Changes in vegetation condition in four sites in the ACT region following the application of traditional cool burns

Report to Molonglo Conservation Group

February 2022

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ACKNOWLEDGEMENTS

Many thanks to the landowners and managers that made it possible to provide access in order to undertake monitoring on their land.

I acknowledge the traditional landowners past and present and the role that they continue to play in maintaining a diverse and resilient natural landscape. My hope is that the understanding of our natural heritage will be strengthened and enriched by enhancing implementation of traditional land practices as well as through further respect for cultural practices.

Photos front page: Bullan Mura insert: prior to the burn; Bullan Mura main: two years after the burn.

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ABSTRACT

Cool burns using traditional indigenous practices were undertaken in autumn 2018 under the direction of Ngunnawal elder, Wally Bell, coordinated by Molonglo Conservation Group. The burns were carried out in four locations in the ACT and region. The aim was to ascertain whether changes to vegetation condition could be identified that correlated with the burns. To assist with interpreting the changes to vegetation monitoring was undertaken in each site, within a plot within the burnt area and a plot outside the burnt area. This report provides the results of the quantitative monitoring undertaken at the four plots.

The plots were monitored up to four times, once in each plot before the burn took place and up to three times afterwards, between autumn 2018 and spring 2020.

Three sites were within Yellow Box – Blakely's Red Gum grassy woodland and one within Brittle Gum *Eucalyptus mannifera* dominated shrubby woodland. Three have previously been or are still grazed by domestic stock and one is within urban ACT. Vegetation condition prior to the burns varied between the sites. In the first two years of the study the sites were subject to severe drought conditions, which were then followed in the final year of monitoring by higher than average rainfall.

The results indicated that the vegetation within each site responded differently to the burns. In the plots with lower herbage mass the burns were more patchy and lighter. The background factors influencing the results were likely to have had overriding influences on the vegetation recovery from the fire. Two of the burnt plots had a positive response in the form of a relatively higher increase in native species diversity in the first spring after the burns (at Wandiyali and Bullan Mura), one of which (Bullan Mura) demonstrated an improved diversity after more than two years. One demonstrated no differences to the unburnt plot (Icon Water) and in the other (Millpost property), the sub-shrubs were burnt and recovered slowly and only partially a year after the burn was undertaken.

Cool burns are designed to have a low short-term impact, without causing a high increase in exposed bare ground. Low burns at more frequent intervals have been shown to increase native species, but it is likely that in sites that have a high introduced annual species load, these species are also likely to respond positively to burning. Given the variability in the sites and in weather conditions no overall conclusions can be drawn, except that the data demonstrated that no deleterious effects on vegetation condition were evident as a result of the burns in the grass dominated sites, although burning plus the drought may have caused some deleterious effects on sub-shrubs in the shrubby woodland in the short to medium term.

1. INTRODUCTION

The trial of the cultural burns was an expansion of a workshop initially funded by the Foundation for National Parks and Wildlife through their Private Land Conservation Grant 2015 program. The burns workshops would provide training for Land For Wildlife members about improving wildlife habitat through bush regeneration. Molonglo Conservation Group collaborated closely with Buru Ngunawal Aboriginal Corporation to provide a local cultural perspective on improving habitat values using bush regeneration.

The cool burns using traditional indigenous practices were undertaken in autumn 2018 under the direction of Ngunnawal elder, Wally Bell, coordinated by Molonglo Conservation Group. The aim was to ascertain whether changes to vegetation condition could be identified that correlated with the burns. To assist with interpreting the changes to vegetation quantitative monitoring was undertaken in each site, within a plot within the burnt area and a plot outside the burnt area in similar habitat. This report provides the results of the quantitative monitoring undertaken at the four plots.

Three sites were situated in Yellow Box – Blakely's Red Gum grassy woodland at Bullan Mura Woodland, Yarralumla (Figure B1), Icon Water Offset Site Williamsdale (Figure I1) and Wandiyali Conservation Reserve Googong (Figure W1) and one was within Dry Shrubby Woodland dominated by Brittle Gum (*Eucalyptus mannifera*) at Millpost property near Bungendore (Figure M1).

The monitoring study design was based on the Vegwatch Community Science Monitoring Program (Sharp and Gould 2014). A comprehensive review of the Vegwatch monitoring program undertaken in 2019/20 was used to further define the most useful and accurate condition indices (Sharp 2020) to use to describe change in condition.

2. AIMS

The burn project aimed to increase understanding of the ecological outcomes of cool burns applying traditional burning practices and explore what contemporary fire management can learn from traditional fire management. The cool burn project has both ecological restoration and reconciliation outcomes.

3. METHODS

Plot establishment

The area to be burnt had been pre-defined prior to survey. Plots 0.04 hectares in size were established within the burn zones, in a representative location. As close as possible to the burnt area, plots with similar vegetation and in similar condition were established outside the burn zone where they would remain unburnt as a comparison (a control). In the case of Millpost this was not established until after the burn had occurred, and in Bullan Mura there wasn't an area similar in condition at the site, so a nearby area in which monitoring has been undertaken since 2014 was used as a control.

Each plot was marked permanently with plastic surveyor pegs in each corner and locational information including GPS was recorded, so that the same area was monitored on each occasion. The sites generally and the plots more specifically were described prior to the burn.

Photomonitoring points were established in the north-western corner of the plot, taken diagonally across the plot.

Plot surveys

As the sites were surveyed prior to the burns in early autumn 2018, repeat surveys were undertaken in spring 2018, autumn 2019 and spring 2020 (Table 1). Not all plots were able to be surveyed each time.

Table 1. Dates of surveys in the plots.

Site	Plots	Pre-burn	Post-burn		
Bullan Mura woodland, Yarralumla	Burnt	1/2/2018	31/10/2018	20/3/2019	11/11/2020
	Unburnt	14/11/2017	31/10/2018		13/10/2020
Icon Water Woodland, Williamsdale	Burnt and unburnt	4/4/2018	23/10/2018	27/3/2019	
Millpost property, Bungendore	Burnt	16/3/2018	19/10/2018	19/3/2019	
	Unburnt		19/10/2018	19/3/2019	
Wandiyali Conservation Area, Googong	Burnt and unburnt	28/3/2018	18/10/2018		27/10/2020

The data collected and methods used to collect the data at each survey were consistent with other monitoring programs (Sharp and Gould 2014; Brawata et al., 2017; ACT Government 2018).

1. Data recorded to describe the characteristics of the plot and the site were recorded at the initial survey:
    - Overstorey and midstorey species presence;
    - Regenerative status of overstorey and midstorey species;
    - Overstorey cover and midstorey cover;
    - Length of fallen timber within the plot;
    - Number of trees with hollows or diameter over 50 cm
2. Plant survey : within each plot each species located with careful inspection was recorded as present and an estimated abundance class allocated: Abundant (greater than 75% cover); Common (26-75% cover); Occasional: less than 25% cover; Rare: less than 1% cover and less than 4 specimens present.
3. Groundcover: along a point-line transect at 80 points at one m intervals around the boundary of the plot a 0.3 mm wire was placed on the ground and whichever species of the above groups touched the wire up to 0.5 m above ground were tallied as present. If multiple groups were touching the pointer each group was recorded; if several species within the one group were touching, that group was only recorded once. As multiple attributes may be recorded at each point, understorey cover could be over 100%, reflecting the complexity and density of the understorey.

    The understorey cover attributes were classified as:
    - Cryptogams on bare ground (mosses, lichens, fungi);
    - Bare ground (including algae);
    - Litter/dead vegetation (if detached from live plants);
    - Rocks or stones (greater than 2 cm in diameter);
    - Native grasses;
    - Native sub-shrubs (less than 1 m tall);
    - Other native groundcover (forbs, sedges, lilies etc);
    - Annual introduced grasses and forbs; and
    - Perennial introduced grasses and forbs.
4. To assist interpretation of the data, photos were taken at the NW corner of each plot at each survey period. Photos from Autumn 2019 are not available, however.

Calculation of condition scores

The data were entered into the Vegwatch database held by Molonglo Conservation Group. The database outputs cumulative species lists and summary data.

These attributes were then used to calculate the measures of condition that were likely to be influenced by the burns. Some of these condition indices utilise several of the attribute values to calculate an overall score. Others utilise the raw data (summarised in Table 2). As Sharp (2020) demonstrated that introduced species and native species values (cover and abundance) are not correlated (Sharp 2020), both native and introduced species condition scores were calculated for each site. Further explanations on calculation of particular scores is provided below.

Table 2. The condition indices and the data used to calculate the condition indices.

Condition indicators	Data	Reference for condition assessment
Native species richness	Species richness (0.4 plot)	Gibbons et al. (2008)
Important species (Box-Gum Grassy woodland) richness		Department of the Environment and Heritage (2006)
Non-grass understorey native species richness		Department of the Environment and Heritage (2006)
Introduced species richness		Inverse condition: Sharp (2020); Department of the Environment and Heritage (2006)
Threatened community status		Department of the Environment and Heritage (2006)
Native vegetation cover	Vegetation percentage cover in the understorey (to 0.05 m) (transect)	Gibbons et al. 2008
Native non-grass cover		Gibbons et al. 20082)
Proportion of native vegetation cover		Department of the Environment and Heritage (2006)
Introduced annual species cover		Sharp and Gould 2014
Introduced perennial species cover		Sharp and Gould 2014

Classification of a remnant as White Box - Yellow Box – Blakely's Red Gum grassy woodland or derived grassland

To meet the criteria as the listed critically endangered community, the patch measured in 'typical' 0.04 ha plots need to have:

a) A predominantly native understorey (calculated as the proportion of native species cover compared to the total cover of native species cover and perennial introduced cover);
b) Twelve or more native non-grass native species present; and
c) At least one important species (Department of the Environment and Heritage 2006).

The number of non-grass native species present and the number of 'important' species present within the plots were identified from the surveys. This then allowed for the identification of whether the patch (plot) met the criteria as a remnant of the community.

Calculation of condition trend

Condition trend is calculated based on how condition changes over time. These are indicated in Table 3, together with the symbols used to represent the trend (ACT Government 2018).

Table 3. Condition trends and symbols used to represent the condition trend

Trend	Trend	Symbol
Improving	Condition indicator is improving	↑
Stable	Condition indicator is stable	←→
Declining	Condition indicator is declining	↓

Comparing changes in condition between the sites and burnt and unburnt plots

Weather conditions over the period of the study varied significantly. In the year of the burn the conditions were dry but became extremely dry the following year. In 2020 seasonal conditions were very moist, well above average. In each year the seasonal conditions influence the soil moisture and therefore growing conditions. In addition, the initial condition of the four sites were variable, and the shrubby site was also likely to respond differently to the grass dominated sites.

Results therefore varied considerably between the sites and over the period of the monitoring. To reduce the influences of the variability between sites and seasons, the change in the condition indicators was calculated as the change over time proportional to the values of the indicators at each of the plots prior to when the burn was applied.

4. RESULTS

The characteristics of the plots that were burnt are summarised in Table 4. At the time of the burn all the sites differed in key characteristics: past disturbance and management, current management, biomass and vegetation structure. Burn intensity and patchiness also varied between the sites. These differences undoubtedly influenced the results. In all but Bullan Mura the control plots were very similar prior to the burn as the burnt plots. No area of similar vegetation occurred in the nearby area, so a plot of higher condition was surveyed.

Table 4. Characteristics of the plots that were burnt.

