

Quantifying the impact of land management practices on priority remnant vegetation across the dryland Mallee landscape:

Interim report

Phase 5: Collection of baseline data at additional sites

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Cover images

Three monitoring sites established in 2013. Photos: Claire Moxham

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Project partners

Quantifying the impact of stock exclusion fencing on remnant vegetation

Phase 5: Collecting baseline data at additional sites

April 2014

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Executive Summary

The Land and Biodiversity program within the Mallee Catchment Management Authority (Mallee CMA) is implementing an asset based approach to natural resource management in the Mallee (MCMA 2008). The Mallee CMA engaged the Department of Environment and Primary Industries, Arthur Rylah Institute for Environmental Research (DEPI, ARI) to develop and implement a monitoring strategy to assess the impact of stock exclusion fencing (SEF) on the quality of priority remnant vegetation. This interim report documents the collection of baseline data at 15 additional sites that have stock exclusion fencing, and provides an overview of the implementation of the monitoring program to date.

Program implementation summary

In 2009 and 2010, 35 monitoring sites were established across three grazing treatments: grazed (controls), ungrazed SEF sites (ungrazed for less than 10 years) and long ungrazed (for more than 10 years) public land reference sites. At the two year monitoring interval in 2012, 25 of these sites were re-surveyed. However, at this time the grazed sites that were originally established as controls were no longer grazed due to destocking and thus can no longer be used as controls. Instead these sites have been incorporated into the stock exclusion treatments where appropriate (i.e. ungrazed sites). Thus the public land long ungrazed sites are used as comparison/reference locations.

In 2011, 39 sites (grazed, ungrazed and long ungrazed) were established to investigate and quantify the impact of SEF on native vegetation in linear remnants. The monitoring program method was adapted for the monitoring of vegetation patches with a high edge to area ratio which are abundant in the Mallee landscape.

In spring 2013, 15 new sites were established across ten farm properties to increase replication in the monitoring program. Of these, two sites were located on public land as long ungrazed reference sites.

The monitoring program now has 50 sites established, and a further 39 sites in linear remnants, totalling an impressive 89 monitoring sites in remnant vegetation across the Mallee landscape. Of the 50 sites, ten are on properties with stock containment areas which were not sampled at the second survey period (2012) due to resourcing. Thirty monitoring sites are in remnants on private land with stock exclusion fencing (including three long ungrazed reference sites), and the remaining 10 sites are reference sites on long ungrazed public land.

Recommendations

- The long term monitoring program articulated in Duncan and Moxham (2009) needs to be continued. As a minimum the monitoring sites need to be re-surveyed at five year intervals. It is also important to continue the monitoring of these sites to tease out the effects of climate and grazing exclusion. Sites established in 2009 and 2010 are due for monitoring in spring 2015 and sites established in 2013 are due for monitoring in spring 2018.
- Interim data analysis and reporting on project outcomes can be undertaken for selected sites in 2015/16 and on the linear remnant data set in 2016/17. However, a full comprehensive analysis should be undertaken across all data sets in 2018/19 when the sites established in 2013 are due for five year monitoring.

- Linear remnants monitoring sites established in 2011 are due for monitoring and analysis in spring 2016.
- The program now has amassed data for an impressive 89 sites in remnant vegetation across the Mallee landscape. Data mining (the use of existing data) should be explored to answer other ecological questions impacting native vegetation of the region. Data mining provides a cost effective mechanism to achieve conservation outcomes. Topics to be explored include:
    - ➢ *Landscape approach to grazing impacts across the Mallee*. Investigate the health of priority remnant vegetation across the Mallee landscape through comparison of remnants on private land and small to medium (5-10 ha) sized remnants on public land enabling a condition snapshot of remnant vegetation across the landscape to inform future conservation activities and benchmark existing remnant condition.
    - ➢ *Sustainability of tree populations across the Mallee*. Landscape-scale approach to tree structure, regeneration and long-term survival - providing essential data on the likely survival of target species (Black Box and Buloke) over the long-term and enabling targeting of conservation programs.
    - ➢ *Benchmarking ecosystem structure and health.* Defining goals for restoration through determining the 'ideal' Mallee plant community composition and structure would allow the success of conservation restoration activities to be measured.
- The monitoring program could be adapted to examine the success of revegetation sites across the Mallee landscape.

