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Review of Grassland Management in south-eastern Australia

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EXECUTIVE SUMMARY

This review aims to assess the information that is presently available on the impacts of management regimes on lowland grassy ecosystems in Victoria. Literature reviews on the role of disturbance in Australian plant communities, including grasslands, are occurring on a regular basis within Australia. This review in no way can be seen as having a complete coverage of all the literature but aims to provide an appraisal of the current situation by focusing on work that has been conducted in south-eastern Australia, particularly that which has been published in the last 5 years.

The literature reviewed on the management of lowland grassy ecosystems here includes peer reviewed articles, government reports and publications, friends groups reports and unpublished data. Peer-reviewed articles were selected on the basis of the most current review or synthesis of the impacts of current management practices. Novel articles that demonstrated insight or were capable of further informing management where also reviewed. Government publications included action statements and fact sheets on similar vegetation types from ACT, New South Wales and Victoria. Friends groups reports included presentations from workshops and small conferences. Unpublished data includes valuable information on the burning frequency of Kangaroo Grass (*Themeda triandra*) dominated systems and the impact of grazing and infrequent fire on the non-*Themeda* dominated systems. All cases in the literature reviewed where statements on the impacts of management were at odds with the data presented, or there was no evidence (or data) presented, these statements were treated with caution and further investigated. We also found that throughout the literature there is an alarming trend for authors to refer to published studies for substantiation of the use of stock grazing as a biodiversity enhancement tool when no actual proof of this enhancement by the original authors was shown. There is also a large body of research which is yet to be published on this area and there are several larger-scale investigations occurring into alternative management using stock within Victorian ecosystems (e.g. Department of Primary Industries / Arthur Rylah Institute for Environmental Research sheep grazing trials at Hamilton). These results are unable to be used in this review as they have not been completed.

The issue that this review first had to resolve was to categorize the grassland communities that are present across the state. We decided to divide the grassland types on the basis of environmental factors and species dominance. This division also reflects a knowledge divide with management of those areas in the wetter *Themeda*-dominated areas much better understood than that of the dry-temperate to semi-arid Spear/Wallaby-grass dominated
communities. The review aims to address the following points for each of the two broad grassland communities: (i) what is the current understanding of the impacts of management on grassland condition; (ii) what is the applicability of the known active management options to maintenance and enhancement of conservation values (such as biodiversity and structural complexity). The review also discusses and acknowledges the shortfalls in the consistent implementation of adaptive management by conservation authorities that have been noted in the literature, and how these can be addressed. For this purpose, we also propose (and go into some detail) as to how the role of adaptive management for conservation management of biodiversity in grassland reserves should be recorded to ensure that these actions will better inform future management and, hence ensure the long-term survival and enhancement of these reserves. It is also important that managers examine new and innovative approaches to managing native grasslands as there has been a continued dramatic decline in the quality and quantity of lowland grassy ecosystems within the state of Victoria despite recent conservation management activities.

1. Kangaroo grass (*Themeda triandra*)-dominated systems

Management of Kangaroo grass-dominated systems is based on the basic principle of reducing biomass to encourage coexistence of small inter-tussock species. Biomass reduction should be undertaken on a regular basis and, as a general rule, more often than it is deemed necessary. Grazing for biomass reduction is a tool to be used with great caution and is seen as a high risk management activity. It has been shown, and continues to be shown, that stock grazing is a degrading pressure in all Kangaroo grass-dominated systems by impacting on the persistence of native flora and fauna, as well as facilitating the introduction and invasion of exotic species. Care needs to be taken to ensure stock camping (where stock sleep and congregate in a small area) and over-selection (i.e. targeting of preferred species by stock) does not occur. Grazing for conservation purposes is a high risk activity and should only be used if no other options are available. It should be used only for short-term maintenance of biodiversity levels whilst other management tools are evaluated. Burning is a traditional tool for biomass reduction which is well understood and has minimal negative impacts on the plant community it is applied to. It shows no negative impacts on the persistence of native flora and can facilitate the re-establishment of plant life forms once present in degraded reserves. Burning intervals of less than 5 years are required to maintain biodiversity at most sites. Shorter intervals, including annual burning, have shown minimal negative effects on plant species and often have positive effects on biodiversity outcomes and habitat complexity. Burning as a management tool should be used on a regular basis and seen as a viable alternative to the degrading process of grazing. In degraded Kangaroo
grass-dominated systems, the option to graze may be viable to control weed densities of some species. Grazing, when used in this context, should only be used for very short periods and should aim to reduce the potential seed set of exotic annuals. There is little knowledge on the application of grazing to reduce seed set of exotic perennial species and the use of grazing for this purpose is not seen as applicable with many perennials able to flower and seed throughout favorable conditions. Grazing should only be utilized during the spring to early summer period for this purpose. To create a simple framework within which grazing of remnant vegetation can be justified, a decision tree has been created and presented at the conclusion of the document.

2. Non-Kangaroo grass-dominated systems (includes Wallaby grass and Spear grass-dominated communities)

The present state (or condition) of non-Kangaroo grass-dominated systems currently within the conservation reserve system can be considered as being modified since the time of European settlement. These systems now consist almost entirely of grazing-tolerant species. For this reason, grazing is generally viewed as having little impact on the persistence of flora in these regions. However, the evidence to imply that grazing is required to maintain floral and faunal biodiversity values of these systems is not present in the literature. There is a growing evidence to suggest that grazing simplifies the complexity, age and size structure of these communities. This reduces the ability of these systems to persist through, and respond to, unfavorable and favorable conditions, which may have detrimental impacts on individual species and, in turn, on the community as a whole. Grazing also maintains plant communities in early successional states. Grazing impacts ecosystem function via soil disturbance associated with the use of hoofed animals, nutrient shifting and the introduction of exotic plant and animal pests. Regardless of how well managed the system is, this disturbance leads to increases in the fluctuation in bare ground levels, facilitates exotic annual weed invasion, leads to degradation of soil crusts and reductions in biodiversity values. The goal of managers should be the removal of grazing in these systems with subsequent monitoring of habitat structure, complexity and biodiversity. Monitoring of grazing removal should follow a similar approach to that used at Fabian’s paddock in Terrick Terrick National Park (and elsewhere, e.g. Kinypanial), where grazing exclusion plots have been set up since 1994. Monitoring of grazing removal allows managers to assess the impacts of removal on habitat and diversity and allows managers to act well in advance of any deleterious effects forewarned by changes in the exclusion plots. By this approach, any unexpected longer-term negative effects caused by grazing removal will be documented in the exclusion plots, well before the majority of the area of the native grassland is threatened.
by deleterious shifts in composition. This process allows managers an extended time frame to undertake actions to ensure that these negative impacts do not spread to the rest of the reserve. It would be recommended that if this system be used, that the process of total stock removal is in a 3-5 years timeframe. As with Kangaroo grass-dominated systems, the use of grazing in degraded vegetation may be a viable option to reduce annual weed densities. The use of grazing should be short and may be more problematic in these areas. Soil moisture needs to be considered in these environments where rainfall can be erratic. Soils need to be wet, but not too wet, to allow for minimal damage to soil crusts. Thus, grazing is recommended to be undertaken when soil moisture remains between 15% and 5% of soil volume. If grazing is maintained above or below these levels, then the likelihood of damage to the soil crust will increase. This may leave a gap of several weeks in spring when grazing may be suitable. Thus, high densities of stock will be required for short periods.

