Applying gap and disturbance treatments for establishing forbs in a remnant Native grassland

Interim report

Merri Creek Management Committee
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Summary

Historical records, research trials and observations suggest that reintroducing a degree of soil disturbance might be beneficial for restoring flora diversity in floristically depauperate Victorian Volcanic Plains Grassland remnants. Researchers have also identified the importance of gaps between tussock grasses for seedling survivorship in native grasslands (eg. Morgan, 2011).

This study examined the germination and establishment from seed of a forb species, (*Calocephalus citreus*) in the presence of both gap creation and soil disturbance in a managed remnant grassland reserve. The study combines soil disturbance and gap creation methods that have been successfully applied separately by researchers in previous studies. This report provides results to the 2 month establishment stage. Further monitoring and reporting on later milestones is planned.

An attempt to establish seedlings in 2012 failed, apparently due to unseasonably dry conditions in spring. A second round of seeding that commenced in autumn 2013 is showing good results with an estimated 28% of sown seed reaching seedling stage at the two month mark.

Slightly higher seedling survivorship is being observed for plots with cages designed to prevent damage from kangaroos. No differences in plant survivorship between plots with two different levels of weed control have been detected to date.

The imperatives for developing this technique for restoration, research and proposed cultural projects are discussed.

This trial has been developed and monitored with staff from MCMC employed primarily as field technicians and with limited input from academic institutions. Some of the challenges and opportunities are touched on throughout this report.

Introduction

Records by the earliest European observers indicate that at the time of colonisation, the harvesting of roots for food on plains in Victoria by aboriginal people was extensive. It is apparent that the digging occurred at a scale where the associated soil disturbance would have had significant ecological effects (Gott, 1992). Digging for roots may have created areas that favoured the germination of a subset of plants that could not otherwise establish among the dominant grassy cover.

The near-annihilation of traditional ways of life in southern Australia that followed European invasion also disrupted the ecological role played by digging for food on the Victorian Volcanic Plain. The rapid dispossession of the Traditional owners around Melbourne and suppression of their culture meant that important details of their contribution to soil disturbance processes were not recorded.

Concurrent with the removal of the influence of Traditional practices, the local extinction of small digging mammals such as Bettongs and Bandicoots removed another major source of disturbance to soils (sometimes termed ‘bioturbation’). The decline of some plant species on the Victorian Volcanic Plains is thought to be associated with the interruption to extensive, small-scale disturbance from these two sources (Robinson 2003 p 68.).

The quantity and diversity of native forbs is often equated with a grassland’s health and its similarity to the state of the grassland as it was under the management regime of Traditional owners at the time of colonisation e.g. ‘The few early European accounts of the Plains often refer … to the wealth of herbs, orchids, lilies and daisies growing among the grasses,…’ (Lunt, Barlow and Ross, 1998 p. 13). It is suspected that grassland with a high diversity of species may be more resilient to weed invasion (Tracy and Sanderson 2004). Pollination and subsequent seed viability has been shown to be carried out at a higher rate where forb diversity is high (eg. Fontaine 2006, Batáry 2010). Pollinator deficit is conjectured to play a role in further decline of remaining forb populations in small and fragmented reserves (Lennartson, 2002).

Trials by Robinson (2003), Reynolds (2006) and Dodd (2009) on forb establishment suggest that reintroducing a degree of soil disturbance might be beneficial for increasing flora diversity in current day grassland reserves. Research by Morgan (1997) indicated the role of gaps in grassland vegetation for forb establishment and the size of gaps needed for seedlings to establish successfully.

MCMC has developed a partnership with the Wurundjeri Tribe Land Cultural Heritage Council Inc. (WTLCHC). One of the key areas of cooperation has been to investigate and update activities based on Traditional Ecological Knowledge with proven ecological benefit and a high degree of cultural value for this area's traditional custodians. Digging's place in traditional culture means investigations are to be developed with regard to their value for fulfilling cultural as well as ecological needs. Investigations performed in partnership with Wurundjeri seek to engage community and share knowledge appropriately.

The primary purpose of this study is to identify whether germination and establishment of direct sown seed of a forb species is successful with a combination of gap creation and soil disturbance.

The value of emulating soil disturbance from traditional practices need to be assessed within the current day context of relictual and fragmented native grassland vegetation and in particular the presence of many invasive exotic plants and animals. Treatments need to be developed that take into account modified ecosystem responses and current conservation needs. A secondary aim of this report is to identify the level of maintenance needed to prevent weed recolonisation affecting seedling establishment and degrading grassland.

A notable feature of this grassland is the continued presence of a small mob (usually five) of Eastern Grey Kangaroos (*Macropus giganteus*), which exert a continuous, low-level of grazing pressure on the site. Kangaroos will potentially affect forb establishment by browsing or squashing small seedlings in their movements across the grassland. Protection from repeated disturbance by mammals was a factor in survivorship of young forbs in the study by Dodd (2009). Small cages have been applied to some plots to assess whether the level of establishment differs where kangaroos are excluded.

