



VELD MANAGEMENT

SUSTAINABLE RANGELAND MANAGEMENT IN NAMIBIA



1. Acknowledgement

In the first half of 2008, the Namibia Agricultural Union called together a large number of land users and rangeland experts to think about a National Rangeland Strategy for Namibia. Part of this process was to identify the fundamental principles that promote the sustainable utilization of Namibia's natural rangelands. The following article is based on this process and due recognition and acknowledgement is given to all its participants; too numerous to mention.

2. The importance of natural rangelands to Namibia

Natural rangelands are what we in southern Africa call "veld"; the richly diverse natural vegetation on which we farm. The extensive animal production system in which domestic livestock and wild game animals roam freely over large areas of veld that may or may not be subdivided into camps, feeding on veld plants, is known internationally as "ranching". This enterprise is very important to Namibia because the majority of our population is in one way or another dependent on it, making a living of it or at least subsisting on animal products. Economically, products derived from ranching contribute about 80% to total agricultural production, which contributes between 5 and 10% to the national economy. In addition, rangelands are the foundation of our eco-tourism industry, making the landscape attractive to visitors and offering a habitat to innumerable wild plant and animal species. By some estimates, tourism and its related activities contribute 25% to Namibia's economy. All this activity is based on plants that grow naturally on the veld, which is why it is so very important to take good care of the natural rangelands so that future generations of Namibians may also make a good living from our natural rangelands. By preserving biodiversity, mankind invests in its future: the commercial exploitation of *Hoodia* spp. would not have been possible if they had been exterminated by over-exploitation.

Despite its omnipresence in all the wide open spaces of Namibia, natural rangeland is actually quite a fragile ecosystem that is easily damaged by natural disasters such as drought or fire or by incorrect veld management. Veld recovers readily from natural disasters because it co-evolved with these events for millions of years. Intensive human utilization, however, is a recent development of technological man and veld has yet to develop effective regenerative coping mechanisms. Thus, very often, if we damage veld through incorrect management, we cause irreparable harm which results in a dramatic loss of production and resilience: fewer and less diverse plants

grow on the veld, animals get less nourishment from it and the veld becomes progressively weaker and less able to recover from setbacks. The decline in animal production decreases the amount of food or money produced on ranches, which makes people poorer. To prevent creeping poverty, we have to learn how to utilize veld in a way that maintains its good health, vitality and productivity in the long term, i.e. its "sustainability". The following nine principles should help Namibian land users utilize their rangelands sustainably:

1. Know the resource and the most important indicator species
2. Plan the farm (ranch) so that forage is utilized effectively
3. Allow forage effective rest after defoliation
4. Adaptive forage management for farm animals
5. Restore the rangeland
6. Make provision for the next drought
7. Monitor rangeland utilization and use records to inform management
8. Take care of the soil
9. Take care of underground water resources

3. PRINCIPLE 1:

Know the resource and the most important indicator species

To manage something well, one needs to know as much as possible about it. What type of management is effective and causes a positive response and what actions have negative consequences? With veld, consequences often only manifest themselves many years after the initial event and it is difficult to link cause to effect. In addition, natural climatic events also cause veld to change, often masking the effect of current management and making it difficult to distinguish between man-made and natural effects. What information does one need about the rangeland, the natural resource that serves as the basis of production?

Of prime importance is information about the vegetation or veld type because every veld type requires its own particular management to be at its most productive and has a different value as feed for animals. This includes botanical information (e.g. the plants that grow in this veld type and their functional groups e.g. pioneer/sub-climax/climax grasses and annual/perennial grasses, etc.), biophysical information (e.g. the dominant soil types and land forms) and ecological understanding (e.g. how will the veld react to certain events like grazing, fire, drought?). How to apply this information is explained below.

Climatic information is also important, especially how much it rains and when (intra-seasonal distribution of rainfall), the highest temperature in summer and lowest in winter and the incidence of frost. These factors determine the length of the growing season of plants and how well woody plants will grow in an area. Information about the quantity and quality of underground resources of water are important as they provide people and livestock with drinking water and crops with irrigation water.

Natural rangelands attain their highest value when converted into animal products that feed or dress man. Therefore, the interaction between the primary resource (veld) and the secondary resource (animals) is very important. In particular, it is imperative to know which plants are preferred as feed by the animals of the land user, i.e. their "preferred forage species". This knowledge enables the land user to manipulate the natural rangeland to increase the abundance of preferred and decrease the abundance of unpreferred forage plants in the veld. If the preferred forage species are suffering and ailing, the present management does not suit them and should be adjusted (see also Principle 3). If unpreferred forage species increase in response to management, the rangeland is deteriorating and animal production will decrease (see also Principle 4). Some of the preferred and unpreferred forage species serve "indicator plants" because they show whether the condition of the veld is healthy or poor and indicate if current management can continue or should change. Therefore, every land user must have at least a basic botanical knowledge of the plants in his/her farming area to identify and know about the most important indicator plants.

difficult to achieve in Namibia's savanna rangeland, which are botanically very heterogeneous and consist of both woody and herbaceous plants of great diversity. It would be much easier to achieve effective utilization if the veld could be made more homogeneous botanically, offering a smaller diversity of forage plants to animals. This is the case with man-made cultivated pastures planted to one or just a few forage species, e.g. a land of "bloubuffel" grass (*Cenchrus ciliaris*). Selective foraging by animals can never be prevented completely but it can be minimized. It is important for the land user to know which forage species on his/her ranch are the ones preferred by animals, because these species will be the indicators of the effect of rangeland utilization on its condition. The choice of preferred forage by animals is affected by their stocking rate, as shown in Figure 1.

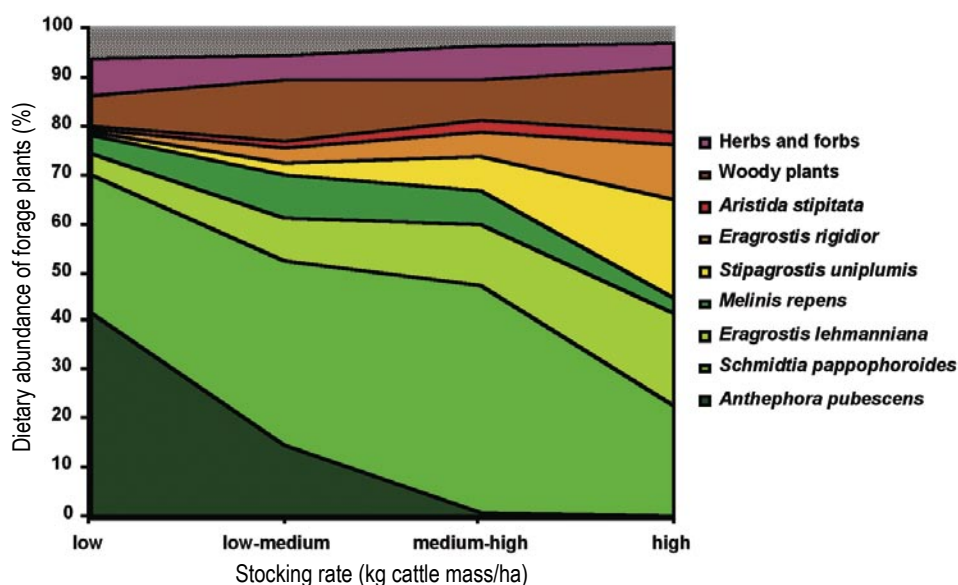


Figure 1: Changes in the composition of the diet of cattle caused by increasing the stocking rate of cattle and thus, competition for the most preferred forage species (Sandveld area)

4. PRINCIPLE 2: Plan the farm so that forage is utilized effectively

Animals convert rangeland plants into food and dress for mankind. "Forage" refers to all the animal feed produced by natural rangelands and is obtained either from woody plants like bushes and trees, in which case it is called "browse" and animals that rely mainly on this type of fodder are referred to as "browsers", or from grasses, herbs and forbs, which are collectively called the "herbaceous plants". Animals that feed mainly on herbaceous plants are called "grazers". Amongst domestic species of livestock, all cattle are predominantly grazers although indigenous breeds like the Sanga tend to browse more than exotic breeds, especially in the dry season (commonly known as "winter"). Most sheep are also grazers but some indigenous breeds like the Damara are actually mixed feeders, utilizing browse and herbaceous forage in about equal measure. In contrast, most meat-type goats are predominantly browsers. Amongst Namibia's wild game animals, there is a wide diversity of feeders, from grazers (e.g. zebra, gemsbok, hartebeest) to mixed feeders (e.g. eland, springbok, warthog) to browsers (e.g. giraffe, kudu, steenbok). Foraging habits of animals are strongly influenced by the season of the year: most browsers tend to graze a little bit during the rainy season, when grasses are young and succulent and similarly, many grazers browse more during the dry season, when grasses are dormant but browse is still green. Most of Namibia's domestic livestock graze, so the subsequent discussion will concentrate more on grazing than on browsing management.