Sites	Vegetation structure	Past use or disturbance	Current management	Biomass	Burn intensity and patchiness
Bullan Mura	Grassy woodland	Dumping	None	Moderate	Moderate, most of area burnt
Icon Water	Grassy woodland	Grazing	Weed control	Very low	Very low, most of area burnt
Millpost	Shrubby woodland	Grazing	Grazing	Low	Low, patchy
Wandiyali	Grassland (derived)	Grazing	Weed control	Low	Moderate, most of area burnt

The data used to assess condition before and after the burns at the four sites are presented in Table 5. At Bullan Mura, in the two years following the burn, native species richness, especially of the non-grass understorey species (small shrubs, forbs, sedges and rushes), increased. The increase was proportionally higher in the burnt plot than in the unburnt plot. Introduced species richness also increased after the burn in relation to the unburnt plot. Following the burn the criteria were met that identified the plot as containing a remnant of the critically endangered Yellow Box – Blakely's Red Gum Grassy Woodland.

The burn undertaken at Icon Water was very cool, with very little litter or herbage mass to burn. After six months there was a slight increase in native species richness and cover but after twelve months there was no differences observed between the burnt and unburnt plots. Any differences over time within and between the plots was more likely influenced by seasonal conditions than the burn.

The burn at Millpost property caused significant scorching to the sub-shrubs. Over the year following the burn, some of the sub-shrubs died, while the majority were recovering, albeit slowly. There was little change in the vegetation condition of the plot overall, given that the condition of the unburnt plot after 12 months had similar species richness and cover. It is likely the drought conditions played a strong role in the slow recovery of the sub-shrubs.

In the Wandiyali plots, after an initial increase in native and introduced species richness six months after the burn, there was little evidence of longer-term responses to the burn, given the burnt and unburnt plots had similar levels of native and introduced cover and species richness after 12 months and again after a further 18 months.

Table 5. The condition indices and the data used from each site, used to calculate the condition indices. The proportion of native understorey cover, number of important species and number of non-grass species in a plot are used to determine whether a site meets the criteria as critically endangered Yellow Box – Blakely's Red Gum Grassy Woodland.

Condition indicators	Reference condition	BGW CEEC	Native species richness	No. important species	No. native non-grass understorey species*	Proportion of native understorey cover	Native understorey cover	Native non-grass cover	Introduced species richness	Invasive species richness	Introduced perennial species cover	Introduced annual species cover
Bullan Mura Burnt												
1/2/2018	48%	No	17	3	7	67%	31%	2%	17	6	15%	2%
31/10/2018		Yes	20	3	12	81%	21%	2%	19	8	5%	1%
20/3/2019		No	13	1	6	43%	17%	6%	11	3	23%	1%
11/11/2020		Yes	29	5	16	70%	35%	11%	26	6	15%	5%
Bullan Mura Control												
14/11/2017	61%	Yes	30	9	21	91%	43%	1%	20	4	4%	6%
31/10/2018		Yes	25	8	17	87%	26%	3%	9	4	4%	15%
13/10/2020		Yes	31	10	25	96%	46%	10%	23	3	4%	10%
Icon Water Burnt												
4/4/2018	54%	Yes	25	5	15	90%	47%	4%	11	3	5%	0%
23/10/2018		Yes	21	5	13	90%	36%	6%	7	1	4%	0%
27/3/2019		Yes	23	4	13	88%	42%	9%	9	3	6%	0%
Icon Water Control												
4/4/2018	57%	Yes	23	6	14	98%	43%	1%	8	3	1%	0%
23/10/2018		Yes	19	5	13	85%	29%	5%	10	3	5%	1%
27/3/2019		Yes	27	5	16	90%	38%	5%	7	3	4%	0%
Millpost Burnt												
16/3/2018	53%	n/a	27	6	17	99%	58%	1%	2	0	<1%	<1%
19/10/2018		n/a	17	6	12	99%	30%	4%	2	0	<1%	<1%
19/3/2019		n/a	22	5	14	99%	30%	1%	2	0	<1%	<1%
Millpost Control												
19/10/2018		n/a	19	5	15	95%	44%	9%	2	0	3%	<1%
19/3/2019		n/a	20	6	13	99%	48%	9%	1	0	<1%	<1%
Wandiyali Burnt												
28/3/2018	61%	No	15	4	9	95%	65%	6%	11	4	4%	0%
18/10/2018		Yes	20	5	15	71%	30%	4%	15	4	13%	4%
27/10/2020		Yes	19	2	14	68%	43%	11%	12	1	20%	79%
Wandiyali Control												
28/3/2018	59%	No	17	3	11	94%	59%	3%	16	6	4%	0%
18/10/2018		No	17	4	11	81%	31%	3%	13	5	8%	3%
27/10/2020		Yes	24	6	19	73%	54%	10%	14	3	20%	59%

5. DISCUSSION AND CONCLUSIONS

Cool burns are designed to have a low short-term impact, without causing a high increase in bare exposed ground. Cool burns at more frequent intervals have been shown to increase native species richness and cover. It is likely that, in sites with a history of disturbance and weed invasion, introduced species, especially annual species, are also likely to correspondingly respond positively in terms of germination and growth to burns. These trends were supported by the results of monitoring at these four sites, although the relative effects of the burns varied significantly between the plots at each site.

A key factor that influenced the changes observed following the burns, comparing the burnt sites to the unburnt plots, was the extreme weather conditions experienced during the period of the study. The region experienced well below average rainfall before and for the 18 months following the burn, resulting in extremely dry soil conditions and consequently, low herbage mass. From early 2020 there was above average rainfall, which resulted in high soil moisture and consequent high vegetation growth rates, of both native and introduced species. These conditions invariably had a strong influence on the response of species to the burns.

Additionally, the sites had different vegetation types and structure and had been subject to different management and disturbance. Three were within Box-Gum grassy woodland and one was in shrubby woodland. Conditions prior to the burns were different in each site.

Overall, however it was possible to determine the trends in the condition indices. The effects of the burns lasted for less than two years, in three of the sites. The exception was the Bullan Mura site, which was initially in the worst condition due to high levels of disturbance and dumping of building and vegetative material but had the greatest positive response to the burn. It is concluded that much of the compostable waste material that had been dumped in the plot was burnt, and that the burn provided the opportunity for the native species that occurred in the site to recover. This area was the only one that appeared to be still demonstrating better condition after two years. It is likely that prior to the disturbance and dumping this small area was similar to the woodland in the rest of the site, which is in good condition. After the burn the plot met the criteria as Yellow Box- Blakely's Red Gum Grassy woodland community.

At Wandiyali neither the burnt nor unburnt plot met the criteria as critically endangered box-gum woodland in autumn prior to the burn. The burnt plots met the criteria after the burn and again in spring 2020, and the unburnt plot at Wandiyali met the criteria in 2020. The change in status of the plots over time indicate the importance of taking into account seasonal variation (time of survey and climatic conditions) in assessing whether a site meets the criteria as Yellow Box- Blakely's Red Gum Grassy woodland community.

At Icon Water it was concluded that because there was so little herbage mass the burns were extremely light, so the species responses to the burn were very short-lived, especially because conditions following the burn were so low. At Millpost damage to the sub-shrubs was significant, possibly exacerbated by the drought conditions. At least in the time of the monitoring the shrubs were negatively impacted by the burn.

6. REFERENCES

ACT Government, 2017. ACT native grassland conservation strategy and action plans. Environment, Planning and Sustainable Development, Canberra.

ACT Government, 2018. Molonglo Valley vegetation condition monitoring report. Environment, Planning and Sustainable Development, Canberra.

ACT Government, 2019. ACT native woodland conservation strategy and action plans. Environment, Planning and Sustainable Development, Canberra.

Brawata, R., Stevenson, B., and Seddon, J., 2017. Conservation Effectiveness Monitoring Program: an overview. Technical Report. Environment, Planning and Sustainable Development Directorate, ACT Government, Canberra

Department of Environment, Climate Change and Water NSW (DECCW), 2011. Operational Manual for BioMetric 3.1. Department of Environment, Climate Change and Water, NSW Sydney

Department of the Environment and Heritage, 2006. White Box – Yellow Box – Blakely's Red Gum grassy woodlands and derived native grasslands. EPBC Policy Statement.

Gibbons P, Briggs S.V., Ayers D.A., Doyle S., Seddon J., McElhinny C., Jones N., Sims R. and Doody J.S., 2008. *Rapidly quantifying reference conditions in modified landscapes*. Biological Conservation 141: 2483 – 2493

Sharp S. and Gould L., 2014. ACT Region Vegwatch Manual: Vegetation and habitat condition assessment and monitoring for Community. Molonglo Catchment Group Inc., Canberra

Sharp S., 2020. Vegwatch Monitoring Program: Practice and Findings 2011 to 2018. Report to the Molonglo Conservation Group, Canberra.

7. SITE REPORTS

A report on each site is presented below to provide more insight and that can be provided to each land manager to help assess the condition of the sites that they manage, to direct their attention to matters that may be applied and to help them determine if further burning may be of ecological value.

BULLAN MURA, YARRALUMLA

Site description

The plot was located in the south-eastern corner of Bullan Mura Woodland, adjacent to the Chinese Embassy and Forster Crescent in Yarralumla ACT. This small patch is on National Capital Authority managed land (indicated by the grey line in Figure B1) and is contiguous with ACT Territory Land (Bullan Mura) and beyond that to the west, Stirling Park (Gurubang Dhaura), managed by National Capital Authority. Bullan Mura and Gurubang Dhaura contain Yellow Box – Blakely's Red Gum Grassy Woodland, an endangered ecological community and a very large, extensive population of Button Wrinklewort *Rutidosis leptorhynchoides.*

Unlike the rest of the woodland in Bullan Mura and Gurubang Dhaura, the area subject to the burn was disturbed from past actions, and contained piles of concrete, holes, dirt mounds and more recently garden refuse has been dumped in the area. The plot contains Yellow Box *Eucalyptus melliodora* and Blakely's Red Gum *E. blakelyi* trees, Native Cherry *Exocarpos cupressiformis*, Green Wattle *Acacia dealbata*, and there are seedlings of the two eucalypt species and Green Wattle. The groundlayer was dominated by Weeping Grass *Microlaena stipoides*. During the period of the surveys four woodland important species and eight invasive species were recorded.

Figure B1. Location of area burnt in May 2018

Management actions

No weeding, slashing or other management has occurred in this part of the woodland for some years. Dumping of vegetation and soil has occurred from adjacent properties for some time, including post-burn, resulting in disturbed, uneven ground and establishment of some garden weed species.

The burn was undertaken in May 2018.

Aims of the monitoring

As one of four sites to be burnt in autumn 2018:

- To measure change in vegetation composition following a cultural burn.
- To identify whether the plot improved in condition following a cultural burn.

Methods

To fit into the space, an odd-shaped plot (25 x 16 m) was established, an area of 0.04 ha. As there was not another equivalent disturbed area within which to establish a control plot, another existing Vegwatch plot nearby, monitored in the same way since 2014, was used to compare proportional changes in diversity. The control plot was in better condition overall than the plot that was burnt, and some of the dates of surveys differ, but adequate data were available for a comparison.

Species richness was assessed within the plots, and understorey cover values at 80 points along a transect on the boundaries of the plots were measured, to provide a (potentially overlapping) proportional cover of native grasses, native shrubs less than 0.5 m, native forbs, introduced annual species, introduced perennial species, litter, bare ground and rocks.

Surveys were undertaken in February 2018 (burnt plot prior to the burn) and November 2017 (unburnt plot) and re-surveyed in autumn 2019 (burnt plot only) and in spring 2020 (both plots). Some differences in species richness and cover reflect seasonal conditions (autumn surveys compared to spring surveys and the drought conditions in 2018 and 2019), so the relative differences in condition attributes between the burnt and unburnt plots are important for identifying changes that correspond to the burns.