Conclusions

Generalizations
- All management needs to be monitored and recorded, preferably using the principles of adaptive management
- Grazing
  - leads to no net biodiversity enhancement
  - leads to weed invasion
  - reduces some native plant’s fitness
  - damages soil crust
  - simplifies habitat complexity
  - is only suitable in low diversity, highly degraded systems

Kangaroo grass-dominated
- Kangaroo grass based systems need to be managed for biomass reduction
- Delayed management of Kangaroo grass-based systems lead to rapid biodiversity loss
- Regular burning will increase habitat complexity

Non Kangaroo grass-dominated
- Non Kangaroo grass-based systems appear to be grazing tolerant (ie early grazing by domestic stock of these systems appears to have led to the loss of grazing-sensitive species from these systems leaving only those species able to tolerate grazing present within the systems)
- Removal of Grazing
  - decreases fluctuation in bare ground
  - has no known negative biodiversity outcomes
  - may reduce annual weeds through increased health of soil crusts
  - increases habitat complexity
  - allows succession from early, grazing-induced states to later states that favour a different suite of plant species
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1 INTRODUCTION

This review aims to assist Parks Victoria in keeping abreast of current knowledge on the management of lowland grassy ecosystems. The information that is contained in this review is seen as the most up-to-date interpretation of the literature. With new and exciting insights into the management and restoration of grassy ecosystems occurring, this is an area that should be at the forefront of Parks implementation of adaptive management regimes. An example of this is the recent research into the differences between slashing and grazing a previously grazed grassy ecosystem in Tasmania, see Verrier & Kirkpatrick (2005). The scientific rigor of the investigation is poor, as it lacks information on stocking rates, soil types and even slash height. However, the outcomes of the practice are astounding and show how management and research can assist in enhancing management.

The areas that this review aims to cover are the lowland grassy ecosystems or those that are dominated by tussock forming grasses, have less than 10% tree or shrub cover, and are below 200 m above sea level (Figure 1).

Figure 1. Estimated extent of lowland grassy ecosystems at the time of European settlement (black). The current distribution of ‘natural’ lowland grassy ecosystems is estimated to be less than 0.5% of this area. Mapping information was obtained from Geosciences Australia’s database using tree, shrub and grass cover to estimate distribution of vegetation types.
2 BACKGROUND

Management of native grasslands in south-eastern Australia has been evolving in recent times from a management system based on harm minimization, protection of private assets and agricultural production, to one of conservation and biodiversity protection and enhancement. Before the recent upsurge in interest in native grassland conservation, the majority of significant remnants which remain today have been either subject to low stocking rates on a yearly basis or, they were subject to annual, biennial or triennial burning regimes based around fuel reduction. These practices have been more intense around rural communities and townships and there are now many high conservation status reserves near rural and now urban communities. The major threat to these reserves is changes in management associated with population concerns over the use of fire. This change in management due to human population shifts will, if allowed to occur, result in losses in the integrity of these threatened communities.

The majority of research within south-eastern Australia into the use of land management techniques for the management of native grasslands has been undertaken in the more productive areas of the volcanic plains in western Victoria, where Kangaroo grass-dominated grasslands occur. The main split in grassland types, and the knowledge of appropriate management regimes, can be divided according to differences in environmental factors and species dominance of these grasslands.

Figure 2. Estimated extent of lowland grassy ecosystems at the time of European settlement separated into rainfall zones. Dark areas are those with annual rainfall more than 450 mm, hatched areas will have annual rainfall below 450 mm in some years, and gray areas have average annual rainfall below 450 mm in all years. Mapping information from Geoscience Australia’s database.
The understanding of the management of grasslands using methods employed over the last century is relatively well understood. There is also an increasing literature on the ability to maintain these systems using grazing as the primary management tool. The grasslands of the higher rainfall regions tend to be dominated by the summer active species Kangaroo grass and form a dense sward with inter-tussock spaces filled by spring growing perennials (Figure 3). The grasslands that exist in the lower rainfall areas tend to be now dominated by spring growing Wallaby and Spear grasses, although there is assumed to have been a diverse range of summer active species (such as Spider grass *Enteropogon acicularis* and Panic grasses) present in the pre-European state. These areas tend to have an open tussock structure with inter-tussock spaces containing a diverse annual flora, well-established lichen crusts and a diverse perennial chenopod sub-shrub component (Figure 4).

The traditional management of these drier grasslands by Aboriginal people is little understood, although it is inferred in the historical records that these areas were subject to a history of regular burning on an approximately a five yearly basis.

**Figure 3.** Basalt Plains grassland structure, reproduced from Patton (1935). *Themeda triandra* tussocks (T) with associated grassland species in the intertussock spaces. The spacing and variation in the size and structure of the Kangaroo grass tussocks within this diagram is the main point to observe. The use of grazing is believed to reduce the variability of tussock size and thus reduce the variability in the size and shape of inter-tussock spaces. If, as many authors and managers assume, the variability in structure is vital for plant recruitment in these systems, as well as faunal habitat, then managing grasslands to achieve variable tussock structure and “making the environment right” to allow natural ecological process to occur should be the aim of management.
Grasslands of south-eastern Australia have long been utilized for agricultural production and in particular, sheep and cattle grazing. All areas of remnant native grassland must be assumed to have been subject to some form of agricultural disturbance. Within this document, the discussion of grassland management shall be split into two sections based on those grassland dominated by Kangaroo grass and those not, generally including Wallaby grass, Spear grass and lowland chenopods herb-fields and other less-studied systems.