Introduction

Livestock exclusion

Livestock grazing is one of the main threatening processes to the retention of native vegetation in the Mallee (MCMA 2006). Overgrazing can result in an increase in bare ground (and subsequent erosion), soil compaction, altered nutrient levels and cycling (including water), increased weed abundance and reduced recruitment and survival of native plants (Lunt *et al.* 2007). Stock exclusion fencing (SEF) aims to provide long term protection to, and improve the health of, waterways and remnant vegetation. It is a simple and effective intervention method for protecting remnant native vegetation from livestock grazing pressure. There are multiple benefits in excluding stock from remnant vegetation (e.g. see Lunt *et al.* 2007). Release from grazing pressure can be critical in providing opportunities for trees, shrubs and grasses to flower, set seed and ultimately establish new individuals (recruitment).

Monitoring rationale

Significant investment in on-ground works has focused on reducing the threats to native vegetation including the threat from grazing (MCMA 2006). It is important to quantify changes in vegetation condition as a result of targeted intervention by the Mallee Catchment Management Authority (CMA). In this case the desired monitoring and management objective is achieving positive changes in vegetation condition through stock exclusion. Such improvements include a decrease in the cover of exotic species and the amount of bare ground, and an increase in the diversity and abundance of native species. However, data is required to assess the impact, of stock exclusion fencing on native vegetation recovery to inform conservation investments and document long-term changes. This long-term monitoring program aims to fill these knowledge gaps.

Ongoing monitoring of the impact of on-ground interventions to control stock on the Mallee's remnant vegetation is a critical part of the adaptive management learning cycle (Figure 1; Holling 1978, Ringold *et al.* 1996, Elzinga *et al.* 1998). This allows for the continuation of best practice management and appropriately targeted interventions across the dryland Mallee landscape. For further information on the rationale behind the current project see Duncan and Moxham (2009) and Moxham and Kenny (2013).

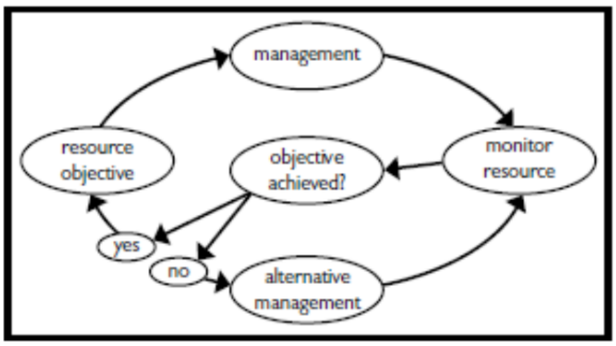


Figure 1. A successful adaptive management cycle. Monitoring provides the critical link between objectives and adaptive (alternative) management (from Elzinga *et al.* 1998).

Objective

The aim of the monitoring program is to determine, in the long-term, the impact of land management interventions, namely SEF, on protecting and restoring remnant vegetation across the Mallee landscape. Implementation of the monitoring strategy contributes to filling key ecological knowledge gaps about the long-term impacts of stock management practices on native vegetation quality. The outcomes of this monitoring will provide the Mallee CMA with valuable information on the implementation of targeted interventions to promote best practice in stock management to reduce threats to native vegetation (Duncan and Moxham 2009).

This report briefly summarises the establishment of 15 new monitoring sites across the Mallee. It also provides an overview of the implementation of the monitoring program and recommendations.

Methods

Landscape stratification

The monitoring program designed by Duncan and Moxham (2009; described briefly below) has been adapted over time to reflect monitoring priorities and resourcing. The program's main focus is the impact of stock exclusion fencing (SEF) on remnant vegetation in the Mallee.

Summary of initial site selection and original stratification

Site selection was initially stratified according to three grazing levels: grazed (controls), ungrazed SEF sites (ungrazed for less than 10 years) and long ungrazed (for more than 10 years) public land reference sites. Duncan and Moxham (2009) recommended that all remnant vegetation (public and private) be included for possible site selection in the monitoring program, because of the relative scarcity of large scale, long ungrazed vegetation on private land. In addition, most ungrazed remnants on private land have been released from grazing relatively recently (within the last five years).

Remnant sites had to be at least two hectares in size, non-linear in shape and have a known grazing history (see Duncan and Moxham 2009 for further detail). The vegetation needed to be representative of a target Ecological Vegetation Class (EVC)/Ecological Vegetation Division (EVD).

