NEW ECOLOGICAL PERCEPTIONS OF ARID RANGELANDS

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ABSTRACT

The range succession model explains fluctuations in vegetation as an orderly change between different vegetation states due to the interaction of - and eventual equilibrium between - the inherent successional tendency of plants (improving the range towards climax condition) and grazing pressure (causing range deterioration and a pioneer condition). This model does not accurately describe and predict changes in arid and semi-arid vegetation communities and is therefore of limited value to the rangeland manager. Consequently, a new model was developed in 1989, but is still untested in the Namibian environment. According to the new state-and-transition model, vegetation can occur in a variety of states with transitions between states occurring in an orderly fashion or not. However, all states and all transitions can be described and this catalogue will extend as knowledge of the ecology of arid rangeland increases. Natural events (primarily rainfall, but also fire) or man-made events (e.g. rangeland management) drive transitions between different states. In Namibia's highly-pulsed environment, the vegetation is in a constant state of inequilibrium because events follow each other rapidly. This has serious implications for the traditional rangeland manager, who prefers a fairly rigid management programme set by a calendar and not the condition of the vegetation. If the state-and-transition model proves to be an accurate reflection of the ecology of Namibian rangeland, the rangeland manager must become more flexible and opportunistic. Several principles of opportunistic range management are discussed, which might serve as a guideline towards developing an appropriate management style for arid rangeland.

INTRODUCTION

In theory, rangeland managers manipulate the productivity and condition of natural veld to achieve the highest possible animal production off the veld without causing veld degradation. In practice, veld degradation often results because the aim of preventing veld degradation remains a theoretical objective only, or because of insufficient knowledge of the ecology of Namibian rangeland. A correct understanding of the veld and factors which cause it to change, is of course essential in order to manage the veld efficiently and manipulate it to achieve farming objectives. It has long been understood that models and theories are tools that aid this process (Fraser & Lugg, 1962). However, it is vital that the model accurately reflects what is going on in the plant community, otherwise it will lead range management down the wrong track.

THE RANGE SUCCESSION MODEL

The most widely accepted model which explains changes in the vegetation community is the range succession model, which was developed at the beginning of this century in northern America and is based on Clementsian concepts of plant ecology. It supposes that the state of a given rangeland varies in a continuum and is determined primarily by two opposing forces, viz. the inherent successional tendency of plants to develop into more productive and stable communities and grazing pressure, which forces plant communities back into less developed states. The most highly developed and stable state is achieved in the absence of grazing and is termed the climax (Holecheck et al., 1995). As grazing pressure on the vegetation increases, its state is continually reduced towards less well-developed states, termed sub-climax states, until eventually the rangeland is heavily grazed, highly degraded and poorly developed. This state is termed a pioneer state. The manager can achieve a stable state in his rangeland by manipulating the grazing pressure until a balance is reached between these two opposing forces, stabilising the vegetation at a state which suits his purpose (Figure 1). This situation is termed an equilibrium.

Other factors than plants' inherent successional tendency and grazing pressure also help in shaping the vegetation, but work in similar ways as these two main factors. Drought for instance affects vegetation in a similar way to grazing, therefore management should respond to drought by reducing grazing pressure to maintain equilibrium. Similarly, successional tendency is accelerated in years of above-average rainfall (Fig. 2) and can be balanced by increased grazing.

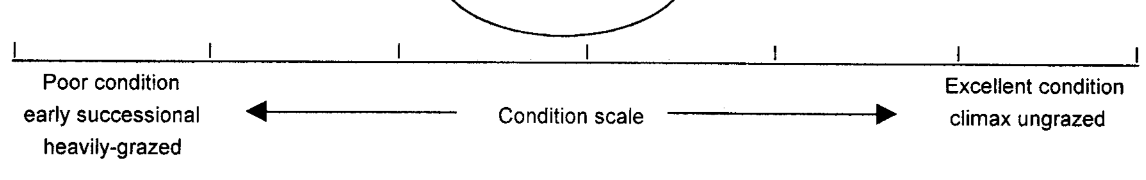


Figure 1. General scheme of the Range Succession Model (Westoby et al., 1989).

