding habits use the same rangelands. Fifthly, compensatory regrowth of grazed and browsed plants, resulting in higher quality and, occasionally, in higher biomass production, is frequently ignored (Behnke and Scoones 1993).

- *Problems of implementation.* Destocking programmes are unpopular with livestock owners. Colonial African regimes were able to implement such programmes. With the possible exception of a USAID-funded range management project in Lesotho (described in Ivy and Turner 1996), I know of no successful attempt by an independent African government to destock communal rangelands or set and subsequently maintain administratively enforced limits on herd growth.

- *Carrying capacity in grazing systems not at equilibrium.* The applicability of the concept of carrying capacity has recently been challenged for areas in which the coefficient of variation of mean annual rainfall is 30% or higher (Ellis et al 1993; Ellis 1995). Under these conditions and in the absence of feed imports, drought-induced crashes in livestock populations may be frequent enough to keep animal numbers below rangeland carrying capacity and limit the impact that animals can have on plants. With the exception of parts of Caprivi Region, all of Namibia has coefficients of annual rainfall variation of 30% or more.

Within the scientific community, stocking rate and carrying capacity estimates are the focus of intense research interest. Estimation techniques are improving, but increased accuracy comes with considerable costs in terms of additional data collection. In the applied arena, approximate estimates of carrying capacity are useful for planning at a broad scale at the regional or national level (Sweet 1997). Beyond this level of precision, however, it is probably best for applied projects like NOLIDEP to leave this controversial, expensive, and specialised field of enquiry to the research community.

There is, however, a practical option for administrators, field workers or policy makers concerned about overgrazing but incapable of precisely determining or enforcing optimal rates. Instead of dictating stocking rates, they can eliminate government policies that distort local decision-making and help to strengthen institutions that will enforce stocking decisions that are locally taken. This is a genuinely participatory approach to the problem of controlling livestock numbers, one that assumes that African stock owners - like commercial ranchers - can make rational decisions about their stocking rates. Appropriate national policies on rangeland tenure and water development are critical components of any effort to encourage rural communities to voluntarily restrict herd growth. These issues are discussed below.

Rangeland tenure in communal areas

The Namibian government is preparing new land laws for the communal areas. Early drafts of this legislation - which is likely to be passed later this year - suggest that it will need fundamental revision in order to provide a conducive environment for community-based range management.

One of the main problems with early drafts of the Communal Land Act concerns the entities that will be able to apply under the new legislation to own land. Experience both in Africa and world-wide shows that rural communities cannot responsibly manage resources on a collective basis unless they have clear rights to these resources. Nonetheless, early drafts of the 'communal' land bill consistently refer to applicants for land ownership as 'persons' and provide no mechanism for formalising communal ownership through group tenure.

Rectifying this oversight should be possible. Legal recognition of community land rights within the Communal Land Bill could build on a large, diverse and still growing body of practical experience on this issue in Namibia. Group entitlements to wildlife resources are already recognised in legislation sponsored by the Ministry of Environment and Tourism (MET) on conservancies in communal areas (Government Notice No. 304 of 1996). Department of Water Affairs (DWA) support for Water Point Committees (National Wrap-up Workshop on Community Management of Water Supply) recognises group management of public water facilities. Both MET and DWA appreciate the need to work with community organisations that have a clear legal status. MET has achieved this objective through legislation; at an earlier stage in the development of its programmes, DWA states that 'the need for legal status [of Water Point Committees] was recognised and accepted,' and work on this issue continues.

Precedents also exist for defining the particular functions of local community organisations with respect to regional and national review bodies. For nature conservancies, this oversight role is performed by Regional Wildlife Councils. With respect to rural water supplies, the DWA has proposed a 'national organisational structure' that subordinates rural communities to Cabinet through a chain of intermediate governmental bodies. A similar hierarchy of authority will regulate the activities of individual co-operatives under the new Co-operatives Act. In none of these cases have local organisations been set free to act as they please; all are regulated and subject, ultimately, to decisions made at Regional and National levels.

Specific recommendations on these issues have been advanced under the heading of 'Community Land Trusts' in submissions on the draft Communal Land Bill by the NGO association NANGOF (in *The Outline of a National Land Policy*, December 1996) and by NAPCOD, the Namibian Programme to Combat Desertification (in *Achieving Land Reform with the Sustainable Use of Natural Resources: NAPCOD Position Paper on the Draft National Land Policy & Communal Land Bill*). Research conducted by the Social Science Division of the University of Namibia supports many of these proposals.

Case study material presented in Annex 2 describes the long-term difficulties for community-based range management programmes if these concerns are not addressed.

NOLIDEP Water development policy

The availability of stock water is one of the most important variables controlling animal movements and numbers in the NCAs. The terms under which new water points are constructed will influence rate at which supplies are expanded, the location of new facilities, and the way these facilities are managed after they are turned over to local communities.

Meaningful community involvement, NOLIDEP has argued, depends on communities making a substantial contribution to the costs of water development. NOLIDEP guidelines for community contributions to water point construction are described below. Later sections of this report will assess the effectiveness of NOLIDEP's cost-sharing approach to water development.[4]

For purposes of calculating community contributions for water development, NOLIDEP distinguishes between three different kinds of construction projects:

- labour-intensive works,
- works carried out by a contractor, and
- works that are experimental or for purposes of demonstration.

Different levels and kinds of community contributions are appropriate to each of these three cases.

Labour-intensive works: Whenever possible, NOLIDEP employs labour-based construction techniques. On projects of this kind, NOLIDEP will obtain and transport to the construction site all materials that are not locally available or must be purchased. In return, the local community will provide labour, locally available building materials, and basic food supplies for the workers. NOLIDEP may also provide limited food supplies, but the project does not routinely pay food or cash for labour when people work on their own projects.

Work carried out by contractors: When labour-based techniques are inappropriate, NOLIDEP will hire contractors to carry out construction and will finance 90% of the contractor's fees. The community will pay in cash the remaining 10% of the contractor's costs, and provide incidental unskilled labour as required. These arrangements will be formalised in a written agreement between the project and appropriate representatives of the participating community, and failure to comply with the terms of this agreement will jeopardise future NOLIDEP support to the community.

Experimental works: NOLIDEP will occasionally test new technologies, apply tested techniques in new settings, or demonstrate the value of a technology. The cash costs of these experimental or demonstration works will be covered by the project. Participating communities will be expected to contribute incidental unskilled labour.

For all water development projects undertaken by the project, NOLIDEP will provide appropriate training, feasibility studies, technical advice and extension support prior to, during and after construction. The costs to NOLIDEP of these support services will not be included in the total project cost figures used to calculate community contributions.

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[4]These guidelines were developed after consultation with the Directorate Rural Water Supply, after examination of Rural Water Supply Strategy Papers 1-8, and following an exchange of information between NOLIDEP Regional Co-ordinators and advisors. Ultimately, the guidelines were approved by IFAD/UNOPS and the Minister for Agriculture, Water and Rural Development.

These guidelines are designed to assist the project to achieve a number of its long-term goals with respect to water development. The levels of community contribution required by NOLIDEP are significant enough to:

- leave no doubt that its is the community that 'owns' and is responsible for maintaining installations constructed in co-operation with the project
- eliminate inappropriate project activities that communities would tolerate if they were provided free of charge, but would never consent to pay for
- reduce unrealistically high demands upon government by asking communities to bear some of the costs of development, and scale down their expectations accordingly
- maintain pressure on NOLIDEP staff to promote low-cost technologies that communities can afford - initially on a subsidised basis and later on fully commercial terms
- promote livestock sales and the commercialisation of livestock management.

ANNEX 2

FIELD STUDIES

This Annex summarises, region by region, the results of field studies conducted by NOLIDEP in project pilot communities. The original field study reports concentrate on issues that are important for particular local communities, and should be directly consulted for information on these points . The emphasis in this overview is on general lessons and recommendations for NOLIDEP's range management programme as a whole.

Each case study summary begins with a description of current grazing systems in the communities studied. We then discuss future development implications in light of the four issues examined in Annex 1- grazing rotation, stocking rate limitations, land tenure and water development policy.

Kunene Region

Material in this section is extracted from *Range and livestock management in the Etanga Development Area, Kunene Region: final report* (51 pages plus maps) by RH Behnke, K Koruhama and J Kaurimuje, February 1998.

The current grazing system

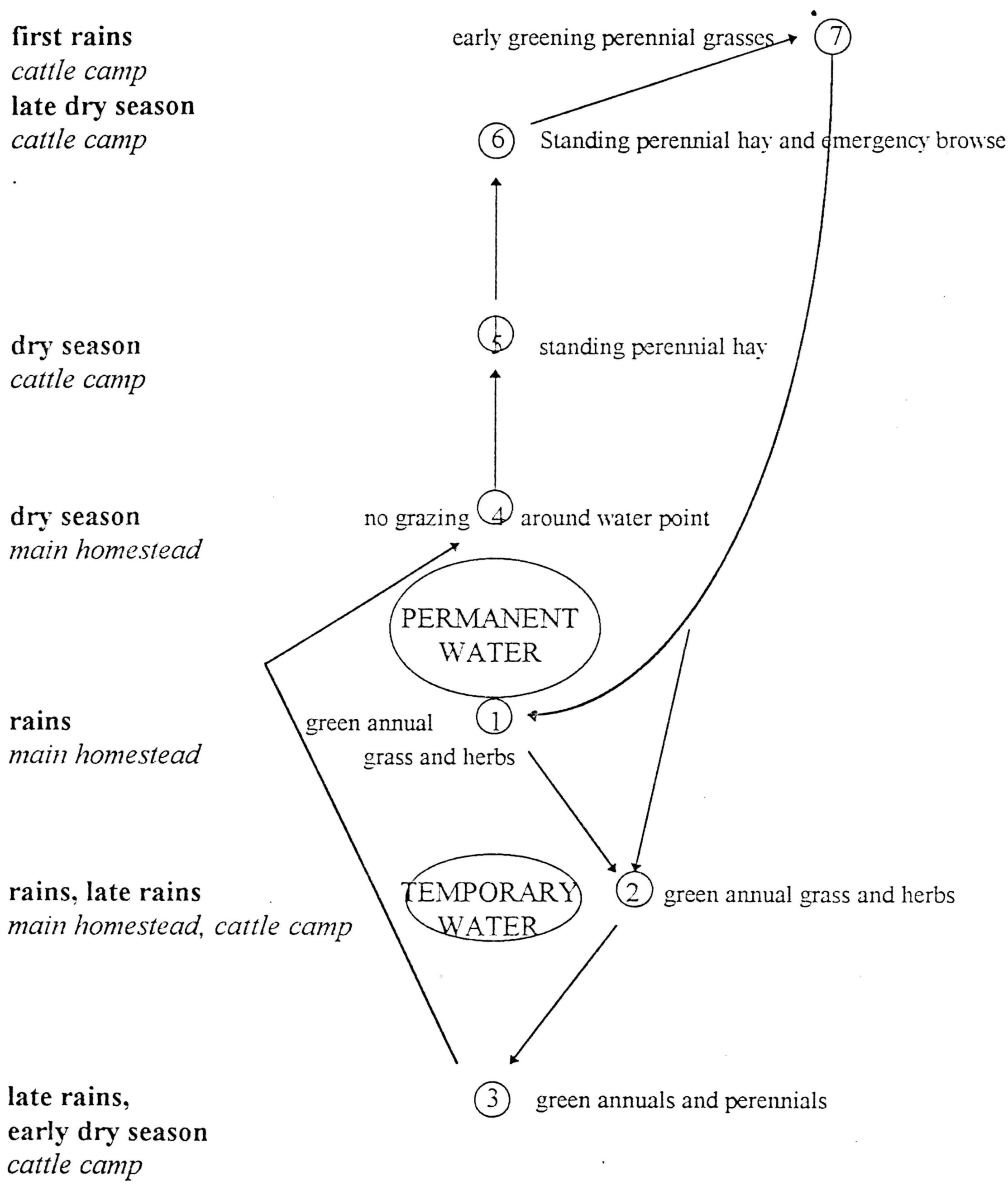
Figure 1 and Table 1 provide a schematic overview of grazing patterns in the Etanga area.

Table 1: Resource use in Etanga by season

Season in Otjiherero and local description	Approximate duration	Stock watering locations	Grazing locations
Okuroro: rainy season; good pasture and abundant milk - stage 1or 2 in Fig.1	Jan-March	ephemeral sources - pools, pans, standing water	around permanent settlements
Okupepera: transitional cold season between rains and the dry season; trees change colour and the grass dries out - stages 2 and 3 in Fig 1	April-June	temporary sources, generally man-made or improved - dams, small hand-dug wells in smaller rivers	vicinity of temporary water sources, starting near the water and working outwards
Okuni: hot dry season in which the trees have no leaves and there is little milk - stages 4 and 5 in Fig 1	July-Sept	permanent sources - boreholes, large hand-dug wells in major rivers, large springs	start near major water point and work outwards as season progresses
Orutene: transitional from the dry season to the rains; the mopane trees get new leaves - stages 6 and 7 in Fig 1	Oct-Dec	permanent dry season sources until significant rains; ephemeral standing water after the rains	as above until the rains break, then shift to grazing areas where early rains are strongest

Herders in Etanga tend to use the same category of resources every year in the same season. Okuroro and Okuni - the rains and the drought, respectively - are the main

Figure 1: Seasonal Cattle Herd Movements in the Etanga area, Kunene Region



seasons. Depending on conditions in a particular year, herders hope to keep their stock in the vicinity of their main village in Okuroro and early Okupepera, and anticipate using their cattle camps and associated grazing areas in the dry seasons of Okuni and Orutene.

The cycle begins in the wet season with most people and their stock in their 'home' settlements, where both water and pasture are readily available at this time. These settlements are located either near permanent (stage 1) or near large and reliable temporary water points (stage 2, Fig 1). This concentration of people and animals at the height of the rains is brief. As soon as the rains have recharged temporary water points, most herds move off to make use of these water sources. Reliance on temporary water sources gives the herds access to peripheral grazing areas (stage 3) which will become inaccessible later in the dry season, and it relieves grazing pressure around permanent water. As the dry season progresses, however, herds are forced to fall back on permanent water points when temporary sources run dry (stage 4). In this season there are no good pastures left around the heavily used permanent water points, and as the dry season progresses animals must walk increasing long distances between the permanent water points and peripheral pasture areas (stages 5 and 6). This pattern persists until the first strong rains of the new wet season, when the herds shift to far-flung pasture areas wherever the rain has been strong enough to promote early grass re-growth and provide ephemeral sources of water. Later in the wet season when rainfall has become more general and the grazing around permanent settlements has recovered, the herds will return to their 'home' areas, and the cycle begins again.

