Savory insights – is rangeland science due for a paradigm shift?

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Introduction

Following a visit by Allan Savory to Kruger National Park, Harry Biggs got together a diverse group of ecologists to visit Allan at the learning site ranch Dimbangombe near Victoria Falls in Zimbabwe which is owned and managed by the Africa Centre for Holistic Management. The group consisting of Harry Biggs, Rina Grant, Vuyi Matokazi, Cathy Greaver, Tony Swemmer, Mike Peel, Luthando Dziba, Kevin Kirkman, Kate Matchett, Norman Owen-Smith, Wayne Twine and Richard Fynn arrived at Dimbangombe on Monday afternoon the 12th of May 2008. The afternoon was spent chatting with Allan and planning how to best utilize our time there over the week. Our aim was to spend time with Allan and see for ourselves what Holistic Management (HM) was about and how it influenced the grasslands, woodlands and wetlands of Dimbangombe. The claims arising from HM have been severely criticized by rangeland scientists so we thought it would be good check it out.

Savory's planned grazing, which is an integral part of HM, use high cattle densities to have a large impact on a grassland by breaking soil crusts with hoof action, crushing down moribund grass tufts thereby removing aerial litter and depositing it on the soil surface, improving light availability to the growing points of grasses and forbs and depositing large amounts of dung and urine. The breaking of the soil surface combined with the laying of litter, dung and urine together with adequate compaction he claims allows seedling establishment in bare spaces leading to greater perennial plant cover. Importantly, a thick litter layer is able to develop on the soil surface because of animal trampling and the exclusion of fire. Closer plant spacing and increased plant density combined with the litter layer in bare spaces in the absence of fire results in much more effective rainfall owing to the litter layer reducing evaporation from the soil surface and the combined effects of high plant density and the litter layer preventing rain water running off into streams, which represent a loss to the system. Moreover, less leaf area and smaller root systems (Coughenour *et al*. 1985; Edroma 1985; Danckwerts and Nel 1989) on grazed vs. ungrazed plants is likely to result in less evapotranspiration in

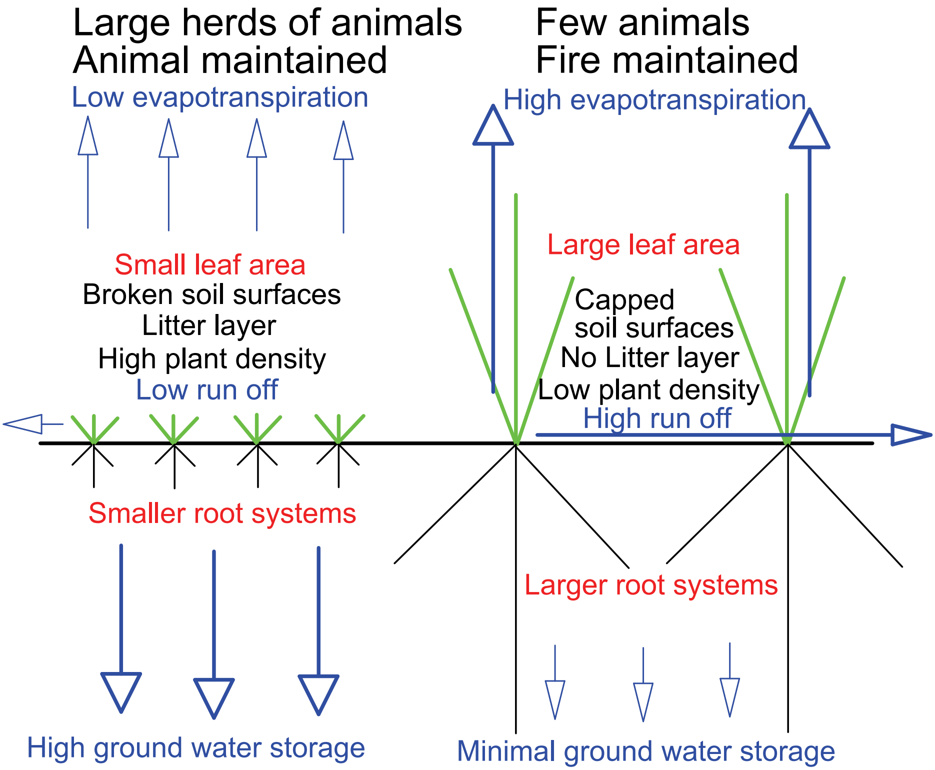


Figure 1. Conceptual model showing how greater plant density, healthy litter layers, broken soil surface and reduced evapotranspiration of grazed down plants under high density grazing may improve hydrological cycles. The effect of grazing on root systems was derived from studies by Coughenour et al. (1985), Eroma (1985) and Danckwerts and Nel (1989). The effect of grazing on evapotranspiration and soil moisture was derived from McNaughton (1985).