The more effectively forage can be converted into animal products, the better for the land user. Effective utilization of forage can only be achieved if the tendency of animals to select preferred forage species first and leave others un- and underutilized can be countered as far as possible. This is very

The most common tool used in Namibia to make natural veld less heterogeneous botanically and to minimize selective foraging by animals is to separate different vegetation units or veld types by fences. Such fences are called "primary" fences. The best way to decide where to erect a primary fence is actually not by looking at the vegetation itself, but on the basis of topography (the shape of the land). Vegetation can change rapidly due to climatic and management factors and is thus not useful as a permanent distinction between different veld types. In contrast, the shape of the land does not change rapidly. In fact, in most Namibian rangeland ecosystems, it does not change at all within the lifetime of a land user. Typically, vegetation that grows on mountains is very different to what grows on mountain slopes or on hills, on flats (plains), in wet spots (leegtes, vleis, pans, marshes, etc.) or in dry spots, on sandy or on stony soils. These different veld types should all be separated from each other by primary fences (Figure 2) to create a greater degree of botanical homogeneity than before. It may not always be practical to fence small areas of a particular veld type or erect a fence on rocky ground or steep slopes, but the land user should try to separate different topographical units from each other as much as possible, within the constraints of practicality and the farm's budget. This will force animals to make more effective use of the forage within one unit as they have less choice of what and where to eat. It will also make it easier to manage each veld type correctly as each can now receive the particular type of management it requires to sustain itself. For example, river veld is much more productive, has a longer vegetative growing season and is less prone to bush encroachment and easier deforested than dry, hilly veld and therefore can be grazed and managed more intensively than dry plains.

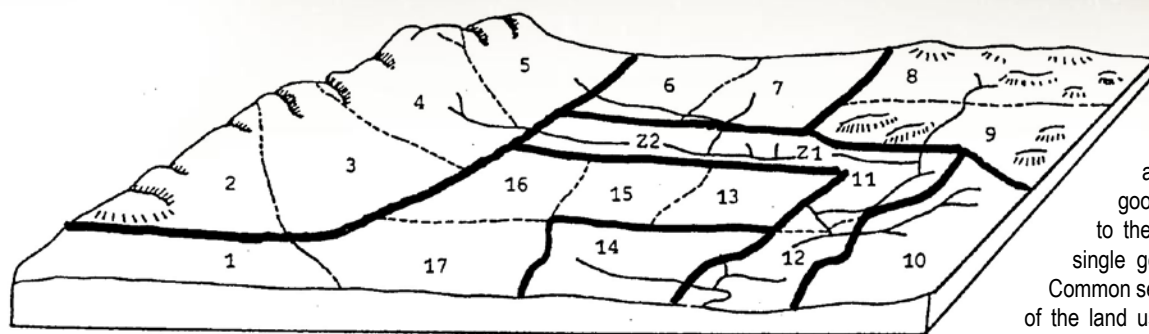


Figure 2: A farm (ranch) on which different topographical units, equivalent to veld types, are separated from each other by primary fences (indicated in bold) to facilitate sustainable rangeland management. The different veld types are in turn divided into smaller, secondary camps (indicated by dashed lines) to facilitate better animal and grazing management. After thorough planning, camps 2, 3, 4 and 5 contain mountain veld; camps 8 and 9 hilly veld; camps 1, 13, 15, 16 and 17 contain dry plains; camps 6, 7, 10 and 14 moister plains and camps 11, 12, Z1 and Z2 contain riverine vegetation. Camps Z1 and Z2 are also erosion camps due to the steeper slope of the river course and require special protection. On the ground, primary and secondary fences are indistinguishable, other than by their purpose.

Sub-dividing natural rangeland into areas of similar landform by primary fences may result in areas that are too large to be managed conveniently for animals, or are ill-supplied with drinking water for livestock. Consequently, primary blocks of veld are sub-divided further into smaller camps that suit a particular animal production system or the farm's water reticulation system. These fences are called "secondary" fences but are indistinguishable from primary fences. They look the same but their purpose differs drastically. Primary fences separate different vegetation units while secondary fences facilitate animal, grazing and farm management. For example, a stud breeder making use of a single-sire mating system requires more and smaller mating camps than a commercial meat producer relying on multiple-sire mating. And it is easier to apply effective recovery from grazing if there are many camps than if there are only a few. Every camp has of course to be supplied with the necessary infrastructure like drinking water, access gates, roads and kraals.

Herding can probably achieve the same effect as fencing, but then it has to be directed and follow a distinct pattern, rather than the herder being merely the guardian of livestock who prevents theft and losses. Fences and herding are tools that can achieve more efficient utilization of forage and allow defoliated plants sufficient recovery time before being defoliated again (see next Principle).

A farmer who takes over an established farm that is already fully planned and fenced has to identify the primary fences that separate distinct veld types on this farm so that s/he can apply type-specific rangeland management. Primary fences should follow the shape of the land closely while secondary camps are usually conveniently rectangular and clustered around a watering point. If the primary fences are in the wrong place (i.e. do not delineate the different veld types clearly), the farmer should strongly consider moving them. In contrast, since secondary fences merely serve the animal production system and make resting of camps easier, their exact location is not critical. If a farmer prefers a different grazing (camping) system to the one used to plan the farm originally, s/he can simply use the existing fences for the new system rather than spend a lot of money shifting secondary fences. It may make life easier, but at huge expense, with little effect on ecological sustainability. It is thus advisable that the existing secondary fencing system should be maintained and used to apply the principles of sustainable rangeland management

explained in this article rather than be changed every so often to follow the newest fad in grazing systems. Any grazing and camping system will yield good results if managed according to these principles and there is no single good or bad camping system. Common sense and the managerial ability of the land user are much more important than the exact location of secondary fences.

When has a forage plant been "effectively" utilised?

When most of its edible parts have been removed by a foraging animal without sacrificing the long-term vitality of the plant. It is difficult to give fixed indications of what constitutes "effective utilization" because it varies between plant species and environmental conditions. The more difficult it is for a plant to replace forage lost to animals, the less of it should be eaten at any one time. Most perennial grasses in Namibia co-evolved with grazing and may be grazed down as low as 10 cm during their growing season (when it rains). Grazing lower may endanger the lateral shoots (tillers) that are developing and elongating at the base of the tuft. Grazing grasses this short should happen fairly rapidly, in less than two weeks during the growing season, to avoid animals re-grazing a grass plant already reduced to stubble height during the same grazing opportunity. This would constitute a "second bite" that removes re-growth before it is mature enough and critically endangers the grass plant (see Principle 3). During the dormant season (in winter), perennial grasses can be grazed to an even lower stubble height over a longer period of time (e.g. two months) as their lateral shoots are now quite close to the ground (in the "crown" of the tuft) and do not grow.

Grazing height recommendations are complicated by the fact that preferred grasses are grazed down more uniformly than less preferred grasses, which are thinned (leaves grazed but stems left) rather than reduced to stubble. Thus, in a mixed stand of various perennial grass species, grazing should stop when preferred grasses such as *Anthephora pubescens*, *Brachiaria nigropedata*, *Digitaria eriantha* and *D. seriata*, *Panicum* species and *Schmidtia pappophoroides* are grazed down to the desired stubble height and not when the less palatable grass species have been grazed that low. Thus, preferred grass species should serve as indicators of when grazing has had its desired effect. Of course, the rancher can decide on which grass species to use as grazing indicators depending on their local abundance and the farming objectives. The danger is that if less palatable grass species such as *Eragrostis rigidior* and *Stipagrostis uniplumis* are used as indicators of when grazing should be stopped, more palatable grass species have already been grazed into oblivion. In addition, forcing animals to graze unpreferred grasses down to stubble height reduces the quality of their diet and decreases animal production. Animals that are constantly forced to eat every grass including less preferred species eventually become smaller and lose productivity, which can only be counter-acted by increased supplementary feeding of licks and hay.

Annual grasses can be grazed very low to the ground but should be allowed to set seed occasionally otherwise there will be no grass next season. Annual grasses depend on seed production to survive from year to year. Herbs and forbs are normally too aromatic to be grazed intensively. Their primary purpose is to supply small quantities of highly nutritious feed at critical times of the year rather than bulk. Woody plants should not have more than about one-quarter of their shoots removed before being allowed to recover from browsing, otherwise their growth rate is reduced too much. Note that most karoid dwarf shrubs have two growing seasons each year, when it is cooler during the early hot-dry season ("spring") and again when it cools off after the main rainy season ("autumn"). During these seasons,

they are especially sensitive to heavy browsing, which should be avoided. Browse normally contains more protein, minerals and vitamins than grasses, but is less digestible and has a lower energy content. Browse may also contain anti-nutrients such as tannins, which are more harmful to grazing than to browsing animals.