The EVD is the primary vegetation stratification unit rather than the EVC. Ecological Vegetation Divisions are groups of EVCs that have been aggregated based on ecological knowledge (Cheal 2010). Three EVDs are the target vegetation types for the program: Dry Woodland, Inland Plains Woodland and Saltbush Mallee. Semi-arid Woodland and Ridged Plains Mallee EVCs of the paleocoastal rises form the Dry Woodland EVD. Ecological Vegetation Classes that occur on relic floodplains, Plains Woodland and Plains Savannah were grouped into the Inland Plains Woodland EVD. Ecological Vegetation Classes that occur on aeolian dunefields and sandplains, Woorinen Mallee, Woorinen Sands Mallee and Chenopod Mallee form the Saltbush Mallee EVD.

Additional sites (2013)
In spring 2013, 15 new monitoring sites were established to increase replication in the monitoring program (Table 1). Of these, two monitoring sites were located on public land as long ungrazed reference sites. The 15 monitoring sites were distributed across three EVDs: Inland Plains Woodland, Dry Woodland and Saltbush Mallee (Table 2), and five EVCs: Semi-arid Woodland, Plains Woodland, Plains Savannah, Ridged Plains Mallee and Woorinen Mallee.

Table 1. The stratification of additional 15 SEF monitoring sites, within the Ecological Vegetation Divisions (EVDs) and grazing level treatments.

EVD	Grazing level treatment			Total
	Grazed*	Ungrazed	Long Ungrazed	
Dry Woodland		2	1	3
Inland Plains Woodland	2	8		10
Saltbush Mallee			2	2
Total	**2**	**10**	**3**	**15**

*Recently grazed at the time of establishing the monitoring sites; these sites are no longer grazed due to fencing and can be incorporated into the ungrazed treatment

Site synthesis
Thirty-five monitoring sites were established in 2009 and 2010 (13 grazed, 12 ungrazed and 10 long ungrazed remnants; Table 2), including nine sites from public land. These latter sites, representing all of the EVDs surveyed on private land, provide a reference set of long ungrazed sites for the area.

Twenty-five sites were re-surveyed in 2012 as part of the second phase of the monitoring program. Grazed sites on private land were originally established as control sites; however, due to destocking of most properties in 2010 these sites are no longer grazed and thus cannot be used as controls. Instead these sites have been incorporated into the stock exclusion treatments where appropriate (i.e. ungrazed sites) as they have not been grazed in the last two years.

In 2011, 39 sites (grazed, ungrazed and long ungrazed) were established to investigate and quantify the impact of SEF on native vegetation in linear remnants. The monitoring program method was adapted for the monitoring of vegetation patches with a high edge to area ratio, which are common in the Mallee region.

The monitoring program currently has established 50 monitoring sites, and a further 39 sites in linear remnants, totalling 89 monitoring sites in remnant vegetation across the Mallee (Table 2).

Table 2. Grazing treatments (as per the original stratification) and associated replication (number of sites) for the monitoring program.

Grazing treatment	Linear remnants	Quantification monitoring sites (year established)				Total
		2009	2010	2013	Total	
Grazed	13	4	9	2	15	28
Ungrazed	13	3	9	10	22	35
Long ungrazed	13	1	9	3	13	26
Total	**39**	**8**	**27**	**15**	**50**	**89**

Summary of monitoring methods

At each site a 50 x 20 m sampling plot was established in an area representative of the site. Care was taken to ensure that it was 20 m away from the edge of the remnant to lessen the impact of edge effects. The start of the 50 m transect was permanently marked with a star picket. Each sampling plot consisted of a 50 m transect, three 10 x 10 m quadrats randomly positioned along the transect, and five sub-transects (Figure 2)[1].