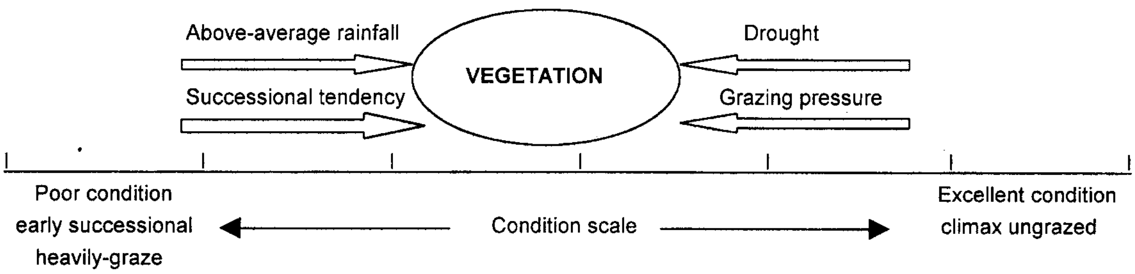


Figure 2. The Range Succession Model incorporating rainfall variability (Westoby et al., 1989).

CRITICISM OF THE RANGE SUCCESSION MODEL

The range succession model accurately explains vegetation changes in humid areas. Here, rainfall is high and occurs regularly so that the inherent successional tendency of plants occurs in a continuum from pioneer through sub-climax to climax states. However, in arid and semi-arid areas, plant succession is not continuous nor is it consistent. Sometimes, it is not even reversible (Westoby et al., 1989). The range succession model does not adequately explain these unorderly changes in states because they are not primarily the result of grazing pressure or successional tendencies.

In arid and semi-arid areas, rainfall dominates all other factors that affect vegetation states. As every Namibian farmer knows, there is no veld to be grazed during a prolonged drought, irrespective of the grazing pressure applied to the range in the preceding seasons. Similarly, Namibian veld types are known to be resilient and able to recover rapidly in seasons of high rainfall, even if fairly heavily grazed. These examples demonstrate that changes occur in the vegetation due to the rainfall it receives and less as a result of grazing pressure. In fact, the carrying capacity of an arid range can be modeled directly on rainfall, incorporating factors such as efficiency of rainfall use, animal dry matter intake and acceptable utilization of the range plants (grasses) as constants (Sweet, 1997a; 1997b):

Carrying capacity (ha/LSU) = 1/(mm mean annual rainfall x 0,00034)

In addition, rainfall in arid areas is highly erratic and unpredictable, causing frequent disruption of vegetation states. The vegetation has hardly recovered from one climatic event when the next one strikes. The vegetation in a highly-pulsed environment like Namibia's is in constant flux, in a constant state of inequilibrium, and a balance between opposing forces is not attained (Westoby et al., 1989).

African savannas are mostly in the arid and semi-arid zones of sub-Saharan Africa, wedged between tropical rainforests and subtropical deserts. They support the biggest diversity of herbivore species and the largest animal biomass of any land ecosystem in the world (Eltringham, 1979; Skarpe, 1991). The herbivores exert enormous grazing pressure on the vegetation, yet it is in climax condition. The vegetation of African savannas evolved together with their herbivory and the plants need defoliation just as much as the herbivores need plant food (McNaughton, 1979). Remove the grazing pressure and the vegetation will become less productive and less resilient. These observations are in direct contrast with the range succession model as the climax state can only be achieved in the absence of grazing.

Grazing pressure and stocking rate are essential concepts of the range succession model, yet they are highly subjective terms and depend on management objectives. Different interpretations of stocking rate will influence the equilibrium state of the vegetation and lead to incorrect management. Behnke (1997) and Behnke and Abel (1996a, 1996b) have argued conclusively that stocking rate changes with a manager's objective and that much of the overstocking and part of the degradation debate is based on misconceptions between people who do not realize that they have different management objectives and therefore different stocking rates, all within the ecological carrying capacity of the range. Their arguments are briefly repeated here to illustrate the variability of the concept "stocking rate" and its implications for the range succession model and rangeland management.