Effective utilization of forage is facilitated by supplementary feeding of licks to livestock animals. In Namibia, licks should only supplement the nutrients that are not already in the veld forage and should not substitute for forage; it's simply too expensive. Typically, a "winter lick" is given for most part of the year while the grasses are dry and dormant and a "summer lick" is given during the short rainy season. Summer lick contains mainly phosphorus (P) and salt. Most Namibian soils are deficient in P and it therefore has to be supplemented to animals. Only on good veld do livestock animals sometimes stop taking summer lick during the growing season, indicating that they derive enough P from actively growing vegetation. However, they still need salt because they lose a lot of salt in sweat and rock salt should then be provided ad lib. (freely, without restriction). Animals will regulate their own intake. In winter, dormant grass veld lacks protein, energy and vitamin A in addition to phosphorus. Vitamin A is best supplemented via injections since it is rapidly oxidized from feeds by the sun, but protein, small amounts of energy, phosphorus and salt are supplied in a "winter lick". It helps animals digest the dormant, dry forage better and increases feed intake, but has to be rationed and formulated correctly to avoid over-indulgence. Changing from winter to summer lick is crucial, not only in terms of animal production but also because most winter licks may not rain wet. Licks can be mixed at home using your own ingredients, but the correct formulation is critical to achieve effective nutrient supplementation and avoid poisoning of livestock. Unless the farmer knows what to do, it is best to leave the compiling of lick to professionals and buy ready-mixed licks in loose or even better, in block form. Licks compressed into blocks reduce wastage and the chance of poisoning. "Production licks" and "energy licks" do not supplement veld nutrients but substitute forage intake. Their role is primarily to facilitate special purposes such as fattening young animals prior to slaughter or flushing animals about to breed.

Effective utilization of forage must always be tempered by allowing the forage time to recover, otherwise there will be no forage during the next grazing cycle. That's why the next principle is one of the most important for sustainable rangeland management!

5. PRINCIPLE 3:

Allow forage effective rest after defoliation

Forage plants cannot be grazed without interruption or adequate recovery from a previous defoliation for they will lose their vitality fast and die off rapidly. Grasses can only make carbohydrate energy while they are green and photosynthesizing. If the green leaves are removed through grazing, fire or other defoliating agents faster than they can be replaced, the grass has to draw on its accumulated energy reserves to re-grow. These reserves are small and quickly depleted because grasses do not have large carbohydrate storage organs like tubers, bulbs or fleshy roots. That is why every land user should practice some kind of rotational grazing, be it with the help of fences and camps or herding or any other tool. The purpose of rotational grazing, in which a herd of animals is rotated cyclically between a number of camps or grazing areas, is to afford recently-defoliated plants sufficient time to recover from defoliation. Grasses will only re-grow if they can access soil moisture, therefore recovery from grazing can only take place during the rainy season; the vegetative growing season. Grasses do not recover from grazing by being rested in winter, or during a dry spell. Such rest periods do not constitute an effective recovery from grazing and the effect of grazing is vastly compounded by drought and aridity. It seems that perennial grasses that are allowed to set seed before being grazed again, have recovered

sufficiently from previous grazing and do not lose vigour (Figure 3). If grasses, especially perennial grasses, are re-grazed before having made seeds, they decline in vigour quickly and may die from (over)grazing within two seasons. Woody plants grow a lot slower than herbaceous plants and need a very long recovery period (several months) before being ready to be browsed again. They also have a longer growing season than grasses because they can access deeper soil water with their taproot system. To allow forage plants time to recover from previous grazing is much more important than how plants are defoliated.

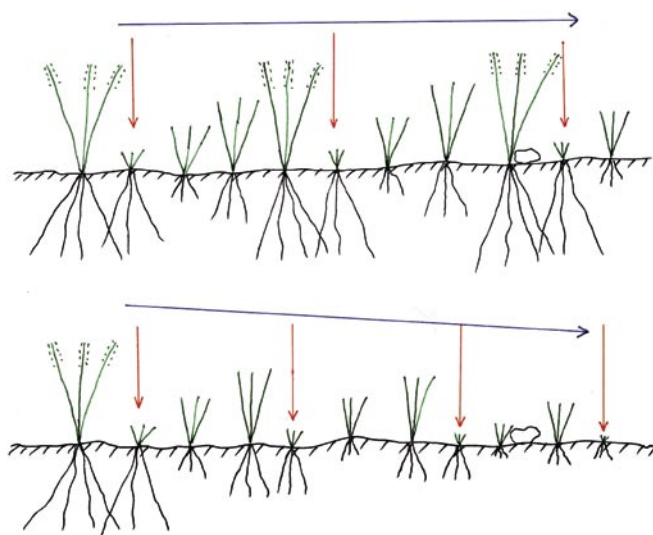


Figure 3: Grazing (red arrow) perennial grasses after allowing them sufficient time to recover to seed-set will retain their vigour (blue arrow, top) whereas too short a recovery period depletes their vigour (bottom). Notice the severe effect of grazing too soon on the underground root structure of the grass.

If animals stay in a camp or grazing area too long, they will repeatedly graze the same grass that they grazed before because young, rejuvenated grasses are more palatable and nutritious than older, mature tufts of the same species. The best way to avoid this "second bite" is to have multiple camps and move the animals out of one camp when its indicator grasses have been grazed down to an acceptable level (refer Principle 2). Animals should only return to this camp when the same indicator grasses have recovered to seed-stage, and this will only happen if it rained while the animals were absent (or if there is carry-over of soil moisture). If the land user has to return animals to a grazed camp before the indicator grasses have set seed again, s/he simply has too many animals. They will "second-bite" the most palatable grasses and if this happens a couple of times in succession, these grasses will die and animals will be forced to eat the next, less palatable grass; with a resultant decrease in veld nutritive value and animal productivity. If this pattern is repeated, perennial grasses will be replaced by annual grasses. When annual grasses become dominant, rangeland condition has already deteriorated. If it rains well, annual grasses are highly productive but they are not persistent and farming with them is a decidedly variable business, cyclically going from boom to bust. If annual grasses are constantly overgrazed, desertification results. Depending on ecological conditions, bush encroachment may intervene and prevent the creation of a true desert (plant-less or largely plant-less), but the land user is still in deep trouble.

Many grazing trials have shown that rotational grazing systems are as ineffective as continuous grazing in maintaining veld condition and vigour. This is because most rotational grazing systems depend on a pre-determined, fixed period of absence decided by the management calendar, e.g. 10 days grazing followed by 40 days rest. If it does not rain during these

40 days of rest, the grasses will not recover from the previous grazing and will still be immature and highly susceptible to grazing when the animals are re-introduced after 40 days. Even if it rained a little, the grasses may not have recovered sufficiently (i.e. to seed-set) and still remain highly vulnerable. Such a deterministic, non-adaptive grazing cycle that ignores the physiological requirements of the perennial grasses, which provide the bulk of Namibia's grazing, are indeed no better than continuous grazing and rapidly weaken the veld. Rotational grazing needs to incorporate effective recovery by perennial grasses from grazing, otherwise it is also a veld-killer! And since our rainfall is highly variable and erratic and cannot be predicted with accuracy, the length of the "rest" period should not be dictated from the office but evaluated in the field. This implies that recovery periods will be of variable length and grazing systems should be flexible. The camp that has best recovered from previous grazing should be grazed first whereas those camps whose grasses have not yet recovered sufficiently, should enjoy a longer rest period. In this manner, the vitality of the grass tufts will best be maintained.

Effective rotational grazing is easier if the land user has many camps to his/her disposal as this will make it possible to rest each camp longer and to choose which of the rested camps is most recovered and ready to be grazed again. The more camps are available to one herd of animals, the easier it is to allow for sufficient recovery from previous grazing, but after about 5 camps per herd, the incremental advantage of longer recovery due to more camps is negligible (Figure 4) and the decision of how many camps to assign to one herd is a practical one, balanced by budgetary and ecological constraints. A similar effect can be obtained by bunching and combining herds and thus reducing the number of herds during the rainy season. Stud breeders forced to practice single-sire mating with a large number of small dam herds are at a disadvantage here compared to those who can practice multiple-sire mating of a single, huge dam herd because most mating seasons coincide with the rainy season. In the absence of many camps, land users have to apply conservative stocking rates to avoid overgrazing of the valuable preferred perennial grasses and forages.

