TITLE:

Winter Hazard Reduction Burning Reduces the Fuel Load in *Themeda* and *Phalaris* during Summer

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Abstract

Hazard-reduction burning is an important component of the bushfire mitigation program in the Australian Capital Territory (ACT). Burning is particularly important in grass fuels at locations that are unsuitable for slashing/mowing or grazing. Ideally grass fuels are burnt in spring however this work is constrained by weather, resource availability and ecological considerations. It would therefore be helpful if the burning season could begin on sunny winter days when grass fuels are well cured.

Previous work conducted during a high rainfall year found that winter burning reduced the fuel load and increased fuel moisture content in treated *Phalaris* fuels compared to untreated fuels. However treated fuels did not comply with ACT fuel management standards because by summer the grass was too high. In this study we expand on that work by:

1) testing across a broader geographic area;
2) testing under different rainfall conditions; and
3) including warm-season *Themeda*-dominated native grasses in the study.

We conducted a Before-After-Control-Impact study in a *Phalaris*-dominated site on the Canberra urban-rural interface and in one large native grass reserve within the Canberra urban area. Fuel load, grass cover and grass height were assessed before burning. Hazard reduction burns were completed in late winter (*Phalaris*) and early spring (*Themeda*) leaving control sectors unburnt for later comparison. All plots were re-measured in February 2013.

The fuel load in treated *Phalaris* and *Themeda* grassland was lower than in the untreated grassland in summer following fire. In addition, the treated plots were within ACT fuel management standards. Our results suggest that winter burning has good potential as a grass fuel management tool in the ACT.

Introduction

Fuel management is an important component of the bushfire mitigation program in the Australian Capital Territory (ACT Government, 2009). Fuel management standards are defined for each bushfire management zone and are implemented by slashing/mowing, grazing, physical removal, chemical treatment and burning. The choice of method is determined according to the suitability of the method at each location, cost, ecological considerations and time-of-year.

The City of Canberra was constructed in a landscape dominated by grassy fuels – Yellow Box (*Eucalyptus melliodora*)-Blakely's Red Gum (*Eucalyptus blakelyi*) Grassy Woodland (Gellie, 2005). Grassy woodland, grassland and pasture surround the city and management of these fuels is a critical component of the bushfire management program.

Six bushfire management zones are defined by the Strategic Bushfire Management Plan and of these three have associated fuel management standards (Table 1; ACT Government, 2009). These are:

1) Inner Asset Protection Zone (IAPZ): strips of land adjacent to vulnerable assets in which fuel is reduced and which provide defensible space.
2) Outer Asset Protection Zone (OAPZ): strips of land adjacent to IAPZs in which fuel is reduced.
3) Strategic Fire Management Zones (SFAZ): corridors of reduced fuel positioned to break up major fire runs.

Table 1. Bushfire management zones in the ACT and the relevant grass fuel standards. Grassland fire hazard (GFH) is determined by multiplying the grass height (m) by percentage grass cover.

Bushfire Zone	Grassland fuel standard
IAPZ	Grassland maintained at >200mm height when grassland curing ≤70%
OAPZ	Grassland fire hazard ≤35 when grassland curing ≤70%
SFAZ	Grassland fire hazard ≤50 when grassland curing ≤70%

Grass fuel in IAPZs is typically managed by slashing and ideally this will occur just at the moment that curing reaches 70%. In OAPZs and SFAZs, fuel treatment is typically by grazing, but where this is not possible or has failed to achieve the standard, burning may be employed.

Grass accumulates more quickly than other fuel types such as fine surface litter, elevated fuels and bark (Tolhurst and Kelly, 2003). Ideally, from a fuel management perspective, grass would be burnt in the spring allowing as little time for accumulation as possible. However in the ACT, spring burning work is constrained for several reasons.

1) Spring weather is wetter and windier than the rest of year (Bureau of Meteorology, 2013).
2) The ACT ecological guidelines are more restrictive in spring than other times of year (Kitchin and Matthews, 2012).
3) The seasonal fire crew program is designed to ensure that staff are available for the summer fire season so recruitment and training usually occurs in spring.