On a curve that depicts animal output (in terms of individual animal output as well as total animal output per unit area) versus the stocking rate, at least three different stocking rates can clearly be identified as management objectives (Fig. 3). They are MN, MY and K. At stocking rate MN, the number of animals on the range is small enough to prevent competition between animals for feed, allow each animal maximum nutrition and therefore enables each animal to perform to the maximum of its genetic ability. Total animal output per unit area has not yet been maximised, but individual animal production has. This stocking rate interests the stud breeder or any other farmer who sells animals based on their own performance or genetic merit.

At a second stocking rate MY, the number of animals utilising the range has been increased to such an extent that they compete for feed, consume less than they could and therefore perform at a lower level than genetically possible. However, the number of animals is high enough to compensate for the decrease in individual animal performance to such an extent that total animal output per unit area is at a maximum, being a function of both the number of animals and their individual output. This stocking rate is of interest to the "intensive" livestock farmer, who aims for the highest possible animal production off his primary resource, the veld.

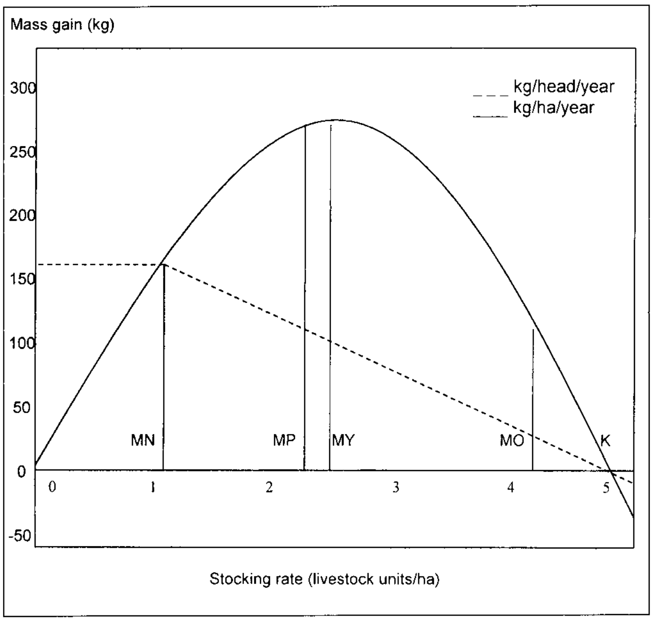


Figure 3. Biologically and economically optimal stocking rates (adapted from Behnke, 1997).

At stocking rate K, the number of animals on the range is very high and competition for feed is intense. Animals barely stay alive, they die at the same rate than young ones are born and gain no weight because they are at maintenance level. This stocking rate is termed the ecological carrying capacity as it represents the absolute maximum number of animals that could be sustained on the range. It might be of interest to the game farmer or parks officer who wants to maximise the number and diversity of animals on a range.

Another two target stocking rates can be identified on Fig. 3 on economic grounds. The first is MP, the stocking rate at which maximum profit is obtained. This occurs at a slightly lower stocking rate than MY, since profit is only made as long as the return is larger than the cost or investment. This does not happen at MY, where return = cost, but at a unit below MY, i.e. the last unit that still yields a return higher than its cost. This stocking rate is of interest to the "businessman" farmer who aims to maximise profit from his farm.

The second economically important stocking rate is at MO, slightly below K. At this very high stocking rate, the animals are performing at a very low individual level since competition for feed is intense. However, they still generate an income, however slight, since they are slightly above maintenance level. This stocking rate is a management objective in communal areas, since even communal subsistence farmers need incidental income to pay for certain expenses, e.g. access to controlled boreholes (Christian, 1998). It represents the maximum number of livestock still capable of earning a small income for their owner and since livestock customarily belongs to many owners, it also accommodates a maximum number of owners, i.e. open access to the grazing lands.

Accusations of overstocking are based on a misunderstanding of different management objectives, since different aims require different stocking rates (Behnke & Abel, 1996a). "Grazing pressure" needs to be carefully defined before being inserted into the range succession model, since one farmer's overstocking may be the next farmer's understocking.

