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Increasing uptake of drought management options to optimise pasture recovery following drought

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Executive Summary

Many of the pasture communities in northern Australia are showing signs of deterioration including loss of palatable perennial grasses and their replacement by less palatable grasses (Tothill and Gillies 1992). Since that report, much of northern Australia has suffered from a period of sustained drought such that pasture deterioration continues to be a major industry issue. This period of prolonged drought has been associated with the maintenance of high cattle numbers.

Extreme drought conditions have continued throughout central and southern Queensland during 2002 and this substantially accentuated the risk of widespread and severe pasture degradation. This, in turn, puts any post-drought recovery of pasture condition and animal production at extreme risk, compounding and prolonging the impact of drought on cattle productivity and producer equity.

The major objectives for undertaking this project were to develop guidelines for recovering pasture condition following this drought and to develop beef producer awareness of the consequences of land degradation both during and following drought.

The project examined the perennial grass basal area and yield responses to either 0, 3, 6 or 12 months exclosure from grazing at a range of sites throughout Queensland. These sites were selected to represent a range of pasture conditions on a range of soil fertilities and ranged from buffel grass on a fertile clay soil to a poor condition native pasture on a soil of poor fertility.

The main findings from this project were:

- There was little recovery of pasture condition at those sites where initial pasture composition had declined.
- The only site to record any improvement in condition had been exclosed for 12 months and this site had received twice the normal monthly rainfall in two consecutive summer months.
- Desirable perennial grasses were virtually absent at one site while undesirable perennial grasses dominated pasture composition at another three sites.
- Highest nitrogen yields occurred at the 12 months exclosure treatments.
- These data have been included in a pasture growth data bank and will be used for further pasture growth modelling aimed at improving grazing management.

Recommendations are made for further research and these include:

- Research be conducted over a longer time frame and
- Research should recognise the impact of specific events, such as above average rainfall, which trigger changes towards improved pasture condition.

Because of the poor pasture composition at some of these sites, it may be difficult in the future for such properties to demonstrate an ability to conform to environmental management systems for sustainable beef production.

Contents

1 Main Research Report

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1.2 Acknowledgements

The cooperation of the following producers who made land available for this study is greatly appreciated:
Shane and Shae Joyce, “Dukes Plain”, Theodore
Pat and Norma Galvin, “Archer”, Bajool
Keith and Annabel Chandler, “Glentulloch”, Injune
Scot Stewart, “Oxford Downs”, Nebo
Rob and Sue Bennetto, “Virginia Park”, Charters Towers.

1.3 Background to project and the industry context

Extreme drought conditions existed throughout central and southern central Queensland during 2002 and this substantially increased the risk of widespread and severe pasture degradation. This, in turn, put the post-drought recovery of pasture and animal production at extreme risk, compounding and prolonging the impact of drought on productivity and equity. This perception was supported by a statewide assessment of land condition and cover undertaken during November-December 2002 by DPI&F staff. Despite patchy, relief rainfall in February 2003, many producers remained in crisis mode, and had substantially reduced stock numbers. Decisions such as further retention of stock and the timing of restocking once the drought breaks, could have important implications for land condition and pasture recovery. Following the historical examination of degradation episodes throughout Australia (McKeon *et al*. 2004), it is considered that there is potential for a “9^{th} degradation event” (G. M. McKeon, personal communication).

Some areas of northern Queensland also appeared to be entering crisis mode with a delayed start to the 2002-03 wet season and only patchy rainfall such that many producers were retaining stock in the hope of a late wet season. Again, the approach to both retention of stock and post-drought restocking would greatly affect pasture recovery, especially in areas in which pastures were still recovering from the impact of droughts of the early to mid 1990s.

The importance of tactical management of grazing pressure, both during and subsequent to drought conditions, seems logical and is supported in principle from limited grazing studies. For example, Orr and Paton (1997) demonstrated the benefit of tactical rest following spring burning, the ECOGRAZE project has demonstrated the benefit of early wet season spelling while the “Wambiana” grazing study is evaluating the impacts of rotational resting. Conventional grazing studies confound existing pasture condition with the imposed grazing treatment within the recovery period but there are little data available to predict the impacts of various tactical management strategies on post-drought pasture recovery

1.4 Project objectives

By completion of the project on 30 November 2004:

1. Fifty percent of beef producers in the project areas will be aware of the consequences for land degradation during and after drought.
2. Guidelines and decision tools for recovery of pasture condition following drought, including tactical rest from grazing, will be available to producers.

1.5 Detailed methodology

Six field sites were selected to cover a range of pasture and of soil types). As far as possible, these sites were selected on the basis of some history of the site / pasture community was available.

- Duke's Plain, Theodore – site of a well managed cell grazing system
- Oxford Downs, Nebo – site of botanical and pasture productivity studies undertaken by G. Bahnisch, PhD. Student, University of Queensland, Gatton Campus.
- Archer, Rockhampton – well managed commercial grazing enterprise
- Virginia Park, Charters Towers – site of the "Sustainable grazing for a healthy Burdekin" project.
- Glentulloch, Injune – site was located in the 50% utilisation, trees cleared treatment of the former *Aristida-Bothriochloa* grazing study.
- Croxdale, Charleville –site with a long term history of heavy grazing and, since the early 1980's, run as a DPI&F experimental station.

At the Theodore, Nebo, Rockhampton and Injune sites, four treatment areas, each approximately 25 x 25 metres, were permanently marked in autumn 2003 to enable repeated sampling. Three of these treatments were exclosed to measure the impact of either, 3, 6 or 12 months exclosure from grazing on pasture condition while the fourth was continuously grazed. (At Theodore the four different grazing regimes are achieved through a cell grazing system).

Severe drought conditions were experienced at Charleville and Charters Towers sites over the 2002-03 summer. Consequently, no pasture sampling was possible, as pasture sampling requires active plant growth so that plants can be identified as alive and, where possible, to species level. Rain in spring 2003 enabled pasture sampling to commence at these two sites however the number of treatment areas at both sites was reduced from three to two exclosures (3 and 6 months exclosure) together with a grazed area.