Methods

Study site and plot locations

Ngarri-djarrang (Central Creek) Grassland Reserve is in Reservoir, a northern suburb of Melbourne, Victoria, Australia (S37 41.777 E144 59.021). It is 9 ha in size and consists of remnant vegetation of Heavier Soils Plains Grassland Ecological Vegetation Class (Department of Sustainability & Environment, 2004).

The reserve contains a mosaic of different vegetation qualities ranging from high quality, diverse grassland to patches of weedy sward. Merri Creek Management Committee have applied weed control, planting, direct seeding and ecological burning to maintain and improve the quality of grassland vegetation at this site since 1993.

24 plot locations were selected in February 2012 within areas of vegetation of 'moderate' to 'high quality' (Bainbridge et al. 2010 p. 14). Areas were selected specifically because they were dominated by Kangaroo Grass (*Themeda triandra*) and contained little diversity of indigenous forbs. Sites were avoided that contained uncommon or significant plant species. Vegetation species composition and cover in the plots was recorded. Plots were located in two areas that were to be subjected to ecological burning in March 2012. Post-burn conditions were considered likely to provide favourable conditions for weed control, suppression of slug populations, seedling establishment and follow up maintenance. Plots were marked with a short starpicket in the south west corner and roughly aligned with compass bearings.

Gap creation

Vegetation within 1 square metre patches were treated with herbicide application on 23rd February 2012. Initial spray-out was with glyphosate (Roundup Biactive 360 gm/L, Monsanto) at a rate of 1:100 parts water. A spray shield was used to limit off-target spray and make consistent gap size (see Appendix 3, Figure 7). Removal of above-ground parts of rhizomatous indigenous forbs was carried out where these species were noticed prior to spraying in an effort to reduce herbicide uptake and so retain these plants.

Burning of the areas containing the plots occurred on 30th March 2012 as part of the ecological burning regime of the reserve.

Plots were re-treated with herbicide on 16th May 2012 with Glyphosate (Roundup Biactive 360 gm/L, Monsanto) at a rate of 1:100 parts water and Metsulfuron methyl (‘Esteem’ 600g/kg Metsulfuron methyl, Sipcam Pacific Australia Pty Ltd.) at 0.5g/5L. The metsulfuron methyl herbicide was used to treat the abundant regrowth of the bulbous weeds **Allium vineale* and **Romulea rosea* within the plots.

Disturbance

Disturbance and seeding of plots took place on 28th and 30th August 2012. Disturbance was applied to the central 50x50cm within each 1 m gap (See Figure 1 below).

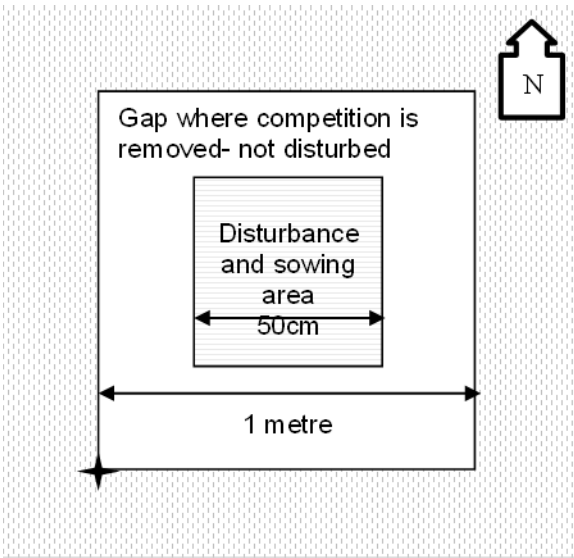

Figure 1 Plot layout

Disturbance of the soil was timed for when the soils was moist but not sodden to provide conditions where a fine tilth of soil could be created. However, soil moisture conditions were found to vary widely between plots and this affected the degree to which soil lumps could be broken down.
Disturbance was carried out to a depth of at least 20cm within the plots (See Appendix 3, Fig. 8), using mattocks and other metal hand-tools. Using hands and hand-tools, soil was manually pulverised prior to refilling the disturbance zone.

For the second attempt at direct seeding in 2013, the same plots were used and the disturbance of the plots was repeated as above however sowing occurred several days later rather than immediately following disturbance.

Direct seeding

Seed for the trial in 2012 was collected in February 2012 from a large (several thousand plants) population of *Calocephalus citreus* from a grassland reserve approximately 4km away from the trial site. Seed for the 2013 trial attempt was sourced from a smaller population (a few hundred plants) in February/March 2013 from a grassland reserve approximately 18 kilometres away from the trial site.

Collected seed was supplied to Victoria University where it was assessed for quantity and germinability of seed. Seed was batched to create packets with sufficient seed and chaff to contain approximately 100 viable seeds. In 2012, sufficient seed for all 24 plots was available for sowing. In the 2013 trial, sufficient seed for only 21 seed packets was collected so three plots were removed from the trial. Two of these plots were chosen on the basis of being the most 'wet' and thus likely to be less suitable for *Calocephalus citreus* (which generally prefers drier soils). These were subsequently used for a trial of seeding by moisture loving *Microseris scapigera*.