This review will state the current knowledge pertaining to management of Kangaroo grass-dominated systems of conservation significance. It will review the recent literature and studies investigating the use of stock grazing to achieve biodiversity outcomes. It will examine the validity of using grazing as a management tool in these systems and examine under what context grazing may be a legitimate management option. The current state of non-Kangaroo grass-dominated systems will be discussed and the implications of this for management, as well as enhancement, will be discussed.

The ability to predict, hypothesize and review the impacts of management are the keys to successful implementation of adaptive management regimes. The ability of public and private land managers to generate hypotheses about the potential outcomes of management strategies is generally limited not by knowledge of the system, but by the complexity of the current knowledge and information regarding these processes. The simplification of this information so that it is more readily able to inform hypothesis-generation on management outcomes is necessary to ensure that management is able to evolve and adapt to allow for
the maintenance and enhancement of the current and future public and private remnants. The role of adaptive management, and its necessity in assisting management decisions, as well as a framework for hypothesis-generation and review will be proposed. A broad discussion of several case studies to identify how these strategies of hypothesis-generation and review should be implemented to help inform future management decision will also be discussed.
3 LITERATURE REVIEW

3.1 Kangaroo grass-dominated systems

3.1.1 Current Knowledge

Kangaroo grass-dominated grasslands in western Victoria have been the subject of ecological survey and scientific study for decades and their ecology is well-known relative to many Victorian ecosystems. From these studies, it has become clear that species co-existence is driven by the dynamics of the dominant grass and the availability of inter-tussock gaps. These gaps would have been naturally created and maintained by native animals (e.g. burrowing animals such as bandicoots), and fire and drought (which leads to the mortality of tussock grasses). The creation of inter-tussock gaps through the removal of biomass from the dominant plant, Kangaroo grass, allows for the germination and persistence of the perennial dominated floras. This process influences the water, light and temperature conditions of the surface on a microscale allowing a highly variable environment where many different species can germinate and persist. Current management of these systems is based around the principle of gap formation through biomass reduction for this reason. Biomass reduction was traditionally achieved using fire on a regular basis (1 – 5 yr intervals) with the intent of reducing fuel loads. With increasing time-since-fire, Kangaroo grass growth smothers intertussock herbs and litter builds up, preventing germination of most native species. Higher fuel loads can lead to fires of higher intensity when grasslands are subsequently re-burnt.

Since the introduction of domestic stock and the intensification of agricultural practices after World War Two, biomass reduction has been inadvertently achieved with the use of domestic stock. The need to maintain viable agricultural communities whilst conserving these ecosystems has resulted in an increase in the level of interest in the questions of maintaining biodiversity whilst utilizing these natural resources, and at what cost to the land holder. There has been little emphasis on examining whether domestic stock grazing should/could be used when conservation outcomes are the primary objective for landholders and broad acre conservation reserve management.

3.1.2 Grazing

The recent reviews and scientific studies of domestic stock grazing in native grasslands that have been undertaken are all based on freehold land in Victoria, Tasmania and New South
Wales. None of these studies has shown any net improvement in biodiversity outcomes by manipulating grazing regimes (Table 1).

<table>
<thead>
<tr>
<th>Study Reference</th>
<th>Summary of findings on grazing impacts on biodiversity outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dorrough, Yen, Turner, Clark, Crosthwaite &amp; Hirth (2004)</td>
<td>Concluded that the most likely impacts of continued ‘status quo’ grazing management was the continued, although slowed, degradation of existing remnants and the continued loss of flora and fauna from these areas. If grazing is to be maintained, the modification of regimes to reduce stock time on the reserves to a minimum in the form of crash grazing was believed to provide the best opportunity for maintaining current reserve condition. Active management is essential for the continued survival and enhancement of these systems. The reintroduction of burning as a management tool in previously grazed remnants needs further investigation as it may be a useful tool for biodiversity enhancement and weed control in these areas.</td>
</tr>
<tr>
<td>Leonard &amp; Kirkpatrick (2004)</td>
<td>Compared areas grazed at low rates and high rates. Showed there may be some benefits of grazing at low intensities but the paper failed to consider grazing density over which there where only 2 categories observed (not the 8 stated). The results indicate that the alteration of management regimes as opposed to the maintenance of ‘status quo’ or strategic grazing is what is maintaining biodiversity. There was little to no evidence to suggest that continuation of grazing of remnants had any biodiversity enhancement benefits regardless of density or intensity of stocking pressure.</td>
</tr>
<tr>
<td>Verrier &amp; Kirkpatrick (2005)</td>
<td>Although this experiment was pseudo-replicated and on areas which may have been historically different, it is informative of the knowledge that can be gained through successful adaptive management regimes. The results indicate that the use of slashing and the subsequent removal of biomass is by far the preferred method for increasing cover of rare and endangered native species and reducing weed cover. Observations like this are the outcomes of properly monitored adaptive management regimes.</td>
</tr>
<tr>
<td>Kirkpatrick, Gilfedder, Bridle &amp; Zacharek (2005)</td>
<td>Compared the changes associated with grazing and burning. Showed that grazing is better than doing nothing and that burning is better than doing nothing. Only gave very brief reference to the interaction of grazing and burning to indicate that combined they reduced weed diversity to a greater extent than each separately. Didn’t directly compare the impact of grazing and burning.</td>
</tr>
<tr>
<td>Lunt &amp; Morgan (1999)</td>
<td>Looked at the impacts of establishing a burning regime in a previously long grazed native pasture. Found that there was an increase in weed abundance and diversity. The main exotic species which increased in abundance where from life form groups which had been eliminated by grazing. These problems may be overcome in the long term with the active reintroduction of native species from these groups.</td>
</tr>
</tbody>
</table>

The manipulation of grazing is used to increase habitat heterogeneity in the landscape and minimize (a) nutrient shifts due to stock camping, (b) the impacts of selective grazing, and (c) soil crust damage. The outcomes of this are the short-term maintenance of biodiversity, with grazing-susceptible species occasionally becoming more abundant in the area. These papers all show that it is possible to maintain the ‘status quo’ of the system by manipulating grazing regimes and maybe even have some positive outcomes for habitat complexity. None of these studies has shown any net enhancement that can be easily attributed to the use of
grazing as a management tool. One of the interesting outcomes of the majority of these studies is that the maintenance of the existing, or ‘status quo’ management regime of ‘natural’ but degraded systems often leads to the continued gradual decline in habitat quality and species diversity. It cannot be assumed that ‘status quo’ management leads to maintaining ‘status quo’ of the system and this idea needs to be challenged given the abundance of literature that is now emerging on the subject. Current management may be gradually degrading the system as it has in the past, but at rates which not perceptible at year-to-year timescales. For example, if adult plants persist under grazing regimes but do not recruit under those same regimes, it is likely that population declines will occur in time as adults die out. This difficult and vexing question requires some urgent research and the quantification of seedling recruitment rates under ‘status quo’ grazing regimes should be a priority.