Overall, the total number of burning days available to fire managers in the ACT is relatively small, averaging 60 days per year (ACT Government, 2009). The months with most burning days are May, June and July, so it would be helpful to determine whether burns conducted during these months could deliver a fire mitigation benefit the following summer.

Previous work conducted during a high rainfall year (2011-2012) found that winter burning reduced the fuel load (5.8 ± 1.2 tha^{-1} versus 11.4 ± 3.5 tha^{-1}) and increased fuel moisture content (133% versus 93%) in treated *Phalaris* fuels compared to untreated fuels (Leavesley *et al*. 2012). However treated fuels did not comply with ACT fuel management standards because by summer the grass was too tall (Height: 0.70m ± 0.20 SD; Grass Fuel Hazard: 57 ± 15 SD). In this study we expanded on that work by:

1) testing a greater number of plots across a broader geographic area;
2) testing under different rainfall conditions - spring rainfall in 2011 was 173mm compared with 132mm in 2012; and
3) including warm-season *Themeda*-dominated native grasses in the study as a comparison.

Method

We conducted a Before-After-Control-Impact study (Green, 1979) at two sites with contrasting grass communities. One site consisted of four *Phalaris*-dominated paddocks on the urban-rural interface in the suburb of Fraser, Canberra (Figure 1, 2).

Figure 1.
The burn map for the hazard reduction burn on the urban-rural interface at Fraser. The grass species was *Phalaris* spp. The sectors were prepared for burning by slashing between them.

Figure 2.
Dense *Phalaris* dominated grassland at Fraser on 23 July 2012 prior to the burn. Fuel loads were measured at $9.1 t ha^{-1}$.

The other site was located in Mulanggari Grassland, a large natural temperate grassland reserve within the Canberra urban area (Figure 3, 4).