Shallow furrows were scratched into the surface to shield seedlings from high winds and retain moisture as recommended by Dodd (2009, p. 84). Packets of *Calocephalus citreus* seed were mixed with a cup of dry builder's sand to help disperse seed. The seed-sand mix was sprinkled by hand across each central 50x50cm patch of disturbed ground. The patches were then watered with approximately 2 litres of water.

Weed management

In the 2012 trial, three different maintenance regimes were to be compared; ten plots receiving 1 monthly tending, 10 receiving 3 monthly tending and 4 controls with no tending at all.

'Tending' includes handpulling of all seedlings and regrowth of exotic plants and of large indigenous grass seedlings (*Poa labillardierei*, *Themeda triandra* and *Austrostipa spp*). Other indigenous forbs and smaller grasses were to be left in place. Unidentifiable seedlings were to be left in place until a positive ID can be made. Handweeding was done as carefully as possible to prevent damage to emerging seedlings.

Handpulling was conducted by crew members with existing skills in plant ID and vegetation management. The species and cover of weeds and indigenous plants was recorded during each monitoring survey. Time taken to tend plots was recorded to establish the labour requirements of maintaining sown sites.

After the failure of the 2012 trial, the plots were inadvertently left without maintenance from the end of October 2012 till the end of June 2013. On recommencing the trial in 2013, it was recognised that the gap zones had been overlooked and needed to be reinstated to maintain their role as a low-competition buffer. The species and cover of regrowing plants in the gap zones was recorded before weeding of the sites was undertaken. Results from this survey are included in Appendix 1.

The results of this assessment provided data on the likely consequences of the 'no tending' controls. Given the undesirability of retaining weedy 'no-treatment' controls in the long term, the four 'no-treatment' plots will be re-assigned to other treatments; three to 'monthly' and one to 'three monthly'. This will also re-establish the number of replicates of treatments that had been reduced due to seed unavailability in 2013.

Kangaroo exclusion

Simple kangaroo exclusion cages were installed on 12 of the 24 plots in the week after sowing. These consist of a large square of chicken wire infolded along its corners to create a more or less rigid structure approximately 20 cm high (See Appendix 3, Figure 9). The cages are pinned to the earth with weedmat pins approximately 10cm long.
This design has a low profile that makes the cages inconspicuous and so less prone to theft or vandalism. The design includes gaps in the base of the structure to reduce the likelihood of reptile entrapment. The pins allow for ready removal for assessment and plot maintenance.

Monitoring

Monitoring of plots through the first two months took place every two weeks to help identify critical factors in mortality. A record sheet for recording information was developed and is included as Appendix 4. A grid was created from a fencing mesh panel with 5cm openings to assist in methodical counting as well as to assist tracking of individual seedlings. This tool is shown in Appendix 3, Figure 11.

Herbivory by slugs, millipedes and Red-legged Earth Mites (RLEM) are likely to reduce seedling establishment. Invertebrate guards for protecting seedlings were described by Robinson (2004) but these appear to require high maintenance and would be vulnerable to vandalism at this site. Organophosphate chemicals typically used for RLEM control are not used by MCMC. These trials therefore proceeded without treatment for invertebrate herbivores and surveyors were merely to monitor RLEM, millipedes and molluscs.

Results and Discussion

The sowing of seeds in 2012 failed. A description of the attempt and reasons for this failure are included as Appendix 2. The regeneration and weed invasion that occurred in the 'gap' zones of the plots between the 2012 and the 2013 trials was assessed in June 2013. Data and a summary of the survey is included in Appendix 1.

Results of the 2013 trial

Seedling emergence and survival

Seeding of 21 of the original 24 plots took place in 23rd May 2012. Weather subsequent to sowing was favorable for germination with rainfall at or above average. (see Figure 2 below).