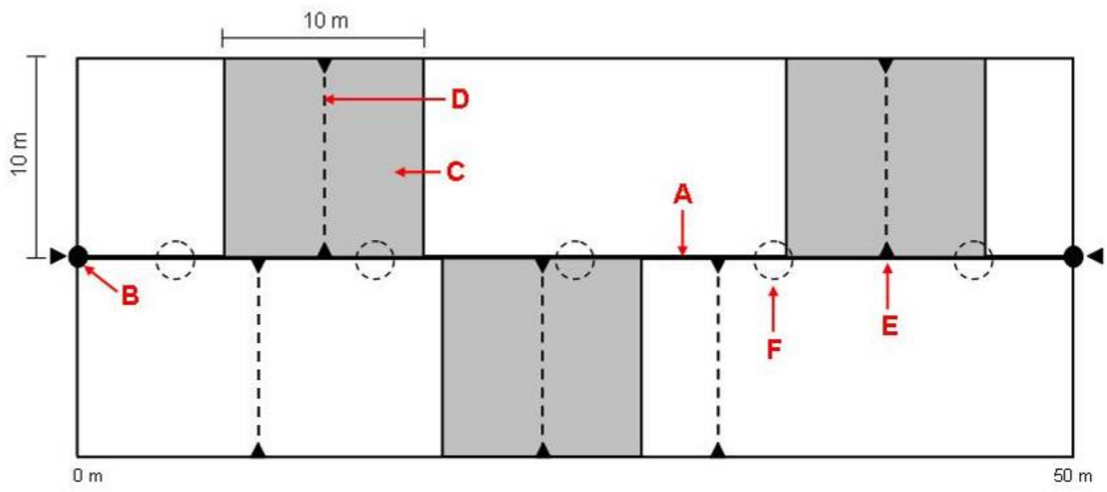


Figure 2. Sampling plot design, the 50 x 20 m sampling plot (modified from Rumpff *et al.* 2009). The elements of the sampling plot include: A = 50 m main transect, B = permanent marker pegs at both ends of the main transect (indicated by '□'), C = three random 10 x 10 m quadrats, D = 10 m sub-transects (indicated by dotted lines), E = 12 photo points (indicated by '▲'), and F = 5 canopy cover photo points (10 m intervals).

At the establishment of the sampling plots, six monitoring components were measured at each site (Table 3).

Table 3. Summary of monitoring components measured as part of the program.

Monitoring component	Monitoring Activity
1) Canopy Species Cover & Recruitment	1.1 Large Canopy Trees
	1.2 Length of Logs
	1.3 Canopy Photos
	1.4 Recruitment
2) Floristics	2.1 Floristic Search & Cover Abundance
3) Understorey Structure	3.1 Understorey Life Forms
4) Fixed Photo Points	4.1 Photo points
5) Soil Nutrient Sampling & Analysis	5.1 Soil Sampling
6) Habitat Hectares	6.1 Habitat Hectares Assessment

1) Canopy species cover and recruitment

Within the 50 x 20 m sampling plot, the species, number of canopy trees and actual DBH of each tree was recorded.

[1] Methods summary adapted from Duncan and Moxham 2009

The length and average diameter of all logs (> 10 cm diameter) within the sampling plots were measured and placed into one of ten length classes (10–20, 21–30, 31–40, 41–50, 51–60, 61–70, 71–80, 81–90, 91–100, > 100 cm).

Five digital images were taken at 10 m intervals along the 50 m central transect using a tripod-mounted digital camera, pointed directly upwards. The pixels in each image were then allocated to either canopy or sky on the basis of colour, using WINCAM (Regent Instruments 2002) software, to derive a value for average canopy cover.

Within each 10 x 10 m vegetation quadrat, all woody species (i.e. trees and large shrubs) were identified, and the DBH of each stem recorded. The number of all dead stems was also recorded to obtain a complete picture of the woody component of the site.

2) Floristics – species richness and composition

A comprehensive floristic survey, identifying all plant species present, was undertaken within the three vegetation quadrats (100 m^2). Each quadrat was randomly located along the main transect, without overlap. Direct percent cover for each species, bare ground, litter and biological soil crust was estimated.

3) Understorey structure – life form frequency

Ground cover (e.g. bare ground, litter and biological soil crust) and understorey life forms were recorded using the point quadrat method along five 10 m sub-transects. These sub-transects were randomly located along the main transect and ran perpendicular to it. At 5 cm intervals along each sub-transect, every life form and the number of hits in contact with a perpendicular steel pin (1 m tall) was recorded, providing 200 points per sub-transect, or 1000 points per sampling plot. Shrubs taller than 1 m were recorded if the foliage clearly intersected a vertical extension of the pin. Life form classes and descriptions follow DSE (2004). Life form classes also included ‘moss’ ‘bryophytes/lichen’, ‘rock’, ‘bare ground’, ‘logs’, ‘litter’ and ‘tree base’.

4) Fixed photo points

A range of photo points were established within each sampling plot. Photo point locations included the start and end of the main transect and each of the life form sub-transects, as well as at the south east corner of the three quadrats. Photographs were taken with a tripod where available for accuracy of repeating the photo.

