DEPARTMENT OF
PRIMARY INDUSTRY, FISHERIES AND MINES

Comparison of rotational grazing and continuous grazing on a buffel grass (*Cenchrus ciliaris*) dominated pasture: preliminary results from Mt Riddock Station.

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This report presents preliminary findings from the grazing trial conducted at Mt Riddock Station as part of the Desert Knowledge CRC project "Rangelands grazing management strategies for improved economics and resource stability" funded by the National Landcare Program. The project was completed by a partnership including DPIFM, CLMA, DKCRC, CSIRO and the Cadzow family of Mt Riddock Station.

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Many individuals were involved with this project throughout its course. Andrea Tschirner, Jo Rodney, Dionne Walsh, Chris Materne, Ben Norton, Leigh Hunt and Neil MacDonald were involved in the initial setting up of the project. Mark Stafford Smith from the DKCRC was instrumental in sourcing funding and getting the project off the ground. Staff from the Department of Primary Industry, Fisheries and Mines, Alice Springs, including Ellena Hannah, Sally Leigo and Chris Materne were involved with field work. Coral Allan provided assistance with processing laboratory samples and data entry. Special thanks to Mark Hearnden for his assistance in data analysis and reporting.

Jillian Fisher, project manager based with the Centralian Land Management Association, provided invaluable assistance throughout the entire project. Jillian managed the overall project, liaised between partners, reported to the funding organisations and assisted with both cattle work and pasture assessments.

The concept of the rotational grazing strategy was designed by the Cadzow family as owners and managers of Mt Riddock Station. The Cadzows had complete responsibility for the ongoing management and implementation of the grazing strategy. Their willingness and enthusiasm to invest time and money into scientific analysis of their management is much appreciated. Their hospitality is second to none!

Abstract

There has been widespread interest by the industry in spelling practices, which hold out the potential for increased production without damage to natural resources or sustained production with recovery of the natural resources. The benefits of rotational grazing in the semi arid rangelands have been little documented and it is therefore difficult for managers to commit to these new grazing strategies. The trial at Mt Riddock Station, 200km north-east of Alice Springs, compares an eight paddock rotation, used primarily by steers, with a continuously grazed paddock. Both the treatment and control paddocks are dominated by the introduced perennial buffel grass (*Cenchrus ciliaris*). The study aimed to test the hypotheses that rotational grazing will; increase carrying capacity, result in more even utilisation of pasture, improve or maintain land condition, increase species diversity, reduce fire risk and frequency and increase average daily weight gain in steers. Given that the trial had only been operating for two years at the time of reporting there is little conclusive evidence to support these hypotheses. Early results suggest that rotational grazing has the potential to improve evenness of use across a pasture. Land condition did not improve under either treatment. Species diversity declined under rotational grazing whilst remaining stable under continuous grazing. Fire risk and steer performance were difficult to assess due to methodology used and the relatively short time period assessed. It is also difficult to draw sound conclusions within this trial as the paddocks differed by far more than just grazing duration and rest. Factors such as stocking rate and distance to water are likely to be large contributors to the results to date.

It is worth noting that the managers felt that the rotational grazing strategy was producing good results with regard to steer performance although they feel that it will take some years before the true impact on the pastures is understood. This is typically the case in central Australia where seasonal conditions can significantly influence the length of time before impacts on natural resources are understood. They find the rotational grazing strategy easy to implement and are very keen to continue with the existing strategy and to also extend it into further parts of the property.

1. Background

Over the past decade the ongoing cost-price squeeze has forced pastoralists to look at using their land more efficiently. There has been widespread interest by the industry in spelling practices, which hold out the potential for increased production without damage to natural resources or sustained production with recovery of the natural resources. A regional survey of central Australian pastoralists conducted in 2004 found that 65% already used management strategies that incorporated some rest from grazing. However, for most enterprises these strategies are opportunistic and constrained by a lack of infrastructure. Because the potential benefits of rotational grazing strategies have been little documented, particularly at a practical business scale, in the climatically aseasonal and variable sector of the rangelands (Norton 2003), it has been difficult for pastoralists to make informed decisions and commitments to develop strategies for their own enterprises.

The theory for implementing rotational grazing is that pastures require a rest from defoliation in order to regenerate. Removing grazing during the growing season allows perennial plants to replenish energy stores in their roots, ensures plants have an opportunity to set seed and allows new plants to become established. It follows that encouraging these processes will improve pasture sustainability and yield, allowing for an increased carrying capacity in the longer term. The higher stocking rates associated with rotational grazing strategies are also thought to increase production as more even use of pasture can be achieved (Norton 2003). Conversely, cattle are selective grazers, choosing their diet between species, within a species and for different plant parts. Selectivity allows them to maximise the quality of their diet. Grazing strategies that use high stocking rates, pasture monocultures and 'force' cattle to use all parts of the pasture, influence diet selection. In these circumstances, cattle may not be able to select their optimum diet and therefore individual performance may decline (McCollum 2004).

The rotational grazing strategy examined in this study was conducted on Mt Riddock Station, 200 km north-east of Alice Springs. During the summers of 2000/01 and 2001/02, Mt Riddock Station, like most of the Alice Springs District, received very much above average summer rainfall. These conditions were highly conducive to the spread of buffel grass (*Cenchrus ciliaris*) particularly under relatively light grazing as was the case in the study area. Much of the eastern half of the station was converted from grassland of native annual grasses with only scattered perennial grasses (including buffel grass) to grassland dominated by buffel grass (S. Cadzow pers comm. 2006).

For pastoral managers, buffel grass provides a vigorous perennial pasture that is capable of producing a high yield of palatable forage, is good for reclaiming degraded country and can provide fuel for controlled fires. It also presents management challenges in that it can become rank and unpalatable to stock subsequently reducing pasture availability and creating fuel for wildfires. A characteristic of buffel grass is it's capability to dominate a pasture. Thick buffel stands compete well with native species reducing plant diversity and the ability for grazing animals to select a varied and nutritious diet (Cavaye 1991, Friedel *et al.* 2006).

The principles of rotational grazing were originally devised in mesic pastures with high and consistent plant production and there is little evidence to suggest that rotational grazing is of greater benefit than continuous grazing in the rangelands (Briske *et al.* 2008). Whilst Mt Riddock is well and truly located in a semi arid climatic zone, the introduction and dominance of buffel grass in the study area significantly increased available palatable yield, providing the managers with an opportunity to intensify infrastructure and management in order to graze steers immediately prior to sale. To do this they introduced a rotational grazing system, with smaller paddocks. Their aims were to maximize feed available by increasing yield, pasture quality and evenness of grazing; reduce fire risk by utilising feed before it became dry and rank; gain a better understanding of the

advantages and disadvantages of buffel grass; achieve a balance between buffel and native grasses; and increase marketability of steers.

Study Site

Mt Riddock Station lies approximately 200km north east of Alice Springs (Figure 1). Average temperatures for the region range from a low of 22.5°C to a high of 38.5°C in January and a low of 5.1°C to a high of 22°C in July. The median October to September rainfall at the homestead is 293mm and the median summer rainfall is 216mm.

The area of land under rotation was on the eastern boundary of Mt Riddock Station flanking Entire Creek. The land systems are described by Shaw and Roeger (1988) as Sandover, along the creek, (20%) and Kanandra (80%) (see Table 1). Whilst there is some variation, the dominant vegetation community is ironwood (*Acacia estrophiolata*) and whitewood (*Atalaya hemiglauca*) over buffel grass.

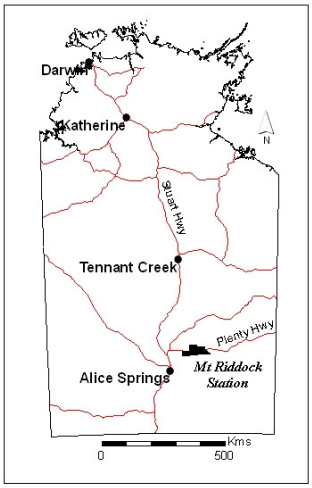
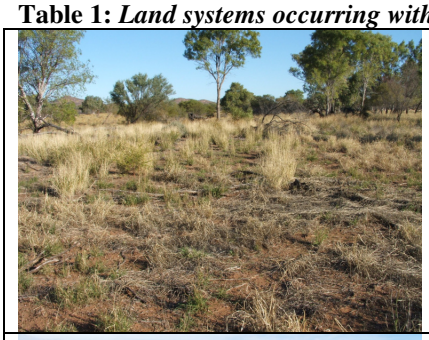


Figure 1: ***Location of Mt Riddock Station within the Northern Territory.***

Table 1: ***Land systems occurring within the trial area.***

	**Sandover** Sandy river plains and broad channels with sandy clay loams. Open woodland of ironwood with gidyea, mulga, whitewood, beefwood and prickly wattle over a grassland of buffel grass with annual grasses and forbs. There are small areas of clayey sands which often grow less buffel grass and have woollybutt, kerosene grass and minor spinifex.
	Kanandra Broad sandy plains with scattered ironwood dominated by buffel grass with woollyoat grass, mulga grass, kerosene grass and forbs. Sandier areas have corkwood, ironwood and whitewood over woollybutt, kerosene grass, woollyoat grass and buffel grass.

The control paddock was very large (196km^2) and almost entirely made up of Kanandra land system with some low, hilly country along the southern edge.

Hypotheses

1. Intensive rotational grazing will increase carrying capacity.
2. Rotational grazing will result in more even utilisation of pasture.
3. Land condition will be maintained or improved under rotational grazing.
4. Under intensive rotational grazing, there will be an increase in species diversity.
5. With better use of the pastures, there will be a reduction in fire risk and frequency.
6. Average daily weight gain of steers will be higher under rotational grazing.

2. Methodology

A continuously grazed control paddock was compared with an eight paddock rotation (Figure 2).