Grazing rotation

Water is unevenly distributed and so, therefore, is the intensity and timing of pasture use. There is resting of grazing resources in the Etanga system, but there is no systematic rotation of the resting and use periods through the seasonal calendar. A particular place (or kind of place) is rested or used for the same reasons at the same time each year. This pattern of exploitation exaggerates the natural heterogeneity in the natural vegetation as intrinsic differences between areas are reinforced by different histories of use. Some pastures are heavily grazed year after year while other pastures are lightly used or used only for short periods of time.

Like professional range managers, Etanga herders recognise pasture degradation and identify critical indicator species with this process. Unlike professional range managers, Etanga herders do not view circum-settlement sites and large water points as inevitably degraded. The plant communities of these areas have a high annual grass component, but within limits this poses few problems since these areas are used for grazing during the rains at the only time of the year when annual grasses are the preferred forage type. Later in the dry season when the annuals around these sites are depleted and would in any case have disappeared with the wind, livestock are using these areas only for water and walking out to more distant pastures dominated by perennials.

Mobility is the primary way livestock keepers in Etanga adjust stocking densities to annual fluctuations in rainfall and forage production. The process of adjusting forage supply and demand is not co-ordinated by any central authority. Each household makes its own decisions based on its assessment of the relative costs and benefits of different locations, and its ability to negotiate grazing rights with a desirable 'host' household or community. Like prices which are set by market forces, grazing pressure in a particular locality is the summation of numerous decisions made by individual actors in their perceived self interest. Contrary to the standard position of professional range managers, it is the absence of a central authority capable of controlling herd numbers and movement that permits stocking rate adjustments in this system.

In sum, livestock owners in the Etanga area practice an indigenous form of range management based on the seasonal use, resting and rotation of grazing areas, as far as possible adjusting stocking pressure to annual rainfall and forage production. Grazing patterns are finely tuned to local environmental conditions and it is difficult to foresee how NOLIDEP can improve technically on the current system of grazing management. Future technical recommendations would need to be based on a sophisticated knowledge of existing grazing resources, which are variable. Local herd owners possess this knowledge. NOLIDEP does not, and MAWRD - which is obliged to operate on a larger scale than NOLIDEP - has neither the personnel nor funding needed to collect detailed information of this kind on all NCA communities. In the Etanga area, local stock managers would closely scrutinise the technical viability of any project proposals to alter current patterns of resource use, and would ignore proposals that were ill-informed or inappropriate.

We conclude that neither NOLIDEP nor MAWRD are in a position to dictate major changes to the existing seasonal rotation system. Nor is it clear at this point that such changes are needed or would be beneficial.

Stocking rates

Etanga households are large, averaging about 12 people. But household herd and flock sizes are also large: a flock of 300 goats and sheep and a cattle herd of 100 head is not unusual. In good years, Etanga stock owners produce a significant number of animals suitable for slaughter. It would appear that the majority of these animals are consumed locally either within the households that own them or - in the case of cattle - slaughtered at ceremonies in which the meat is distributed to visitors, guests, neighbours and kin.

Kunene livestock owners were by administrative edict cut off from outside markets for decades (Bollig nd). Despite this history of isolation, Etanga now markets a significant (but unknown) number of both small and large stock and owners have responded enthusiastically to Meatco auctions held at the new auction facility constructed by the local community with support from NOLIDEP. **But Etanga herd owners sell animals in order to obtain cash, not as a means of limiting their herd sizes.** Household cash consumption needs are minimal, and some of the money from stock sales is reinvested back into improved herd production and growth. Veterinary drugs are occasionally purchased from traders and would be used more frequently if they were readily available. Herders are also prepared to sell animals in order to finance water development, in the past directly paying commercial contractors and today paying a portion of construction costs through NOLIDEP.

Destocking through stock sales at the onset of drought was not previously an option in Etanga because adequate marketing facilities did not exist. Whether the new auction pen in the community will encourage pre-drought destocking is not clear since this study took place in a reasonably good rainfall year. In any case, migration is the routine mechanism from adjusting livestock feed demand to localised shortfalls in feed supply, as discussed above. Given the highly erratic rainfall in Etanga, livestock numbers are probably controlled over the long term by population 'crashes' in drought years.

Land tenure

At all levels - the household, village/neighbourhood group and within the jurisdiction as a whole - Etanga is an integrated and cohesive community. Etanga residents consider themselves to be the owners of their natural resources and control access to resources according to customary practice, which is as yet unquestioned. Patterns of control are subtle because everyone knows and is related to everyone else. Positions of authority exist but are subject to public scrutiny and challenge. Thus, restricted ownership and access to critical resources is recognised, but shared resource use is common and there are no barriers to movement or access that are not subject to negotiation.

Water development

Stock managers want NOLIDEP to enlarge and/or construct new seasonal water points - primarily dams. These improved watering facilities would prolong the period of time livestock can remain in wet season grazing areas before falling back upon heavily-used permanent sources of dry-season water. The short-term impact of this kind of water development on herd output would be positive. Extending the geographical spread of seasonal water points would also improve the ability of herders to avoid areas of low rainfall.

In the absence of detailed ecological studies, it would be safest to locate new water points in remote areas, and limit the size of these installations by requiring communities to contribute to the cost of their construction. This is NOLIDEP's current policy in Kunene Region. The strongest challenge to this policy probably comes not from the Etanga community but from government policy. Especially in drought years when large amounts of money are allocated and must be spent for political reasons, there is a temptation for Rural Water Supply to quickly build large-capacity water points without community contributions, in easily accessible areas where the returns on investment are likely to be better, the demands on staff time are reduced, where money can be spent more quickly and a short-term programme has more to show for its efforts. Environmental problems would emerge long afterwards. Such environmental problems are primarily the result of poor and irresponsible central planning, rather than any inherent inability of rural communities to manage resources effectively.

This is not to say that the Etanga community is a trouble-free partner in water development. For local residents (especially for older men who have had little contact with NOLIDEP), playing the 'water development game' is rather like buying a national lottery ticket. In both instances, the initial investment is small - very little money is required for the lottery ticket, and all that is required to participate in the water development game is a bit of time and energy spent importuning outside technicians or government representatives. Nothing comes of most of these encounters. Most lottery tickets are torn up, and whatever they may be forced into promising, most government representatives do not deliver. But if the possibilities of a favourable payout are infinitesimally small, the payout - should it ever arrive - is huge. Persistent and unrealistic demands for water development make sense in these terms - small initial investment, small probability of success, but large unpredictable rewards on rare occasions. Why not have a go?

NOLIDEP's water development policies in Etanga have attempted to counter these expectations, by asking communities to prioritise their water needs, contribute to the costs of water development, and accept formal contractual obligations in return for the reliable provision of promised inputs. Sensible and environmentally sustainable water development requires this kind of community involvement. If local communities and technicians are to make this system work, politicians must also relinquish some of their power to dispense largesse in response to personal appeals.

Water is the single most important variable influencing rangeland use in Etanga, a fact that local herders clearly understand. Etanga residents already possess an impressive understanding of their local environment. Putting this knowledge at the service of a restrained water development policy will require both new local institutions and a national policy environment that is conducive to their operation. As things now stand, this is possible. But it is not assured.

Kavango Region

Material in this section is drawn from *Kavango Grazing Systems Study: Final Report* by RH Behnke (February 1998, 42 pages). Field work was conducted in a series of contiguous riverine villages about 100 kilometres east of Rundu and in Fumbe, an inland NOLIDEP pilot community situated on an omuramba about 15 kilometres south of the Agricultural College at Mashare.

The current grazing system

Many Kavango households pursue a diversified livelihood strategy based on formal and informal employment, remittances, pensions, crop farming, gathering, hunting, fishing and livestock production. This diversity of interests is reflected in current grazing patterns which are relatively simple and constrained by many considerations in addition to optimising livestock production and range management.

In particular, seasonal stock movements are influenced by the availability of water, the location of cropped areas, and the cost of labour. These considerations set up a simple seasonal oscillation: stock graze the periphery of settled areas under the supervision of a herder in the wet season when crops are growing, and are left free to roam around harvested fields, in the vicinity of settlements, or further afield in the dry season after the harvest is collected.

Table 2 provides an overview of the seasonal rhythm of crop and livestock husbandry practices. The agricultural year in Kavango communities oscillates between two extremes - the rainy and the dry season. During the rains (Nov to April), crops are in the fields and cattle are both herded and milked. At this time the floodplains adjacent to the Kavango River are inundated and riverine stock are pushed inland for grazing. Animals from Fumbe also tend to graze inland from the village at this time to avoid competing for grazing with riverine stock, staying away from fields situated on the heavier soils in the omuramba and around the settlement.

Table 2: Seasonal calendar of Kavango agriculture - riverine villages

Season	Approximate duration	Farming activities	Primary stock feed resource	Management practices
kwenye (dry)	Aug-Oct	land clearing	floodplain vegetation	no herding
kurombo (wet)	Nov-Feb	plowing and planting	upland vegetation	herding, milking cattle
lipemba (wet)	late Feb-April	weeding	upland vegetaton	herding, milking cattle
kufu (dry)	May-July	harvesting and threshing	harvest residues	no herding

During the dry seasons (May to Oct), cattle are not closely herded for there are no crops to damage, nor - because of the declining quality of feed - are cattle commonly milked. In these seasons stock accumulate along the river to graze on exposed floodplain vegetation and on both natural vegetation and crop residues on the terrace above the river. In Fumbe, herds are free to return to the omuramba and graze the residues in the harvested fields, though some animals may stray as far as the river.

Grazing rotation

A rudimentary system of pasture rest and rotation already exists around Kavango villages: stock move away from settlements towards areas with sandy soil in the cropping season, and back towards the settlements and cultivated areas on heavier soils after the harvest. But the factors that sustain the existing pattern of stock movement could also discourage the adoption of the more elaborate systems of grazing rest and rotation found on commercial ranches. These factors include:

- Herding labour is the major recurrent expense (in cash or domestic labour) connected with livestock keeping. Losses due to the theft of free-ranging animals are not uncommon and can be catastrophic. That small herd owners accept these risks suggests that they would not be inclined voluntarily to herd year-round to achieve the marginal increases in output that could result from improved systems of grazing management requiring continuous herding.

- Burning is one of the major factors controlling the availability of grazing during the dry season. Nonetheless, livestock-related reasons are not cited by informants as the probable motives for setting intentional fires. Villagers know that burning is frowned upon, they continue to burn, and assess the costs and benefits of burning in terms of gathering versus hunting. It is doubtful if current burning practices would change in order to institute a novel grazing management system.

- The physical distribution of arable activity - rather than the location of favoured grazing areas - determines herd movement. Community opinion - represented in heavy fines for stock damage to crops - supports arable over pastoral interests. Moreover, most farmers do not see forage availability as a severe constraint. The current system of seasonal pasture rotation is therefore primarily driven by the need to separate crops and livestock during the growing season, rather than to obtain higher quality forage.

In sum, range management - which involves the more intensive exploitation of finite forage resources - probably has little to offer households with access to the abundant grazing in the Kavango interior. Maintaining the physical separation of wet season grazing areas from cultivated fields is a locally recognised need. Some inland communities discourage settlement and cultivation around designated pans which are reserved for use by stock during the cropping season. Because the heavier soils found around pans may also be suitable for cultivation,

these restrictions are often difficult to maintain as communities grow in size, land pressure builds, and all areas suitable for cropping are put to the plow. In Kavango NOLIDEP supports the distinction between arable and pasture in areas where there are uninhabited pans around settlements. This is done by endorsing local efforts to designate and enforce separate zones for cultivation and grazing, and by helping communities to deepen pans (see below).

Stocking rates
Attempts to control herd growth or enforce destocking are misguided in Kavango and would be opposed by local herd and flock owners.

In areas where forage is not abundant, herd owners have a low-cost alternative to both intensive forage production and destocking - they move their homestead to a less-populated area where natural forage is still abundant. Large herd owners - who would have the most to gain from intensive grazing management in their over-crowded home villages - lead the resettlement process. The long-term consequences of this process are an increase rather than decrease livestock numbers.

For the foreseeable future, resettlement will probably continue to be the most efficient way to deal with localised overstocking and feed scarcity: 95% of the Region's total population lives along the Kavango River terrace on about 5% of the Region's land area. While less dramatic, livestock population densities follow the same pattern (Tolmay 1996).

Attempts to encourage the selling of more or younger cattle are unlikely to appreciably increase offtake in the short term. Kavango herd owners sell cattle when they are old, sick, injured, dead or dying. Economic analysis suggests that this is a rational cattle marketing strategy for Kavango producers given the relative value of live-animal products versus sale for slaughter. High rates of sale - especially among small herd owners - diminish the capacity for crop production and should not be encouraged by MAWRD.

Goats are kept for meat production and sale, but they are less numerous than cattle and constitute a small proportion of total ruminant biomass. Few households own goats that do not already own cattle, and goat flocks rarely exceed 30 head. Goat fertility is high, but so is morbidity and mortality, especially in years of high rainfall. These natural factors, rather than any conscious culling programme, appear to severely restrict flock expansion.

Land tenure
In Kavango routine decisions about land tenure devolve upon small social units consisting of those who have an active interest in using the resources in question. For example, authority from senior tribal authorities is sometimes, but not invariably, sought by pioneer households creating new settlements in areas not previously farmed. Once permission is obtained, however, subsequent settlers are vetted by the first occupants or by the acknowledged leader of the community. While ultimate authority over land issues resides with the senior customary authorities, routine management decisions are decentralised, with senior authorities responding to initiatives taken at the local level.

- Fully-settled communities form after a water point has been created, not before. Present policies encourage the large herd owners who initiate settlement to recruit additional, poorer settlers in order to qualify for government assistance. While the evidence is circumstantial, cash contributions to water development would probably limit access by poorer herd owners to installations built on a cost-sharing basis. This is presently the case at privately owned boreholes where non-owners must pay for water.

- Kavango residents are accustomed to receive public services free of charge, and would be reluctant to participate in an isolated programme that challenged the principle of free entitlements.

Caprivi Region

The following summary is based on *Caprivi Livestock Systems Study: a sociological account of small-holder agro-pastoral production and marketing in two NOLIDEP pilot communities* by Patrick Sikana with assistance from Otto Kamwi (1997, 44 pages excluding annexes and maps).

