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Jewels in the Landscape

Managing very high conservation value ground-layers in Box-Gum Grassy Woodlands

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All photographs, unless acknowledged otherwise in the caption, were taken by the authors.

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A range of tree age classes, some shrubs and a diverse ground layer provide three important components of this very high quality Box Gum Grassy Woodland

Section 1
Introduction to this Guide

This guide aims to help managers recognise, understand and manage Box-Gum Grassy Woodlands that contain particularly high conservation value ground-layers with a diversity of native wildflowers. It draws on long-term scientific research to understand what makes the ground-layer diverse, and highlights management regimes that are beneficial or detrimental to this diversity.

Key messages

- This guide focuses on rare, very high conservation value diverse ground-layers in Box-Gum Grassy Woodlands, which are typically dominated by Kangaroo grass and/or Poa Tussock.
- It aims to help land managers – including local councils, developers, community groups, natural resource managers, landcare groups and rural fire agencies – recognise and maintain the high biodiversity values of these woodland ground-layers.
- The guide brings an ecological perspective, focusing on how the native plant diversity and weediness of the ground-layer depends on disturbance regimes (particularly fire, grazing and mowing).
- Key research underpinning the guide was undertaken in the NSW Central and South West slopes regions. Many of its principles are relevant across the broader Box-Gum Grassy Woodlands of south-eastern Australia.
- The guide can assist practical implementation of woodland management by providing background for developing a site management plan – a current legislative requirement for most lands administered by a government body.

Section 1
Introduction to this Guide

Scope

Temperate grassy eucalypt woodlands once covered extensive areas across inland Victoria, New South Wales, Tasmania and southern Queensland, but owing to the productive country they occur in, they have been widely converted to crops and pastures.

Woodlands with diverse native grassy ground-layers, including the original dominant grasses and a variety of wildflowers, have become particularly rare 'jewels' within these landscapes. High conservation value grassy ground-layers such as these are often overlooked because they superficially resemble other pastures and paddocks, but they are highly valued for the many rare and declining native plant species they support. They also provide reference areas for the types of plant species that can be used to restore degraded woodlands.

Focus of this guide

This guide synthesises outcomes from scientific research and observations undertaken in grassy woodlands containing very high conservation value native ground-layers (see Box 1 for definition), focusing on the widespread but nationally threatened woodland type known as *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland* (hereafter Box-Gum Grassy Woodland, Appendix 1).

The guide is intended to increase awareness of these very high conservation value ground-layers, assist in their identification, and inform management decisions for natural resource managers who have a legislative responsibility for biodiversity conservation.

The research forming the basis of this Guide was focused in the NSW South and Central West Slopes regions. The principles are sufficiently general to be relevant to the wider Box-Gum Grassy Woodlands, and other temperate grassy eucalypts woodlands and grasslands of south-eastern Australia. However some aspects of management that are more important in other regions, such as control of exotic perennial grasses such as Coolatai Grass (*Hyparrhenia hirta*) or Serrated Tussock (*Nassella trichotoma*), or management of summer-growing native plants on the NSW North West Slopes, are not covered in this guide.

High conservation value grassy ground-layers are often overlooked because they superficially resemble pastures and paddocks, but they are highly valued for the many rare and declining native plant species they support.

Figure 1: This guide focuses on managing Box-Gum Grassy Woodland sites with a very high conservation value ground-layer of native orchids, lilies, wildflowers and sub-shrubs (above images). The dominant grasses in such sites are typically Kangaroo Grass (*Themeda triandra*) and Poa Tussock (*Poa sieberiana*). Lower image credit: Linda Broadhurst

Box 1: The rare jewels – what is a 'very high conservation value ground-layer' in Box-Gum Grassy Woodlands?

This guide focuses on remnants of Box-Gum Grassy Woodland that support a diverse native ground-layer dominated by Kangaroo Grass (*Themeda triandra*, also known as *T. australis*) and/or Poa Tussock (*Poa sieberiana*). These sites typically retain a high diversity and abundance of native wildflowers (also termed forbs or herbs), orchids, lilies, rushes and sedges. Descriptions and pictures for the key species are detailed further in Sections 2 and 3.

Consequently in this guide we will be referring to these sites as '*very* high conservation value ground-layers'. This distinguishes them from other high conservation value native ground-layers that have undergone a greater degree of degradation.

For these other sites a typical degradation sequence (resulting from livestock grazing) is the replacement of Kangaroo Grass and Poa Tussock with other native grasses (e.g. wallaby grasses *Rytidosperma* spp., spear grasses *Austrostipa* spp. or red grasses *Bothriochloa* spp.), the gradual loss of grazing-sensitive wildflower species, and invasion by weeds. Because livestock grazing and clearing for cropping have been so widespread in Box-Gum Grassy Woodlands, even the more modified native ground layers are considered to be of high conservation value and are protected by State and Commonwealth legislation (see Appendix 1).

More detail on identifying very high conservation value native ground-layers is provided in Section 3.

Elements of this guide are relevant to high conservation ground-layers more generally. However, some components, particularly Sections 4 and 5 focusing on disturbance regimes, are most relevant where Kangaroo Grass and Poa Tussock are prominent in the ground-layer.

Figure 1A: An example of a very high conservation value native ground-layer dominated by Poa Tussock (*Poa sieberiana*) and wildflowers

Other woodland management guides

For those interested in broader aspects of woodland management, including maximising biodiversity in native pastures on farms or more general guides to woodland management and restoration, see the 'References and further reading' sub-section at the end of this guide.

Appendix 1 is a useful summary of current best practice national guidelines for Box-Gum Grassy Woodlands. These national guidelines apply to Box-Gum Grassy Woodlands in varying states of ecological condition rather than only to sites with very high conservation value native ground-layers, which are the focus of this booklet but many of the principles are overlapping.

It is recommended that users of this guide read and understand the 'Important Disclaimer' in the front pages before undertaking management actions in Box-Gum Grassy Woodland communities. While it is important to take a precautionary approach, finding time to walk in, look at and 'read' the site will assist understanding as to how these woodlands function and, in conjunction with the information presented here, help guide the appropriate management actions.

Figure 2: The native ground-layer of most Box-Gum Grassy Woodlands has been converted to crops or pasture over much of its former range, so managing remaining high conservation value woodlands is vital.

Who is this Guide for?

All land managers and land users have a legislative responsibility at the State and Commonwealth level to protect and maintain biodiversity and ecosystem function in sites defined as a Box-Gum Grassy Woodland. These woodlands are classified as a Critically Endangered Ecological Community (see Appendix 1) at the Commonwealth level.

This guide is designed to assist professional staff and community members to recognise, understand and manage sites of the listed ecological community that have very high conservation value native ground-layers. Managers may include:

- Shire Council staff who manage cemeteries, historic and Trust sites, town commons, roadsides, parks and reserves and other natural areas, or are responsible for land-use zoning;
- Land developers and on-ground staff who undertake work such as approval of development applications, assessments for clearing vegetation or any other preliminary development work, so they are familiar with how to identify these sites prior to any works proceeding;
- Management Committees, Landcare and Bushcare groups, farmers and local residents who care about and assist in managing these sites;
- Natural resource management agency staff who manage native vegetation including travelling stock reserves, provide agricultural production advice, or undertake biosecurity or emergency management;
- Railway corridor and on-ground staff who manage vegetation adjoining railway lines;
- Local bush fire brigades who may assist with bush-fire control or strategic burns on-site, and others planning to use fire or mowing as a management tool;
- Any person or authority developing a management plan for a site – under NSW legislation local government must prepare a draft plan of management for all community land.

Creating a management plan

One of the most effective ways to implement the information in this booklet is to develop a management plan. A management plan can be a legislative requirement for community land managed by local government, but more importantly it provides a mechanism to address issues of concern regarding management, maintenance, community use and environmental protection. It doesn't need to be long or complicated and assists with planning.

The following elements can be considered when drafting, implementing or re-visiting an existing plan:

1) Objectives, scope and purpose of the plan.
2) A section summarising the interested parties (e.g. Local council, trusts, community groups) and the sites unique cultural, social, ecological and conservation values and issues.
3) Management actions, persons / group responsible for management actions, priorities and work programs.
4) Mapping of zones that require different management actions e.g. High Conservation Zone, burial areas and buffers, stockpile areas for excess soil waste and rubbish.
5) Simple signage to explain conservation values, management actions and reduce user concerns such as mowing times and frequency.
6) Planning for waste and rubbish removal to avoid excess soil waste and rubbish stock piles on high conservation value ground layers.

Figure 3: The management guidelines in this booklet are designed to assist a wide audience including local councils, land managers for cemeteries, reserves and private land, and others considering using fire, mowing, slashing or grazing as one of their management tools.

Section 2

What are Box-Gum Grassy Woodlands?

Box-Gum Grassy Woodlands were once widespread across the inland slopes and plains of the NSW wheat-sheep zone, extending into Victoria and southern Queensland. They are now largely cleared or modified for agriculture, and to a lesser degree, urban and other infrastructure development. Information in this section aims to help managers identify the key components of Box-Gum Grassy Woodlands. Section 3 focuses in more detail on very high conservation value ground-layers.

Key messages

- The Box-Gum Grassy Woodlands occur across south-eastern Australia and are frequently in poor to moderate ecological condition.
- The focus of this booklet is on rarer sites where the diverse ground-layer remains in very good ecological condition, although lower quality sites, often dominated by wallaby, red and spear grasses with lower plant diversity, can benefit from many of the management principles.
- Characteristic species of these very high conservation value woodland ground-layers include Kangaroo Grass, Poa Tussock, Western and Silver Wattle, White Box, Yellow Box and Blakely's Red Gum, along with a diversity of native wildflower species
- In 'derived native grasslands' trees will be sparse or absent but the understorey remains intact.
- Being able to identify key components and condition of a woodland, including the main tree, shrub and grass species, enables better management and planning.
- Site-scale management actions can be more important for the persistence of ground layer grass and wildflower species than landscape-scale issues such as remnant size or connectivity, so even very small remnants (<1 ha) can be highly significant.

Section 2
What are Box-Gum Grassy Woodlands?

Where do we find Box-Gum Grassy Woodlands?

Box-Gum Grassy Woodlands extend across the cropping and grazing lands on the inland slopes and tablelands of NSW, Victoria and southern Queensland, in the area commonly described as the sheep-wheat belt. They typically occur on undulating to flat terrain with moderate to high fertility soils and with mean annual rainfall between 400 and 800 mm at altitudes of 170-1200m above sea level (NSW Scientific Committee 2002; Threatened Species Scientific Committee 2006).

The high agricultural value of this woodland country led to widespread clearing and livestock grazing early in the history of European settlement, to the extent that few pristine woodlands remain today. Rather, the woodlands now persist as fragments or 'remnants' in varying degrees of ecological condition scattered throughout the landscape.

What does high quality Box-Gum Grassy Woodland look like?

Key components

- Very diverse native grass and wildflower ground-layer.
- Patches of shrubs (occasionally absent or scattered but never a continuous layer).
- A range of tree sizes and ages of characteristic Box-Gum species with a open woodland canopy (although in derived grasslands trees may not always be present).
- Vegetation layers providing complex habitat for wildlife.
- Presence of tree-hollows and fallen timber.
- Effective ecological processes such as soil nutrient cycling and litter turnover, and plant-soil-animal interactions.

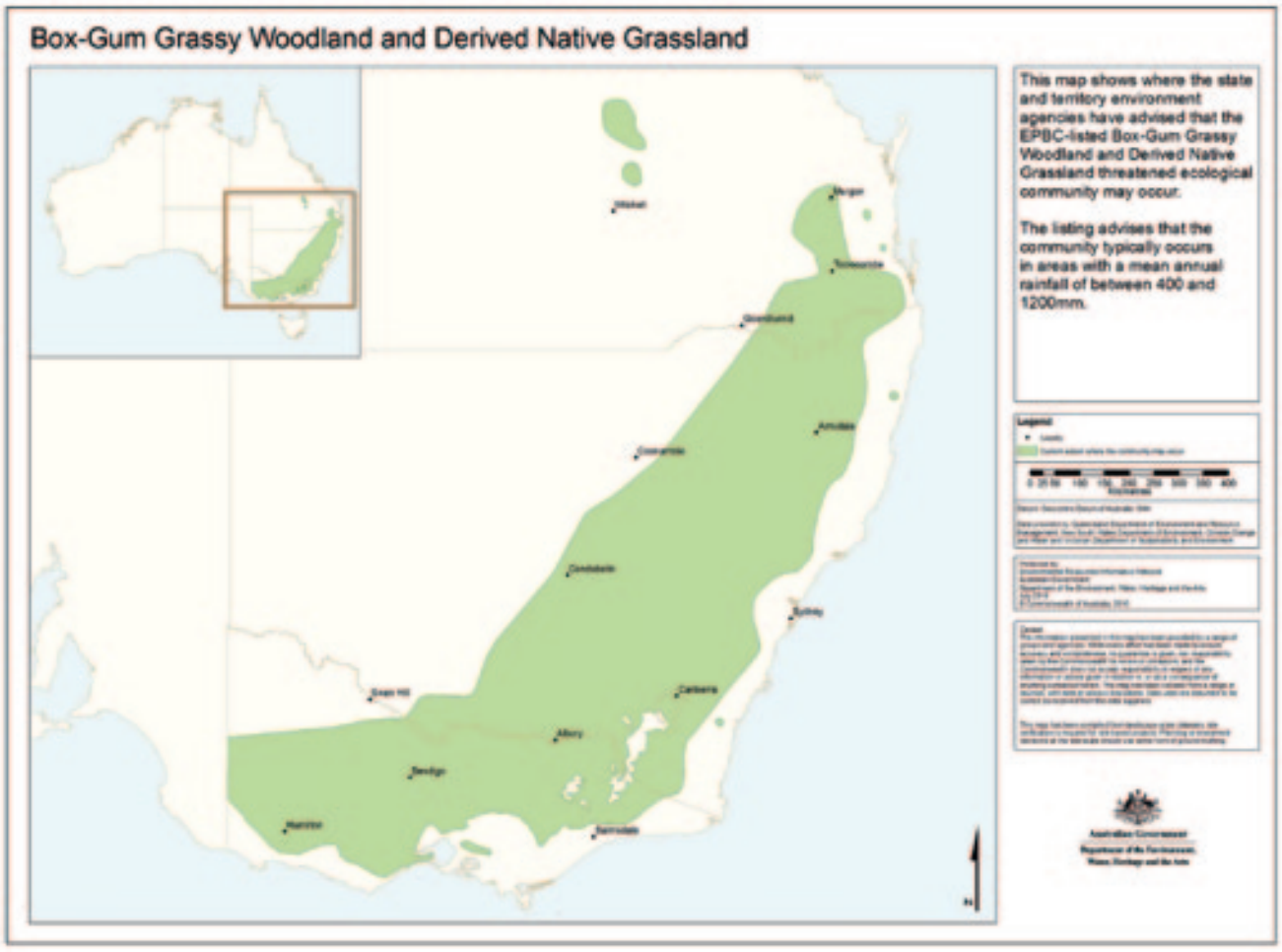


Figure 4: Distribution of Box-Gum Grassy Woodlands. More than 90% of its pre-European distribution is estimated to have been cleared. Less than half of the remaining 10% is considered likely to meet the minimum condition criteria of the listed ecological community (Threatened Species Scientific Committee 2006). Reproduced from the National Recovery Plan for White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland (2010).