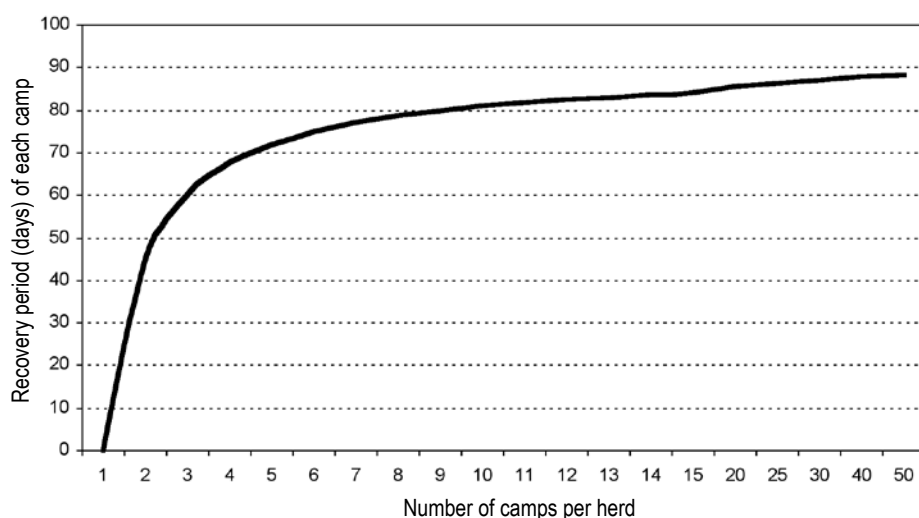


Figure 4: Relationship between the number of camps available per herd of animals and the length of the recovery period between two successive grazing events, if the total grazing cycle is 90 days long

Namibian experience has shown that, on its own, allowing rangeland sufficient recovery from previous grazing will not maintain long-term grass vitality and rangeland condition in our arid, variable climate. It appears that all rangeland should be allowed one complete growing season's rest every 3-5 years, depending on the aridity of the farming area. A growing season may start as early as November and end only in May. In a dry area (e.g.

southern and western Namibia), all veld should receive a growing season's rest every 3 years and as this is spread around the farm, in practice it means that one-third of the farm is rested every year from November to May. This part of the farm can be utilized for winter grazing, or as a drought reserve. In wetter parts (e.g. eastern and northern Namibia), the fraction of the ranch rested for the whole growing season can be reduced to one-fifth, and the one-fifths should be spread around so that the whole ranch was rested for a growing season after 5 years. The rested parts do not only provide excellent winter grazing, but can also be mown for hay production (see Principle 6) or burned for bush control (see Principle 4) and have a higher resilience against ecological set-backs such as drought or invasion by grass-eating harvester termites.

Additionally, veld may be rested for a particular purpose. Veld that is being reclaimed, fortified and restored may be rested for seed production in one year and for seedling establishment the next. Or, where fire is used to control bush, veld may be rested for one growing season to accumulate a lot of fuel, burned in the dormant season and rested again in the subsequent growing season to allow grasses to recover from the fire. In this manner, all grazed veld needs regular recovery and the occasional cure for a specific ailment. After all, if the land users' child develops an illness or a weakness, it is allowed to recuperate. But we expect our veld to produce year after year, drought after fire, without adequate rest?!

6. PRINCIPLE 4: Adaptive forage management for farm animals

One of the most essential principles that facilitates sustainable rangeland management, but also one of the most difficult to practice, is to stock the land according to its capacity. Rangeland produces forage in relation to the rainfall it receives and the fertility of the soil that nourishes the plants. Soil fertility does not vary from year to year but rainfall does and hence, the ability of rangeland to produce forage that supports animals, i.e. its carrying capacity, varies greatly from year to year. It should be obvious that the

number of animals that are allowed by the land user to utilize the rangeland, i.e. the stocking rate of animals, should not exceed its ability to support them. This is akin to a household living within its financial means; if it exceeds its income, it creates debts and problems for the household. In the case of rangeland, exceeding its carrying capacity by either having too many animals ("overstocking") or by allowing animals to utilize it for too long without adequate rest ("selective over-utilization") causes transformation and eventually degradation of the rangeland (Figure 5), loss of feeding value (Figure 6) and will eventually decrease animal production (Figure 7) and the income of the land user. To avoid this development, the land user should never exceed the carrying capacity of the range for long periods of time. The carrying capacity of rangeland and the stocking rate of animals are

both expressed in hectares per Large Stock Unit (ha/LSU) or in kg animal mass per hectare (kg AM/ha, the "biomass principle"). These units are inter-convertible because a LSU is defined as an imaginary animal of 450 kg mass, so that a carrying capacity of, say, 10 ha/LSU equals 45 kg AM/ha.

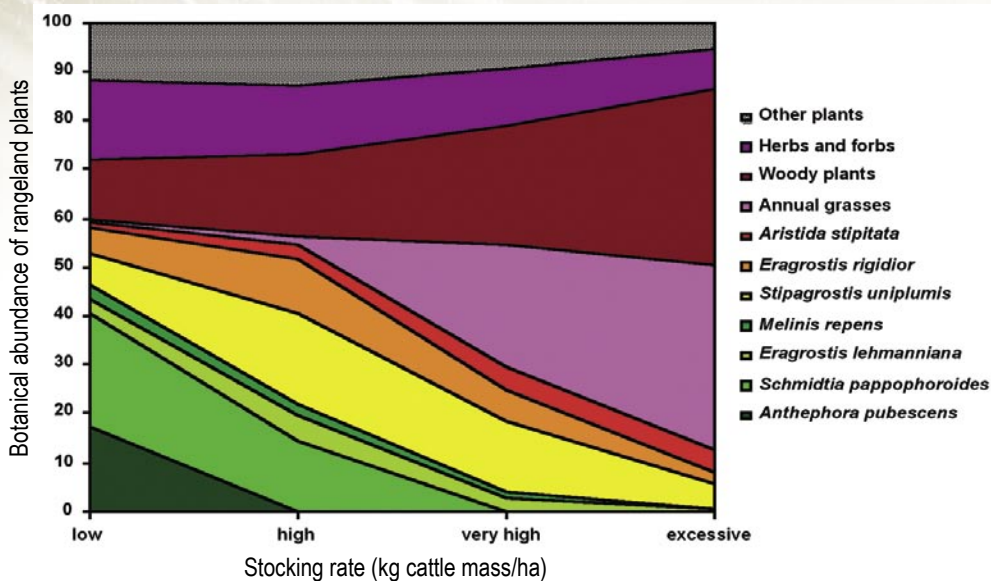


Figure 5: Increasing the stocking rate of grazing animals transforms the rangeland and eventually causes degradation. Note the threshold at 45-50 kg cattle mass/ha ("high") at which bush encroachment sets in (Sandveld area).

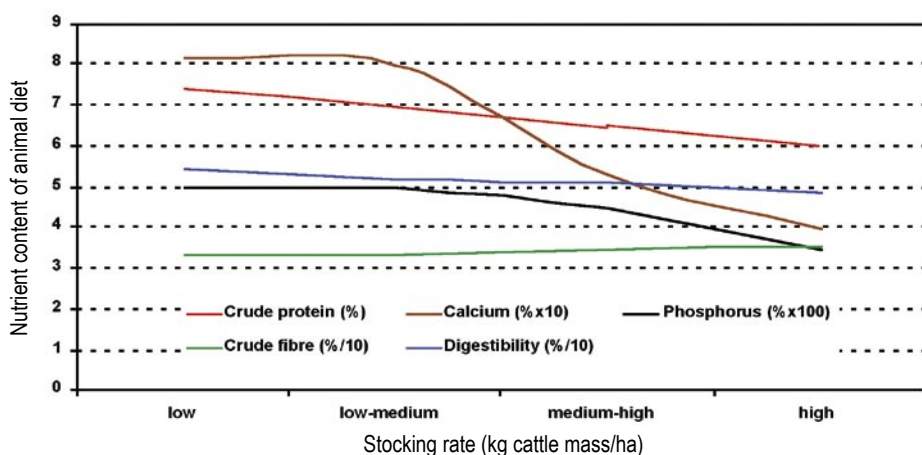


Figure 6: The value of veld forage to animals decreases with rangeland degradation caused by an increase in the stocking rate (Sandveld area)

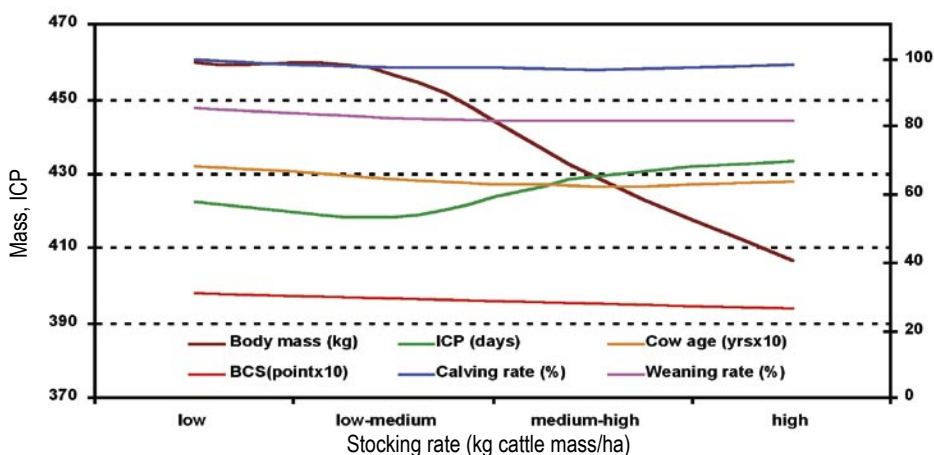
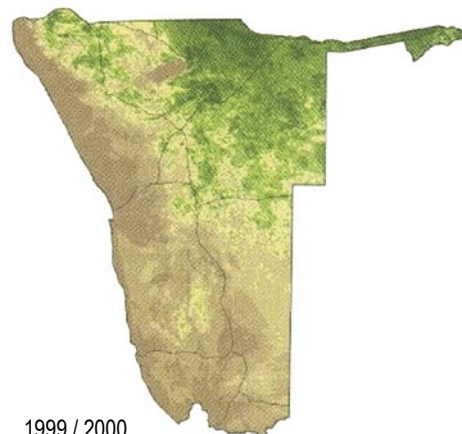