Results

Some differences in species richness and cover reflect seasonal conditions (autumn surveys compared to spring surveys and the drought conditions in 2018 and 2019), so the relative differences in condition attributes between the burnt and unburnt plots are important for identifying changes that correspond to the burns. Weather conditions throughout 2018 and 2019 were very dry, with well below average rainfall. This undoubtedly impacted emergence of some species, both native and introduced. Conditions were well above average in 2020. Richness and cover of native and introduced species in both the burnt and unburnt plots responded to the moister conditions in 2020. The influence of the seasonal conditions is apparent in the photomonitoring results (Figures B2a-c).

Pre-burn

Prior to the burn the plot was structurally relatively diverse, with some dumped materials such as concrete providing additional habitat value. Tree canopy cover and shrub cover (mostly immature trees) was approximately 30%. Prior to the burn the condition of the site in terms of native species richness was moderate to low. Introduced species richness was high and introduced species cover was moderately high. The control plot was in better condition, with greater native diversity, although introduced species richness and cover was similar in both plots.

Post-burn

Visual differences before and after the burn are shown in Figure B2a to c. Many woody species were scorched to a height of about one metre - some burning occurred to the outer bark on the lower trunks of the trees. Eucalypt seedlings and saplings and Acacia shrubs were burnt heavily (Figure B2b) and there was some mortality of the Green Wattle seedlings. Structurally the site was simplified, particularly as a result of the reduction of Acacias and lack of high grasses. Bare ground increased after the burn and litter cover decreased, compared to the unburnt plot.

a) Pre-burn, 1 February 2018 b) Post-burn 31 October 2018 c) Post burn 11 November 2020

Figure B2. Changes in vegetation and structure after the burns. No photo is available from autumn 2019.

Changes in vegetation condition attributes in the burnt plot compared to the unburnt plot

The data of each of the condition indicators from each survey are in Table B1. Bare ground increased significantly in both the burnt and unburnt plots and litter cover was reduced in the burnt plot. After the burn, native and introduced species richness increased over time, although was lower in autumn than in

the spring surveys. Although condition changed in the unburnt plot, the changes over time were not as pronounced.

Table B1 Values of vegetation attributes. Groundcover: attribute at ground level. Understorey cover: cover up to 0.5 m. Total ground and understorey cover may overlap, therefore be over 100%. The unburnt plot was not surveyed in Autumn 2019.

Attributes	**Bullan Mura burnt plot**				**Bullan Mura unburnt plot**		
Survey dates	**Summer 2018**	**Spring 2018**	**Autumn 2019**	**Spring 2020**	**Spring 2017**	**Spring 2018**	**Spring 2020**
Species richness							
Native species richness	17	20	13	29	30	25	31
BGW important* species richness	3	3	1	5	9	8	10
Non-grass understorey species richness	7	12	6	16	21	17	25
Introduced species richness	17	19	11	26	20	9	23
Groundcover (at ground level, totalling 100%)							
Bare groundcover	2%	26%	17%	26%	6%	0%	29%
Litter groundcover	92%	60%	63%	64%	84%	79%	67%
Total vegetation groundcover	6%	14%	20%	10%	10%	21%	3%
Understorey vegetation cover (to 0.5 m)							
Native grass cover	29%	19%	11%	24%	42%	24%	46%
Native sub-shrub and forb cover	2%	2%	6%	11%	1%	3%	10%
Introduced perennial cover	15%	5%	23%	15%	4%	4%	4%
Introduced annual cover	2%	<1%	1%	5%	6%	15%	10%

*Important species: species used to identify if a site meets the criteria as critically endangered box-gum woodland

The survey data were converted to demonstrate the proportional change from the initial data, measured prior to the burns (Figures B3, B4). This conversion takes into account the intrinsic differences between the two plots (the burnt plot was in poorer condition to start with than the unburnt plot) and the variable seasonal conditions during the monitoring period. While there could be no assessment of statistical significance, the trends in of the change in the burnt plot compared to the unburnt plot was identified, as summarised in Table B2. Native species richness increased in the burnt plot more than in the burnt plot, as did the number of important species and non-grass native species. Native understorey cover was little different between both burnt and unburnt plots. Introduced species richness increased to some extent after the burn, and introduced annual cover was substantially higher, the cover of introduced perennial species remained similar in both the burnt and unburnt plots.

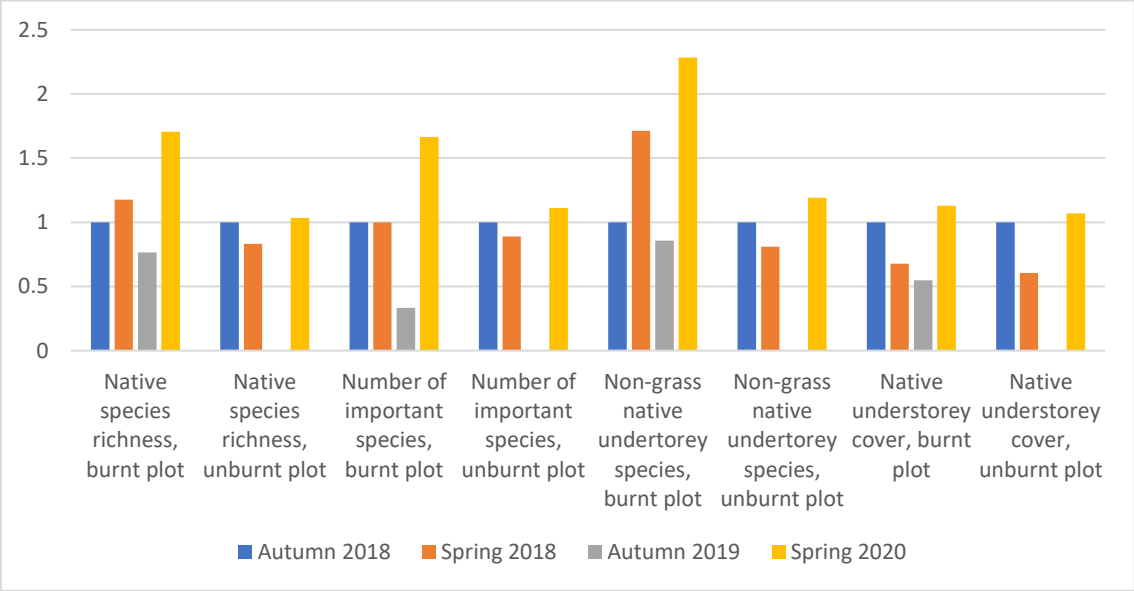


Figure B3. Proportional change in native species condition indices. The initial values (pre-burn) are set at 1. The unburnt plot was not surveyed in Autumn 2019.

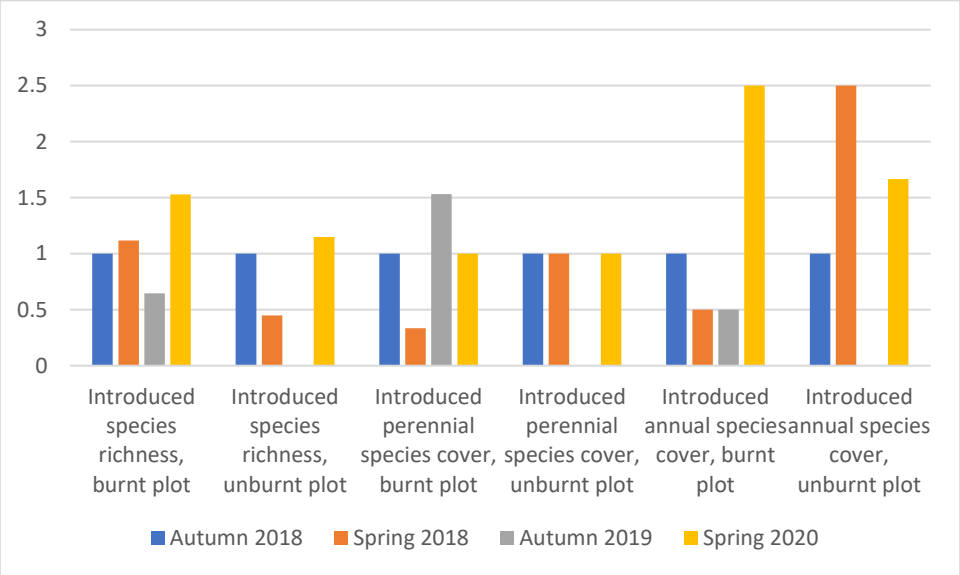


Figure B4. Proportional change (%) in introduced species condition indices. The initial values (pre-burn) are set at 1. The unburnt plot was not surveyed in Autumn 2019.

Table B2. Trends in change in condition indices between the burnt and unburnt plots.

Condition index	Relative change	Comments
Native species richness	↑	Increased proportionally in the burnt plot
Native non-grass species richness	↑	Increased proportionally in the burnt plot
Important species richness	↑	2 years post burn there were proportionally more important species than prior to the burn
Native understorey cover	↔	No difference between the burnt and unburnt plots
Introduced species richness	↑	Increased proportionally in the burnt plot
Perennial introduced u'storey cover	↔	2 years post burn there was no difference
Annual introduced u'storey cover	↔	No difference between the burnt and unburnt plots

Discussion and conclusions

While the extreme seasonal conditions following the burns (extremely dry to early 2020, followed by a higher than average rainfall period till after the final survey) undoubtedly influenced growth, the results indicate that after the burn there was an increase in condition of native species, but at the same time, also an increase in introduced species richness (Table B2). After the burn the plot met the criteria as critically endangered community. Additional native species were found following the burn, indicating that, despite its past disturbance, there was a recovery by native herbaceous species (which would have been in the plot, but presumably suppressed by weeds). Beyond the recovery caused by increased soil moisture it is concluded that the burn had a positive effect on the native vegetation condition in the plot.

Species list, burnt plot, Bullan Mura

Species in blue are woodland 'important species' as defined in the Critically Endangered Ecological Community criteria (Department of the Environment and Heritage, 2006). Species in red are invasive species, being of high ecological concern. Abundance was estimated as: Common: 26 – 75% cover; Occasional: 6-25% cover; Rare: less than 5% cover and less than 4 specimens being present.