heavily grazed systems. The combination of the above factors is likely to result in much better soil moisture and better hydrology, wetlands and rivers under HM (Figure 1).

We spent as much time as possible in the field on Tuesday and Wednesday looking at a whole range of sites and the effects of HM on the grasslands and wetlands of the area. We saw how a tightly bunched herd of cattle can reduce a tall grassland to a few standing stems leaving a thick litter layer on the soil surface. We saw how stockading the animals overnight for a week on large bare and degraded areas results in impressive rehabilitation of the site. It appears that the large urine and dung inputs on the degraded soil and the seed inputs with the dung result in a good grass layer developing where it would have been impossible to do so without intervention. This technique definitely has great potential for restoration of degraded and eroded areas. We watched a large herd of cattle and goats out in the veld with their full-time herders. It was interesting to see that cattle and goats can be used together as a single herd very effectively. We saw the effects of this management on wetlands where water was seeping through wonderful sponges and previously dry rivers now ran clear and pure. We also got to look at degraded rangelands in adjacent communal areas. Overall the trip was well worthwhile and insightful and it was great to finally meet the man we had heard so much about.

Savory's background and insights

Insight into ecological systems is best derived from spending lots of time on the ground observing phenomena across environmental gradients and changing conditions while distilling one's observations with deep thinking and reading. Insight cannot be obtained by observing phenomena under static conditions and at single points on environmental gradients because patterns and trends do not emerge. This unfortunately has been the case for most of rangeland science; experiments are conducted at a single location (at too small a scale), with a single land-use and are guided by and interpreted under a specific paradigm.

Savory was fortunate to spend many years in Africa on the ground observing veld condition in many different locations, landuse types and environmental conditions. He started off with a degree in Botany and Zoology at the University of Natal and at the age of 20 obtained a job with the Northern Rhodesian game department in the Luangwa valley and subsequently in the Southern Rhodesian Game department. It was here that he observed wildlife management before fences and the removal of people from the land. The Luangwa at that time had massive herds of game with herds of buffalo in excess of 4000 animals. He saw how the land began to change once people were removed from wildlife areas destined for future national parks and the animals became more sedentary and altered their behaviour. Overgrazing took place and the reedbeds and grasslands degraded. Culling did nothing to reverse the situation. Savory observed that hunting by people and predators are important for keeping the game moving and maintaining tightly bunched herds that have a high impact on the veld. He also noticed that animal behaviour in small herds is not the same as in large herds, nor do they have the same effect on the veld. Animals in small herds have more freedom to move around obstacles and graze selectively whereas animals in very large herds tend to graze less selectively and smash down everything in their path: bushes, tree seedlings and large grass tufts. This is especially so when they are being harassed by predators where the main defence of many herbivores is to bunch into tight herds.

Later, while working as a Tsetse fly control officer in Zimbabwe, he noticed that shooting out all the game in a region did not improve the veld but worsened it. During the Zimbabwe bush war he led a tracking unit following up on insurgents. Tracking forces one to observe and examine the soil and veld with acute intensity and detail. This enabled him to observe conditions in the veld under diverse landuse types such as wildlife, commercial ranching and communal landuse and confirmed his earlier observations that resting of veld and partial rest under light stocking rates and diffuse herds of animals results in wide plant spacing, bare patches and moribund grass tufts. At this point it is pertinent to note that few, if any, rangeland ecologists ever get exposed to what Savory experienced, especially the effects of massive herds of game on rangelands and the consequences of their removal. It is unlikely, therefore, that conventional rangeland ecologists will ever get insight into the relationship between veld condition and large herd dynamics. Savory's observations showed that the best veld occurs where massive herds of game have a localized heavy impact, scuffing the soil surface, crushing down shrubs, tree seedlings and old unpalatable grass tufts and depositing a litter layer on the soil surface. This is in direct contrast to the currant range management paradigm which predicts that veld condition will be best under conditions that minimize the intensity of trampling and grazing impacts. Under the rotational grazing management paradigm managers seek to allow animals to graze down certain key grasses only lightly before moving them. In the last decade rotational grazing has come under increasing criticism and it is clear that it has failed to produce results (Briske *et al*. 2008).