Figure 7: Degradation of the rangeland due to increasing the stocking rate of animals decreases the productivity of individual animals (BCS: body condition score, ICP: inter-calving period) (Sandveld area)

The difficulty is to accurately and objectively determine the carrying capacity of the land. The long-term carrying capacity of a ranch is a contentious matter subject to continuous debate and revision. Various methods exist but none is at once easy and rapid and satisfactorily reliable. Traditionally, the yield of grasses is determined by clipping and weighing all grasses within a large number of quadrats randomly placed in the rangeland at the end of the growing season, from which the grazing capacity of standing grass forage that has to take grazing animals through the dry season and last until the next rainy season can be calculated. One can also use a calibrated picture guide to deduce grazing capacity of the standing grass crop at the end of the growing season from standardized photos. This is the method of choice by resource-poor farmers in Namibia who apply Local Level Monitoring. The most promising development is to estimate continuous seasonal plant production from satellite images, but this method has not yet been refined for use at farm level in Namibia, even though it yields spectacular images of plant production in the country (Figure 8).

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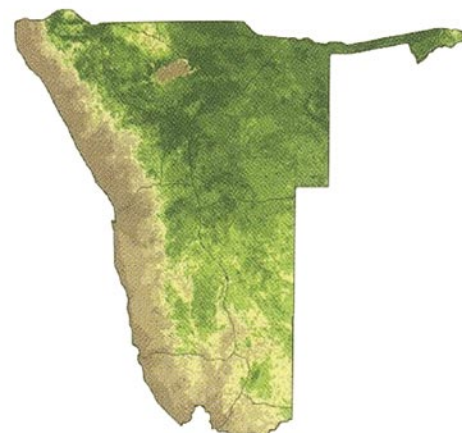


Figure 8: An example of plant productivity as measured by satellite, depicting a very poor season with low rainfall (1998/1999) and a very productive season due to high rainfall (1999/2000). The grass-based carrying capacity still has to be calculated from these images.

Browse yield is even more difficult to determine, by either the box method of collecting all edible browse within a box of known dimensions stuck into the peripheral canopy of a woody plant or from calculating browse yield from canopy volume via experimentally pre-determined, species-specific correlations. In the face of this uncertainty and the great damage wrought to the veld by overstocking, it is wise to err on the safe side and apply a conservative stocking rate, i.e. stock land with fewer animals than it could probably sustain. But how many land users can actually afford to do this at a time when input costs rise faster than product prices and farms become ever smaller due to increasing demand for land by a growing population? The result of this choice squeeze is there for all to see in the landscape-level degradation of the natural rangelands of Namibia, which after all necessitated this article.

Once a land user has obtained a reasonably reliable estimate of the land's long-term carrying capacity, e.g. that of the Ministry of Agriculture, Water & Forestry (Figure 9), s/he must annually adjust the number of animals in response to the year's rainfall: increase the number of animals when good rains increase forage production and decrease the number of animals due to poor rains that result in little forage production.

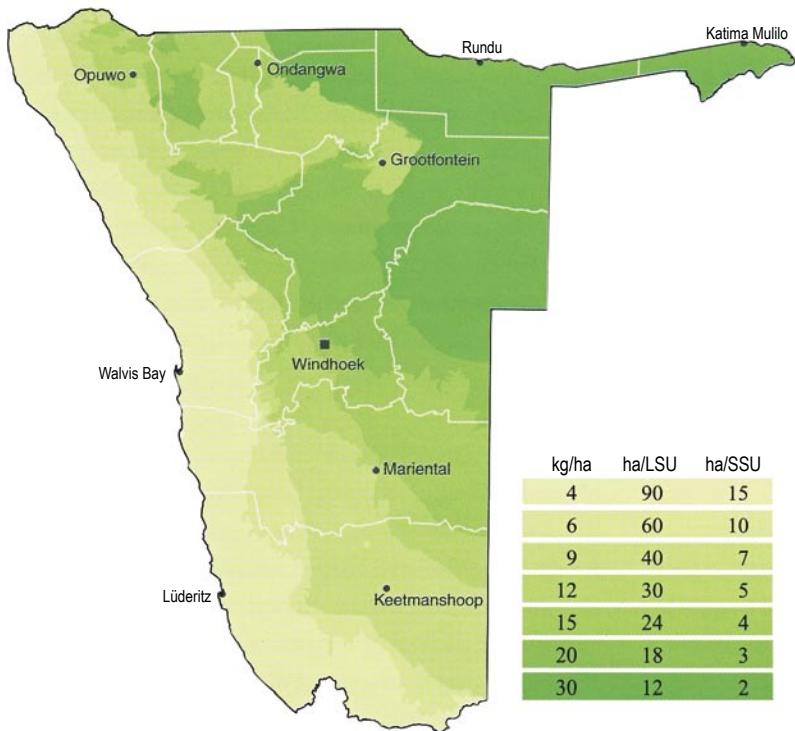


Figure 9: Estimated grass-based carrying capacity of Namibian rangelands, in kg animal mass/ha, ha per Large Stock Unit (LSU) and ha per Small Stock Unit (SSU)

This is "adaptive" management and should be done for grazers and browsers separately. It is illustrated by the "realistic flexibility" in animal numbers depicted in Figure 10. Timely adjustment of animal numbers in response to changing environmental conditions should be a continuous process, especially during the vegetative growing season (rainy season), although traditionally many ranchers only assess the balance between carrying capacity and stocking rate at the end of the growing season. "Ideal

flexibility" (Figure 10), where animal numbers follow the rainfall exactly is probably not possible in practice except in large, little-managed systems like national parks. Rangeland should ideally be evacuated if a drought causes forage production to fail completely and all the fodder reserves have been used up (see Principle 6).

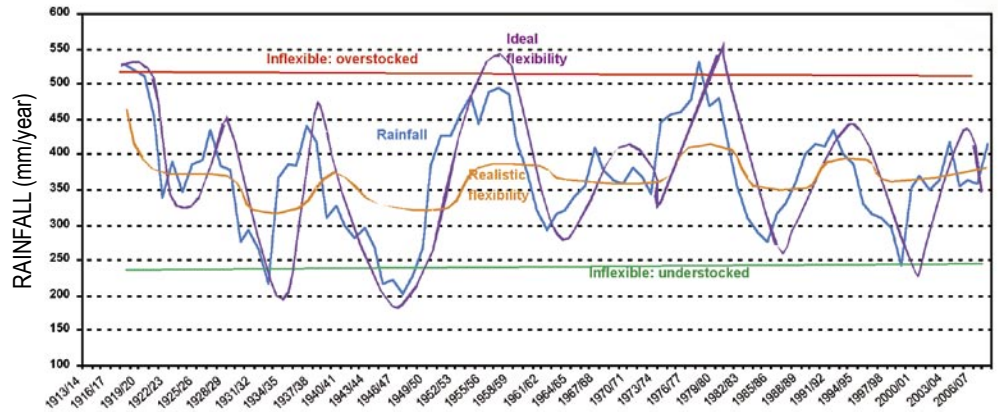


Figure 10: Various animal stocking rate strategies in response to annually varying rainfall

Since the feed supply of the veld is not fixed and constant, but highly variable in terms of quantity and quality, ranchers should not maintain a constant herd size or fixed stocking rate. The very last strategy a Namibian rancher should follow is to have the same number of animals year after year, unless s/he stocks well below capacity ("inflexible: understocked" in Figure 10). In this scenario, the land user forfeits extra income in most years because of the low stocking rate. If the land user follows the opposite strategy and maintains a fixed stocking rate at a high level, the animals will suffer hunger with low production in most years and the veld will be damaged considerably by overgrazing ("Inflexible: overstocked" in Figure 10). Rangeland on game ranches can also be over-utilized by wild animals as over-utilization is not limited to domestic livestock! Non-adaptive strategies will eventually force the land user into a downward spiral of decreasing income, degrading resources and off the land.