Table 1. Pasture condition and soil fertility at 6 field sites across Queensland

		Pasture condition		
		Good	Fair	Poor
Soil fertility	Good	Buffel on clay (Duke's Plain, Theodore)	Bluegrass on clay (Oxford Downs, Nebo)	
	Fair		Black speargrass (Archer, Rockhampton)	Indian bluegrass (couch) (Virginia Park, Charters Towers)
	Poor		Aristida-Bothriochloa (Glentulloch, Injune)	Mulga (Croxdale, Charleville)

Each treatment at each site was sampled for pasture yield and composition at approximately 3 monthly intervals using BOTANAL (Tothill *et al*. 1992) with 3-4 trained operators assessing 40 quadrats per treatment area. Perennial grass basal area was measured with a point frame consisting of 5 points spaced 15 cm apart. Between 1 000 and 1250 points were recorded (all by the project leader) at each site in autumn 2003 and again in autumn 2004.

To determine nitrogen yield at the time of the autumn 2004 pasture sampling, three bulk pasture samples were collected in each treatment at each site, dried and analysed for nitrogen content.

1.6 Results

1.6.1 Rainfall

A major feature at most sites was that the rainfall was generally below the long term average (Table 2). The one exception to this overall trend occurred at the Archer site where, in December 2003 and January 2004, this site received almost twice the long term mean rainfall for that site.

Table 2 Monthly rainfall totals and the mean long term monthly rainfall at the nearest long term rainfall recording station

(a) Dukes Plain (Courtesy of Chris Chilcott)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
2003	35	174.5	51.2	71	3.8	8.4	13.4	55	3.5	52.5	7.4	104.8
2004	128.4	98.4	40.4	6.2	0	0						
Mean	96.1	90.6	52.7	40.8	40.0	26.0	30.4	28.8	28.7	57.4	80.8	92.7

(b) Oxford Downs

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
2003				6.2	30.6	43.8	2.2	1.6	0	47.6	0.8	225.0
2004	43.0	107.4										
Mean (Nebo)	142	135	108	44	35	39	25	21	19	32	55	97

(c) Archer

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
2003						25.8	18.2	30.4	0	80.4	6.8	225.8
2004	238.6	55.6	20.2	44.6	1.6	1.6	3.2	15.6	0.4	64.5		
Mean (Bajool)	136	133	90	41	42	37	31	23	23	53	75	108

(d) Virginia Park

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
2003			46.8	0	24.3	25.5	0	0	0	0	8	60
2004	102.8	108.8	7.5									
Mean (Mingela)	141	142	104	37	25	22	13	11	10	19	37	80

(e) Glentulloch

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
2003						44.8	19.2	59.0	2.0	73.8	34.6	83.2
2004	325.6	70.2	42.2	52.6	2.4	1.0	0.2					
Mean (Westgrove)	94	87	67	39	35	33	31	23	26	48	62	86

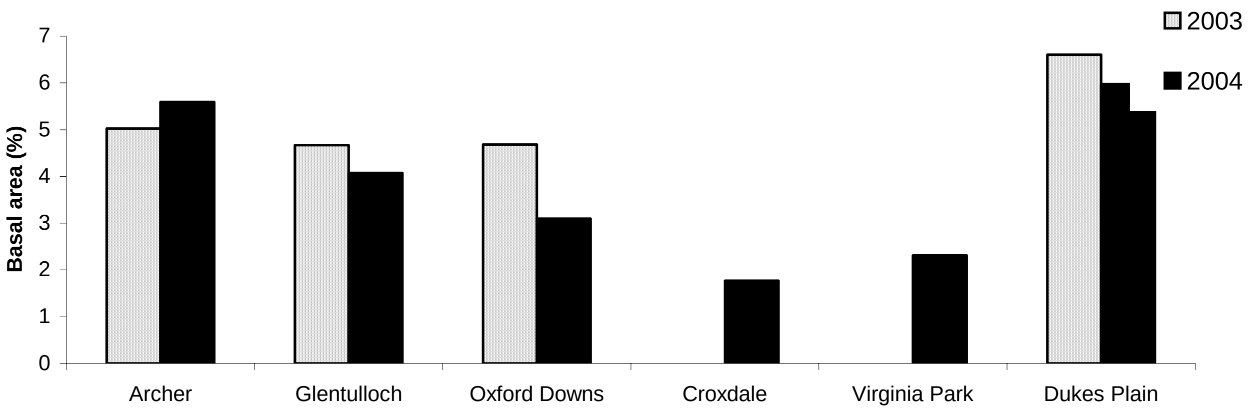
(f) Croxdale

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
2003											17.8	31.2
2004	174.6	57.4	53.0						100			
Mean (Charleville)	68	69	58	32	31	28	28	20	22	35	44	56

1.6.2 Basal area of perennial grasses

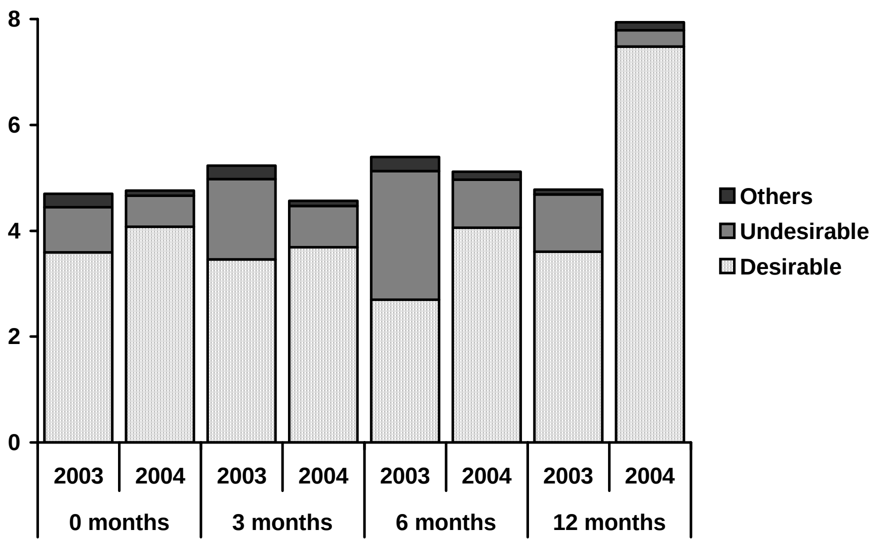
Total basal area of perennial grasses in autumn 2003 was 4.7% at both Oxford Downs and Glentulloch, 5.1% at Archer and 6.4% at Dukes Plain (no measurements were possible at Virginia Park or Croxdale) (Figure 1). Changes in perennial grass basal area at any site between 2003 and autumn 2004 were small and there was only one treatment effect which occurred at Archer. Perennial grass basal area at Virginia Park and Croxdale in autumn 2004 was much lower than that at any of the other four sites.