For land managers whose primary concern is the conservation of native grasslands, grazing can only be seen as a short-term tool to maintain biodiversity. It is also a tool that will likely lead to the gradual degradation of these systems with managers continually gambling on the level of biomass reduction needed, weather patterns and weed presence. Grazing cannot be referred to as or used as a biodiversity enhancement tool as implied by some. In fact, most studies tend to show that if grazing is slightly mismanaged, it can have negative and sometimes catastrophic effects for biodiversity due to problems associated with selective grazing, over-grazing and soil degradation.

Selective grazing, particularly of grazing-sensitive forbs, can lead to short-term reductions in density and longer-term losses in biodiversity, and the loss of food sources and habitat for native faunal species. Grazing is known to reduce and eliminate taller forbs and shrubs from grassy ecosystems in south-eastern Australia. Species are often unable to fully recover from even single grazing episodes. This leads to a reduction in the fitness of an individual and increases the probability of local species extinction.

### 3.1.3 Burning

The traditional method of biomass reduction in Kangaroo grass-dominated systems is one of burning on a regular basis. Investigations of burning of these systems have tended to focus on intervals of burning in years, and all studies show similar trends. There are many references in government publications to the possibility of over-burning Kangaroo grass-dominated systems, although all published studies and unpublished data that we have seen show that the short interval between fires produces positive outcomes for biodiversity of
plants. There have been no studies in the refereed literature, or examples in government publications, highlighting areas that have shown reductions in biodiversity due to over-burning in Victorian Kangaroo grass-dominated systems. On the basis of current knowledge it can be clearly stated that in grasslands that have a history of fire, the shorter the interval of burning, the greater the plant species richness that exists in those areas. Fires between 1 and 4 to 5 year intervals would usually be considered within the usual fire cycle that produces positive biodiversity outcomes, whereas fire intervals beyond 5 years have been shown to be too infrequent to maintain diversity (see Figure 5).

![Figure 1](image.png)

**Figure 1.** Example of biodiversity changes with different frequency of burning taken from data collected for Evans St Native grassland reserve Unpublished data (Morgan & Wong, 2005).

The major problem facing the conservation of grasslands in south-eastern Australia (not just Victoria) is the lack of (or discontinuation of) regular or systematic burning. This will quickly lead to losses in biodiversity values of many small and large reserves that may be impossible or too costly to repair. Lack of burning leads to greater fuel loads, increased heat of fire, increased danger associated with fire, loss of patchiness of burning, and increased pest invertebrate (e.g. exotic slugs) and vertebrate populations (e.g. mice). The outcomes for biodiversity under current burning regimes appear to be similar regardless of the season or intensity of burn. The question that conservation managers appear to be asking is “how often should we burn?” The question that they should be asking is “how can we get this grassland to burn?” Regularly burnt grasslands tend not to burn uniformly, allowing refugia for flora, and vertebrate and invertebrate fauna, and may reduce pest fauna such as slugs and red legged earth mites by reducing feeding and regeneration sites and encouraging predators. A grassland that won’t burn across the entire site because of lack of fuel is a grassland that is burnt on a regular basis with a natural mosaic burn pattern and a heterogeneous structure.
allowing for a greater diversity of flora and fauna to exist. This patterning allows for refugia during burns for smaller, less mobile fauna, minimizing the need for strip burning and allowing for an approach which may mimic traditional burning practices.
3.2 Non kangaroo grass-dominated systems

3.2.1 Current State

The non-Kangaroo grass-dominated systems are those of the drier sections of the Wimmera Plains and the western sections of the Northern Plains. These are characterized by the presence and general dominance of chenopod shrubs and sub-shrubs. Other non-Kangaroo grass-dominated systems occur in regions where Kangaroo grass may have once dominated but has now been lost due to overgrazing. They are generally either on sandier, free-draining soils, or have a history of intensive agriculture and are dominated by species in the genera *Austrodanthonia* and *Austrostipa*. These regions are generally, although not always, highly modified due to removal of over storey species, addition of fertilizers and exotic pasture species, and a history of overgrazing. This document will concentrate on the knowledge that is available for the Northern Plains. It is assumed that the processes occurring in the lower rainfall areas of the Northern Plains are similar to those occurring on the Wimmera Plain, although this has not been explicitly compared..

Management of these systems post-1900 has been typically by set stocking in large fenced paddocks at low densities. All remnants have been utilized for grazing, or Travelling Stock Routes, and all roadsides subject to light grazing during driers months of the year or heavy grazing during drought periods. For this reason, no reserve or roadside can be considered to be ungrazed by stock. This practice has declined in recent years with almost all shires banning the activity of droving sheep and cattle along roadsides. It can be safely assumed that all remnants of the region have been modified by the presence of domestic stock. The references in the historical literature and the consistent statements of local land holders to succulent and non-succulent shrubs, and an abundance of plants now rarely recorded in the Northern Plains, are all indicators to the effects of stock on this system. The majority of plant groups mentioned in these statements and records cover those that are assumed to be most heavily impacted by stock grazing. Many studies in similar regions in NSW, and now in the Northern Plains, indicate that the vegetation that is seen today is the result of stock grazing and little change is observed under the removal of grazing in the short-term. This indicates, as pointed out by an abundance of authors, that conservative grazing has little impact on the presence of the present native plant communities in the region, although these communities may now differ from their pre-European state. The impact of grazing regimes on restoration of plant communities to their pre-grazing condition is unknown. For this reason, this paper will not debate whether grazing has a negative or positive effect on the composition of Northern Plains grasslands. Rather, it will discuss if grazing is the most appropriate management tool for the long-term management and enhancement of these systems, as well
as highlighting several other possible management tools and the knowledge of their impacts on native flora and fauna.

### 3.2.2 Grazing

With all public and private grassland remnants subject to modification by stock, the willingness to use stock as a management tool for grassland conservation is probably the most widespread in this region. To discuss the role of domestic stock in drier grasslands, the impacts of these animals should first be considered, as well as the impacts of removing stock. These impacts are likely to depend on the timing of grazing (within a year) and the climatic cycle (in relation to ENSO–drought cycles).

