Changes in Grassland Composition with Grazing Management in the Mid-North of South Australia: Continuous, Rotational and Pulse Grazing

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Abstract

Remnant native grasslands of the Mid North of SA have historically been extensively grazed and most are in degraded condition. Grazing trials were established to investigate the effects of different forms of grazing management on species diversity and productivity of native grasslands. Extended periods of low density grazing resulted in a decline in the productivity of native perennial grasses and a significant increase in bare ground. Phenologically based seasonal rotational grazing treatments generally reduced herbage production of native perennial grasses and resulted in a decline in species diversity and stocking rates. Removal of livestock is commonly advocated as a method to increase the diversity of native grasslands, results from this trial indicate a significant reduction in species diversity in the absence of grazing animals. The application of high density, short duration grazing periods based on plant growth rate increased the basal cover and herbage production of native perennial grasses and supported higher stocking rates than all other treatments. Improvements in the health and composition of native perennial grasslands may be achieved through managing livestock differently and basing graze periods on plant growth rates. The results presented here indicate that grazing livestock may be a valuable tool for restoring grassland community diversity while improving the health and productivity of native grasslands.

Introduction

Native grasslands and grassy woodlands were once extensive across the Mid-North of South Australia (SA), but are now extensively cleared. It is estimated that 98% of all remnant native grasslands are on private property and over 98% of these areas are grazed. The grasslands primarily exist as extensively grazed areas on private land which are predominantly on rocky or relatively steep slopes. Most are in a degraded condition, dominated by annual grasses such as wild oats (*Avena barbata*), brome grasses (e.g. *Bromus molliformis*, *Bromus rubens*), and barley grass (*Hordeum leporinum*), although some retain a high diversity and cover of native grassland flora.

To address this problem, in 1999, the Mid-North Grasslands Working Group (MNGWG) secured funding from the National Heritage Trust (NHT) to initiate the establishment of grazing trials throughout the region. The Best Practice Grazing Trials project was established to demonstrate to landholders that by using improved forms of grazing management it was possible to increase simultaneously the productivity, biodiversity and conservation of native grasslands in the Mid-North.

As part of this project, sites were established on seven commercial sheep/cropping properties (Kahn, these proceedings) and a scientific site was established where 6 different forms of grazing management were established within what was originally a single paddock. The aim of the trial at the scientific site was to investigate the effect of different forms of grazing management on species diversity and structure in native grasslands. This presentation will focus on results from the scientific site.

Body

Methods

The experimental site was established on the property, “Anama”, 15 km north of Clare (138º 35’E and 33º 47’S), SA. The paddock used for the experimental site had a history of summer rest and periodic grazing for the remainder of the year such that annual stocking rate was estimated to be the equivalent of 2.5 dry sheep per hectare.

The treatment design had two approaches to timing the period of rest (absence) from grazing which were either according to season or pasture growth rate and herbage mass. The seasonal approach involved resting native grasslands during certain "seasons" and, rather than using calendar seasons, the year was divided into four "phenological seasons", defined according to the phenological stages of the predominant native grasses present in the pastures, *Austrodanthonia* spp. and *Austrostipa* spp.

A total of six treatment paddocks, the area of each ranged between 5-6 ha, were established on the site. The grazing management treatments were:

Treatment 1: Summer rest from grazing - grazed continuously from April 17 to December 16 at a rate equivalent to an annual stocking rate of 2.5 sheep/ha. This was considered district practice and served as the control.

Treatment 2: Spring / summer rest from grazing - rotationally grazed during autumn and winter between April 17 and August 24.

Treatment 3: Autumn / summer rest from grazing - rotationally grazed during winter and spring between June 17 and December 13.

Treatment 4: Spring, summer and autumn rest from grazing during 2001/02 - rotationally grazed between June 17 and August 24 2001 (summer/autumn rest) and in subsequent years rested from grazing during spring and summer - rotationally grazed between April 17 and August 24.

Treatment 5: High density and short duration (HDSD) grazing periods were based on plant growth rate able to be applied at any time throughout the 12 months of each year.

Treatment 6: No grazing at any time throughout the 12 months of each year.

Rotational grazing in treatments 1-4 was applied with a 40 day graze period followed by a 50 day rest. During the period of grazing, paddocks were stocked with appropriate numbers of sheep to achieve an equivalent annual stocking rate of 2.5 sheep/ha. No stocking rate restriction was applied to Treatment 5, this paddock was stocked with between 500 and 650 sheep for between 2 and 6 days to graze pastures to leave a minimum residual of 750 kg DM/ha.