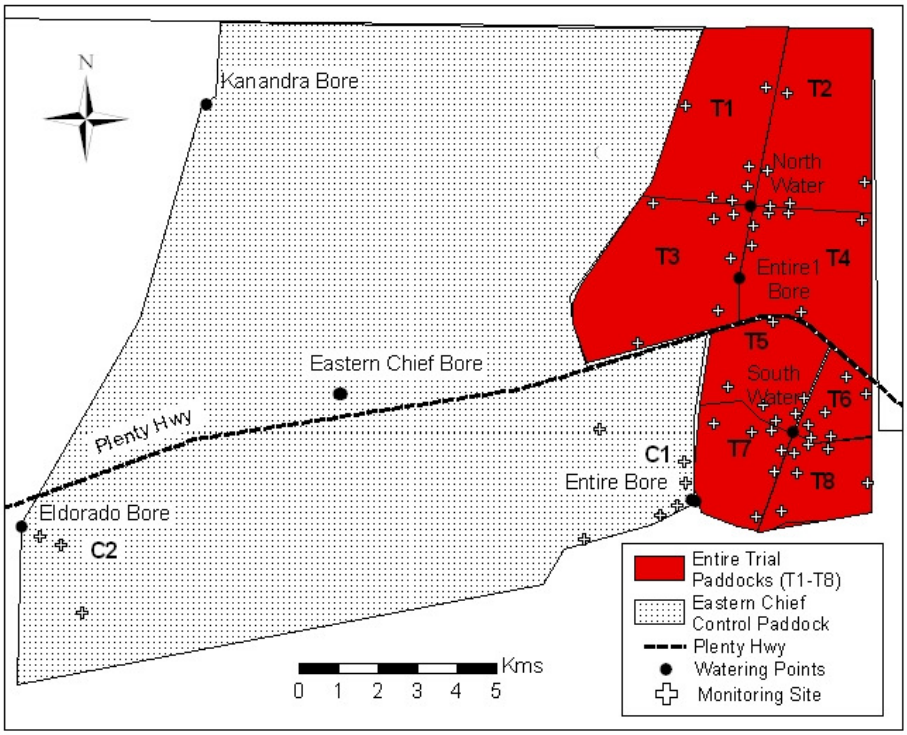


Figure 2: ***Layout of rotationally grazed paddocks and adjacent continuously grazed control paddock, Mt Riddock Station.***

Grazing Strategies

Rotationally grazed treatment

For the five years prior to the trial the rotationally grazed paddocks were only very lightly and intermittently grazed. The rotationally grazed treatment consisted of eight paddocks that are considerably smaller than the district average of 335km^2 (Leigo 2006). The four northern paddocks range from 10.2km^2 to 13.5km^2 and cover a total of 46.6km^2. The four southern paddocks range from 3.1km^2 to 6.4km^2 and cover a total of 20.5km^2. To date, a rotation of steers from weaning to sale has typically used either the northern or southern paddocks. When cattle are moved from one paddock to another within the rotation they are simply trapped through the yard at the central watering point. Trap gates are set by one person on a routine bore run. All areas of the paddocks were within 5.5km from water.

Continuously grazed control

For the five years prior to the trial the control paddock was stocked with approximately 800 steers (350kg steer = 0.8 Animal Equivalents[1] (AE)) giving a stocking rate within 5km of water of 5.3AE/km^2. Class of stock and numbers varied slightly over this time period due to seasonal conditions and management goals. The control consisted of one continuously grazed paddock (Eastern Chief paddock). Eastern Chief paddock is 196km^2 of which approximately 120km^2 are within 5km of water. Whilst cattle can travel large distances from water, it has been found that grazing intensity declines with distance from water (Fisher 2001). To simplify our calculations, we have assumed that most grazing occurs within 5km of water. The paddock was watered by four separate watering points, Entire, Eastern Chief, Eldorado and Kanandra.

[1] Animal equivalents (AE) based on the *Grazing Land Management Workshop Notes (2005)*. 1AE = 450kg/dry cow.

Stocking rate

Rotationally grazed treatment

For each rotation, the stocking rate was determined by manager Steve Cadzow using a predetermined graze time and a visual estimation of the forage available to determine how many animal equivalents could be sustained in a given paddock. Carrying capacity varied slightly between paddocks within a rotation. Steve set herd numbers and adjusted grazing time between individual paddocks so that the paddock with the lowest carrying capacity would not be over grazed. Steve planned for two rotations per paddock per year. Cattle spent approximately two weeks per rotation in each of the southern paddocks and four weeks per rotation in each of the northern paddocks. This comes to a total of 48 weeks of the year that cattle could be grazed in the rotationally grazed paddocks. In reality, this was not always achieved due to other management demands.

Continuously grazed control

Stocking rates were calculated in relation to a twelve month period defined as the summer rainfall period (Oct-Mar) and the subsequent six months. Stocking rates within the control changed in response to seasonal conditions.

Seasonal Conditions

Rainfall data from prior to the trial was from the homestead, 70 km west of the trial site. During the trial rainfall records were collected via an accumulating rain gauge located at Eldorado and automatic gauges at Entire and Entire 1 bores.

Pasture Assessment

Stratified site sampling was used to gauge pasture quality, quantity and cattle grazing distribution. All of the pastures were assessed prior to commencement of the trial. The four southern paddocks were all assessed immediately after grazing for both rotations. The only post grazing assessment in the four northern paddocks occurred in May 2007, several months after grazing. The control paddocks were only assessed at the beginning of the trial period and again in May 2007. Tables 2-3 show grazing and pasture assessment dates for all paddocks.

Table 2: *Assessment record for rotationally grazed paddocks. ✓ – Information collected.*

ROTATIONALLY GRAZED PADDOCKS					Assessments Completed	
Graze TIme	**Paddock**	**Date In – Date Out**	**Days**	**Assessment Date**	**Pasture Status**	**Defoln. & Cattle Activity**
Pre Trial	Sth T5 – T8			Jan 2006	✓	
Pre Trial	Nth T1 – T4			July 2006		
Rotation 1	South T7	9/3/06 – 16/4/06	39	May 06	✓	✓
Rotation 1	South T5	17/4/06 – 8/5/06	22	May 06	✓	✓
Rotation 1	South T8	9/5/06 – 28/5/06	20	July 06	✓	✓
Rotation 1	South T6	29/5/06 – 23/6/06	25	July 06	✓	✓
Rotation 1	South T5	25/6/06 – 3/7/06	9			
Rotation 2	North T4	25/9/06 – 6/11/06	46	Nov 06	✓	✓
Rotation 2	North T2	7/11/06 – 11/1/07	64	May 07	✓	
Rotation 2	North T1	12/1/07 – 7/2/07	39	May 07	✓	
Rotation 2	North T3	18/2/07 – 26/3/07	37	May 07	✓	
Rotation 3	North T3	28/3/07 – 24/4/07	28	May 07	✓	
Rotation 3	South T6	16/4/07 – 24/4/07	8	May 07	✓	✓
Rotation 3	South T6	24/4/07 – 13/5/07	20	May 07	✓	✓
Rotation 3	South T5	14/5/07 – 24/5/07	11	May 07	✓	✓
Rotation 3	South T8	25/5/07 – 7/6/07	14	May 07	✓	✓
Rotation 3	South T7	8/6/07 – 29/6/07	22	Sept 07	✓	✓
Rotation 4	North T4	3/9/07 – 21/9/07	18	Not assessed		
Rotation 4	North T4	22/9/07 – 5/10/07	14	as of		
Rotation 4	North T2	6/10/07 – 5/11/07	31	March 2008		
Rotation 4	North T1	6/11/07–10/12/07	35			
Rotation 4	North T3	11/12 –28/12/07	18			
Rotation 4	North T1	29/12/07 – 6/1/08	8			
Rotation 4	North T2	7/1/08 – 29/1/08	22			

Table 3: *Assessment record for continuously grazed paddock.*

CONTINUOUSLY GRAZED PADDOCKS			Assessments Completed	
Graze TIme	**Paddock**	**Assessment Date**	**Pasture Status**	**Defoliation & Cattle Activity**
Pre Trial	Eastern Chief C1	Jan 2006	✓	✓
Pre Trial	Eastern Chief C2	July 2006	✓	✓
Continuous	Eastern Chief C1-C2	May 2007	✓	✓

Two sites were sampled at 500m, 1km and 3km from water within each rotationally grazed paddock and three sites at each distance within the control. Sites were selected to ensure that the vegetation was representative of the dominant vegetation community within the trial. In the rotationally paddocks it was not always possible to locate sites at 3km from water. Where this was the case, sites were located at least 2km from water and generally as far as possible. At each site, two parallel 150m transects were described with $1m^2$ quadrats assessed every 10m.

Each quadrat was assessed for cover, total yield, buffel grass as a percentage of yield, percentage of rank material, perennial grass basal area, species presence, cattle activity and defoliation.

Cover was described as a percentage of soil surface covered with vegetative matter, living or dead. The assessment of cover was a visual estimation.

Yield assessments were also visually estimated with observers calibrating their estimates at the end of every day with ten dry weight samples. Yield did not include rank material.

Buffel grass as a percentage of yield present was also recorded as a visual estimation.

Rank material was described as lignified or grey, unpalatable grass material left over from previous seasons. The amount of rank material was described as a percentage of total standing dry matter.

Regardless of species, the ***basal area of perennial grasses*** was estimated as a percentage of total ground cover within the quadrat. The basal area was defined as the area where the plant emerges from the soil.

All plants present within a quadrat were identified to at least genus and then species where possible. A species was considered present if any part of the plant was found within the quadrat regardless of basal location. This data was used to provide an assessment of plant ***species diversity***.

Cattle activity was described using a qualitative index based on the relative abundance of dung and/or hoofprints (Table 4).

Table 4: ***Cattle activity index***

Score	Description
0	No sign of cattle activity
1	Light activity
2	Moderate activity
3	Heavy activity

Heavy activity was described as either a well used stock pad or where nearly all of the non-vegetated part of the quadrat was covered with either manure or hoofprints. Whilst it did not refer to actual grazing it provided an insight into how cattle moved around a paddock.

Defoliation was described using an index based on estimated percentage of yield that had been removed (Table 5).

Table 5: ***Defoliation index***

Score	% Defoliation	Description
0	No defoliation	No grazing
1	>0 and ≤ 5%	Slight grazing
2	>5% and ≤ 25%	Moderate grazing
3	>25% and ≤ 50%	Heavy grazing
4	>50% and ≤ 75%	Very heavy grazing
5	>75% and ≤ 100%	Severe grazing

Pretrial pasture sampling was undertaken in two stages. One of the continuously grazed watering points and the southern rotationally grazed paddocks were assessed in January 2006. The second continuously grazed watering point and the northern rotationally grazed paddocks were assessed between June and July 2006. At both assessments the pasture was fairly dry however there may be some differences in the data that relate to time since rain and season of rainfall. Because both the control and treatment areas had data from each assessment period all the pretrial data was combined for each treatment for the pretrial assessment.

With the exception of the first rotation, where pasture yields were assessed immediately prior to and post grazing, yield was only assessed at the end of the summer growing period. This made it impossible to use yield to determine utilisation. Attempts were made to determine utilisation using calculated intake (Shrubb 2000). Calculated daily intake was described as a percentage of body weight. This was determined using an equation of feed quality (dry matter digestibility, crude protein, metabolisable energy (ME)) and average daily weight gain. Dividing the amount of ME (MJ/day) required per day to achieve the given daily weight gain by the ME (MJ/kg) value of the diet determines the amount of feed (kg/day) required to achieve this growth rate. However yield assessment dates did not correlate well with rotations so this method was not successful. Given these limitations, defoliation was used as a surrogate for utilisation.

Stock Performance

The initial induction of steers into the trial (March 2006) included both the treatment and control animals. As the animals were processed, every fourth steer was designated for the control. As other paddocks on the property were mustered, steers were weaned and placed into the trial until the required stocking rates had been reached.

The control steers were placed in Eastern Chief Paddock. These steers were processed in May 2007 and then returned to the control paddock until their sale in February 2008.

Steers were individually identified, weighed and assigned a condition score at the commencement of a rotation and then again at completion, immediately prior to sale. Whilst in the rotation, steers were not handled unless they were being moved from the northern paddocks into the southern paddocks in which case they were trapped then walked, using motorbikes and horses. Supplementation was continuously provided in the form of both Boost block and LNT Uramol dry season block. The control steers were subject to similar management practices. All trial animals were vaccinated for botulism.

Statistical analysis

Each site was averaged for the thirty quadrats and Mann-Whitney U Tests were used to compare treatment effects for each time period. ANCOVAs were used to examine distance from water trends between treatments and times.