This study covered two NOLIDEP pilot communities: Chinchimani and Kabbe. Chinchimani is located in Sibinda Constituency and falls within the Mafwe chiefdom. It lies within the Linyanti drainage (an extension of the Kwando River) in Mopane woodlands and Liambezi-Linyanti grassland (Mendelsohn and Roberts 1997). Kabbe is located in the Kabe Constituency under the Masubiya chiefdom. Kabbe lies within the Zambezi drainage in Zambezi woodlands, transitional and floodplain grasslands (Mendelsohn and Roberts 1997).

The current grazing system

Grazing patterns in Chinchimani are complicated by changes in rainfall and river flows that probably began around 1980 but, according to local residents, effected local husbandry practices in the early 1990s.

Pre-1993 grazing patterns in Chinchimani and surrounding villages are summarised schematically in Figure 2. During this period local residents practised a simple form of seasonal transhumance. The forest zone was used from around November, with the on-set of the rains when water collected in numerous pans and depressions, locally know as *bihubi*. The animals would remain in the forest zone up to the end of August the following year, when these pans were dry. In September, the animals were moved to the flood plain, where they were kept for the remaining two months of the dry season (September and October).

This annual cycle provided both sufficient water and grazing. The forest zone is extensive and contains nutritious forage species, and pans were evenly and widely distributed throughout the forest. This meant that the villages around Chinchimani all used their own pans for most of the year, and localised overgrazing and overcrowding occurred only at the end of the dry season when these dried up and stock were moved to the Linyanti floodplains. Even in this season grazing conditions were not particularly difficult because all sections of the Linyanti River/Mukuni Channel retained water in scattered depressions throughout the dry season. This meant that livestock could be evenly dispersed along the stream. Finally, since villages were all positioned on the sloping ground in the transitional zone between forest and floodplain, grazing and water were both available within reasonable walking distance from the villages, and the movement of stock did not necessarily involve the movement of people as well.

Figure 2: Chinchimani area grazing system before 1993

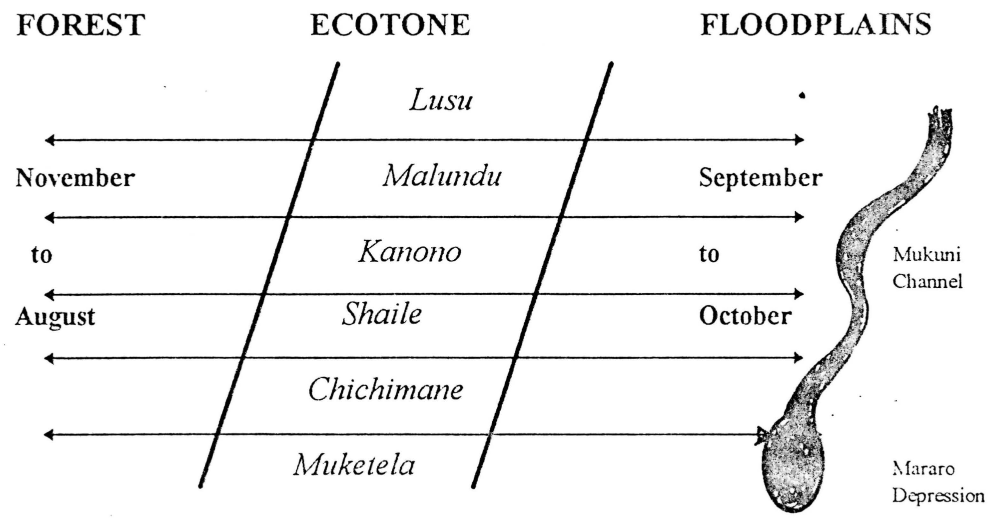


Figure 3: Chinchimani area grazing system after 1993

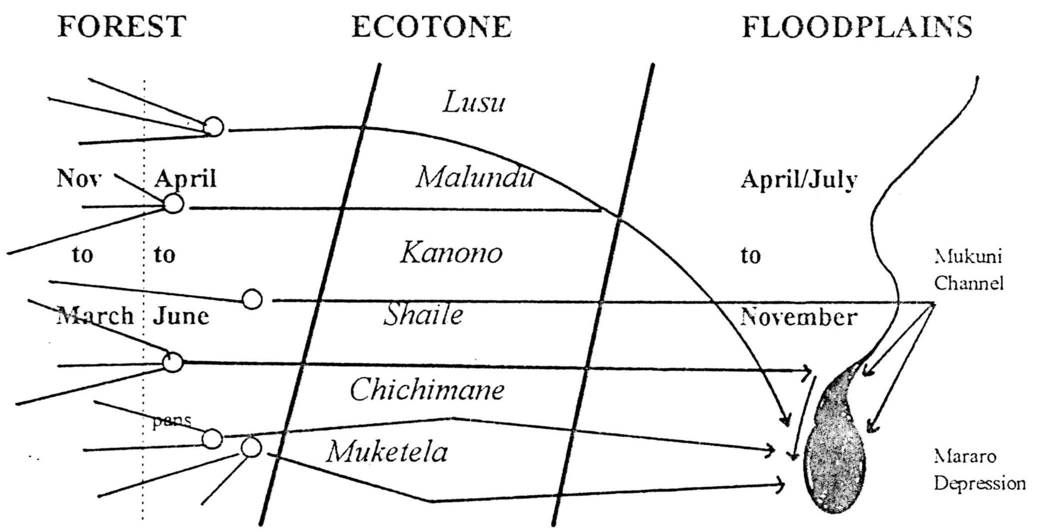
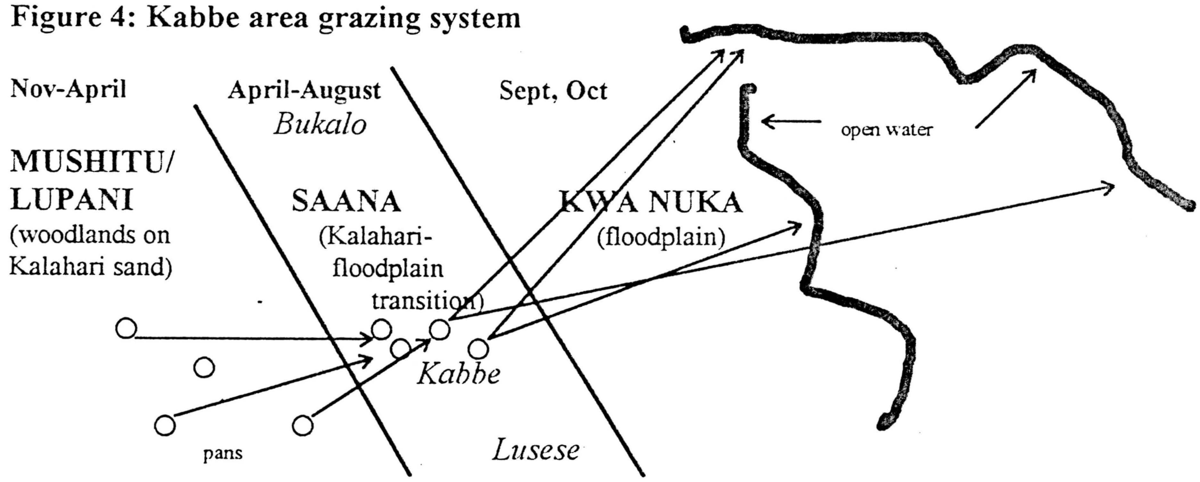


Figure 4: Kabbe area grazing system



After 1993 the availability of stock water was severely reduced in both the forest and floodplain zones, causing major changes in transhumance patterns in Chinchimani and the five surrounding villages. Due to reduced local rainfall, most of the smaller forest pans now retain water to the end of the rainy season in March, when herds are forced to congregate around a small number of larger forest pans. Depending on their size and the strength of the rains in a particular year, even these larger forest water points dry up in the early dry season from April to July, and herds are forced to relocate to the floodplains.

Conditions have also deteriorated in the floodplains. Apparently due to low river flows in the Linyanti River, only the southern two villages now have direct access to sections of the floodplains with assured permanent water supplies - Chinchimani from the southern Mukuni Channel and Muketela from the Mararo Depression (see Figure 3). The contraction of dry season water supplies has led, in turn, to the concentration of larger numbers of livestock for longer periods of time in a smaller area, with attendant problems of crowding, overgrazing and political struggles to secure access to scarce water. Some herd owners use village boreholes for their dry season water, and can operate year-round from their home village. However, many residents of the northern villages must now construct temporary dry-season cattle camps since their cattle can no longer regularly walk the distance between homestead and water point.

Kabbe stock also move seasonally from a forest-upland area, through a forest-floodplain transition zone, to riverine floodplain grazing. Four main pans (one deepened by NOLIDEP) support the stock during the rains from November to April in the forest zone. When these water sources are depleted in April, stock move to four other pans (one deepened by NOLIDEP) in the forest-floodplain transition zone around Kabbe itself. Here they stay until August when they disperse to finish the dry season at eight hamlets scattered on the Zambezi floodplain at locations favourable to arable farming (see Figure 4). Although the floodplain is large, the distribution of animals is linked to the availability of agricultural land, which is limited, and the number of herd-owners who can claim land in a particular place. Plains hamlets that attract many residents from several sub-villages within Kabbe may experience high grazing pressure at the end of the dry season, which is exacerbated by the poor quality of natural forage on the plains and uncontrolled veld fires.

Grazing rotation

Chinchimani and Kabbe stock owners practice various forms of seasonal grazing rotation - by living year-round in one place but moving their animals to different pasture areas (Chinchimani), moving between the main homestead and cattle post (Chinchimani), or shifting the entire household and herd between the main village on the plateau and dry-season floodplain hamlets (Kabbe).

Conventional forms of rest and rotation borrowed from commercial ranches may not be suitable in Caprivi. In Kabbe, the period of greatest nutritional stress occurs in the late dry season when stock are dependent on seasonally inundated pastures grazed during the floods by fish, which are difficult to fence out. In any case, problems do not arise because there are insufficient quantities of vegetation, but because it is rank and the burning that renders it edible is uncontrolled. NOLIDEP is currently investigating

- with local community support - the construction of fire breaks that would permit controlled burning. This programme was initiated after completion of the field study summarised here.

The immediate problems of Chinchimani may be more appropriately addressed by water development than by elaborate rotational systems. Decade-long shifts in regional hydrology have forced the concentration of stock in certain seasons in the Chinchimani area, and instituted an involuntary long-term resting programme for the pastures formerly used by villages north of Chinchimani, which now lack sufficient stock water. **It is inconceivable that any rotational grazing system instituted in Chinchimani could come close to having the impact achieved by more even distribution of watering points and grazing pressure. Local herders know this, and it is equally inconceivable that they would implement elaborate grazing schemes if NOLIDEP was unable to address the obvious water problem.**

Stocking rates

Caprivi is the only NCA region in which aggregate cattle numbers have expanded markedly in the last decade (Table 3).

Table 3: Long-term Trends in NCA Cattle Numbers, by Regions

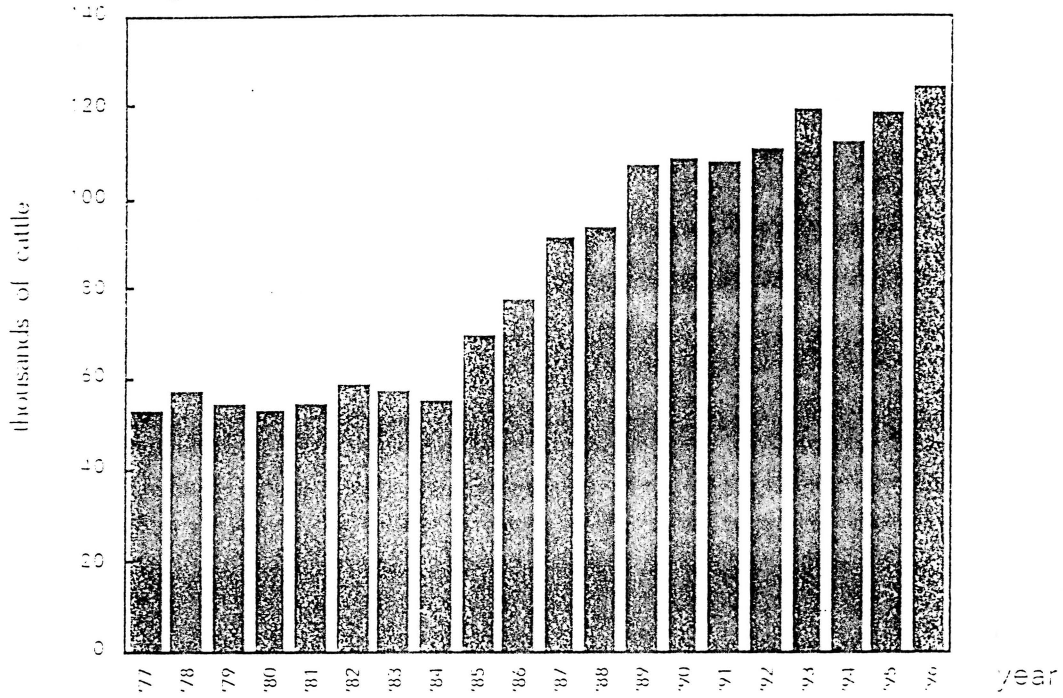
Year	Kaokoland	Ovambo	Okavango	Caprivi
1962	73,500	379,542	50,300	12,312
1969	161,312	567,283		
1972	96,920	481,410	73,231	
1973				
1978	128,895			
1981	60,296			
1982	15,000		105,634	39,254
1987			83,881	76,101
1988	72,835	282,000*	84,567	78,879
1989	80,137	350,000*	83,913	92,605
1990	85,000	350,000*	87,740	93,550
1991	88,494	350,000*	93,315	97,510
1992	94,025	485,520	89,848	91,489
1994	95,670	334,169	106,209	95,825
1995			99,029	
1996	153,837	476,658	80,339	123,191

Notes: Drought 1959/61; good rains 1963/69; drought 1970/72; good rains since 1973; drought 1979/82

Sources: cited in Rawlinson 1994: 115 and KPMG Peat Marwick Namibia 1993, Tables 3 and 4. Original sources - 1962 Odendaal Report; all other years DVS. *denotes estimated value.

As documented in Figure 5, Caprivi cattle herd expansion began in 1986 and has more than doubled in the last 11 years. Mendelsohn and Roberts (1997) attribute this increase to two probable causes: improved veterinary coverage and lower river levels which improved access to floodplain pastures (1997: 26); they conclude that 'much of eastern Caprivi is probably over-stocked with cattle (1997: 27). While it is impossible to assess the accuracy of their judgement, it is clear that official concern about overstocking has more apparent justification in Caprivi than in other parts of NOLIDEP's project area.