Many studies have been carried out on the selectivity of stock in similar grassland regions in Australia, as well as the changes that are associated with the removal of stock. As a general principle, the utilization of domestic stock results in the decline in the abundance and ability of many forbs and woody shrubs to persist and reproduce in these systems. As many of these species are long-lived and rely on infrequent, favourable conditions for recruitment, the use of stock to manage these systems may have further significant long-term implications. Areas that are set-stocked are expected to have lower cover of palatable forbs and minimal shrub cover. These effects can be reduced by minimizing the period of stock presence in the reserves, although this strategy can still have impacts on the persistence of highly palatable species. The use of stock in these areas will also have ramifications for weed invasion and soil stability and conservation. Hard-hoofed animals are capable of breaking soil crusts and unprotected surfaces within these systems. This damage may remain evident for many years leading to negative feedback loops. This feedback of resources and modification of structure is known to lead to invasion and persistence of weed species in other environments and it is not unreasonable to assume that it may occur here. These impacts may possibly cause irreversible changes if stock are not managed carefully. The impact on the soil crust and soil surface may increase the ability of exotic annual plants to establish and invade. Damage to soil crusts may be an explanation as to why exotic species dominate patches of grassland that have been over-grazed or cultivated. The damage is not only caused by domestic stock; tyre marks from vehicles remain for decades after access in inappropriate conditions (e.g. wet weather).

The success of stock utilization for conservation management in degraded systems in this region is unproven. It can be assumed that the use of stock to control annual grass weeds in these systems would be similar to other environments. The use of stock in degraded systems
should be limited and should follow simple guidelines. In degraded areas (i.e. those previously cultivated), stock may need to be present on the reserve from the start of flowering of introduced annual grass species to the beginning of annual grass senescence. This process should allow for the least degradation of the establishing soil crust and reduce the seed set of annual grasses dramatically. The use of slashing and burning for this process are areas that should carry a high priority for further research as they may provide a low impact alternative to the use of domestic stock.

3.2.3 Burning

Burning as a management tool at patch scales (as opposed to landscape-scales) has stopped in the past 20 years in northern Victoria. The only information on the relevance of burning as a management tool relates to areas that had previously had a history of regular burning for fuel reduction purposes (e.g. rail reserves such as that found at Hunter in the central north). These areas still contain grasslands of high conservation value, although they have degraded since burning ceased. These remnants appear to be refugia for plants that are rare in the largely grazed, unburnt landscape. A single study conducted at Terrick Terrick National Park examined the effects of small-scale burning on the Northern Plains grassland community. This study showed that there was little residual effect of burning after two years. The exception was a reduction in exotic plants. Burning regimes indicated by the historic literature of every five years may aid in the control of exotic plants, enhance gap creation and may promote biodiversity benefits but its relevance to current-day landscapes remains largely unknown. If fire is to be used in these systems, then the timing of fire needs to be determined to allow for the minimization of detrimental impacts on native plant and animal species.

All threatened native, non-avian fauna present in the Northern Plains utilize soil cracks and logs for shelter during harsh climatic periods. It would not be unrealistic to assume that the less mobile species of the grasslands would be able to avoid the impacts of low intensity spring/summer fires by sheltering in soil cracks or under logs as has been demonstrated in other regions. The impact on native avian fauna would be limited to the Plains Wanderer and fire would need to be timed to minimize impacts on nesting and rearing of chicks. This would mean that fire should not be utilized from the start of September to the end of January to avoid nesting and mating times. Impacts of fire on this species may be minimal as they occupy the least productive areas of the grasslands and these areas will rarely carry fire, as observed in some recent trial burns. The use of crash grazing may also be appropriate to
reduce the risk of fire in the Plains Wanderer areas as domestic stock preferentially graze the areas where Plains Wanderer inhabit. It may be that grasslands are initially grazed for a short period prior to burning of non-Plains Wanderer habitat.

### 3.3 Conclusion

There is a clear divide in the management of grasslands (or the intensity of management) necessary in Victoria to maintain biodiversity; this divide is principally that which separates grassland types according to rainfall. Dry area grasslands (i.e. the Northern Plains grasslands) are generally dominated by succulent herbs and wallaby grasses and require gaps for herb germination and establishment. These gaps are generally created by climatic episodes and these systems appear to be self-maintaining. On the other hand, the wetter grasslands dominated by Kangaroo grass overgrow their gaps and require intervention to allow for the maintenance of biodiversity. These systems are maintained by gap creation generally through burning, although there has been an increase in the willingness to utilize stock for this process. The use of stock for this process has greater negative impacts on soil crust composition as well as the ability of native palatable forbs to establish and persist in these areas. The continued use of stock for the process of gap creation and biomass reduction may have long-term negative impacts on these systems. The use of stock needs to be minimized and, according to the current literature, should not be used for conservation purposes as it is not compatible with the long-term conservation of these systems. The use of stock to reduce annual weeds in low diversity degraded systems may, however, be an appropriate option. The use of slashing and fire to achieve similar outcomes needs to be further investigated.
4 MODELLING MANAGEMENT

One of the important roles of managers is to document the management approaches that they utilize for reserve management. The documentation of the initial state of the reserve and the management tools applied, and the predicted outcomes of these methods, are essential components of this documentation. These outcomes are also essential for the use of adaptive management techniques to refine and modify existing management practices. This creates a management framework which is flexible and maintains or enhances the system being managed rather than documenting decline and degradation of these systems or reserves due to inflexibility of management.

4.1 Adaptive Management

Adaptive management is an essential tool to allow for the continued improvement of grassland management and reserve management as a whole. The role of adaptive management in improving our knowledge of grassland responses to alternate management regimes appears to be little utilized, with minimal evolution of management due to its implementation and often significant criticisms in the consistency of its implementation. The process of adaptive management allows for the assessment of best management guesses in situ and creates a situation in which these guesses can evolve towards a more appropriate management regime. To successfully utilize adaptive management, the development of clear and well-defined management goals, and the documentation of current and future reserve conditions are required. The continued and rigorous implementation of these best guess regimes is required for accurate and fair assessment of their outcomes.

The general aims of grassland management are clear and simple to define. The main concerns are over the methods by which these outcomes are achieved and the appropriateness of these methods. The aims of grassland management for the maintenance of biodiversity values are clearly understood as:

1. the reduction of biomass and creation of gaps to allow for the regeneration of native plant species; and
2. the maximization of habitat complexity and of the grassland structure to increase the probability of faunal components persisting and reproducing in the remnant.