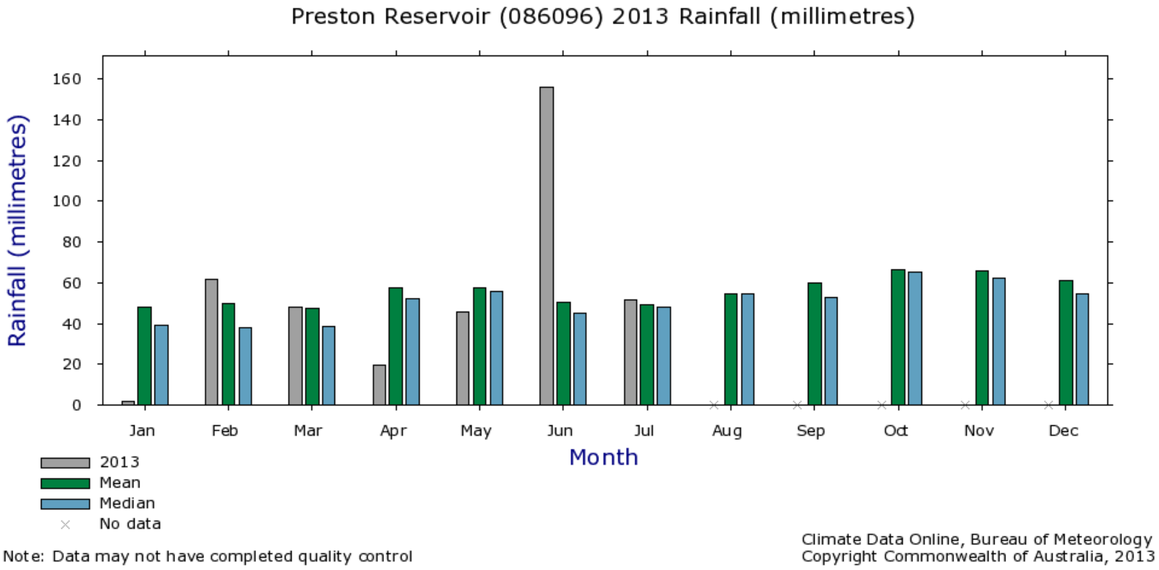

Figure 2 Rainfall records for 2013

Seedling numbers across the 21 plots increased from 468 seedlings 14 days after sowing to 1385 at the 1 month from sowing. A decline in numbers of surviving seedlings has been noted at subsequent surveys at the 6 week and 2 month mark. (see Figure 3 below)

Survivorship thus far appears to be following a typical Type III survivorship curve (species that generate large numbers of offspring). At 56 days from sowing, an average of 28 seedlings per plot was present with a standard deviation of 17.6.

A target of approximately 5 mature plants within the 50 x 50 cm square has been selected as a target to emulate natural densities of sites where this species is common (e.g. see Appendix 3, Figure 13). At the two month mark, only four plots had less than ten surviving plants, with the least successful plot having 5 plants.

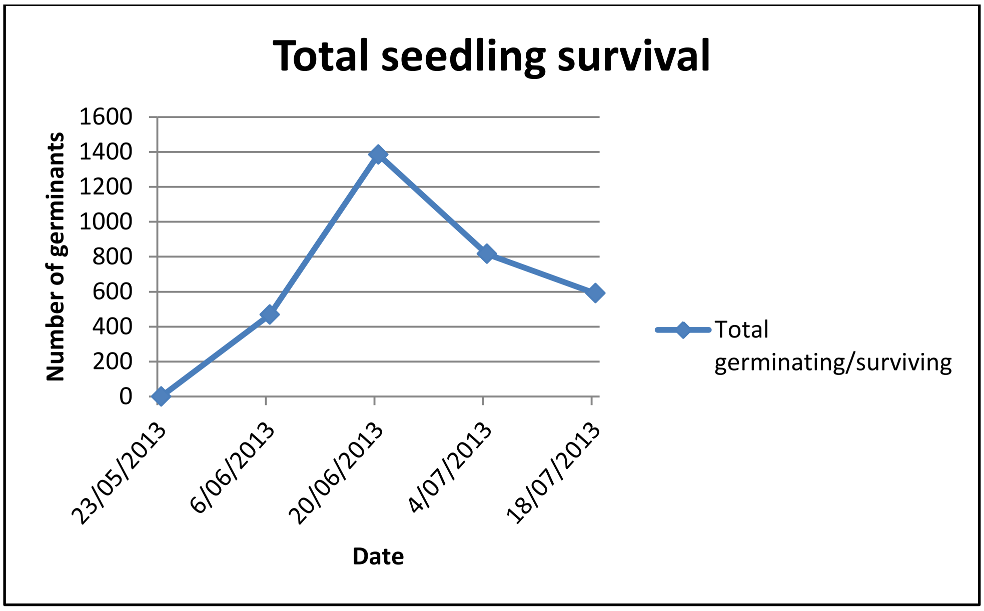

Figure 3 Total seedlings extant over time

Kangaroo exclosures

Of the 21 patches seeded in 2013 there are 12 plots with exclosures and 9 without. At two months, a slightly greater number of seedlings is present in the plots with exclosures compared with the plots without exclosures, however the difference is not statistically significant at the 95% confidence interval (see Figure 4 below).

Observations of paw-prints (see Appendix 3, Figure 10) within most of the uncovered plots suggest that squashing of seedlings could constitute a significant threat to seedling survival. Within grassland, patches of bare ground presumably provide a preferred route for a moving kangaroo due to greater visibility so gaps may be subjected to increased kangaroo traffic compared to vegetated ground. This may be especially severe where plots are close to existing movement routes (e.g. between 'loafing' areas and feeding or accessible drinking points).