Figure 5: Caprivi cattle numbers 1977-96



Source: Mendelsohn and Roberts 1997: 26.

Sikana and Kamwi document considerable concern among Caprivi livestock owners about localised overstocking, e.g. around the Mararo Depression and the lower Mukuni Channel in the Chinchimani area. However, rural attitudes towards destocking are eloquently summarised by a quotation from a local headman at the beginning of Sikana and Kamwi's report:

> I have already heard that you are going around asking questions about cattle. We like people who ask questions about cattle because that is our livelihood. But I personally do not like some of your so called solutions. Recently I attended a meeting in Katima Mulilo to discuss the problems facing our livestock, and what did we get? We were constantly harangued that the best solution is for us to sell our animals. Now, it there any sanity in such a suggestion?

Antipathy to destocking is clear; less clear are the reasons why local herd owners take this position. Local marketing authorities hope to 'try and break traditional barriers' by encouraging cattle keepers to market their animals (Sikana and Kamwi 1997: 39). But the problem may be more intractable than simply changing 'conservative' attitudes.

Sikana and Kamwi argue that in Caprivi - as in Kavango - live cattle have a use value to rural people that exceeds their sale value at a young age. Animals are therefore sold at the end of their working/breeding career. As a result, local stock owners cannot profit from the meat grading system used by Meatco which favours young slaughter animals of the kind produced on commercial ranches. The informal marketing system - which does cater to the needs of Caprivi consumers - offers uniform prices for a kilogram of meat irrespective of the animal's age, and gives producers better prices for their animals. In informal markets the problem is not under- but over- supply:

> Although the informal market is relatively attractive in terms of price per unit animal, and is also congruent with the production goals and circumstances of traditional small-scale producers, it is not big enough to absorb all the marketable animals from the traditional sector. Potential traders have to queue before it is their turn to slaughter. According to key informants who regularly use these markets, it is not possible for an individual to slaughter more than one animal per month. Furthermore, sales are low during mid-month when most salaried employees have run out of cash. This makes the informal market ... quite risky and unsuitable for those who may wish to engage in large scale cattle marketing. We contend that this situation is likely to continue for a long time to come, because Caprivi does not only have a low concentration of salaried urban population but it is also quite isolated from other potential consumption centres in other regions (Sikana and Kamwi 1997: 41).

Finally, the extent to which increased market offtake will depress animal numbers is open to doubt. Investment patterns may be as important as sales patterns. Sikana and Kamwi write:

> Our investigations revealed that most of [the] capital originates from the formal employment sector, because many Caprivians routinely invest saving from wage employment into the traditional agro-pastoral sector. For example, most of the local school teachers at Kabbe, including female teachers, reported that they maintain a herd of cattle in their villages of origin, and that they routinely send money home to pay for hired herders.
>
> For many Caprivians, formal employment is viewed as an ephemeral episode in a person's life, and that one day everyone has to retire and settle back in their village of origin. For this reason, investing wages into the agro-pastoral sector is seen by many as part of their preparations for their eventual retirement and possible settlement in the country-side. Thus, our contention is that increased access to urban incomes will increase, rather than reduce stocking levels in the country-side (Sikana and Kamwi 1997: 36).

To an extent that is difficult to assess, expanding cattle numbers in Caprivi may be caused by prudent urban investors rather than culturally conservative rural producers. Indeed, MAWRD employees may be (a small) part of the 'problem'.

To summarise, total herd numbers in Caprivi have increased in the last decade. Whether these increases have caused higher stocking rates is not known because there has also been an increase in the availability of pasture due to reduced

flooding. Localised overstocking is recognised as a problem by Caprivi stock owners, but whether the region is generally overstocked - or in what sense it might be overstocked - is unknown. Local herd owners are opposed to destocking, but the nature of their production system and marketing constraints probably are more influential than 'cultural attitudes' in causing low cattle sales rates. Caprivi wage earners invest in cattle, and these investments may be as important as low offtake rates in explaining regional herd growth.

Land tenure

Chinchimani village is part of a district-level herding system which includes at least six villages and is managed through the senior district-level customary authority who resides at Muketela. Chinchimani controls the wetter portion of the Mararo Channel, and any attempt to manage Chinchimani pastures in isolation would violate established use rights and would be resisted by cattle owners in villages north of Chinchimani. This does not imply 'open and unfettered access to grazing and water resources of all and sundry. Instead...access to grazing and water must be negotiated on the basis of cross-cutting and multifarious linkages such as kinship, marriage, political rank and the degree of cordiality between different herd owners' (Sikana and Kamwi 1997: 6). However, tensions can run high when pasture and water are in short supply: 'Sometimes they refuse us to set up cattle posts. We just go there by force. We are prepared to be killed if it comes to that. We have no other choice' (informant quoted by Sikana and Kamwi 1997: 15). In sum, access is restricted to critical resources, but territorial units are not neatly compartmentalised, isolated units.

Much the same conclusions apply to Kabbe. For the most part, Kabbe village shares borders with communities that do not compete directly with each other for the same grazing and water resources. Also, because the hamlets that make up Kabbe are more dispersed than in Chinchimani; the territorial boundaries between the different sub-villages within Kabbe are more pronounced, but they are not rigid. On the Zambezi floodplains, garden sites are scarce, valuable and constantly contested, and both residence and grazing locations are determined by individual access to these sites. Because individuals inherit in both the male and female lines, neighbourhood and territorial groups that operate during the wet season on the plateau correspond to but are not perfectly replicated on the plains during the dry season.

Many influential Caprivians, often urban residents with salaried jobs, are of the opinion that improved cattle management is impossible without dismantling communal tenure in favour of private tenure. These people are, in some cases, already investing in private boreholes in the Chinchimani area.

Water development

Caprivi livestock keeping is sustained by cash remittances from salaried employees in urban areas, in order to hire labour, purchase animals and develop private water supplies. Caprivi communities therefore appear to have the financial resources needed to contribute in cash to the development of communal water supplies. Furthermore, it would appear that they are willing to do so and have valuable technical advice to offer on questions of siting and improved water retention through the 'seeding' of new dam sites with indigenous plants. This latter suggestion deserves closer technical scrutiny through NOLIDEP's adaptive research programme.

Sikana and Kamwi are clear about the problems of free water development:

> The two [NOLIDEP dams constructed by NOLIDEP in Chinchimani without community contributions] were constructed by an external contractor using heavy equipment and then bequeathed to the community, with minimal contribution from the local people. For this reason, the dams are seen as a gift from government, in the same manner that Mararo is seen as a gift from God. In such circumstances, it is very difficult for the traditional village authority to prevent their kin and friends in neighbouring villages from using these water facilities (1997: 19).

In developing water it is important for NOLIDEP to work with closely local customary authorities, which is current project policy. However, certain communities in Caprivi are historically disadvantaged within the customary system, and the project must take special care not to neglect these communities.

Oshikoto Region

Material summarised here is based on *The privatisation of rangeland resources in Namibia: enclosure in eastern Oshikoto* (J Cox, C Kerven W Werner and R Behnke 1998, 114 pages, Overseas Development Institute, London).

The following discussion pertains to the NOLIDEP pilot village of Onghumbula, within the Egodi Constituency of Oshikoto Region, and associated grazing areas extending eastwards from Onghumbula to the border with Kavango Region.

Eastern Oshikoto is a frontier area of recent settlement and in-migration from more heavily populated regions to the north and east. Driving this process of colonisation is an oscillation between deficits and surpluses of feed and water. Established farming villages to the west tend to have well-developed supplies of water for livestock, and forage availability is the primary constraint on herd performance; vice-versa in the sparsely settled grazing zones of eastern Oshikoto. But this situation is unstable over time. As settlement density increases and cattle are forced to migrate further and further afield in search of forage, villagers are tempted to relocate their farming operations closer to adequate grazing. Surplus grazing tends to be located in areas where there is a water deficit which prevents year-round habitation and use of the area. But as water sources are developed and more people relocate, a cattle post gradually becomes a village, a grazing surplus is transformed into a deficit, and the process begins anew.

In the Onghumbula area this wave of colonisation is moving from west to east, north to south. Onghumbula, for example, was established in the early 1970s; fifty kilometres to the east, Okangele village was established in the early 1990s. Large-scale private fencing is advancing from the opposite direction. Apparently, private enclosure of communal rangeland began to the south and east adjacent to the commercial farming area around Tsumeb and the Mangetti Farms, and is expanding to the north and west. Two antithetical forms of land use - peasant agriculture and large-scale commercial ranching - are therefore expanding into eastern Oshikoto from opposite directions, meeting in the area south of Okangele and eastwards to Okavango (Fencing Map Figure 7).

Current grazing system

Herd movements in eastern Oshikoto are flexible and tailored to the needs of individual operators. Regional migratory patterns are therefore complex. For much of the year many of the cattle owned by Onghumbula residents are not in the vicinity of the village, while many of the cattle using the Onghumbula borehole came from elsewhere. Herds are drawn from a variety of sources and move onwards towards a variety of destinations. Moves of a few kilometres and long-distance migrations across regional boundaries into Okavango or across international borders into Angola are all possible. Figure 6 provides a schematic overview of movement patterns, and Kerven has given the following account of these movements (1997: 66, 67).:

> The cycle of livestock movement starts with the move eastwards after the harvest when livestock have consumed most of the stubble from grain fields, and natural ponds begin to dry up. This is the dry season (*okwenye*) from

about June to November, and the cattle are moved slowly eastwards by groups of young men, grazing new pastures as they move, a process termed *onthanda*. Water in the dry season is taken from hand-dug wells or boreholes along the route of travel. Once the rainy season (*ukulombo*) begins, some of the milk cows will be brought back to the villages, provided there is sufficient grazing, in order that families can have the benefit of the milk. Plough oxen must also be returned to the villages as cultivation takes place at this time. But the bulk of the oxen and milk cows may remain at the cattle posts throughout most of the rainy season, and return only briefly to the villages for the following season, (*ukufu*) the time of harvest from April to July. Cattle are brought back home at this season in order to manure the fields and feed off the post-harvest stubble, while the herdboys are re-united with their families.

There is limited north-south transhumance centred around the new boreholes dotted along the main west-east road (see Figure 6), but few cattle are sent to graze in the areas south of Oghumbula because the soil is sandy and cannot hold water even in the rainy season. There are also few deep wells in this area which provide water for cattle in the dry season.

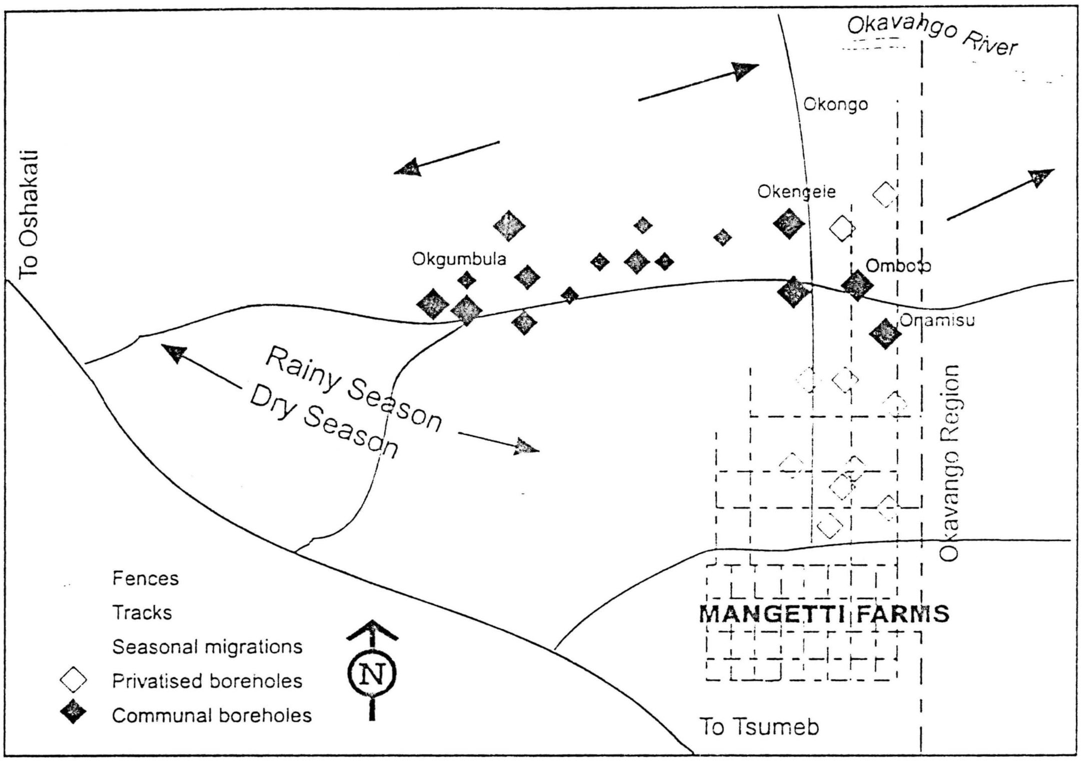
The length and direction of transhumance is determined by the quality of grazing available. Following good rains cattle are kept around the settlements for longer after the harvest, before being sent off to the cattle post zones. Similarly, cattle may be brought back earlier from the cattle posts to the villages if there is ample green forage early in the rainy season. If, however, the rains are poor, a herdowner may have to send his cattle further afield to find sufficient pasture. How far away and how long cattle can be herded at cattle posts also depends on the labour a family has available, and their herd size. A family with no young men willing to herd or with few cattle will not send their cattle far. But a relatively large cattle-owner will divide his herd into several groups, each under the care of a young male relative.

Grazing rotation and the control of stocking rates

As in most other parts of the NCAs, Oshikoto herds follow a transhumant form of seasonal rotational grazing.

In eastern Oshikoto, individual villages or grazing areas are parts of a much larger regional system of livestock and human population adjustments. Short-term imbalances in feed supply and demand are adjusted by seasonal migratory movements, herd splitting and pooling. Long-term adjustments require resettlement and the creation of new villages. The institutions that facilitate human and stock movements are sophisticated, flexible and cheap. As long as the frontier remains open, these techniques permit herd growth, make individual herd owners richer and Oshikoto more productive. Conventional Western approaches to range management that control stock numbers and restrict movement are of limited use to herd operators in this environment, and it is difficult to conceive of a community voluntarily adopting these practices.