3. Results

Seasonal Conditions

In the five years prior to the trial, rainfall was greatly above average or average, except for the year immediately prior when almost no rain fell at all (Table 6). Seasonal conditions for the duration of the trial to date are described in Figure 3. Rainfall totals are provided for the period of October to September 2005/06 and 2006/07. In the treatment and control areas, rainfall for the 12-month period was generally below the median except for the control paddock in 06/07.

Table 6: Summer rainfall and percentiles leading up to the trial recorded at Mt Riddock homestead.

Rainfall period	Rainfall (mm)	percentile
2000/01	437	>90
2001/02	319	80
2002/03	245	60
2003/04	209	40
2004/05	48	<10

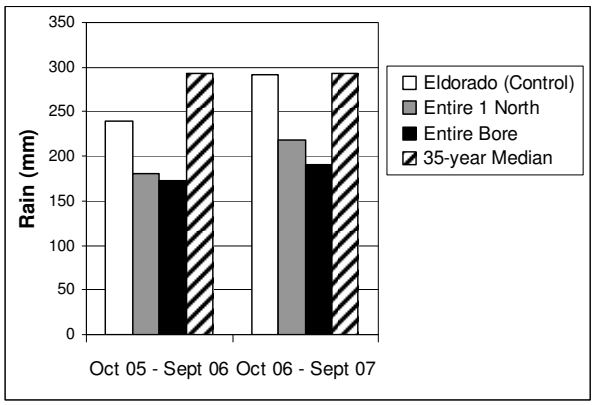


Figure 3: ***Mt Riddock rainfall for the 12 month period October to September for 2005/06 and 2006/07. Median data is from the homestead.***

12 month rainfall totals do not necessarily reflect seasonal pasture growth. Figure 4 shows the monthly totals which suggest that rain fell in most months throughout both summers. This is likely to have allowed pasture to become robust and more resilient to grazing.

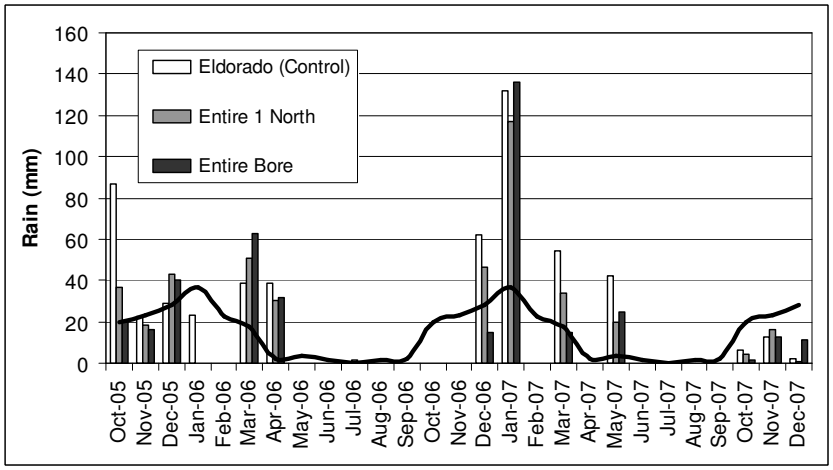


Figure 4: ***Mt Riddock monthly rainfall from October 2005 to December 2007.***

Stocking Rates

Rotationally grazed treatment

Because paddock size and grazing time varied within the rotationally grazed treatments, a range of stocking rates were used (Table 7).

Continuously grazed control

The stocking rate for the continuously grazed paddock varied only slightly throughout the project so the average of 5.3 AE/km^2 was used. The herd primarily consisted of steers and occasionally heifers. When calculating stocking rates for the control paddock, the area described is only that within 5km of water as it is unrealistic to expect that all the paddock is utilised evenly (Norton 2003, Quirk & McIvor 2006, Low 1972, Fisher 2001, Hunt *et al.* 2007).

Table 7: ***Stocking rate per rotationally grazed paddock***

Year	Rotation	Paddock	Area (km^2)	Days	AE Days	AE/km^2/year
2005-2006	One	T7	5.9	39	11201	5.2
2005-2006	One	T8	5.1	31	6299	3.4
2005-2006	One	T6	3.1	20	8101	7.2
2005-2006	One	T5	6.4	25	9727	4.2
2006-2007	Two	T4	10.2	46	9881	2.7
2006-2007	Two	T2	11.8	64	14666	3.4
2006-2007	Two	T1	11.1	39	9716	2.4
2006-2007	Two	T3	13.5	65	11603	2.4
2006-2007	Three	T5	6.4	11	2437	1.0
2006-2007	Three	T8	5.1	14	3153	1.7
2006-2007	Three	T7	5.9	22	5058	2.3
2006-2007	Three	T6	3.1	28	4629	4.1
2007-2008	Four	T4	10.2	32	8672	2.3
2007-2008	Four	T2	11.8	53	17891	4.2
2007-2008	Four	T1	11.1	43	14557	3.6
2007-2008	Four	T3	13.5	18	6261	1.3

With the exception of the first rotation, stocking rates in the rotationally grazed paddocks were lower than in the continuously grazed paddocks (Figure 5).

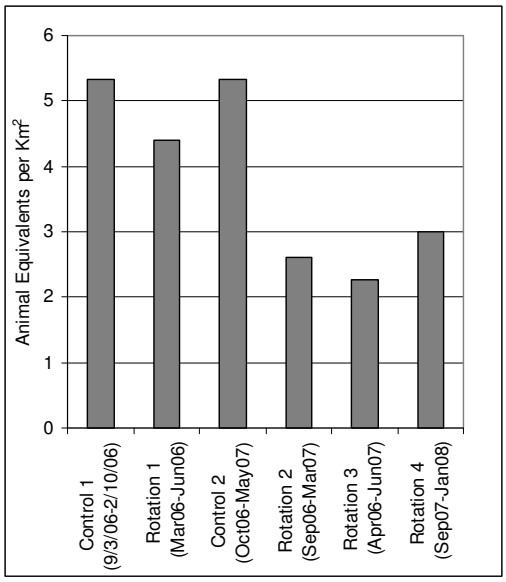


Figure 5: ***Stocking rates within the rotationally grazed and continuously grazed paddocks.***

The continuously grazed paddock had double the average (over time) stock days per water point than the rotationally grazed paddocks (Table 8).

Table 8: Head per water for the different treatments over time.

Treatment	average head/water	total days	stock days per water
Rotation	294	261	73089
Control	200	730	146000

Carrying Capacity

Yield can be an indicator of carrying capacity because it is an indication of the amount of feed available. Yield was significantly higher in the rotationally grazed paddocks than in the continuously grazed paddock at both assessment periods (Figure 6, Table 9).

Table 9: Yield - differences between treatments over time at Mt Riddock Station. Mann-Whitney U Test.

Treatment	Continuous Grazing	Rotational Grazing	
Time of Assessment	Median Yield	Median Yield	p-level
Pretrial 2006	105	688	0.00003
Post Grazing 2007	339	550	0.03

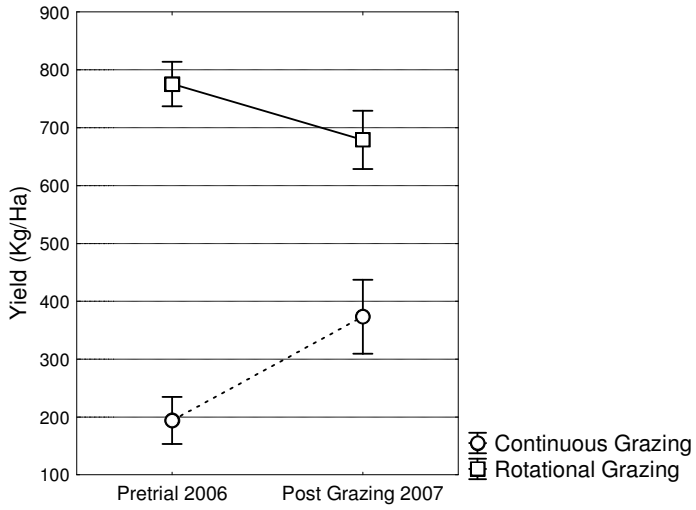


Figure 6: ***Change in yield over time between treatments. Mean and 95% confidence intervals.***

Yield varied significantly with distance from water (Figure 7, Table 10). In the continuously grazed paddocks, yield was much lower within 1km of water than at 3km. There was no significant effect of time or treatment on trend in yield with distance from water.

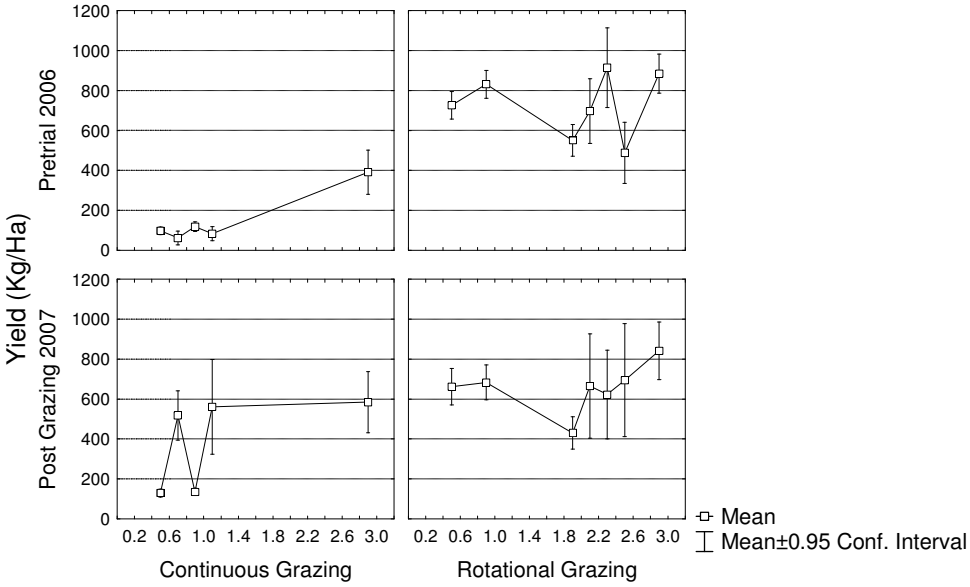


Figure 7: ***Effect of time and treatment on trend in yield with distance to water at Mt Riddock Station.***

Table 6: ***Effect of time and treatment on trend in square root yield with distance from water. ANCOVA.***

Effect	F value	p value
Distance	6	0.01
Time	0	ns
Treatment	24	0.0000
Time by distance interaction	0	ns
Treatment by distance interaction	3	ns
Time by treatment interaction	2	ns
Distance by Season by Treatment interaction	0	ns

Utilisation of pasture

Defoliation

Differences between the control and treatment paddocks in the gradient of use out from waters were statistically significant (Tables 11-12). Continuously grazed paddocks had higher defoliation closer to water, which dropped off more steeply further from water (Figure 8). This compares with the rotationally grazed paddocks, which were much more evenly grazed with distance from water. There was no significant effect of season on the pattern of defoliation out from water (Tables 11-12).