Savory was not the only one to notice that high impact grazing resulted in much better basal cover and veld condition. Clive Buntting in KwaZulu-Natal uses high densities of cattle to graze the veld to lawns. Clive has realized independently of Savory that the best veld occurs under high impact grazing for a season or two followed by at least a season's rest. Surely this simulates what occurred under natural conditions where large herds of game grazed down one region and then moved on to the next region. Sam Fuhlendorf uses the focal grazing system with Bison in prairie grasslands where Bison heavily graze focal burnt patches for a season but leave those to focus on new burnt patches in the following season. In contrast, areas grazed diffusely by Bison where a much larger area is burnt have much higher invasions of alien plants because the Bison are free to select more palatable native species (Fuhlendorf *et al*. 2006). The problem with any system that allows diffuse herds of animals and light grazing intensity is that the animals have minimal impact on tree recruitment and graze only the palatable grasses which allows bush encroachment and gives the unpalatable grasses an unfair advantage over the palatable grasses. Take the Transkei grazing lawns as an example: grazing is extremely heavy but non-selective and has resulted in almost complete dominance by a species considered to be intolerant of heavy grazing, *Themeda triandra* (pers. obs.). Moreover, basal cover is excellent, far better that any commercial ranchers achieve; except perhaps those who use high density grazing like Clive Buntting.

This brings us to the question of

our obsession with species composition as an index of veld condition. If veld has over 50 % *T. triandra* it is considered to be in good condition by most ranchers and rangeland scientists yet it may have poor basal cover, capped soils between the tufts and no surface litter. Another grassland with no *T. triandra* and dominated by *Hyparrhenia hirta* but with excellent basal cover would be considered to be in much poorer condition. The latter grassland is much better from an ecosystem function perspective and *H. hirta* is a good grazing species when grazed short.

Is fire necessary and does it maintain healthy grasslands?

Savory's opinion is that grasslands have changed from animal-maintained to fire-maintained grasslands. Herbivory can be more effective than fire in preventing bush encroachment. Fire only reduced bush density on the Kruger burning plots in areas where there were higher concentrations of herbivores (Mills and Fey 2005). *En masse* recruitment of trees was shown to be clearly correlated with *en masse* die-offs of herbivores during the rinderpest and more recent anthrax outbreaks (Prins and van der Jeugd 1993). Browsers in the Serengeti were shown to be just as effective as fire in preventing tree recruitment to upper layers (Belsky 1984). Winston Trollop's burning experiments at Alice in the Eastern Cape show the same trends; goats and fire resulted in much more open grassland than fire alone (pers. obs.). The Serengeti is a classic example of an animal-maintained grassland with very few trees. In the low-rainfall short-grass plains herbivores consume almost all the biomass (McNaughton 1985) severely constraining the influence of fire. Here is the paradox: Minimal fire, yet wide open grasslands. Although shallow soils play a part, the effects of trampling, browsing and grazing by massive herds of animals undoubtedly also prevent tree recruitment in these grasslands. Clearly fire is not needed to maintain open grasslands. On the contrary, animals can do a much better job provided that the herds are big enough and concentrated enough to have a large localized effect.