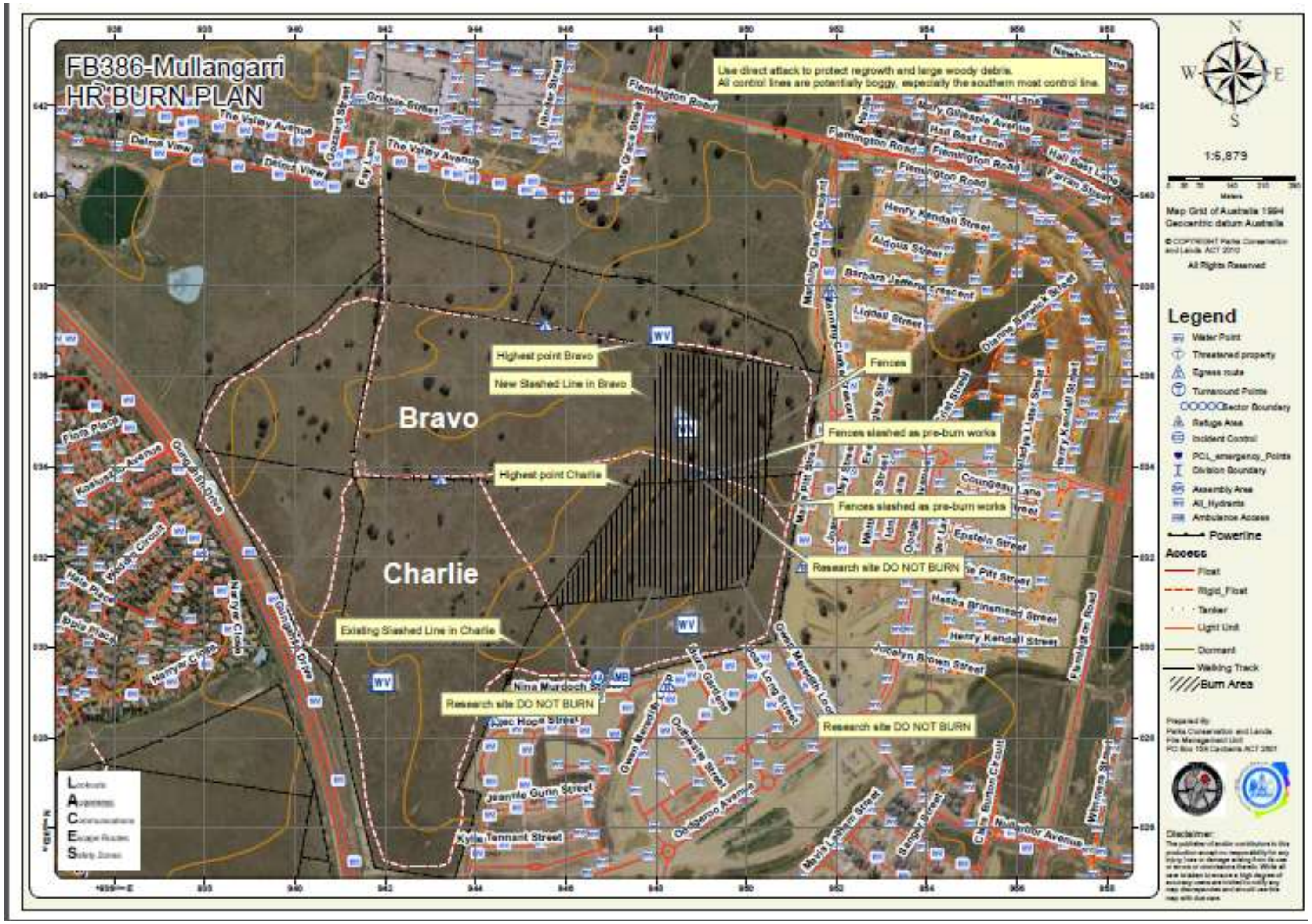

Figure 3.
The burn map for the hazard reduction burn at Mullangarri Grasslands, part of Canberra Nature Park, within the Canberra urban area. The dominant grass species was Kangaroo Grass (*Themeda triandra*), though Charlie sector also had a lot of Wallaby Grass (e.g. *Austrodanthonia* spp.) and Spear Grass (e.g. *Austrostipa* spp.).

Figure 4.
Dense *Themeda triandra* grassland on 23 July 2012 at Mulanggari Grassland Nature Reserve prior to the burn. Fuel loads were measured at 7.0tha^{-1} – 10.2tha^{-1}.

Mulanggari Grassland is dominated by Kangaroo Grass (*Themeda triandra*) but also has Wallaby Grass (e.g. *Austrodanthonia* spp.) and Spear Grass (e.g. *Austrostipa* spp.). Control plots were approximately 2500m^2 in size and located directly adjacent to the treated areas to minimise variation between them. At Fraser the control and treatments plots were established directly either side of the slashed control lines on similar slopes. Potentially confounding factors such as trees and the edges of the control lines were avoided. The maximum distance between pairs of treatments and controls was approximately 40m. At Mulanggari, the controls were established by slashing a control line within the planned burn area. The controls were located on the edges of the burn to minimise:

1) the risk of escape; and
2) the length of burn edge requiring a wet line.

Fuel load, grass cover and grass height were assessed at all plots before and after burning. Fuel load was determined by removing the fuel from five 1m^2 quadrats from each replicate. The fuel was dried at 105°C for 24 hours to obtain the oven-dried weight (Matthews, 2010). Grass cover and height were estimated from a plot of 3m radius around the fuel sample using a 1m ruler and a fuel cover guide (Hines *et al*. 2010). Grass cover and height were used to produce a Grassland Fire Hazard index (GFH; ACT Government, 2009). Hazard reduction burns were completed in late winter (*Phalaris*; Figure 5, 6, 7) and early spring (*Themeda*; Figure 8, 9) leaving control sectors unburnt for later comparison. Crews conducting the burns were briefed on the need to avoid disturbing the experimental areas. Use of fire retardant foam was not permitted. Fuel load, grass height and grass cover was re-measured in the treated and control plots in February 2013.

Assumptions of normality for data were tested using a Kolgomorov-Smirnov test. All variables were normally distributed: fuel load ($Z = 0.9$, $p = 0.4$), grass height ($Z = 1.2$, $p = 0.1$); grass cover ($Z = 1.2$, $p = 0.1$) and were analysed using a single factor ANOVA ($\alpha = 0.05$). Analyses were conducted using SPSS 19 (IBM Corp., 2010).