Species Name	Common Name	1/2/2018	31/10/2018	20/3/2019	11/11/2020
Native grasses					
Anthosachne scabra	Common Wheatgrass				Occasional
Austrostipa bigeniculata	Kneed Speargrass	Occasional	Occasional	Occasional	Occasional
Austrostipa scabra	Slender Speargrass			Occasional	Occasional
Dichelachne sp	a plumegrass	Rare			
Microlaena stipoides	Weeping Grass	Common	Common	Common	Common
Panicum effusum	Hairy Panic	Occasional	Occasional		
Poa sieberiana	Snow Grass				Occasional
Rytidosperma sp. 1	a wallaby grass	Occasional	Occasional		Occasional
Rytidosperma sp. 2	a wallaby grass	Occasional			Occasional
Themeda triandra	Kangaroo Grass				Rare
Native forbs					
Bulbine bulbosa	Bulbine Lily				Occasional
Cheilanthes sp.	a rockfern	Occasional		Occasional	Occasional
Chrysocephalum apiculatum	Common Everlasting	Occasional	Occasional	Occasional	Occasional
Convolvulus angustissimus	Pink Bindweed				Rare
Cotula australis	Common Cotula		Rare		
Desmodium varians	Southern Tick Trefoil		Rare	Rare	
Einadia nutans	Climbing Saltbush	Occasional	Occasional	Occasional	Occasional
Erodium crinitum	Blue Storksbill				Occasional
Euchiton sphaericus	Japanese Cudweed				Occasional
Geranium sp.	a geranium		Rare	Occasional	
Glycine tabacina	Glycine Pea	Occasional	Rare		Occasional
Goodenia pinnatifida	Scrambled Eggs		Occasional	Rare	Occasional
Lomandra bracteata	Small Matrush	Occasional	Occasional		Occasional
Oxalis perennans	Native Oxalis	Occasional	Occasional		Occasional
Plantago varia	Variable Plantain				Occasional
Rumex sp.	a dock		Rare		
Tricoryne elatior	Yellow Rush Lily	Occasional	Occasional		Occasional
Wahlenbergia capillaris	Common Bluebell		Rare		Occasional
Wahlenbergia luteola	Yellowish Bluebell				Rare
Wahlenbergia multicaulis	Tadgell's Bluebell				Rare
Native shrubs and trees					
Acacia dealbata	Green Wattle	Occasional	Occasional	Occasional	Occasional
Cassinia sp.	a cassinia				Rare
Eucalyptus blakelyi	Blakely's Red Gum	Occasional	Occasional	Occasional	Occasional
Eucalyptus melliodora	Yellow Box	Occasional	Occasional	Occasional	Occasional
Exocarpos cupressiformis	Native Cherry	Rare	Rare	Rare	Rare
Introduced species					
Acacia baileyana	Cootamundra Wattle	Rare			Occasional
Aira sp.	a hairgrass				Rare
Arctotheca calendula	Cape Weed		Occasional		Occasional
Avena sp.	Wild Oats	Occasional		Occasional	
Briza maxima	Quaking Grass				Occasional
Carthamus lanatus	Saffron Thistle		Occasional		Occasional
Cirsium vulgare	Spear Thistle	Occasional	Occasional		Occasional
Cynodon dactylon	Couch Grass	Occasional	Occasional	Occasional	Occasional
Echium plantagineum	Paterson's Curse		Occasional	Occasional	Occasional
Echium vulgare	Vipers Bugloss		Occasional	Occasional	
Festuca arundinacea	Tall Fescue	Occasional		Occasional	
Hirschfeldia incana	Buchan Weed	Occasional	Rare	Occasional	Occasional
Hypericum perforatum	St John's Wort	Occasional	Occasional	Occasional	Occasional

Species Name	Common Name	1/2/2018	31/10/2018	20/3/2019	11/11/2020
Hypochaeris radicata	Flatweed	Occasional	Occasional	Occasional	Occasional
Lactuca serriola	Prickly Lettuce		Occasional	Occasional	Occasional
Lepidium sp.	intr. peppercress	Occasional		Rare	Occasional
Lolium perenne	Rye Grass				Occasional
Modiola caroliniana	Mallow	Occasional	Occasional		Occasional
Nandina domestica	Japanese Sacred Bamboo				Rare
Nassella neesiana	Chilean Needlegrass	Occasional	Occasional		Occasional
Nassella trichotoma	Serrated Tussock	Occasional	Occasional		
Paspalum dilatatum	Paspalum	Occasional	Rare		Rare
Petrorhagia nanteuilii	Proliferous Pink				Occasional
Plantago lanceolata	Plantain	Occasional	Occasional		Occasional
Rubus fruticosus complex	Blackberry	Occasional	Occasional		Rare
Rumex acetosella	Sheep Sorrell	Rare	Occasional	Rare	Occasional
Sanguisorba minor	Salad Burnet				Occasional
Sonchus asper	Prickly Sowthistle				Occasional
Trifolium dubium	Yellow Suckling Clover		Rare		Occasional
Verbascum thapsus	Great Mullein	Occasional			
Verbascum virgatum	Twiggy Mullein		Rare		
Vulpia sp.	Rat's Tailed Fescue				Occasional

ICON WATER WOODLAND BIODIVERSITY OFFSET SITE WILLIAMSDALE

Site description

The site is located on the Icon Water Woodland Biodiversity Offset site, Williamsdale, to the south of the electricity sub-station (Figure I1).

The trial plots were within a patch of Yellow Box open woodland containing Blakely's Red Gum (*Eucalyptus blakelyi*) mature trees and regrowth seedlings and saplings (Figure I2) and the surrounding area consists of open woodland and secondary native grassland. There was a high diversity of native grasses, a moderate diversity of native forbs and one native sub-shrub. During the surveys seven important woodland species were recorded and three invasive species. There were relatively few weeds, except St John's Wort, which was abundant across the site.

Management actions

St John's Wort was treated in March 2018, prior to the first survey. There was evidence of treatment of Briar Rose (*Rosa rubiginosa*) in the past, but there was regrowth.

A cultural burn was undertaken in May 2018.

Figure I1. Location of area to be burnt, Williamsdale

Figure I2. The southern plot was burnt

Aims of the monitoring

As one of four sites to be burnt in autumn 2018:

- To measure change in vegetation composition following a cultural burn.
- To identify whether the plot improved in condition following a cultural burn.

Methods

Two 0.04 ha monitoring plots were established side by side within similar habitat, one of which was burnt, the other surveyed as a comparison.

Species richness was assessed within the plots, and understorey cover values at 80 points along a transect on the boundaries of the plots were measured, to provide a (potentially overlapping) proportional cover of native grasses, native shrubs less than 0.5 m, native forbs, introduced annual species, introduced perennial species, litter, bare ground and rocks.

The plots were surveyed prior to the burn in early autumn 2018 and, after the burn in spring 2018 and in autumn 2019. Some differences in species richness and cover reflect seasonal conditions (autumn surveys compared to spring surveys and the drought conditions in 2018 and 2019), so the relative differences in condition attributes between the burnt and unburnt plots are more important than changes year to year.

Results

In 2018 and 2019 the region was subjected to drought conditions. The low soil moisture conditions were well below average, limiting emergence and longevity of some perennial native forbs and of introduced annual forbs and grasses. The influence of the seasonal conditions is apparent in the photomonitoring results (Figures B2a-c).

Pre-burn

The plots were surveyed in early autumn 2018 before the burns were undertaken in May. Prior to the burn, the species diversity and abundance, composition, structure and condition were similar in the two plots,. Structurally the plots were relatively sparse, with scattered mature trees with a canopy cover of approximately 10%, and few saplings or seedlings, and no shrubs or sub-shrubs. The native groundflora were relatively diverse.

Post burn

The burn was very cool – tree seedlings were burnt but recovery was evident during the first post-burn survey. There were few other visible signs of the burn, including litter loss or scorch marks. It was difficult by spring 2018 to identify where the burn occurred (Figures I3a-d). In both plots there was evidence of grazing by kangaroos.

a) Burnt plot, prior to the burn, 4 April 2018

b) Burnt plot, four months after the burn, 23 October 2018

c) Unburnt plot, 4 April 2018

d) Unburnt plot 23 October 2018

Figure I3. Changes in vegetation and structure in the burnt and unburnt plots.. No photo is available from autumn 2019.

Changes in vegetation condition attributes in the burnt plot compared to the unburnt plot

The data from each survey of the condition indicators are in Table I1. Bare ground increased considerably in the burnt plot, although litter cover (mostly leaves from the trees) were similar in both the burnt and unburnt plots. After the burn, native and introduced species richness changed little in either plot. Native grass cover decreased after the burn, but a similar trend occurred in the unburnt plot, indicating this was unlikely to be as a result of the burn. Introduced species cover and richness was very low in both plots and did not change over time.

Table I1. Values of vegetation attributes. Groundcover: attribute at ground level. Understorey cover: cover up to 0.5 m. Total ground and understorey cover may overlap, therefore be over 100%.

Attributes	**Icon water burnt plot**			**Icon Water unburnt plot**		
Survey dates	**Autumn 2018**	**Spring 2018**	**Autumn 2019**	**Autumn 2018**	**Spring 2018**	**Autumn 2019**
Species richness						
Native species richness	25	21	23	23	19	27
BGW important* species richness	5	5	4	6	5	5
Non-grass understorey species richness	15	13	13	14	13	16
Introduced species richness	11	7	9	8	10	7
Groundcover (at ground level, totalling 100%)						
Bare groundcover	19%	16%	34%	11%	10%	19%
Litter groundcover	54%	55%	41%	60%	59%	64%
Total vegetation groundcover	27%	29%	25%	29%	31%	17%
Understorey vegetation cover (to 0.5 m)						
Native grass cover	44%	30%	34%	41%	24%	33%
Native sub-shrub and forb cover	4%	5%	9%	1%	5%	5%
Introduced perennial cover	5%	4%	6%	1%	5%	4%
Introduced annual cover	<1%	<1%	<1%	<1%	1%	<1%

*Important species: species used to identify if a site meets the criteria as critically endangered box-gum woodland

The survey data were converted to demonstrate the proportional change from the initial data, measured prior to the burns (Figures I4, I5). This conversion takes into account any differences between the two plots and the variable seasonal conditions during the monitoring period. While there could be no assessment of statistical significance, the trend of the change in the burnt plot compared to the unburnt plot was identified (Table I2). Native species richness and non-grass native understorey species increased proportionally in the burnt plot in spring after the burn, but this did not remain a trend into the second year post burn. Native understorey cover was not proportionally different in the burnt plot from the unburnt plot. Introduced species richness and cover were very low in both plots. The significantly higher proportion of introduced perennial cover in the unburnt plot is exaggerated by the very low cover, the actual increase being from one to 5% cover, then to 4% cover (Figure I5). No differences between condition indices were identified between the burnt and unburnt plots (Table I5)

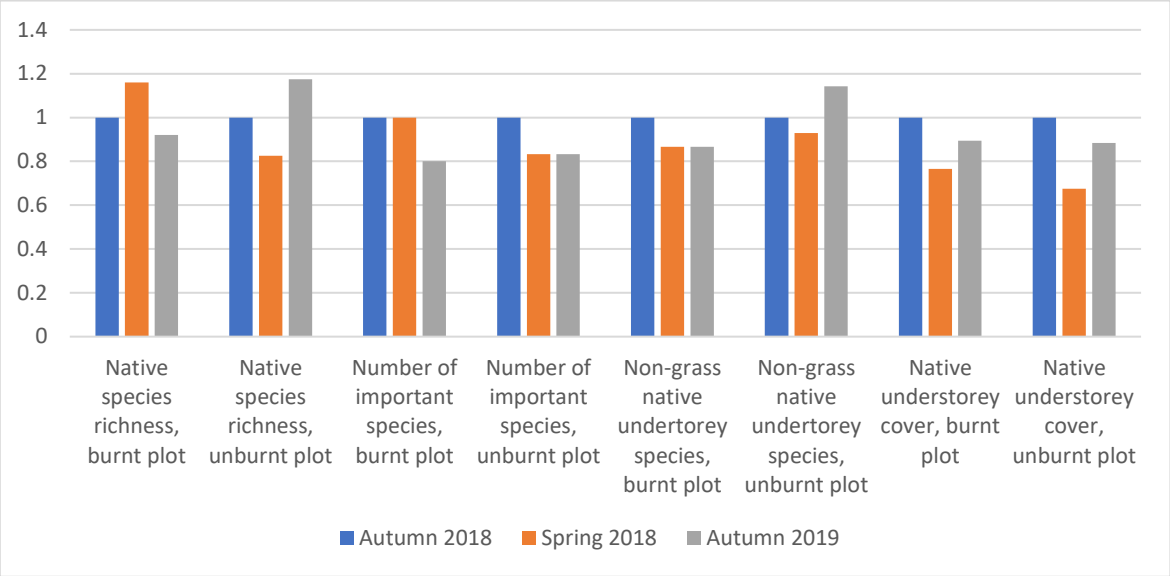


Figure I4. Proportional change in native species condition indices. The initial values (pre-burn) are set at 1.