There is evidence that the frontier in Oshikoto is now closing down, but - unfortunately - not in a way that will encourage small-scale livestock owners to look



Sketch map of seasonal migration and fencing in eastern Oshikoto

Source: The Knife Cuts on both Blades: Redefining Property Rights in Eastern Oshikoto by C. Kerven in Cox et al. 1997.

for narrow technical solutions for their stocking problems. The large-scale enclosure of eastern Oshikoto by politicians, businessmen and civil servants (described below) has already had an impact on the grazing areas and water points that remain under communal control. Headmen complain that cattle are being squeezed between the new fenced farms and the Kavango boundary, metaphorically caught between the two blades of the traditional double-bladed Ovambo dagger. The immediate effect of this squeeze is being borne by 'front-line' villages such as Okengele, Omboto and Omotoko which lie adjacent to enclosed areas but still operate communal boreholes (in contrast to many government-supported boreholes which have been privatised). With the former seasonal flow of cattle from west to east now largely impeded, the mass of cattle are being turned back westwards and exerting inordinate pressure on the few accessible areas remaining.

Villagers in these areas feel that they have no recourse when confronted with a fence and expropriation of their fields, pastures or hand-dug wells. The only authorities with which the local populace are familiar are the traditional tribal leaders. As the permission to enclose is granted and upheld by these very authorities (see below), the headmen and cattle owners point out that their complaints have little chance of redress. The general feeling of helplessness is summed up by one headman: 'Even though local people want action about the fences, we are not part of the government, so who will answer us?' (Kerven 1997: 78,79). A NOLIDEP-sponsored workshop on fencing in Oshikoto further concluded:

> Local headmen and women uniformly emphasised the negative effects of private enclosures on the welfare of the owners of small herds using communal grazing lands and public water points. Loss of customary grazing areas and watering points had resulted in increased livestock deaths, crowding in the remaining open areas, tensions between rural residents and enclosure owners and employees, and the forced movement of Oshikoto herders and their livestock to areas outside Oshikoto Region. Whatever the benefits of enclosures for their owners, it was generally accepted that enclosure created numerous problems for those still trying to maintain themselves in communal grazing areas.

Technicians may have very little to contribute in this situation. **If cabinet ministers are fencing thousands of hectares, it is difficult to convince a household with fifty cattle to destock 'in the public interest'.**

Land tenure

The allocation of rights in pastures, arable field sites and for sites for water development is controlled by the Ndonga King and the hierarchy of traditional authorities under his leadership. Senior headmen - who preside over a number of villages - are responsible for allocating residential plots and field sites. The King and his counsellors are directly responsible for the control of grazing areas and for granting permission to individuals to fence these areas. The maximum size of a parcel for which fencing is permitted is 6 km on each side, though the customary authorities also admit that sometimes the area fenced by an individual exceeds the allocated area.

The extent of fencing in 1996 and early 97 for a portion of eastern Oshikoto is depicted in Figure 7. By late 1997 the extent of fencing had increased in the area covered in Figure 7, and was ongoing despite a Presidential ban against the fencing of more than 10 ha announced on March 14 1997 (Kerven personal communication; see also *The Namibian* story 'Fencing ban 'non-starter' - Nujoma's 'moratorium' appears groundless' Sept. 24 1997).

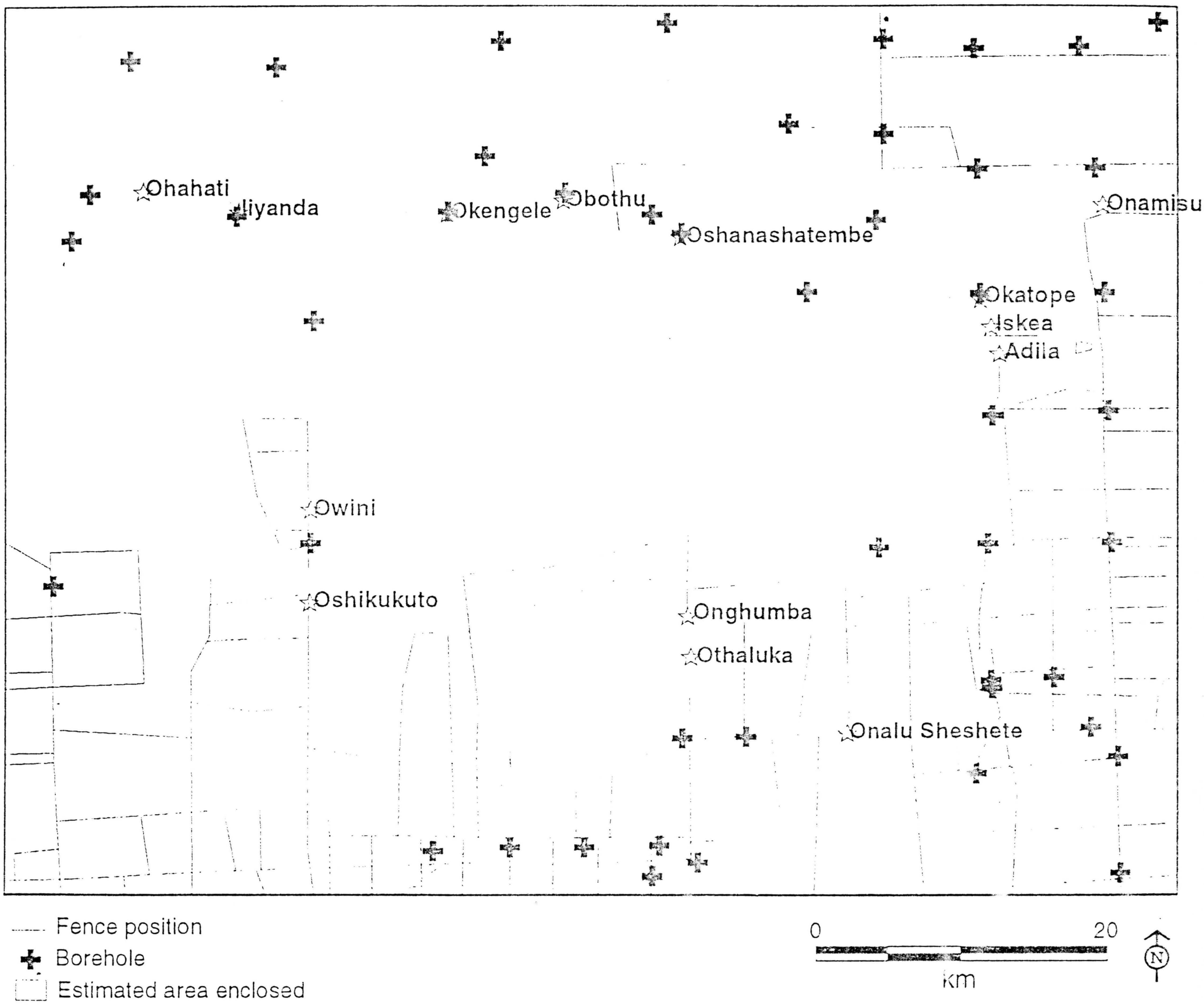
One response by some local individuals has been to erect their own 'defensive fences' around government boreholes. Their aim is to control the number of other herders' livestock reaching he water and thus depleting the surrounding vegetation, and in some cases, to earn some income by charging users for watering their animals.

Another response is for individuals to take their animals along narrow corridors past the fences and eastwards into Kavango Region. The continued existence of these open corridors - when all other sections of the Kavango-Oshikoto border are closed by fencing - suggests that the Oshikoto authorities have given some thought to the question of how to displace surplus Oshikoto stock onto Kavango pastures. This option is rapidly closing down, however, as communities and traditional authorities in Kavango are no longer willing to accommodate livestock from Oshikoto (Behnke 1997).

Water development

The fencing of communal land has been accompanied by the privatisation of government boreholes by local headmen and non-residents. In 1995, herders were 'chased away' from the borehole at Okatope as the local headman had started enclosing it with a fence. The same was occurring in 1996-97 at Omtoko borehole and to a solar borehole at Omtwewashambundu. The privatisation of government boreholes by town-based ranchers has been far more common. Today all government boreholes north and south of Onamisu have been enclosed by private fencing (Kerven 1997: 73-76).

A comprehensive picture of the water situation in the eastern Oshikoto is difficult to compile. Sources held ;by the Department of Water Affairs do not always agree with one another, often reports refer only to a particular drilling programme at a particular time, lists of installations are out of date, do not contain information on private boreholes, or precise geographical co-ordinates were not given for installations. **Constructing an accurate list of installations and making this list available to the public would be an important step both towards effectively planning future drilling and controlling borehole abuse in the Region.**



Estimate of the distribution of fences and boreholes in eastern Oshikoto, early 1997

Source: Cox et al. 1997.

Omusati and Ohangwena Regions

The material summarised here is extracted from *Grazing management study funded by NOLIDEP for three of their pilot communities* (I Christian, 1998, 52 pages). This study covers three NOLIDEP pilot communities - Oshambelo and Onaanda in Omusati Region and Omatunda in Ohangwena Region. Additional information on livestock management and household economics for these villages is provided in *Livestock Production in Omusati and Ohangwena Regions, Namibia* by L Denaiu, O Mukulu and F Blanc. Material in this latter report is not included in this overview.

Following Christian, we begin with a capsule summary of the study villages:

> **Oshambelo** (Omusati Region East of Tsandi) is part of the Kingdom of Uukwaluudhi and has direct access to a cattle post area used by all Uukwaluudhi communities. Because the area is recently settled, land pressure is low and households have both large crop fields and large *ekoves*, fenced grazing reserves around the homestead. The community is not serviced by either a pipeline or water canal and many households must walk about 7 km for their drinking water supplies. The cattle post area is equipped with boreholes, most with diesel pumps.
>
> **Onaanda** (also in Omusati Region) is an established community with both large crop fields and large *ekoves*, which are sometimes splint internally into camps. Water for home consumption is provided by a pipeline. The community has direct access to a large cattlepost area that is partly served by the pipeline, but there are no boreholes due to groundwater salinity problems, and water must be obtained by hand-dug wells in the remoter parts of the grazing area which are not covered by the pipeline. Parts of the cattlepost area are lightly stocked because access is restricted due to lack of water.
>
> **Omatunda** is a small and densely settled community in Ohangwena Region. The community has no direct access to a cattle post area and local oshanas, seasonally inundated water courses, and patches of remaining forest provide dry season grazing. Some herds migrate seasonally over long distances or are permanently resident far from the community, but the majority of smaller herds remain year-round in the village area. Land pressure is high, in part because of refugees from Angola which are now accepted as community members. Grazing around a homestead is reserved for its residents, but *ekoves* are common and essential for the preservation of late dry season forage.

The current grazing system

Tables 4 and 5 provide an overview of cattle movements and grazing resources by season.

Table 4: Seasonal cattle movements and feed sources -Omusati Region

Season	Approximate duration	Location	Primary feed sources
Okwenye - dry seson	August to December	cattle posts	dry perennial grasses
Othinge - rainy season	January to March	around settlements	green annual grasses and perennials
Okufu - post-harvest season	April and May	around settlements	stover on harvested fields
Oshikufuthinge - early dry season	June to August	move from settlements to cattle posts	dry grass and supplementary browse

Table 5: Seasonal cattle movements and feed sources - Ohangwena Region

Season	Approximate duration	Location	Primary feed sources
Okwenye - late dry season	August to October	around settlements	dry perennials and emergency feeds
Oshitemamuula - early rains	Nov to January	around settlements	dry perennials supplemented with crop stover
Okulombo - rains	February to April	around settlements	fresh grass
Okufu - cold season	May to July	around settlements	harvest residues and browse

In general, cattle make two major moves per year - to a cattle post which serves as a dry-season grazing area and subsequently back the vicinity of the village. Once they have arrived at their cattle post, the stock are not commonly moved a second time. Although the level of knowledge varies between and within the three pilot communities, herd owners are aware of the forage value of different grass species and the changing nutritional value of particular species as they mature. However, the use of grazing resources is not closely related to this botanical knowledge because herd operators are constrained by other factors such as the availability of water, herding labour and the accessibility of distant pastures.

In areas where grazing pressure is not extremely high, such as the Onaanda cattle posts, herders may control access to their own hand-dug wells and thereby assume control over the pastures within walking distance of these wells. This permits a degree of pasture management such as the initial grazing of pastures close to the water point to prevent the loss of this forage by trampling as cattle transit between the water point and more distant pastures, or the reservation of the most unpalatable forage species for utilisation late in the dry season.

Supplementary feeding occurs during ploughing season to improve the condition of draught animals as well as during droughts or in the late dry season to improve herd survival rates. Emergency drought feeds include palm leaves, branches of the Marula tree, and grass originally reserved for roof thatching. The Omatunda headman, for example, forbids the grazing of areas where thatching grass is collected, but these areas can also be used for emergency feed in difficult years.

There is little cultivation of fodder crops, though some farmers were familiar with Lucerne based on their experiences working on commercial farms. Interest was expressed in acquiring more acacia trees for the production of seed pods for livestock feed and in closer participation in NOLIDEP's fodder trials. Natural forage is at present reserved in fenced ekoves adjacent to households and only utilised once communal pastures are depleted. Farmers preserve natural forage or cultivate fodder in order to improve herd survival rather than to increase livestock production through improved animal performance.

Grazing rotation
A rudimentary form of grazing rotation is maintained through seasonal transhumance between main settlements and peripheral cattle posts. This system is under increasing pressure as farmers request more water points in order to achieve a more even distribution of cattle over all available pasture areas. Rotation and resting also occurs when stock are excluded from household *ekoves* during the plant growing season and return to these areas in the dry season after communal pastures have been exhausted.

Stocking rates
The use of animal sales to lower stocking rates and improve pasture conditions depends on the level of commercialisation, which varies enormously among the study communities. In Omatunda, for example, pasture is so scarce that herd owners cannot realistically foresee any improvement and even large herd owners are extremely reluctant to sell animals for cash. In Onaanda, on the other hand, production is semi-commercial and timely sales are discussed as a way of avoiding stock deaths and monetary loss during droughts. Improving marketing facilities in order to encourage sales has already occurred through NOLIDEP programmes to repair crush pens and through negotiations with Meatco officials.

Livestock also circulate among rural households through a system customary cattle loans. Typically, rich cattle owners loan some animals to a household with little or no livestock. Lenders retain rights to offspring, obtain herding labour, and spread risk through dispersal of their animals. In return, borrowers obtain milk and manure and the prestige associated with livestock holding. Although it has important social and economic implications, the gifting and loaning system has negligible impact on overall cattle movements or off-take rates.

Land tenure
Grazing resources are used communally but not managed collectively by any controlling body that is elected or traditionally empowered to strictly regulate access

to defined areas. Provided certain minimal conditions are met, households can pasture their animals or set up new cattle posts in communal grazing areas. The minimal conditions vary among the study villages:

- in Oshambelo new arrivals must receive permission to water their stock from the controller of the borehole, though they can survive for same time at hand-dug wells if permission is not given
- in Onaanda they must own a hand-dug well
- in Omatuuda they must own a house in the settlement.

