PROCEEDINGS OF THE AUSTRALIAN RANGELAND SOCIETY

BIENNIAL CONFERENCE

Official publication of The Australian Rangeland Society

Form of Reference

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

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

For example:

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

The Australian Rangeland Society

Optimising fire management in grazed tropical savannas

Robyn Cowley[AB], Caroline Pettit[A], Trisha Cowley[A], Lester Pahl[B] and Mark Hearnden[A]
[A] NT Department of Resources, GPO Box 3000, Darwin, NT 0801
[B] Qld Department of Agriculture, Fisheries and Forestry, PO Box 102, Toowoomba, Qld 4350
[C] Corresponding author. Email: robyn.cowley@nt.gov.au

Keywords: fire management, grazing, tropical savannas

Abstract

Fire is an integral component of tropical savannas, but is often actively excluded from commercially grazed systems in northern Australia. The Kidman Springs Fire Trial (Victoria River District, NT), established in 1993, assessed the impact of fire management on woody cover and pasture condition. The trial is replicated on calcarosol and vertosol sites, with grazed experimental plots burnt early or late in the dry season, every two, four and six years, as well as unburnt controls. On calcarosols four-yearly *late* season fires were required to manage woody cover, whereas on vertosols, four-yearly *early* or *late* burns were adequate. Two-yearly fire or *early* dry season fire increased the proportion of dicots and suppressed the increase of perennial grass yield through time on the calcarosols; and on the vertosols, two-yearly or early fire increased annual grass yield but decreased total yield. Bio-economic modelling of a commercial cattle station found that implementing four-yearly fire improved animal production and enterprise profits, with late season fire providing the greatest benefits. There was an opportunity cost of implementing early season fire (as recommended for carbon and biodiversity outcomes) of $85/km^2 compared to burning later in the year.

Introduction

The incidence of fire across the more productive pastoral lands of northern Australia is low compared to conservation and indigenous land, where frequent late season fires have prompted calls to reduce fire frequency and intensity to abate emissions and improve carbon storage and biodiversity (Russell-Smith *et al.* 2003). The low fire frequency on pastoral land has been implicated in woodland thickening (Lewis 2002), and reduced pasture production and carrying capacity (Dyer and Stafford Smith 2003). This study aims to review best practice management for fire on pastoral land, in the light of the latest results from a long-term fire trial in the VRD, and the emerging carbon economy.

Methods

The study sites are located in the semi-arid tropical savannas of the Victoria River District, NT, (median rainfall 679mm) on Victoria River Research Station (VRRS). Two trial sites were established in 1993 on a calcareous red earth (calcarosol) and on grey cracking clays (vertosol). At each site eight replicated treatments varied in frequency (none, 2, 4, 6 years)

and season of burning, with an early (E) dry season burn in June and late (L) dry season burn

in October. The 16 x 2.6 ha plots per site were open to grazing by domestic cattle.

Total pasture yield, ground cover and species yield were visually estimated using Botanal; annually from 1994 to 2001, and then biennially until 2011. Canopy cover (CC) and tree basal area (TBA) were measured prior to burning in June 2009 using a bitterlich gauge.

The impact of season and frequency of burning, and pasture type on woody cover was analysed using a factorial ANOVA and Tukey's HSD test for *post hoc* comparisons. The impact of season and frequency of burning and time on total yield, ground cover and functional group yield was analysed using repeated measures ANOVA and Bonferonni test for *post hoc* comparisons.

Bio-economic modelling of the impacts of no fire, and early and late four-yearly fires on carrying capacity, animal production and property level economics were simulated for a VRD property from 1982 to 2011 using GRASP and Enterprise models (MacLeod *et al.* 2011). Tree basal area assumptions for the different scenarios were based on those observed in the field trial. In the fire scenarios one quarter of every paddock was burned every year (as is recommended by Dyer *et al.* 2001) on June 30 for early, and November 1 for late season fires. Stocking rates were selected to maintain B land condition.

Results

On the calcarosol site late season burns were required to significantly reduce CC and TBA (Figures 1 - 2). TBA was nearly 40% lower in the late and the two-yearly burnt plots compared to the unburnt controls (average 2.3 vs. 3.7 m^2/ha, Tukey's HSD test $p<0.05$ for both comparisons). Only the two and four-yearly late dry season burnt plots had lower CC than the control (Tukey's HSD test $p<0.05$, Fig. 2).