Table 117: ***Effect of time and treatment on trend in defoliation with distance from water. ANCOVA.***

Effect	F value	p value
Intercept	172	0.0000
Distance	25	0.0000
Time	0	ns
Treatment	39	0.0000
Time by distance interaction	0	ns
Treatment by distance interaction	4	0.0000
Season by treatment interaction	33	0.0000
Distance by Season by Treatment interaction	1	ns

Table 8: ***Equations describing trend in defoliation with distance from water***

Treatment	Time	Equation
Continuous	Pretrial	Defoliation = 4.455-0.8101* distance from water
Continuous	Longterm	Defoliation = 3.709-0.9063* distance from water
Rotation	Pretrial	Defoliation = 1.1257-0.3671* distance from water
Rotation	Longterm	Defoliation = 1.8326-0.4902* distance from water

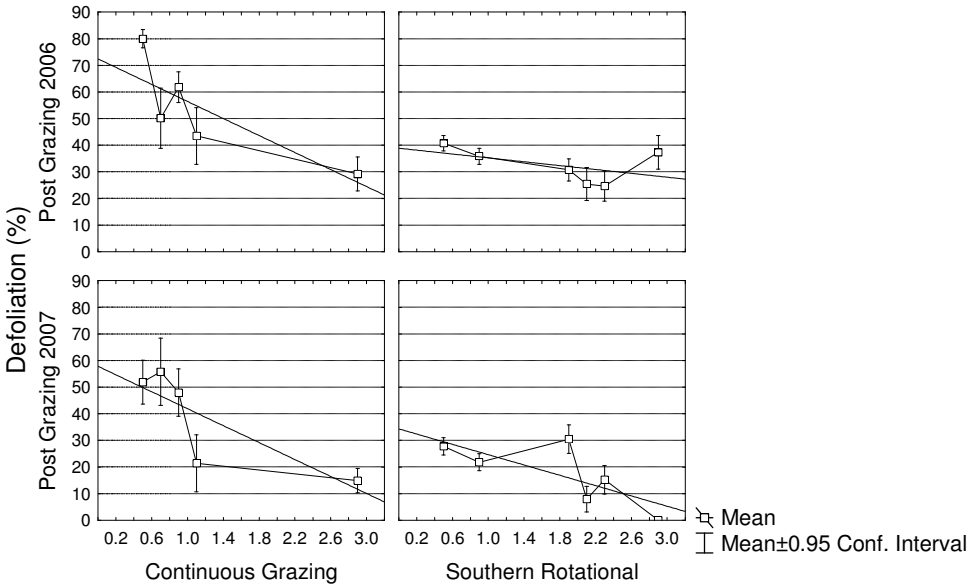


Figure 8: ***Effect of time and treatment on trend in defoliation with distance to water at Mt Riddock Station.***

Cattle Activity

Post grazing in 2006 and 2007, cattle activity in the rotationally grazed paddocks was significantly different to that in the continuously grazed paddock (Table 13). There was some difference in cattle activity with distance from water in both treatments (Figure 9). In 2006 the control paddock had higher cattle activity at 500m from water. At 1km from water the activity was still relatively high but by 3km cattle activity was very low. In comparison, cattle activity within the rotationally grazed paddocks was moderate and consistent at all distances from water suggesting that cattle were readily accessing all parts of the paddock. Cattle activity in the rotationally grazed paddocks post-grazing in 2006 was higher and more uniform than the comparable assessment in 2007. However, the apparent decline in activity at 2.85km is a little deceptive as it refers to only one site. The remaining sites were all less than 2.3km from water and recorded similar cattle activity to sites closer to water.

Table 9: ***Effect of time and treatment on trend in cattle activity with distance from water. ANCOVA.***

Effect	F value	p value
Intercept	132	0.0000
Distance	13	0.0003
Time	1	ns
Treatment	24	0.0000
Time by distance interaction	2	ns
Treatment by distance interaction	0	ns
Season by treatment interaction	5	0.03
Distance by Season by Treatment interaction	1	ns

Table 14: ***Equations describing trend in cattle activity with distance from water***

Treatment	*Time*	*equation*
Continuous	*Pretrial*	Cattle activity = 2.7975-0.4907*distance from water
Continuous	*Longterm*	Cattle activity = 1.8344-0.3634* distance from water
Rotation	*Pretrial*	Cattle activity = 0.7758-0.1812* distance from water
Rotation	*Longterm*	Cattle activity = 1.1092-0.2204* distance from water

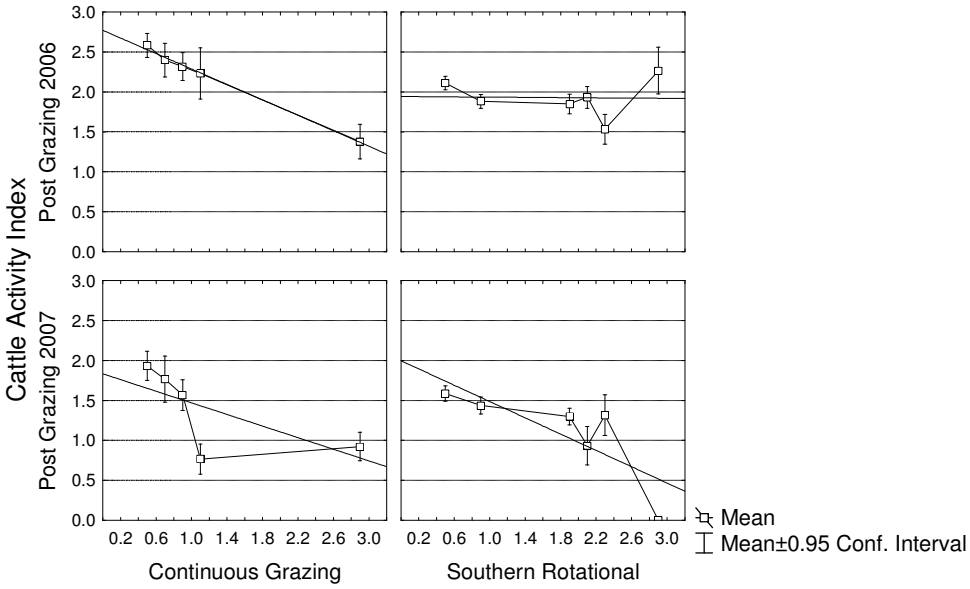


Figure 9: ***Effect of time and treatment on trend in cattle activity with distance to water at Mt Riddock Station.***

Land Condition

Perennial grass basal area

Over time both the rotationally grazed and continuously grazed paddocks showed a decline in perennial grass basal area (Figure 10). At both assessment times the PGBA was significantly lower in the continuously grazed paddock than in the rotationally grazed paddocks (Table 15).

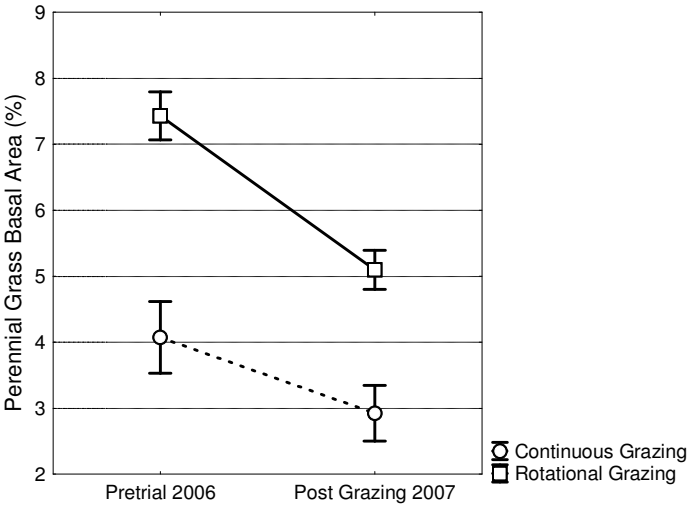


Figure 10: ***Perennial grass basal – differences between treatments over time at Mt Riddock Station. Mean and 95% confidence intervals.***

Table 15: ***Perennial grass basal area - differences between treatments over time at Mt Riddock Station. Mann-Whitney U Test.***

Treatment	Continuous Grazing	Rotational Grazing	
Time of Assessment	Median perennial grass basal area	Median perennial grass basal area	p-level
Pretrial 2006	4	6.4	0.004
Post Grazing 2007	2.8	4.7	0.01

PGBA did not show a clear trend with distance from water regardless of the grazing strategy although overall PGBA was much lower in the continuously grazed paddocks than in the rotationally grazed paddocks (Figure 11).

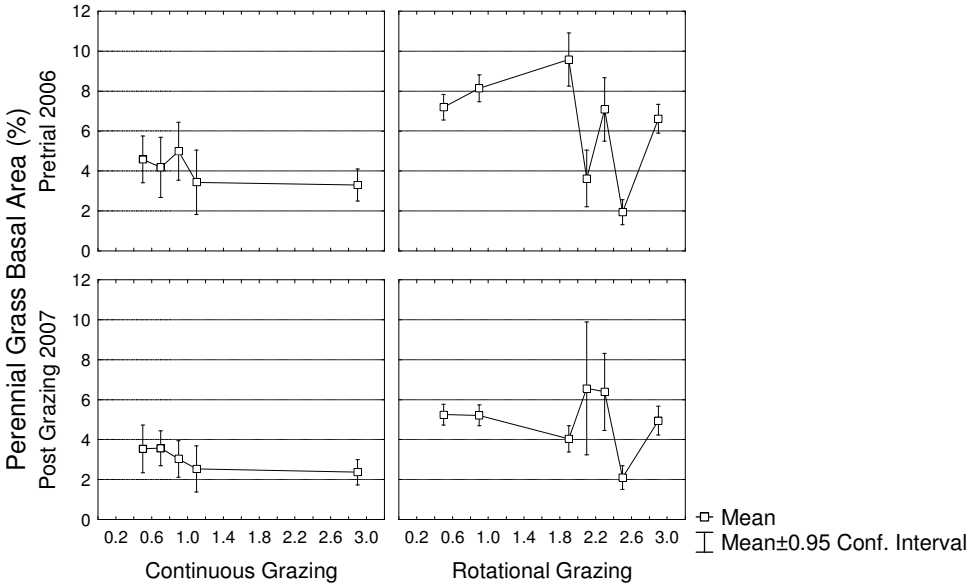


Figure 11: C*hange in perennial grass basal area over time and with distance from water at Mt Riddock Station.*

Total ground cover

The rotationally grazed paddocks had significantly higher cover than the continuously grazed paddocks both pretrial and after grazing (Figure 12 & Table 16). There was little change in cover between the pretrial and post grazing assessments in the rotationally grazed paddocks. The continuously grazed paddock showed an increase in cover.