These may not always be the goal of grassland managers (e.g. in degraded grasslands, shifting the balance between native and exotic species may be the management goal and
this highlights that aims need to be well-defined at the start of any management program in conservation reserves). To achieve and document these aims, initial reserve condition needs to be assessed. A discussion on the methodologies and establishment of adaptive management regimes so that they are better able to inform management and research is undertaken in the following sections. The process of change that will lead to the desired level of gap creation and habitat complexity needs to be hypothesized. After the management process has been implemented, the post-management condition of the reserve needs to be assessed and the outcome compared to what was expected from the management action, thus validating or rejecting the management option for the purpose it was utilized for.

4.2 Research & Modelling Management Decisions

Management is one of the most valuable and often under utilized forms of research. Research is the process of asking a question, gathering information, testing the question and assessing the outcomes of the test. Management is the process of asking the question of what is the most appropriate management regime, gathering information to determine the validity of the management regime, testing the validity of the management regime and the assessing the validity of the management regime. The area of land that is managed is far greater than the area of land that is studied specifically for research purposes. Managers, including private and public landholders, are able to contribute to research through the continued monitoring and documentation of management. Documenting initial reserve condition, management techniques applied and reserve condition following application of management regimes gives all interested parties insights into how management affects reserve condition and the processes that occur in these reserves.

How do you most effectively utilize management as a research activity and how do you do it in a way that is applicable across many different reserve types and climatic regions?

Modelling management decisions allows managers to quickly and effectively justify, predict and assess the outcomes of available management options. The ability to simplify complex decisions will allow management to quickly and easily inform future management decisions. A simple, effective way of showing predictions of management regimes as well as documenting management outcomes will be discussed. The model used here is the State and Transition model, which was first introduced into Australian land management by Westoby et al (1989) and has been evolving and increasing in utilization, not just in its initial area of Australian rangelands, but into grassy systems, forested ecosystems, wetland modelling, as well as faunal applications. The model was developed with the aim that it be
easy to use and intuitive to understand. An advantage to this type of model is that once it is
developed it is able to be generalized at a regional scale and specialized at a local scale.
There are two main parts to the model that are generated: state of the system and the
transitions that can occur (see below).

4.3 State and Transition Models

4.3.1 States

A state can be easily defined as the current condition of the reserve. This definition of the
current state may be applied to the whole reserve or a section of the reserve. For example,
you may have areas that are weedy, non-weedy, having high diversity or low diversity, areas
of habitat and non-habitat for a particular species, as well as any other definitions you
choose to adopt. How you define and, by default, measure a state is determined by the
outcomes you are trying to achieve. As a general rule, it is important in defining a state to
take into account of 1) species present and 2) their abundance in that state, as well as 3) habitat measures. An example of the sorts of things that can be recorded to define the state
of a site is given in Table 2.

Table 2. State box showing example of what can be recorded to simply inform management and
describe particular states.

<table>
<thead>
<tr>
<th>Species</th>
<th>Abundance</th>
<th>Habitat Value</th>
<th>Faunal Food Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Themeda triandra</td>
<td>70%</td>
<td>Medium</td>
<td>Macropods and grazers</td>
</tr>
<tr>
<td>Native annuals</td>
<td>5%</td>
<td>Low</td>
<td>Invertebrates</td>
</tr>
<tr>
<td>Perennial Shrubs</td>
<td>10%</td>
<td>High</td>
<td>Invertebrates</td>
</tr>
</tbody>
</table>

The locations of species that are of interest in the reserve (e.g. rare species) are also
important to document and the effects of management on these components should be
assessed. The procedure for assessing the state of a grassland is outlined in the generalized
case study in Chapter 8. In addition, locating and mapping the rough extent of rare species,
as well as individual population counts, may help to inform managers of the state of the
reserve.

4.3.2 Transitions

Transitions are the pathway for change from one state to another, there is the potential in the
model structure for a site to stay within a specific state. The process of identification of transitions allows us to highlight the knowledge gaps that need to be addressed. Transitions
that are currently well-known are those that generally degrade the conservation significance of a reserve (e.g. effects of soil disturbance, effects of fertilizer application). Very little information is available in the transitions that enhance the conservation values of a reserve.

To simplify the model for management, the transitions could be thought of as actions rather than processes. This is illustrated by the following statement: burning is an action whereby the process of biomass reduction is achieved (see Figure 5).

Transitions that should be considered in grassland management can be classified as degrading, maintaining or enhancing. These transitions can overlap and change depending on timing, intensity of activity, and other external factors. Transitions that will be highlighted are those expected to occur, or have occurred, in grassland remnants: burning, low intensity set stocking, high intensity crash grazing, slashing/mowing, fertilizer applications, cultivation and no active management. These transitions will be highlighted for ungrazed remnants, grazed remnants of high and low diversity on both grassland types.

<table>
<thead>
<tr>
<th>State I</th>
<th>Abundance</th>
<th>Species</th>
<th>Species</th>
<th>Faunal Food Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>70%</td>
<td>Themeda triandra</td>
<td>Medium</td>
<td>Macropods and grazers</td>
</tr>
<tr>
<td></td>
<td>5%</td>
<td>Native annuals</td>
<td>Low</td>
<td>Invertebrates</td>
</tr>
<tr>
<td></td>
<td>10%</td>
<td>Perennial Shrubs</td>
<td>High</td>
<td>Invertebrates</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>State II</th>
<th>Abundance</th>
<th>Species</th>
<th>Species</th>
<th>Faunal Food Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40%</td>
<td>Themeda triandra</td>
<td>High</td>
<td>Macropods and grazers</td>
</tr>
<tr>
<td></td>
<td>10%</td>
<td>Native annuals</td>
<td>Low</td>
<td>Invertebrates</td>
</tr>
<tr>
<td></td>
<td>5%</td>
<td>Perennial Shrubs</td>
<td>Medium</td>
<td>Invertebrates</td>
</tr>
</tbody>
</table>

Figure 5. Basic state-and-transition diagram showing example of how these may be used to describe management outcomes or hypothesis. Transitions between states are hypothesized between a “rank” Kangaroo grass dominated area subject to burning. State I describes the pre-burn condition/state of the vegetation. The vegetation is then subject to a Transition (the burn) and State II (a post transition state) is the outcome. Of course, without burning or active management, State II will revert to State I where the Transition (management option) can be imposed to obtain the desired state, State II. Note that all states are described in terms of abundance of life forms. How states are described is up to the manager as is the definition of the desired state. These models allow for the easy assessment of the success of active management.
5 DECISION TREE TO ASSIST MANAGERS TO DETERMINE APPROPRIATENESS OF GRAZING AS A MANAGEMENT TOOL

Is grazing a legitimate option in your grassland? To assist with this decision, managers should determine which grassland type applies to them by using this simple key (Figure 6). This is a type of decision tree, and it can be used to assist in the identification of grassland type, and to identify an appropriate management regime.