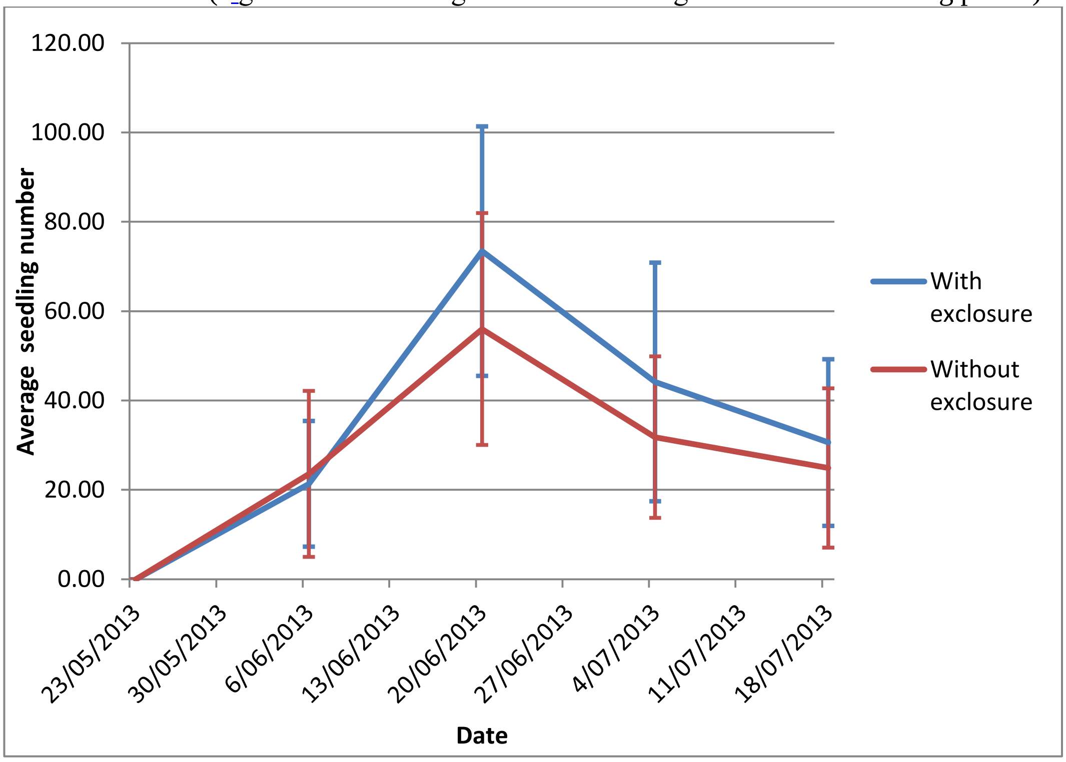

Figure 4 Average seedlings present (including st. dev.) with and without exclosure

It is likely that the number of plots is insufficient to provide such evidence given the variables of this site. A larger number of samples using plot layouts that are either randomized or stratified to consider the movements of kangaroos would be needed.

Maintenance levels

At the two month mark, only small differences are apparent in seedling numbers present between plots subject to different maintenance frequencies however these differences are not significant. See Figure 5 below.

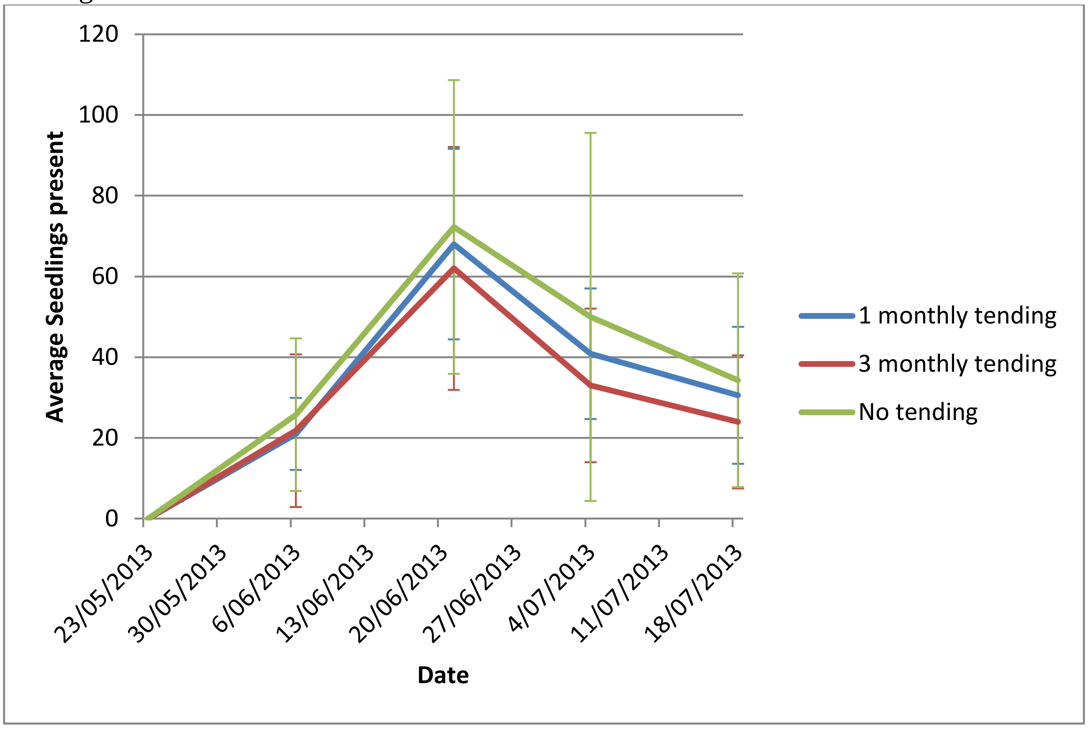

Figure 5 Average seedlings present in plots with different tending levels

The time spent monitoring and maintaining plots was recorded and the average calculated separately for those plots that had maintenance compared with those that had no maintenance. These figures are presented in Table 1 below.