In each paddock, 5 permanent 50 m transects were established to monitor changes in a number of vegetation parameters over time. Monitoring of pastures in the first year was undertaken during September but in each subsequent year monitoring occurred during November. Measurements from each paddock included:

i) Estimation of the contribution of the dominant pasture species to the total dry weight of herbage mass using the BOTANAL procedure (Haydock & Shaw 1975). Along each transect the dry-weight-rank was assessed in each of ten 50 x 50 cm quadrats (area of quadrat $0.25m^2$). In each $0.25m^2$ area, dry weight was visually assessed and the species present were ranked in order of their contribution to the dry weight of pasture.

ii) The presence or absence of plant species was recorded in the same $0.25m^2$ quadrats. Presence/absence data is expressed as the percentage frequency of occurrence of each species in the total number of quadrats measured. These data enabled calculation of the average number of species which occurred within each quadrat and along each transect.

iii) The number of perennial grasses per transect was measured by counting the number of individual native perennial grass plants present in each of the ten 50 x 50 cm square quadrats along two transects in each paddock.

iv) The 100 point quadrat method was used to determine plant basal cover. A 1 m^2 quadrat with points located 10 cm apart was used. Three replicates were measured in each treatment paddock with the 100 point quadrat being located 5 m from the end of three transects. The 100 point method gives a measure of the percentage ground area (i.e. basal cover) occupied by living plants. It also gives an indication of basal cover composition and percentage bare ground, litter, rock and lichen.

For statistical analysis, these data were subjected to analysis of variance (SAS Institute Inc, 1990) using generalised linear models after the normality of the data was confirmed.

Results & Discussion

At the initial measurement, within all treatments, pasture composition was dominated by annual grasses, in particular false brome (*Brachypodium distachyon*) and wild oats (*Avena barbata*) with the bulbous cape tulip (*Homeria flaccida*) being another dominant pasture component. Across all treatments native perennial grasses contributed 31.5% of the total pasture biomass at the initail sampling. At the final sampling this contribution had increased to 39.6% (Table 1). The dominant perennial grasses were brush wiregrass (*Aristida behriana*) and speargrasses (*Austrostipa* spp.), other native perennial grasses present included wallaby grasses (*Austrodanthonia* spp.), kangaroo grass (*Themeda australis*) and Queensland bluegrass (*Dicanthium sericeum*).

The mean contribution of native perennial grasses increased in all treatments with the exception of the spring rest treatment (Paddock 3) at the final measurement. The percentage contribution of native perennial grasses to pasture biomass at the initial and final measurements and the relative change over time is presented in Table 1.

Table 1. Mean percentage contribution of native perennial grasses to pasture biomass within each treatment paddock at the initial measurement in Sept 2000, the final measurement in Nov 2002 and the relative change over time.

	Paddock 1	Paddock 2	Paddock 3	Paddock 4	Paddock 5	Paddock 6
September ‘00	43.0	34.3	39.7	27.6	15.7	28.4
November ‘02	51.0	47.5	34.0	40.0	30.8	34.4
% Change	+ 18.6%	+ 38.4%	- 15.4%	+ 44.9%	+96.2%	+21.1%

The general increase in the percentage contribution of native perennial grasses to pasture biomass across most treatments over time was not reflected in the total biomass production of these pasture components. Pasture growth during 2001 was above average, corresponding with higher than average rainfall during the growing season. In contrast, pasture growth during 2002 was below average and production from annual grasses and total biomass was low. Although differences were not statistically significant, the autumn rest (Paddock 2) and HDSD grazing treatments (Paddock 5) were the only paddocks where the biomass of native perennial grasses showed a trend to increase over the previous season (Fig. 1).

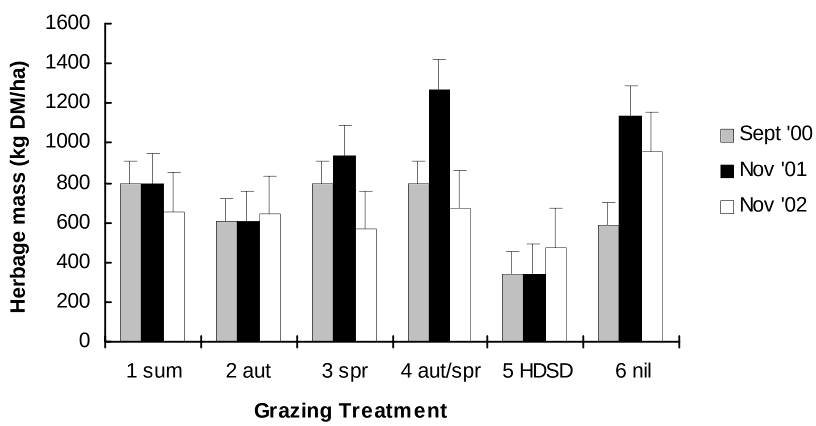

Fig. 1: Pasture dry weight (± standard error) of all native perennial grass species for the period 2000-2002 from all treatment paddocks.