Even these preconditions can be avoided if households have kin, good friends, or loan cattle into the receiving community. Usually neighbours or fellow livestock owners are approached for permission, rather than the village headman.

People can precisely indicate the boundaries between settlements and cattle post areas within a community as well as the boundaries between neighbouring communities, and headmen assert that these boundaries are enforced. However, headmen both allocate land and regulate access to grazing areas, and land allocation is one of the last profitable privileges retained by headmen. In reality, clear-cut boundaries are replaced by boarder zones in which the village affiliation of post owners gradually shifts from one settlement to another, or one form of land use gradually gives way to another. One possible exception is the village of Oshambelo where a new environmental regulation fixes the boundary between settlement and agriculture versus cattle posts and grazing areas, and the traditional authorities claim to have initiated and enforce this regulation.

People insist that 'There is no private grazing' despite the existence of numerous fenced plots in settlement and grazing areas. However, enclosures - no matter how large they are - are not considered private grazing reserves as long as a house is built or in the process of being erected and the fenced areas - *ekove* - are adjacent to the household's cultivated fields. The size of *ekove* depends on the density of settlement and the tolerance of neighbours towards enlargement. *Ekoves* tend to be large in sparsely settled areas where households are distant from one another. In densely populated communities like Omatunda, the largest *ekoves* are held by those who first settled in the area. Only one case was reported in the study communities in which an enclosure was considered to be a private grazing reserve or *eekamba.* A legal action against this reserve has been taken to the High Court in Windhoek through the initiative of the local community, and a trial is pending.

Water development

Stock watering facilities - and especially boreholes equipped with a diesel engine and drilled by government - are more closely regulated than grazing areas.

Diesel-equipped boreholes are maintained by government and typically controlled by a near-by cattle post holder. This individual is registered in Ondangwa at the Department of Water Affairs and is responsible for ordering service and repairs through the government, collecting yearly fees from all users (at N$2.00 per head of cattle per year), and organising diesel supplies which can be obtained free of charge from the government. However, trespassers at the watering point are not charged for water because of lack of control.

In many cases borehole controllers have assumed rights over the installation beyond their original duties. Often they admit only a restricted number of herds to the borehole and thereby control to some extent access to the surrounding grazing area. The number of herds allowed to use a borehole can vary due to emergency conditions such as drought, and controllers report that it has become increasingly difficult to control access because of higher animal pressure.

Access is privately controlled by individual owners of hand-dug wells or unrestricted at pipeline supplies where no contribution for water is required. In these cases a water committee is responsible for forwarding service and maintenance requests to the Department of Water affairs and for settling conflicts among users, and headmen will refer to the committee in cases of conflict. Despite community cost contributions, it is doubtful whether communities can control access to the planned dams to be constructed by contractors under NOLIDEP. Previously built water points where a limited group of people helped pay for constriction costs, in Omatunda for example, are now used without charge by anybody in need of water, irrespective of whether this individual contributed to construction costs.

ANNEX 3

Carrying Capacity and Rangeland Degradation in Semi-Arid Africa: Clearing away Conceptual Rubble[5]

Abstract

The opening section of this review models the effect on beef output caused by adding more and more cattle to a constant area of grazing land. The results of this process of intensification are expressed as a production function for meat output at various stocking densities. This production function identifies at least six optimal stocking densities beyond which a rangeland might reasonably be judged to contain too many animals, i.e. six potentially distinct definitions of a rangeland's appropriate carrying capacity. These results suggest that the correct stocking rate for a grazing system cannot be set except in relation to the production strategy and the social and economic circumstances of the rangeland user - there is no single optimum density. Small-scale African producers do not share the production objectives of large scale commercial ranchers. Carrying capacity estimates and estimation techniques appropriate in a ranching context are irrelevant to any meaningful assessment of the stocking rates of indigenous rangeland users.

The second section of the review examines the concept of rangeland degradation. In areas where rainfall is reasonably constant, large livestock populations may indeed consume enough vegetation to alter significantly the plant life that they leave behind. But these changes are not proof of degradation. Almost by definition, agriculture alters native vegetation to produce a crop, and there is little reason to expect range-based agriculture to be the exception to this rule. For agriculturalists, the conservation of pristine vegetation is of less concern than the expected length of time that output can be maintained from altered vegetative states under different management regimes. Botanical assessments that confound rangeland 'use' or 'heavy use' with 'degradation' ignore the more useful but difficult task of assessing a system's sustainability.

Climax is often defined as an outcome in the absence of defoliation, as if grazing and browsing were pathological influences having no rightful place in a decently organised botanical world. This climax is often an aberrant plant community found nowhere outside exclosure plots. For most vegetation the natural end point of succession is some equilibrium between plant composition and grazing pressure. Graeme Caughley

[Experimental] controls (no treatment applied) are a misnomer.... Savanna ecosystems have evolved with grazing and fire as agents of natural selection. Controls which exclude these agents are in effect a treatment, and often result in more marked changes than the treatments being investigated.... T G O'Connor

[5] I would like to thank Nick Abel and Carol Kerven for their assistance and critical comments on earlier drafts of this work. Parts of this review originally appeared in a series of articles co-authored with Nick Abel and published in 1996 in the World Animal Review. The present version was presented at a Rangeland Desertification Workshop in Reykjavik, Iceland, in September 1997 and in Windhoek at the 1997 meeting of AGRISSON, the Namibian professional association for agricultural research..

The concepts of carrying capacity and degradation are commonly used to evaluate the long-term viability of pastoral land use systems. Sometimes the resulting evaluations disagree because observers employ different definitions of these terms. This paper examines the logical pitfalls that foster these disagreements, with special reference to botanical assessments of Africa's semi-arid open rangelands.

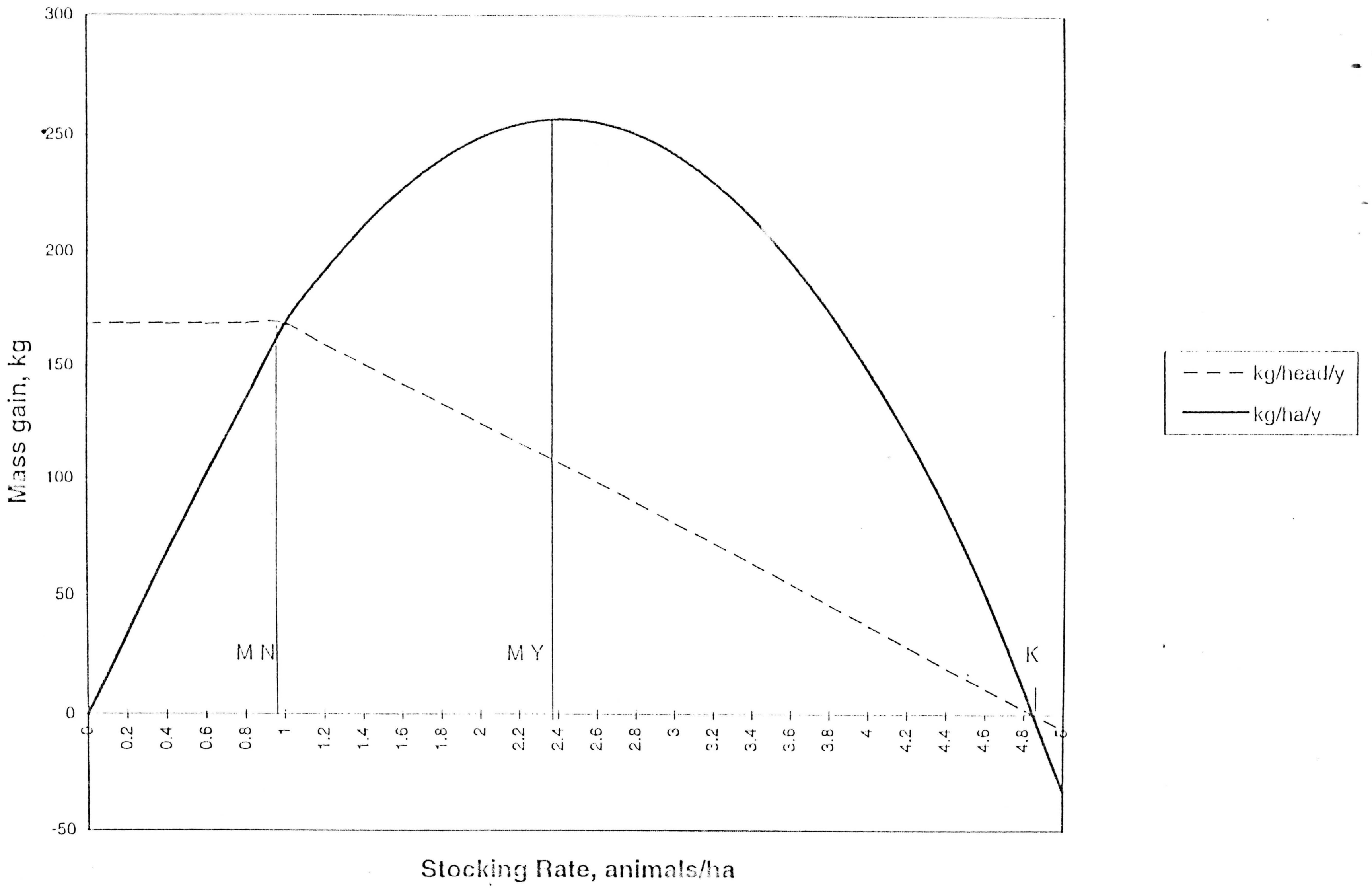
I will argue that the concepts of carrying capacity and degradation are troublesome because, like naughty children, they have been insufficiently socialised. Bio-physical variables - plants, soils and climate - are the master inputs that underpin any form of rangeland production. But this does not mean that appropriate management recommendations flow effortlessly from a reading of bio-physical conditions. A meaningful interpretation of the natural ecology must reflect the requirements of different production systems, and becomes increasingly difficult when scientific observers and land users do not agree upon management objectives, as is commonly the case in pastoral Africa.

Carrying capacity

Conceptual ambiguity, measurement error and the practical difficulties of implementing recommended stocking rates, have induced some observers to argue that the concept of carrying capacity is useless for open rangelands (Bartels 1993). Others have simply noted that the concept is 'nebulous' and better avoided by 'purist scientists' (Stuart-Hill and Aucamp 1993 10: 1). But our interest in and need for the concept remains undiminished; the attempt to determine appropriate stocking rates has 'probably generated more rangelands literature than any other factor of management,' simply because 'stocking rate is the most important management variable affecting productivity and stability in rangelands' (Ash and Stafford Smith 1996: 216, 217). Producer concerns, research interest and the intrinsic importance of the topic suggest that we should attempt - yet again - to clear up some of logical problems that beset the carrying capacity concept.

The approach taken here is to model the effect on beef output caused by adding more and more cattle to a constant area of grazing land. The relationship between product output and cattle densities is expressed diagrammatically in Figure 1, which summarises the results of numerous grazing intensity experiments on a wide variety of pasture types (Jones and Sandland 1974; Butterworth 1985; Ash and Stafford Smith 1996). In Figure 1, weight gain per animal (dashed line) is constant at low stocking densities (*0-MN*) because forage is abundant and additional animals have little impact on animal performance. When forage does become a constraint at densities above *MN*, maximum nutrition, weight gain per animal decreases as an inverse linear function of stocking density. Beef production per hectare (solid line) is a function of the per caput output of individual animals at different stocking densities, multiplied by the total number of animals at those densities. The result is a parabola; gain per hectare initially increases to a point of maximum yield (*MY*) and then declines quadratically to zero at *K*, the feed-imposed ceiling on further herd growth. At *K*, sometimes termed ecological carrying capacity, animals receive a maintenance diet, forage production

Figure 1. Stocking Rate and Beef Production
(Jones and Sandiland, 1974)



equals consumption, and animals die at the rate they are born and gain weight at the same rate they lose it.[6]

Figure 1 displays the biological output or physical yield of a grazing system. A technique for assessing the profitability of alternative stocking rates is illustrated in Figure 2, which converts physical outputs into cash equivalents and then compares these returns with operating costs at different stocking densities. Figure 2 identifies two additional critical stocking densities - *MP* and *MO*. For commercial ranchers, the economically optimal stocking density - *MP* or maximum profit - is the stocking rate which maximises the differential between total revenue and variable costs. This economic optimum can be roughly identified by visual inspection; it occurs at the point of greatest vertical distance between the revenue and variable cost curves. Finally, *MO* - the density at which rising costs finally equal declining revenues - represents the outer margin of viable economic operation on the rangeland in question. Beyond *MO* the costs of herd operation would exceed returns, rendering insolvent anyone who persistently operated at these densities.[7]

Let us now review Figure 2, examining in greater detail the various stocking densities beyond which different observers - or producers - might be inclined to conclude that the system contained too many animals.