5) Soil nutrient sampling and analysis

Within each quadrat, the top 10 cm of soil was sampled at five randomly selected locations. The five soil samples were pooled for each quadrat in a bag and mixed. A 200 g sub-sample (approximately) was then pooled for analysis. Soil analysis was undertaken by CSBP Limited Soil and Plant Analysis Laboratories, in Western Australia.

6) Habitat Hectares assessment

The general quality of the vegetation in each remnant was assessed using the ‘habitat hectares’ procedure (DSE 2004). This assessment produced two condition scores. The first provides an approximate index of the vegetation condition at a site in relation to a benchmark (score/75), the second (landscape score) provides an estimate of the landscape context of the site (score/25).

Analyses

This interim report presents summary data for the 15 sites and the associated grazing level treatments - grazed, ungrazed (SEF) and long ungrazed public land sites (including one SEF). The summary data focuses on the floristic data, namely plant species richness (total, native and exotic), species composition (life form cover and abundance) and species life cycles (perennial/annual).

Database development

An Access database has been developed to store the monitoring data. This allows data to be curated and manipulated for reporting purposes. Data collected in the linear remnants component of this monitoring program has also been incorporated into the database. Further development of this database could develop an interface to facilitate data entry.

Landholder reports

Eleven reports were developed to provide feedback on the progress of the monitoring program to participating landholders. These brief reports outlined the monitoring site location, EVC, Habitat Hectares condition score and a species list of all plants recorded at the site.

Survey Results

This section provides a descriptive summary of selected baseline data across the 15 sites. Note that the number of sites in each grazing sample is: grazed = two, ungrazed = ten, and long ungrazed = three.

Floristics - species richness and composition

The average cover of total, native and exotic species varied across the grazing levels (Figure 3a). Long ungrazed sites had the lowest cover of exotic species and the highest cover of native species. Total species cover was lowest in long ungrazed sites. Ungrazed sites had the highest cover of exotic species and total cover. The average total species richness was constant across the three grazing levels (Figure 3b). In general, long ungrazed sites had the highest native and lowest exotic species richness.

(a)

(b)

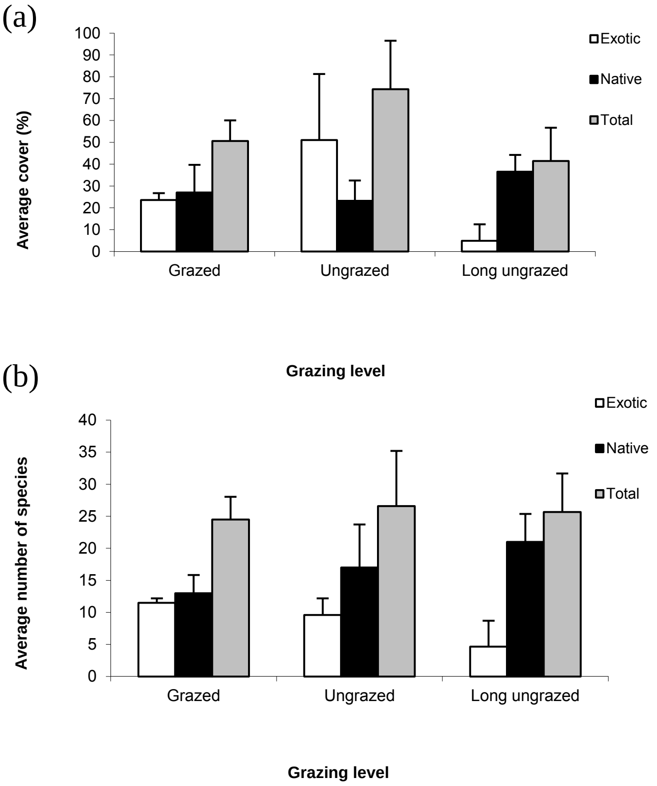
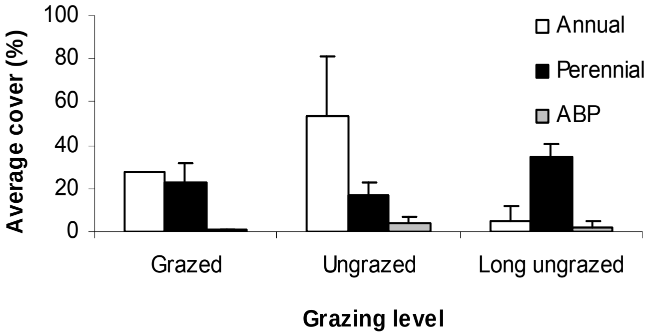


Figure 3. Average (a) percent cover and (b) species richness (± standard error) for total, native and exotic species for the three grazing levels (grazed, ungrazed and long ungrazed).