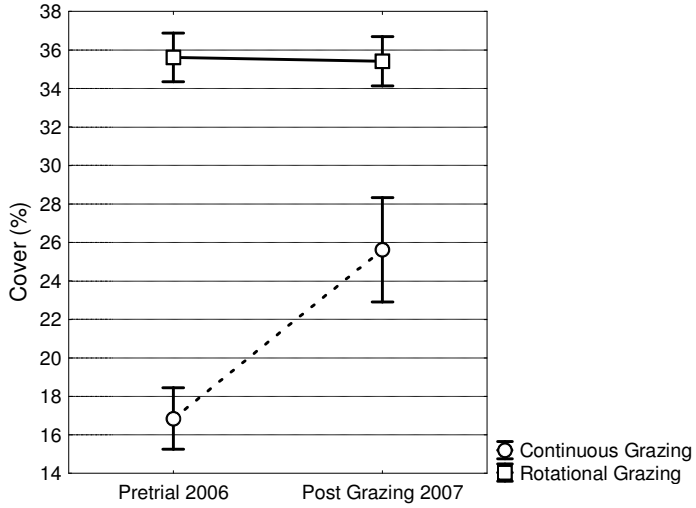


Figure 12: ***Cover – differences between treatments over time at Mt Riddock Station. Mean and 95% confidence intervals.***

Table 16: ***Cover - differences between treatments over time at Mt Riddock Station. Mann-Whitney U Test.***

Time of Assessment	Median Cover Continuous Grazing	Median Cover Rotational Grazing	p-level
Pretrial 2006	17	36	0.00002
Post Grazing 2007	15	34	0.02

It is also important to note that there was little difference in cover with distance from water within the rotationally grazed paddocks whilst cover within the continuously grazed paddocks declined closer to water (Figure 13, Table 17) post grazing 2007, although there was no significant effect of treatment on trends in cover with distance to water.

Table 17: ***Effect of time and treatment on trend in cover with distance from water. ANCOVA.***

Effect	F value	p value
Intercept	85	0.0000
Distance	13	0.0003
Time	0	ns
Treatment	18	0.0000
Time by distance interaction	1	ns
Treatment by distance interaction	3	ns
Season by treatment interaction	0	ns
Distance by Season by Treatment interaction	1	ns

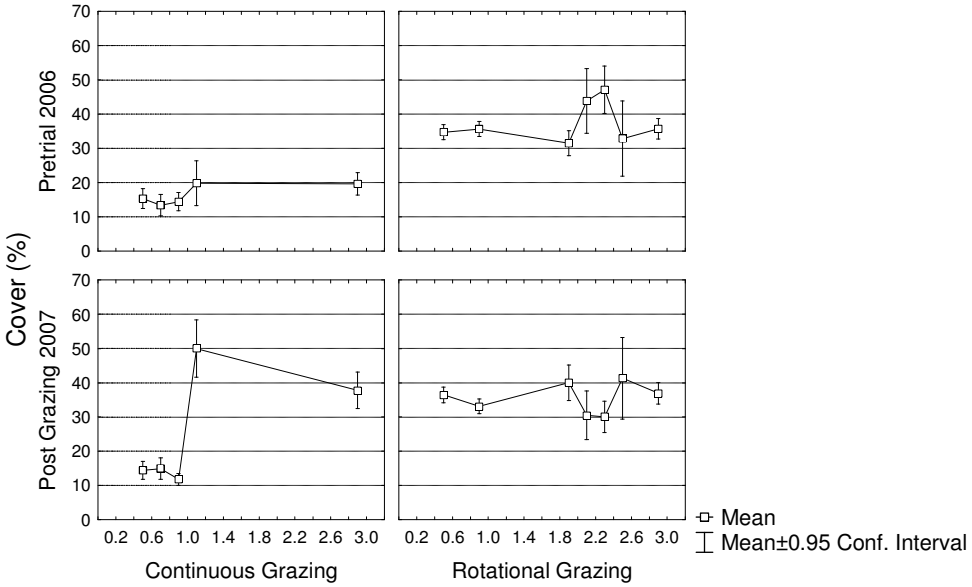


Figure 13: ***Change in cover over time and with distance from water at Mt Riddock Station.***

Species composition

The treatment and control paddocks had slightly different species composition as is evidenced through the significant differences for some of the most frequent species between the treatments (Table 18). The frequency of these species fluctuated through time, but seasonal changes were similar for both treatments and there was no obvious time and treatment interaction, except for buffel frequency which did not differ between treatments pretrial, but was significantly higher in rotationally grazed paddocks at the end of the trial.

Table 1810: ***Effect of time and treatment on species frequency of abundant species at Mt Riddock Station. Mann-Whitney U Test. * denotes significant difference between treatments for a time period, P<0.05.***

Timing	Pretrial 2006		Post Graze 2007	
Treatment	Continuous	Rotational	Continuous	Rotational
Cenchrus ciliaris	87.4	91.5	*75.2	87.4
Aristida holathera	*40.4	12.4	*45.6	18.8
Enneapogon polyphyllus	*26.7	6.8	*42.2	8.2
Enneapogon avenaceus	*17.8	3.9	*22.2	1.9
Tribulus terrestris	0.4	0.3	*25.6	10.9
Fimbristylis dichotoma	*7.0	30.4	*3.0	22.7
Tripogon lolliformis	7.0	14.7	8.1	16.2
Indigofera colutea	0.4	0.1	16.7	25.8

With the exception of sedges in the rotationally grazed paddocks there was typically a rise in all functional groups immediately after rain. The frequency of annual grasses was always higher in the continuously grazed paddocks and the frequency of sedges was always higher in the rotationally grazed paddocks (Figures 14 – 15, Tables 19-20).

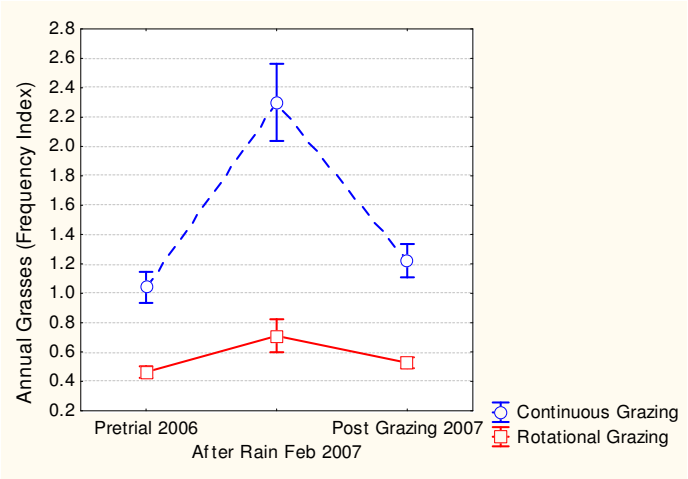


Figure 14: ***Change in frequency of annual grasses over time between treatments. Mean and 95% confidence intervals.***

Table 11: ***Frequency of annual grasses - differences between treatments over time at Mt Riddock Station. Mann-Whitney U Test.***

Time of Assessment	Median Frequency Continuous Grazing	Median Frequency Rotational Grazing	p-level
Pretrial 2006	1.0	0.4	0.003
After Rain Feb 2007	2.4	0.6	0.02
Post Grazing 2007	1.3	0.5	0.0005

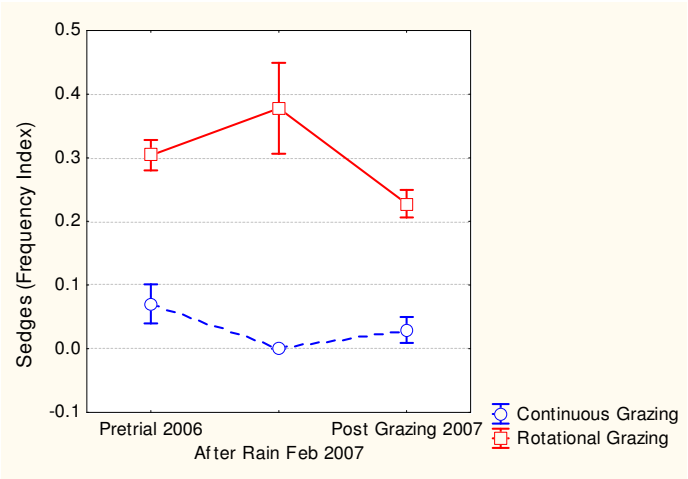


Figure 15: ***Change in frequency of sedges over time between treatments. Mean and 95% confidence intervals.***

Table 12: ***Frequency of sedges - differences between treatments over time at Mt Riddock Station. Mann-Whitney U Test.***

Time of Assessment	Median Frequency Continuous Grazing	Median Frequency Rotational Grazing	p-level
Pretrial 2006	0	0.2	0.002
After Rain Feb 2007	0	0.3	0.01
Post Grazing 2007	0	0.1	0.02

In contrast forb frequency was significantly lower in the rotationally grazed paddocks only at the end of the trial, perhaps suggesting a treatment related change through time (Figure 16, Table 21).

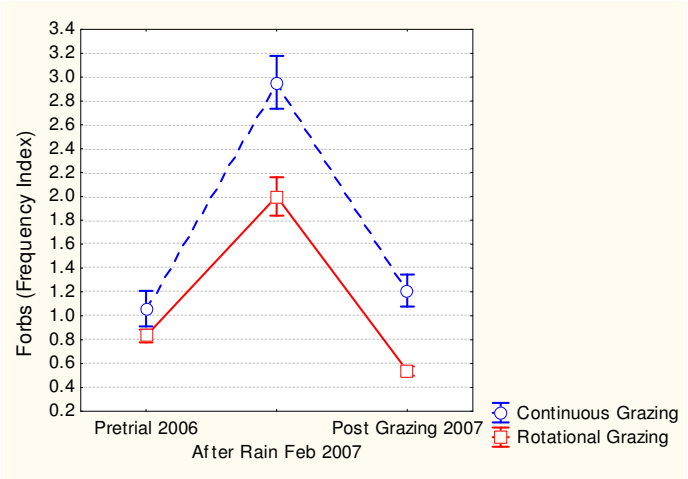


Figure 16: ***Change in frequency of forbs over time between treatments. Mean and 95% confidence intervals.***

Table 13: ***Frequency of forbs - differences between treatments over time at Mt Riddock Station. Mann-Whitney U Test.***

Time of Assessment	Median Frequency Continuous Grazing	Median Frequency Rotational Grazing	p-level
Pretrial 2006	0.7	0.8	ns
After Rain Feb 2007	2.9	1.9	ns
Post Grazing 2007	1.0	0.5	0.0006

There was no significant difference in frequency of perennial grasses between the rotation or the continuous grazing (Figure 17, Table 22).

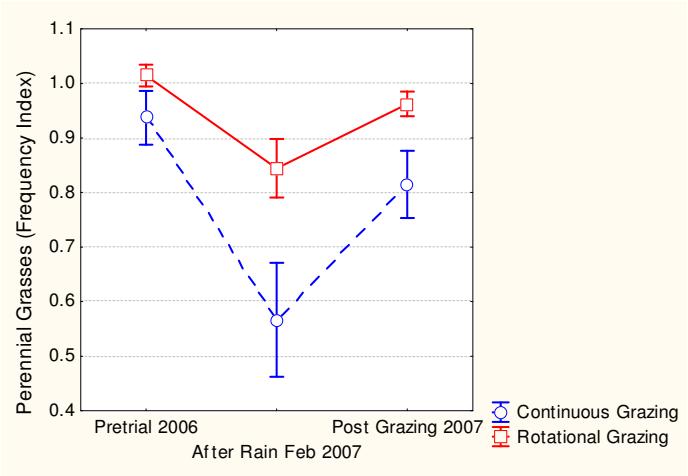


Figure 17: ***Change in frequency of perennial grasses over time between treatments. Mean and 95% confidence intervals.***

Table 14: ***Frequency of perennial grasses - differences between treatments over time at Mt Riddock Station. Mann-Whitney U Test.***

Time of Assessment	Median Frequency Continuous Grazing	Median Frequency Rotational Grazing	p-level
Pretrial 2006	1	1	ns
After Rain Feb 2007	0.6	1	ns
Post Grazing 2007	0.8	1	ns

Species Diversity

Total species recorded declined in both treatments over time (Table 23). In the following species rank abundance graphs (Figures 18 – 21), species are only included when frequency is >1%. Species composition was generally dominated by *Cenchrus ciliaris* and this was more extreme in the rotationally grazed paddocks.