The three most characteristic tree species across the woodlands are:

Yellow Box (*Eucalyptus melliodora*).
A tree to 30 m high; bark present on lower trunk and larger branches, grey or pale brown or yellow-brown, fibrous-flaky (`box'); bark is smooth above, grey, grey-brown or yellow, shedding in short ribbons; leaves light green/grey or bluish, narrow lance-shaped.

White Box (*Eucalyptus albens*).
A tree to 25 m high occurring from south-eastern Queensland throughout the western slopes of New South Wales into eastern Victoria, with isolated occurrences in South Australia. Bark present on entire trunk, pale grey with whitish patches, fibrous-flaky (`box'), smooth predominately white (sometimes grey) branches. Adult leaves broad, grey to blue green.

Blakely's Red Gum (*Eucalyptus blakelyi*).
A tree to 20 m high; bark smooth, patchy white, grey to brown or red; dull or grey green broad-lanceolate leaves.

Figure 5: Elements of a Box-Gum Grassy Woodland in excellent condition include an overstorey of trees, with a patchy shrub layer and a diverse grassy ground-layer, supporting a variety of fauna and ecological processes.

Overstorey

The mature tree layer is characterised by an open canopy of medium sized woodland trees ranging from occasional new saplings to old, large trees with hollows and limited amounts of dieback (i.e. dead branches or leaf loss). Tree cover is generally discontinuous with clearly separated canopies. Remnants cleared of trees – known as 'derived native grasslands' – are still classified legislatively as Box-Gum Grassy Woodlands for the values in the ground-layer (see Section 3.1).

Figure 6: White Box Woodland on a crown reserve on the North West Slopes of NSW showing characteristic open tree canopy. Historical and scientific studies indicate that typical densities of mature trees average around 30 per hectare in woodlands, although this varied with environmental conditions such as soil fertility.

Box-Gum Grassy Woodlands differences between the flowers, fruits and bark

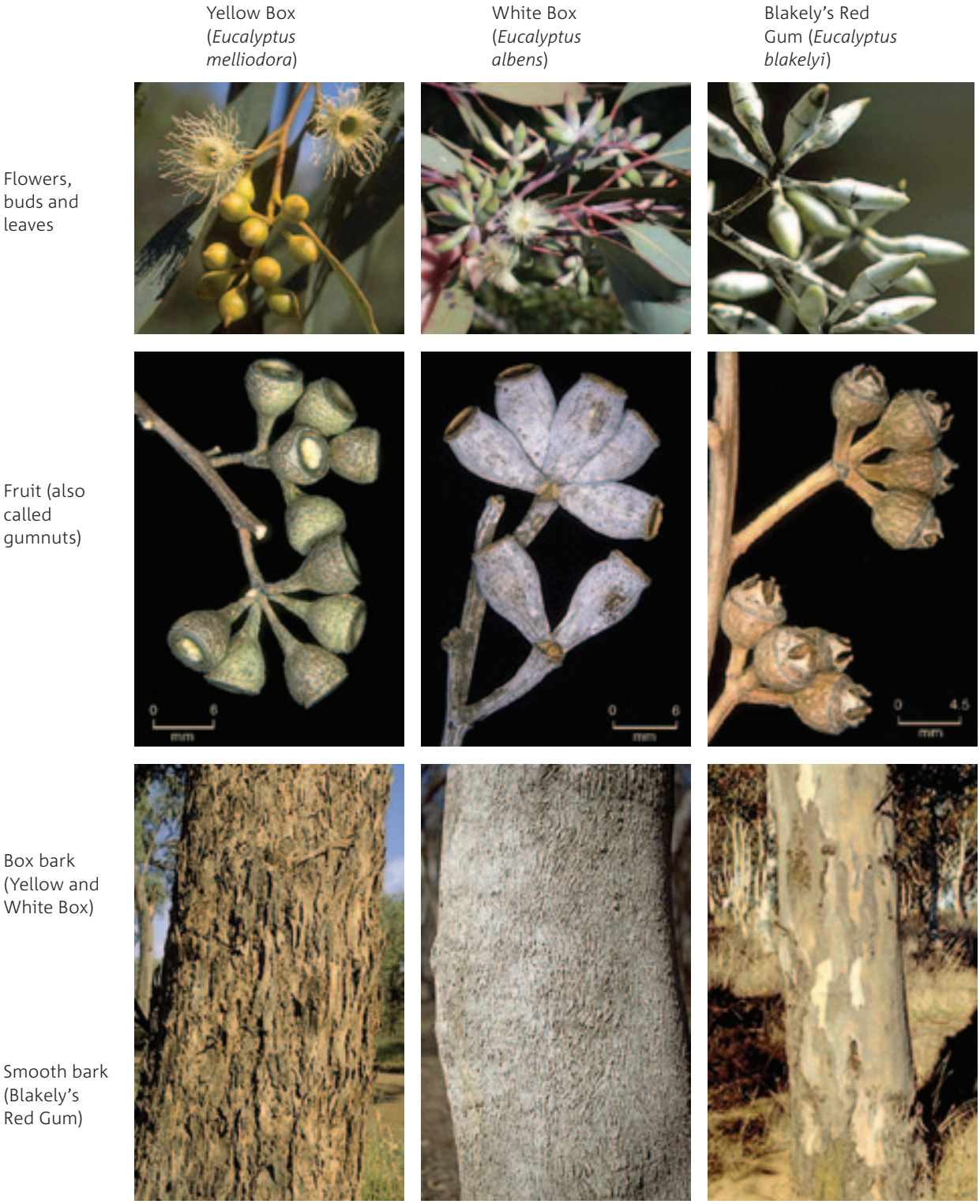


Figure 7: Differences between bark (of the lower trunk), fruit, flowers, buds and leaves of three characteristic tree species of the Box-Gum Grassy Woodlands. Images courtesy of Centre for Plant Biodiversity Research, CSIRO Publishing.

Shrub layer

Unlike many Australian forests and woodlands, a mature grassy woodland is characterised by a relatively sparse or patchy mid-layer of shrubs and young trees. Communities with a continuous shrub layer of more than 30% cover are excluded from the listed ecological community, as they are considered to be shrubby woodland (DEH 2006).

Figure 8: A relatively sparse or patchy layer of shrubs, rather than a continual shrubby layer, is one of the indicators of a woodland in excellent condition

Although this Guide focuses on the herbaceous ground-layer, the mid-storey shrub layer is also important, especially as habitat for many bird species. A healthy mid-layer includes regenerating shrubs and trees scattered amongst mature individuals.

Characteristic mid-layer shrubs and small trees include:

Figure 9: Western Wattle (*Acacia decora*). A spreading, rounded shrub growing 1–4 m high and wide.

Figure 10: Silver Wattle (*Acacia dealbata*). A shrub or tree growing 2–15 m or more, with an erect main stem, and silvery grey-green foliage (close-up lower image). A close relative, Dean's Wattle (*A. deanii*), is also a common woodland shrub.

Although this Guide focuses on the herbaceous ground-layer, the shrubs in the mid-storey layer are also important, especially as habitat for many bird species.

Figure 11: Tick Indigo (*Indigofera adesmiifolia*). A small shrub to 1.5 m high with leaves up to 6.5 cm long and leaflets up to 5 mm long. Image: Bruce Clarke

Figure 12: Spreading Bush-pea (*Pultenaea microphylla*). A prostrate to erect small shrub to 1m with small leaves 4-6mm. Bitter-peas (*Daviesia* spp.) and the Parrot-peas (*Dillwynia* spp.) are some of the other types of small pea shrubs present in the woodlands.

Ground-layer

A defining feature of Box-Gum Grassy Woodlands is the rich ground-layer of native grasses and wildflowers (also called forbs or herbs). The two key native grasses pictured here, Kangaroo grass (*Themeda triandra,* also known as *Themeda australis*) and Poa Tussock (*Poa sieberiana*), are characteristic of very high conservation value ground-layers. Section 3 elaborates on other characteristics of a healthy ground-layer.

Figure 14: Kangaroo Grass (*Themeda triandra*), a warm-season medium sized perennial (long-lived) tussock grass with attractive seed heads was once dominant over much of the fertile Box-Gum Grassy Woodlands.

Kangaroo Grass is a dense, leafy, clumped grass growing to 1.2m, with leaves 10-50 cm long and 2-5 mm wide, green to grey drying to an orange brown in summer. It has distinct large red-brown spikelets, which occur on branched stems. Once a dominant tussock grass over much of eastern Australia, it does not compete well under prolonged livestock grazing and in many places has been replaced by other native or introduced grasses.

Figure 13: An example of the rich ground-layer in a very high conservation value Box-Gum Grassy Woodland at Wallabadah Cemetery, NSW including Purple Flax lilies (*Dianella spp.*), Smooth Darling-pea (*Swainsona galegifolia*) and Bulbine Lily (*Bulbine bulbosa*)

Figure 15: Poa Tussock (*Poa sieberiana*) is a cool-season, medium-sized green grey tussock grass with attractive rounded habit, and soft green to pinkish seedheads.

Poa Tussock is a large tussocky grass to 1m high with very narrow, thread-like leaves, that flowers and sets seed in Spring and Summer. There are 3 varieties or sub-species where leaves have either dense or sparse hairs or the leaf colour varies from distinctly green (often dull green) to bluish green.

Structured plant layers contribute to healthy ecological processes

These different woodland plant layers contribute to what is called the 'ecological functioning' of the woodland. For example, the plants in all layers contribute to healthy soils by protecting the soil surface from sun, wind and rain, and returning organic matter through decaying plant material. Healthy levels of soil moisture, microbial activity and nutrient cycling in turn contribute to plant growth.

Similarly, each vegetation layer provides habitat and resources for many fauna species, and the fauna contribute to a wide range of woodland functions such as pollination and seed dispersal.

Fauna

High quality woodlands can have a diverse range of fauna above and beyond the more common animals, such as Galahs (*Eolophus roseicapillus*) and Eastern Grey Kangaroos (*Macropus giganteus*), that thrive in a paddock environment. Woodlands can provide excellent wildlife habitat with nesting sites, logs and foraging opportunities in the tree, shrub and ground-layer for a wide range of native birds, insects, possums, gliders and bats.

These include declining woodland birds, eg. Brown Treecreeper (*Climacteris picumnus*), Varied Sittella (*Daphoenositta chrysoptera*), Hooded Robin (*Melanodryas cucullata*) , Superb Parrot (*Polytelis swainsonii*), Regent Honeyeater (*Anthochaera phrygia*); reptiles like the Eastern Bandy Bandy (*Vermicella annulata*), Nobbi Dragon (*Diporiphora nobbi*) and Inland Carpet Python (*Morelia spilota* ssp. *metcalfei*); mammals such as the Squirrel Glider (*Petaurus norfolcencis*), Brush-tailed Phascogale (*Phascogale tapoatafa*) and Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) and a wide diversity of invertebrates.

In Australia a far greater proportion of wildlife species are dependent on tree hollows for survival compared to that on other continents. Hollows only develop as trees become older so the presence of larger older trees in these woodlands increases the likelihood of nesting and den sites being present.

Figure 16: The Hooded Robin (*Melanodryas cucullata*), photographed here after being banded for a research project, is a quiet, shy bird that is uncommon to rare throughout its range. Changes to the structure of grassy woodland habitat, such as removal of fallen timber and litter, has contributed to its decline (Action Plan No. 15, Environment ACT, 1999).

Landscape context

Box-Gum Grassy Woodlands were once relatively continuous across large tracts of the landscape, or formed mosaics with other types of vegetation associated with different soils or landforms.

Now that the woodlands have become highly fragmented due to the intensification of agricultural activities, woodland management decisions need to consider the landscape context of a woodland remnant as well as its management at the site-scale.

Landscape features that enhance high quality Box-Gum Grassy Woodlands typically include:

- large remnant size, rather than smaller, to permit viable population sizes of a greater number of species,
- large remnant size and/or buffer zones to minimise edge effects such as fertiliser run-on from neighbouring crops or pastures (Figure 17),
- different land management techniques (i.e. a diversity in management regimes) across the landscape to promote landscape level diversity,
- connectivity to other woodland patches across the landscape (e.g. scattered or clumps of paddock trees, shelter belts, fallen timber and tussocky ground-layer) which will contribute to population viability and year-round resource availability, especially for mobile fauna.