Figure 6. A decision tree, used to assist in the identification of grassland type, and to identify an appropriate management regime. Areas shaded in gray indicate grassland types that are considered to be degraded, and where grazing may be applicable for weed control and biomass management.
5.1 Identification of grassland types

A list of species which may occur and could be used to distinguish the grassland types are listed for each community type. This list is in no way exhaustive and not all species will be present at each site of any particular type. The presence of one species from the list may indicate that grassland type. This list can be further refined by the use of local knowledge.

**Type 1**: Beauty Heads (*Calocephalus* spp.), Button Wrinklewort (*Rutidosis leptorhynchos*), Rice Flowers (*Pimelea* spp.), Pussy Tails/ Mulla Mulla (*Ptilotus* spp.), Everlasting Daisy (*Chrysocephalum* spp.) etc.

**Type 2**: Grass Cushion (*Isoetopsis graminifolia*), Common Sunray (*Triptilodiscus pygmaeus*), Blue Pincushion (*Brunonia australis*), Magenta Stork’s-bill (*Pelargonium rodneyanum*), Native Flax (*Linum marginale*), Austral Adders-tounge (*Ophiglossum lusitanicum*), Grass Trigger-plant (*Stylidium graminifolium*), Creamy Candles (*Stackhousia monogyna*) etc.

**Type 3**: Yellow Bulbine Lily (*Bulbine bulbosa*), Chocolate and Vanilla Lilies (*Arthropodium* spp.), Flax Lilies (*Dianella* spp.), Milk Maids (*Burchardia umbellate*), Fringe Lily (*Thysanotus* spp.), Orchids etc.


**Type 5**: Kangaroo Grass (*Themeda triandra*), exotic perennials and annuals

**Type 6**: Yellow Bulbine Lily (*Bulbine bulbosa*), Vanilla Lilies (*Arthropodium* spp.) Early Nancy (*Wurmbia* spp.), Fringe Lilies (*Thysanotus* spp.), Orchids (*Prasophium* sp., *Diuris* sp.) etc.


**Type 8**: Wild Oats (*Avena* spp.), Annual Rye Grass (*Lolium* spp.), Medics (*Medicago* spp.), Wallaby Grass (*Austrodanthonia* spp.), Rough Spear Grass (*Austrostipa scabra scabra*) etc.

**Type 9**: Wallaby Grass (*Austrodanthonia* spp.), Spear Grass (*Austrostipa* spp.), Australian Stonecrop (*Crassula sieberiana*), Creeping Salt Bush (*Atriplex semmibaccata*), Paper Sunray (*Rhodanthe corymbiflora*)
6 KNOWLEDGE GAPS

There are knowledge gaps that exist in our understanding of grassland systems. These knowledge gaps are defined as areas where there is insufficient published research to answer the basic questions in relation to their general impacts on these systems (labelled with a (?) in Table 4). Great uncertainty therefore exists about their role(s) in grassland management and utility for biodiversity conservation. Basic research needs to be undertaken in these areas.

A positive impact (+ve in Table 4) promotes or maintains biodiversity levels, increases habitat heterogeneity and leads to a reduction in annual weed abundance. A negative impact (-ve) results in the maintenance of biodiversity in a best-case scenario and probably decreases habitat heterogeneity and increases annual weed abundance. These impacts are generally well-documented in the scientific literature although they may be influenced by individual site conditions.

Table 4. Impacts of different management regimes. Those areas where there is no apparent knowledge (i.e. a knowledge gap exists) are labelled with a (?).

<table>
<thead>
<tr>
<th>Management Option</th>
<th>Grassland Type</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grazing</td>
<td>-ve -ve -ve</td>
<td></td>
<td></td>
<td></td>
<td>?</td>
<td>?</td>
<td>-ve-ve-ve</td>
<td></td>
<td></td>
<td>+ve</td>
</tr>
<tr>
<td>Intermittent burning (+5years)</td>
<td>-ve ? ? ? ? +ve +ve ? ?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To ameliorate the decline in grassland condition and distribution that is being observed across Victoria, the role of management and, in particular, the role of fire, grazing and slashing in the maintenance and enhancement of these systems needs to be better understood. At present, there is little information on the roles of any of these management activities on the enhancement of native lowland grassy systems and all the studies of grazing or burning reviewed fail to compare the impacts of grazing and burning explicitly. Many studies compare grazing with no management and burning with no management, but all fail to compare grazing of diverse native lowland grassy ecosystems with frequent or infrequent burning of these systems. These studies also focus on the changes associated with the underlying flora and do not address the complexity of the habitat. Future directions should focus on the roles of fire, slashing, strategic grazing and other management options on
improving the biodiversity, and also the habitat complexity of sites so that they are able to secure the long-term survival of not just the flora but the fauna of these systems.

There is sufficient knowledge available to manage areas of high conservation significance to maintain their biodiversity value. There is now a real need to learn how to enhance the conservation reserve system. This does not mean the purchase of more semi-degraded “natural” grasslands but an increased focus on how to secure species and communities not just on the scale of individual sites but across regions.