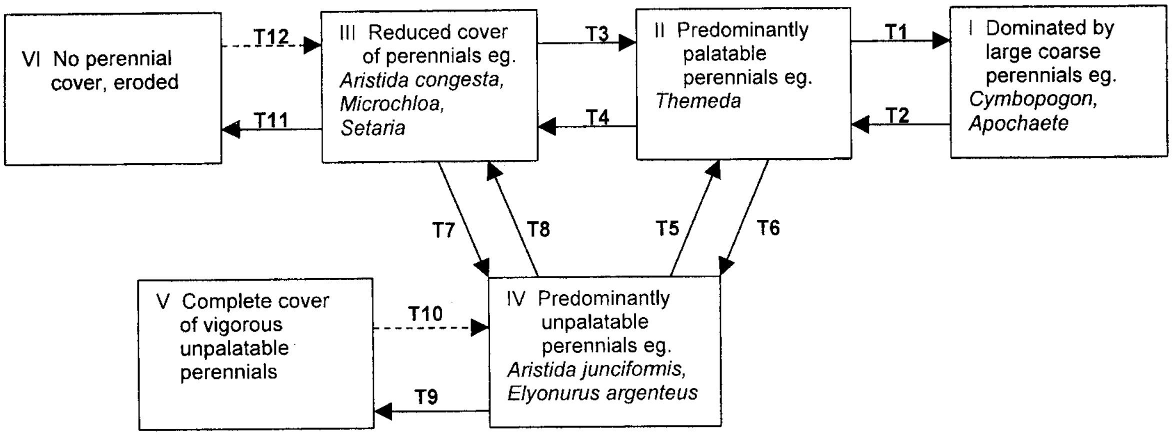
These then in short are some of the criticisms leveled at the range succession model. Over time, it became evident that this model did not satisfactorily explain changes in the semi-arid and arid rangeland and a new model was required.

THE STATE-AND-TRANSITION MODEL

The state-and-transition model was formally proposed by Westoby and co-workers in 1989 to substitute the range succession model in arid and semi-arid areas, although its origins can be traced a long way back (Walter & Vlok, 1954; Westoby, 1980). It states that vegetation communities can exist in several discrete states and can change from one state to the next by means of a transition that was caused by an event. Changes between states can be orderly and consistent or not, depending on the event that caused the transition(s). However, all states and all transitions can be clearly described and this catalogue will probably expand as knowledge of arid environments increases. Events can be natural (e.g. climate, fire) or man-made (e.g. grazing management, veld reinforcement, destruction or introduction of plants) or a combination of these, but the dominant event is rainfall. This model abstracts and summarizes knowledge about range dynamics without distortion, as it is purely a descriptive model. Although no state-and-transition model has yet been compiled for a Namibian veld type, an example for tall grassveld in South Africa is presented in Figure 4.

The veld manager is a tactician who has to identify the various transitions which might take place at any one time and decide whether they present an opportunity or a hazard. Opportunities are to be exploited and hazards must be avoided or, if they cannot be avoided, then at least their damage must be contained. By understanding which events cause what kind of transition(s), the veld manager can adjust his management in time. This enables him to react proactively, which is unusual in a field shaped by reaction to nature and crisis management. Traditional farm managers tend to follow a fairly rigid, calendar-bound management programme that does not suit the opportunistic and flexible management style required if arid rangeland indeed change according to the state-and-transition model.

However, managers also need supportive structures that augment opportunistic management. If, for example, a sudden drought forces a grazier to rapidly sell some of his livestock, even if they are not yet in a marketable condition, market structures that are able to absorb these sudden fluxes are needed (Scoones, 1994). If rainfall does indeed play a dominant role in determining the state of the range, and meteorologists are increasingly able to forecast unusual meteorological events such as this year's El Nino successfully (Hutchinson, 1993; Olszewski, 1993), then range managers will enter a new phase of opportunistic management suited to our highly variable environmental conditions, which would have a positive effect on the whole Namibian economy.



Catalogue of States

State I. Dominated by large, coarse perennial grasses, eg. *Cymbopogon excavatus, Apochaete hispida* (so-called 'increaser 1' species).