Species with an annual life cycle were more abundant at grazed and ungrazed sites in terms of both species richness and cover (Figure 4). Species with a perennial life cycle had the highest species richness and abundance in long ungrazed sites.

(a)



(b)

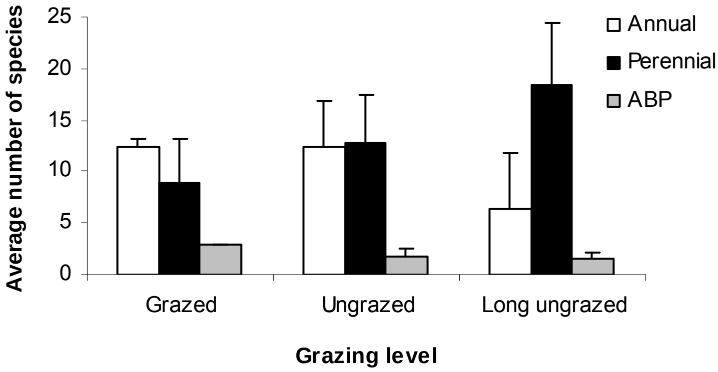


Figure 4. Average (a) percent cover and (b) species richness (± standard error) for perennial, annual and mixed (ABP = annual, biennial, perennial) species across the three grazing levels (grazed, ungrazed and long ungrazed).

Life forms

Grazed sites had a high cover of bare ground (50%), with litter, graminoids (grasses), herbs and trees dominating the remaining 50% (Figure 5). Whereas, the ungrazed and long ungrazed sites had a greater diversity of life forms and environmental attributes distributed more evenly across the site.

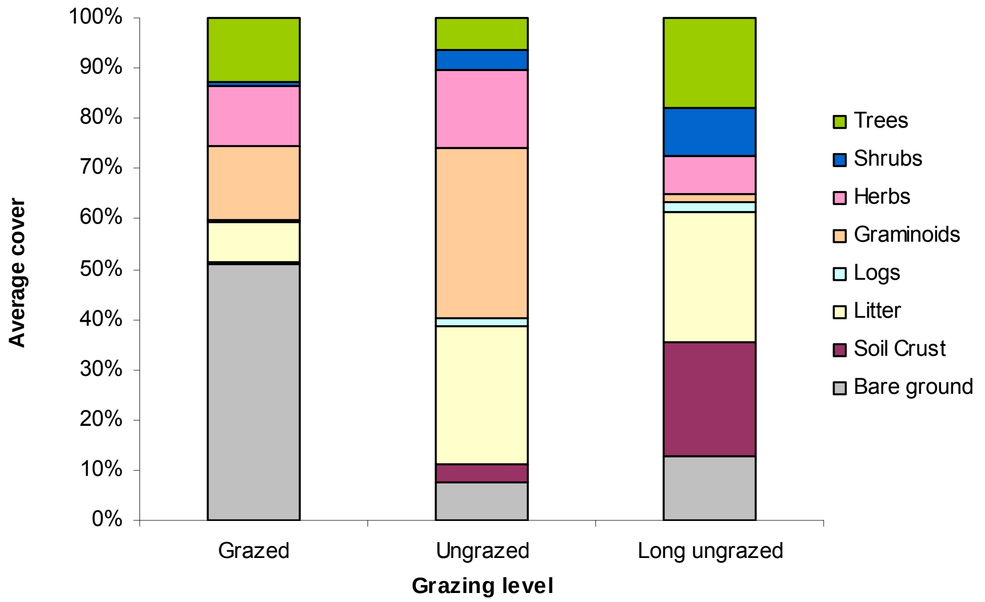


Figure 5. Average life form and environmental attributes cover, for the three grazing levels (grazed, ungrazed and long ungrazed).

When examining understorey life form data in more detail exotic life forms tend to dominate the grazed and ungrazed sites (Figure 6). Conversely in the long ungrazed sites native life forms tend to dominate. The diversity of life forms is also greater in long ungrazed sites.