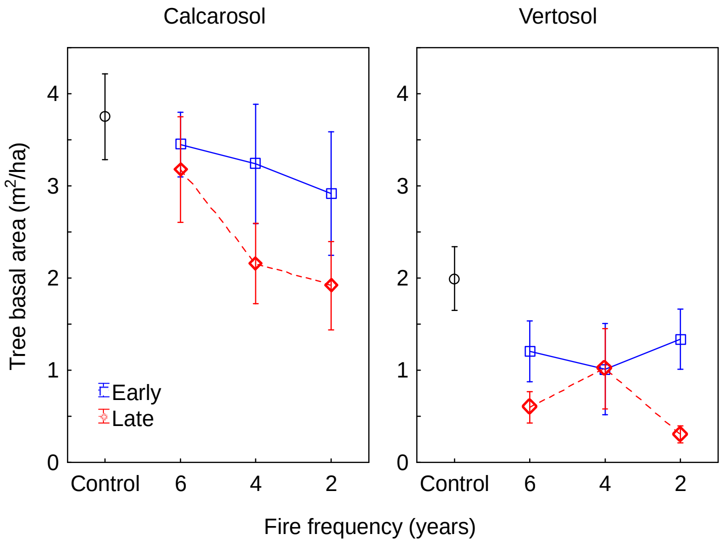

Fig. 1. Effect of fire season and frequency on TBA for calcarosol and vertosol soils on VRRS, June 2009. Mean +- standard error.

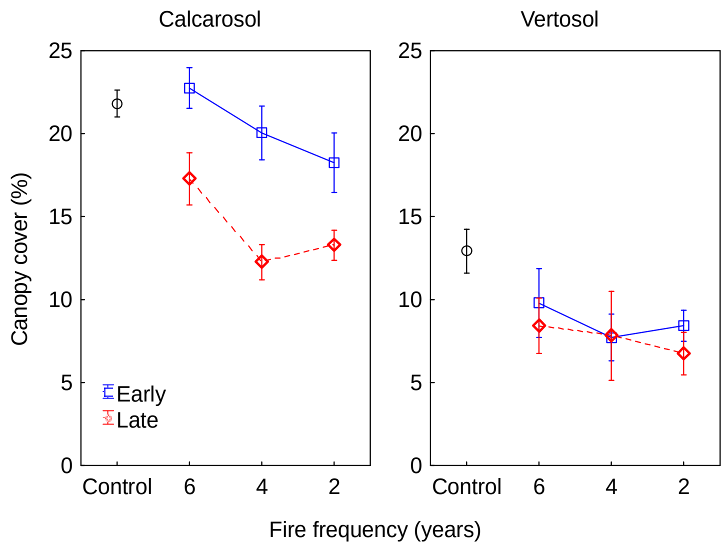

Fig. 2. Effect of fire season and frequency on CC for calcarosol and vertosol soils on VRRS, June 2009. Mean +- standard error.

On the vertosol site, TBA was significantly lower with late season fire than with no fire (Tukey's test $p<0.05$, Fig. 1) but all frequencies of fire were equally effective in reducing TBA compared to control sites. For CC, there was no significant effect of season or frequency of fire, but two and four-yearly burnt plots had lower CC than the unburnt control (Tukey's test $p<0.05$, Fig. 2).

At the calcarosol site pasture yield was higher on the unburnt control than all the burnt sites (average 1892 vs. 1622-1677kg/ha for burnt sites, $F_{3,56}=3.72$, $p=0.02$), but there was no effect of season of fire.

At the vertosol site, pasture yield was significantly lower in two-year burn plots than the unburnt control (average all years 2071 vs. 2380kg/ha, $F_{3,56}=3.24$, $p=0.03$) and early burnt plots had significantly lower pasture yield than late burnt (average 2162 vs. 2356kg/ha, $F_{1,56}=6.38$, $p=0.01$).

Ground cover did not vary significantly between any fire and control plots at the vertosol or calcarosol sites.

On the calcarosol site early and 2-yearly burns resulted a higher proportion of dicots (17% for early burns, 19% for 2-year burns, vs. 10% for controls, Bonferonni test $p<0.05$), and a smaller increase in perennial grass through time (year by season $F_{12,672}=3.62$, $p<0.001$ and year by frequency $F_{36,672}=2.56$, $p<0.0001$). Annual grass yield increased more through time with more frequent fire (year by frequency $F_{36,672}=4.57$, $p<0.0001$).

On the vertosol site annual grass yield was 28% higher on early than late-burnt and unburnt controls, and 74% higher on 2-yearly burnt, than 4 and 6-yearly burnt or unburnt controls (Bonferonni test $p<0.05$).