If the average spent on sites receiving monitoring alone is subtracted from sites receiving monitoring + maintenance, a rough estimate of time spent on maintenance per plot is calculated. 1.4 minutes was spent on tending (handweeding) on the 20/6/13 and this increased to 4.3 minutes for the 18/7/13 round. It is anticipated that tending time will need to increase in the spring time monitoring visits and then reduce over summer.

Table 1 Mean Monitoring and maintenance times for sites

Date of visit*	20/6/2013	4/7/2013	18/7/2013
Total time spent monitoring (minutes)	197	163	231
Mean monitoring time (mins), without tending	8	8.6	9.6
Mean monitoring time (mins) with weed removal	9.4	N/A	13.9

**Time spent monitoring was not recorded for the first monitoring visit on 6/6/13. Due to delays, data included the 20/6/13 date was collected over three dates, and one figure included in 18/7/13 column was collected on 31/7/13. Plots were not scheduled for tending on the 4/7/13 monitoring visit.*

Monitoring methods

During conduct of this trial, limitations in the experimental design and varying levels of skill in field staff conducting monitoring have at times affected the confidence in the results.

The following elements needed greater attention;

- alignment of monitoring grid onto disturbed zone was variable, reducing capacity to correlate seedlings between survey periods. Pins are to be inserted into the ground for all corners to provide guides for placing the grid.
- Identification of small germinants requires the use of visual guides and, preferably, mentoring with experienced observers. A database of images of seedlings of the grassland is being developed to generate seedling ID charts.
- increased monitoring frequency was determined as necessary following the 2012 trial in order to identify critical early mortality factors.

Application of this work for cultural projects

Developing a reliable means of increasing forb diversity and managing the impact of enhanced weed growth are important pre-requisites for proposed cultural activities in native grasslands that involve soil disturbance. Merri Creek Management Committee has commenced investigations with the Wurundjeri Tribe Land Compensation and Cultural Heritage Council into using the grasslands as a venue for activities such as digging and enhancing populations of tuberous food plants used by traditional custodians of the area. Such activities have potential to re-develop connection to country, Traditional Ecological Knowledge and for cultural interpretation.

It is hoped that principles and practices needed to conduct soil disturbance that result in ecological benefits will be deduced from these studies and can then be applied as part of processes conducted for cultural purposes as well as being incorporated into routine management of the grassland for ecological purposes.

Conclusion

This interim report documents that abundant seedling establishment to the two month stage is possible for the forb species, *Calocephalus citreus*, using the combination of gap and disturbance treatments described. The success of the technique and its feasibility as a means of re-establishing a species in natural grassland will be assessed when later milestones, in particular flowering and seeding are reached.

Maintenance needs for gap and disturbance to ensure treated areas don't degrade from enhanced weed establishment are still to be determined.

Evidence of improved survivorship from using kangaroo exclusion cages is still weak. However the low cost~~,~~ installation and maintenance requirements of the cages used for this project suggest they be included in direct seeding projects wherever kangaroos are plentiful and there is a need to maximize the outcomes from scarce seed sources and high labour inputs.

The fate of the 2012 seeding attempt indicates that autumn sowing may be more reliable in the Merri catchment area than spring. Autumn sowing makes it an imperative to begin establishing plots 10 to 12 months in advance owing to the need to ensure treatment of winter-active bulbous weeds and ensure that sufficient degradation of residual herbicides has taken place to prevent affecting sown seed.

Resources to develop skills in identification of seedlings such as mentoring staff and developing identification resources is critical for effective monitoring and tending of direct seeding projects.

Progressions from this study to consider for future trials or academic collaborations include;

1. Identify whether remnant or planted plants can form a reliable source of seed for gap and disturbance plots established adjacent to them (forming the basis of a technique that can be integrated into routine management of grasslands).
2. Test application of disturbance/gap creation for other species of conservation significance in the Merri Creek valley including; *Chrysocephalum* sp. 1, *Geranium* sp. 1, *Helichrysum sp.* aff. *rutidolepis, Velleia paradoxa, Glycine tabacina, Bulbine bulbosa, Pimelea glauca, Dillwynia cinerascens, Ptilotus spathulatus, Arthropodium milleflorum, Goodenia pinnatifida.*
3. Identify whether variations in method are needed to apply the technique in grassland microclimates such as gilgai and stony knoll habitats
4. Investigate the effect of applying control methods for Red-legged earth-mite, exotic millipedes, slugs and snails.
5. Investigate interaction between timing of application of gap and disturbance treatments with ecological burns.
6. Investigate whether activity of different guilds of nectar and pollen feeding invertebrates respond to the increased availability of flowering forbs in a grassland reserve resulting from successful application of these techniques.

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Appendices

Appendix 1 Recolonisation of undisturbed 'gap' zones

Species and cover of plants that colonised the 'gap' zones in the hiatus between the 2012 and 2013 trials (13 months since last herbicide application) were assessed on 25th June 2013, prior to weeding to re-establish their low-competition condition. This included;

- those species retained within the site deliberately (through protection from herbicide)
- species that spread from outside of the plot
- species establishing from seed.