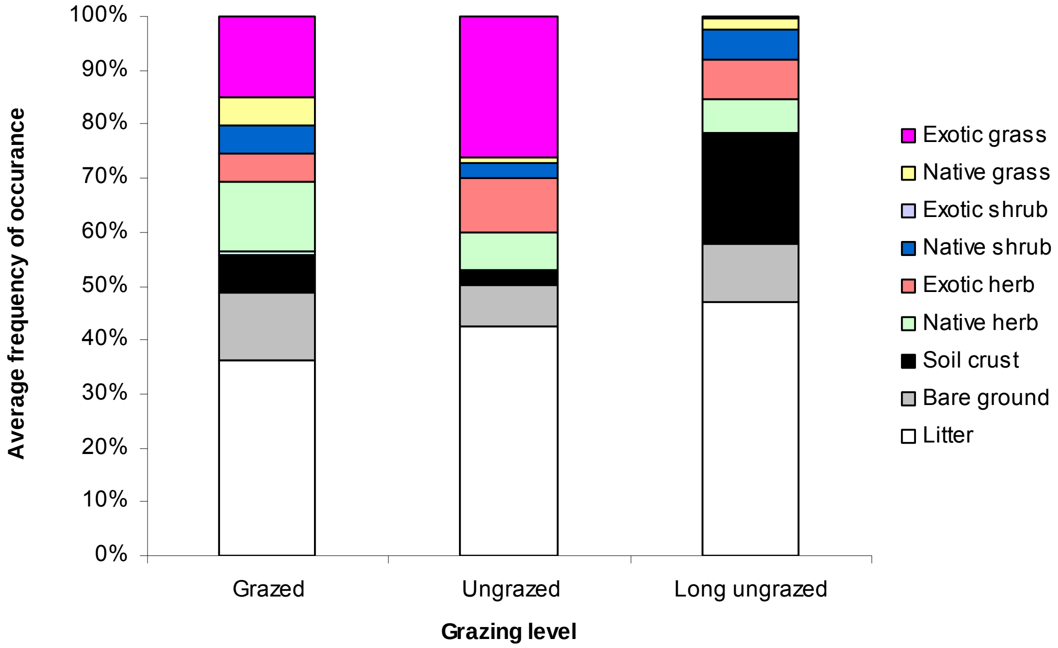


Figure 6. Average understorey life form frequency, for the three grazing levels (grazed, ungrazed and long ungrazed).

Habitat Hectares

Habitat Hectare site condition scores ranged between eight and 50 (out of 75) across the 15 monitoring sites (Table 4). As expected long ungrazed sites had the highest scores. The site condition scores varied greatly between the three EVDs reflecting the grazing levels and site replication. The majority of sites were ungrazed and in the Inland Plains Woodland EVD.

Table 4. The average Habitat Hectares site condition score (x/75) and their ranges (in brackets) across the three grazing level treatments and the three Ecological Vegetation Divisions.

Attribute	Number of sites	Habitat Hectares site condition score x/75 (range)
Grazing level		
Grazed	2	28 (31-25)
Ungrazed	10	20 (33-8)
Long ungrazed	3	42 (50-31)
Ecological Vegetation Division		
Saltbush Mallee	2	37.5 (44-31)
Inland Plains Woodland	10	21.2 (33-8)
Dry Woodland	3	30.1 (50-16)

Synthesis

Summary of revised stratification

The monitoring program has established 50 monitoring sites, and a further 39 sites in linear remnants, totalling 89 monitoring sites in remnant vegetation across the Mallee (Table 5). Of the 50 sites, ten are on properties with stock containment area; these sites were not sampled at the second survey period (2012) due to resourcing limitations. Thirty monitoring sites are in remnants on private land with stock exclusion fencing (including three long ungrazed reference sites) and the remaining 10 sites are long ungrazed on public land (reference sites).

To counter the loss of grazed sites as control sites (due to the destocking of properties where grazed monitoring sites were established) we propose to revise the trial stratification from three grazing treatments (grazed controls, ungrazed and long ungrazed) to recently ungrazed sites (< 10 years) and long ungrazed sites (> 10 years; Tables 5 and 6). This two level grazing treatment can be applied to all sites including the linear remnant sites. When detailed data analysis is undertaken after the five year survey period sites can also be examined by time since grazing. That is, a continuous variable (or scale range) of time since grazing.

Table 5. The two grazing treatments and associated replication (number of sites) for the revised stratification of the monitoring program.