At the initial measurement there was no significant difference in herbaceous species diversity, measured by the average number of species recorded per transect across all sites. Significant effects of grazing management emerged during November 2001 where a greater number of species were recorded in the summer rest (Paddock 1) and the HDSD (Paddock 5) treatments (Fig. 2). At the November 2002 measurement differences between the treatments declined but the same trend was evident.

The lowest level of species diversity was recorded in the nil grazing treatment (Paddock 6), this treatment also produced the greatest level of change from initial measurements (Fig. 2). Removal of grazing livestock from areas is often advocated as a means of improving biodiversity and conservation value of grasslands. These data indicate a negative effect of removal of livestock on biodiversity of grasslands.

The higher level of species diversity in the summer rest treatment (Paddock 1) was thought to be due to the higher level of bare areas (Fig. 5) allowing expression of more annual species, particularly annual forbs, in the pasture. In the HDSD treatment (Paddock 5) the suppression of the dominance of annual grasses with the application of pulse grazing timed to complement plant growth rates also allowed the expression of a greater number of species in the pasture. The later mechanism, in reverse, would also account for the reduction in number of species in the nil graze treatment (Paddock 6).

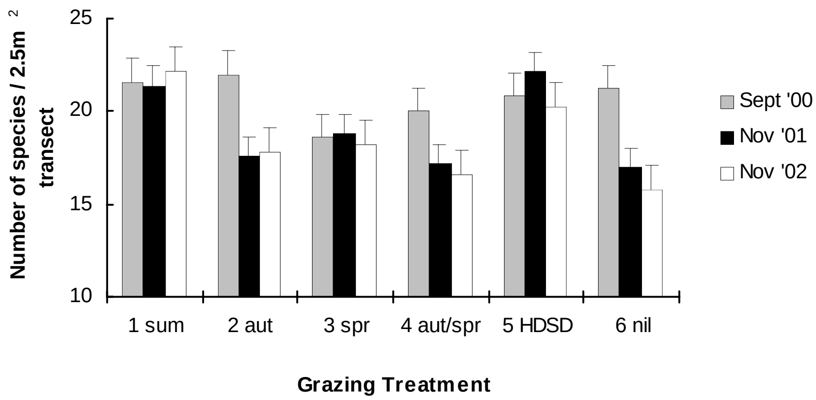

Fig. 2: Mean number of herbaceous species (± standard error) recorded on each 2.5 m^2 transect in all treatment paddocks for the period 2000-2002.

The mean number of individual perennial grass plants recorded per transect increased in those treatments grazed according to phenological season and at relatively low stock densities, Paddocks 1 to 4 (Fig. 3), although these changes were not statistically significant. In each of these treatments there was a continuing trend for the number of perennial grass plants per transect to increase over time, increases of 50, 40, 22 and 34% respectively from the initial measure. However, this trend for increasing numbers of grass plants did not correspond with an increase in the total biomass production of native perennial grasses (Fig.1) indicating an increased number of smaller or less productive individual plants. The occurrence of an increasing number of individual plants with small basal diameter was apparent in field observations.

In the HDSD treatment (Paddock 5) a small increase (10%) in the number of perennial grasses per transect was recorded over time (Fig. 3). This increase in the number of plants corresponded with a 40% increase in native perennial biomass recorded in this treatment (Fig. 1) indicating that, compared to the other grazing treatments, relatively fewer individual plants grew more vigorously and produced a greater amount of biomass. The nil grazing treatment (Paddock 6) was the only treatment which recorded a reduction in the number of native perennial grasses per transect over time (Fig. 3). This trend suggests declining vigour of native perennial grasses in the absence of grazing livestock.

