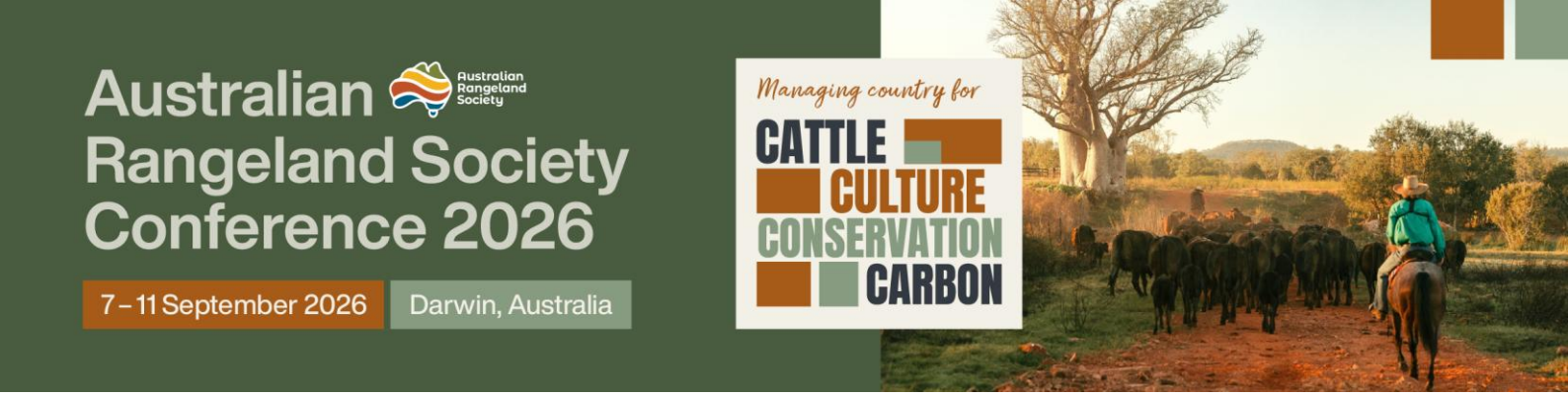


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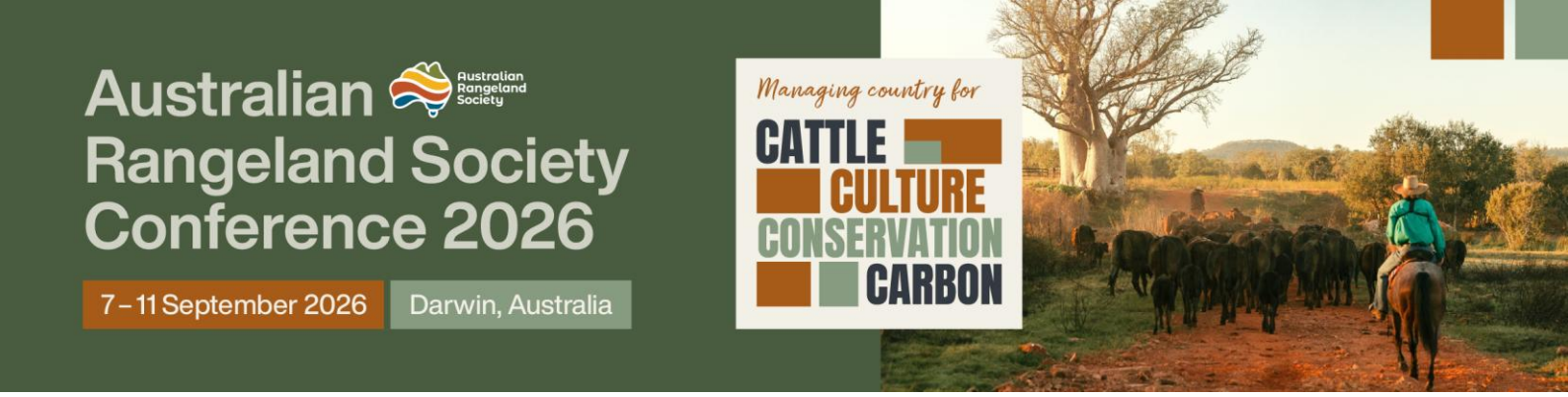
Darwin, Northern Territory

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Flexible stocking and spelling are key to managing climate variability

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Abstract
Rainfall variability is a major challenge to grazing land management in northern Australia. We present data from a long-term grazing trial near Charters Towers in Queensland comparing the performance of different stocking strategies over 27 years of highly variable rainfall. Strategies involved combinations of different stocking rates, fixed versus flexible stocking and wet season pasture spelling.