Grazing treatment	Linear remnants	Quantification monitoring sites (year established)				Grand total
		2009	2010	2013	Total	
Ungrazed (< 10 years)	26	7	18	12	37	63
Long ungrazed (> 10 years)	13	1	9	3	13	26
Total	**39**	**8**	**27**	**15**	**50**	**89**

Table 6. The stratification of SEF monitoring sites (excluding linear sites), within the Ecological Vegetation Divisions (EVDs) and the two grazing level treatments.

EVD	Grazing level treatment		Total
	Ungrazed	Long Ungrazed	
Dry Woodland	7	5	12
Inland Plains Woodland	19	4	23
Saltbush Mallee	11	4	15
Total	**37**	**13**	**50**

Future sampling schedule

At a minimum the sites should be monitored for all ecological components (canopy species cover and recruitment, floristics, understorey structure, fixed photo points, soil nutrients, and Habitat Hectares assessment) at five year intervals. The following sampling schedule is recommended for the current monitoring sites:

- Monitoring sites established in 2009 and 2010 sites - undertake the five year monitoring in spring 2015 (2015-2016 financial year), interim data analysis and reporting;
- Monitoring sites established in 2013 - undertake the five year monitoring in spring 2018 (2018-2019 financial year);
- Full data analysis of all sites (excluding linear remnants) in the 2018-2019 financial year; and
- Linear remnants monitoring sites established in 2011- undertake the five year monitoring in spring 2016 (2016-2017 financial year), data analysis and reporting.

Limitations

As with any field based monitoring and research, indeed particularly for long-term studies, limitations in resourcing and changes in site level drivers and management will impact program outcomes. In this instance the removal of grazed sites or controls alters the original program design, decreasing statistical rigor in future analysis. However, the long ungrazed treatment can be used as a comparison to evaluate vegetation changes in the long-term.

Recommendations

To increase the value of the existing project, and utilise the data to its full extent and purpose, it is recommended that:

- Future monitoring of existing sites be undertaken at the intervals outlined in the Monitoring Strategy, Field Test and Implementation Plan (Duncan and Moxham 2009). At a minimum sites should be monitored at the five year interval. It is also important to continue the monitoring of these sites into the future to tease out the interacting effects of climate and grazing exclusion.

- Interim data analysis and reporting project outcomes be undertaken for selected sites in 2015-2016 and on the linear remnant data set in 2016-2017. However, a full comprehensive analysis should be undertaken across all data sets in 2018-2019 when the sites established in 2013 are due for five year sampling.

- The program has now amassed data for an impressive 89 sites in priority remnant vegetation across the Mallee landscape. Data mining (the use of existing data) should be explored to answer other ecological questions impacting native vegetation of the region (i.e. ecosystem services, health, function). Data mining provides a cost effective mechanism to achieve outcomes. For example the following investigations could be undertaken:

  - *Landscape approach to grazing impacts across the Mallee*

    Investigate the health of priority remnant vegetation across the Mallee landscape through comparison of remnants on private land and small to medium sized remnants on public land. Remnants on both land tenures are often highly degraded and grazed (by stock, native and feral herbivores). It is assumed that remnants on public land are in better condition; however, due to the fragmented nature of Mallee vegetation knowledge on the current state of health of these small and medium sized remnants is limited. This exercise would provide information to enable a condition snapshot of remnant vegetation across the landscape to inform future conservation activities (including existing sites) and benchmark existing remnant condition.

  - *Sustainability of tree populations across the Mallee*

    Investigate tree structure, densities and regeneration at a landscape scale to provide information on sustainability of tree populations in the Mallee. Focussing on Black Box and Buloke, this exercise will document the age structure and existing regeneration of these species throughout the Mallee to provide a snapshot of long-term sustainability. This will provide essential data on the likely survival of these target species over the longer term enabling targeting of conservation programs.

- *Benchmarking ecosystem structure and health*

  An articulated goal for restoration through benchmarking Mallee plant communities. Data mining of existing state government and Mallee CMA datasets, to establish standard species composition and structure of these Mallee communities. This information is required to provide a baseline measure to enable measurement of conservation restoration activities success. Enabling conservation schemes to re-establish whole Mallee plant communities of the appropriate species composition and densities, and importantly a benchmark goal to measure success towards this state.

- The monitoring program could be adapted to examine the success of revegetation sites across the Mallee landscape. Including:
  - What does success look like?
  - How are we travelling to achieve this?
  - What tools (if any) are required to achieve this?

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