Figure 1. Changes in the total basal area (%) of perennial grasses pooled across four treatments at six sites in 2003 and 2004.



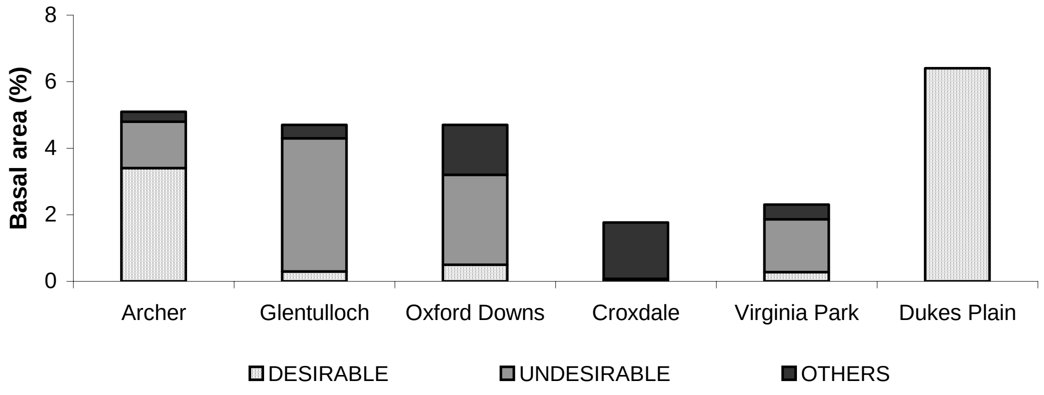
At Archer, there was a large increase in perennial grass basal area between 2003 and 2004 for the treatment exclosed from grazing for 12 months but this effect was not apparent at any of the three other treatments (Figure 2). This large increase in basal area was due to an increase in the basal area of Heteropogon contortus and this increase occurred in response to the above average rainfall at that site in December 2003 and January 2004.

Figure 2. Changes in the contribution of desirable, undesirable and other perennial grasses to perennial grass basal area in four treatments in 2003 and 2004 at Archer.



At the Glentulloch, Oxford Downs, Croxdale and Virginia Park sites the contribution of desirable perennial grasses to total basal area was low (<10%) (Figure 3). Of particular interest was the virtual absence of desirable perennial grasses at Croxdale, the undesirable *Chloris* spp. and *Bothriochloa decipiens* at Glentulloch and the undesirable *Aristida* spp. and *Panicum* spp. at Oxford Downs. *B. pertusa* was the dominant undesirable perennial grass at Virginia Park.

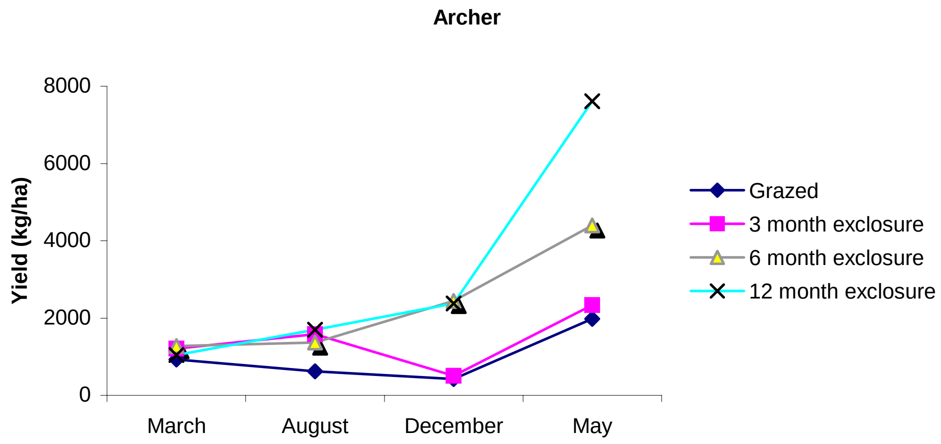
Figure 3. Contribution of desirable, undesirable and other perennial grasses to perennial grass basal area at six sites in autumn 2004.