Nevertheless, many organisms of small stature, such as herbaceous plants, can maintain large populations even in small, isolated remnants, and landscapes opened up by clearing can increase distances that pollen can disperse.

Remnant size and landscape connectivity are often less important than site-scale management for such species, and site-scale management is the focus of this Guide.

Figure 17: Edge effect at Monteagle cemetery. Nutrients and weed seed load have spread from the highly disturbed green area (left side of fence) downhill into a very high conservation value grassland with Kangaroo Grass.

Landscapes with larger remnants, differing management types and with connectivity to other woodland patches will assist in the long term healthy viability of these woodlands.

Section 3
The grassy ground-layer

Much of the plant diversity in Box-Gum Grassy Woodlands occurs in the herbaceous ground-layer. This section describes how to recognise a very high conservation value ground-layer, why they are rare, and the places they are more likely to be found.

Key messages

- Very high conservation value ground-layers in Box-Gum Grassy Woodlands have an especially diverse range of native ground layer species, such as grazing-sensitive orchids, lilies, wildflowers, sub-shrubs and grasses. The dominant grasses are typically Kangaroo Grass and Poa Tussock.
- Less diverse ground-layers can still be of high conservation value and qualify as part of the listed Threatened Ecological Community.
- Woodlands can be highly valuable even if most or all of the trees are not present but these 'derived native grasslands' can be difficult to recognise.
- If Kangaroo Grass and Poa Tussock are the most common grasses on the site then many other important woodland plant species are likely to be present.
- Very high conservation value woodlands usually have only relatively low abundances of weeds.
- Woodlands have been widely grazed for livestock production or cleared for cropping – areas escaping these land uses, such as unused areas in cemeteries, travelling stock routes and reserves, railway easements, town commons, some Crown reserves and 'back paddocks' can contain some of the best remaining native ground-layers.

Section 3.
The grassy ground-layer

The devil's in the detail: recognising a very high conservation value ground layer

It's not unusual to rely on the dominant trees to identify a remnant of Box-Gum Grassy Woodland. However, as most of the plant diversity in the woodlands is in the grassy ground-layer, a remnant can be of very high value for plants even if most of the trees have been cleared or are no longer present.

Indeed, it is rare to find both high quality overstorey and understorey together in woodland landscapes today. Rather, the ground-layer element often needs to be conserved and managed where the whole woodland is not intact. These cleared remnants are known as 'derived native grasslands', and can be particularly difficult to recognise.

A very high conservation value native ground-layer is characterised by the identity and diversity of plants it contains. The three main elements to look for are i) a high diversity of ground-layer plants, ii) the presence of Kangaroo Grass and/or Poa Tussock and iii) low abundance of weeds.

i) A high diversity of ground-layer plants

A diversity of native wildflowers would be expected, with perhaps 40 to 80 species in sites of 1 to 10 ha. Some native wildflowers are particularly vulnerable to livestock grazing and nutrient enrichment, so their presence is a good indicator of a very high conservation value native ground-layer. Grazing-sensitive species include:

- Daisies such as the Yam Daisy (*Microseris lanceolata*), Billy Buttons (*Craspedia variabilis*), Lanky Buttons (*Leptorhynchos elongatus*), Scaly Buttons (*L. squamatus*) and Showy copperwire daisies (*Podolepis jaceoides*);
- Orchids such as the Purple Donkey-orchid (*Diuris punctata*) and Golden Moths (*D. pedunculata*);
- Legumes such as Swainson-peas (e.g. *Swainsona sericea*), Leafy Templetonia (*Templetonia stenophylla*) and Austral Trefoil (*Lotus australis*);
- Lilies such as Milkmaids (*Burchardia umbellata*) and Fringe Lilies (*Thysanotus tuberosus and T. patersonii*);
- Other wildflowers such as Small St John's Wort (*Hypericum gramineum*) Native Flax (*Linum marginale*), Curved Rice Flower (*Pimelea curviflora*), Buttercups (*Ranunculus lappaceus, R. pachycarpus*) and Creamy Candles (*Stackhousia monogyna*).

In spring, colourful wildflower displays are not unusual, but these may not be apparent in dry years, at times of year other than spring, or when native grasses have been allowed to grow too dense. Undertaking a walk during Spring will help managers familiarise themselves with this diversity.

Figure 18: Knee-high Yam Daisies (*Microseris lanceolata*) blooming in this derived native grassland, contrasting with the grazed pasture in the woodland behind the fence. Image: Margaret Beemster.

(a) (b) (c) (d)
(e) (f) (g)
(h) (i)
(j) (k) (l)

(a) Showy Copper-wire Daisy (*Podolepis jaceoides*)
(b) Kneed Swainson-pea (*Swainsona reticulata*)
(c) Yam Daisy (*Microseris lanceolata*)
(d) Bulbine Lily (*Bulbine bulbosa*)
(e) Stinking Pennywort (*Hydrocotyle laxiflora*)
(f) Small St. John's Wort (native) (*Hypericum gramineum*)
(g) Milkmaid (*Burchardia umbellata*)
(h) Austral Trefoil (*Lotus australis*)
(i) Native Flax (*Linum marginale*)
(j) Purple Donkey-orchid (*Diuris punctata*)
(k) Yellow Buttons (*Chrysocephalum apiculatum*)
(l) Scaly Buttons (*Leptorhynchos squamatus*)
Images: K. Thiele & S. Prober

Figure 19: Bulbine Lilies (*Bulbine bulbosa*), Creamy Candles (*Stackhousia monogyna*), Convolvulus (*Convolulus sp.*), Native Plantain (*Plantago debilis*), Swainson-pea (*Swainsona sp.*) and Blue Flax-lily (*Dianella revoluta*) contributing to a diverse ground-layer beneath trees in this wooded remnant.

ii) Presence of Kangaroo Grass and Poa Tussock

A very high conservation value ground-layer will have a high proportion of Kangaroo Grass and/or Poa Tussock, rather than wallaby grasses (*Rytidosperma* spp.), red grasses (*Bothriochloa* spp.) and spear grasses (*Austrostipa* spp). The latter are more common in sites grazed by livestock, and are also naturally more common on poorer soils or in more arid sites.

If Kangaroo Grass and Poa Tussock are the common grasses, it is likely that many other ground-layer species are present even if not currently evident due to lack of flowering. A good rainfall year in Spring will provide the best opportunity to observe how many of the other native plant species are present.

iii) Low abundance of weeds

These ground-layers will have a low abundance of weeds, particularly the more robust exotic annuals such as wild oats (*Avena* spp.), rye grasses (*Lolium* spp.), bromes and Paterson's Curse (*Echium plantagineum*).

Small exotic annuals such as hairgrasses (*Aira* spp.) and clovers (*Trifolium* spp.) will often co-exist with natives even in a very high conservation value native ground-layer.

Figure 20: Exotic annual grasses such as wild oats (*Avena spp.*), rye grasses (*Lolium spp.*), and bromes (*Bromus spp.*) are bright green when actively growing in spring, signifying a degraded ground-layer.

Box 2 Avoiding costly mistakes: high conservation value native ground-layers can be easy to overlook

It is easy to mistake important remnants of the native ground-layer of Box-Gum grassy woodland for "cleared paddocks". For example, in 2012 a housing estate was constructed on 4.5ha of rare Box-Gum Grassy Woodland ground-layer, owing to miscommunication between developers and consultants. The developers consequently undertook a series of remedial actions, including funding research and rehabilitation work in Box-Gum Woodlands. More detail on the Commonwealth and NSW legislative requirements that will specifically identify Box-Gum Grassy Woodlands are provided in Appendix 1.

Figure 21: Development in Box-Gum Grassy Woodlands require a rigorous and comprehensive assessment process under local, state and commonwealth legislation.

Some other attributes considered desirable in a very high conservation value ground-layer include a complex structure with plants of varied heights and life-forms, including: tussock grasses with gaps between them for wildflowers; plant recruitment; leaf litter; mosses and lichens; and some fallen timber, which is desirable as fauna habitat.

However, it is important to remember that this description applies specifically to the highest-quality grassy ground-layers that are the subject of this guide. Other, somewhat degraded ground-layers can still be of high conservation value and still qualify as part of the listed Threatened Ecological Community.

Why are diverse native ground-layers so rare?

While the Box-Gum Grassy Woodlands are geographically widespread, ranging from southern Queensland to western Victoria, woodlands with high or very high conservation value native understorey are extremely rare. Understanding why they have become rare helps us to know where to find them in today's landscapes.

When settlers first came into the Box-Gum Grassy Woodlands, much of the country seemed like a ready-made pasture. Early settlers and explorers saw "very rich beautiful country, well watered, wooded, and peculiarly well suited for settlers" (Governor Macquarie 1820) and places where "the soil is exceedingly rich and produces the finest grass intermixed with a variety of herbs" (George Evans, Deputy Surveyor-General 1813–16).

Figure 22: The grassy woodlands were ready-made for grazing by sheep and cattle, so few areas escaped their influence. Red Grass is a common dominant in grazed native pastures such as this one, replacing the original Kangaroo Grass and Poa Tussock.

These reports led to a land rush with settlers and squatters rapidly taking up these open, fertile, richly grassed and better watered woodland areas. It didn't take long for these richly grassed areas to change – by 1850 sheep and cattle were being run from the Burnett River in Queensland to the Portland district of Western Victoria. Soon the dominant native grasses such as Kangaroo Grass and Snow Grass were replaced by other, shorter native grasses, and weeds began to encroach. Even by as early as 1854 a New England school master William Gardiner noted that 'the sheep have pretty well swept the grasses out of sight'.

The pressures on the Box-Gum Grassy Woodlands intensified even further from the 1860's. The gold rushes, expansion of railways and reduction in size of leaseholds led to consolidation of settlement, with more intensive grazing and clearing for cropping.

By the turn of the century, overgrazing by livestock and rabbits, and a harsh extended drought had impacted heavily on native pastures and soils. Over the following 50 years, a new wave of clearing resulted from the expansion of cropping, facilitated by increasing mechanisation. As sown pastures and fertilisers increased, weeds such as wild oats, silver grasses (*Vulpia* spp.), bromes (*Bromus* spp.) and Paterson's Curse (*Echium plantagineum*) quickly invaded, outcompeting and replacing many of the grazing sensitive wildflowers.

Figure 23: Exotic annuals, including Quaking Grass (*Briza maxima*) and Common Century (*Centaurium erythraea*), are now common in Box-Gum Grassy Woodlands. Images: Don Bruce & Lorraine Oliver.

...And where can they be found?

This history of settlement, combined with the vulnerability of native wildflowers and grasses to livestock grazing and nutrient-enrichment, has meant that very high conservation value ground-layers of Box-Gum Grassy Woodland remain only in rare parts of the landscape that were never fertilised, and were fenced from livestock grazing early in the history of settlement.

These include places such as small, little-used country cemeteries that were fenced early on and were often looked after by local committees that undertook frequent burning. Some railway easements also remain in very good condition today, although a widespread shift from burning to weed spraying by management authorities has led to losses in biodiversity value over more recent decades.

Networks of travelling stock routes and reserves (TSRs), town commons, State Forests and 'back' paddocks or bush blocks on farms are also important remnants for native woodland biodiversity. Because they were historically only intermittently grazed, more native plants have been able to persist in many of these sites, even though the ground-layer is typically more degraded than in ungrazed sites.

Importantly, very high conservation value ground-layers in remnants in cemeteries, rail easements, TSRs and town commons usually occur in the more productive and fertile parts of the landscape, where Box-Gum Grassy Woodlands are most characteristic. Such areas are relatively poorly represented in the conservation estate, which historically was biased towards the least productive parts of the landscape. In the past 20 years, significant efforts have been made to redress the lack of representation of the Box-Gum Grassy Woodlands in the National Reserve System through the inclusion of (historically-farmed) properties from this more productive country.

Figure 24: Monteagle rail easement with Kangaroo Grass and purple Chocolate Lilies (*Dichopogon fimbriatus*).

Figure 25: Travelling stock reserves and routes (TSRs), particularly the more out of the way TSRs with less intensive grazing histories, can have diverse ground-layer native plants often not found in the adjoining paddocks (Monteagle to Murringo tree-covered TSR).

Figure 26: Native daisies (*Pycnosorus thompsonianus*) and Smooth Darling Pea (*Swainsona galegifolia*) in the Delungra-Ashford Rd TSR).

Figure 27: Gum Flat cemetery, NSW with Spur Velleia (*Velleia paradoxa*) in the foreground.

Figure 28: Showy copperwire daisies (*Podolepis jaceoides*) and bluebells (*Wahlenbergia spp.*) on the Narrallen – Murringo roadside, NSW.

Figure 29: A rare jewel – over 80 native ground-layer species were identified during just one survey in this 80ha back paddock, on a cattle grazing property near Yass, NSW.

Where Kangaroo Grass and Poa Tussock are the common grasses many other ground-layer species are often present and a good rainfall year in Spring will provide the right conditions for seeing these colourful wildflowers.

Section 4

Disturbance regimes and ground-layer plant communities

This section describes scientific research findings on using disturbance regimes to manage very high conservation value ground-layers of Box-Gum Grassy Woodlands, to maintain the diversity of plant species they support. These findings form the basis for 6 principles for managing these ground layers (Section 5). Disturbance regimes potentially include the use of mowing, grazing or fire, with fire in particular a potentially valuable ecological tool. As fire can endanger lives, property and the environment if inappropriately used, all due process and care must be taken when considering its use as a management tool.