Figure 5.
Hazard reduction burn in *Phalaris* dominated grassland at Fraser conducted on 22 August 2012.

Figure 6.
Unburnt fuel quadrat ($1m^2$) after the burn in *Phalaris* dominated grassland at Fraser. Five quadrats were taken from each replicate to determine the fuel load. All fuel was removed from the quadrat and dried at 105°C for 24 hours to determine the oven-dried weight.

Figure 7.
Residue and re-growth of *Phalaris* dominated grassland at Fraser on 28 September 2012, 37 days after the burn.

Figure 8.
Burning the natural temperate grassland at Mulanggari Nature Reserve on 3 September 2012.

Figure 9.
Mulanggari Grasslands on 2 October, 30 days after the burn. A control plot is in the centre of the picture. The control plots were protected by slashing around them and running a wet line during the burn.

Results

In February 2013, the fuel loads in treated *Phalaris* and *Themeda* grassland were lower than in the untreated grassland (*Phalaris*: $F = 57.6$, $df = 7$, $p < 0.001$; *Themeda*: $F = 34.5$, $df = 5$, $p < 0.001$; Figure 10). Grass height (*Phalaris*: $F = 43.9$, $df = 7$, $p < 0.001$; *Themeda*: $F = 21.9$, $df = 5$, $p < 0.001$; Figure 11) and GFH (*Phalaris*: $F = 57.7$, $df = 7$, $p < 0.001$; *Themeda*: $F = 26.3$, $df = 5$, $p < 0.001$; Figure 12) were also lower.

The treated grassland in both fuel types was within ACT fuel management standards (ACT Government, 2009).

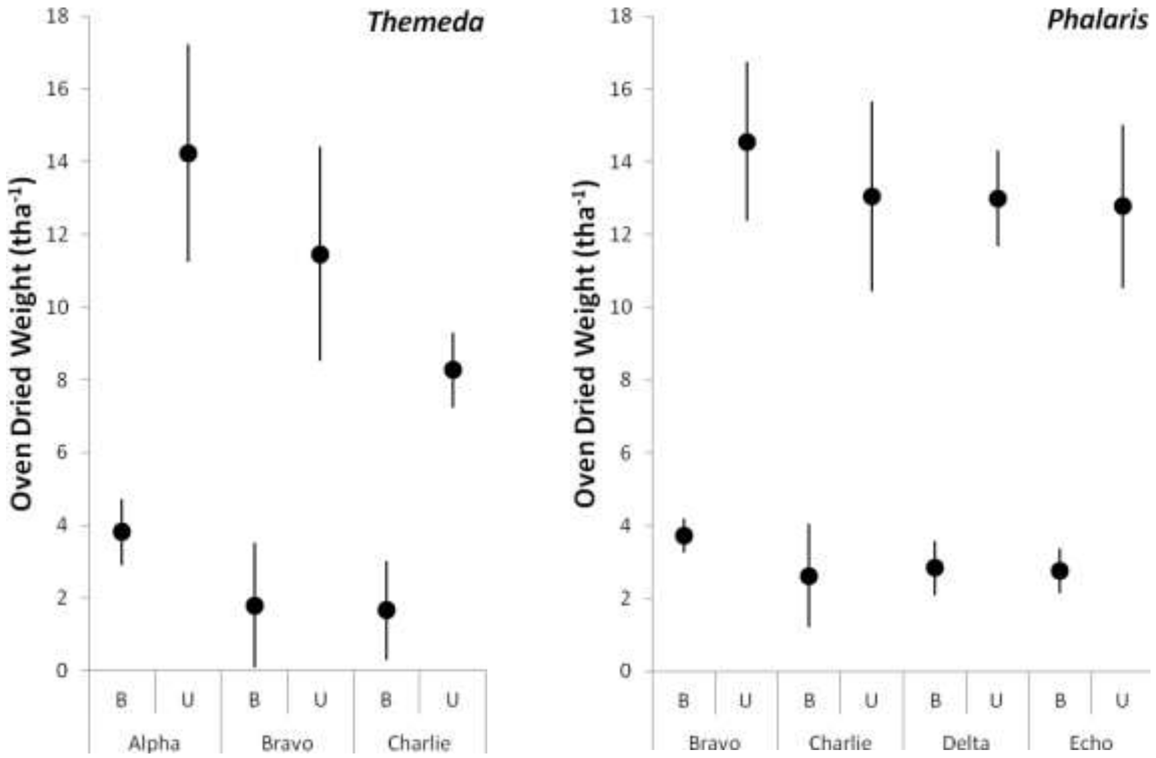

Figure 10. Fuel loads measured in February 2013 in treated and untreated grass plots. Error bars indicate the standard deviation.