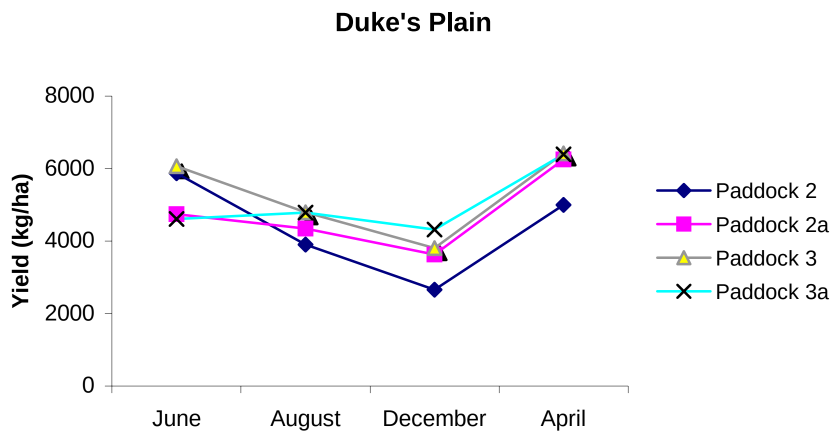


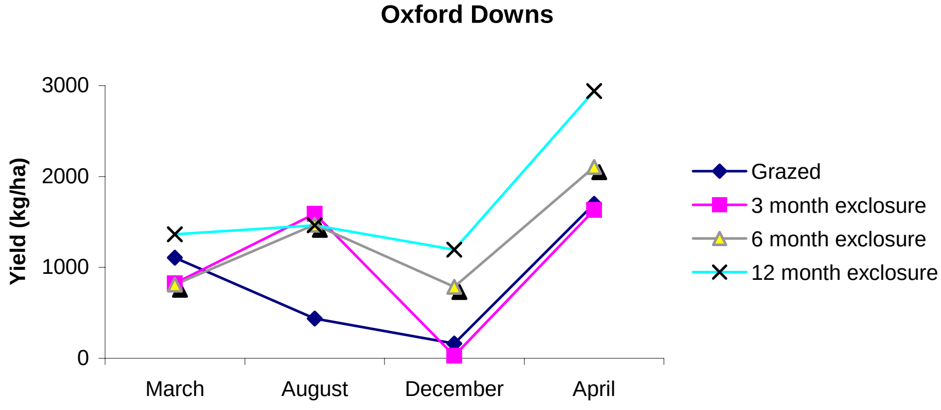
1.6.3 Total pasture yields

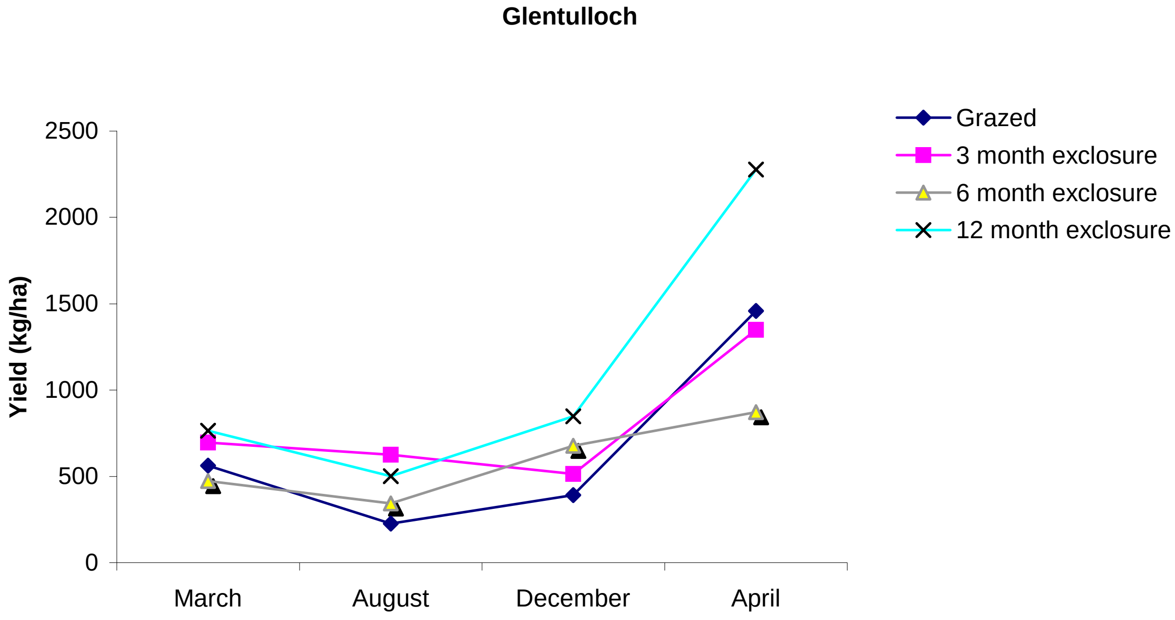
By autumn 2004, the highest total pasture yields occurred at the longest period of exclosure (Figure 4). The effect of 6 and 12 months exclosure treatments were most obvious at Archer and Oxford Downs in December when compared with the yields in the grazed and 3 month exclosure treatments. At Dukes Plain, a feature of the total pasture yield data was the uniformity of yield changes between the four sites reflecting the uniformity of grazing under the cell grazing system. At the 4 sites where yield was measured in December 2003 pasture yield increased between then and April / May 2004 reflecting the impact of summer rainfall on pasture growth.

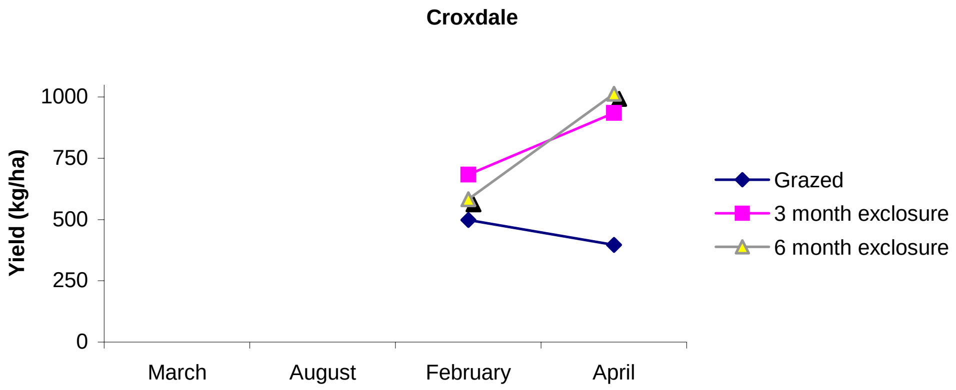
Figure 4. Changes in total pasture yields (kg/ha) at 4 sites between autumn 2003 and 2004 and 2 sites between summer and autumn 2004.