Table 15: ***Total number of species recorded.***

Time of Assessment	Rotational Grazing	Continuous Grazing
Pretrial 2006	44	75
Post Grazing 2007	35	48

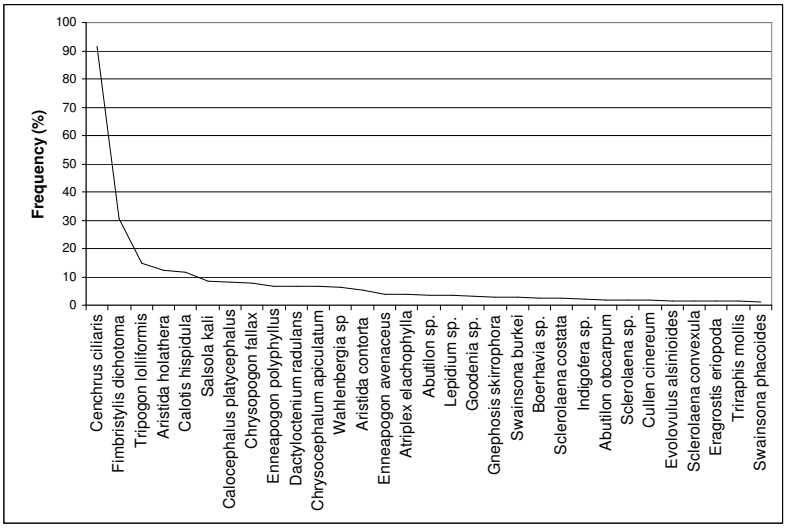


Figure 18: ***Rank abundance of species in rotationally grazed paddocks, pre grazing 2006.***

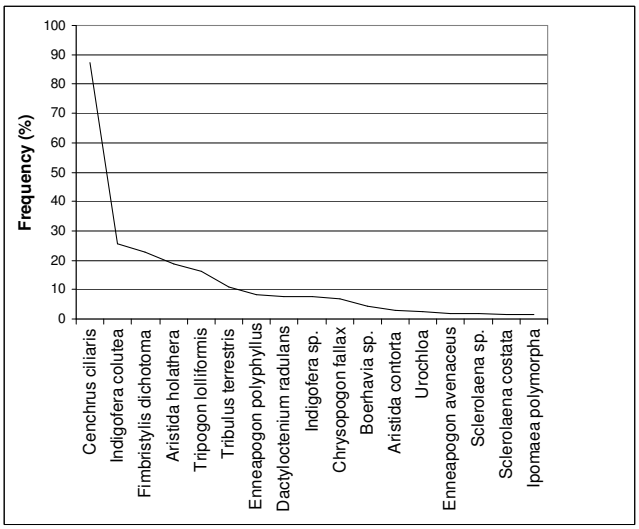


Figure 19: ***Rank abundance of species in rotationally grazed paddocks, post grazing May 2007.***

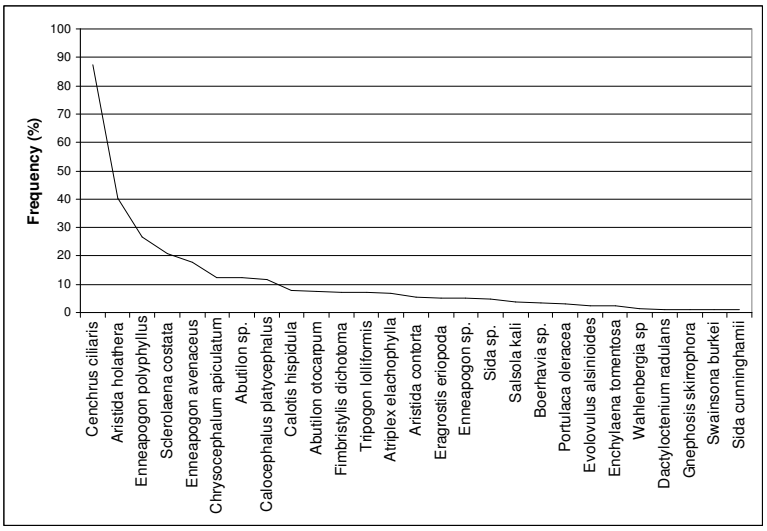


Figure 20: ***Rank abundance of species in the continuously grazed paddock, pretrial 2006.***

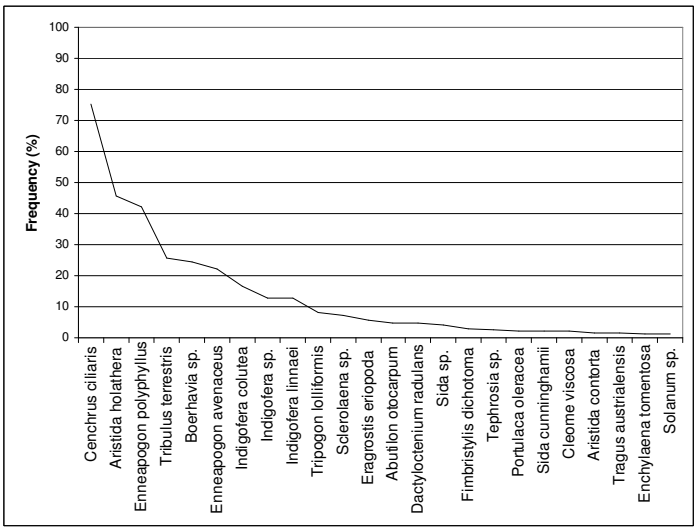


Figure 21*: Rank abundance of species in the continuously grazed paddock, May 2007.*

At the start of the trial, there was no significant difference between species diversity or species richness in the continuously grazed paddock and the rotationally grazed paddocks (Table 24). Species richness describes the number of species found within a site. Simpson's Index provides an index of diversity. After rain and at the final assessment, species diversity and richness in the rotationally grazed paddocks were significantly lower than in the continuously grazed paddock. At the final assessment, species diversity and richness had declined below the pretrial level in the rotationally grazed paddocks (Figures 22 - 23). Whilst species richness did not increase in the continuously grazed paddock, the diversity across the pasture did, reflecting greater numbers of individuals of species that had been less frequent in the first sampling period.

Table 16: ***Species richness and diversity- differences between treatments through time at Mt Riddock Station. ns – not significant.***

Time of Assessment	Diversity Indicator	Mean Continuous Grazing	Mean Rotational Grazing	p
Pretrial 2006	Species Richness	18.3	17.9	ns
	Simpson's Index	6.6	5.7	ns
After Rain Feb 2007	Species Richness	19.3	14.1	0.04
	Simpson's Index	11.8	7.7	0.006
Post Grazing 2007	Species Richness	18.6	12.2	0.002
	Simpson's Index	8.1	4.9	0.0005

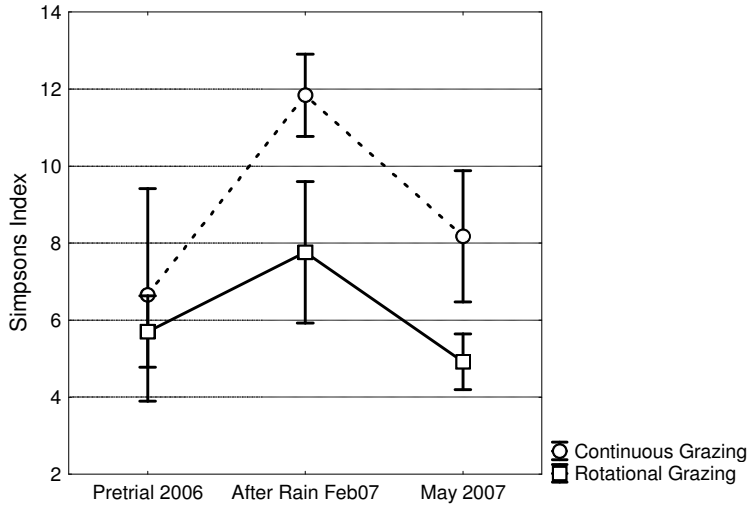


Figure 22: ***Simpsons Index of species diversity - differences between treatments through time at Mt Riddock Station. Mean and 95% confidence intervals.***

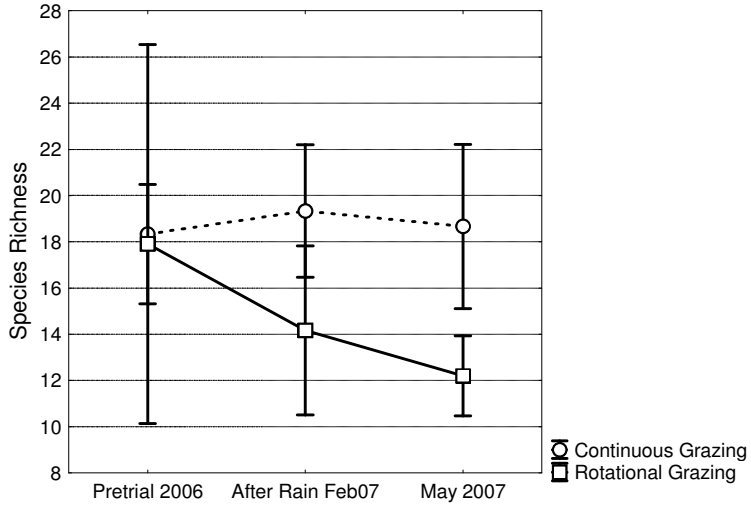


Figure 23: ***Species richness - differences between treatments and through time at Mt Riddock Station. Mean and 95% confidence intervals.***

Pasture Quality (Rank Material)

Rank material was not recorded in the pretrial assessments for the southern rotationally grazed paddocks or for one of the control areas so these areas could not be included in the analysis. Rank material in the rotationally grazed paddocks increased over time whilst in the continuously grazed paddock there was a decline in rank material (Table 25, Figure 24). Throughout the trial, rank material in the continuously grazed paddock was much lower than in the rotationally grazed paddocks. There was little change in rank material with distance from water in either treatment (ANCOVA P>0.05) (Figure 25). There was a significant effect of treatment on change in % rank through time (time by treatment interaction, ANCOVA F=4, P=0.02)

Table 17: ***Frequency of % rank - differences between treatments over time at Mt Riddock Station. Mann-Whitney U Test.***

Time of Assessment	Median Frequency Continuous Grazing	Median Frequency Rotational Grazing	p-level
Pretrial 2006	6	10	ns
Post Grazing 2007	3	31	0.0000

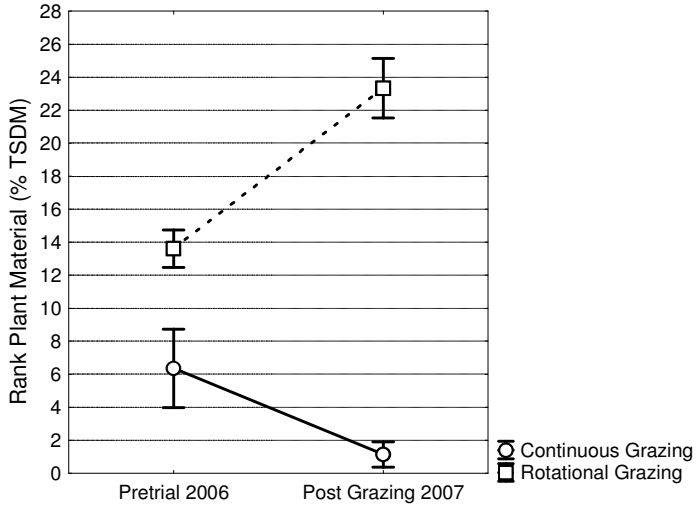


Figure 24: Percent rank plant material – differences between treatments over time at Mt Riddock Station. Mean and 95% confidence intervals.