Key messages

- The diverse native ground-layer of Box-Gum Grassy Woodlands evolved with the regular application of fire by Aboriginal people.
- Disturbances such as fire provide open spaces between grass tussocks, which in ground-layers dominated by Kangaroo Grass can otherwise become overgrown, smothering native wildflowers.
- Today, burning, mowing, slashing and grazing are potential management tools to maintain these open spaces and promote native wildflower diversity, although the ecological impacts of these different disturbance types are not identical.
- There is no simple 'recipe' for the appropriate disturbance regime to use at any particular site, rather, the six principles suggested in Section 5 can be used to help guide actions.
- As grass growth varies according to seasonal conditions, the best indicator for timing of disturbance is the thickness and density of the grassy ground layer.
- Having a mix of Kangaroo Grass and Poa Tussock provides flexibility and resilience to changing conditions.
- In long-unburnt, wooded sites fire may not be necessary to maintain the current plant species composition.
- In sites where it is appropriate to use fire, burning is often more practical during late autumn or early winter, and that timing is beneficial for native wildflowers.
- Moderate fire intervals can favour native plants and disadvantage exotic annuals, as exotic annuals decline more quickly than native plants with time since fire.
- Repeated fire in conjunction with drought can compromise the native ground-layer and soil health.
- All fire risk hazards and available resources must be fully assessed and relevant permits and approvals obtained before considering or undertaking management burns.

Section 4
Disturbance regimes and ground-layer plant communities

What is a disturbance regime?

In ecology, a *disturbance* is any relatively discrete event that disrupts an ecosystem, community or plant or animal population, changing its structure or character. Natural disturbances include fire, wind, floods, and disease epidemics. A *disturbance regime* describes the pattern of disturbances that shape an ecosystem over a long time scale[1].

Natural ecosystems have typically evolved with particular disturbance regimes, such as frequent, low intensity fire and grazing by native herbivores in the case of Box-Gum Grassy Woodlands. The plant and animal species belonging to the community become adapted to that disturbance regime, and in some cases, require that disturbance regime to be able to persist.

On the other hand, if a disturbance regime differs distinctly from those under which the ecological community evolved, it can lead to substantial changes in the species making up those communities. These types of disturbance may be a change in fire regimes, and disturbances that are new to the ecosystem such as the introduction of livestock grazing with European settlement.

Aboriginal burning in Box-Gum Grassy Woodlands

Frequent planned burning by Aboriginal people contributed to the maintenance of biodiversity and created spatial variation in structure and composition in the Box-Gum Grassy Woodlands. Fires were used to promote 'green pick' for marsupial grazers, and to favour important food plants such as the Yam Daisy.

Figure 30: Henry Godfrey watercolour from 1843 in Victoria, depicting gathering yams from the Yam Daisy (*Microseris lanceolata*), a species promoted by fire. Courtesy of the State Library of Victoria.

Given this history of Aboriginal burning over many thousands of years, many woodland and grassland plants are adapted to or benefit from relatively frequent fire. Many Australian plants, and most woodland and grassland plants, resprout after fire. Although fire can reduce their cover temporarily, these species will quickly regrow after fire. However, there is little detail documented regarding the specific frequency, intensity, or spatial patterning of Aboriginal fire regimes in Box-Gum Grassy Woodlands.

Disturbance regimes in grassy woodlands today

Since European settlement, the disturbance regimes of most Box-Gum Grassy Woodlands have changed. Most remnant woodlands have been grazed by livestock and are no longer regularly burnt, leading to quite different ground-layers, as highlighted in Section 3.

For the rare remnants with very high conservation value ground-layers, disturbance regimes have been variable. Some have not been burnt, mowed or grazed by livestock for many years. In other sites, especially in cemeteries and on rail easements, fire has been a part of more recent historical management regimes. Kangaroo grazing has continued at many of these sites but livestock grazing is characteristically infrequent or absent.

Today, the use of fire requires specific approvals and permits from local councils and relevant State fire authorities. Understanding the requirements of current legislation, while ensuring expert knowledge is available to minimise risks, means that using fire requires careful planning. Availability of local government and volunteer resources can also challenge implementation of fire management.

Ultimately, the benefits of integrating fire into management of Box-Gum Grassy Woodlands warrant consideration of new pathways for implementation, potentially through grant schemes and collaborating with local Aboriginal people, especially in sites containing culturally significant ground-layer plant species.

Ecological research

To help design effective disturbance regimes for maintaining an abundant and diverse native ground-layer in Box-Gum Grassy Woodlands today, a range of ecological studies have been undertaken.

These include observational studies comparing remnant woodlands and derived grasslands that had different management histories, as well as experiments such as a twelve-year study that researchers undertook at the Woodstock and Monteagle Cemeteries (see Box 3).

In the rest of this section we summarise some of the conclusions from these studies. Section 5 then draws on these conclusions to list some principles for the use of disturbance regimes to manage very high conservation value Box-Gum Grassy Woodland ground-layers.

1 Definitions from Pickett, S.T.A., and P.S. White. 1985. The Ecology of Natural Disturbance and Patch Dynamics. Academic Press, Inc. Orlando, Florida.

Box 3: The Monteagle and Woodstock 'Disturbance Experiments'

The results from these two experimental sites form a key basis to our understanding of woodland management (See Section 4.4.1 onwards) and this box describes these experiments in more detail.

In 1993 experiments were set up at two sites, the Monteagle and Woodstock Cemeteries. Both sites occur on the Central West Slopes of NSW, and receive average annual rainfall of around 600 mm. These sites are representative of two extremes of very high conservation value Box-Gum Grassy Woodland ground-layers, as described below.

At the start of the experiment, **Monteagle** had a diverse native ground-layer dominated by Kangaroo Grass, with some Poa Tussock. The trees were cleared in early-settlement, and at the start of the experiment the site had been burnt by the local bush fire brigade every 4 to 8 years for the past 40 years.

Woodstock had a diverse native ground-layer dominated by Poa Tussock, with some Kangaroo Grass. The trees are still present, and according to local knowledge the site hadn't been burnt since before World War II prior to the start of the experiment.

The following disturbance regimes were applied in 5 x 5 m experimental plots over 12 years:

- no burning or mowing
- 2 yearly burning (May-June)
- 4 yearly burning (May-June)
- 8 yearly burning (May-June)
- 2 yearly mowing to 150mm (May-June, slash not removed, Monteagle only)
- fencing to exclude kangaroos and rabbits (Woodstock only)

Every few years, measurements were made of the diversity and abundance of the native and exotic ground-layer plants, the health of the native grassy sward and the health of the topsoils.

Although these are only two sites across the wide range of the Box-Gum Grassy Woodlands, these experiments, combined with other observational studies, have helped us to learn more about disturbance needs of high quality ground-layers today.

Figure 31: The first burning treatments at Monteagle (top) and Woodstock (above) in 1994. Left: Suzanne Prober with Keith Butt (Fairfields). Keith led the Monteagle Bush Fire Brigade and associated burning at Monteagle Cemetery for many years, including assistance with the Monteagle burning trials (image Margaret Beemster).

Disturbance regime and recent history interact

An important lesson from the Monteagle and Woodstock disturbance experiments is that, even though ground-layers of Box-Gum Grassy Woodlands evolved under frequent Aboriginal burning, disturbance regimes of the last 20 to 50 or so years can influence the response of the ground-layer to disturbance regimes applied today.

At Monteagle and Woodstock for example, the effects of burning differed between sites, probably owing to their different tree clearing and burning histories. Fire was more beneficial to maintaining plant diversity on the Kangaroo Grass dominated open sites (Monteagle) whereas plant diversity was maintained without fire over the experimental period at the long unburnt treed site (Woodstock).

Thus, there isn't a simple disturbance regime (i.e. 'recipe') that is best for all sites. Instead, *understanding the principles (Section 5) underlying the effects of disturbance* can help guide management choices.

A mix of Kangaroo Grass and Poa Tussock gives flexibility

The frequency of burning strongly influences which native grasses dominate the native grassy ground-layer. For example, when researchers introduced frequent fire to the long unburnt site at Woodstock, the dominant

grass changed from Poa Tussock to Kangaroo Grass. When burning stopped in the site that had been frequently burnt (Monteagle) the dominant grass changed from Kangaroo Grass to Poa Tussock.

Both of these can be favourable outcomes because in most cases the grassy layer continues to provide a healthy native ground cover. A sward (i.e. the grassy ground-layer) containing a mix of Kangaroo Grass and Poa Tussock is ideal, because it is easily able to adapt to more frequent or less frequent fire.

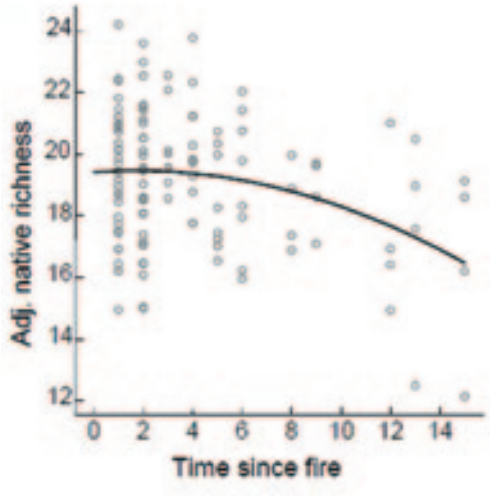
Nevertheless, in sites dominated by Kangaroo Grass, the sward can eventually become overgrown and tussocks begin to die if the sward isn't burnt often enough.

Wildflower diversity is maintained by fire – but not always!

Wildflowers germinate, establish and grow primarily in the spaces between the tussock grasses, where light, water and nutrients are available. If these spaces are occupied by accumulating live and dead grasses, especially Kangaroo Grass, the number and abundance of native wildflowers can decline over time (see Graph 1).

The rate at which the wildflowers decline is dependent on how fast the grass grows, which in turn is dependent on site conditions (e.g. soil type) and climate. At any particular site, growth rates also vary each year depending on the rainfall.

At Monteagle (the derived grassland with a history of regular burning), it was found that about 3 species out of 20 would be lost from the 5 x 5 m plots after 15 years without burning, assuming rainfall was around average levels. The data suggested that burning every 4 to 6 years would be an effective fire regime at this site during average rainfall years.



Graph 1: Data from the Monteagle experimental site showing how native plant species richness declines with time since the last fire (years). The number of native plants appearing in any year depends on rainfall, so values for native richness (per 5 x 5 m plot) are adjusted ('Adj') to average rainfall. Grey circles are data points in the 12 year dataset and the black line shows the statistically significant trend (P=0.003). Reproduced from Prober et al. (2013).

In wet years (or in sites with more fertile soils or higher rainfall), the sward becomes overgrown more quickly, so burning may need to be more frequent. In dry years (or in sites with less fertile soils or lower rainfall), the sward grows more slowly, so fires are needed less often. Drought years can act in a similar way to fire, causing the grass to die back, and opening up the space for wildflowers, thus no other disturbance might be needed during drought.

The best measure of when a site like this needs burning is thus not how many years it was since the last burn, rather how thick and dense the grass is.

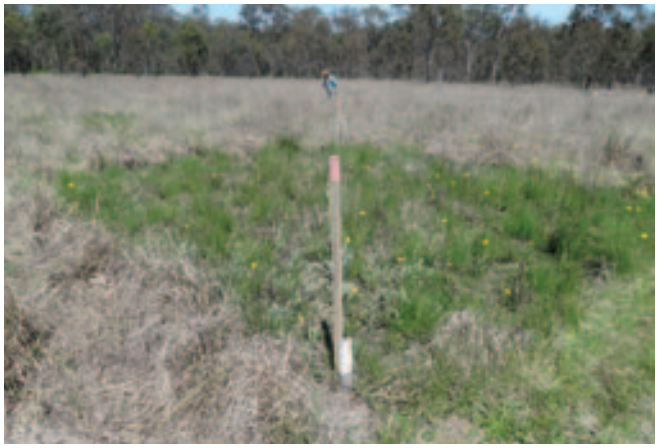


Figure 32: An overgrown Kangaroo Grass layer in a Monteagle experimental plot is regrowing strongly after an early winter burn. Note minimal flowering of the yellow Yam Daisies in the surrounding unburnt grassland.

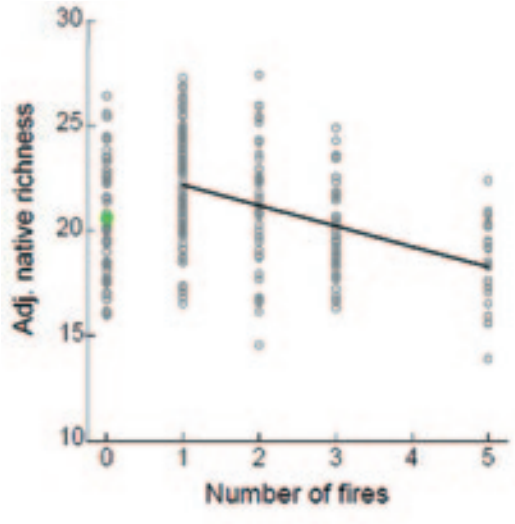
Although regular burning was found to be important for maintaining plant diversity at Monteagle, this was not the case at Woodstock, the long-unburnt experimental site dominated by Poa Tussock (Figure 33). Indeed, after five burns in 12 years, surveys showed that plant diversity had actually declined compared with unburnt plots (Graph 2).

Figure 33: Burning was not essential for maintaining wildflower abundance and diversity at this long-unburnt site at Woodstock, even when fenced from kangaroos (images show plots not known to have been burnt since before 1950 but still with diverse wildflowers). However, some fire-loving species such as Fringe Lilies (*Thysanotus tuberosus*) and Purple Donkey-orchids (*Diuris punctata, D. dendrobioides*) are not present at this site. The fine leaved Poa Tussock is the dominant tussock at this long- unburnt site.