26 indigenous plant species and 18 introduced species persisted in or colonised the unmaintained buffer zones. Three species had an average cover greater than 1%: *Themeda triandra* (16%), **Briza* spp. (3.9%) and **Plantago lanceolata* (7.7%). *Themeda triandra* and **Romulea rosea* occurred in all plots and **Plantago lanceolata* in 96% of plots.

On average 20.3% indigenous and 13.3% exotic weed cover was recorded across all plots.

Table 2 Species cover and frequency in 'gap' zones of plots following 13 months of no intervention

Species	Average cover†	Freq. plots	Freq as a % of plots
INDIGENOUS			
Acaena echinata	0.0	1	4%
Arthropodium strictum	0.3	9	39%
Asperula conferta	0.3	10	43%
Austrostipa sp.	0.6	13	57%
Convolvulus sp.	0.0	1	4%
Dianella amoena	0.0	1	4%
Dichelachne crinita	0.0	1	4%
Elymus scaber	0.1	2	9%
Eryngium ovinum	0.0	1	4%
Galium sp.	0.0	1	4%
Geranium sp.	0.0	5	22%
Gonocarpus tetragynus	0.0	1	4%
Haloragis heterophylla	0.1	9	39%
Juncus sp.	0.1	1	4%
Lomandra filiformis	0.7	9	39%
Oxalis sp.	0.0	1	4%
Poa morrisii	0.2	4	17%
Poa labillardierei	0.6	10	43%
Pimelea sp.	0.0	2	9%
Rytidosperma sp.	0.2	5	22%
Senecio quadridentatus	0.2	7	30%
Shoenus apogon	0.3	8	35%
Themeda triandra	16.0	23	100%
Trichoryne elatior	0.3	8	35%
Veronica gracilis	0.2	7	30%
Wahlenbergia sp.	0.0	3	13%
**EXOTIC*			
**Allium vineale*	0.0	2	9%
**Annual grasses*	0.5	10	43%
**Brassica sp.*	0.0	4	17%
**Briza sp.*	3.9	14	61%
**Dactylis glomerata*	0.3	5	22%
**Hypochaeris radicata*	0.0	2	9%

**Linum trigynum*	0.0	1	4%
**Lolium multiflorum*	0.0	3	13%
**Medicago sp.*	0.0	1	4%
**Moraea sp. (M. miniata, M. flaccida)*	0.0	2	9%
**Nassella neesiana*	0.1	1	4%
**Phalaris aquatica*	0.2	4	17%
**Helminthotheca echioides*	0.0	1	4%
**Plantago lanceolata*	7.7	22	96%
**Romulea rosea*	0.3	23	100%
**Sonchus oleraceus*	0.1	2	9%
**Stellaria media*	0.0	1	4%
**Vicia sp.*	0.1	11	48%

†Cover percentages shown as ‘0.0’ are cover that is less than 0.1 %

Appendix 2. Fate of 2012 trial

Direct sowing trials by Robinson (2003) and Reynolds (2006) both occurred in August. Delays in getting seed processed and the preference to avoid sowing into areas recently sprayed with residual herbicide meant that the 2012 seeding trial did not occur until 28th August.

- 12/9/12 (15 days after sowing) - seedling germination was at an early stage observed.
- 20/9/12 (23 days from sowing) - 315 seedlings were counted
- 16/10/12 (49 days from sowing) - 29 seedlings were detected.
- A subsequent inspection in the following two weeks failed to detect any seedlings and monitoring of the plots was abandoned as weather became unsuitable for further establishment of seedlings.

Irregular rainfall and periods of dry, windy weather occurred in the weeks following sowing. Rainfall figures were significantly lower than average at Preston Reservoir weather station which is 3.2 km away (see Figure 6 below). During surveys, the soil was noted to be very dry and seedlings were found mainly on moist sites or in deep, sheltered crevices among the soil. The observations strongly suggested that dessication due to drying winds and low or irregular rainfall was the primary cause of mortality for seedlings and, possibly, failure to germinate. Preston Reservoir weather station records suggest June and July are the least variable months for rainfall in this area so sowing in May could reduce risk of seedlings trying to establish in a drought.

Shrivelled seedlings that might confirm desiccation as the cause of mortality could not be found. This might be due to the tiny size of the seedlings and relatively long intervals between surveys. It is therefore possible that predation of seedlings also played a role in the failure.