Total live weight gain (LWG)/ha was highest at heavy stocking rates, but gross margins lowest due to reduced product value and drought feeding costs. Heavy stocking was also unsustainable in the longer term. Individual LWG and product price were highest at moderate stocking rates applied with or without wet season spelling. However, all fixed stocking strategies required destocking in the 2022/23 drought because stocking rates were not aligned with declining forage supply. In contrast, long term flexible stocking was as profitable as fixed moderate stocking while avoiding the need to destock in drought years.

After 27 years, land condition as indexed by the density of 3P (palatable, perennial and productive) grasses was lowest under heavy stocking and highest under flexible stocking with spelling. This emphasises the need to adjust stocking rates with seasonal conditions and apply wet season spelling.

Over the long term, heavy stocking is a high risk, unprofitable and unsustainable strategy. Fixed, moderate stocking strategies are lower risk but will still lead to degradation if stocking rates are not reduced in dry years. Climate variability should thus be managed using flexible stocking rates in a pro-active, risk averse manner coupled with regular wet season spelling. These should be applied adaptively based on seasonal conditions and observed responses to management actions.

Introduction
Interannual variability in rainfall and forage supply is a major management challenge in northern Australia. Failure to manage for this variability has led to economic loss and shifts in land condition to other, less productive states. While grazing strategies such as stocking at long term carrying capacity or flexible stocking exist to manage for this variability, adoption of these strategies has been disappointing. This is due, in part, to a lack of data on their performance relative to more conventional management. To address this issue, we established a large grazing trial in 1997 to assess the relative performance of different strategies to manage for this variability.

Methods
The trial is on Wambiana station, 70 km south of Charters Towers, Queensland. Long term (116-year) mean annual rainfall is 643 mm (C.V.= 40%), with 70% falling in the hot summer months. The vegetation is an open Eucalyptus-Acacia savanna overlying C4 tropical grasses on kandosol, sodosol and vertosol soils. The native shrub *Carissa ovata* is also common and expanding to form dense thickets on sodosols and heavy clays.

Strategies selected for testing were heavy stocking (HSR: 4 - 5 ha/AE [animal equivalent: 1 AE=450 kg steer]), moderate stocking (MSR: 8 - 10 ha/AE), rotational wet season spelling (R/Spell: 8 - 10 ha/AE), flexible (Flex) stocking (4 - 20 ha/AE) and flexible stocking with wet season spelling (Flex+Spell). The stocking rates used were based on the advice of the trial's grazier advisory committee. Strategies were replicated twice in paddocks approximately 100 ha in size. Paddocks are grazed with Brahman steers 1.5 and 2.5 years old and managed according to industry best-practice guidelines. Cattle are weighed at the start and end of the grazing year with older steers going to the meat works (O'Reagain *et al.* 2009). Gross margins (GM) were calculated as product value less supplementation, vaccination, drought feeding and interest on livestock capital costs (O'Reagain et al. 2011). Pasture species

frequency is monitored annually with 100 quadrats (0.25 $m^{2)}$ spaced along five 100 m transects on 67 permanent, 1 ha monitoring sites using the BOTANAL procedure (Tothill et al. 1992). Here we present the density of 3P (perennial, palatable and productive) grasses, primarily *Bothriochloa ewartiana*, *Dichanthium sericeum, Eulalia aurea* and *Heteropogon contortus.* The data shown is for the sodosol soils which comprise more than half the area of all trial paddocks.

Results

Rainfall varied widely (246 - 1240 mm) over the trial period reported here (1998-2025) with two extended drought (≤ decile 3) periods. The 2014/15 season (246 mm) was the 4 th lowest rainfall year in the 116-year rainfall record for Trafalgar station, 17 km NW of the trial site. Drought feeding was required in the HSR in seven out of 27 years but only once in the other strategies (Table 1). The nominal heavy stocking rate in the HSR could only be sustained for the first eight years and thereafter had to be cut in 11 different years due to forage scarcity. The HSR treatment was destocked in 2022/23 and thereafter ceased.