Adaptive forage management implies that land users have to develop their marketing structures to buy and sell animals quickly. Land users have to improve their resilience by accumulating reserves of fodder and of finance to smooth natural cycles and keep going in tough times. Otherwise, the stay on the land may be short and the departure unpleasant. It is the natural variability of the enterprise that makes livestock ranching in Namibia difficult.

Land users who farm with indigenous breeds of livestock or their crosses have an advantage in that indigenous breeds are accustomed to our harsh and variable environment, having evolved in it, and cope by decreasing their production. Over time, this caused their smaller body size, longer legs, better heat resistance and parasite tolerance, earlier maturity and higher fertility. They also have slightly different patterns of foraging and ruminal digestion of forage which enables them to survive on coarser and less nutritive forage, but at the expense of production. Animal breeds introduced to Namibia from temperate regions of the world are not as well adapted to local conditions, cannot scale back their productivity to the same extent as local breeds and have to be supported by better management and a more constant feed supply or else they fail and die. Of course, the land user will choose the breed s/he loves, but take note that some breeds simply require more attention and inputs than others.

The production system also plays a role in deciding sustainability. Generally, Namibia's semi-arid rangelands are not suitable for intensified animal production systems and some systems, e.g. tollie (steer) or pelt production and game ranching, are ecologically more sensible in arid areas than dam-and-offspring breeding systems.

7. PRINCIPLE 5: Restore the rangeland

Most Namibian rangelands are unfortunately already in a state of degradation and in need of rehabilitation and restoration. The top layer of soil is in a poor condition, rainwater is flowing away from the land rather than infiltrating, the grass sward has been weakened to the point where ranching with cattle and sheep may have become unprofitable, bush has encroached the land and turned it into a thorny thicket and the land's biodiversity is severely depleted. Restoring the soil and protecting groundwater will be addressed in Principles 8 and 9.

Under lenient grazing pressure (refer Principle 4) and with adequate recovery from grazing (refer Principle 3), most Namibian rangelands have a dominant grass sward that consists primarily of perennial grasses, amongst them a multitude of highly palatable and preferred species such as *Antheophora pubescens*, *Brachiaria nigropedata*, *Digitaria eriantha* and *D. seriata*, *Panicum* species and *Schmidtia pappophoroides*. As a result of unsustainable grazing practices and high grazing pressure, they give way progressively to less palatable and eventually, unpalatable grass species (Figure 11). Transformation of the grass sward towards an unfavourable composition can best be countered by relieving the grazing pressure on the most preferred grass species and making sure they enjoy adequate recovery after grazing.

Figure 11: Reaction of grass species to an increase in the stocking rate of cattle. Functional grass groups consist of most preferred (MP), preferred



(P), least preferred (LP), unpreferred (UP) and annual grass species (AG) and illustrate the sequence of transformation of the grass sward of a semi-arid Namibian savanna

At a certain threshold level and in response to favourable climatic conditions and exclusion of hot, effective fires, bush encroachment sets in. Bush encroachment refers to the thickening of indigenous woody vegetation on a rangeland, most often of just one particular species so that eventually the rangeland is covered by a monostand of bush. There is only so much soil

water available to plants and if a dense bush thicket uses most of it, very little is left for grass. As a result, the grass cover on bush-encroached rangeland is very weak and consists mainly of annual grasses and some opportunistic weeds. It offers grazing animals very little forage, especially in dry years when the annual grasses and forbs cannot germinate and establish and the soil under the woody canopy is largely bare. Even browsing animals struggle to get sufficient nourishment from the bushy monostand because it offers mainly one kind of forage with little dietary diversity. The bush-encroached rangeland can only sustain a fraction of its original carrying capacity and animal production decreases severely. It is estimated that 30 million hectares of Namibian rangeland, or 36% of the country, is affected by bush encroachment and that Namibian ranchers forego about N\$700 million annually in beef value that they could not produce because of bush encroachment! It is a serious problem in Namibia and most savanna rangelands are affected by it, but generally, the problem is worse in the moister north-eastern parts. The most common invasive woody species are various indigenous *Acacia* species, particularly *Acacia mellifera* (swarthaak) as well as *Dichrostachys cinerea* (sekelbos, omutjete), *Terminalia sericea* (geelhout), *Colophospermum mopane* (mopani, omusati) and *Rhigozum trichotomum* (driedoring) in the south. Their density can sometimes exceed 10 000 bush/ha, i.e. a bush on every square meter!

Bush encroachment often becomes visible only decades after the initial process took place. For many years, bush saplings stay below grass-emergent height and are not easily noticed. They give an early indication of the disaster that is to come and can easily be wiped out by an effective, hot fire if noticed early enough. Once mature, the bushes are virtually impossible to get rid of naturally and man has to intervene actively to clear the bush from the land. In the interest of maintaining what little biodiversity is left and having a balanced approach to the encroachment problem, it is best not to eradicate the bush completely, but rather to thin it to a "natural density", which may be twice as many bush per hectare as the average annual rainfall. Obviously, thinning should only affect the invasive species and not those other species of woody plants that may have survived the invasion.

Thinning can be performed biologically, manually, mechanically or chemically. Unfortunately, biological control through fungi, fire and browsers is least effective of all. Fungi appears to be site-specific, can only affect mature, old bushes and then only in wet years. Fire can only kill immature bushes, saplings and seedlings and those bushes coppicing after prior treatment but is ineffective against mature bush and a dense thicket. Unplanned fires can also damage the grass sward more than the woody component. Heavy browsing will keep woody re-growth in check and might eliminate bush seedlings but is ineffective against thickets.

Manual control through felling is highly selective but tedious and slow. However, it can yield a good quantity of by-products such as firewood or charcoal. The stump has to be treated chemically or dug out, otherwise it is likely to coppice and re-grow. Mechanical control through heavy machinery such as bulldozers is effective in killing the bush, but wreaks havoc on the soil and smaller life forms which can leave an area barren and exposed to soil erosion and weed infestation. It is thus not recommended

Chemical control through the use of arboricides is highly effective but comparatively expensive. The arboricides are toxic to all plants and

selectivity is achieved by careful application to the stem, roots or leaves of the targeted problem bush species. Collateral damage to non-target trees growing within 20-50 m of treated target trees is common because of the intertwined lateral root system of most savanna trees and bushes. Arboricides also kill grasses and forbs, but these re-grow again even in the same season because the residual effect in the soil is weak. Some arboricides (e.g. bromacil) are toxic to aquatic life forms and should not be used on sandy soils with shallow ground water, or near wells, boreholes and fountains. Most chemical arboricides are non- or only slightly toxic to bees and birds and not toxic to large animals and man, but care should always be practiced in their application and manufacturers' instructions should be adhered to strictly. No arboricide residues have ever been found in the meat of domestic livestock animals, but since our export markets' consumers are very sensitive to ecological issues and perceptions, Namibian land users should use arboricides responsibly and under strictly controlled conditions, lest our export product acquires a poor image. Fortunately, in most cases of chemical bush control, the grasses will take a season to recover from the competitive suppression by woody plants and grazing of a treated area will likely resume only once the arboricides are well past their relatively short half-life, so that residual contamination should not be a danger.

Bush control is not an one-off event. It requires proper aftercare and a change in the management practices that caused it in the first place, otherwise bush encroachment will cyclically return to the rangeland every 15-25 years. Fire and browsing pressure are most effective as aftercare agents that can successfully prevent re-infestation of *Acacia* species if applied in the correct manner. Heavy browsing keeps bush seedlings and coppiced bushes below grass-emergent height if it does not kill them outright. A planned fire can be most effective in preventing bush encroachment by *Acacia* species in the first place. Seedling establishment of most of the invasive *Acacia* species appears to be a sporadic event and if a hot fire is applied when *Acacia* seedling establishment is observed, it will prevent bush encroachment from occurring. A planned fire has to be hot enough to kill young *Acacia* plants, which requires a fuel load of at least 1 ½ to 2 tons of herbaceous dry matter per hectare. The best time to burn bush is in late winter, when it breaks its dry season dormancy and is especially sensitive to fire, while the perennial grasses will have a green tuft base at that time and are thus more tolerant of a hot fire. Controlled fires are allowed by the Forestry Act of 2001 but land users have to ensure compliance with the National Guidelines on Fires and Fire Management as far as safety precautions are concerned. In the sweetveld areas of Namibia, the only "good" reason for a fire is for bush control; all other fires should be prevented. Only in the sub-humid north-eastern part of Namibia can controlled fires serve another purpose than bush control as part of routine management of sourish grassveld, including parasite control. Note that *Dichrostachys cinerea* should not be burned as it is stimulated by fire!