State II. Dominated by palatable perennial grasses such as *Themeda triandra, Eragrostis racemosa, E. capansis* (so-called 'decreaser' species). Lesser percentages of various increaser species types.

State III. Dominated by grasses such as *Aristida congesta, Microchloa caffra, Setaria flabellata* (so-called 'increaser 2' species), with substantial bare ground, and many annuals and microperennials (short grasses).

State IV. Dominated by large, established tufts of unpalatable grasses such as *Aristida junciformis, Elyonurus argenteus* (so-called 'increser 3' species) with little bare ground. Lesser but significant amounts of decreaser and increaser 2 species (see States II and III).

State V. Vigorous full cover of increaser 3 species (see State IV).

State VI. Bare ground and annuals.

Catalogue of Transitions

Transition 1. According to one hypothesis is due to 'overresting'; others regard State I as a variant of State II perhaps due to local soil effects; others again would group State I with State IV.

Transition 2. Light grazing.

Transition 3. Complete or nearly-complete relaxation of grazing pressure.

Transition 4. Moderate-to-heavy grazing imposed in a way which does not allow animals to avoid eating unpalatable species.

Transition 5. According to one hypothesis does not occur, since palatable grasses are not capable of increasing in the face of established dominance by the unpalatable perennials. Others believe this transition does occur given total destocking, but is very slow. There is also a hypothesis that relative competitive advantage can be shifted by exact timing of grazing at the beginning of a wet season. Under this hypothesis, which grass grows best varies from year to year, depending on when the first rain falls and on the sequence of early rains. Thus Transition 5 could be assisted by selecting years in which the palatable grasses are favoured and grow best, and grazing very lightly during this period of early growth.

Transition 6. Moderate grazing which allows animals to choose palatable species and avoid unpalatable species; by this means competitive advantage shifts to the unpalatable 'increaser 3' species. Most commonly this would come about under moderate set-stocking. Another factor might be early-season grazing in years when palatable grasses are disadvantaged by the pattern of rainfall (see Transition 5).

Transition 7. Comes about if grazing pressure is relaxed but not as completely as for Transition 3, so that while biomass and ground cover accumulate in all plant groups, there is selection against palatable species.

Transition 8. Very heavy grazing in short bursts, and/or burning. It is not well understood what exact amounts or sequences of heavy grazing or fire can counter the competitive advantage of unpalatable species without demolishing the capacity of the palatable perennials to regenerate.

Transition 9. Same processes as Transition 6, continuing to the point where dominance by unpalatable grasses is complete.

Transition 10. Very slow, or in practical manage terms not a feasible transition, because in State V virtually all the sward is occupied by large, vigorous, established tussocks of unpalatable grasses.

Transition 11. Continued heavy grazing to the point where neither tussocks nor seed bank of perennial grasses remain, and soil erosion is serious.

Transition 12. Only possible with soil reclamation work and reseeding.

Opportunities and Hazards

There are 2 principal routes by which the productive capacity of the rangeland can be degraded. One is simple overgrazing, down the route from State II to State III and ultimately to State VI. The most serious hazard is the route from State II to State IV and ultimately to State V. This is a more serious hazard both because Transition 6 can be made at quite moderate levels of stocking compared to Transition 4, and because recovery from State IV is much slower than from State III. An important variant hazard is that if one seeks to recover from State III to State II by reducing grazing pressure, and if that is done in such a way that the remaining grazing is selective against palatable species, there is a serious risk of making Transition 7 rather than the desired Transition 3.

Two types of opportunity for returning from State IV to State II deserve mentioning. One is the possibility that the return can be made much more quickly via Transition 8 followed by Transition 3 than by Transition 5. The other is the possibility that there exist windows of time in some years at the beginning of growing seasons in which unpalatable grasses are more vulnerable to grazing than palatable grasses, and vice versa in other years. By identifying such years and grazing heavily during such windows of time it might be possible to direct grazing pressure strongly against unpalatable species.

Allied Situations

Rangelands with similar features occur in British hill pastures, which become dominated by the unpalatable *Nardus* if grazed in a way which selects too strongly against palatable *Agrostis* and *Festuca* species.