Stocking rates in the R/Spell and MSR were sustained in nearly all years, but both treatments had to be destocked in 2022/23 due to the shortage of forage. Stocking rates in the two Flexible strategies varied widely with rainfall. Importantly, the progressive reduction in stocking rates with declining forage availability in preceding years ensured that these strategies could remain stocked in the 2022/23 season, albeit at very low stocking rates (20 ha/AE).

Average individual live weight gain (LWG) was lowest in the HSR, with a resultant decrease in carcass price (O'Reagain *et al.* 2022). Total LWG/ha was highest in the HSR, but gross margin lowest due to reduced product value and the high costs of drought feeding (Table 1). Note the far greater variability in production and gross margin in the HSR over time compared to the remaining strategies. The two flexible stocking strategies were as profitable as the MSR and R/Spell but importantly, the early adjustment of stocking rates as conditions declined in preceding years avoided the need to destock in 2022/23.

Table 1. Average (+/-standard error) liveweight gain (LWG) per steer, LWG per hectare (ha), gross margin (GM) per ha and the number of years (Yrs) drought feeding was needed over the trial period. The density of 3P grasses on the sodosol soils after 27 years is also shown.

Treatment	LWG/hd (kg)	LWG/ha (kg/ha)	Yrs drought feeding	GM/ha (AU$/ha)	3 P Density (Plants/m^2)
Flex	119 (+/- 8)	14.7 (+/- 1.7)	1	$12.8 (+/- 0.9)	1.3 (+/-0.2)
Flex+Spell	117 (+/- 6)	14.9 (+/- 1.5)	1	$12.8 (+/-0.8)	2.3 (+/-0.3)
HSR	98 (+/- 11)	18.5 (+/- 2.3)	7	$5.8 (+/- 3.7)	0.3 (+/-0.1)
MSR	117 (+/- 8)	13.9 (+/- 1.1)	1	$12.8 (+/-0.8)	1.0 (+/-0.2)
R/Spell	117 (+/- 8)	14.3 (+/-1.1)	1	$12.4 (+/- 0.8)	1.4 (+/-0.2)

Land condition declined to various degrees in all strategies over the trial period on the sodosol and vertosols soils (data not shown). This appears to be due to a combination of drought, particularly the extreme 2014/15 drought, and the marked expansion of *Carissa ovata* on the former soils. Nevertheless, there were strong treatment effects: after 27 years, land condition as indexed by 3P grass density on the sodosol soils, was by far the lowest in the HSR (Table 1). Amongst the other strategies, the density of 3P grasses was highest in the Flex+Spell strategy, followed by the Flex, R/Spell and the MSR.

The extremely low 3P density in the HSR reflects the cumulative effects of sustained heavy grazing compared with the moderately stocked MSR and R/Spell treatments. However, 3P densities in the MSR and R/Spell treatments were markedly lower than in the Flex+Spell, indicating that maintaining fixed stocking rates during dry years limited pasture recovery. In the MSR treatment, the absence of wet season spelling further reduced 3P density. The absence of spelling also adversely impacted 3P density in the Flexible strategy, despite the fact that stocking rates in this strategy were reduced in low rainfall years.

Discussion

The results clearly show that heavy stocking is a high risk, relatively unprofitable strategy that will significantly reduce land condition and carrying capacity. Moderate fixed stocking is far more profitable and carries lower risk, but failure to reduce stocking rates in drier years will reduce land condition and could result in forced destocking. Flexible stocking is as profitable as moderate fixed stocking, but experiences learnt over the trial period showed that numbers need to be adjusted quickly as forage availability and seasonal conditions decline (O'Reagain *et al.* 2022). Upper limits also need to be set on stocking rates in even the best seasons to avoid the legacy effects of heavy grazing prior to the inevitable return to below average seasons. Results from this trial (O'Reagain *et al.* 2022) and elsewhere e.g. (Ash *et al.* 2011) also clearly emphasise that wet season spelling is essential to maintain and improve land condition.

Conclusion

Climate variability should be managed using flexible stocking in a pro-active, risk averse manner coupled with regular wet season spelling. These should be applied adaptively based on seasonal conditions and observed responses to management actions.

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