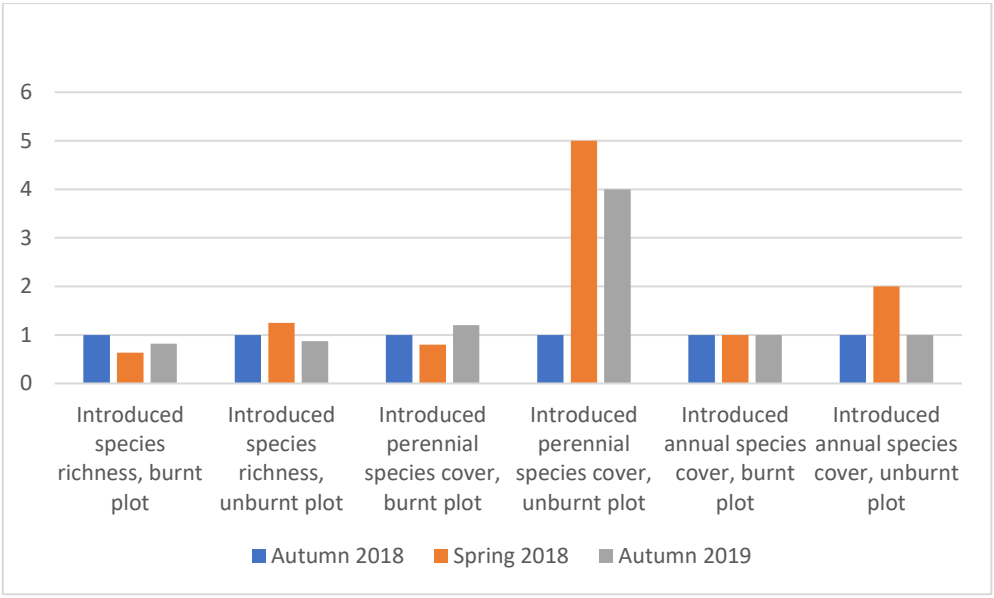


Figure I5. Proportional change in introduced species condition indices. The initial values (pre-burn) are set at 1.

Table I2 Trends in change in condition indices between the burnt and unburnt plots.

Condition score	Relative change	Comments
Native species richness	←→	Initial increase in the burnt plot, no difference after one year
Native non-grass species richness	←→	No difference between the burnt and unburnt plots
Important* species richness	←→	No difference between the burnt and unburnt plots
Native understorey cover	←→	No difference between the burnt and unburnt plots
Introduced species richness	←→	No difference between the burnt and unburnt plots
Perennial introduced u'storey cover	←→	No difference between the burnt and unburnt plots
Annual introduced u'storey cover	←→	No difference between the burnt and unburnt plots

Discussion and conclusions

The burn undertaken at Icon Water was very cool, as there was very little litter or herbage mass to burn. After six months there was a slight but not notable increase in native species richness and cover but after twelve months there was no differences observed between the burnt and unburnt plots. Any differences

over time within and between the plots was more likely influenced by seasonal conditions and possible influences of kangaroo grazing rather than the burn.

There were no measurable differences between the burnt or unburnt plots, and no significant change in condition as a result of the burn. Changes measured were more influenced by when the surveys were undertaken (higher values for native and introduced species richness and cover in spring than in autumn). It is speculated this is because there was negligible litter or herbage mass to burn.

Species list, Icon Water

Species in blue are woodland 'important species' as defined in the Critically Endangered Ecological Community criteria (Department of the Environment and Heritage, 2006). Species in red are invasive species, being of high ecological concern. Abundance was estimated as: Common: 26 – 75% cover; Occasional: 6-25% cover; Rare: less than 5% cover and less than 4 specimens being present.

Species Name	Common Name	4/4/2018	23/10/2018	27/3/2019	4/4/2018	23/10/2018	27/3/2019
		Burnt plot			Unburnt plot		
Native Grasses							
Anthosachne scabra	Common Wheatgrass						Occasional
Aristida ramosa	Purple Wiregrass	Occasional		Occasional	Occasional		Occasional
Austrostipa scabra	Corkscrew Grass	Occasional	Occasional	Occasional	Common	Common	Occasional
Bothriochloa macra	Redgrass	Common	Occasional	Occasional	Occasional		Occasional
Dichelachne sp	A plumegrass	Rare		Rare			
Enneapogon nigricans	Nine-awned Grass			Occasional	Rare		Rare
Microlaena stipoides	Weeping Grass	Common	Common	Common	Occasional	Occasional	Occasional
Panicum effusum	Hairy Panic (grass)	Occasional	Occasional	Occasional	Occasional	Occasional	Occasional
Poa sieberiana	Snow Grass	Occasional	Occasional	Occasional	Common		Occasional
Rytidosperma carphoides	Short wallaby grass		Occasional	Occasional		Common	Occasional
Rytidosperma sp.	A wallaby grass	Occasional	Occasional		Occasional	Common	Occasional
Rytidosperma sp. 2	A wallaby grass	Occasional					
Native forbs							
Cheilanthes sp.	A rock fern	Occasional	Occasional	Occasional	Occasional	Occasional	Occasional
Chrysocephalum apiculatum	Common Everlasting	Occasional	Occasional	Occasional	Occasional	Occasional	Occasional
Chrysocephalum semipapposum	Clustered Everlasting				Occasional	Occasional	Occasional
Desmodium varians	Slender Tick-trefoil	Occasional	Occasional	Occasional	Occasional	Rare	Occasional
Glycine tabacina	Vanilla Glycine	Occasional		Occasional	Occasional	Occasional	Occasional
Plantago varia	Variable Plantain	Rare	Occasional		Occasional		
Triptilodiscus pygmaeus	Common Sunray		Occasional				
Acaena ovina	Sheeps Burr	Occasional	Occasional	Rare	Occasional	Rare	Rare
Carex inversa	Knob Sedge			Occasional			
Convolvulus angustissimus	Australian Bindweed			Rare			
Cymbonotus lawsonianus	Bear's Ear		Occasional			Rare	
Dichondra repens	Kidney Weed	Occasional	Occasional	Occasional	Occasional		Occasional
Einadia nutans	Climbing Saltbush						Rare
Epilobium billardiereanum	Willowherb	Rare					
Euphorbia dallachyana	Caustic Weed	Occasional					
Geranium sp.	A native geranium	Occasional			Occasional	Occasional	Occasional
Hydrocotyle laxiflora	Stinking Pennywort					Occasional	
Lomandra filiformis	Wattlematrush	Occasional			Occasional		
Lomandra sp.	a wattlematrush		Rare	Occasional		Rare	Occasional
Melichrus urceolatus	Urn Heath	Rare	Rare	Rare	Rare	Rare	Rare
Oxalis perennans	Native Oxalis		Rare				Rare
Rumex brownii	Swamp Dock	Rare		Occasional			Rare

Species Name	Common Name	4/4/2018	23/10/2018	27/3/2019	4/4/2018	23/10/2018	27/3/2019
		Burnt plot			**Unburnt plot**		
Schoenus apogon	Common Bogsedge						Occasional
Senecio quadridentatus	Cotton Fireweed				Rare		
Solenogyne dominii	Smooth Solenogyne					Occasional	Rare
Vittadinia muelleri	Small New Holland Daisy				Rare		Rare
Wahlenbergia communis	Native Bluebell	Occasional	Rare	Occasional	Occasional	Rare	
Xerochrysum viscosum	Sticky Everlasting	Rare	Rare	Rare			
Native trees							
Eucalyptus blakelyi	Blakely's Red Gum	Common	Common	Common	Common	Common	Common

Species Name	Common Name	4/4/2018	23/10/2018	27/3/2019	4/4/2018	23/10/2018	27/3/2019
		Burnt plot			**Unburnt plot**		
Introduced species							
Hypericum perforatum	St John's Wort	Occasional	Occasional	Occasional	Occasional	Occasional	Occasional
Nassella trichotoma	Serrated Tussock	Rare		Rare	Occasional	Occasional	Occasional
Rosa rubiginosa	Briar Rose	Rare		Rare	Occasional	Occasional	Occasional
Acetosella vulgaris	Sheep Sorrell				Occasional		
Aira sp.	A Hairgrass	Occasional		Occasional			
Centaurium erythraea	Common Centaury	Rare		Rare	Occasional	Occasional	
Chondrilla juncea	Skeleton Weed	Occasional		Rare			
Cirsium vulgare	Spear Thistle	Rare			Occasional	Rare	
Hypochaeris glabra	Smooth Catsear		Occasional				
Hypochaeris radicata	Flatweed	Occasional	Occasional	Occasional	Occasional	Occasional	Occasional
Introduced unknown		Occasional	Occasional			Rare	
Petrorhagia nanteuilii	Proliferous Pink				Occasional		Rare
Plantago lanceolata	Ribwort					Rare	Rare
Tragopogon sp.	Salsify	Rare				Rare	
Trifolium sp.	a clover		Occasional	Rare		Occasional	Occasional
Verbascum thapsus	Great Mullein		Rare	Rare			
Verbascum virgatum	Twiggy Mullein	Occasional	Rare				

Common (26 – 75% cover); Occasional (1 – 25% cover; Rare (<5% cover and <4 specimens)

MILLPOST PROPERTY, BUNGENDORE

Site description

The site is located in the hills south-west of Bungendore, on a property managed for both sheep production healthy native vegetation.

The site contains woodland on the slopes above a low-lying grassland with similar groundflora. The woodland is dominated by Brittle Gum *Eucalyptus mannifera*, there is a sparse shrub layer, and the understorey contains diverse native forbs, grasses and a high cover of sub-shrubs. During the surveys there were 11 important woodland species recorded and only two introduced species, neither of which are considered invasive.

Figures M1, M2. Burn site, Millpost property, near Bungendore

Management actions

The site is on a property and is rotationally grazed by sheep.

A cultural burn was undertaken in May 2018.

Aims of the monitoring

As one of four sites to be burnt in autumn 2018:

- To measure change in vegetation composition following a cultural burn.
- To identify whether the plot improved in condition following a cultural burn.

Methods

One 0.04 ha monitoring plot was established within the lower part of the woodland. A second site that was not burnt was established in spring 2018, for comparison.

Species richness was assessed within the plots, and understorey cover values at 80 points along a transect on the boundaries of the plots were measured, to provide a (potentially overlapping) proportional cover of native grasses, native shrubs less than 0.5 m, native forbs, introduced annual species, introduced perennial species, litter, bare ground and rocks.

The plots were surveyed prior to the burn in March 2018 and re-surveyed after the burn in October 2018 and again in March 2019. Some differences in species richness and cover reflect seasonal conditions (autumn surveys compared to spring surveys and the drought conditions in 2018 and 2019), so the relative differences in condition attributes between the burnt and unburnt plots are more important than actual changes year to year.

Results

In 2018 and 2019 the region was subjected to severe drought conditions. The low soil moisture conditions were well below average, limiting emergence and longevity of some perennial native forbs and of introduced annual forbs and grasses. The influence of the seasonal conditions and the burn are evident in Figure M3 a to c.

a) Burnt plot prior to the burn, 16 March 2018

b) Burnt plot, 19 October 2018

c) unburnt plot, 19 October 2018.

Figure M3 a-c. Changes in vegetation and structure after the burns. No photo is available from autumn 2019.

