PROCEEDINGS OF THE AUSTRALIAN RANGELAND SOCIETY BIENNIAL CONFERENCE

Official publication of The Australian Rangeland Society

Form of Reference

The reference for this article should be in this general form;

Author family name, initials (year). Title. *In*: Proceedings of the nth Australian Rangeland Society Biennial Conference. Pages. (Australian Rangeland Society: Australia).

For example:

Anderson, L., van Klinken, R. D., and Shepherd, D. (2008). Aerially surveying Mesquite (*Prosopis* spp.) in the Pilbara. *In*: 'A Climate of Change in the Rangelands. Proceedings of the 15th Australian Rangeland Society Biennial Conference'. (Ed. D. Orr) 4 pages. (Australian Rangeland Society: Australia).

The Australian Rangeland Society

SEED BANKS AND SAFE SITES IN GRAZED ARID GRASSLANDS

J.E. Kinloch and M.H. Friedel

CSIRO Sustainable Ecosystems, PO Box 2111, Alice Springs, NT 0871

ABSTRACT

We assessed the seed bank dynamics, standing herbage dynamics and soil loss along two gradients of grazing with different histories of grazing use, in the arid grasslands of central Australia. We also examined the impact grazing had on the number of 'safe sites' for seeds by assessing the fine- and broad-scale trapping of resources. It is likely that the size of seed banks was reduced in the first instance by the indirect effects of grazing through the loss of 'safe sites'. For both gradients, the process of soil destabilisation and loss preceded changes to the vegetation composition. This suggests that, in this environment, soil-based rather than vegetation-based indicators would provide a better early warning of rangeland deterioration.

INTRODUCTION

To determine why plants fail to germinate and establish on degraded areas we need to understand how grazing interacts with the underlying ecological processes of arid ecosystems. Previous studies in the calcareous grasslands of central Australia showed that, on areas which had a long history of heavy grazing, herbaceous vegetation failed to recover despite major reductions in stocking levels and good rainfall (Friedel 1997). It appeared that heavy grazing and trampling by livestock had changed resource distribution processes, leading to nutrients and water becoming decoupled (Tongway *et al.* submitted). Consequently the lack of plant germination and establishment may be attributable to a disconnection between the availability of nutrients and water in space and time. Alternatively a lack of propagules may have prevented plant germination and establishment. Grazing can either directly reduce the number of propagules through grazing of seed-bearing plants, or the effects can be indirect through changes to the soil and landscape processes that maintain 'safe sites' for seeds.

In this study we examined the soil, herbage and seed banks along two gradients of grazing with different histories of grazing use, in the arid grasslands of central Australia and we investigated what impact different grazing use had on the number of 'safe sites' by assessing the fine- and broad-scale trapping of resources.

METHODS

The study was located on two stations south of Alice Springs on grazed calcareous grasslands. At station A, the watering point had been permanent for only 16 years prior to the study, and grazing over that time had been moderate. At Station B, the watering point had been permanent for 42 years prior to the study and had been heavily grazed by current standards; the long-term stocking rate was more than twice that at Station A. Grazing had continued at Station B during a severe drought that began soon after the watering point was made permanent. Study sites, 150m^2 in area, were set up at intervals along a radius of grazing use centred on each watering point. The most intensively grazed site at each watering point was less than 500m away and the least grazed site was greater than 6.2km away. Each site was subdivided into nine 50m x 50m tiles and these tiles formed the basic unit of measurement.

Six monthly vegetation surveys were conducted on the sites, post-winter and post-summer, to assess the frequency of all non-woody species. At the same time, soil cores were taken from the study sites for germination trials in a glasshouse. These germination trials gave an estimate of the 'readily germinable' component of the seed bank. Vegetation and seed bank data were collected over a three year period at Station A, and over a one year period at Station B.

The fine-scale (<1m^2) trapping of resources was evaluated by assessing the soil surface condition at each of the study sites using the methods outlined in Tongway (1994). The evaluation of the broad-scale resource traps at Station A focused on recording the presence of 'active resource traps' for all sites. Active resource traps are physical barriers (≥1m^2), such as *Maireana astrotricha* shrubs, *Acacia* spp. trees and associated soil mounds or remnant log mounds, which had a greater herbaceous cover than their surrounds, suggesting that the supply of resources such as water and nutrients were favourable. At Station B, the number of *Maireana astrotricha* shrubs per unit area (Friedel *et al.* submitted) indicated the potential for broad-scale resource capture along the grazing gradient.

Pit traps, 20cm in diameter, were installed at each site along the gradient at Station A to give an indication of the amount of soil loss at each site. The traps were in place for three years and were emptied every two months. They collected any soil, litter or seed blowing or washing across the soil surface.