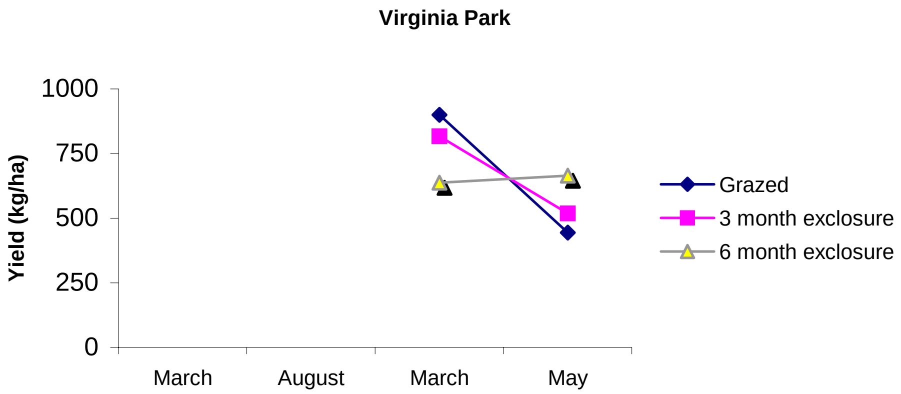



Duke's Plain
Yield (kg/ha)
8000
6000
4000
2000
0
June
August
December
April
Paddock 2
Paddock 2a
Paddock 3
Paddock 3a


Oxford Downs
Yield (kg/ha)
3000
2000
1000
0
March
August
December
April
Grazed
3 month exclosure
6 month exclosure
12 month exclosure


Glentulloch
Yield (kg/ha)
2500
2000
1500
1000
500
0
March
August
December
April
Grazed
3 month exclosure
6 month exclosure
12 month exclosure



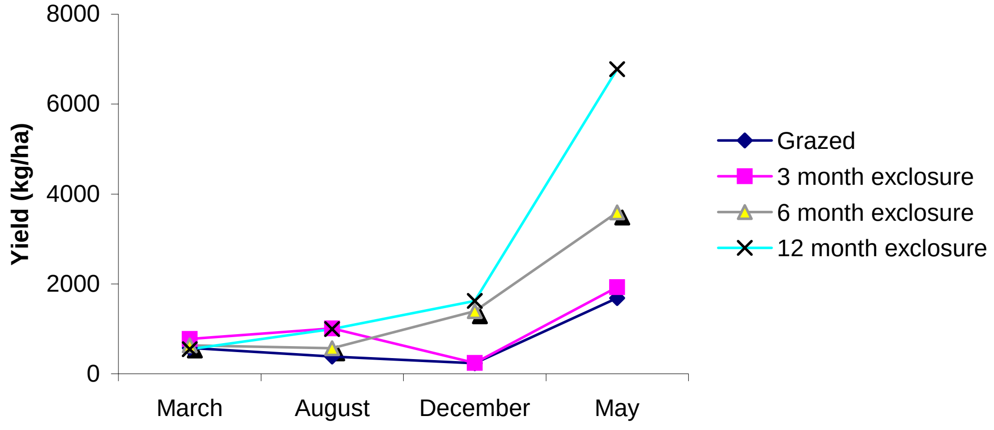


1.6.4 Species composition

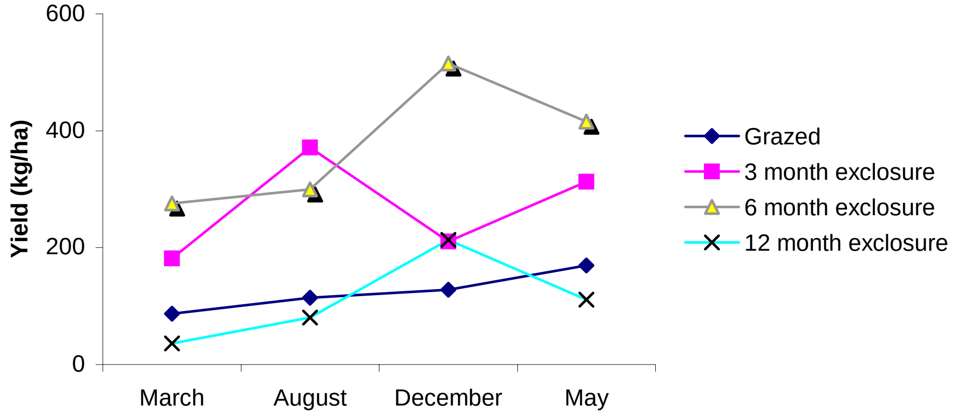
A large increase in the perennial grass basal area and total yield at the Archer site was reflected in a similar large increase in the contribution of the desirable *H. contortus,* but not of the undesirable *Aristida* spp., to total yield and also to perennial grass basal area (Figure 5). In contrast, much of the increase in total yield at both Oxford Downs and Glentulloch reflected increasing yields of undesirable species. At Oxford Downs the undesirables *Aristida* spp. and *Panicum* spp. and at Glentulloch the undesirable *Bothriochloa decipiens* and *Chloris* spp. were the major contributors to total yields and also to perennial grass basal area.

Figure 5. Changes in the yields of (a) *H. contortus* and (b) *Aristida* spp at Archer, (c) *Chloris* spp. and (d) *B. decipiens* at Glentulloch and (e) *Aristida* spp. and (f) *Panicum* spp. at Oxford Downs between autumn 2003 and autumn 2004.