There are two potential reasons for this result. First, the biomass of the unburnt native grassy sward at Woodstock (site with trees) was only half that of Monteagle (open site). The presence of overstorey trees at Woodstock (but not Monteagle) may contribute to this – trees can compete with the grasses, keeping the grassy sward more open. This may naturally provide more space for wildflowers without additional disturbance.

Second, some plants that benefit from fire may have already died out at Woodstock before the experiment began. For example, even though Woodstock has a higher plant diversity overall than Monteagle, there are no Fringe Lilies or orchids, and only small numbers of Yam Daisies, all of which are fire-loving species. This is called a 'legacy' effect – because wildflowers don't tend to have long-lived seed banks, and it is so far to the next site containing these species, these plants can't easily return when fire is re-introduced.

In long-unburnt, wooded sites (like Woodstock) fire doesn't appear necessary to maintain the current plant species composition.



Graph 2: A greater number of fires applied over a 12 year period reduced native plant richness at Woodstock. The number of native plants appearing in any year depends on rainfall, so values for native richness (per 5 x 5 m plot) are adjusted ('Adj') to average rainfall. Grey circles are data points in the 12 year dataset and the black line shows the statistically significant trend (P<0.001). Reproduced from Prober et al. (2013).

Drought plus frequent fire can compromise the grassy layer and soil health

Although frequent burning can be beneficial, at Monteagle where Kangaroo Grass was dominant, the experimental trials found that burning every two years made the grassy layer (sward) more vulnerable to drought.

On these plots, many of the Kangaroo Grass tussocks died during prolonged drought (2003-2006), and the ground became bare and open. The bare, open soils were less able to capture rainfall – there was less infiltration, and this resulted in lower biological activity and poorer growth of the tussock grasses.

Again, this emphasises the importance of looking at the state of the grassy sward to help decide when to burn – if the sward is weak and there is too much bare soil, it shouldn't be burnt.

SEASON AND INTENSITY OF BURNING

Although it remains unclear what time of year Aboriginal people burnt this country, it is most practical for managers today to burn during late autumn to early winter (April to June), when there is low fire danger but adequate dry grass to burn, providing the resources, approvals and permits are in place.

Figure 34: Many woodland wildflowers, such as this Yam Daisy (*Microseris lanceolata*), survive the hot dry summer by dying back to underground tubers or other storage organs. The plants resprout after the autumn or winter rains arrive. Burning before these species emerge avoids any reduction in tuber replenishment, flowering and seeding. Image: K. Thiele.

This timing is also beneficial for maintaining native wildflowers. Many native wildflowers die back to underground roots or tubers over the summer, and don't emerge again until the rains begin in the late autumn or winter. Burning before they emerge, or not too long after, will thus reduce the grass cover without affecting the wildflowers.

Burning during the wildflower growing season (winter to early summer depending on location) could potentially prevent flowering and seeding of the wildflowers, and reduce the amount of energy the plants can store in their roots and tubers for the next season.

Figure 35: Fires would typically be relatively mild in intensity, burning the tussocks with low flame heights, and with particular care taken to avoid scorching trees by moving accumulated material from around their bases

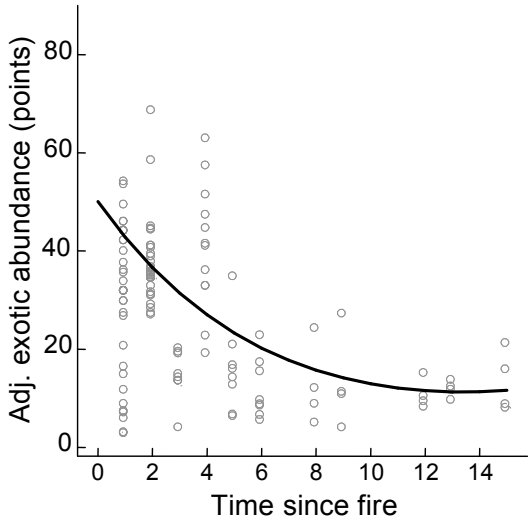
Disturbance can benefit weeds so manage for the trade-offs

Another consideration for managers of the grassy ground-layer is the abundance of weeds. Even the best remnants of native ground-layers in Box-Gum Grassy Woodlands contain some weeds; usually these are quite diminutive exotic annuals such as clovers and hairgrasses.

The aim is to keep these at low abundance. Experiments and observations show that the exotic annuals can grow more vigorously immediately after disturbances such as fire. In high rainfall years even the small exotic annuals may compete with native wildflowers.

In sites where wildflowers also benefit from fire, this means there is a management trade-off – encouraging more wildflowers, also encourages more exotic annual grasses. However, these exotic annuals tend to decline in abundance much more rapidly with time since the fire than the native species do. This means that moderate fire intervals (e.g. 4–6 yearly under average rainfall at Monteagle) can favour the native wildflowers and disadvantage exotic annuals.

In sites where burning is not needed to promote wildflowers, this simultaneously helps to reduce exotic annuals.



Graph 3: This line highlights that the abundance of exotic annuals declines rapidly at Monteagle with time since fire (years). Grey circles are data points in the 12 year dataset. Abundance is measured as 'points' out of 50 at which exotic plant species were recorded (abundance of exotic annuals in any year depends on rainfall, so values for exotic abundance are adjusted ('Adj') to average rainfall). S. Prober unpub. data.

Disturance regimes such as burning, mowing or crash grazing can be important to help maintain woodland plant diversity in some sites.

Alternatives to burning – mowing, slashing and strategic grazing

Although fire can be a valuable ecological tool in some sites, burning can be difficult for some managers to apply in certain situations, and fire requires careful planning, including obtaining relevant permits and approvals. Experiments and observations show that other techniques can mimic the effects of burning, although the effects aren't identical.

These include:

i) Slashing and mowing

Mowing removes some of the bulk of the grasses, in a similar way to burning. The frequency of mowing needs to be balanced between the amenity required for human use and the needs of the grassland. As for burning, the grassy sward is best left unmown during the wildflower growing, flowering and seeding season (winter to mid-late summer depending on location and seasonal conditions).

In some locations, such as the Southern Tablelands, there is still flowering of some species in mid-summer (Blue Devils *Eryngium ovinum*, Pale Everlastings *Helichrysum rutidolepis*, Parsons Bands *Eriochilus cucullatus* , Lemon Beauty-heads *Calocephalus citreus*). So where these mid-summer seeding species are present, then biomass management should only be undertaken when these have shed their seeds.

At Monteagle it was found that mowing in May or June every second year (to a grass height of 100–150mm, without removing slash) was similar to burning every four years – an effective disturbance regime. There was some change in composition of the wildflowers, including fewer lilies and more grass-like species. Exotic Flatweeds (*Hypochaeris* spp.) also increased with mowing compared with burning.

At other ACT and southern NSW sites such as the Hall and Murrumbateman Cemeteries, more frequent mowing still maintains a healthy ground-layer but is avoided between late August and late January to allow native orchids and wildflowers to flower and set seed. The timing of mowing in January is flexible depending on the season – if drier conditions prevail then often flowering is finished earlier, or if wetter then flowering and seeding is later.

Figure 36: Experimental plot in foreground demonstrating excellent ground-layer characteristics in response to 2 year mowing regime, with good capacity for wildflowers, orchids and other plants to establish and grow between the tussocks. Pins in the lower image show where native seedlings have emerged (each cell is 10x10cm).

ii) Common mowing and slashing issues

Some other issues managers need to consider when using mowing include:

i) Too frequent and too short mowing regimes lead to loss of Kangaroo Grass and Poa Tussock, and their replacement by shorter native grasses or weeds, and even excessive areas of bare soil (see Figure 37).

ii) Deep rows or piles of grass clippings can smother grasses and wildflowers, release nutrients from dead material and encourage weeds to colonise. If windrows form, mowing a second time as soon as possible can assist spreading grass cuttings.

iii) Avoid introduction of weed seeds into these important sites by ensuring protocols for clean mower hygiene are part of standard mowing practices i.e. mowing 'clean' sites before weedy sites, cleaning machinery and vehicles before arriving at significant sites.

iv) Thatch (dead plant material) can accumulate where plant biomass is high and not decomposing. If there is no bare ground visible with substantial amounts of thatch it may need removal via a mower catcher, dethatched or a management burn.

Figure 37: The widespread flatweed (*Hypochaeris radicata*) can become abundant with frequent mowing, whereas it declines with burning.

iii) Crash grazing by livestock

High stocking densities of livestock grazing for short durations (e.g. several days) have been used effectively in some sites to reduce the bulk of native grasses in a similar way to fire. There are some key potential pitfalls to avoid when using this approach:

- Grazing should be avoided in the wildflower growing season (winter to early summer depending on location), recognising some species still flower in mid-summer.
- Grazing when the soil is moist or wet causes soil compaction and other long term damage, so should be avoided.
- Ensure livestock are weed free, remembering that seeds can be present both in the gut where it may take weeks to pass through their system, or on fleeces/coats.
- Grazing too frequently can lead to the local extinction of grazing-sensitive native wildflowers, and lead to dominance by grasses other than Kangaroo Grass and Poa Tussock (see Section 6).

Figure 38: Crash grazing can be used instead of fire to reduce the grassy sward. Care needs to be taken with the timing because animals such as cattle can damage soils and plants, particularly after rain where hooves cause pugging and soil compaction.

iv) Grazing by kangaroos and rabbits

Kangaroos and rabbits are present at most sites and can provide some reduction in the native grass biomass. However these animals can't be relied on to produce the same effects as fire or mowing.

For example, a decline in species richness occurred in the absence of burning at Monteagle despite free access for kangaroos and rabbits. At Woodstock, kangaroos and rabbits reduced the total amount of plant biomass by about one third, but fencing them out did not have strong impacts on native wildflower composition or abundance.

Equally, there are cases where numbers of these animals are very high and can damage the native swards.

Figure 39: Kangaroos and rabbits are often a part of the background disturbance regimes in remnant woodlands, including cemeteries with very high conservation value ground-layers. However, they may not be sufficient to maintain wildflower diversity in sites with a history of regular burning or mowing (Canowindra Cemetery).

Figure 40: Delicate grazing sensitive orchids such as this Purple Donkey Orchid are a preferred snack for the Eastern Grey Kangaroo (right hand image with remaining stem after grazing). Orchids will persist under this light grazing. However, under heavier livestock grazing and fertilisers, this species has declined in the wider landscape.

Section 5.

Principles for maintaining diverse native ground-layers using disturbance

This section offers six principles for maintaining very high conservation value ground-layers and are derived from observations and experiments described in Section 4. The principles are designed for ground-layers where Kangaroo Grass and Poa Tussock are the most common grasses, rather than ground-layers dominated by other native grasses (ie. wallaby and red grasses). Nevertheless many of these principles are likely to be more widely applicable.

6 Principles

1. **There is no simple recipe.** Growth rates of the grassy sward vary with site and season, and need for disturbance depends on recent management history, so there is no "one size fits all" disturbance regime.
2. **If it worked keep doing it.** If the site supports a high conservation value ground-layer, the disturbance regime applied in the last 20-50 years is likely to be suitable for the plant species still present.
3. **'Read' the grassland.** Walking through the grassland to observe whether grassy tussocks are overgrown or not, and whether spaces are present between them, provides a good way to assess disturbance needs.
4. **Balance management trade-offs.** Not all actions benefit all species, so
   i) if using fire only burn small sections of the site at any one time
   ii) apply longer fire intervals to minimise exotic annuals
   iii) maintain a balance of Kangaroo Grass and Poa Tussock
   iv) consider the objectives for the site within the larger landscape picture
5. **A healthy ground-cover for healthy soils.** Aim for good ground cover of grasses, wildflowers, leaf litter and lichens to protect soil surfaces and sustain soil function.
6. **Adjust as the environment changes.** Elements such as tree cover and climate will vary over short and long timeframes, so adjust the management actions and their frequency to reflect these changes.

Section 5.
Principles for maintaining diverse native ground-layers using disturbance

There is no simple recipe

There is no single "one size fits all" disturbance regime that is optimal for all Box-Gum Grassy Woodland remnants with very high conservation value ground-layers. This is because the optimal disturbance regime for a site will depend on:

- how quickly the native grasses grow, which depends on rainfall, temperature, soil fertility and the length of the growing season, and
- the management history of the site, e.g. whether trees have been cleared and whether fire-loving or grazing-sensitive wildflowers are still present.

The good news is that the natural ecosystem has many ways to compensate for changes in disturbance regimes – this is called a 'resilient' ecosystem. With some basic understanding of the key attributes to look out for, there is flexibility in suitable disturbance regimes.

If it worked...keep doing it

A simple rule of thumb in an unchanging environment (e.g. in the absence of climate change, see below) is for disturbance management to be guided by the recent historical disturbance regime (the past 20–50 years or so), if that has already kept the site in good condition. This is likely to be optimal for the balance of species that are currently present in the site.

This principle doesn't apply where past management has caused degradation (e.g. frequent low mowing leading to very short swards with limited Kangaroo Grass). In these cases it may be possible to improve outcomes (e.g. by reducing mowing frequency and increasing mowing height).

A substantial change in management regime may be necessary under some circumstances, for example burning to reduce fire hazard. Although there is flexibility in suitable disturbance regimes, managers should be aware that in a small, isolated remnant, a change from the historical regime could lead to a net loss of native species and should be undertaken with caution.

'Read' the grassland

Learning to understand the signals provided by the grassy ground-layer itself is the best way to approach day-to-day and year-to-year management decisions regarding very high conservation value ground-layers.

Figure 41 shows an example sequence from a site with a history of frequent burning, to guide managers in answering these questions. Remember that the ground-layer can look different in different years and in dry years especially there may be little flowering and grasses may not be actively growing.