RESULTS AND DISCUSSION

Station A

Where grazing use had been moderate and relatively short (<2 decades), neither the size of the germinable seed bank nor its composition were related to grazing (Table 1a). On the other hand, differences in the capacity to trap and retain resources, at both the fine and broad scale, were related to grazing: the number of 'safe sites' declined as grazing intensity increased. At the fine scale, trends in soil surface attributes, especially those related to stability of the soil surface, were related to grazing (Table 1b). For example cryptogams, which indicate a stable soil surface, were not present at the three sites closest to water and the amount of eroded sand was a lot greater at Sites 1 and 2. A similar trend is also evident for the broad-scale active resource traps. These traps were only present in the majority of the nine tiles on each site, for the less intensively grazed Sites 4 and 5 (Table 1c).

This declining trend in resource-conserving capability is well illustrated by the increased amount of soil loss, over a three year period, on the more intensively grazed sites (Fig. 1). Such a dramatic increase in soil loss suggests that the ability of the landscape to trap and store resources like water and nutrients, as well as seed, has been much reduced.

Despite the apparent decline in the number of 'safe sites', we found that standing herbage was still able to recover after rainfall (data not shown) indicating that, at that point in time, the replenishment of seed supply was sufficient to overcome the declining number of 'safe sites' for seed capture. At this site, changes to the soil surface and resource-trapping capability appear to have preceded any changes to the vegetation.

Table 1. Summary for Station A of (a) mean number per survey of germinable herbage seeds over the three year study period, (b) soil surface stability and (c) the number of tiles (out of 9) where active resource traps were present. Soil stability attributes were assigned to classes (1–4; where 1 = nil cover of cryptogams and 1 = >50% cover of eroded sand). Distance of sites to water: Site 1 = 0.5km; Site 2 = 0.9km; Site 3 = 1.7km; Site 4 = 3.0km; Site 5 = 6.2km.

	Site 1	Site 2	Site 3	Site 4	Site 5
(a) Mean number/survey of germinable seeds	188	207	303	114	236
(b) Soil surface stability					
Median index of cryptogam cover	1	1	1	2	2
Median index of eroded sand cover	2	2	3	3	3
(c) Number of active resource traps	1	1	1	7	6

The number of germinable seeds was greatest when the soil crust was intact and when soil infiltration and litter cover were high. These conditions were only present across individual tiles on up-slope areas of Site 3 and may explain why this site had the higher number of germinable seeds (Table 1a). The large particle size of the sandy soils, in these tiles, allowed the seeds to more readily move vertically down the soil column and enter the seed bank. Conversely lower numbers of germinable seeds were present when the soil clay content was high and a hard physical soil crust was present. These soil conditions prevailed over the majority of tiles on Site 4 and probably accounts for the low seed bank size on this site (Table 1a).