Figure 4. A State-and Transition-Model for tall grassveld in South Africa with a catalogue of states and transitions as well as management hazards and opportunities (Westoby et al., 1989).

SUGGESTED PRINCIPLES OF OPPORTUNISTIC RANGE MANAGEMENT

If acceptance of the state-and-transition model by the scientific community leads to a change in management style of rangeland managers from rigid, pre-planned to flexible, pro-active and opportunistic, then scientists must also supply some guidelines as to what constitutes opportunistic rangeland management. The following principles are therefore offered for discussion on whether they are relevant to the current situation.

Flexibility means to adjust quickly to changing conditions, but opportunistic management refers to the ability of the manager to make use of suddenly and unpredictably appearing good opportunities because he was prepared for this eventuality occurring, with the only uncertainty being *exactly when* it would occur. Similarly, the manager has alternative action plans ready for sudden hazards and is able to apply pro-active damage-control. Principles of opportunistic range management should include that stocking rates should track the rainfall, flexible herd composition, a grazing system that simulates natural patterns of rangeland use, fodder banking, purposeful rotational resting of the veld, preventing successive grazing of perennial grasses at the same phenophase, using fire and hay-making opportunistically as management tools, mixing grazing and browsing species of livestock and using indigenous breeds as baseline breeds. Surely, other principles could be added to this list and priorities can be reassigned.

Probably the most important conclusion that arises from the state-and-transition model is that livestock numbers should track the rainfall (Behnke & Scoones, 1992; Behnke & Kerven, 1994). Since rangeland productivity and condition depend primarily on rainfall, livestock numbers should be adjusted according to the rain received, with as short a delay period as possible to reduce stress on the environment in the face of an approaching drought or minimise lost opportunity when the rains resume again. Namibian farmers will profit from a habit of measuring the carrying capacity of their veld on at least an annual basis, since this would enable them to destock or restock rapidly according to the available fodder and be in harmony with an ever-changing environment. This increases the sustainability of the farming enterprise, reduces grazing pressure on drought-stricken veld and exploits opportunities presented by good rains and rapidly growing veld. There are many satisfactory methods of measuring the condition and productivity of veld, some tailored especially to Namibian conditions (Lubbe, 1997).

However, to be able to respond quickly to increases or decreases in the fodder supply by increasing or decreasing the number of livestock on the range respectively, a farmer has to have access to stock reservoirs when restocking and processing facilities which can cope with a sudden influx of disposed livestock when destocking. It is probably more difficult to obtain livestock at the end of a drought, when most farmers are in a herd-rebuilding phase, than it is to get rid of surplus livestock at the onset of a drought. Fortunately, a drought seldom strikes all of Namibia at once and with the same severity (Hutchinson, 1993). District-sized pockets of good grazing remain productive even while the country is in the grip of a drought and may serve as a pool from which to restock once the drought has passed. A large number of commercial beef farmers follow a weaner production system that supplies feedlots with young growing stock for fattening. After a drought, when the price of grains used in fattening diets is still high because of recent crop failures but rangeland productivity is already increasing rapidly, it is conceivable that a grazier could compete successfully with the big feedlot companies for the purchase of weaners from weaner production systems and use them to grow out on his newly productive rangeland.

When farmers are warned in advance of an impending drought, as they were this year of the El Nino drought, they can dispose of surplus animals in good time, while they are still in a marketable condition and can obtain a fair price. If the farmer holds on to his livestock for too long, they will not only have lost condition, but he will also be selling at a stage when most farmers are forced to sell, and the market is saturated, prices are low and the farmer suffers a loss on his investment. The commercial farmer in Namibia at least is served by an existing marketing and processing infrastructure (Rawlinson, 1994) and should be able to destock profitably, but the communal farmer is not in the same position (Holtzman & Kulibaba, 1995). In the communal areas, such structures still have to be created or are in the process of being created, but the attachment of the communal farmer to his livestock, which is his wealth and status, presents an additional psychological barrier to this type of flexibility. Traditional pastoralists used to be nomadic, simply escaping the effect of a localised drought through transhumance (Behnke & Scoones, 1992; Dahlberg, 1994), but this option is increasingly unavailable due to increasing human population density (Anon., 1994).