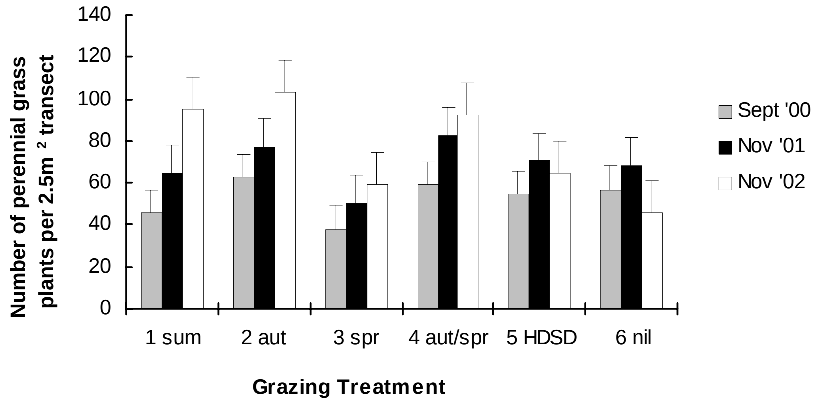

Fig. 3: Mean number of native perennial grass plants (± standard error) recorded on each 2.5m^2 transect in all treatment paddocks for the period 2000-2002.

The percentage basal cover of native perennial grasses increased from the initial measurement in all rotationally-grazed treatments, Paddocks 2 – 5 (Fig. 4). Although these changes were not statistically significant the trends exhibited in each treatment were relatively consistent. The greatest relative increase (64%) occurred under the HDSD regime (Paddock 5) where basal cover was recorded to have increased from 3.7% to 6.0% over the duration of the trial period. Native perennial basal cover increased to a lesser extent in the seasonal grazing treatments.

Under the nil grazing management (Paddock 6) the level of cover provided by native perennial grasses declined to the greatest extent (33%) after an initial increase (Fig. 4). This result also suggests the detrimental effect of the long absence of livestock on the vigour of native perennial grasses. In the summer rest treatment (Paddock 1) the basal cover of native perennial grasses declined at a similar rate over time, supporting the previous observation of a decline in size and vigour of individual plants.

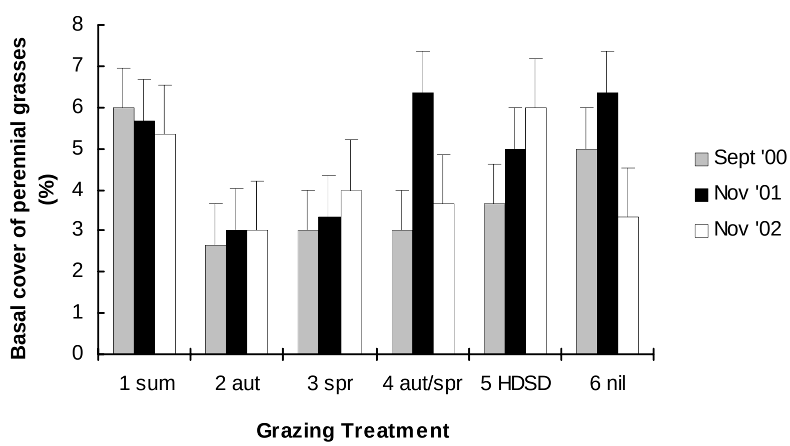

Fig. 4: Mean percentage basal cover of native perennial grass plants (± standard error) recorded per 1 m^2 quadrat using the 100 point quadrat in all treatment paddocks for the period 2000-2002.

The relatively low soil moisture conditions experienced at the site during the 2002 growing season resulted in a significant decline in the level of total plant basal cover at the site, largely due to a reduction in the amount of cover provided by annual grasses. In treatments 2 – 5, this was compensated by an increase in the amount of plant litter present on the soil surface and consequently only relatively small increases in bare ground were recorded (Fig. 5). In the HDSD treatment (Paddock 5) the amount of bare ground changed little over time, increasing from 4 to 5%. In the summer rest treatment (Paddock 1) a significant increase in the percentage of bare ground was recorded from an initial measure of 4% the amount of bare ground at the final measurement was 43%.

The presence of high levels of bare ground in grasslands inhibits organic matter turnover and effective functioning of mineral cycling within the soil. The high level of bare ground recorded in Paddock 1 represents significant degradation of the resource base associated with long-term exposure to low numbers of sheep stocked at low density. In the absence of any disturbance from livestock and the accumulation of plant material in the nil grazed treatment (Paddock 6) no bare ground was recorded following the initial measurement (Fig. 5).