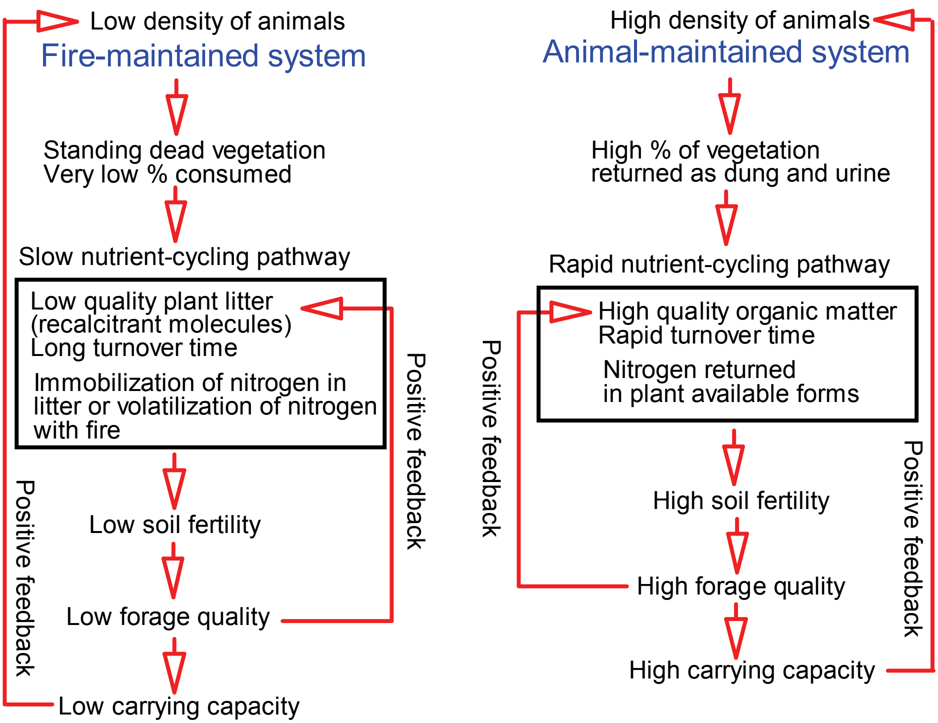
Savory is strongly against the use of fire and where you can use animals to prevent the build up of moribund grass tufts and prevent bush encroachment then I would agree with him because not only do large herds of animals do a better job than fire in preventing bush encroachment but also because of the negative effect of fire on a range of ecosystem properties. Fire dries out the soil by removing surface litter which greatly increases evaporation from the soil surface (Redman 1978; Snyman 2002; Fynn *et al*. in prep). Apart from drying the soil through surface litter removal perhaps the greatest effect that removal of surface litter has is to expose the soil surface to raindrop impact resulting in soil capping and reduced infiltration. This combined with no surface litter to slow overland flow of rainwater results in much greater losses of rainwater into streams rather than being stored as ground water and in the soil itself. Fire, therefore, results in much less effective rainfall and a drying out of the system, degraded wetlands, reduced stream flows and greater drought effects. The healthy wetlands, sponges and clear flowing streams on Dimbangombe, where fire has been replaced by increased animals resulting in a surface litter built up, were testimony to the negative effects of fire on the hydrology of a region. Independent evidence for this comes from the long-term fire experiment plots at Nwanetsi and Marheya near Satara in the Kruger National Park. *Panicum maximum* is a resource-loving species (Fynn and O'Connor 2005) and especially favours moist sites (Fynn *et al*. in prep). In the plots with regular fire it occurs only under trees where fertility and moisture are higher but in the unburnt plots it has become a dominant in the open sites between trees, clearly indicating that soil resources are much better where fire is excluded.

It is not just soil moisture that is affected by fire. Long-term fire reduces total soil nitrogen and rates of nitrogen mineralization (White and Grossman 1972; Ojima *et al*. 1994; Fynn *et al*. 2003; O'Connor *et al*. 2004). In addition, fire reduces grassland productivity (Tainton *et al*. 1978; Snyman 2004). Fire may improve productivity in high rainfall regions because it removes dead material and improves light availability but has the opposite effect in dry seasons because of its negative effects on soil moisture (Knapp *et al*. 1998). Thus, the more arid the environment or the poorer the soils the more negative the effect that fire has on grassland productivity. The combined negative effects of fire on soil moisture and nutrient availability results in an increase in abundance of earlier succession grasses such as *Eragrostis racemosa* (O'Connor *et al*. 2004) because it is a good competitor under low soil resources (Fynn *et al*. in prep). Thus, taken as a whole, fire reduces soil quality and nutrient and moisture availability, reduces stream flows and exacerbates drought effects. Regularly burnt habitats become less productive and more xeric. By contrast, grazing without fire results in greater rates of nitrogen mineralization and increased soil moisture levels (McNaughton 1985). The effect of grazing on soil moisture resulted in grassland productivity being poorly correlated with rainfall and strongly correlated with grazing intensity (McNaughton 1985).