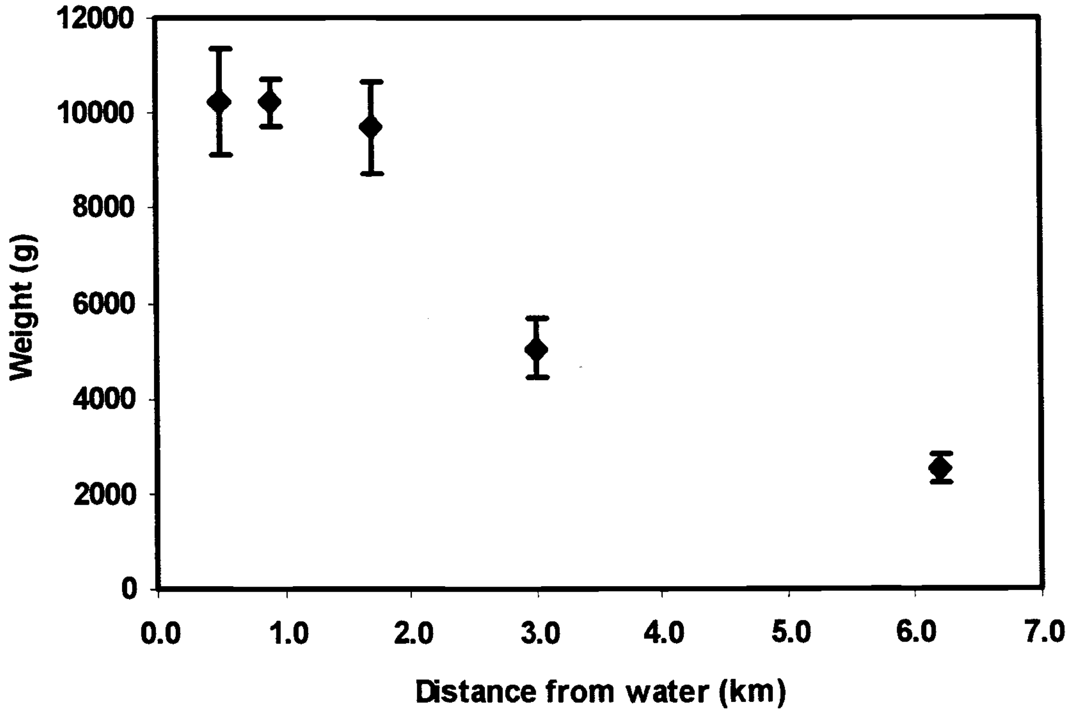

Fig. 1. Variation in the mean amount of total soil and other material caught in pit traps over a three-year period at different distances to water at Station A. Vertical bars indicate 1 SD. Number of replicates at each site differed as data were not available for the full three-year period for all traps. Number of replicates: Site 1 = 5; Site 2 = 5; Site 3 = 7; Site 4 = 6; Site 5 = 6.

Station B

Where grazing had continued over a long time (>4 decades), and included a period of drought, permanent changes to the standing herbage, soil surface condition and resource traps were apparent. The size of the germinable seed bank at sites 1 and 2 was less than half that found at the less intensively grazed Site 3 (Table 2a). The composition of both the germinable seed bank (data not shown) and standing herbage (Friedel 1997; Friedel *et al.* submitted) were also changed at the two most intensively grazed sites.

Differences in the fine- and broad-scale resource traps were similar to those found at Station A. Lower cryptogam cover and higher cover of eroded surface sand at sites 1 and 2 indicated a decline in soil stability (Table 2b). At these same sites fine-scale microtopographic relief was reduced (Table 2c), thus limiting the potential of the sites to trap soil, water, nutrients and seeds. Larger resource traps also declined, since fewer *Maireana astrotricha* shrubs were present closer to the watering point (Table 2d). This deterioration of the fine- and broad-scale resource traps where grazing is intensive indicates that the number of 'safe sites' for plant germination and establishment has declined on this grazing gradient.

Table 2. *Summary of (a) mean number per survey of germinable herbage seeds over the one year study period, (b) soil surface stability, (c) soil microtopography and (d) number of* Maireana astrotricha *shrubs at Station B. Distance of sites to water: Site 1 = 0.3km; Site 2 = 4.5km; Site 3 = 8.6km. Soil surface stability data from Tongway* et al. *(submitted) and shrub data from Friedel* et al. *(submitted).*

	Site 1	Site 2	Site 3
(a) Mean number/survey of germinable seeds	46	37.5	98
(b) Soil surface stability			
Median cover of cryptogams (%)	1.4	1.7	2.7
Median cover of eroded sand and gravel (%)	44	45	32
(c) Microtopography			
Median value of maximum microtopographic depression (mm)	3.1	3.2	4.3
Median value of maximum microtopographic hummock (mm)	10.0	9.0	15.6
(d) Number of Maireana astrotricha shrubs (per m^2)	0.01	0.08	0.41

There is insufficient evidence to determine whether direct effects of grazing, through reduced seed supply, or indirect effects of grazing, through changed soil and landscape processes, caused the initial decline in the seed bank at Station B. However, it is unlikely that seed supply would have been limiting in the early stages of degradation. The seeds of many species present are wind-borne and would be readily replenished from outside the immediate area. It is more likely that the decline in 'safe sites', together perhaps with decoupling of nutrients and water, constrained plant germination and establishment in the first instance. The direct effects of grazing may have become more important in the long term when sustained heavy grazing had brought about widespread plant species compositional change.

We conclude that soil-based indicators of rangeland condition would probably provide an earlier warning of rangeland deterioration in this environment than would conventional vegetation-based indicators.

REFERENCES

Friedel, M.H., Sparrow, A.D., Kinloch, J.E. and Tongway, D.J. (submitted). Degradation and recovery processes in arid grazing lands of central Australia 2: Vegetation. *Journal of Arid Environments.*

Friedel, M.H. (1997). Discontinuous change in arid woodland and grassland vegetation along gradients of cattle grazing in central Australia. *Journal of Arid Environments* 37: 145-164.

Tongway, D.J. (1994). Rangeland Soil Condition Assessment Manual. Melbourne: CSIRO Publishing. 69 p.

Tongway, D.J., Sparrow, A.D. and Friedel, M.H. (submitted). Degradation and recovery processes in arid grazing lands of central Australia 1: Soil and land resources. *Journal of Arid Environments.*