Pre-burn

Native upper and mid foliage cover was estimated at 5% canopy cover. Native species richness was high and introduced species richness very low. Eleven (Box-Gum Woodland) 'important' species were surveyed during the monitoring program. There were only two introduced species identified during the survey, indicating a very low level of past disturbance to the site, even though it has been used for stock grazing for a long period of time. Structurally the site was diverse, although the site lacks old-growth trees and low amounts of fallen timber. There was a high cover of bare ground and cryptogams, reflecting at least in part the dry seasonal conditions. The unburnt control plot contained similar vegetation structure and composition.

Post burn

Weather conditions after the burn were extremely dry, soil moisture condition having dropped to well below average. This undoubtedly impacted recovery of some species from the burn, as well as seasonal emergence of both native and introduced species. The burn covered about 70% of the plot on the western

side. Many of the sub-shrubs were burnt to the ground, although nearly all had some new growth on them a year after the burn (Figures M3 a-c).

There was a considerable decrease in native grass cover and litter cover after the burn and corresponding large increase in bare ground cover. Overall condition decreased, but this was also reflected in the unburnt plot established adjacent (Tables M1, M2).

Changes in vegetation condition attributes in the burnt plot compared to the unburnt plot

The data of the condition indicators from each survey are in Table M1. Bare ground increased significantly in both the burnt and unburnt plots and litter cover was reduced in the burnt plot. After the burn, native species richness decreased, but native species richness was similar in the unburnt site. Introduced species richness and cover did not change in either the burnt or unburnt plots over time.

Table M1. Values of vegetation attributes. Groundcover: attribute at ground level. Understorey cover: cover up to 0.5 m. Total ground and understorey cover may overlap, therefore be over 100%. The unburnt plot was not surveyed in Autumn 2018.

Attributes	**Millpost burnt plot**			**Millpost unburnt plot**		
Survey dates	**Autumn 2018**	**Spring 2018**	**Autumn 2019**	**Autumn 2018**	**Spring 2018**	**Autumn 2019**
Species richness						
Native species richness	27	17	22	no data	19	20
BGW important* species richness	6	6	5		5	6
Non-grass understorey species richness	17	12	14		15	13
Introduced species richness	2	2	2		2	1
Groundcover (at ground level, totalling 100%)						
Bare groundcover	13%	25%	31%		18%	26%
Litter groundcover	75%	49%	54%		59%	49%
Total vegetation groundcover	12%	26%	15%		23%	25%
Understorey vegetation cover (to 0.5 m)						
Native grass cover	56%	26%	29%		35%	39%
Native sub-shrub and forb cover	2%	4%	1%		9%	9%
Introduced perennial cover	<1%	<1%	<1%		3%	<1%
Introduced annual cover	<1%	<1%	<1%		<1%	<1%

*Important species: species used to identify if a site meets the criteria as critically endangered box-gum woodland; although not relevant to this vegetation community, the data are included as a comparison to data in other sites.

The survey data were converted to demonstrate the proportional change from the initial data, measured prior to the burns (Figures B3, B4). This conversion takes into account other variables affecting the data during the monitoring period, including seasonal conditions and grazing impacts. Because there were no data from the unburnt plot from the initial survey, the values from the adjacent burnt plot prior to the burn were used to set the comparative change in values. No indices substantially differed between the burnt and unburnt plot, except native understorey cover which was lower in the burnt plot than the unburnt plot. While there could be no assessment of statistical significance, the trend of the change in the burnt plot compared to the unburnt plot was identified (Table M2).

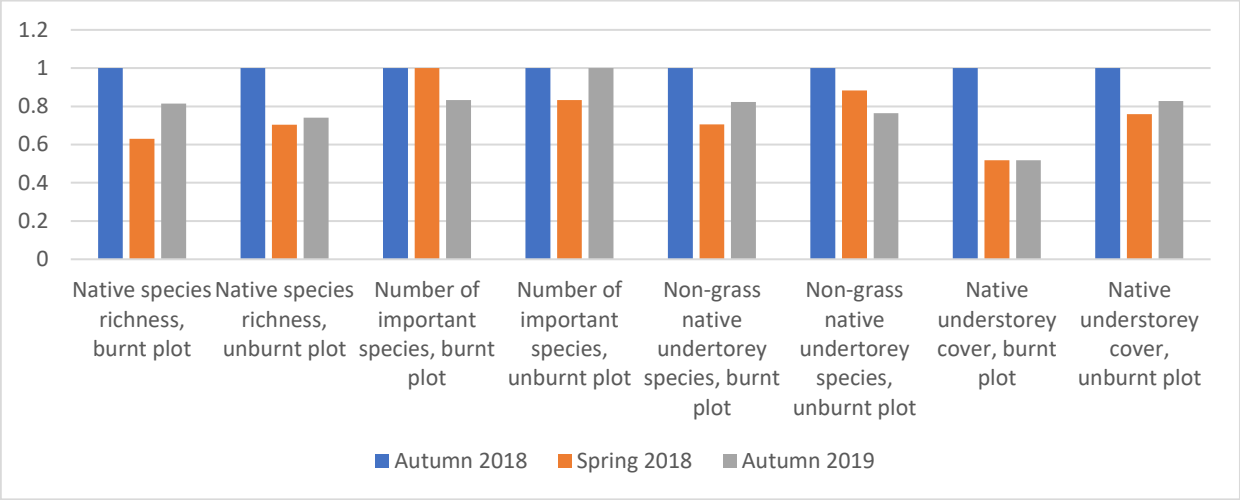


Figure M4. Proportional change in native species condition indices. The initial values (pre-burn) are set at 1.

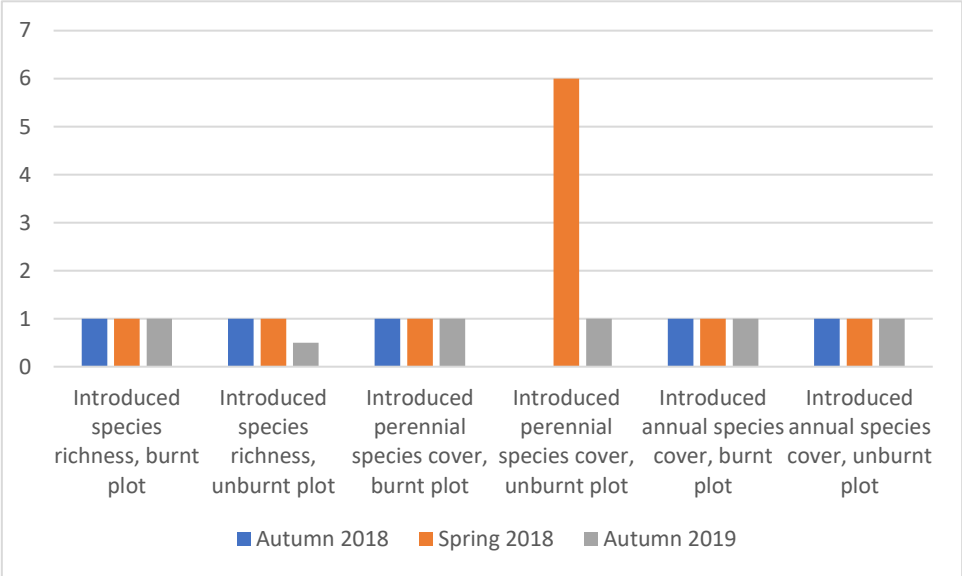


Figure M5. Proportional change in introduced species condition indices. The initial values (pre-burn) are set at 1.

Table M2. Trends in change in condition indices between the burnt and unburnt plots..

Condition score	Relative change in attributes following the burn	Comments
Native species richness	↔	No difference between the burnt and unburnt plots
Native non-grass species richness	↔	No difference between the burnt and unburnt plots
Important* species richness	↔	Initial increase in the burnt plot, subsequently no difference
Native understorey cover (to 1 m)	↓	Decrease in the burnt plot
Introduced species richness	↔	No difference between the burnt and unburnt plots
Perennial introduced u'storey cover	↔	No difference between the burnt and unburnt plots
Annual introduced u'storey cover	↔	No difference between the burnt and unburnt plots

Discussion and conclusions

The burn significantly scorched many of the sub-shrubs, some of which subsequently died. The amount of dead and scorched shrubs is of concern, as was the reduced overall native understorey cover. In conclusion it is posited that the burn had a deleterious effect on the native vegetation, although recovery from the burn may have improved after the drought broke. The drought conditions were likely to have significantly influenced the condition over the period of the monitoring.

Species list, Millpost property

Species in blue are woodland 'important species' as defined in the Critically Endangered Ecological Community criteria (Department of the Environment and Heritage, 2006); as the site does not contain this vegetation community, it is included as a comparison only to the other sites subject to burns. Abundance was estimated as: Common: 26 – 75% cover; Occasional: 6-25% cover; Rare: less than 5% cover and less than 4 specimens being present.

Species Name	Common Name	16/3/2018	19/10/2018	19/3/2019	19/10/2018	19/3/2019
		Burnt plot			Unburnt plot	
Native grasses						
Aristida ramosa	Purple Wiregrass	Common	Occasional	Common	Occasional	Common
Bothriochloa macra	Redgrass	Occasional		Occasional		
Eragrostis brownii	Brown's Lovegrass	Occasional				
Microlaena stipoides	Weeping Grass	Occasional	Occasional	Occasional	Common	Occasional
Poa sieberiana	Snow Tussock	Rare		Occasional		
Rytidosperma pallidum	Red-anthered Wallaby Grass				Occasional	Occasional
Rytidosperma spp	wallaby grasses	Occasional			Occasional	Occasional
Themeda triandra	Kangaroo Grass	Occasional	Occasional	Occasional		Occasional
Native understorey forbs and sub-shrubs						
Caladenia sp.	Caladenia orchid	Rare				
Desmodium varians	Southern Tick-trefoil	Rare				
Diuris chryseopsis	Golden Moths		Rare			
Drosera peltata	Pale Sundew				Occasional	
Euchiton sp.	A cudweed	Occasional	Rare	Rare	Occasional	
Goodenia hederacea	Ivy Goodenia	Occasional	Occasional	Rare	Occasional	Occasional
Haloragis heterophylla	Variable Raspwort			Occasional	Rare	
Hibbertia obtusifolia	Hairy Guineaflower	Occasional	Occasional	Occasional	Occasional	Occasional
Hovea heterophylla	Creeping Hovea	Occasional		Occasional		Occasional
Hydrocotyle laxiflora	Stinking Pennywort	Occasional	Occasional		Occasional	
Hypericum gramineum	Small St John's Wort	Occasional		Rare		Occasional
Juncus sp.	A native rush	Rare				
Leptorhynchos squamatus	Scrambled Eggs		Occasional		Occasional	
Lomandra bracteata/filiformis sp.1	A small matrush	Occasional	Occasional	Occasional		Occasional
Lomandra bracteata/filiformis sp. 2	A small matrush			Occasional	Occasional	Occasional
Schoenus apogon	Common Bogsedge	Occasional				
Solenogyne dominii	Smooth Solenogyne	Occasional	Occasional	Rare	Occasional	
Stylidium graminifolium	Grass Triggerplant	Occasional		Rare		
Triptilodiscus pygmaeus	Common Sunray		Occasional		Occasional	
Vittadinia muelleri	Narrow-leaved New Holland Daisy			Rare		Rare
Wahlenbergia sp.	a bluebell				Rare	
Acacia gunnii	Prickly Acacia	Occasional			Rare	Rare
Brachyloma daphnoides	Daphne Heath					Rare
Dillwynia sericea	Showy Parrotpea	Occasional			Occasional	
Dillwynia sp.	parrotpeas	Occasional		Occasional		Occasional
Leucopogon fletcheri	Twin-flowered Beardheath		Occasional		Occasional	
Lissanthe strigosa	Peach Heath			Rare		
Melichrus urceolatus	Urn Heath	Occasional	Occasional	Occasional	Occasional	Occasional
Native sub-shrub			Occasional			
Native shrubs and trees						
Acacia dealbata	Silver Wattle	Occasional		Occasional		Rare
Acacia genistifolia	Ploughshare Wattle					Occasional
Daviesia mimosoides	Narrow-leaved Bitterpea					Rare
Eucalyptus mannifera	Brittle Gum	Rare	Rare	Rare		Rare
Kunzea ericoides	Burgan	Occasional	Rare	Occasional		
Introduced species						
Centaurium erythraea	Common Centaury	Occasional	Occasional	Occasional	Occasional	Occasional
Hypochaeris radicata	Flatweed	Occasional	Occasional	Rare	Occasional	

C: Common (>50% cover); O: Occasional (1-25% cover; R: Rare (<1% cover and <4 specimens)

* Introduced species

WANDIYALI CONSERVATION AREA, GOOGONG

Site description

The site is located in NSW on the western side of Old Cooma Road near Googong on the property 'Wandiyali', a privately owned conservation reserve (Figure W1).