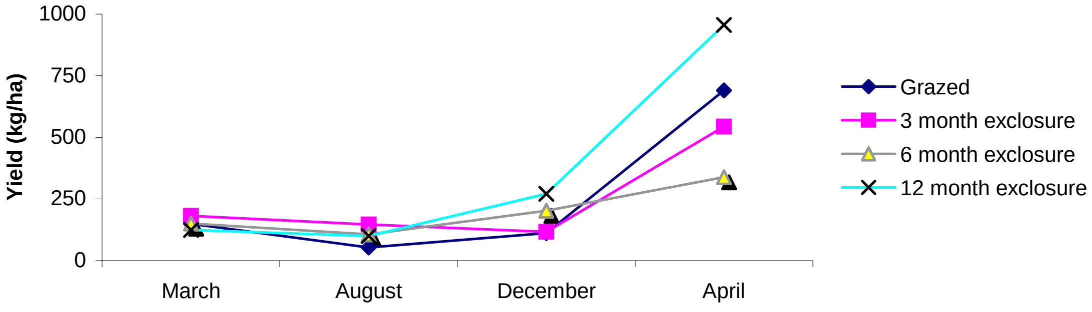
Archer - *H. contortus*



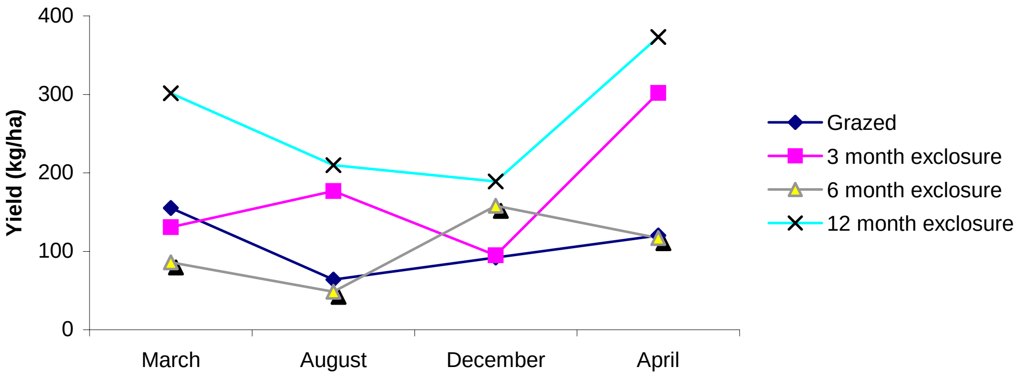
Archer - *Aristida spp*



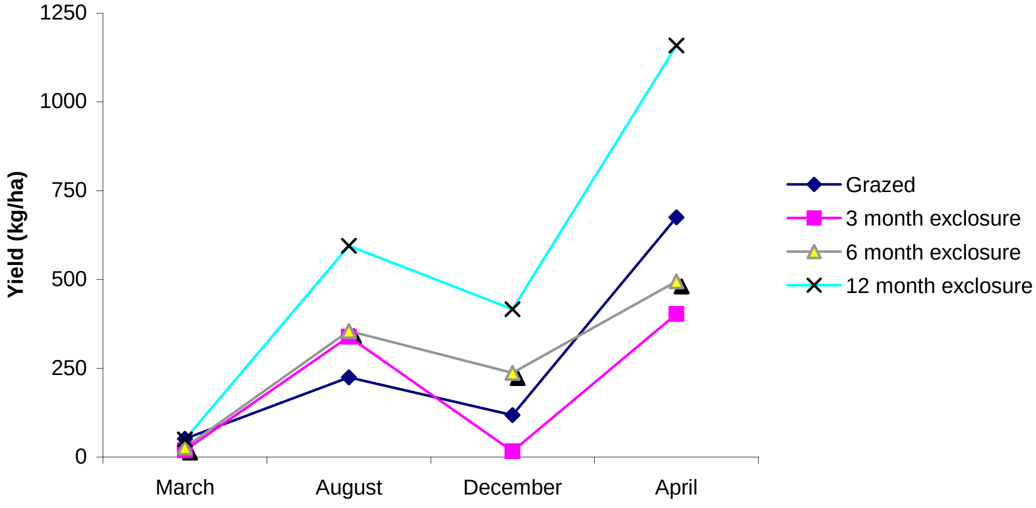
Glentulloch - *Chloris spp*



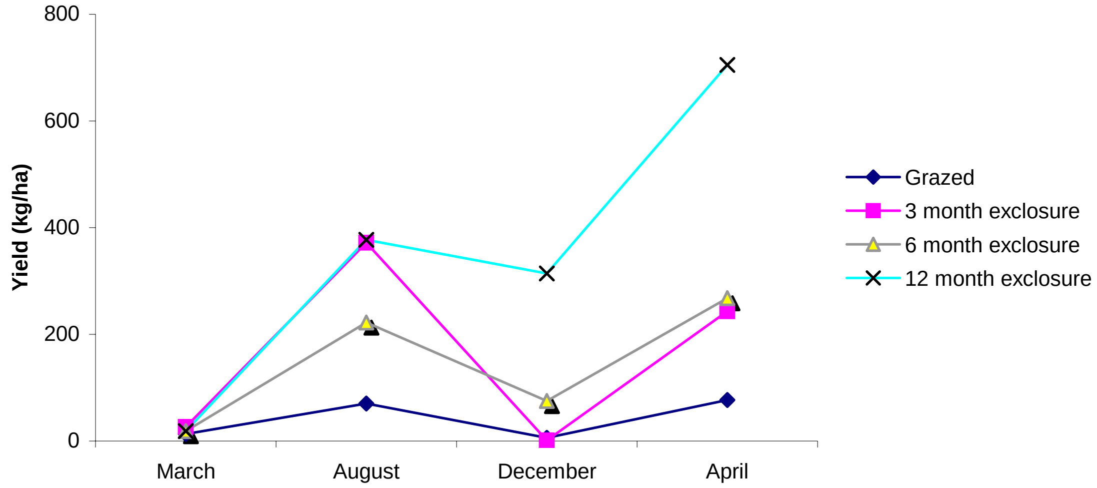
Glentulloch - *B. decipiens*



Oxford Downs - *Aristida spp.*



Oxford Downs - *Panicum spp*



1.6.5 Nitrogen yields

Nitrogen concentrations in autumn 2004 ranged from 0.39% at Dukes Plain up to 0.76% at Oxford Downs (Figure 6). Within each site, there was little consistent variation between treatments except at Archer where nitrogen concentration was lower at the 12 months exclosure than at the other three sites. Nitrogen yields (i.e. nitrogen concentration x total pasture yield) ranged from 4 kg/ha at Virginia Park up to 24 kg/ha at Dukes Plain (Figure 7). There was a clear trend for nitrogen yields to be highest in the 12 month exclosure treatments.