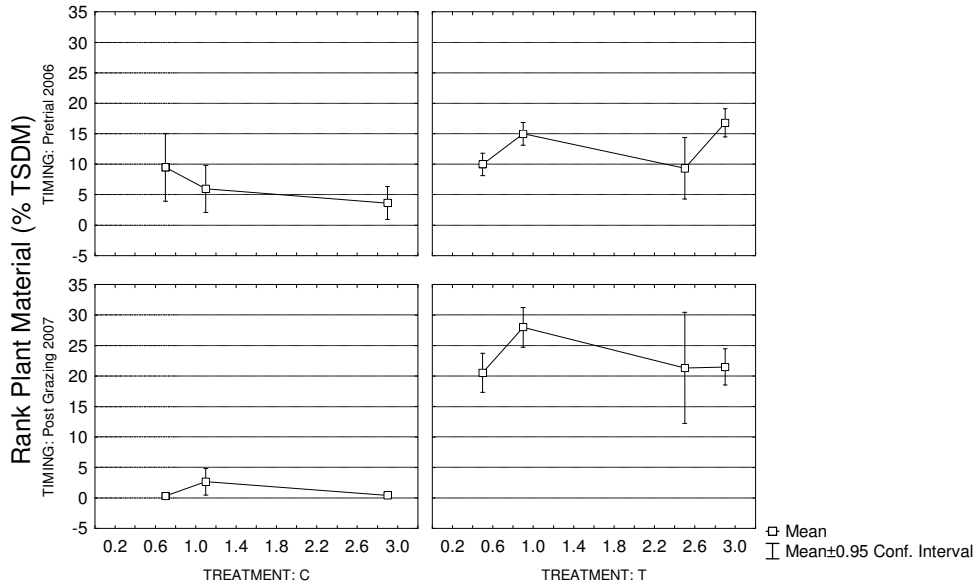


Figure 25: ***Change in % rank material over time and with distance from water at Mt Riddock Station.***

Stock Performance

The majority of the steers in the rotationally grazed paddocks were replaced with new steers at each rotation. In comparison, the control steers remained the same throughout the life of the project. Comparison of weight gains between the treatment and the control is compromised as the steers were not truly comparable with regard to life stage or seasonal pasture quality. With the exception of the second weigh period for the control steers, the rotationally grazed steers had a higher average daily weight gain at all times (Figure 26).

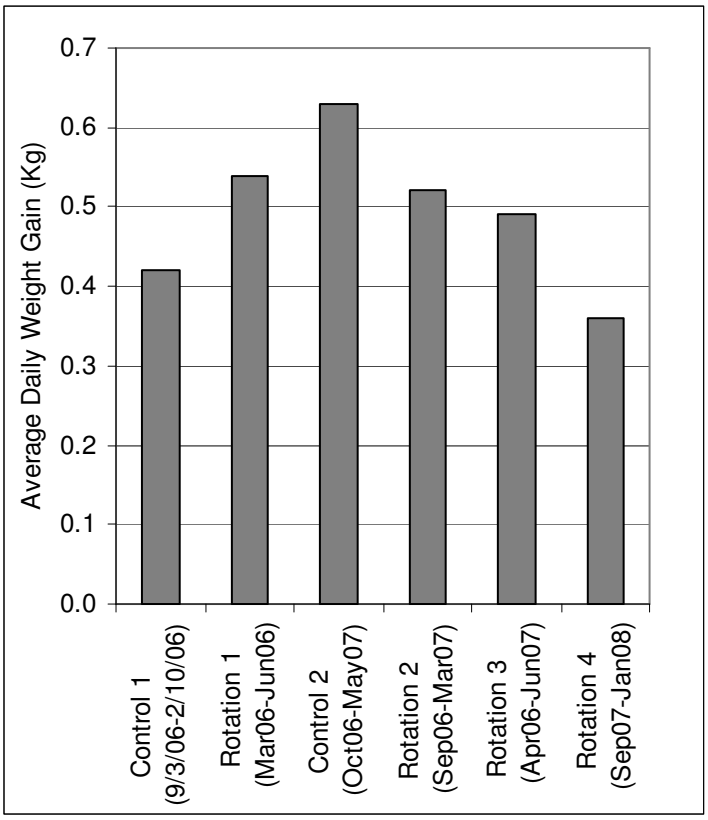


Figure 26: ***Average daily weight gains for steers.***

4. Discussion

When considering the results, it is important to consider all the differences between the rotational and continuous grazing strategy treatments and how these might have affected the results, because the paddocks differed in more ways than just grazing duration and rest. The two strategies present differences in terms of grazing duration, stocking rate, paddock size, distance to water, head per water and pasture yield, composition and cover at the start of the trial. Even within the rotationally grazed paddocks, timing of rest periods in relation to rainfall varied, perhaps resulting in differences in pasture growth.

Of particular importance is the issue of stocking rate. Whilst the stocking rate of the rotationally grazed paddocks is much higher than the control during grazing periods it is only for a short period of time. High stocking rates can encourage cattle to use parts of the pasture that they normally would not in a continuously grazed system. Whilst this can lead to improved production for a given area, it may be to the detriment of individual animal performance. Stocking rate has a big impact on animal performance, perhaps more so than actual grazing system employed (Heitschmidt *et al.* 1990).

Seasonal conditions

The summer of 2005/06, immediately preceding the trial, and the subsequent summer of 2006/07 were both below the median for rainfall although they could still be described as within a 'normal' range of variation. In both years the continuously grazed paddock received more rainfall than the treatment areas. This may have resulted in a higher potential for plant growth and/or a higher quality pasture in the continuously grazed paddock compared to the rotationally grazed paddocks. Seasonal effects are considered throughout the discussion.

Carrying Capacity and Profitability

Increased carrying capacity is often attributed to rotational grazing strategies for a number of reasons. The first assumption is that rest from grazing helps to maximise forage available. Secondly, high, short term stocking rates are thought to encourage stock to graze all parts of the pasture thus making best use of the available feed (Humphries 1991).

The rotationally grazed paddocks had been only very lightly grazed, in the five years immediately prior to trial commencement. Yield in all rotationally grazed paddocks declined very slightly after the first graze period as would be expected following grazing with no further growth events prior to assessment. The exception to this was the northern paddock T2 which experienced an exceptional growth event immediately after grazing. The southern rotationally grazed paddocks experienced a second grazing episode although at a lower stocking rate than the first graze. Subsequent yield assessments remained similar to the previous assessment period. This suggests that stock in the second graze period consumed all of the intervening growth. It is interesting to note the significant decline in yield after the first grazing period in the southern paddock T7. This paddock had by far the longest graze period (39 days c.f. average of 22 days) as it was not possible for management to move stock. At the time, the manager felt that this paddock had been over grazed and no other paddocks were utilised to that extent.

The most important observation is that yield in the continuously grazed paddock was always much lower than the rotationally grazed paddocks. If stocking rates were to be determined based on utilising 20% of the yield available within 5km from water as of May 2007, the rotationally grazed paddocks would have allowed a carrying capacity of 3.2AE/km^2/year (which is close to what they

did carry) whilst the continuously grazed paddocks would only carry 2AE/km^2/year (compared with the actual stocking rates of more than double this). Hence the continuously grazed paddock had more than double the utilisation rates of the rotationally grazed paddocks – unless stock significantly utilised areas further than 5km from water in the continuously grazed control. In May 2007, high yields at the continuously grazed sites (C2 only) are explained by the comparatively higher rainfall received in this area, the flush of annual species following rain and a temporary reduced stocking rate just prior to assessment. Once the annual species died, the carrying capacity would have declined.

Stocking rate in the rotationally grazed paddocks was always lower than in the control. This is not an indication of carrying capacity, rather a reflection on management decisions. A lower stocking rate can allow steers to select a more nutritious diet, thus increasing their performance. Subsequent profitability can increase as the return on individual animals' increases.

In this instance, growing steers for sale is more profitable if beasts are of a premium weight. For the first year of the trial, the average daily weight gain for the steers in the rotation exceeded that of the control steers despite the rotation paddocks receiving slightly less rain than the continuously grazed paddock. In the second year the control steers appear to have outperformed the rotation steers. This may have been due to higher rainfall totals received in the control paddock however, given that the control steers were more mature animals than those in the rotation it is not possible to draw accurate conclusions.

Cattle behaviour

Maintaining or improving land condition also tends to raise long term profitability of a grazing enterprise. How grazing animals use a paddock, both spatially and temporally, impacts on land condition. In this instance, it is also important to note that the uniformity of buffel grass, particularly in the rotationally grazed paddocks, may help to reduce the intensity of patch grazing compared with a more heterogonous pasture (Teague & Dowhower 2003).

Cattle activity and defoliation in the southern rotationally grazed paddocks were relatively uniform across the whole area in 2006. The pattern of defoliation suggests that the rotational grazing strategy achieves more evenly distributed grazing across the paddock, minimising the effect of the grazing gradient and subsequent pasture degradation close to water. In 2007, the pattern appears similar with the exception of the site furthest from water. In fact there is a steeper slope in the data suggesting that cattle activity is declining with distance from water. Herd size and average number of days per paddock varied between the two grazing events and it is possible that these factors have contributed to cattle behaviour within the paddocks. It is also possible that the results seen in 2006 are a product of grazing from a new watering point meaning that the pasture had a uniform grazing history throughout the paddock.

The continuously grazed paddock is quite different and shows that there is heavy cattle activity and defoliation close to water and much lighter impact at 3km from water. This type of activity can lead to the formation of grazing gradients and overgrazing of pastures close to water.

More even activity across the paddock means that cattle are not camping in favoured areas. This is desirable as areas where cattle camp are characterised by large amounts of manure and urine. This means that nutrients obtained across the pasture are redistributed and become concentrated at the camps, potentially leading to a decline in nutrients available to the broader pasture (Humphreys 1991, Pieper & Heitschmidt 1988).

Generally, both cattle activity and defoliation were higher at 3km from water in the rotationally grazed paddocks than in the continuously grazed paddocks suggesting that cattle were moving and grazing throughout this area.