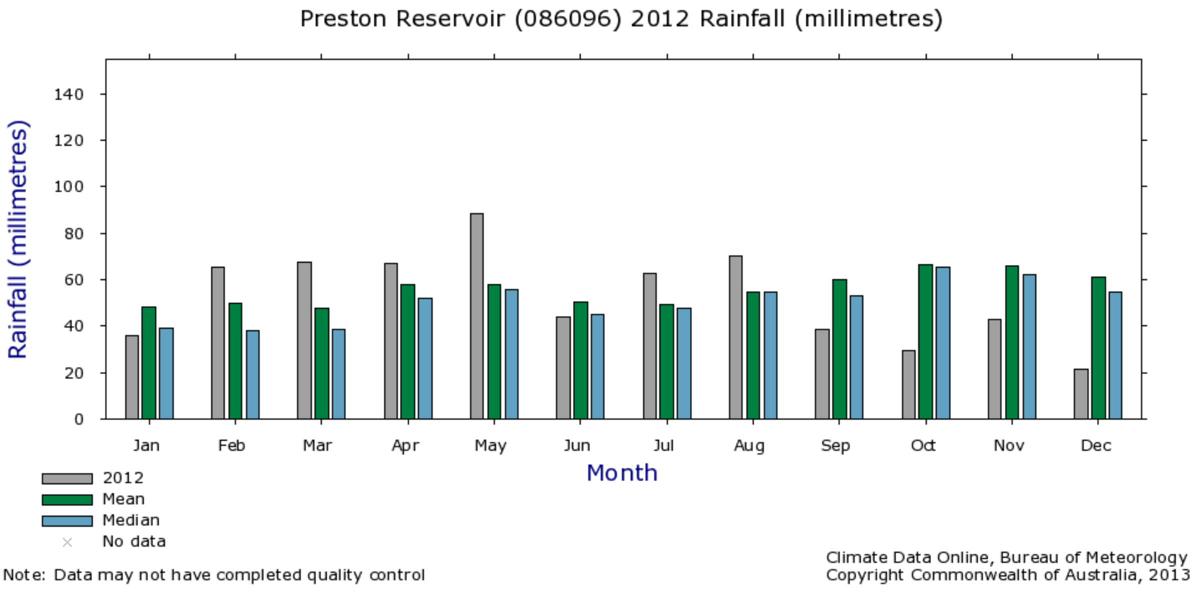

Figure 6 Rainfall data for Preston Reservoir for 2012

The application of herbicide containing metsulfuron-methyl (a soil active herbicide with residual action as a pre-emergent herbicide) three months before sowing is also conjectured as a possible reason for the poor results. The cultivation and redistribution of the soil through the profile would have greatly reduced the amount of herbicide residue on the surface where it would have most effect on germinating seed however a longer lead time would have been preferred.

The most serious bulbous weeds in this area (*Oxalis* spp., *Romulea rosea*, and *Moraea miniata*) emerge in autumn. For these weeds MCMC uses herbicides containing metsulfuron- methyl, which has soil-active residual action. This residual action can last for 6 months. Where bulbous weeds are to be treated, they will need to be targeted 9-12 months before an autumn seeding to maximise effect on weeds and minimise chances of residues effecting germination.

Appendix 3- Photos

Figure 7 Initial spray out showing spray shields in operation. February 2012. The lightweight spray shields have been constructed from wooden stakes and recycled tree-guards. They are cheap and can be quickly set up and moved between patches.

Figure 8 Soil removed from central 50cm square of gap to a depth of 20cm prior to pulverizing and refilling. A 'skirt' of weedmat was temporarily installed to reduce spilling into adjacent vegetation. .

Figure 9 Kangaroo exclusion cage constructed from folded chicken wire, pinned to the ground with weedmat pins.

Figure 10 Kangaroo prints in plot ND 14 in July 2013

Figure 11 Monitoring grid in use. Grid is constructed from a folded fencing panel with heavy-duty tape. The grid is also marked on the reverse, allowing it to form a raised grid approximately 15cm above the ground to allow it to be used on larger plants.

Figure 12. A cluster of seedlings of *Calocephalus citreus* at the 4-leaf stage, 68 days after sowing.

Figure 13 Dense stand of *Calocephalus citreus* at Cooper Street Grassland , Campbellfield in 2006 when this area was still subject to biomass reduction and disturbance due to horse grazing. Subsequently, removal of grazing has seen Kangaroo Grass become dominant and *Calocephalus* decline (similar to existing reserve visible beyond fenceline).

Appendix 4- Sample Data monitoring sheet

Gap & Disturbance trials for Forb establishment monitoring 12-13

Plot Code		**Surveyors**	**Date**
Tending	**Exclosure**	**Time start; : Time end; :**	**Time spent on monitoring + maintenance**
Seedling establishment			
No. surviving germinants			
% cover			
5 largest plants			
Height (mm)	Width (mm)		
			Notes on mortality *dessication, waterlogging, browsing, unknown*
Flower production			
No. flowerheads			

						N						
		A	B	C	D	E	F	G	H	I	J	
	1											
	2											
	3											
	4											
W	5											E
	6											
	7											
	8											
	9											
	10											
						S						

Weeds & indigenous grasses		
Species	Percentage cover	Notes/treatment

Other indigenous plants		
Species	Percentage cover/origin/location	Notes
	% / /	
	% / /	
	% / /	
	% / /	
	% / /	
	% / /	

Herbivory	Extent	Evidence
Kangaroo, Prints, browsing, observed, Red-legged Earth-mite, Silvery markings, mites Millipedes ; Millipedes observed, Molluscs ; Slime trails		