Regular visits to the site, especially in warmer months and after good rainfall when wildflowers are visible, is recommended to check these questions each year.

Figure 41: Example sequence after fire in the derived native grassland at Monteagle (the experimental site with a history of frequent burning).

Small tussocks and large gaps between them means the ground-layer needs more time to recover before burning, mowing or grazing are required again

This ground-layer state has model attributes – some bare ground with no weeds, and native wildflowers (Common Everlasting – *Chrysocephalum apiculatum*) between actively growing Kangaroo Grass tussocks. No disturbance required at this stage.

This ground-layer is getting dense but still with some wildflowers emerging. It is ready for burning, mowing or crash grazing. Note also the increasing prevalence of Poa Tussock, the finer leaved-grass.

Burning (or mow/graze) overdue – the grass tussocks are overgrown and are crowding out all available spaces for wildflowers. Burning at this point is still likely to result in benefits but could have already led to reduced numbers of wildflowers.

Questions to ask when looking at the grassy ground-layer include:

1. Do native wildflowers still have space to grow between the grass tussocks?

   If yes, no burning, mowing or crash grazing is required.

2. Are the grass tussocks still small or weak, with lots of space and bare ground between them?

   If yes, it is probably too soon to burn, mow or graze again.

3. Are the native grasses becoming very dense, overgrown and dead-looking?

   If yes, burning, mowing or crash grazing is likely to be beneficial.

Balance management trade-offs

This Guide focuses on maintaining the native grasses and wildflowers in the ground-layer, because these elements of Box-Gum Grassy Woodlands have become very rare across the landscape.

However, not all actions are optimal for all elements of a woodland ground-layer. There can be trade-offs between the best disturbance regimes for:

- native ground-layer plants and native animals that depend on the ground-layer,
- native and exotic plants,
- Kangaroo Grass and Poa Tussock,
- disturbance-loving and disturbance sensitive native wildflowers.

Managing these trade-offs often focuses on maintaining variability within or across sites, as outlined below. If the use of fire is appropriate for that site smaller burn areas and longer fire intervals are part of these trade-offs.

Cater for both native plants and animals by burning in smaller sections

Many species of reptiles and frogs can live in the native ground-layer. If too much is burnt at once, these will have nowhere to live while the grassland recovers.

Burning programs should thus be designed to burn small sections each year, rather than whole sites.

Longer fire intervals maximise native wildflowers and minimise exotic annuals

Research and observations are showing that burning to promote wildflowers can also promote exotic annuals, but the flush of annuals after fire is short-lived. *Longer intervals between fires will minimise the benefit to exotic annuals.*

Optimal intervals will depend on the rainfall and fertility of the site, but as a guide, experiments found burns at 4 to 8 yearly intervals were preferable to burns at 2 yearly intervals at Monteagle, except in extremely wet years.

Figure 42: Exotic annuals (mostly clovers) establishing abundantly in the gaps between the Kangaroo Grass tussocks on a recently burnt plot at Woodstock.

Balancing your Kangaroo Grass with your Poa Tussock gives management flexibility

To allow flexibility in disturbance frequency, aim to maintain a presence of both Kangaroo Grass and Poa Tussock in the ground-layer. If disturbance becomes less frequent for a while, Poa Tussock can establish and re-grow to keep the sward healthy; if disturbance becomes more frequent, Kangaroo grass will help the ground cover re-establish more quickly.

This balance should be easily achieved within a wide range of disturbance frequencies if both species are present to begin with. At Monteagle and Woodstock, Poa Tussock persisted (but was becoming uncommon) when burnt or mowed every two years. Similarly, Kangaroo Grass remained present after fifteen years without burning at Monteagle, but became overgrown and unhealthy especially during the very wet years of 2010–11.

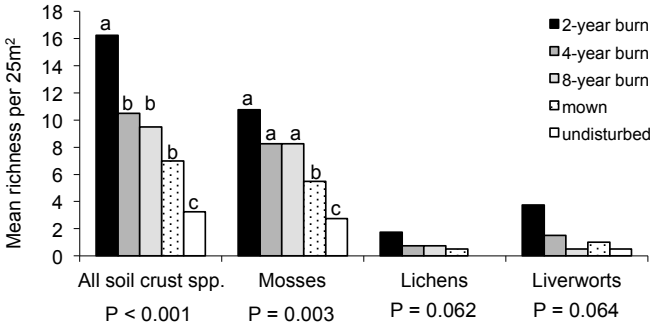
This flexibility is a useful tool – often planned burns can be delayed due to practical on-ground considerations such as fire weather suitability or availability of fire crews and equipment.

Consider the disturbance-loving and disturbance sensitive native plants at a landscape scale

Remnant Box-Gum Grassy Woodlands with different management histories already support different suites of native plants. Maintaining a diversity in disturbance regimes between sites across landscapes (and if a site is large enough, within sites) ensures that all species have the opportunity to thrive somewhere.

Wildflowers that appear to benefit from burning include Yam Daisies, Fringe Lilies and Purple Donkey Orchids, and these can be uncommon or absent in unburnt sites. In contrast the unburnt sites can favour other species, including Native Geranium (*Geranium solanderi*), Kidney Weed (*Dichondra repens)* and Native Picris (*Picris angustifolia*).

Burning also favours mosses, lichens and liverworts in Box-Gum Grassy Woodlands (e.g. see Graph 4). These species can respond rapidly after fire to protect the bare soil surfaces.



Graph 4: Increasingly frequent fires led to increasing richness of soil crust plants (mosses, lichens and liverworts) at Monteagle (different letters above bars show which means are significantly different within each group at P<0.05). Reproduced from O'Bryan et al. (2009).

Maintain healthy groundcover for healthy soils

A healthy ground cover of Kangaroo Grass and Poa Tussock, wildflowers, leaf litter, mosses, liverworts and lichens protects soil surfaces, helping to keep the soil soft, moist and well-aerated as it is more efficient in capturing and retaining rainfall. Prolonged exposure of the soil surface to sun and rain drops leads to hardening of soil surfaces, greater run-off, and reduced infiltration, soil carbon, biological activity and water holding capacity. This in turn limits plant growth, potentially leading to a downward spiral in soil and vegetation condition.

It is therefore important to avoid prolonged periods where the soil is exposed. Managers can use Figures 43a–c as a guide to poor, adequate and good ground cover. In southern NSW sustainable land management guidelines recommend a minimum of 80% but ideally between 80 and 100% groundcover. The level of groundcover to prevent loss of soils, water and nutrients will vary according to rainfall, slopes, soils and their erodibility so apply Principle 3 to "read the grassland".

Soil surfaces can become bare immediately after disturbance, particularly fire, so allow the site to recover as quickly as possible. Disturbances should not be repeated until the ground cover has recovered.

Adjust as the environment changes

Our first principle suggests that continuing recent historical management is a good starting point for managers to gauge appropriate disturbance regimes in remnant Box-Gum Grassy Woodlands with very high conservation value ground-layers.

However, it is also important to remember that management regimes may need to be adjusted over time due to:

- *gradual re-establishment of trees in cleared sites* – this can be a good thing, especially if the trees are scattered so the ground-layer is not depleted by dense tree regeneration. It may mean slower growth rates for the grasses and hence longer periods between disturbances.
- *moderately increasing aridity under climate change* – this would result in slower grass growth and hence longer periods required for recovery between disturbances.
- *substantially increasing aridity under climate change* – this could lead to replacement of Kangaroo Grass and Poa Tussock by other native grasses such as wallaby and spear grasses in drier parts of the landscape, mirroring the composition of more semi-arid woodlands. Sites might also become prone to increased numbers of native woody shrubs. If these changes begin to occur, it will be important to adopt principles for managing more semi-arid woodlands, involving only occasional fire after major rain events to manage shrub densities.

Observing the ground-layer on a regular basis (Principle 3), in particular walking through the site in spring, will help managers to adjust to longer term changes such as these.

Figure 43: (a) Poor, (b) adequate and (c) good litter and tussock cover in the wooded remnant of Box-Gum Grassy Woodland at Woodstock. Note hardened soil surfaces in (a).

Section 6.

What not to do – disturbances that damage the native ground-layer

This section highlights four key disturbances; prolonged livestock grazing, fertilisation, soil disturbance and inappropriate application of herbicides, that can potentially damage or destroy very high conservation value native ground-layers in Box-Gum Grassy Woodlands. These types of disturbance should be avoided except in special circumstances.

Key messages

- Prolonged grazing by livestock is detrimental for high conservation value native ground-layers, but 'crash grazing' for several days every few years can be beneficial if soil compaction and weed introduction are minimised.
- Levels of soil phosphorus and nitrate are naturally very low in woodlands so avoid direct fertilisation and limit fertiliser drift from neighbouring sites.
- Minimise any soil disturbance including rabbit burrowing – it leads to bare ground and releases nitrogen which assists rapid invasion by exotic annual plants.
- Keep livestock trampling and vehicle use to a minimum to limit soil compaction, and avoid these in moist conditions where they create ruts, break up soil crusts and damage sensitive plants.
- Where herbicides are needed to control weeds, use appropriately targeted application methods and selective herbicides. Misapplied herbicides can kill the native ground-layer, releasing nutrients and promoting rapid invasion by exotic annual plants.

Section 6.
What not to do – disturbances that damage the native ground-layer

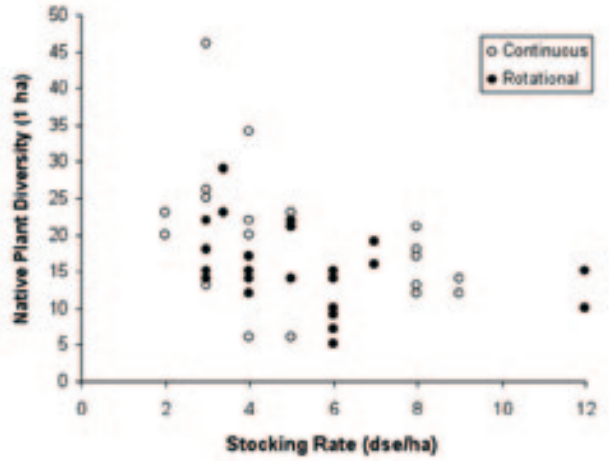
As described in Section 3, very high-quality ground-layers of Box-Gum Grassy Woodland tend to remain only in rare sites that have escaped livestock grazing, fertilisation and significant soil disturbances over the past 100 or more years. This means these disturbances, as well as others such as use of non-selective herbicides, need to be avoided to conserve the native ground-layer in these types of remnants.

Livestock grazing

A key priority for managing Box-Gum Grassy Woodland ground-layers is to avoid prolonged grazing by livestock, or if there is already some livestock grazing, to avoid increasing the levels of grazing from those applied in the past. One exception is 'crash' grazing (see Section 4), which might be applied over several days once every year or two to reduce the grass biomass.

Even though Box-Gum Grassy Woodland plants evolved with native grazing animals, many plants are poorly adapted to regular grazing by hoofed livestock such as sheep, cattle and horses. Sustained stocking with sheep or cattle eliminates grazing-sensitive plant species, promotes weed invasions, simplifies wildlife habitat by removing tall to medium-sized tussocks and shrubs, and prevents tree regeneration. Kangaroo Grass and Poa Tussock in particular are sensitive to livestock grazing, and are quickly replaced by other native and exotic grasses.

Figure 39 illustrates how native plant diversity rapidly declines as stocking rate increases. Even where there is intermittent grazing, such as in the valuable Box-Gum Grassy Woodlands in travelling stock reserves, the density of native wildflowers is lower than in ungrazed sites. In very high conservation value ground-layers in cemeteries such as Woodstock for example, native plant species richness commonly reaches 25 species in a 5x5 m patch.



Graph 5: Plant diversity is typically higher at low stocking rates, and is not influenced by the type of livestock grazing regime i.e. continuous or rotational (Dorrough et al. 2012).

Fertiliser or other nutrient enrichment

Levels of soil phosphorus and nitrate are naturally very low in Box-Gum Grassy Woodlands (nitrate <3mg/kg and phosphorus <10mg/kg*). Native plants are well adapted to these low nutrient levels. This means when nitrogen or phosphorus are added for improved pasture productivity or cropping, it favours nutrient-loving exotic annuals, and typically leads to loss of native plants.

It is thus important to protect very high conservation value ground layers from sources of nitrogen or phosphorus addition. This includes avoiding direct fertilisation, as well as aiming to limit fertiliser drift from neighbouring paddocks. Some remnants are already buffered by roadsides or other, unfertilised lands. Where fertiliser drift appears problematic (e.g. evident from weed invasion at edges, Figure 17), a buffer zone of trees and shrubs in the source paddock could be considered.

* available phosphorus Colwell

Soil disturbance

Woodland soils were once naturally disturbed by small, digging marsupials, such as bettongs, bandicoots and bilbies, which are now extinct across the Box-Gum Grassy Woodlands. Today however, the release of nutrients and creation of bare ground due to soil disturbance can cause rapid invasion by exotic annual plants, which can in turn prevent native species from re-establishing.

These new types of soil disturbances include rabbit and hare diggings, scrapes and compaction caused by livestock or machinery, cultivation for cropping or firebreaks, and soil movement for cemetery operations.