Without further intervention, the herbaceous plants most likely to grow on the thinned rangeland are pioneer and sub-climax grasses and opportunistic herbs and forbs best suited to the high level of nitrogen in the soil (most invasive woody plants are legumes that fix atmospheric nitrogen in the soil) and with a relatively low grazing value. On most bush-encroached rangelands, the preferred grass species became locally extinct years ago and will not re-occur unless they get seeded into the thinned range. This is best achieved if their seed is collected (e.g. in the road reserve) and mixed into dung cakes, which are then placed under the felled canopy drawn over the stem or strewn into the remaining bushes or in protected places where they can germinate successfully before being exposed to the highly selective appetites of grazing animals. Encasing grass seeds in dung will protect them against predation by seed eaters such as ants, rodents and birds. Most climax grass species germinate best after a dormancy period of 9-12 months and are best sown the year after the seed was collected. Make sure that the seed was stored in a cool, dry, dark place and treated chemically against weevils. Veld fortification by fertilization works only where

the annual rainfall exceeds 600 mm/year and then it is more likely to result in luxurious growth of pioneers and weeds rather than the preferred perennial grass species.

A special case of bush encroachment is the infestation of Namibia's dry river beds by the exotic *Prosopis* spp. (mesquite, "suidwesdoring"). This valuable fodder tree spreads like wildfire but is largely limited to river beds. It is spread by goats and humans who eat its sweet seed pods and spread the seed in their faeces. If pods are collected to be fed to livestock, they should first be milled through a fine sieve to destroy the seeds before feed-out. Control is mainly by felling big trees to recover the valuable timber and chemical control of young stands. A seed-boring beetle was recently introduced to effect biological control of *Prosopis*, but since it attacks mostly ripe pods fallen to the ground and these are picked up by goats and people before the beetle can do its destructive work, this method does not seem to work. *Prosopis* exudes a plant growth inhibitor through its roots that prevents other plants from growing on cleared ground, thus leaving river banks bare and exposed to erosion by the next flood. Bare river banks need to be protected physically against erosion for a season or two, until the root exudate has leached from the soil.

8. PRINCIPLE 6:

Make provision for the next drought

In Namibia, the more it rains, the more likely that next season will be a poor one with less forage produced than normally expected. Thus, drought planning should start in the rainy season already. The worst effect of a drought is that it depletes the feed of animals but it also destroys shallow and ephemeral soil seed banks and kills some susceptible plant species, e.g. the bulky grass *Stipagrostis uniplumis*. A disaster drought of several years' duration will hit land users hard but are rare, fortunately. Most droughts last just a single season and can be overcome by land users themselves without major intervention and assistance from outside, just with good contingency planning and on-farm risk management.

Weather forecasts are getting more reliable by the year and as the evidence mounts that the next rainy season will not deliver the expected amount of rain and forage, the land user should start getting rid of some of his livestock. The old, sick, lame and lazy and thereafter, the young growing livestock should be sold off progressively as the rains fail to arrive. Up to 30% of all animals on a ranch can be gotten rid of in this way without seriously impacting the reproductive ability of the herd. Early and progressive disposal of non-core animals saves some of the veld forage they would have eaten for the core of animals that the land user does not want to dispose of. In addition, the earlier animals are sold, the better their condition and the price they achieve, since national prices are still high as most Namibian land users tend to cling on to their animals until emergency sales flood the market with excess animals and prices drop precipitously. Land users need to develop marketing methods and structures for this purpose in time and retain the income thus generated to fund re-stocking after the drought.

Once the animal numbers on a drought-stricken farm have been reduced to the core that needs to be retained at all costs, the land user has to feed these animals with emergency supplies of feed. To buy feed during the drought when demand exceeds supply is financially suicidal, so it is best purchased during the rainy season already. Even better, every land user should grow his/her own drought feed and accumulate a fodder bank. Cultivated but dryland pastures of indigenous perennial grasses (especially of *Cenchrus ciliaris*, "bloubuffel" grass and *Anthephora pubescens*, "borseltjiegas") and plantations of drought-resistant fodder crops (*Opuntia* spp., spineless cactus and *Atriplex nummularia*, oldman saltbush, are common in Namibia) should be established on at least 10% of the ranching area; and more in more arid areas. Namibian ranchers fear the expense and expanse of cultivation but

should see this as an investment in their own resilience! In good seasons, the grass pastures can be mown to make hay for drought storage or cash sale. The drought-resistant fodder crops should be planted in erosion-prone areas or on capped soil and left to accumulate bulk which is harvested, processed (half-dried) and fed out to animals during dry times.

Drought feeding of core animals should occur in pens (kraals) and not on the open veld. It will seriously damage forage plants repeatedly defoliated at a time that they cannot re-grow sufficiently because of lack of soil moisture, plus animals waste energy in search of forage, the land user incurs transport expenses driving feed to his animals and control over animals is lacking at a crucial time when losses may be expected. It makes more sense to confine animals to a pen, kraaled separately per group and treated against internal and external parasites and vaccinated against diseases of the pulmonary system (e.g. pasteurella) before confinement. Animals should only be fed every second day but then two day's supply should be given at once so that weaker animals also get their share thanks to the temporary surplus of feed. Drinking water should also only be given every second day, alternating with feeding days, because thirsty animals eat less. The land user has to decide whether to feed all animals to their maintenance requirement only (providing feed equivalent to 1 ½ % of body mass daily) and forsaking production or to feed some animals to their production requirement (providing feed equivalent to 3% of body mass daily) to enable them to raise their offspring or conceive during a drought.

When the drought is broken by rains, the land user should continue feeding animals in kraals until veld grasses have recovered to seed stage. This will be most difficult as both the animals and the land user want to get back onto the range, but early release will cause irreparable damage to the range, to the future detriment of the farmer. Another instance in ranching where immediate gain has to be forsaken for future prosperity. As the productivity of the rangeland recovers, the farmer can gradually re-stock the land with bought-in animals, using the financial reserves accumulated from the sale of surplus animals at the onset of the drought. Organized agriculture still needs to lobby government to minimize taxation of these contingency funds.

9. PRINCIPLE 7: Monitor rangeland utilization and use records to inform management

As should be evident by now, sustainable rangeland management demands a long-term approach because rangelands are in a continual state of change ("disequilibrium") and building long-term prosperity is often more important than maximizing short-term gain. The land user has to continually monitor rangeland condition to differentiate between short-term fluctuations (due to normal climatic variability and severe events such as fire, floods, insects etc.) and long-term trends (due to animal management and global warming). The land user should also monitor the vigour and abundance of indicator plants, the establishment of bush seedlings and the ease of infiltration of rainwater into the soil. The frailty and bias of human memory requires that written records are kept, and are kept objectively and accurately. It is the

task of the land manager to turn such records into information on how to manage the rangeland productively and sustainably, thus the records should be practical. This is both an art and a science and like all skills improves with practice and experience.

Records are a result of prior planning and in turn lead to re-evaluation and re-planning of the enterprise. Which records contribute most to sustainable rangeland management? No Namibian farmer can do without rainfall records, collected daily, because total rainfall and especially its intra-seasonal distribution directly determines plant production. Secondly, a grazing log should be kept of every camp or grazing area, reconciled at the end of the year to indicate whether a particular camp was over-utilized or not (Table 1). The grazing log should contain details of the annually varying carrying capacity of the camp and the stocking rate applied, e.g. the animals that grazed it and when the grazing took place, as transcribed from a diary. If this is done for every camp every year, a clear picture will emerge of how the camp was utilized and this might explain its present condition. If the land user is dissatisfied with the present condition of the rangeland in the camp, indicated by a subjective mark on the log, the grazing practice might have to be adjusted and the log would even show what to change (e.g. the stocking rate, grazing time and stage or type of animal). In compiling the rangeland condition score, the land user should consider the amount of soil covered by plant canopies, the composition of the grass sward, degree of bush encroachment and erosion or insect damage to the veld in a camp or grazing area.

Table 1: Example of a grazing log kept of three camps, every year. The information in the green part of the log pertains mainly to the veld (carrying

CAMP NUMBER	1			2			3		
CAMP SIZE	550 ha			490 ha			575 ha		
CARRYING CAPACITY	10.5 ha/LSU			9.3 ha/LSU			11.6 ha/LSU		
CAPACITY: LSU-DAYS	19 119			19 231			18 093		
GRAZING OPPORTUNITY	first	second	third	first	second	third	first	second	third
DATE IN	1/12/06			1/4/07	1/6/07	1/12/07	15/5/07	1/8/07	
DATE OUT	15/1/07			15/4/07	31/6/07	15/12/07	31/5/07	31/8/07	
GRAZING PERIOD (days)	46			15	31	15	16	31	
GRASS GROWTH STAGE AT GRAZING	active growth			translocation	dormant	active growth	dormant	commencement	
ANIMALS	249 cows+ calves, 8 bulls			249 cows+ calves	232 dry cows	251 cows+ calves	232 dry cows	251 dry cows	
ANIMALS (LSU)	403			391	299	394	299	324	
LSU-DAYS	18 538			5 865	9 269	5 910	4 784	10 044	
SUM OF LSU-DAYS	18 538			21 044			14 828		
CAPACITY RE-CONCILIATION	97.0%			109.4%			82.0%		
REMARKS				over-grazed			spare capacity	due to termites	
SUBJECTIVE CONDITION SCORE	4/5			3/5			2/5		

capacity) whereas the brown part pertains mainly to veld management (animal stocking rate). The importance of the log lies in the reconciliation of these two components (in the blue part of the log) from which the land user can deduce what action – if any – to take next.