The drying up of many streams around southern Africa is a consequence of the reduction in effective rainfall as a result of bad land management. The Kruger National Park is no exception. On the surface the veld looks good with a high dominance of perennials such as *T. triandra*. Closer inspection, however, reveals large bare spaces between tufts and capped soils and little or no surface litter, hence *P. maximum* can only survive under trees. The concern is that long-term frequent fires in Kruger will result in continuing drying out of the system, loss of top soil, and increases in the undesirable fire-driven species *Bothriochloa radicans*, as we see under annual burning in the burning plots. Not only is *B. radicans* unpalatable but when it dominates it forms mono-specific stands with massive (50 cm +) bare spaces between tufts. Plant diversity in these stands is appalling. If this species becomes the major dominant in the future, Kruger will be as good as dead. This is a question that South African National Parks (SANParks) needs to take really seriously: what is fire really doing to Kruger's ecosystem functioning, productivity and sustainability? Could we see, or have we already seen, a state change to a much less productive system incapable of supporting the large herds of game it was once proclaimed to conserve?

Kruger has extremely low animal biomass per hectare relative to many other national parks in Africa. I believe this is due to several factors: 1) Animals can no longer migrate across to the much more productive grasslands at the base of the escarpment where rainfall is very high and deep productive soils exist. Most of these sites are under orchards or human settlement now (Barberton, Nelspruit, Hazyview, Graskop, Bushbuck ridge, Tzaneen and Thoyandou regions) but would have once been a dependable source of forage

Figure 2. Effects of herbivores on nutrient cycling pathways, forage quality and carrying capacity (Derived from McNaughton 1985 and 1988)



in winter and especially during droughts – key resource areas; 2) Losses of big herds of game (take the wildebeest as a recent example) have resulted in Kruger becoming a fire-maintained system rather than a grazing-maintained system. The catastrophic declines in rare antelope species such as sable, roan, eland and reedbuck could possibly have been caused by a general drying of the habitat, loss of wetland function, changes in plant composition and increased drought effects. Buffalo numbers crash with every major drought prompting Kruger to stop culling them (See Kruger population dynamics graph on page 11). It is likely that drought will continue to constrain their numbers. These crashes would not be as severe if the high rainfall western key-resource areas were still available to grazers and if Kruger's grasslands had a more effective water cycle through being maintained by grazers rather than fire (see McNaughton 1985). Moreover, the lack of heavy grazing results in most plant material being left to decay as standing dead litter which becomes low quality and nutrients are, therefore, cycled through slow-cycling pathways rather than being converted to dung and urine and cycled through rapid cycling pathways (See McNaughton 1988). This results in several feedbacks on plant quality and nutrient availability, rates of nutrient cycling and carrying capacity (Figure 2).

A large watershed-scale experiment is urgently needed to test how grazing-maintained rather than fire-maintained systems affect stream flow, wetland function, habitat productivity and bush density. If results show that grazing-maintained systems are far better than fire-maintained systems then game ranchers could replace fire management of their bush/grasslands with cattle management as Savory has successfully done. Game and cattle go very well together and it is time to get away from this spurious mindset of separating game and cattle. It is clear from writings by the early African explorers that most areas of Africa prior to European settlement had a mix of game and cattle (Isaacs 1836; Livingstone 1865). Even in the Tsetsi fly dominated areas herders knew where they could move their cattle without them being bitten (Livingstone 1865). Ted Reilly in Swaziland runs a fantastic Nguni herd with his game. His Ngunis are hardened to Africa's diseases and natural selection is allowed to run its course with no dipping or veterinary intervention