Clear management goals need to be set for each grassland reserve and ways of achieving these goals need to be included in management plans. Management plans, if they are to assist in the bridging of the current knowledge gaps, need to include monitoring and adaptive management techniques and should not be just about maintaining current reserve conditions, but about increasing knowledge and enhancing reserve condition.
7 A VISION FOR MANAGEMENT

Future reserve management should aim to enhance habitat quality while maintaining and enhancing biodiversity levels. Information gained from the management of reserves and the outcomes of different management methods should be freely and easily accessible to better inform current management. To achieve this, managers need to be informed of, as well as informing others of, current best management of the lowland grassland reserve system. Simple and effective modelling of management actions is required to achieve these outcomes. The state and transition modelling method has been utilized in other areas and countries to effectively achieve these outcomes. The following general hypothetical case (section 7.1) is used to show managers an example of how these ideas can be applied to document reserve condition and management. The use of these modelling methods requires little extra effort on the part of the manager but also allows for the simple sharing of information and the further empowering of managers.
7.1 A generalised case study to determine grassland management options and document outcomes

Imagine a situation whereby a lowland grassy system is having its management reviewed. The first thing that the manager needs to do is to assess the current condition of the site. The different grassland vegetation types should be first visually defined. They may be defined by landscape position, distance from fence, dominant species or other attributes as determined by the manager. Within each of these pre-defined vegetation types, quadrats should be used to assess pre-management condition. The location of quadrats should be marked and recorded for later comparisons. Number and size of quadrats will (in general) be unique to the site (and may be influenced by time and cost factors), although a minimum of 10 should be used and a suggested size of 5m x 5m is considered appropriate. If there is also a desire to assess the complexity of habitat and the changes in habitat structure, then line transects or point quadrats, as defined below, should be used. The above mentioned methods require the use of multiple transects/quadrats to successfully assess the condition of the reserve. It is suggested to successfully assess the condition of the reserve that permanent sampling points be placed across the reserve covering all vegetation types.

**Line Transect Method**

The line transect method is used to assess habitat complexity and structural changes.

Measure 5m to 10m between 2 marked pegs as shown in Figure 7.

![Figure 7. Measured distance between two pegs.](image)

Place a tape tightly stretched between the two pegs

Run your hand along under the tape from the 0m point until it reached a patch where you can no longer keep contact with the ground. Record the distance (0 – 50cm *inter patch*). From the point you meet the patch to the far side of the patch still directly under the tape measure the distance again (i.e. 50cm – 60cm *patch*). If you desire you can record the species present in the patch (there may be more than one) and the species present in the *inter patch*. You can also record the actual size of the patch as you may only run over the edge. It is recommended that you record the maximum width, depth and height as shown in Figure 8.
Figure 8. Tape measurements and dimensions to be made following this approach.

**Point Quadrat Method**

The point quadrat method is similar except that this method gives a more detailed account of the actual composition of the transect. For assessing the *heterogeneity* of the grassland the above method is recommended. For assessing the *composition* and accurate structural composition, the point quadrat method is recommended.

**Point Quadrats**

Table 5. Recommended template for Northern Plains semi arid grasslands in the Glassons Grassland Reserve management plan (Diez & Foreman, 1996).

| 1.5m | 0.2 | 0.4 | 0.6 | 0.8 | 1 | 1.2 | 1.4 | 1.6 | 1.8 | 2 | 2.2 | 2.4 | 2.6 | 2.8 | 3 | 3.2 | 3.4 | 3.6 | 3.8 | 4 | 4.2 | 4.4 | 4.6 | 4.8 | 5 | Total |
|------|-----|-----|-----|-----|---|-----|-----|-----|-----|---|-----|-----|-----|-----|---|-----|-----|-----|-----|---|-----|-----|-----|-----|---|
| Liber |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |
| Bryophyte |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |
| Crustose Lichen |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |
| Foliose/Fructose Lichen |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |
| Ca long lived native grass |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |
| Pr. Nat. Herb |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |
| Nat. Lily |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |
| (3) Nat. Grass |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |
| Ann. Nat. Herb |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |
| Bare Ground |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |
| Ca short lived native grass |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |
| Ex. Lily |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |
| Ex. Ann. Herb |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |
| Ex. Nat. Grass |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |
| Total |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |     |     |     |   |     |

Table 5 is the template recommended for Northern Plains semi arid grasslands in the Glassons Grassland Reserve management plan and based on that found in Diez & Foreman (1996). The monitoring of these sites would be based on a similar setup to that of the line transect and in fact identical lines can be used. The recording methodology for these sites is to first go to the 0.2m distance from the 0m peg and place a point (often a rod or narrow pin) vertically into the ground. Any vegetation that contacts the rod is recorded in that column of the data sheet. Ground cover or bare ground that intercepts the rod is also recorded.
This method fails to give an estimate of the variability in the size of structural patches although it is extremely accurate in determining bare ground levels and species composition. A combination of the two methods listed above would be ideal for monitoring grassland condition. Although if structural variability is the main goal of management then the linear transect method should suffice.

The data collected using either or both of the methods above can be used to describe the initial state of the reserve. The state of the reserve can now be defined using the decision tree above or any other informative methods that may be unique to the site (i.e. weed species present). The current management and the assumed result of management need to be considered. Remember that status quo management may not in the longer term lead to maintaining status quo of the condition of the reserve. By filling in the state and transition diagram, the hypothesized outcomes of the management options available can be qualified. The state is now identified independent of previous management. The hypothesized changes that will result from continued management and different management regimes can now be articulated. Changes can be described in terms of plant life form cover, weed abundance or structural changes. If the management option results in no change to the current state, then the transition does not occur and can be assumed to stay within the current state.

Management options that should be described as common practice are the continuation of current management, no active management and alternative “best guess” management strategies. This gives the manager a good idea of the effect on the reserve of delaying a management decision. The current hypothesized states should be described in at least the life form composition changes and structural changes that are expected. (i.e. introducing set stocking to a reserve will decrease the structural complexity and reduce the cover of tall forbs. It may also damage soil crusts and facilitate increases in exotic annuals).
Figure 9. State and transition model for hypothesizing management outcomes in grasslands.

When the state and transition diagram is completed, then the best guess management case(s) can be trialled at the reserve if it is different to the current management regime(s). The resultant best management option(s) should be initially trialled in a smaller area of the reserve whilst current managements is continued on the rest of the reserve. The pre-management state of these smaller areas are assessed and the best management guess(es) imposed. After management has been trialled (generally 3 years as a minimum to allow changes in composition and structure to take effect, although it should be noted that grasslands can show enormous inertia to change over short timescales), then areas to which the best management guess(es) management technique(s) and areas to which the current management technique were applied should be re-sampled. Changes in the reserve due to management can now be noted and the effects of the management regimes analysed. The state and transition diagram can be upgraded to included the known outcomes of management. Outcomes of whichever management option is now utilised are able to be shown and the process by which change has occurred is able to be clearly stated. If the best management guess(es) are to be utilised across the reserve, then the initial trials should be maintained. Continued monitoring of these trials allows for managers to be informed early of any medium to long term issues that may arise from the new best management guess.
REFERENCES


Foreman, P. (1996) In Ecology of Native Grasslands on Victoria's Northern Riverine Plain Unpublished B.Sc. (Masters) thesis. La Trobe University, Bundoora.


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