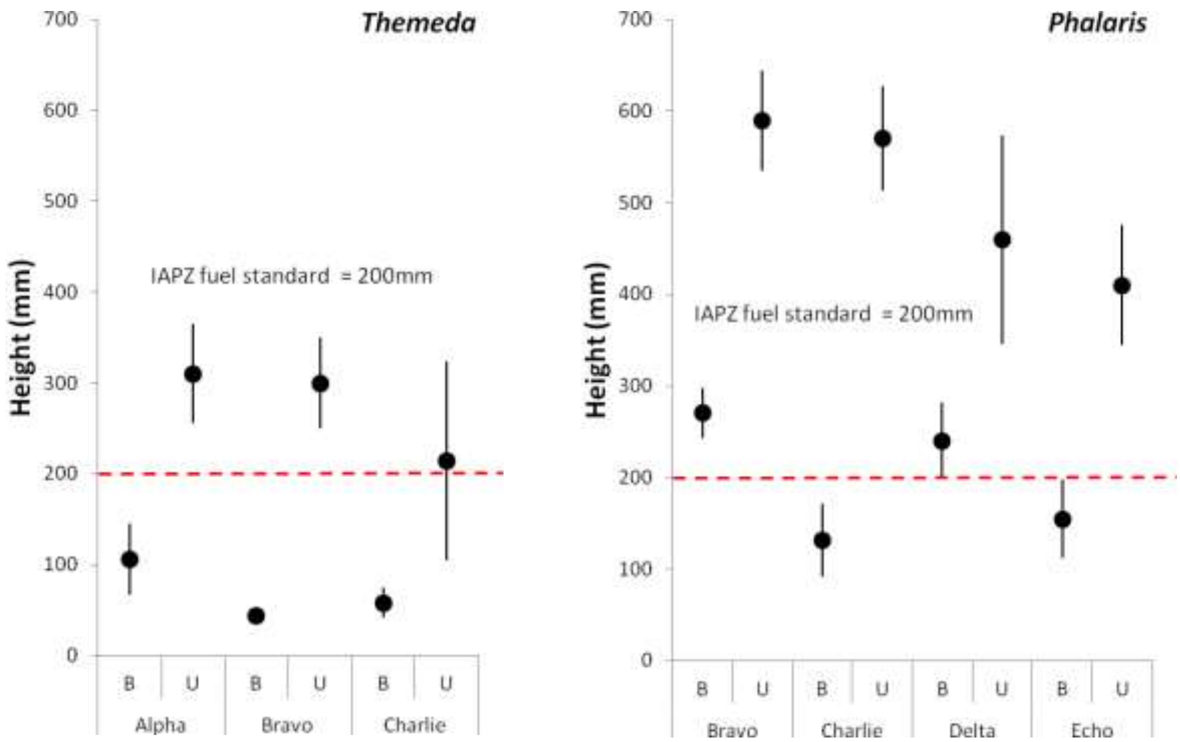

Figure 11. Height of grass measured in February 2013 in treated and untreated grass plots. Error bars indicate the standard deviation.