The effects of grazing and fire along ecological gradients

Savory says that the effect of resting veld will differ on a gradient of soil and atmospheric moisture distribution throughout the year or what he calls a "brittleness scale". Brittle environments have periods of severe soil and atmospheric moisture deficit in various seasons whereas non-brittle environments have no soil or atmospheric moisture deficit over the year, with most systems lying somewhere in between. The development of this brittleness scale actually makes good ecological sense because the scale reflects a gradient of litter (dead plant material) accumulation. In environments with periods of moisture stress of sufficient duration plants senesce *en masse* during the dry period resulting in formation of a large amount of standing litter. By contrast, plants growing in environments with little or no soil moisture stress at any point in the year have no reason to senesce as a whole plant but individual leaves will senesce when they get old. So in these environments there is not the *en masse* death of plants that occurs at the end of the wet season in more brittle environments. Thus, non-brittle environments supposedly do not experience the problem of moribund grass tufts and masses of light inhibiting litter experienced in brittle environments and, therefore, resting non-brittle environments is less damaging. I question whether there is much use in this brittleness scale for rangeland ecologists because there are very few rangelands on earth where there is not a dry period and *en masse* senescence of plants (even in the tropics). Perhaps in a tropical rainforest there is no distinct period of senescence and litter accumulation but of what relevance is that to rangeland ecologists? Moreover, even if a grassland did not have a period of senescence and litter accumulation because there was no period of moisture limitation, it would accumulate a lot of litter because, having no moisture stress, it would be very productive, and is well recognized that litter production is directly related to productivity. If these productive grasslands were not grazed they would end up with a few shade-tolerant dominant plants and very low diversity (Proulx and Mazumder 1998; Osem *et al*. 2002: Bakker *et al*. 2006). Thus, the brittleness scale fails in its predictions; resting of non-brittle grasslands will almost certainly result in loss of species diversity, as they are productive owing to favourable conditions for growth throughout the year.

I feel that a far more useful and tangible scale for land managers would be a productivity scale determined by rainfall, landscape position and soil depth. It is clear that deep moist soils near rivers will be much more productive and produce much more litter than shallow-dry upland soils (Osem *et al*. 2002). In addition, fertile clay soils will produce more than leached sandy soils (Deshmukh 1984). Also, the higher the rainfall of a region, the higher the productivity of that region (Deshmukh 1984). Rainfall, soil type and depth and landscape position are parameters that are easy to determine and, therefore, it would be easy for a manager to work out a grazing plan for a farm based on the particular combination of these parameters in the various parts of the farm. The manager can get tangible, objective answers using these parameters, whereas it appears to me that there is no clear way of determining the brittleness of a region. Even in the tropics rangelands have dry seasons so, in effect, all rangelands are going to be classified as brittle to some extent. Also, the whole farm is classified as brittle or not brittle so it cannot be applied to developing a grazing plan for the different areas of the farm. What is the use then of the brittleness scale for rangeland managers?

Finally, ecological research has shown that the effect of grazing on diversity varies predictably along productivity gradients. Resting dry unproductive grassland resulted in increased diversity with the reverse being true in moist productive grassland (Proulx and Mazumder 1998; Osem *et al*. 2002: Bakker *et al*. 2006). Burgess (2001) reports on several examples of where planned grazing has failed to improve the land and they are all from the unproductive arid American west, as I would have predicted from simple ecological knowledge. Even on Savory's own ranch Dimbangombe, there was no evidence that planned grazing had resulted in any improvement of the land on dry rocky uplands relative to adjacent communal lands on the same soil types; both were dominated by annuals. Where we did see the positive effects of planned grazing was on better, more productive soils. Again this result was easy to predict because the extremely unproductive grasslands on the shallow dry rocky upland soils at Dimbangombe do not produce enough litter to result in moribund grassland or severe light limitation so grazing has no benefit in this regard. In contrast, the more productive grasslands on the better soils closer to river lines needed grazing or fire to remove the light-inhibiting litter and, therefore, responded nicely to planned grazing. It is clear, therefore, that dry grasslands (unproductive owing to poor soils or low rainfall) need less grazing to maintain health than moist productive grasslands. This is the sort of information that managers for need for planning not this vague, intangible notion of brittleness, which is almost impossible to quantify and does not appear to vary sufficiently in rangelands to be of much use for management.