Apart from the farmer's marketing and support systems, his herd has to be flexible enough to enable him to destock and restock rapidly in the first place. Most conventional livestock enterprises are not geared towards marketing a sizeable number of animals at an unforeseen stage, since most herds contain too high a proportion of breeding animals to possess the required degree of flexibility. While any emergency sale of livestock helps to postpone or alleviate the effect of drought, it is empirically estimated that a farmer should reduce his herd's feed consumption capacity by at least one-third in order to make a significant saving on the reduced availability of rangeland feed, although the grazier can select the probability level best suited to his conditions (Danckwerts & Tainton, 1996). Setting the level of breeding animals at a low but stable level and filling the remaining carrying capacity with readily disposable animals such as young, growing-out stock, castrates and replacement females enables the grazier to react to dry spells by disposing of filler livestock without having to cut into his real capital, the breeding herd (except if conditions deteriorate catastrophically) and react to wet cycles by retaining all home-bred progeny and purchasing additional fillers. However, the herd has to be actively managed to increase the proportion of fillers and the degree of flexibility this provides.

A system of controlled selective grazing (CSG), making use of a relatively low stocking rate and long grazing periods, has been used in Namibia with a fair amount of success (Bester, 1993). However, when compared to the way wildlife utilizes the range, it is doubtful that CSG simulates natural utilization patterns. Before the advent of commercial farming, huge herds of herbivores used to roam the veld (Skinner & Smithers (1990) mention a herd of springbok 120 km long and 18 km wide!), exerting enormous grazing pressure on the range but for relatively short periods of time. Wild herbivores were constantly on the move: the more a species relies on grazing, the more migratory it is (Eltringham, 1979). Traditional pastoralism, with its pattern of transhumance (shifting people and their livestock in space and time between exhausted and fresh resources), resembles natural utilization patterns far more accurately than most commercial grazing practices.

A grazing system based on the principle of short duration grazing (SDG) is possibly much more in line with natural rangeland use than the CSG advocated currently. However, SDG has cost implications because it demands more intensive fencing. In unskilled hands, its destructive potential is frightening: a large concentration of livestock restricted to a small camp can irreparably damage the vegetation. Even in the late 1970's, it was still possible for Namibian commercial farmers to use a similar escape mechanism to that of traditional pastoralists, by moving their herds temporarily to government-owned drought grazing reserves. The notion that all land has to be in production (i.e. none can lie in reserve) and increasing commercialisation put paid to this last escape mechanism and now farmers have to endure a drought on their own farms, allowing their veld hardly any opportunity to recover. When a farmer is able to evacuate his farm during a drought, and return only once his veld has recovered, the grazing system (whether CSG or SDG) is possibly less crucial than when the veld has to endure grazing even during a drought.

Fodder banking is a principle of opportunistic management that is already widely adopted by Namibian farmers. Whenever the rains are good and result in a surplus of grazing, farmers put aside some of the surplus in the form of hay or foggage (deferred grazing) to be utilised during the next dry spell. In fact, deferred grazing is an integral part of most grazing systems advocated in Namibia (Joubert, 1974; Bester, 1993), serving at once the need to accumulate a fodder bank and to rest a proportion of the farm each year for a full growing season. The proportion of rested veld increases with the aridity of the farm, from as little as 10% of the farm in the northern regions to as much as 33% in the dry south of Namibia.

Similarly, purposeful resting of veld is an integral part of many of the grazing systems advocated in Namibia today (Bester, 1993), acknowledging the ecological requirement of the most important grazing plants to be spared occasionally during the most critical stages of their lifecycle, when grazing would be at its most harmful. It is of course only possible to rest veld if there is sufficient other veld available for grazing at the same phenophase. Rotational grazing systems were designed to achieve this, since a mere withdrawal of a camp from grazing (e.g. during the vegetative dormant phenophase in winter) does not necessarily constitute an effective resting opportunity for the plants.