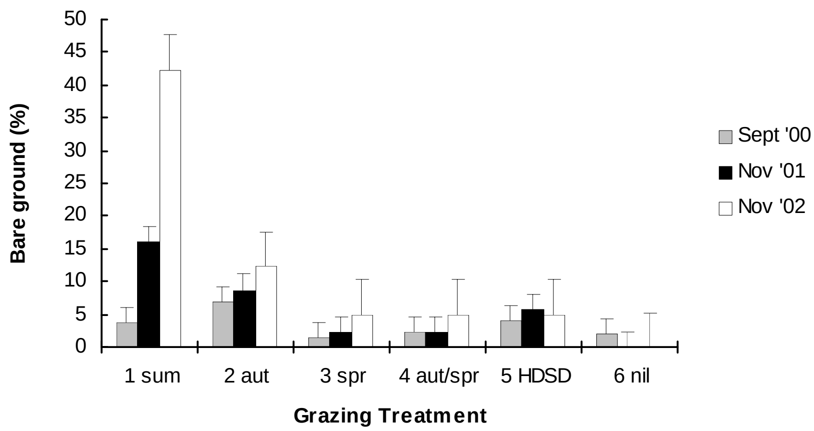

Fig. 5: Mean percentage bare ground (± standard error) recorded per 1 m^2 quadrat using the 100 point quadrat in all treatment paddocks for the period 2000-2002.

In any livestock production system the objective of improving the health and condition of pastures must also consider the potential effects on livestock productivity. Similarly, changes in pasture composition must also be assessed in light of the total grazing pressure to which each area is exposed during the course of any 12 month period. Table 2 shows the stocking rates (DSE/ha) recorded during each year of the trial within each grazing treatment. Figures were adjusted on the basis of animal production (weight gain or loss) during the time livestock were present in the respective treatments.

Table 2. Annual stocking rates (DSE/ha) recorded in each treatment paddock at the scientific site located on “Anama”.

	Grazing treatment				
	1	2	3	4	5
Year	Summer rest	Autumn rest	Spring rest	Aut/Spr rest	HDSD
2001	2.7	3.0	3.7	4.0	7.1
2002	2.4	1.8	1.7	1.3	3.0

The stocking rates recorded for each treatment would indicate that positive vegetation change in grazed pastures is less a function of the number of animals in each paddock but rather more related to the time that plants are exposed to defoliation by livestock and the length of time allowed for plants to recover from previous grazing events. In the second year the 50 day rest provided between grazing periods was insufficient for plants to recover from previous grazing and regrow and livestock lost weight while grazing these pastures.

CONCLUDING REMARKS

Native perennial grasses provide stability and structure to grasslands and a combination of warm season and cool season grasses present in a pasture will provide stability to livestock production systems. Implementation of pulse grazing enhanced the growth, productivity and cover of native perennial grasses and supported a higher stocking rate than all other treatments.

Removal of livestock is commonly advocated as a method to increasing biodiversity and the conservation value of grasslands. Results from this trial indicate the detrimental effect of removing livestock on the health and vigour of native perennial grasses and biodiversity. Grasses are well adapted to defoliation having evolved to tolerate various forms of intermittent disturbance (Jones 2003). In the absence of livestock, total biomass increases, nutrient cycling decreases and the ability of native grass plants to produce new growth and regenerate is inhibited.

The seasonal-based rotational systems (Treatments 2 – 4) all had the effect of decreasing plant species diversity. The spring rest treatment (Paddock 3) resulted in a decline in the percentage contribution of native perennial grasses to pasture dry weight and the autumn rest treatment was the only calendar based rotation treatment to record a marginal increase in perennial herbage mass at the final measurement. However, all showed a slight increase in the basal cover of native perennial grasses over time. Importantly, these grazing treatments resulted in reductions in stocking rate and have difficulty in application because they cannot be applied across an entire farm.

Continuous grazing of small numbers of sheep stocked at low density for extended periods of time at the same time each year is thought to be the primary cause of the degradation of native grasslands in the region. The results of this study would support such a conclusion. The summer rest treatment (Paddock 1) resulted in a reduction in herbage mass production of native perennial grasses, reduced vigour and basal cover of perennial grasses and a significant increase in bare ground over the duration of the trial period. That stocking rate was little affected by year suggests short-term stability in stocking rate may be at the direct expense of long-term production and biodiversity.

Monitoring of a range of parameters relating to vegetation change in grasslands is important to generate a more complete assessment of the mechanisms responsible for generating change in composition and health of native grasslands. No single measurement will accurately describe grassland condition or identify the direction of change. Vegetation change is a dynamic process expressed in changes in the relative vigour, abundance and competitive interactions between component parts.

The results from this study emphasise the importance of continuing grazing management studies over a period in excess of 3 years. A number of trends were apparent in the data showing the advantages of pulse grazing native grasslands in response to plant growth and rate of recovery from grazing events, however, there were few statistically significant differences. The apparent trends show that through managing livestock differently animals may be a valuable tool for restoring grassland communities and improving the health of perennial native grasses.

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