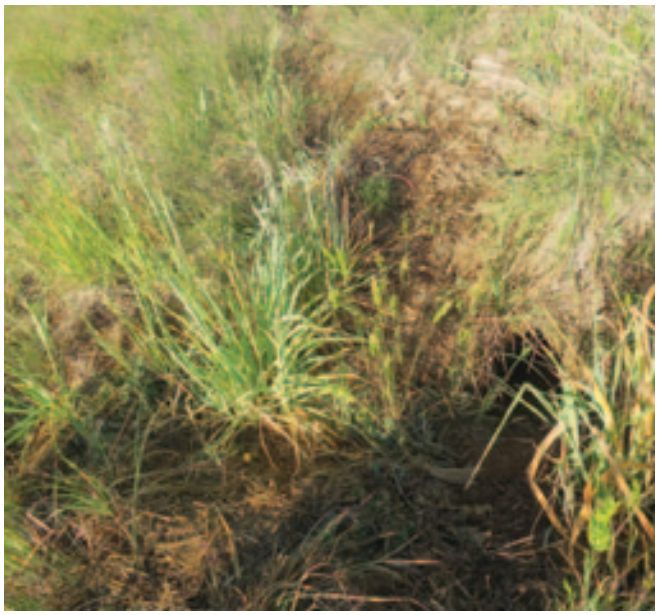


Figure 44: The taller exotic annual grasses are in the process of invading a very high conservation value ground-layer at Toogong Cemetery, NSW due to rabbit diggings.

Stock trampling and use of vehicles on woodland soils can also very quickly damage soils through compaction. In moist conditions especially, they can create ruts, break up soil crusts and damage sensitive plants. These lead to a decline in the health of the soils, including reduced organic matter, compacted soil structure, lower soil biological activity and eventually lower plant growth.

Continuing to maintain soils in little-disturbed condition is thus central to maintaining a very high conservation value ground-layer in Box-Gum Grassy Woodlands. This might involve:

- using non-mechanical methods to control rabbits and hares,
- taking particular care that use of machinery or vehicles is avoided when soils are too damp, and the amount of use is kept to a minimum,
- if possible, choosing mechanical equipment that is appropriately designed (e.g. wider, balloon type tyres under low pressure with appropriate tread patterns),
- maintaining cemetery stockpiles in a dedicated location outside the significant grassland,
- avoiding grading or cultivating (e.g. for firebreaks).

Use selective and targeted herbicide application to control weeds

As discussed in Section 7 it may be necessary to use herbicides to control weeds. An important principle when using herbicides is to ensure that a selective herbicide is applied that will not kill native grasses, or alternatively, is applied very carefully to avoid contact with non-target plants.

Using a broad-spectrum or otherwise inappropriate herbicide to control weeds can kill the native grassy sward. This can result in similar effects to soil disturbance, leading to a release of nutrients and light, promoting rapid invasion by exotic annuals such as wild oats (Figure 45). Once these species have invaded, the native sward may not recover unless intensive restoration techniques are applied (see Section 7).

Figure 45: Spraying with a non-selective herbicide while controlling St John's Wort (*Hypericum perforatum*) killed native grasses and led to wild oats establishing and invading this very high conservation value ground-layer. A more selective and targeted herbicide application would have prevented this weed invasion.

Avoiding potentially detrimental activities such as prolonged livestock grazing, fertilisers, soil disturbance and inappropriate herbicides will help keep your woodland in good shape.

Woodstock Cemetery, NSW with Poa Tussock and wildflower ground-layer

Section 7.
Other common issues

In this section, further aspects of managing very high conservation value ground-layers in Box-Gum Grassy Woodlands, including managing for people, weeds and feral grazing animals, and small-scale restoration, are considered.

Key messages

- Apply targeted techniques and selective herbicides for weed management to avoid damaging native species.
- Control feral animals that cause soil disturbance, but avoid methods such as ripping rabbit warrens that exacerbate soil disturbance and weed invasion.
- Foster local community awareness of the multiple values of a site, using field days, guided wildflower walks and well-designed signage.
- Collaborate with interested individuals and groups in developing site management plans and actions.
- Address community expectations for frequent short mowing regimes (e.g. in cemeteries) through explanatory signage, awareness events, narrow mow paths and zones with mowing frequency and height designated according to access and conservation value.
- In less-used parts of frequently-mown sites, leave places with longer grasses and fallen timber as these can be beneficial for biodiversity.
- Apply small-scale restoration methods to weed invaded or otherwise degraded patches in very high conservation value ground-layers. For example, re-establish a Kangaroo Grass ground-layer that can outcompete nitrogen-loving exotic annuals with the aid of gas-powered burners, sugar or combinations of these.

Section 7.
Other common issues

Managing weeds

A Box-Gum Grassy Woodland with a very high conservation value ground-layer will by definition have generally low abundance of weeds compared with most other remnants. However, there are always some weeds present, and these require different types of management. The main groups include:

1. Small exotic annuals, including hairgrasses, silver grasses, and clovers.
2. Tall exotic annuals such as rye grasses, wild oats and Paterson's curse.
3. Exotic perennial grasses such as Coolatai grass, African Lovegrass (*Eragrostis curvula*) and serrated tussock.
4. Other exotic herbaceous perennials such as a variety of bulbs (e.g. freesias), bridal creeper (*Asparagus asparagoides*) and St. John's Wort.
5. Woody weeds such as sweet briar (*Rosa* spp.) or wild plums (*Prunus* spp.).

Small exotic annuals will usually be present to some degree, especially immediately after fire, but generally don't require targeted management. Tall exotic annuals are best managed by minimising soil disturbance and controlling potential sources of nutrient enrichment as discussed in earlier sections.

Exotic perennials may require control using a combination of strategies, including prevention (e.g. hygiene measures or avoiding soil disturbance) and herbicides.

Specific information regarding the control of weeds is not the subject of this guide, rather is best sourced through local weeds officers, state agricultural agencies and their websites. Careful planning is required to ensure any herbicides used do not have detrimental effects on native grasses. If using herbicides, precise application using spot-spraying is the preferred method. If using spot-spraying, then non-target killing of desired plants can be minimised by using a hood over the spray nozzle to prevent spray-drift. An even better option is to use a weed-wiper or other methods of daubing herbicide onto the target weeds.

Figure 46: Problematic weeds in some Box-Gum Grassy Woodlands with very high conservation value ground-layers.
(a) Bridal creeper (*Asparagus asparagoides*) and (b) exotic bulbs, Woodstock Cemetery; (c) Coolatai grass (*Hyparrhenia hirta*), Winton Cemetery.

Effective weed management relies on identifying which of these five different weed groups is problematic then applying targeted control for that weed type.

Managing feral grazing animals

Box-Gum Grassy Woodlands with very high conservation value ground-layers are vulnerable to damage by digging animals such as rabbits and hares. This can lead to invasion by exotic annuals, or to bare, eroded soil surfaces. Remnants can also harbour foxes, and hence be viewed negatively by neighbouring landholders.

Methods for controlling feral animals are not the subject of this guide, rather this information is better obtained from government agencies. However, it is important to ensure that methods are selected that avoid soil disturbance, and that actions such as ripping rabbit burrows are avoided.

Figure 47: Bare soil and invasion by exotic annuals in a patch with heavy rabbit use at Woodstock Cemetery

Managing for people

Very high conservation value Box-Gum Grassy Woodland ground-layers typically occur in sites dedicated to other land uses, particularly cemeteries. This can sometimes lead to conflicting interests that need to be recognised, understood and carefully managed. Particular considerations often include access and expectations around tidiness, mowing and bush fire hazard. Local communities often value significant remnants highly, and become closely engaged in their management.

Raising awareness

Important first steps to avoid public concerns are to raise community awareness of the multiple values of a site.

Good signage can assist in explaining biodiversity values and management actions such as mowing in areas zoned for their high conservation value. Signs that describe a woodland cemetery as a 'Bush Cemetery' or a 'Rural Cemetery' (Figure 49) clarifies that it is not a lawn cemetery, helping to avoid unrealistic management expectations.

Field Days and "Wildflower Walks" with local managers and expert speakers are popular activities that provide opportunities to learn and understand these valuable sites and to discuss management issues.

It is important that planning is an open process that engages the community and accounts for people's views and concerns. Involving community members can take some time, but can be very effective for communicating concerns and engaging willing stewards.

Figure 48: Local residents often value and contribute to the management of important remnants of Box-Gum woodlands (Currabubula Cemetery Field Day).

Figure 49: Signage providing explanations of bush cemetery values and management actions

Mowing and access

A common issue in actively used sites such as cemeteries is the need to keep grass low and neat. This has led to large areas being low-mown on a frequent basis, leading to bare soil, a patchy ground layer and replacement of Kangaroo Grass and Poa Tussock with other shorter species such as wallaby grasses, spear grasses and red grasses (Figure 50).

Figure 50: Too low and too frequent mowing changes the dominant grasses to shorter wallaby and spear grasses in this cemetery on the NSW Central West Slopes and favours exotic catsear (*Hypochaeris spp.*) over native wildflowers.

One reason for low-mowing is that people need to access graves across different sections of cemeteries, or may like to walk through remnant woodlands to enjoy their natural values. Because low-mowing through-out a site is not desirable from a biodiversity perspective, a compromise can be made to provide regularly mown pathways for foot traffic.

It is important these paths are narrow (Figure 51a), otherwise they are likely to be used by vehicles, causing greater compaction and damage. Mowing should use a 'light-touch' approach; otherwise frequent low-mowing will lead to bare ground and loss of tussock grasses (Figure 51b).

A site may also be divided into zones of more and less intensive use. Intensively-used areas such as paths and areas close to graves might be scheduled for mowing more frequently and to lower heights than less intensively-used areas. Areas away from graves can also be managed using burning, with allowance for regeneration of trees and shrubs.

Figure 51: Walking tracks into graves at two NSW cemeteries (a) lightly slashed narrow track discourages vehicle use. (b) bare ground resulting from too low and frequent mowing is exacerbated by maintenance vehicles also using this track.

Tidying fallen timber and long grasses

Another aspect of neatness is the presence of dead timber and longer grasses around trees and fence lines. Sometimes the dead timber is removed and the long grasses are sprayed. This removes habitat for native animals such as lizards, and for native grasses and wildflowers that prefer unmown or unburnt areas.

Strategically leaving some dead wood and some areas with longer grasses can thus be beneficial for biodiversity.

Simple management guidelines such as providing regularly mown narrow pathways for pedestrian access allow for areas to be kept in a more natural state to maintain the biodiversity values of the woodland.

Figure 52: These three different skink species were observed on a collection of fallen timber / woody debris in a cemetery on the NSW North West Slopes. If woody debris is problematic in situ, consider strategically relocating some of it to parts of the site that are less intensively managed.

Small scale restoration – establishing Kangaroo Grass is the key

Invasion by taller species of exotic annuals such as Wild Oats, Bromes and Paterson's Curse is a common problem in Box-Gum Grassy Woodlands, which can limit the plant diversity in the ground layer. As was shown in earlier sections, these invasions can be promoted at small scales by rabbit scratching and other soil disturbances, fertiliser run-on and damage from inappropriate herbicide use. Even dying trees can release nutrients, resulting in invasion by exotic annuals.

Where community resources are available, it is possible to regenerate small patches invaded by exotic annuals through the active re-establishment of Kangaroo Grass. Kangaroo Grass has been recently found to play a pivotal role in suppressing exotic annuals, because it uses up excess soil nitrate, leaving little available for the nitrogen-loving weeds.

Because it is quite intensive, this technique is most suitable for very high conservation value remnants with small areas of weed invasion.

Re-establishing Kangaroo Grass can play a pivotal role in suppressing weeds and restoring woodlands by using excess soil nitrate and leaving little for the nitrogen loving weeds.

Figure 53: Exotic annuals invading experimental plots at Woodstock after tree mortality during the millennium drought. This was likely caused by release of nutrients held in the tree roots.

Establishing Kangaroo Grass for long term suppression of exotic annuals

Restoration using this approach requires the following steps:

1. Obtain an appropriate source of Kangaroo Grass seed, with the awns still attached. An awn is a corkscrew like appendage on the seed, which allows it to self-drill into the soil. The best source is to collect from the site at which the restoration is taking place, to maintain local gene pools. A number of seed harvesting methods have been developed for native grasses – further information can be obtained from relevant State agencies.

2. Control the exotic annuals temporarily using any of a number of possible techniques. If the annuals aren't temporarily suppressed, the Kangaroo Grass seed will not establish well. Possible methods for controlling exotic annuals temporarily include (see Table 1, Graph 6):

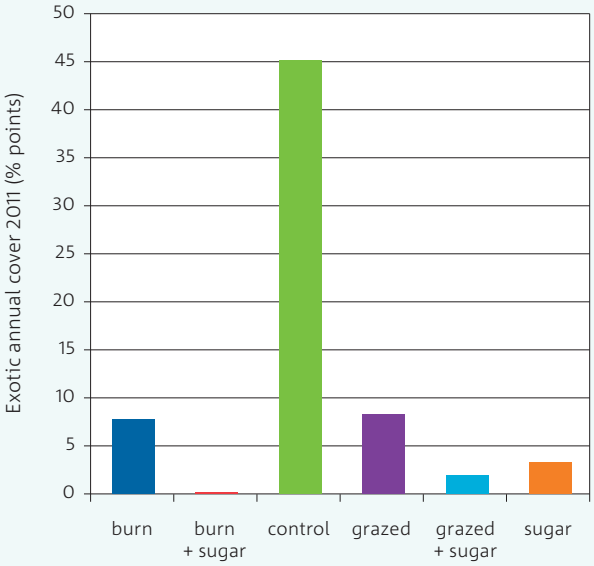
    - Burning in late spring with a gas-powered weed burner. This should be done before the exotic annuals set seed, but not too early to allow ongoing weed growth after the treatment (e.g. early November for the Central West Slopes). This treatment prevents the exotic annuals from seeding and creates an open seed bed in which Kangaroo Grass can establish over the following summer and autumn. Another burn the following spring can improve establishment.
    - Crash grazing in late spring can be used as above instead of burning. It is less effective so may need to be done for two or three years in a row as the Kangaroo Grass establishes. This method is more appropriate for larger, uniformly invaded sites (e.g. paddocks) rather than small weed patches in multi-use sites such as cemeteries.
    - A novel but recently proven approach is to add sugar (0.5kg/m^2) to the soil surface. Sugar provides a temporary food source for soil microbes, which in turn actively take up soil nitrate. The taller, most problematic exotic annuals grow poorly with low soil nitrate levels (<3 mg/kg), providing a window of opportunity to establish Kangaroo Grass. Timing is crucial with this method as the sugar effect lasts only about three months. Sugar should be applied just before the exotic annuals are due to germinate (after autumn rains typically about May), and three months later. A follow up application is beneficial the following May and August to allow the Kangaroo Grass to grow large enough to outcompete the exotic annuals.
    - A combined method can be used in mid-winter to early spring when exotic annuals have already established (Figure 54). Burn off the existing growth with a gas-powered weed burner, then add sugar (0.5kg/m^2) to the soil surface to prevent further establishment of exotic annuals through to summer, when they naturally die back.