Conclusion

In conclusion, our trip to Allan Savory's ranch was extremely worthwhile and insightful and everyone was impressed with what they saw, and was determined to return. I feel that Savory's experience on the ground in such a wide variety of unique landuse impacts, changing animal numbers and environments combined with some clear thinking allowed him to gain several insights into African rangeland ecology that could bring important breakthroughs in rangeland management. His ideas have met with much scorn and resistance but that happened to all who challenged incorrect paradigms (e.g. Galileo). I fully support his thinking that the current paradigm of resting veld to restore it and minimizing grazing and hoof impact in rangeland management is false, at least for moderate to high productivity grasslands. Moreover, I believe that the role of fire in rangeland management needs to be re-evaluated. The evidence is clear; fire reduces soil quality and grassland productivity and interferes with hydrological cycles. Herbivores used in the correct way can prevent bush encroachment without the negative effects of fire on ecosystem properties. Rotational grazing has been buried (Briske *et al*. 2008) so now is the time to take some of Savory's ideas and to put them to test. It would be useful to look at the mechanisms through which Savory's grazing methods affect grasslands. Do animal-maintained grasslands with no fire have higher plant density, broken soil surfaces, increased surface litter, higher seed germination, reduced surface runoff of water, greater infiltration, higher soil moisture, higher recharging of ground water and better wetlands and stream flow relative to fire-maintained grasslands with little grazing? Also, are root systems of grasses bigger or smaller in animal-maintained grasslands with no fire relative to fire-maintained grasslands with little grazing? Research on the effects of clipping grasses on their root systems suggests that animal-maintained grasslands will have smaller root systems than fire-maintained grasslands (Coughenour *et al*. 1985; Eroma 1985; Danckwerts and Nel 1989). This is not necessarily a bad thing because grazed-down grasses with low leaf area and smaller root systems are likely to draw out much less soil moisture than grasses with lots of leaf area and big deep root systems. I believe that the hydrology of animal-maintained grasslands may be better than fire-maintained grasslands not only because of higher plant density, more surface litter and broken soil surfaces but also because of lower evapotranspiration by the grasses owing to their lower leaf area and smaller root systems. These are the things that rangeland ecologists need to start to examine.

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Allan Savory (left, in bare feet) elaborating on his observations on grazing effects on rangelands

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Drought effects on buffalo numbers in Kruger

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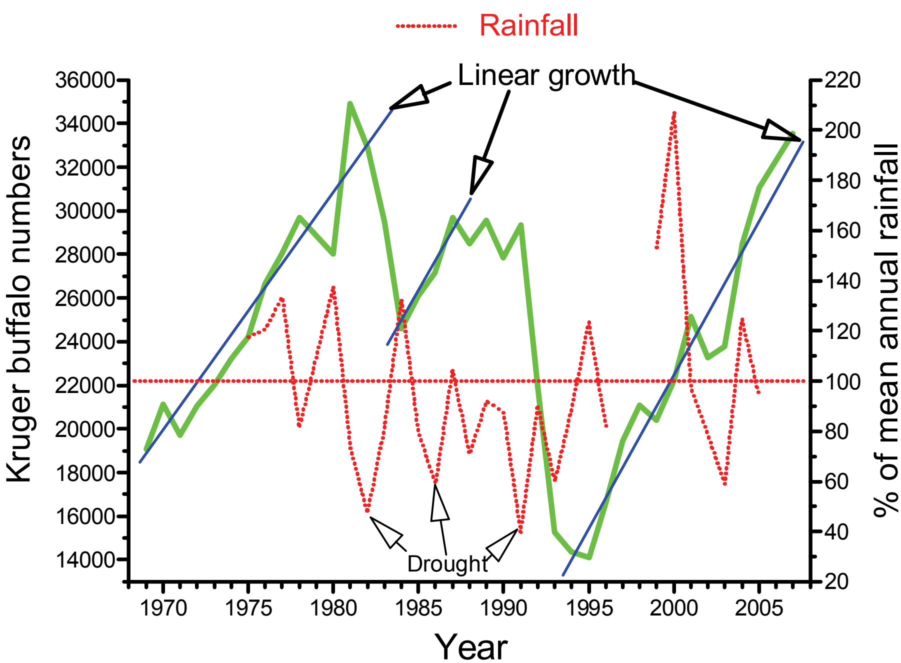

Drought effects on buffalo numbers in the Kruger National Park. Strong evidence for the non-equilibrium dynamics as argued by Ellis & Swift (1988. Journal of Range Management, 41:450-459). An equilibrium system will exhibit density dependent feedbacks on population growth resulting in an asymptotic growth curve. Non-equilibrium systems are controlled by external abiotic drivers such as rainfall rather than internal biotic feedbacks and consequently population growth has no evidence of density dependence (linear growth curves). This is exactly what is observed in the Kruger buffalo population and is caused by the fact that buffalo no longer have access to the high rainfall savannas at the base of the escarpment (regional key resource areas) which would provide more dependable forage during drought and buffer its effects on population numbers. Consequently, animal numbers never rise to levels that affect grass biomass during normal years, as seen in Kruger.

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