Scenario 1. The lowest of these values is density *MN* - the density at which feed availability first becomes a constraint. Beyond this 'critical' stocking rate, increases in density entail a progressive decline in livestock nutritional levels, individual animal productivity and overall herd condition (Malechek 1984). Because of these detrimental effects, *MN* has been widely invoked as a baseline for determining appropriate intensities of rangeland use. As Figure 2 illustrates, however, stocking densities that sustain cattle at peak condition are unlikely to match the aggregate output of more heavily stocked areas, despite the record levels of individual animal performance that can be achieved at low densities, usually under experimental conditions. Breeders of very expensive animals for the show ring or to be sold for

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[6] At densities between *MN* and *K* in Figure 1, the relationship between productivity per animal and stocking rate is expressed as

1. gain per animal = $a - bS$

where S is the stocking rate in animals per unit land area and a and b are constants for particular pastures of types of livestock. Productivity per unit area is therefore

2. gain per unit area = $aS - bS^2$

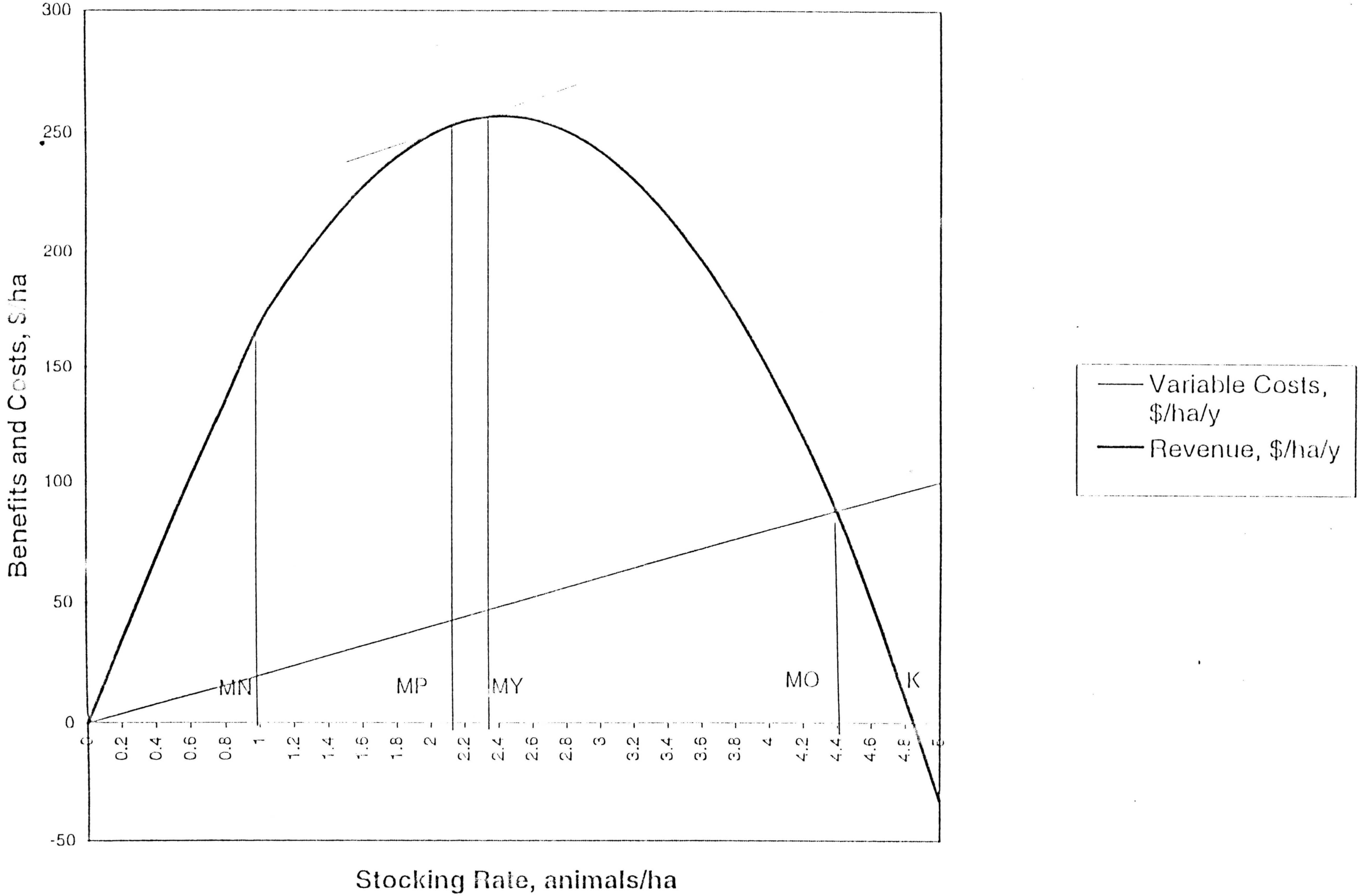
with a, b, and S as in equation 1.

[7] Profit per unit area is

3. $Pa = P[aS - bS^2] - cS - FC$

Where Pa = profit per unit area, P = price per unit weight of beef, c = variable cost per animal, FC = fixed costs per unit area, and a, b, and S are as defined for equations 1 and 2. See Booysen *et al* 1975, Carew 1976, Hildreth and Riewe 1968, Workman 1986, and Wilson and Macleod 1991 for further discussion.

Figure 2. Economically and Biologically Optimal Stocking Densities



their pedigree may be the only examples of commercial enterprises that can afford to maintain stocking densities that maximise individual animal performance. Since it would be unreasonable to transform Africa's open rangelands into a pan-continental stud farm, this initial definition of optimal stocking density is irrelevant, although it has contributed significantly to a vague notion of 'overstocked' African rangelands.

Scenario 2. A second possible target stocking density occurs in the vicinity of *MP*, the most advantageous stocking density for commercial ranchers who are trying to maximise their profits. The self-interest of rangeland users will encourage the adoption of this stocking target whenever rangelands are monopolised by one firm or producer who is in a position to capture all the profits generated by a restrained stocking policy. The precise location of the commercial optimum is sensitive to changing cost levels and output prices (Workman 1986; Wilson and Macleod 1991; Jarvis 1991).

Scenario 3. *MY*, maximum yield, marks the density at which a herd owner can obtain maximum aggregate output per unit area. For the commercial rancher on private land, *MY* marks no management goal. On the other hand, the maintenance of densities near *MY* may be consistent with the objectives of subsistence-oriented pastoralists who directly consume their own produce and seek to provision large human populations (Behnke 1994)..

Scenario 4. *MO* (open access equilibrium) maximises the number of independent herding operations using an area. Stocking densities in the vicinity of *MO* are possible when rangeland is unowned and herders are free to enter and use a pasture at their own discretion. New operators and their animals will be attracted to the area until aggregate stocking densities approach *MO*, and declining revenues equal rising operational expenses, removing any further incentive for new entrants. This 'open access equilibrium' can occur at high densities which depress yields and is not a desirable stocking target for any group of producers except the very poor. For this group, free access to under-exploited resources can provide at least temporary escape from low wages and unacceptable working conditions. If enough poorly paid workers respond to these incentives, free access to natural resources can provide both a refuge for the poor and create labour scarcities that, for a time, drive up minimum wages and improve living standards.

Scenario 5. The fifth stocking ceiling, *K*, marks the limits of what is biologically feasible in a particular grazing environment. *K* is what wildlife and population biologists are referring to when they talk about 'ecological carrying capacity' - the level at which a herbivore population would naturally stabilise in the absence of predators and assuming a relatively constant forage supply. Since herds at *K* generate no offtake but simply maintain themselves, this stocking density is not routinely of interest to owners of domestic stock. But K may represent a positive stocking goal for wildlife managers - a herbivore population undisturbed by human predation (Caughley 1979; Bell 1985).

Scenario 6. The highest conceivable levels of stocking lie beyond *K* and are not depicted in Figure 2. These densities - at what might be termed *K+* - may be caused by an overabundance or sudden dearth of vegetation and are, by definition, unsustainable. The expansion of animal numbers beyond *K* can occur when new herbivore species are introduced into favourable habitats, temporarily releasing normal controls on population growth. This is the typical herbivore eruption: animal populations increase exponentially, overshoot available feed supplies and crash (Caughley 1981). The botanical asset stripping which underpins the herbivore eruption has its commercial parallels. Assuming that a rangeland cannot maintain pastoral incomes at levels comparable to opportunities elsewhere in the economy, the rapid depletion of vegetation at *K+* densities is, at least in theory, a feasible commercial proposition. An area is 'mined', abandoned, and profits are re-deployed elsewhere.

In sum, there exist multiple optimal stocking densities beyond which a grazing system might reasonably be judged to contain too many animals. The preceding discussion has identified six different criteria that could be used to identify these different optima - individual animal performance (*MN*), profit (*MP*) versus yield maximisation (*MY*), the number of herding operations (*MO*) and, finally, the total number of livestock which could be supported on a permanent (*K*) or temporary basis (*K+*). Confusion arises because different densities are appropriate to different management and production systems or advocated by different sets of professional observers. It is no wonder that carrying capacity has proved to be such a slippery concept. Within the limits of what is biologically feasible, the correct stocking rate for a grazing system must be determined in relation to the production strategy and the social and economic circumstances of the rangeland user. There is no single optimum density and, hence, little point to simply characterising an area as overstocked.

This conclusion is especially pertinent to sub-Saharan Africa. Different livestock breeds, species and output mixes, variable levels of market involvement and different systems of land tenure are characteristic of open-range African herding versus large-scale commercial ranching. The combined effect of these differences is, in general, to position comparable stocking thresholds - *MY*, *K* etc. - at higher stocking rates in pastoral than in ranching systems. Two of the biological mechanisms that sustain distinctive pastoral stocking strategies - the physiology of indigenous African stock and the broad mix of products derived from these animals - are discussed below.

Animal physiology

Indigenous African cattle are smaller and lighter than improved breeds, and can match neither the absolute level of output per animal nor the efficiency of the rate of feed conversion into livestock product achieved by improved breeds (Richardson 1994). But African cattle breeds are less sensitive to high stock densities and low feed availability, and can survive, produce and reproduce under conditions that are inadequate by the standards of commercial breeds in temperate climates. The physiological mechanisms that sustain this resilience include:

- the capacity of water- and/or feed-deprived animals to reduce their energy expenditure quickly to a fasting metabolic rate that is two-thirds of the rate of animals on a full maintenance ration, to reduce the energy cost of walking as body mass declines in the dry season, and to conserve energy by allowing larger fluctuations in body temperature at lower body weights (Payne 1965; Finch and King 1979; King 1983; Western and Finch 1986);

- a capacity for high rates of compensatory regrowth when forage is abundant, which offsets weight losses in periods of stress (Payne 1965 and King 1983);

- the ability of cows to sustain milk output during minor fluctuations in pasture conditions, and the ability of calves to gain weight over the long term despite reduced levels of milk intake (Lampkin and Lampkin 1960; Coppock 1989);

- the capacity to convert feed more efficiently when water-deprived and the ability to reduce the loss of excreted nitrogen through voluntary restriction of water intake (King 1983).

Because indigenous breeds have low dietary maintenance requirements, output per hectare is maximised at higher stocking densities than with the larger, improved breeds (Richardson 1994; Tawonezvi *et al.* 1988). Indigenous breeds are also better able, through the mechanisms discussed above, to survive drought. While improved animals might be more productive in the favourable forage conditions prevailing after the rains return, few of these animals would have survived that long.

Product mix

There are several reasons for supposing that the density-dependent production functions for dairy produce, animal fibre, fertiliser products and draught power - all important pastoral and agro-pastoral products - are significantly different from the output curves for beef.

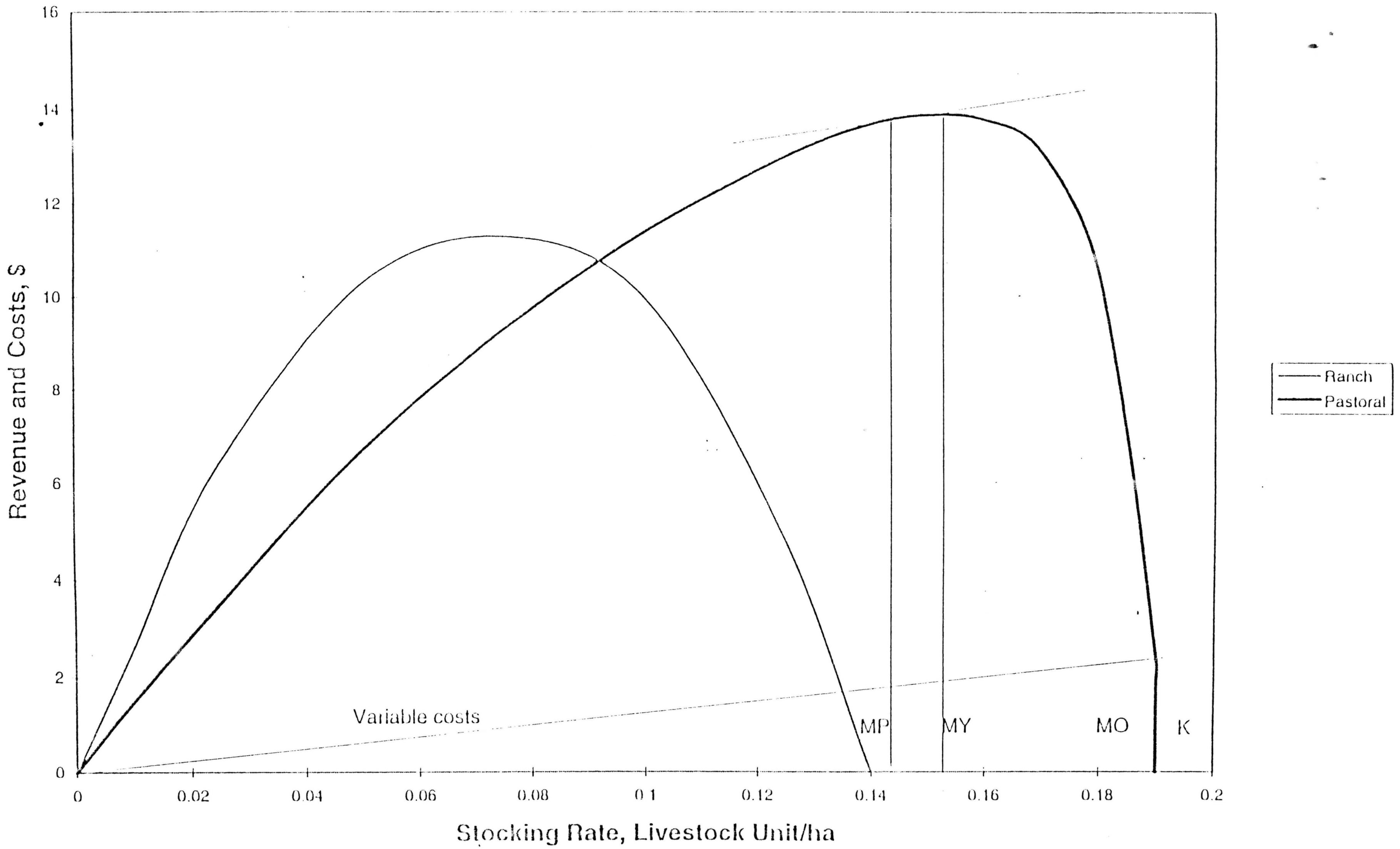
Pastoralists can obtain over 2.5 times more energy from combined meat and milk offtake than from meat offtake alone, because of the greater efficiency of conversion of both feed energy and nutrients - principally nitrogen - from pasture into milk (Western 1982; Western and Finch 1986; Blaxter 1962; King 1983; Spedding 1971). If production and reproduction can continue during periods of weight loss, stocking rates that maximise live animal outputs such as fibre, manure or milk will also be higher than those that maximise meat output. This has been experimentally confirmed for wool versus meat production in sheep (Donnelly et al.1983; Donnelly et al. 1985); similar patterns emerge from modelling cattle milk and manure production compared with meat output (Behnke and Abel 1996).