Another effect of the rotational grazing systems in widespread use in Namibia is to avoid grazing the same camp at a similar stage of development for several consecutive seasons. Successive defoliation during the most sensitive phenophases (commencement growth in spring/early summer and translocation in late summer/autumn) must be avoided to retain the vigour of the natural vegetation. A grazing system which regularly "forgets" this aspect is the otherwise progressive system of open rotation grazing. However, this is probably less a fault of the system than its improper implementation. Even the best grazing system can be corrupted by improper implementation whereas capable management can rescue a poor system.

The above four principles of opportunistic rangeland management (the type of grazing system, fodder banking, rotational resting and preventing successive grazing at the same phenophase) are part of most grazing systems already in use in Namibia, have been discussed by the farming population for many years and find widespread application (Versveld et al., 1988). One is left with the impression that farmers think they have now done enough and need not adapt further to our variable environment. However, some important principles remain:

Fire is the declared enemy of most commercial farmers in Namibia and understandably so considering its short-term destructiveness. However, fire is also a natural event in arid and highly seasonal rangeland (Trollope, 1993) and plays an important part in maintaining the balance between woody and herbaceous plants in the African savanna (Smit et al., 1996). It modifies savanna vegetation in a way which cannot be explained by the range succession model (Teague & Smit, 1992). Considering the large amount of effort and money spent on more artificial means of bush control (especially chemical and mechanical measures), it seems logical to suggest that the emphasis should change from preventing fire at all costs to utilizing it constructively to achieve certain management objectives.

The foremost requirement of a constructive veld fire is that it should be hot enough to effectively kill small- and medium-sized woody plants, the main components of bush encroachment. This is only possible if there is at least 2 t/ha of combustible dry matter (primarily grass) on the veld, otherwise the fuel load is insufficient to cause a hot-enough fire. Such an accumulation of surplus grass dry matter will only occur occasionally, following exceptional rains (witness the uncontrolled veld fires which ravaged the Witvlei area at the start of the 1997/98 rainy season following the exceptional 1996/97 rains, causing loss of livestock and several human lives) and farmers should make use of these rare events to enlist fire as a management tool rather than an enemy. Conditions under which a fire can be used constructively have been well researched and are widely known (e.g. Trollope, 1993), yet the widespread fear of fire persists. An alternative, but without the beneficial effect on bush encroachment, is to stack the surplus grass away as hay.

Finally, opportunistic rangeland management should employ a mix of domestic livestock species and use indigenous breeds more widely. A wide spectrum of herbivore species utilize arid rangeland in the wild, separated from each other ecologically while occurring side by side, thereby preventing competition for feed and increasing the efficiency of utilization of the available vegetation (Eltringham, 1979). The most common species of domestic livestock in Namibia are cattle and sheep, both grazers, while goats (the only browsing species) are really numerous only in the communal areas (MAWRD, 1997). Effectively, a large proportion of Namibian rangeland is utilised by a monoculture of grazers, quite unlike the natural situation and with devastating results for the balance between woody and herbaceous plants in the savanna.

In addition, indigenous breeds of livestock are much better adapted to our variable environment, survive droughts in a better condition and are more productive than exotic breeds (Hetzel, 1988) and should be much more widely used, if only in a crossbreeding programme with exotic breeds with more desirable production characteristics (Moyo et al., 1996). Indigenous breeds have had up to 2000 years to adapt to local conditions and have an indisputable advantage over exotic breeds when it comes to animal output per unit area in an unfavourable environment. Although the popularity of browsing species such as the goat (helped along by the growth in the game farming sector) and of indigenous breeds is increasing steadily, much more can still be done in this regard to increase the flexibility and sustainability of Namibian rangeland management.

This list of principles of opportunistic rangeland management is certainly not complete and much of the proof is still outstanding. Its purpose is to encourage discussion and a thorough rethinking of our attitude towards a highly variable primary resource of great importance and how we utilize it. Degradation of the Namibian range is widespread, irrespective of whether the land is used commercially or communally (Bester & Reed, 1997) and has to be halted before this valuable resource is damaged beyond repair.

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