The site is predominantly secondary native grassland, dominated by Kangaroo Grass and Redgrass; the copse of trees in the north-eastern area and scattered trees on the ridge are Yellow Box and Applebox. There is tree regeneration occurring, but not within the plots. The vegetation association is White Box – Yellow Box – Blakely's Red Gum tall grassy woodland (BGW). After the burn the plots and therefore the site met the criteria as a remnant of critically endangered BGW. There was a low to moderate number of native herbaceous species present. There was, however, high introduced species richness and cover, with species present that are typical of past pastoral use, including thistles and annual grasses. there were eight important woodland species recorded, and eight invasive species recorded.

Figure W1. Location from Old Cooma Road, location of study area in red.

Management actions

There is no domestic stock grazing. After spring 2018 a predator proof fence was erected which likely affected kangaroo grazing occurrence. Stock grazing was undertaken for production prior to establishment of the property as a conservation reserve.

A cultural burn was undertaken in May 2018.

Aims of the monitoring

As one of four sites to be burnt in autumn 2018:

- To measure change in vegetation composition following a cultural burn.
- To identify whether the plot improved in condition following a cultural burn.

Methods

Two 0.04 ha monitoring plots were established side by side within similar habitat, one of which was burnt, the other unburnt, as a comparison.

Species richness was assessed within the plots, and understorey cover values at 80 points along a transect on the boundaries of the plots were measured, to provide a (potentially overlapping) proportional cover of native grasses, native shrubs less than 0.5 m, native forbs, introduced annual species, introduced perennial species, litter, bare ground and rocks.

The plots were surveyed in March 2018 prior to the burn, in October 2018 following the burn and again in October 2020, more than two years after the burn.

Results

Some differences in species richness and cover reflect seasonal conditions (autumn surveys compared to spring surveys and the drought conditions in 2018 and 2019), so the relative differences in condition attributes between the burnt and unburnt plots are important for identifying changes that correspond to the burns.

Pre-burn

Prior to the burn the plot was structurally relatively sparse, with no trees or shrubs and no rocks There was little bare ground. The native species richness was moderate in both plots prior to the burn, with a high number of non-native understorey species, including important species. Introduced species richness and cover were relatively low. There was a high cover of native grasses but low cover of native herbaceous species. Very few annual introduced species were observed.

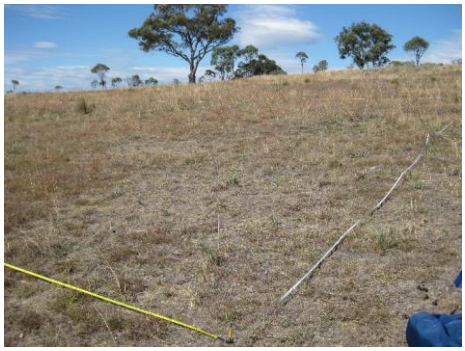
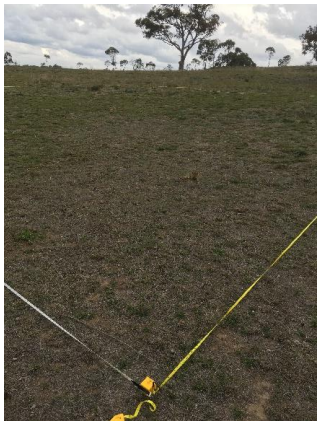
Post burn

Weather conditions following during 2018 were very dry, with well below average rainfall all year. This undoubtedly impacted emergence of some species, both native and introduced. Conditions were even dryer in 2019, but soil moisture levels were well above average in 2020. Richness and cover of native and introduced species in both the burnt and unburnt plots responded considerably to the moister conditions in 2020. The influence of the seasonal conditions is apparent in the photomonitoring results (Figures W2a-f). In the burnt and unburnt plots, the native and introduced species richness was lower in the autumn surveys than in the spring surveys (Tables W1, W2), especially in spring 2020.

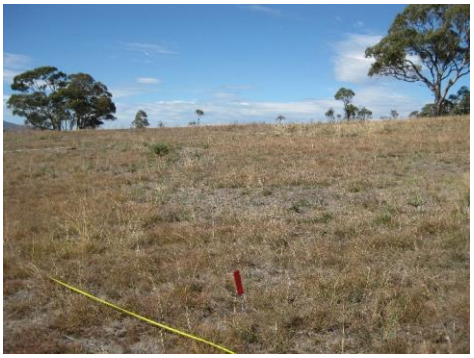
Several months after the May burn there was little evidence of the burn, other than some charred litter. The lack of evidence was likely influenced by the dry conditions, as herbage mass was low in the burnt and unburnt plots. There was, however, moderate recovery of the herbaceous understorey, to the extent that both the burnt and unburnt plots met the criteria as critically endangered box-gum woodland.

Changes in vegetation condition attributes in the burnt plot compared to the unburnt plot

The data of the condition indicators from each survey are in Table W1. There was an increase in bare groundcover and relative litter cover in both plots. There was an increase in both native and introduced species richness in the burnt plot within six months after the burn, and initially, comparably a greater increase in native species richness in the burnt plot than the unburnt plot. In 2020 both the burnt and unburnt plots had a higher native species richness, cover and introduced species richness and cover compared to the two previous survey periods. Introduced annual species cover increased substantially in both plots (Figure W2c, f).


Burnt plot: a) 28/3/18 (prior to the burn) b) 18/10/18 c) 27/10/20



Unburnt plot: d) 28/3/18 e) 18/10/18; f) 27/10/20

Figure W2a - f. Change in structure in the burnt and unburnt plots over two years.

Table W1. Values of vegetation attributes. Groundcover: attribute at ground level. Understorey cover: cover up to 0.5 m. Total ground and understorey cover may overlap, therefore be over 100%.

Attributes	Wandiyali burnt plot			Wandiyali unburnt plot		
	Autumn 2018	Spring 2018	Spring 2020	Autumn 2018	Spring 2018	Spring 2020
Species richness						
Native species richness	15	20	19	17	17	24
BGW important* species richness	4	5	2	3	4	6
Non-grass understorey species richness	9	15	14	11	11	19
Introduced species richness	11	15	12	16	13	14
Groundcover (at ground level, totalling 100%)						
Bare groundcover	3%	4%	13%	3%	3%	21%
Litter groundcover	61%	65%	45%	59%	45%	41%
Total vegetation groundcover	36%	31%	42%	38%	52%	38%
Understorey vegetation cover (to 0.5 m)						
Native grasses cover	59%	26%	32%	56%	29%	44%
Native sub-shrub and forb cover	6%	4%	11%	3%	3%	10%
Introduced perennial cover	4%	13%	20%	4%	8%	20%
Introduced annual cover	<1%	4%	78%	<1%	3%	59%

The survey data were converted to demonstrate the proportional change from the initial data, measured prior to the burns (Figures B3, B4). This conversion takes into account the intrinsic differences between the two plots, the variable seasonal conditions during the monitoring period and a potential change in

macropod grazing after the predator proof fence was erected. While there could be no assessment of statistical significance, the trends in of the change in the burnt plot compared to the unburnt plot was identified, as summarised in Table B2.

The number of native species increased proportionally in the burnt plot, but in 2020 the species had also increased to the same extent in the unburnt plot. After two years there were proportionally more important species surveyed in the unburnt plot, with a decrease in the burnt plot. Non-grass native understorey species richness increased proportionally more in the burnt plot. Native understorey cover increased more in the unburnt plot than in the burnt plot in Spring 2020 (Figure W3).

There was initially a small increase in introduced species richness in the burnt plot in proportion to the unburnt plot, but this stabilised after two years (Figure W4). There was no difference in introduced perennial or annual species cover between the two plots (Figures W4, W5). There was however, in both plots an extremely high proportional change in cover of introduced annual species in spring 2020 (Figure W5).

While there could be no assessment of statistical significance, the trend of the change in the burnt plot could be identified (Table W2). Initially there was an increase in native species richness, but the relative differences in the condition indices in the burnt and unburnt plots were not apparent after two years.

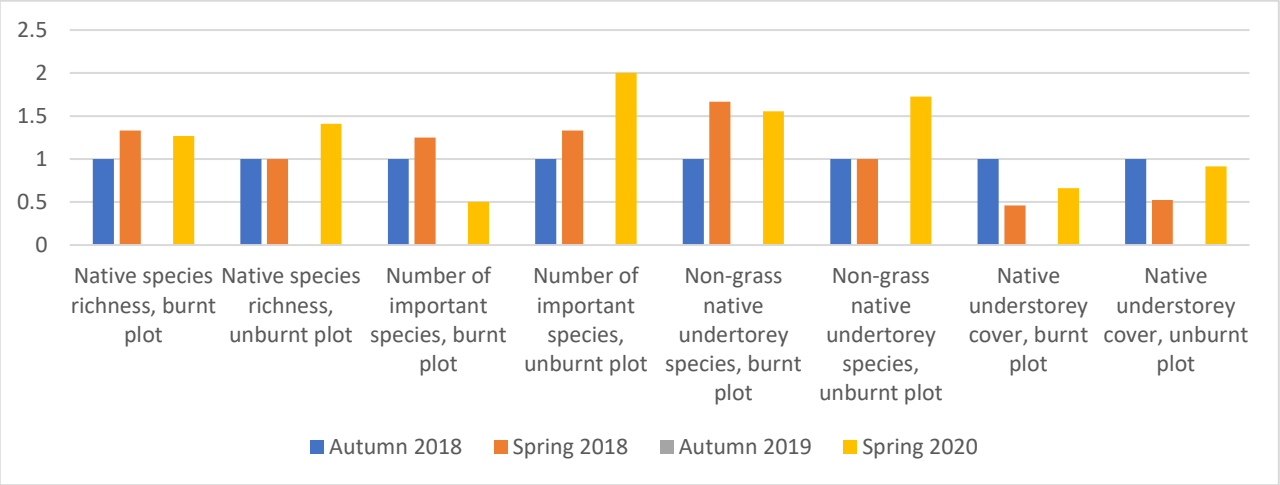


Figure W3. Proportional change (%) in native species condition indices. The initial values (pre-burn) set as 1. Surveys were not undertaken at Wandiyali in autumn 2019.