Other useful records are an event log of fires and similar events striking the grazing area or parts of it and their effect on the range, as well as

any treatment applied. The same is true for bush thinning, over-seeding or other restorative measures taken by the land user. Finally, fixed-point photography, i.e. photos taken every couple of years from the same spot in the same direction at the same time of day and stage of the season, will help the land user record changes in rangeland condition over time. With this comprehensive set of records, the land user will be able to gain a lot of useful management information to guide and facilitate sustainable rangeland management by being able to identify harmful and beneficial management practices.

Then, of course, there is a wide range of farm and livestock production records which are very important for performance and financial reasons but outside the scope of this article. Of all livestock management records, live weight and body condition scores (BCS) are the most valuable for rangeland management purposes. Animals perform as well as the veld is able to feed them and their live weight and body condition directly reflects their nutritional status and thus indirectly whether they received enough feed of satisfactory quality from the veld. Recording live weight or BCS of livestock on a monthly basis is the ideal but very time consuming. The least a rancher should do is to record it at three critical stages of female animals' production cycle, viz. one month before the start of the mating season to see if flush supplementation is required, one month after the start of the mating season to monitor if dams are fed well enough to conceive and again when the offspring are weaned, to see how much weight loss the dam suffered and estimate whether the veld forage can compensate for it. Young growing animals should be weighed or condition scored every 2 to 3 months to monitor their weight gain.

10. PRINCIPLE 8: Take care of the soil

The soil supports the plants that feed the animals and is thus the first link in the chain of food and dress production for mankind. It needs to be preserved in a condition that facilitates plant production and establishment from seed. Rangeland utilization by animals has a critical effect on soil condition, especially of the top layer of soil. It has to be relatively loose to allow rainwater and air to penetrate the deeper soil layers. It also has to be covered by plant material, preferably living but a mulch of plant litter is also good, so that it is shaded from the sun and protected against the erosive forces of wind and water. If these conditions exist, then the soil water content will be higher, soil microbes will flourish and plants will relish the conditions in the soil and grow well while plant seedlings will establish easily. If, by contrast, the top layer of soil is hard (capped) and impermeable and the soil is bare and exposed to the sun, the soil becomes drier because rainwater flows overland instead of infiltrating, causing soil erosion; soil microbes die, plants will struggle to grow and seedlings will not be able to establish. About 90% of all soil in Namibia is actively eroding, severely weakening the first link in the chain of extensive animal production.

Compassionate grazing that leaves a good cover of plants or their litter on the soil and cultivates the soil through light hoof action is the best method to maintain the top layer of soil in a favourable condition. Harsh grazing that removes too much plant material and disturbs the top soil too much is not conducive to sustainable rangeland management, as is no grazing at all, because this will eventually weaken the veld through lack of rejuvenation. Many plants become moribund if they are not pruned occasionally and the soil is not enriched by the excrement of animals. In arid areas such as Namibia, very little above-ground plant matter is re-cycled into the soil. Most of the plant nutrients are lost through oxidation, or turned into animal excrement. Where animals are stocked thinly, the manure-concentrating effect of animals returning to a kraal or watering point regularly is apparently negligible and does not affect the nutrient cycle a lot. Much more important is the re-cycling and soil cultivation performed by dung (scarab) beetles in returning animal manure to the soil and thus preventing fly and nematode

infestations, and of snouted termites in re-cycling dead plant matter and bringing soil from deep down to the surface. The nutrients in the organic matter are then made available to plants by soil microbes. These highly beneficial macro- and micro-organisms should be protected and promoted at all times. Dung beetles can be protected by using dung beetle-friendly drench remedies, insecticides and antiparasitics on livestock (identified as such on the label). The mounds of snouted termites should be left intact and they should not be confused with harvester termites, which can be very harmful to grassy rangeland.

Maintaining the soil in good condition is the first step in maintaining a high degree of biodiversity on the land, which strengthens the resilience of the ecosystem and the farming system. It also protects the underground water resources.

11. PRINCIPLE 9: Take care of underground water resources

Most of Namibia's underground water is fossil water that may be thousands of years old and is replenished very slowly. It is estimated that only about 1 – 4% of our rainfall eventually reaches the underground water and recharges our aquifers. Water is withdrawn more rapidly from most of our aquifers than it is replenished naturally and the time will come that aquifers are pumped dry – what then? We should thus use as little water as possible (preservation of a scarce resource) and get maximum output from whatever water we do extract (optimum utilization of a scarce resource). Wherever possible, for example, sprinkle and drip irrigation should be used instead of flood irrigation as it is less wasteful and much more effective. Drinking troughs for livestock should not leak water, helping to reduce the incidence of parasites. Soil should be maintained in a condition where rainwater can infiltrate instead of running off and shade protects soil from overheating and erosion, to maintain the water cycle especially in the upper soil layers where all grass and many bush and tree roots occur. Land users should refrain from erecting pit latrines or rubbish disposal dumps near shallow ground water sources or riverbeds lest the water is polluted.

Bush-encroached rangeland loses at least three times more water through transpiration than grassy rangeland and very little rainwater infiltrates deep enough into the soil to supplement underground water resources. In many instances in Namibia, the water level in a borehole is lowered considerably due to bush thickening but once the bush is thinned, the water level rises again. Natural fountains stop flowing due to bush encroachment and start to flow again after bush control. Considering that a bush thicket also does not produce the right type of forage to feed our domestic and wild animals, land users have so much more reason to control bush infestation.

In terms of water reticulation for domestic and livestock purposes, land users should connect the various water storage facilities on the farm to re-distribute water if one source (borehole) or storage facility (reservoir) breaks down and cannot be repaired in time. It is advisable to have spare water storage capacity at every stock watering point rather than pumping the water (or even worse, letting it flow by gravitation) through kilometres of pipeline while livestock are drinking. The pipe flow will be too slow and the drinking trough will run dry. Livestock will go thirsty and might damage the trough in their frustration. If there is spare storage capacity at the watering point, the water only has to flow a few meters and the trough will fill up quickly. Cattle can drink up to 100 litres of water in one sitting, so for a herd of 200 cattle that frequent a watering point, one day's supply amounts to 20 000 litres and requires a 1.5 m high x 4 m wide reservoir.

In conclusion

Sustainable rangeland management has many more aspects than the few basic principles outlined above and this article does not claim to be exhaustive or appropriate for every situation. But in summary, the three most important actions that Namibian land users can take to manage rangelands sustainably are:

- separate different veld types so that the smaller units are more homogeneous than the larger whole and can be managed more appropriately,
- keep well within the long-term carrying capacity of the rangeland while reacting opportunistically to annual fluctuations, and
- allow the perennial grasses to recover from grazing to seed-set during the rainy season.

This requires constant monitoring of the carrying capacity of the rangeland and adjusting the stocking rate of animals which should preferably be written down to identify trends in rangeland condition before we forget.

Many specific tools can be used to achieve the broad principles outlined above. The land user should pick those tools (e.g. grazing system, animal breed, monitoring yardsticks, etc.) that best suit his/her personality and circumstances. There is no single tool that is always the best under all circumstances and the deciding criterion of successful rangeland management should be whether the rangeland's productivity and condition can be maintained over the years, or not; and if not, how it can be restored. Land users should learn from each other's best practices and be flexible and practical in their approach. Sustainable rangeland management requires a

long-term approach to farming that plans further ahead than next year's tax return or the land user's imminent retirement, but considers the future wealth of the next generation of people on the land. We should do more than acknowledge the traditional wisdom that states that we don't own the earth but only keep it in trust for our children; we should actually live by it. This is the honourable obligation of Namibian land users!

There are also a couple of land management issues outside the direct control of the individual land user, but with immense implications on sustainable rangeland management. First and foremost in southern Africa is the issue of land tenure and ownership. Is the policy environment in which the land user has to operate, conducive to sustainable resource utilization? How can the human population explosion be stemmed to ease the pressure on land and natural resources generally? How do we deflect the dangers of global warming, caused by our pollution? These questions are outside the scope of this article and the control of individual land users, but should none-the-less be addressed by those who can, to ensure that sustainable resource management is addressed in a holistic manner and not devolved to the lowest common denominator. Policy makers have an even bigger obligation than land users to ensure the sustainability of natural resource use and to plan for a bright future!

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