Bio-economic modelling indicated that carrying capacity of the early burn scenario was not much higher than the no burn scenario (Table 1), because although growth was higher, stocking rates had to be reduced following early season fire until the next rains so that remaining pastures were not overgrazed. However, the better growth in the early burn scenario resulted in higher animal production on a per head and area basis, which led to 28% higher profits than the no fire scenario. Late fire was the best scenario for most indicators because it had the lowest TBA and highest growth. Also, there was only 2 months between burning and the next rains, hence stocking rates did not need to be reduced as much as for the early burns to prevent overgrazing (Table 1). However, the number of years fire was able to be implemented was lower for late season fires (66 vs. 77 % of years) due to lower fuel loads later in the year. Adding early and late season fire increased the gross margin per square kilometre by $37 and $122 respectively above that of the unburnt scenario.

Table 1. Simulated model impacts of different burn scenarios for a VRD case study property 1982-2011. Average of all paddocks and years (weighted for paddock size).

Scenario	TBA (m^2/ha)	Pasture growth **(**kg/ha**)**	Stocking rate (AE/km^2)	LWG (kg/hd/yr)	LWG (kg/ha/yr)	Average annual profit	No. years with a loss
No fire	3.7	1200	5.1	96	4.8	$647,737	6
Early burn	2.8	1253	5.2	107	5.4	$828,234	6
Late burn	1.9	1530	6.2	112	6.7	$1,174,405	4

Discussion

Only four-yearly *late* season fire effectively reduced woody cover on red soil, but on vertosols both early and late four-yearly fires were adequate. Two-yearly fires should be avoided unless required to promote rapid change in woody cover, because of the deleterious effects on pasture condition and the higher emissions. The poorer pasture condition of early season burnt sites may be due to cattle preferentially grazing burnt patches for the six months until the next rains. Stock may need to be completely removed from early burnt paddocks to prevent land condition decline, which would further increase the costs of implementation.

While *early* season fire is recommended to reduce emissions and impacts on biodiversity (e.g. Russell Smith *et al.* 2003), it promoted pasture decline in this commercially grazed environment. *Late* season fires may be better for tree cover management (on red soils), pasture condition, animal production and enterprise profits. Early season fire resulted in longer periods of reduced forage for stock, and required a greater decrease in stocking rate to implement without causing land condition decline, compared to late season fire. However, implementing late season fires is not without its hazards as they are more difficult to manage and are more likely to escape planned burn zones and destroy property infrastructure. They are also less likely to be implemented due to lower fuel loads later in the year, unless stocking rates are adjusted to achieve fuel load requirements.

On pastoral land there are obvious trade-offs between production and emissions management, which we can now cost. Although early season fires are promoted to maximise biodiversity and emissions abatement, modelling suggests implementation of property wide early fire can have a large opportunity cost (in this scenario it was \$85/km², or \$346,171 per annum) compared to late fires.

References

Dyer, R., Russell-Smith, J., Grice, T. McGuffog, T., Cooke, P., and Yibarbuk, D. (2001). Using fire to manage savanna. *In*: 'Savanna Burning: understanding and using fire in northern Australia'. (Eds R. Dyer, P. Jacklyn, I. Partridge, J. Russell-Smith and R.J. Williams.) pp. 50-80. (Tropical Savannas CRC, Darwin.)

Dyer, R., and M. Stafford Smith (2003). Ecological and economic assessment of prescribed burning impacts in semi-arid pastoral lands of northern Australia. *International Journal of Wildland Fire* **12**, 403-413.

Lewis, D. (2002). 'Slower than the eye can see: environmental change in northern Australia's cattle lands. A case study from the Victoria River District, Northern Territory'. (Tropical Savannas CRC: Darwin.)

MacLeod, N.D., Scanlan, J.C., Whish, G.L., Pahl, L.I., and Cowley, R.A. (2011). Application of bio-economic simulation models for addressing land management issues for northern Australia. *In*: 'MODSIM2011, 19th International Congress on Modelling and Simulation. Modelling and Simulation Society of Australia and New Zealand, December 2011'. (Eds F. Chan, D. Marinova and R.S. Anderssen.) pp. 801-807. (www.mssanz.org.au/modsim2011/B1/macleod.pdf)

Russell-Smith, J., Yates, C., Edwards, A., Allan, G.E., Cook, G.D., Cooke, P., Heath, B., and Smith, R. (2003). Contemporary fire regimes of northern Australia, 1997-2001: change since Aboriginal occupancy, challenges for sustainable management. *International Journal of Wildland Fire* **12**, 283-297.