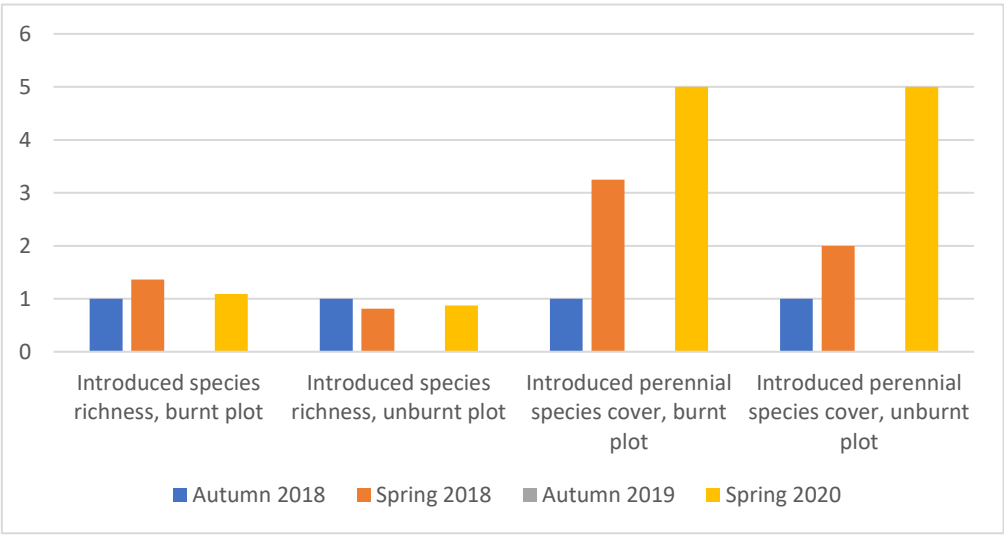


Figure W4. Proportional change (%) in introduced species condition indices. The initial values (pre-burn) are set at 1. Surveys were not undertaken at Wandiyali in autumn 2019.

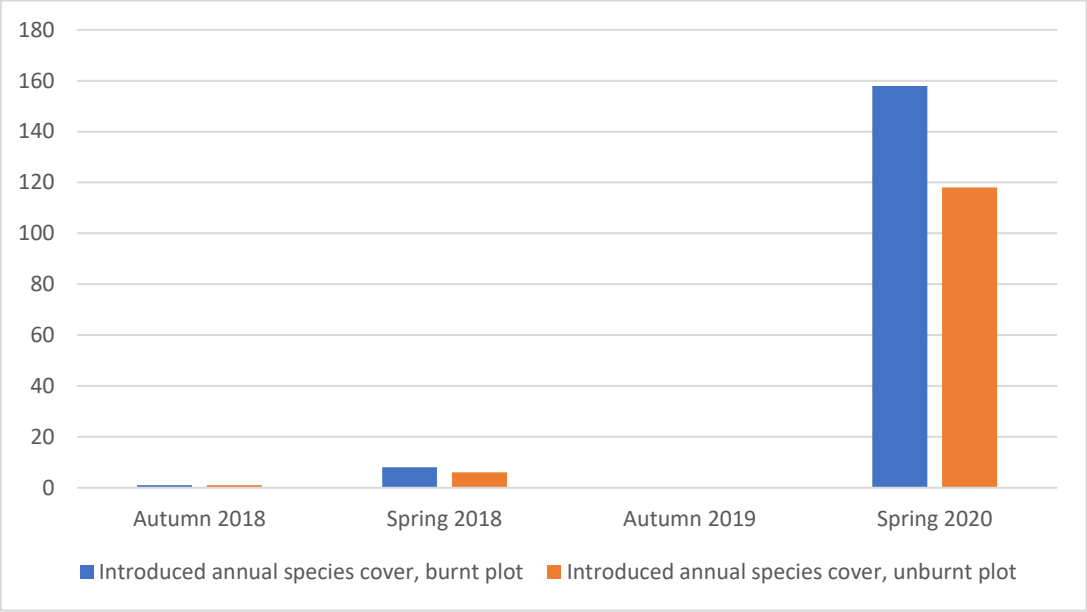


Figure W5. Proportional change (%) in introduced annual species cover. The initial values (pre-burn) are set at 1. Surveys were not undertaken at Wandiyali in autumn 2019.

Table W2. Trends in change in condition indices between the burnt and unburnt plots.

Condition score	Relative change in attributes following the burn	Comments
Native species richness	←→	Initial increase in burnt plot, after 2 years, no difference
Native non-grass species richness	←→	Initial increase in burnt plot, after 2 years, no difference
Important species richness	←→	Initially a similar number in both plots, 2 years post burn there was a decrease in the burnt plot. (unlikely due to the burn)
Native understorey cover (to 1 m)	←→	2 years post burn there was a decrease in the burnt plot. (unlikely due to the burn)
Introduced species richness	←→	Initial increase in burnt plot, after 2 years, no difference
Perennial introduced u'storey cover	←→	Initial increase in burnt plot, after 2 years, no difference
Annual introduced u'storey cover	←→	Similar changes in both burnt and unburnt plots; the Increase in both the burnt and unburnt plots in 2020 is likely to be a result of the high rainfall.

Discussion and conclusions

Any change in condition after the burns were apparent only in the first spring after the burn. After two years there was no evidence of any differences between the burnt and unburnt plots.

In the initial survey in autumn neither of the plots met the criteria as critically endangered box-gum woodland. The burnt plot met the criteria after the burn and again in spring 2020, and the unburnt plot met the criteria in 2020. The change in status of the plots over time indicate the importance of taking into account seasonal variation (time of survey and climatic conditions) in assessing whether a site meets the criteria as critically endangered.

Species list, Wandiyali Conservation Area.

Species in blue are woodland 'important species' as defined in the Critically Endangered Ecological Community criteria. Species in red are invasive species (refer to Attachment A for an explanation).

		Burnt plot			Unburnt plot		
Species Name	**Common name**	**28/03/2018**	**18/10/2018**	**27/10/2020**	**28/03/2018**	**18/10/2018**	**17/10/2020**
Native grasses							
Anthosachne scabra	Common Wheatgrass			Rare			Rare
Asperula conferta	Common Woodruff			Occasional			Occasional
Austrostipa bigeniculata	Kneed Speargrass				Occasional	Occasional	Occasional
Austrostipa sp.	a speargrass	Occasional	Occasional				
Bothriochloa macra	Redleg Grass	Occasional	Occasional	Rare	Occasional	Occasional	
Panicum effusum	Hairy Panic	Occasional	Occasional		Occasional	Occasional	
Poa sieberiana	Snow Grass	Occasional		Occasional		Occasional	Occasional
Rytidosperma pallidum	Red-anthered Wallaby Grass				Rare		
Rytidosperma spp.	wallaby grasses	Rare	Occasional	Occasional	Rare	Occasional	Occasional
Themeda triandra	Kangaroo Grass	Common	Common	Occasional	Common	Common	Common
Native forbs							
Acaena ovina	Sheep's Burr		Occasional	Rare	Rare	Occasional	Occasional
Bulbine bulbosa	Bulbine Lily						Rare
Carex inversa	Knob Sedge	Occasional		Occasional	Occasional		Occasional
Chrysocephalum apiculatum	Common Everlasting						Rare
Convolvulus angustissimus	Australian Bindweed		Occasional		Rare		
Crassula sieberiana	Australian Stonecrop			Occasional			Occasional
Cymbonotus lawsonianus	Bear's Ears		Rare	Occasional			Occasional
Daucus glochidiatus	Australian Carrot			Rare			Rare
Epilobium billardiereanum	Variable Willowherb	Occasional	Occasional		Occasional		
Erodium crinitum	Blue Storksbill		Occasional			Occasional	Occasional
Euchiton involucratus	Star Cudweed			Occasional			
Euchiton sphaericus	Japanese Cudweed			Occasional			Occasional
Euphorbia dallachyana	Caustic Weed				Rare		
Geranium sp. 1	a geranium	Occasional	Occasional	Occasional	Occasional	Occasional	Occasional
Geranium sp. 2	a geranium		Occasional	Occasional		Occasional	Occasional
Juncus filicaulis?	Thread Rush?		Rare				
Lomandra bracteata	Small Matrush	Occasional	Occasional	Occasional	Occasional	Occasional	Occasional
Lomandra filiformis subsp. *coriacea*	Wattle Matrush	Occasional	Occasional		Occasional	Rare	
Lomandra filiformis subsp. *filiformis*	Wattle Matrush		Occasional				
Lomandra longifolia	Long-leaved Matrush					Rare	Rare
Myosotis australis	Australian Forget-me-not						Rare
Oxalis perennans	Native Oxalis		Occasional	Occasional	Occasional	Rare	Occasional
Rumex brownii	Swamp Dock	Rare	Occasional	Rare	Occasional	Rare	Rare
Schoenus apogon	Common Bogsedge	Occasional	Occasional			Occasional	
Tricoryne elatior		Rare	Occasional				
Vittadinia cuneata	Fuzzweed	Rare		Rare			
Vittadinia muelleri	Narrow-leaved New Holland Daisy				Occasional	Rare	Occasional
Wurmbea dioica	Early Nancy						Rare
Introduced species							
Avena sp.	Wild Oats		Occasional	Common	Rare	Occasional	Occasional
Bellardia latifolia	Red Bartsia						Occasional
Bromus hordeaceus	Soft Brome	Rare	Occasional	Occasional	Occasional	Occasional	Occasional
Carduus nutans	Nodding Thistle		Rare				
Carthamus lanatus	Saffron Thistle					Rare	Rare
Centaurium erythraea	Common Centaury				Rare		
Cirsium vulgare	Spear Thistle	Rare	Rare		Occasional	Occasional	Rare
Echium plantagineum	Paterson's Curse	Occasional	Occasional	Occasional	Occasional		Occasional
Hirschfeldia incana	Buchan Weed	Occasional			Occasional		

		Burnt plot			Unburnt plot		
Species Name	**Common name**	**28/03/2018**	**18/10/2018**	**27/10/2020**	**28/03/2018**	**18/10/2018**	**17/10/2020**
Hypericum perforatum	St John's Wort	Occasional	Occasional		Occasional	Occasional	
Hypochaeris glabra	Smooth Catsear		Occasional				
Hypochaeris radicata	Catsear	Rare	Occasional	Occasional	Rare	Occasional	Occasional
Lepidium sp.	an introduced peppercress						Rare
Modiola caroliniana	Red-flowered Mallow		Rare				
Orobanche minor	Lesser Broomrape			Rare			Rare
Paspalum dilatatum	Paspalum	Rare					
Petrorhagia nanteuilii	Proliferous Pink			Occasional			
Plantago lanceolata	Plantain		Occasional	Occasional	Occasional	Occasional	Occasional
Rosa rubiginosa	Briar Rose				Rare	Rare	
Rumex acetosella	Sheep Sorrell	Occasional	Occasional	Occasional	Occasional	Occasional	Occasional
Sanguisorba minor	Salad Burnet				Rare	Rare	
Thistle 1	unidentified thistle				Rare	Occasional	
Tragopogon sp.	Salsify		Rare				
Trifolium arvense	Hare's Foot Clover			Occasional			Occasional
Trifolium repens	White Clover	Occasional	Occasional	Common	Occasional	Occasional	Occasional
Verbascum virgatum	Twiggy Mullein	Rare	Occasional	Rare	Rare	Rare	
Vulpia sp.	Rat's Tailed Fescue	Occasional	Rare	Occasional			Occasional

Rare: less than 4 specimens; Occasional: less than 25% cover; Common: 26-75% cover.