In the northern rotationally grazed paddocks, manager Steve Cadzow observed that cattle were rarely seen further than 2km from water. These observations, in conjunction with the lack of grazing at the furthest distance from water in the southern paddocks, perhaps highlight the relationship between grazing pressure and paddock utilisation. This suggests that as long as there is sufficient bulk and quality of feed within 2km of water then cattle prefer not to walk further than this unless required.

Achieving even use across a paddock requires a delicate balance in order to avoid overgrazing near the watering point. Even though the 2006 results suggest that cattle are using the southern rotationally grazed paddocks very evenly it is important to remember that the watering point was new and had never been grazed before. This means that there were no areas of recent regrowth that might be considered more favourable to a steer.

Defoliation in 2007 appears to decline slightly with distance from water. Herd size and length of grazing time were both smaller in 2007 and this is likely to have influenced cattle activity. Whilst yield had declined and percentage rank material had increased between the pretrial and post grazing assessments, there had been some regrowth which would have been higher quality than relict plant material from previous seasons. Steers are likely to be preferentially grazing the regrowth but would also consume some older material at the same location. It is also possible that a flush of palatable, ephemeral species had increased grazing pressure close to water. Thirdly, given that the herd size was smaller (379 head cf. 307 head) in 2007, competition between animals may have reduced. It is not possible to quantify these suspicions as pasture quality was not recorded. If cattle are eating their fill closer to water they are perhaps less likely to venture further from water in search of preferred forage. When cattle preferentially graze areas in relation to distance from water then a grazing gradient will form within the rotationally grazed paddocks (Bastin *et al.* 1993, Hodder & Low 1978, Lange 1969).

Land Condition

Land condition is difficult to quantify. The presence of palatable perennial grass such as buffel grass is considered to be a sign of good pasture condition (Chilcott *et al.* 2005). Large perennial grass basal areas and other forms of ground cover help achieve maximum pasture production, protect soil from erosion, catch runoff and nutrients and maintain ecosystem processes (Teague & Dowhower 2003).

On average, perennial grass basal area and cover was consistently lower in the continuously grazed paddock compared to the rotationally grazed areas, particularly at areas close to water. This may be due to historical grazing being lower in the rotationally grazed paddocks. This may mean that the ability of the continuously grazed paddock to produce useful forage is lower than that of the rotationally grazed areas. Whilst there is a significant increase in cover in the continuously grazed paddock in May 2007, perennial grass basal area has not increased at the same time. This increase in cover is due to short lived annual species that will not contribute greatly to long term land condition improvement.

The data show that perennial grass basal area declined over time in both treatments. The reduction in basal area may reflect the natural (season induced) decline following a run of very high rainfall years which led to increases in buffel at the sites. Nevertheless the downward trend is potentially a concern to land condition status. However long term monitoring would be needed in order to

separate land condition trends from seasonal response. Another possibility is that although observers did undergo training to reduce observer variation, an observer's estimates may still vary through time and different observers for different sample periods may also cause variation through time. For this reason trends in perennial grass basal area through time may be due to observer variation rather than actual trend.

There was a change in species frequency over time in both the rotationally grazed and continuously grazed paddocks. However this reflected seasonal conditions experienced within the trial and was usually not an effect of treatment. Exceptions were lower forb frequency and higher buffel in the rotational grazed paddocks only at the end of the trial, potentially suggesting a separating out of species composition.

Species Diversity

When buffel grass becomes very dominant in a pasture it causes a decline in native ground cover species (Friedel *et al.* 2006). One possible cause is the sheer physical size of the plant outcompeting and shading other plants. The frequency of buffel grass didn't vary between the rotationally grazed paddocks and the continuously grazed paddock, but the degree to which it dominated yield was quite different. The buffel plants in the continuously grazed paddock were much smaller than in the rotation, as is evidenced by the smaller perennial grass basal area for a similar frequency of buffel, perhaps allowing a greater response of ephemeral, annual species to germinate. This may help to explain why the number of species remained consistent and higher in the continuously grazed paddock compared to the rotationally grazed paddocks. This observation is confounded by the fact that the continuously grazed paddock received slightly more rainfall in 2007 than the rotation. Given the decrease in perennial grass basal area in the rotationally grazed paddocks the species diversity may increase through time in response to gaps opening up.

Pasture Quality

It is not surprising that the percentage of rank material was much higher in the rotationally grazed paddocks as prior to the commencement of the trial, these paddocks had not been grazed for five years. This coincided with very wet years that generated a lot of growth that had become rank and unpalatable. In contrast, the adjacent control paddock had been continuously grazed resulting in much less opportunity for pasture to become rank.

The managers had hoped that the high, short term stocking rates would result in a reduction of rank material. The short duration of the trial and the lower stocking rates in the rotation may have contributed to this not being achieved yet. This has not occurred and it is likely that fire, or some other form of intervention, is required to remove this rank load. Best practice methodologies in the subtropical pastoral regions tend to recommend fire as a tool for refreshing rank pasture (Materne 2005). The long term aim is that the rotation strategy will allow cattle to better utilise buffel growth before it becomes rank. The trial had not been running long enough for this to be tested.

Fire Risk

The hypothesis to reduce fire risk using rotational grazing is based on the potential ability to reduce the amount of rank material that is produced and also to break the load and continuity of fuel through grazing. As discussed elsewhere, it is not yet possible to determine the impact of rotational grazing on the formation of rank material.

Fuel loads of greater than 1,200kg/ha are considered to be a fire risk in perennial *Astrebla* communities (Materne pers. comm. 2008) and this may be a comparable for buffel grass. In central

Australia, fuel in excess of >1,000 kg/ha is recommended for remedial burning (Chilcott *et al.* 2005). In comparison, fuel loads in the rotationally grazed paddocks had initial yields of approximately 775kg/ha and post-grazing yields of 679kg/ha, and may not have caused a significant fire hazard at either time. However, fire risk is a combination of fuel load and fuel continuity so breaking up the continuity of fuel is also desirable in reducing fire risk. Cover was significantly higher in the rotation than in the control and did not change through time perhaps suggesting that continuity of fuel does not decline in a rotationally grazed system. Defoliation in the rotationally grazed paddocks was also quite even across the landscape compared with the continuous grazing perhaps also suggesting that the continuity of fuel does not vary much across the landscape with rotation. Neither cover nor defoliation truly describes fuel continuity and it was not within the scope of this project to undertake more detailed sampling.

Conversely, increasing or at least maintaining, yield and cover is desirable in terms of carrying capacity and land condition status respectively.

Stock Performance

It is not possible to accurately compare average daily weight gain with the rotation steers and the control steers due to the difference in their weigh dates. The managers have certainly been impressed with the average daily weight gain in the rotationally grazed steers and have received excellent prices on sale. Long term analysis of average daily weight gain and stocking rate need to be considered in order to determine whether it is the rotation, or perhaps a lower stocking rate that is delivering the best results.

5. Future Work/Conclusions

Hypotheses

Few of the original hypotheses could be supported by the data collected to date.

Intensive rotational grazing will increase carrying capacity.

Although the managers wanted to increase the carrying capacity using rotational grazing, they have actually run fewer animals per watered area in the rotation. Hence they didn't really test this aspect, although the added infrastructure will have increased CC due to an increase in watered area on the property, but not due to the rotations per se.

Rotational grazing will result in more even utilisation of pasture.

It appears as though the rotational grazing strategy in the smaller southern paddocks may help to achieve more even use of pastures. This may be a combination of the high stocking rate and short grazing period, forcing cattle to spread out across the paddock. Conversely, the relatively low stocking rate when compared to continuous grazing combined with small, better watered paddocks means that cattle have the opportunity to always select only the most attractive parts of the pasture. These confounding factors mean that evenness of use may or may not be due to the rotational nature of grazing. Observations from the manager suggest that evenness of use is not as obvious in the northern rotationally grazed paddocks and he intends to locate a second watering point so that cattle do not have to travel more than 3km from water to access the whole paddock. Achieving more even use requires a delicate balance so as not to create a grazing gradient. If, as discussed earlier, a grazing gradient is being formed in the rotationally grazed paddocks then it is likely to become more obvious in the future.

Land condition will be maintained or improved under rotational grazing.

There was little evidence that land condition improved for either treatment. Ground cover and buffel frequency trends suggest that the rotational grazing strategy has some potential to at least maintain land condition, although the decline in perennial grass basal area would suggest otherwise, but this may be more seasonal.

Under intensive rotational grazing, there will be an increase in species diversity.
Contrary to the expectation that species diversity would increase under rotational grazing, diversity declined in the rotation, while the continuous remained stable. It is important to remember that the nature of central Australia's extremely variable climatic conditions can have a big impact on plant growth making it notoriously difficult to distinguish between management effects and seasonal influence in a time period of only two years. Trends should become more obvious in future years.

With better use of the pastures, there will be a reduction in fire risk and frequency.
Fire risk was difficult to assess within this project. Whilst yield and cover did not decline in the rotationally grazed paddocks, rankness of pasture increased rather than the anticipated decline. The goal of reducing a fuel load is, in some ways, contradictory to the goals of increasing carrying capacity and land condition.

Average daily weight gain of steers will be higher under rotational grazing
Cattle performance has largely been described using average daily weight gain. Due to a lack of comparable control data it is difficult to draw any conclusions at this stage. Hopefully, as the trial progresses in the coming years, more useful data will be forthcoming.

It is difficult to draw sound conclusions within this trial as the paddocks differed by far more than just grazing duration and rest. Factors such as stocking rate and distance to water are likely to be large contributors to the results to date.

It is worth noting that the managers felt that the rotational grazing strategy was producing good results with regard to steer performance although they feel that it will take some years before the true impact on the pastures is understood. This is typically the case in central Australia where seasonal conditions can significantly influence the length of time before impacts on natural resources are understood. They find the rotational grazing strategy easy to implement and are very keen to continue with the existing strategy and to also extend it into further parts of the property.

<u>Technical Implications</u>
Grazing strategies must be implemented for many consecutive years before reliable conclusions can be made. This is particularly the case in the aseasonal, variable climate of central Australia. Further time is needed to assess long term impacts of this particular rotational grazing strategy.

Study designs must be carefully planned to ensure that factors such as stocking rate do not override the effects of the grazing system in impact. The considerably higher stocking rate in the continuously grazed paddock highlights the need for it to be stocked according to forage availability in the watered area also, not just the rotational paddocks.

A more thorough understanding of the elements that affect fire risk would have ensured a more comprehensive study design thus allowing the relevant hypothesis to be more thoroughly tested.

Industry Recommendations

More even utilisation of paddock area can be gained through smaller, better watered paddocks. Ensuring that productive pastures are all within 3km of water would have similar benefits.

To date, this study provides little evidence that rotational grazing will improve species diversity, land condition, rankness or fire frequency. Rather, species diversity and rankness of pasture worsened under the rotational grazing system.

Ultimately, stocking rate is potentially the most important factor contributing to land condition and productivity.

Rotational grazing strategies, through the characteristic of having very high stock densities for short periods of time, encourage managers to assess forage availability and therefore carrying capacity and hence adaptively match stock numbers to available forage. This factor alone may determine the benefits from rotational systems rather than the usually attributed rotation and rest.

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