A hypothetical model of pastoral output

The combined production effects of indigenous breed characteristics and agro-pastoral output mixes are depicted in Figure 3, which presents a hypothetical revenue or physical product curve for ranching and pastoral systems. The salient differences between commercial and pastoral productivity as depicted in Figure 3 are as follows:

- At low stocking densities pastoral output is probably lower than ranch output, reflecting the capacity of improved breeds to outperform indigenous stock under favourable nutritional conditions.

Figure 3. Ranch and Pastoral Revenues and Costs at Various Stocking Rates



- In pastoral systems both maximum yield (*MY*) and maximum herd size (*K*) occur at higher stocking densities than would be feasible under ranch conditions, reflecting both the importance of live animal produce and the capacity of pastoral stock to withstand nutritional stress.

- In pastoral systems, herd output falls precipitately from the point of *MY* to zero yield at ecological carrying capacity, reflecting a non-linear relationship between stocking density and live animal outputs such as fibre, milk or manure.

- Maximum yield from the pastoral system is higher than ranch output as a result of the combined effects of a broader products mix, exploitation of live rather than terminal animal products, and the greater physiological resilience of native breeds - all of which are compatible with the profitable maintenance of higher stocking densities.

- Operating costs for inputs other than labour are very low for many subsistence-oriented herd operators, giving the gently sloping variable cost curve depicted in Figure 3. When variable costs are minimal, *MP*, the stocking rate that maximises net revenue, shifts to the right, effectively eliminating for subsistence-oriented systems the distinction between those stocking rates that optimise economic profits (*MP*) versus gross output (*MY*) (Tapson 1990).

In sum, the shape of the pastoral output curve combined with the 'flat' variable cost curve minimises the difference between *MP, MY, MO* and *K*; it also positions these thresholds at very high stocking densities relative to commercial ranching. These factors help explain why African pastoral producers can achieve their production goals with stocking rates near ecological carrying capacity.

Degradation

Let us be clear about the limitations of the preceding analysis. The stocking rate and output model summarised in Figure 1 is the product of carefully controlled experimental reductionism in which realism and complexity have been sacrificed in the interests of standardisation and replication. This is a model that is 'good to think'; it helps to clarify our conceptual vocabulary, and it shows us how sloppy and impoverished that vocabulary can be when confronted with even a schematic representation of animal-plant interactions. But the model remains, after all, only a schematic representation, and one that ignores two of the most salient features of the African pastoral landscape - spatial heterogeneity and temporal variability (Behnke and Scoones 1993; Ash and Stafford Smith 1996).

The model also gives us little information about our second concern, rangeland degradation in semi-arid Africa. That subsistence-oriented producers can meet their production targets at much higher stocking rates than commercial producers does not mean that the land they occupy is more resilient (Stafford Smith 1996). To the contrary, it implies that there are strong incentives for African herd owners to stock heavily for their immediate benefit but with potentially disastrous long-term environmental consequences. This is not a problem that most stocking experiments are equipped to examine, since they rarely continue long enough to pick up the lagged effect of high stocking densities on output levels (Ash and Stafford Smith 1996).

In the absence of long-term output data, range condition and trend assessment is routinely used to appraise the health of grazing systems. Although field methods vary, these assessments commonly grade a rangeland from 'excellent' to 'poor' condition depending on the extent of retrogression from climax vegetation and declines in plant cover. The Clementsian theories which underpin these techniques have, of late, been subjected to intense critical scrutiny (Westoby et al 1989; Friedel 1994). Additional problems arise, however, when we consider not the validity of these assessments but the uses to which they may be put.

In areas where rainfall is reasonably constant, large livestock populations can be expected to consume and walk on enough vegetation to alter the plant life that they leave behind. In the main, we would expect standing plant biomass to be reduced as denser livestock populations captured a larger proportion of primary production, with more palatable species being depleted more quickly than less attractive or delicate forage plants. This translates in Figure 3 into a general movement from 'excellent' to 'poor' rangeland condition as one shifts from left to right along the horizontal axis, from low to high stocking densities. Though sensible, this is hardly a profound conclusion. Most livestock operators would also endorse this assessment, in that most would prefer dense, high-quality over sparse, low-quality forage, and agree that lightly stocked areas usually provide better grazing conditions.

Problems emerge, however, if we push our interpretation a step further and equate heavy use with irreversible environmental damage. It takes but a small linguistic elision, and one that is all too often made in practice, to assume that rangeland in poor condition is necessarily degraded or degrading. Once made, this equation can be sustained by a logical circularity of breathtaking simplicity: We can see that an area is degrading because of the presence or absence of critical indicator species, and we know that these are critical species because they are associated with degradation. Despite the excessive tidiness of this argument, some loose ends remain. Figures 2 and 3 reveal that, short of *MY*, the equation of declining condition with increasing degradation means that ranges become more productive as they become increasingly degraded. In these terms, densely populated and intensively used areas - that is, most of the open ranges of semi-arid Africa - are degraded almost by definition.

But what has this 'evaluation' achieved, aside from confounding use and abuse, insulting the competence of our pastoral clients, and blunting our critical faculties? Wrapped comfortably in a blanket environmental condemnation of the current situation, what incentive do observers have to do discerning, practical science - science that will address the very real problems of densely stocked systems, identify critical ecological thresholds and tell us which systems are probably sustainable and for how long?

The logical error that underpins these distortions is a non-agricultural definition of degradation predicated on the assumption that rangelands are - or should be - 'natural' ecosystems. In this respect, our expectations regarding the environmental impact of range-based animal agriculture are different from the criteria we use to evaluate the environmental consequences of other forms of agriculture. While conservationists might disagree, few agriculturalists would assume that a wheat field or rice paddy was degraded simply because the farmer had eliminated or drastically altered the natural vegetation in order to harvest a profitable crop. Few would look askance when the hoe was diligently applied to the last remaining indigenous flora in an arable field in order literally to 'weed it out'. Agriculture works by changing the natural vegetation, and we generally accept the environmental consequences of arable farming because, implicitly, we adopt an economic rather than a floristic definition of degradation: Degradation occurs when crop yields decline and are unlikely to recover because the farming system is not sustainable and the land is abused. Degradation in this instance is effectively defined as the long-lasting or permanent loss of an economic good. While definitions are a matter of taste and convenience, I can see no reason why the viability of range-based animal agriculture should not be subject to assessment standards that are broadly applicable to other forms of agriculture. This does not rule out the use of botanical criteria to identify rangeland degradation. But it does imply that botanical indicators are surrogates for underlying economic trends, and it is the responsibility of the analyst to demonstrate - not simply assume - that these proxy indicators are reliably associated with genuine economic losses.

This is no longer easy to do. A decade ago the image of degraded African rangelands went hand in hand with the presumption that African pastoral and agro-pastoral production systems were low-yielding in comparison with more lightly stocked commercial enterprises. Today, it is clear that animal product output per hectare from extensive African husbandry systems exceeds - usually by a wide margin - per hectare output from commercial operations in comparable environments (Prins 1989, 1994; Behnke and Able 1996). Moreover, in those parts of semi-arid Africa where reliable statistics exist (typically in southern Africa), many livestock populations have either been stable or grown for decades (see Scoones 1993 for Zimbabwe; Fortmann 1989 for Botswana; and Tapson 1993 for Kwazulu). While far from conclusive, the comparative material available at this time lends little credence to the hypothesis that widespread degradation has, as yet, significantly undermined output or the ability of many areas to sustain high animal numbers.

Current botanical evidence is also equivocal. Convincing accounts of grazing-induced botanical degradation abound in the literature and require no special citation here. But it is also possible to tell another story.

North Africa

In a wide-ranging review, Seligman and Perevolotsky concluded that 'grazing by domestic ruminants is seldom irreversibly destructive to landscape values' for the winter rainfall regimes of the Mediterranean Basin (1994: 93, 94). Animal output in these systems is higher under heavy grazing (Crespo 1985; Gutman et al 1990b), and long-term studies have shown that primary production may not be significantly reduced by heavy stocking (Gutman et al 1990c). Moreover, removal of animals can create dense oak thickets that reduce biodiversity (Naveh and Whittaker 1979; Specht et al 1990), pose a fire hazard (Naveh 1975; Gutman et al 1990a), and depress the recharge of underground aquifers (Rozenzweig 1972). After centuries of heavy use, 'these vegetation communities are not only well adapted to heavy grazing, but low grazing pressure can have undesirable ecological and management consequences (Seligman and Perevolotsky 1994: 93).

Sahel and Sudan

Following the 'first' Sahelian drought in 1969-73 and during subsequent droughts in the 1980s, researchers from Lund University carried out a series of studies on land degradation in pastoral areas of the Sudan (Hellden 1988; regional studies include Ahlcrona 1988, for White Nile Province; Olsson 1985, for East Kordofan; Hellden 1984, for North Kordofan). This research documented deteriorating environmental conditions during periods of low rainfall, but found little evidence of man-made land degradation, aside from apparent declines in the quality of the natural vegetation. Long-term satellite monitoring of the Sahara's southern border has subsequently cast doubt even on this botanical evidence. It would now appear that the Saharan-Sahelian boundary expands and contracts with annual variations in rainfall, that no directional trends are evident, and that no evidence of large-scale anthropogenic degradation can be found (Tucker et al. 1991). These results were confirmed by one of the few long-term rangeland monitoring programmes carried out in the Sahel. Initiated in 1984 by the International Livestock Centre for Africa in the Gourma region of Mali, this study concluded that: 'The strong seasonality which characterises the Sahelian environment reduces the risk of overgrazing damaging the environment to short periods in time and consequently confined areas....Sahelian vegetation appears very resilient to natural and pastoral stresses because of the strong dynamism of its seed production, dispersion and germination cycle...(Hiernaux 1996: 16).

East Africa

The South Turkana Ecosystem Project, a long-term interdisciplinary study of pastoralism in Northwest Kenya, examined the interactions between people, plants and livestock in an area of low and erratic rainfall. In this environment, droughts were frequent enough and herd recovery slow enough that livestock numbers were never given an opportunity to grow to the point that they could severely damage grazing resources (Coughenour et al. 1985; Ellis and Swift 1988; Ellis et al. 1993). On the better watered plains of East Africa, large assemblages of wild ungulates do influence the species composition, density and spatial distribution of plant communities, and are implicated in major shifts from grasslands to woodlands. East African pastoralists have appropriated a part of the niche formerly occupied by wild grazers, and filled that niche with domesticated stock that can also be expected to influence their botanical environment. For pastoral districts of Kenya and Tanzania in the 1980s, however, stocking rates exceeded neither calculated vegetation carrying capacities nor the stocking densities of wild ungulates in comparable protected areas, leading one observer to conclude that:

> Overgrazing is not a problem in itself, and ... what is observed is a stable form of land use which is characterised by patches of bare soil, a certain level of erosion and occurrence of unpalatable plant species -

> degraded land in the eyes of many a range scientist but forming a stable herbivore-plant interaction ... (Prins 1989: 294).

These were also husbandry systems that yielded about double the output per hectare of commercial ranching (Prins 1994).

Southern Africa
A review of 126 field experiments on savanna grasslands in southern Africa demonstrated that rainfall was of overriding importance in explaining compositional shifts in vegetation (O'Connor 1985). The impact of grazing pressure, on the other hand, varied according to rainfall level and soil type:

> Stocking rate trials have shown no significant effects on compositional trends in the mesic sandveld or high rainfall regions ... but have shown significant effects in the semi-arid savannas and on the heavier textured soils of mesic savannas.... It is also notable that grazing system trials have shown no significant effects on [botanical] composition over a wide range of savanna types ... even though many of these studies compared continuous grazing and some form of rotational grazing. Furthermore, there is no evidence that controlled selective grazing has any influence on botanical trends (O'Connor: 1985: 42).

These results were endorsed by a literature review of rangeland degradation in South Africa's communal areas, the former 'homelands' (Shackleton 1993) . This review revealed few changes in plant species composition in high rainfall areas, and variable results from research in dryer areas - some studies reporting grazing-induced species change and others not. The reviewer concluded that:

> There is little empirical evidence to support any statements, positive or negative, about the condition of these communally managed grasslands. There is certainly inadequate evidence to support the hypotheses of large-scale degradation of these grasslands. Moreover, whatever changes have occurred appear to be reversible (Shackleton 1993: 72).

Attempts to apply classical range management techniques to communal areas in South Africa have, on occasion, yielded perverse results: resting an area can encourage both bush encroachment and the overgrazing of preferred grass species when undesirable species escape grazing, mature, and become unpalatable (Forbes and Trollope 1991). Finally, the environmental literature on grazing in Botswana is large and sharply divided between those observers who perceive widespread degradation and those who do not. While too voluminous to discuss here, a comprehensive and even-handed review of this material has been provided by Dahlberg (1996).

In conclusion

Range management has never been a culturally free and wholly objective undertaking. As an applied science, range management was developed in the western United States to address the needs of large-scale commercial producers who had recently occupied perennial grasslands. For this purpose, degradation could be conveniently identified by comparing current botanical conditions with those that prevailed before the introduction of domestic stock. These evaluation techniques were easily adapted to settler-dominated areas outside North America, such as Australia and parts of East and Southern Africa.

But this approach has little relevance to the open rangelands of semi-arid Africa. The Sahel is characterised by a combination of extremely infertile soils, erratic rainfall, and annual - as opposed to perennial - pastures. High stocking densities and overcrowding may be unacceptable, but are nonetheless a reality in the former homelands of South Africa and Zimbabwe, though some of the residents of these homelands can look over fences on to neighbours who do have enough land to indulge in the pleasures of mainstream range management. And in North and East Africa there is no credible botanical 'before'. Our species evolved in East Africa, and the Pleistocene is a long time to have to reach backwards for vegetative benchmarks. Given its central geographical location, North Africa entered early into the Neolithic, and was intensively exploited in Classical times. These are thoroughly domesticated, intensively used and ecologically distinctive landscapes in which the notions of 'natural' and 'pristine' lack practical significance as a yardstick for judging the sustainability of current husbandry systems. Africa, it would seem, affords us an opportunity to develop a more inclusive concept of rangeland degradation, one that is not tied to a particular continent or privileged settlement pattern.

This is a practical as well as a theoretical undertaking. The literature abounds with descriptions of rangeland degradation. But we should not forget our larger purpose, which is not just to describe disasters but to mitigate and prevent them. For a variety of reasons, many African governments exert a relatively superficial influence on rural affairs in their countries. Especially in sparsely settled and unproductive dryland areas, those who really manage the land are those who use it. If the scientific community is to influence land use it must retain a capacity to converse with these herders and farmers, as well as with policy makers and with ourselves. Scientifically defensible and locally relevant notions of carrying capacity and degradation are an important part of maintaining these links. Lose them and we will have many more disasters to describe.

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