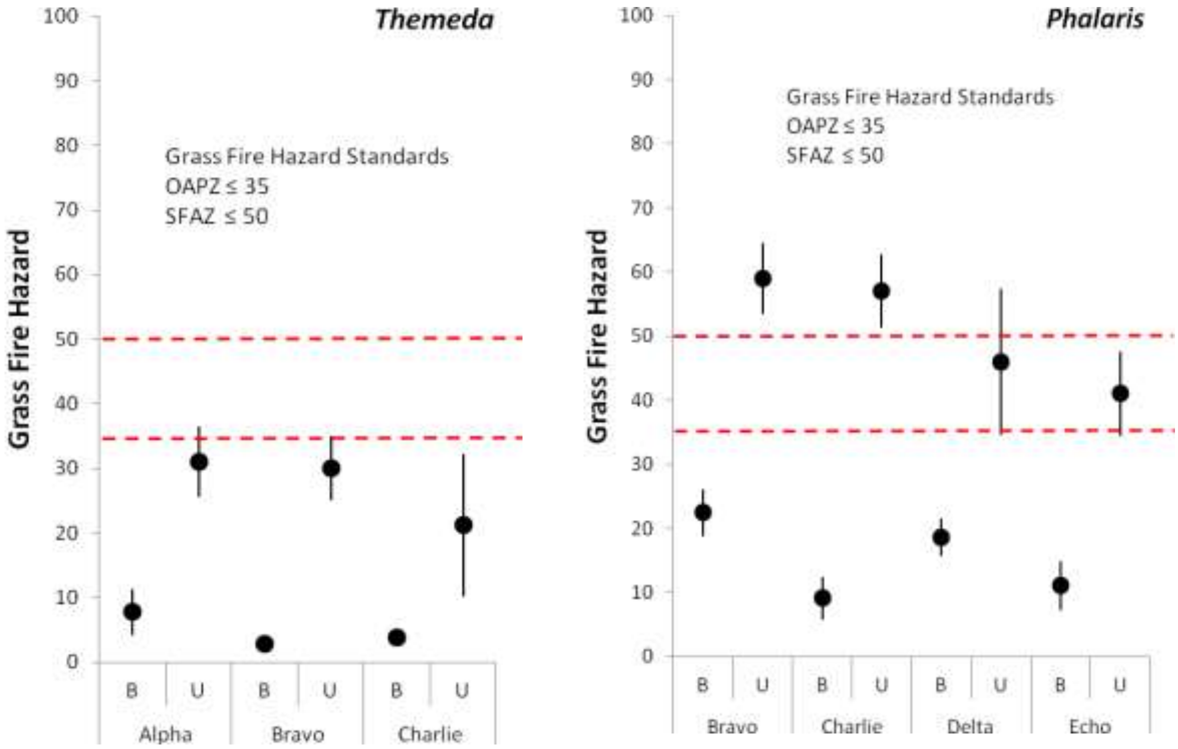

Figure 12. Grassland fire hazard measured in February 2013 in treated and untreated grass plots. Error bars indicate the standard deviation.

Discussion

Themeda grassland burnt in early spring 2012 met the ACT fuel management standard for all zones (ACT Government, 2009). In contrast, the grassland dominated by *Phalaris* grassland marginally failed the IAPZ standard, but met the OAPZ and SFAZ standards. It therefore appears that there is considerable potential for the use of early-spring and winter burning as a grass fuel management tool for *Themeda* and *Phalaris* dominated grasslands in the ACT.

The effect of burning is generally mediated by rainfall (King *et al*. 2012). *Themeda* dominated grasslands are considered to be ‘warm season’ and most productive in summer. Spring rain is therefore less likely to alter fuel loads until later in the fire season. In contrast, *Phalaris* dominated grassland is most productive in spring (Leavesley *et al*. 2012), so it is likely to be more sensitive to spring rainfall than *Themeda* dominated grassland. Previous work conducted in spring of 2011 in the ACT showed that *Phalaris* has the capacity to exceed fuel management standards in IAPZs and OAPZs in a single high rainfall spring (Leavesley *et al*. 2012). Potential reasons for the differential result in this study include different productivity between the sites, annual variation between years and longer period of re-growth in the 2011 study – in that study the grass was burnt in an unplanned fire in June.

Neither the *Themeda* or *Phalaris* dominated grasslands had been treated during the previous two years of above average rainfall. In both instances, the fuel loads were heavy prior to treatment but much reduced afterwards. This suggests that even in instances where burning may not deliver the required fuel management standard, it will still reduce the intensity and rate of spread of unplanned fires (Sullivan, 2010). This effect will aid fire suppression and is therefore still likely to be of benefit to bushfire management.

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