Figure 6. Nitrogen concentration (%) for 3 or 4 treatments at 6 six sites in autumn 2004. (Vertical bars indicate the standard error of the mean).

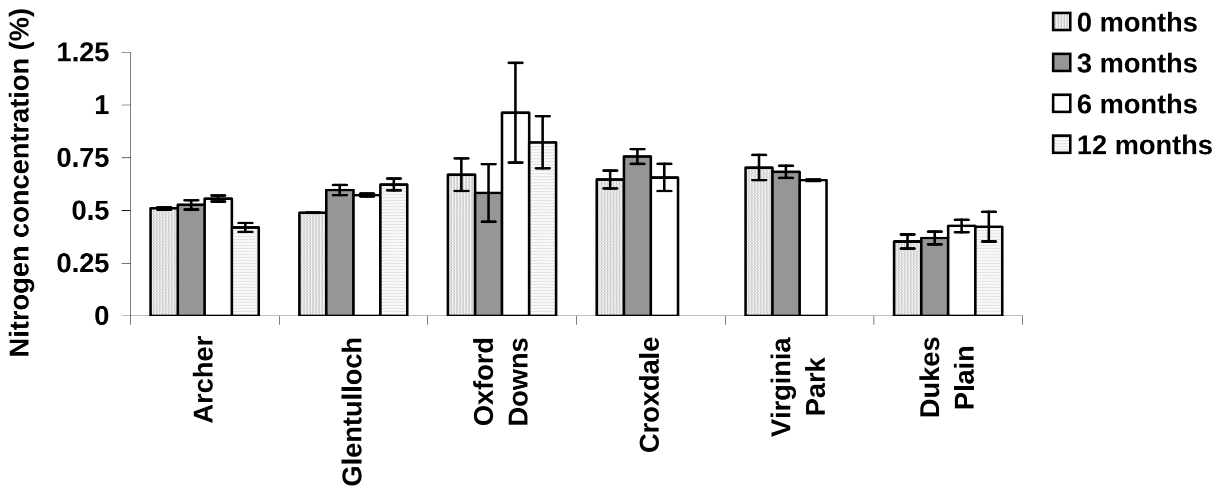
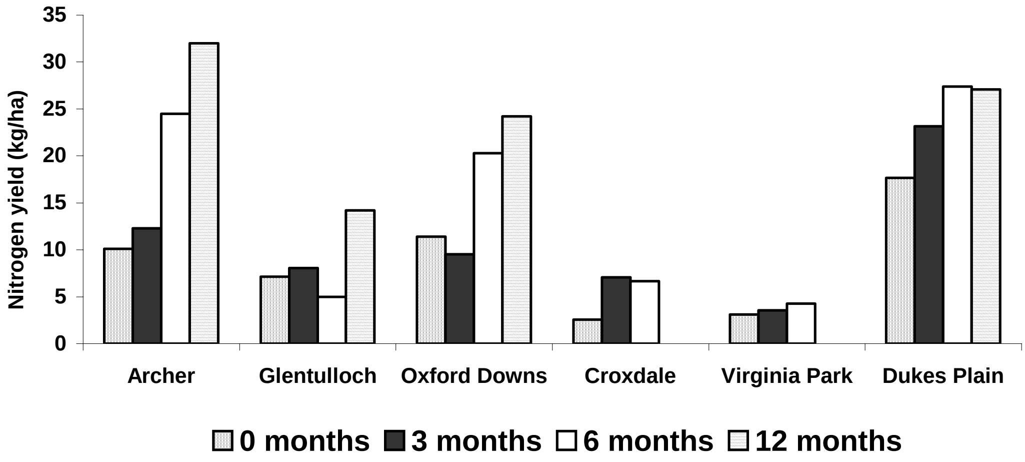


Figure 7. Nitrogen yield (kg/ha) at 3 or 4 treatments at 6 sites in autumn 2004.



2 Discussion

This study has indicated that there has been little recovery in pasture composition particularly at those 4 sites where pastures were not initially in fair to good condition. This result indicates that recovering pasture condition following drought cannot be achieved simply by excluding livestock for short periods, particularly when rainfall is only average or below.

The one notable exception to this generalisation of poor pasture recovery was the response of *H. contortus* at the 12 months exclosure treatment at Archer. This response was mediated through above average rainfall during December 2003 and January 2004 and which resulted in a large increase in basal area *H. contortus* because of large increases in the size of existing tussocks rather than from seedling recruitment. Pastures at Dukes Plain were in good condition at the commencement of this study – high perennial grass basal area and high pasture yield – and these pastures remained in good condition despite only "average" rainfall over the 2003-04 summer. A feature of the pasture at Dukes Plain was the uniformity in changes in pasture yield across the four treatments. This fact highlights the cell grazing system at Dukes Plain where animals graze each treatment for short periods and this rotation of animals maintains a relatively even pasture yield between the paddocks.

Perennial grass basal area at the other four sites – Glentulloch, Oxford Downs, Croxdale and Virginia Park – was moderate for these vegetation types and this was despite long periods of drought and history of moderate to heavy grazing. Despite this, however, these sites were in poor condition as indicated by the low contribution of desirable grasses. Desirable grasses were virtually absent at Charleville while pastures at both Glentulloch and Oxford Downs were dominated by undesirable pasture species. Furthermore, these undesirable species, *Bothriochloa decipiens* and *Chloris* spp. at Glentulloch and *Aristida* spp. and *Panicum* spp at Oxford Downs were the species displaying the greatest increase in yield.

One important finding from this project has been the reduction in nitrogen yield with increased exposure to grazing. This result occurred across all sites. In the early development of the GRASP model (McKeon *et al.* 2000) it was suggested that there is a reduction of nitrogen uptake (Ash and McIvor 1995) associated with heavy utilisation such as occurs during drought. The results from the current project extend the above findings and modelling to other land types. Hence this "drought recovery" project has contributed significantly to the simulation of the impact of high stocking rates on pasture productivity across Northern Australia. The mechanistic basis for this lower nitrogen uptake under grazing is likely to be due to reduced root density. However, there have been few studies to support this hypothesis (e.g. Crider 1955) and hence a more mechanistic modelling of this phenomenon in GRASP (i.e. by simulating root biomass) is unlikely to be supported by adequate data.

Little data are available on recovering pasture condition throughout northern Australia (Whalley 1993, Filet 1993). Despite this, Orr (1980) documented the role of above average rainfall in effecting changes in pasture composition in Astrebla (Mitchell grass) grassland. Furthermore, Orr et al. (1997) and Orr and Paton (1997) demonstrated the role of strategic spring burning in reducing *Aristida* spp. dominance in *H. contortus* pastures and how strategic burning interacts with grazing management. In that research, spring burning "triggered" an increase in the composition of *H. contortus* while either exclosure from grazing or substantially reduced stocking rate over the summer growth period enhanced this "trigger" effect. An important factor leading to the re-establishment of *H. contortus* was seedling recruitment which resulted from good seed set in the previous autumn.

Spring burning would probably act as a "trigger" to reduce *Aristida* spp. at Oxford Downs. However, little is known about what "triggers" a reduction in Panicum spp. or an increase in the desirable Dichanthium sericeum at Oxford Downs. Orr (1980) recorded large increases in the contribution of Dichanthium sericeum in response to a series of summers with above average summer rainfall: this increase probably resulted from improved seed set, resulting seedling recruitment and subsequent plant growth during this series of "wet" summers. Little is known of what "triggers" a reduction in the contribution of the undesirable *Bothriochloa decipiens* and *Chloris* spp. at Glentulloch.

The Virginia Park site contained a relatively high contribution of *Bothriochloa pertusa*. This species is either desirable or undesirable depending on the reader's viewpoint. It is undesirable in that it has replaced the more desirable *H. contortus* and *B. ewartiana* through it's greater tolerance of heavy grazing pressure although it is undesirable in that it is probably less protective of the soil surface than the two tussock grasses that it has replaced. In terms of restoring the original vegetation, it is suggested fire will probably be an effective "trigger", at least in restoring *H. contortus* composition.

Clearly, identifying such "triggers" may be necessary to expedite pasture composition change that will lead to improved pasture condition. Further research is necessary in order to measure changes in response to a range of treatments and so lead to the identification of these "triggers".

3 Success in achieving objectives

3.1 Objective 1. Fifty percent of beef producers in the project areas will be aware of the consequences for land degradation during and after drought

This objective was not achieved.

3.2 Objective 2. Guidelines and decision tools for recovery of pasture condition following drought, including tactical rest from grazing, will be available to producers

The research undertaken in this project has failed to result in the development of guidelines for recovering pasture condition. Certainly, rainfall conditions throughout the study were generally unfavourable for the recovery of pasture condition. Furthermore, this research has demonstrated very clearly that short term exclosure from grazing, in the absence of favourable rainfall, does not lead to pasture recovery. Also, the short time frame of this project has allowed only limited improvement in the understanding of the processes of pasture recovery.

4 Impact on Meat and Livestock industry – now and in five years time

The study has indicated that the condition of some pasture communities, at least in the sites selected, is poor and that recovery of pasture condition is not simply a matter of short-term exclosure from grazing. This result raises concerns about the long-term viability of beef production from a pasture resource that can be considered to being utilised in an unsustainable manner.

Beef production which cannot demonstrate long-term sustainability has important ramifications for the Australian beef industry. Firstly, international trading is moving towards quality assurance programs for land management practices and it is likely that there will become sanctions for those producers who cannot comply with such quality assurance programs. Secondly, increasing community concern is currently focusing on the impacts of land management practices on downstream effects including water quality and the Great Barrier Reef. These indications suggest that pasture condition needs to be improved in order to comply with both quality assurance programs and community expectations of sustainable land use practices.

5 Conclusions and recommendations

5.1 Conclusions

Short term exclosure from grazing, particularly in the absence of above average rainfall, does not lead to a rapid recovery in pasture condition. Results from this study suggest that some pasture communities, or at least at the project study sites, are not in good condition.

5.2 Recommendations

Further research is required to develop an understanding of “triggers” for vegetation change in northern Australian pasture communities. Such an understanding should enable the development of guidelines and decision tools to recover pasture condition. Given the unreliable nature of rainfall, this research, ideally, should be conducted over a more appropriate time frame that would allow the reporting of event driven processes, rather than the conventionally time bound milestones, to be reported.

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7 Appendices

Queensland Country Life, 25 November 2004 (article attached below).

DPI&F principal scientist Dr David Orr, Rockhampton, checks the germination of perennial grasses in trial assessing native pasture species composition.

Good pasture overrun

A SNAPSHOT study to gauge the impact of exclusion from grazing on the recovery of pasture condition following prolonged drought does not paint a rosy picture for some pasture communities.

Department of Primary Industries and Fisheries principal scientist Dr David Orr, a sustainable pasture research specialist at Rockhampton, said the 18-month project sponsored by Meat and Livestock Australia was initiated in March, 2003.

Dr Orr said six statewide locations were selected across a range of pasture communities and varying soil types at Theodore, Nebo, Bajool, Charters Towers, Injune and Charleville.

"To be fair, the representative plant

for two consecutive summer months.

The study used four unreplicated 25m by 25m plots to examine the impact of nil, three, six and 12 months exclusion from grazing following prolonged drought.

By sampling pasture at three-monthly intervals, the study showed no major change in the perennial grass basal area although the black speargrass population did increase substantially in the full 12-month grazing exclusion at Bajool.

Dr Orr said a concerning feature of the perennial basal grass species composition at four sites was the relatively high contribution of undesirable species such as wire grass,

"The loss of palatable perennial grasses and their replacement by less palatable inferior grass species is indicative of the deterioration of many northern Australian pasture communities."

Total pasture yields to autumn, 2004 were highest in the 12-month grazing exclusion sites, as were the highest nitrogen yields, but there was little recovery of pasture condition where initial pasture composition had declined.

Dr Orr said he would make a recommendation to extend the study across a longer timeframe.

A positive outcome from this short-term study was that it provided