Figure 54: Using a gas powered weed burner in southern NSW during August to reduce exotic annuals prior to the establishment of native plant tubestock and ii) applying sugar to reduce nitrate levels and weed growth

Crash grazing in late spring can be used instead of burning. It is less effective so may need to be done for two or three years in a row as the Kangaroo Grass establishes.

Table 1: A summary of the reliability and effectiveness of sugar, spring-burn and spring-graze (high stocking density for short duration) treatments for controlling exotic annuals and promoting native grasses. Outcomes will depend on seasonal conditions – wetter years promote abundant exotic annual grasses and native warm season grasses establish well in wet summers. Source: I. Cole, I. Lunt, S. Prober.

TREATMENT	TO CONTROL EXOTIC ANNUAL GRASSES	TO CONTROL BROADLEAF ANNUALS	TO PROMOTE NATIVE GRASSES
Sugar	good	good	moderate
Spring burn	good	poor	good
Spring crash graze	moderate	poor	good



Graph 6: Cumulative treatment effects on exotic annuals (Cumberoona TSR near Albury). All treatment controlled annuals far better than doing nothing. Note there were few broadleaf exotic annuals in 2011. Source: I. Cole, I. Lunt, S. Prober

3. Apply the Kangaroo Grass seed to the soil surface either before or immediately after controlling the exotic annuals. If applying before burning, allow sufficient time for the seed to drill into the soil. It is advisable to apply high seeding rates (perhaps 5x that recommended by seed companies) as the effectiveness of the method relies on establishing a dense Kangaroo Grass sward. The seed is likely to germinate after repeated summer or autumn storms; hence a wet summer is most effective. Using seasonal forecasts, such as a predicted 'La Nina' wetter than average season, can assist this process.

   Once the Kangaroo Grass is established, it will help to suppress tall exotic annuals over the long term.

Kangaroo Grass seed is likely to germinate after repeated summer or autumn storms; hence a wet summer is most effective.

Figure 55: The landowners of this very high conservation value woodland property undertake an annual autumn program of small burns across different areas of their destocked paddocks to help manage the growth and dry matter build-up of Kangaroo Grass and provide more open areas for wildflowers and other plants to grow.

Concluding remarks and summary table

This guide has described ways to recognise and manage very high conservation value Box-Gum Grassy Woodland ground-layers to maintain a healthy grassy sward dominated by Kangaroo Grass and Poa Tussock, and optimize native plant diversity.

A summary of key management options and benefits described in Sections 4–6 is provided in Table 2.

Appendix 1 lists a summary of current best practice national guidelines listed for Box-Gum Grassy Woodlands in the National Recovery Plan for Box-Gum Grassy Woodland.

Table 2: Summary of key management options for land managers

MANAGEMENT ACTION	RECOMMENDED / NOT RECOMMENDED	POTENTIAL ISSUES FOR CONSIDERATION
No active management	Not recommended	With no active management: • If grass tussocks become overgrown there can be a decline in native plant species abundance and ecological functioning • Tussock death can occur in high productivity sites / cleared remnants • If uncontrolled, feral grazers eg. rabbits and hares can cause damage • Weeds can progress unimpeded • 'No active management' does not include making decisions that disturbances such as burning are not presently needed, e.g. during extended drought, or when grass biomass is low
Burning	Recommended where historic management and current conditions indicate it can be beneficial	• Careful planning is required to ensure resources and expertise are available, and fire safety, containment methods, permits and approvals are in place • Remember to adjust management for seasonal conditions (i.e. decreasing frequency during drought) • Learn to read ecological signals for appropriateness of timing for burn • Understand that burns are not necessary or appropriate for all remnants • Burn in smaller patches, not the whole site
Mowing/slashing	Recommended where historic management and current conditions indicates it can be beneficial	• Ensure that mowing maintains good groundcover and minimise bare areas by applying correct mow height and frequency • Adjust management to seasonal conditions (i.e. decreasing frequency during drought) • Prevent introduction of weed seeds on mowers and vehicles • Use appropriate equipment to minimise heavy vehicle soil compaction • Avoid piles and windrows of grass cuttings that smother ground layer plants
Livestock grazing	Strategic	• Highly strategic high density, short duration grazing by livestock has been used successfully • Soils need to be dry to avoid 'pugging' • More intensive livestock grazing regimes lead to different dominant grass species & can remove grazing sensitive wildflowers • Avoid compacting soils and introducing weeds
Tidying	Strategic	• Tidying up fallen timber and spraying longer native grass around fences and trees for neatness, can reduce habitat for flora and fauna • Strategically limit tidying to walking paths and other key socio-cultural features e.g. graves or memorials
Grazing (native and feral herbivores)	Mixed	• Levels of grazing may not be sufficient to prevent plant biomass accumulation in sites needing disturbance • Can have adverse impacts at high grazing levels
Controlling feral animals	Recommended	• Rabbits and hares can cause substantial damage to native swards, disturb soils and cause weed invasion • Foxes are problematic for neighbours and wildlife
Develop management plan	Recommended	• Create 'Management Action Table' with specific management actions, works required, responsibilities and dates for completion • Map management zones on the basis of differing socio-environmental values and associated management actions e.g. graves, buildings, lawns, paths, conservation areas; • Define clear boundaries for high conservation areas and locations of any threatened plants • Include Legislative guidelines as woodlands fall under State and Commonwealth legislation as either vulnerable, endangered or threatened vegetation communities • Include appropriate signage and specific waste removal area
Signage	Recommended	• Simple signage can explain conservation values, management actions and reduce user concerns such as mowing times and frequency
Waste and rubbish removal	Recommended	• Avoid excess soil waste and rubbish stockpiled on high conservation ground-layer • Place woody debris strategically in appropriate areas rather than removing as rubbish (see Figure 52)

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The Grassy Box Woodland Conservation Management Network http://www.gbwcmn.net.au/about

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Glossary

Annual plants are plants that germinate, grow, flower and seed within a seasonal/yearly cycle. They typically have a small and undeveloped root system.

Biennial plants complete their lifecycle within 2 years after germination but don't flower in the first year.

Biomass (as referred to in this guide) is the total quantity or weight of live and dead plant material in a given area.

Box-Gum Grassy Woodland is formally defined as White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland and is listed as a critically endangered ecological community under the Environment Protection and Biodiversity Conservation Act 1999. The ecological community can occur either as woodland or derived native grassland (i.e. grassy woodland where the tree overstorey has been removed). It is characterised by a species-rich understorey of native tussock grasses, herbs and scattered shrubs (where shrub cover comprises less than 30% cover), and a dominance or prior dominance of White Box (*Eucalyptus albens*) and/or Yellow Box (*E. melliodora*) and/or Blakely's Red Gum (*E. blakelyi*) trees. In the Nandewar bioregion, Grey Box (*E. microcarpa* or *E moluccana*) may also be dominant or co-dominant. In the woodland state, tree cover is generally discontinuous and of medium height with canopies that are clearly separated. See Appendix 1 for full definition.

Canopy the leaf and branch layer formed by the tree crown. In a mature woodland tree crowns are typically discontinuous and separated unless in earlier stages of regrowth.

Crash grazing refers to a high stocking density for short duration (e.g. a few days to reduce the grass bulk).

Derived Native Grassland (also known as secondary grassland) – an expression of the ecological community that develops when the tree canopy cover of the grassy woodland is removed or suffers dieback and natural regeneration is prevented, and in which the understorey remains relatively intact.

Disturbance is an event that removes biomass and opens up space which can then be colonised by the same or different plant or animal species e.g. fire, mowing, grazing, herbicide application, cultivation.

Dominant species are those that make up a large proportion of biomass (biological material derived from living, or recently living organisms) or number of organisms in a community.

Exotic Annuals are non-native herbaceous plants with an annual life-cycle. They include species such as capeweed (*Arctotheca sp.*), wild oats (*Avena spp.*), brome grasses (*Bromus spp.*), hairgrasses (*Aira spp.*), silver grasses (*Vulpia spp.*), common centaury (*Centaurium erythraea*), hop and haresfoot clover (*Trifolium campestre* and *T. arvense*).

Exotic species A species occurring outside its natural past or present range (in the context of this Guide, typically from outside Australia), its presence being due to human actions (either deliberate or accidental). The same meaning as non-indigenous, alien and non-native.

Forbs are herbaceous (non-woody) plants other than grasses. They include Yam daisies, lilies, orchids and many of the wildflowers discussed in this guide.

Ground-layer is the structural layer closest to the ground, composed of grasses, herbaceous plants and sub-shrubs and including leaf litter.

High conservation value ground-layers typically have a diversity of native grasses, wildflowers and sub-shrubs, which may be grazing sensitive and generally uncommon in the wider landscape.

Perennial plants are those that germinate, grow, flower and seed over more than two years and typically have a well-developed root system.

Remnants (or remnant vegetation) are those areas of woodland of any size or shape both publicly and privately owned still remaining within an otherwise cleared or modified landscape.

Very high conservation value ground-layers are high conservation value ground-layers (see above) with the least degree of degradation. Kangaroo grass (*Themeda triandra*) and Poa Tussock (*Poa sieberiana*) are common dominants, grazing-sensitive native wildflowers are frequent, weeds are relatively low in abundance and soil surfaces are relatively intact.

Weeds are plants not wanted where they are found. This is a subjective determination based on human values. Weeds usually have detectable economic or environmental effects and are often both exotic and invasive (plants with potential for rapid expansion).

Figure 56: Fring Lily (*Thysanotus patersonii*). Image K Thiele

Appendix 1.
Commonwealth and State Legislation regarding Box-Gum Grassy Woodlands

There are a range of legislative responsibilities in relation to Box-Gum Grassy Woodlands for all land managers and approval authorities, including local councils, under both State and Commonwealth legislation. The following information is extracted from the National Recovery Plan for White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland (2010) prepared by the Department of Environment, Climate Change and Water NSW, Sydney and on advice from the Department of Environment are provided here as an example for reference only.

Full guidelines and appropriate legislation should be referred to in all situations. Information about the nationally-listed ecological community can be found at: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=43&status=Critically+Endangered

Further information on legislative requirements, advice and assistance is provided below.

STATE / COMMONWEALTH	RELEVANT LEGISLATION
National	White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland is listed as a Critically Endangered ecological community under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)
New South Wales	White Box-Yellow Box-Blakely's Red Gum Woodland is listed as an endangered ecological community under the Threatened Species Conservation Act 1995 (TSC Act)
Australian Capital Territory	Yellow Box-Red Gum Grassy Woodland, a component of this ecological community, is listed as endangered under the Nature Conservation Act 1980 (NC Act)
Queensland	The ecological community is a component of a number of Regional Ecosystems (ecological communities assigned a conservation status based on its current remnant extent in a bioregion) listed as endangered under the Vegetation Management Act 1999 (VM Act)
Victoria	The ecological community broadly equates to a number of Ecological Vegetation Classes (EVC) which are listed as Endangered, Vulnerable or Depleted. Threatened communities are managed through Flora and Fauna Guarantee Act 1988 however none of the vegetation communities currently listed align with Box-Gum Grassy Woodland Ecological Community

Commonwealth Government Responsibilities

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Australian Government's key piece of environmental legislation. Under the EPBC Act land managers need approval from the Australian Government environment minister for any proposed action – including projects, developments, activities, or alteration of these things – likely to have a significant impact on a matter protected by the EPBC Act. Matters of national environmental significance include:

- world heritage properties
- national heritage places
- wetlands of international importance (listed under the Ramsar Convention)
- listed threatened species and ecological communities
- migratory species protected under international agreements
- Commonwealth marine areas
- the Great Barrier Reef Marine Park
- nuclear actions (including uranium mines)
- a water resource, in relation to coal seam gas development and large coal mining development

The EPBC Act also protects the environment where actions proposed are on, or will affect Commonwealth land and the environment; and where Commonwealth agencies are proposing to take an action.

Before taking an action that could have a significant impact on a matter protected by the EPBC Act, the matter must be referred to the Department. The Department will determine if an assessment is required. Further information on the referral process, including referral forms can be found on the Departments website at http://www.environment.gov.au/protection/environment-assessments.

For advice on whether a referral is required contact: compliance@environment.gov.au

For assistance with a referral please contact: epbc.referrals@environment.gov.au

These information sources are current as of June 2015

Legislative listing

COMMONWEALTH GUIDELINES DEFINING A BOX-GUM GRASSY WOODLAND

(Note NSW, Victorian and Queensland State Legislation definitions are different to Commonwealth)

White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland is listed as a critically endangered ecological community under the *Environment Protection and Biodiversity Conservation Act 1999*. The ecological community can occur either as woodland or derived native grassland (i.e. grassy woodland where the tree overstorey has been removed). It is characterised by a species-rich understorey of native tussock grasses, herbs and scattered shrubs (where shrub cover comprises less than 30% cover), and a dominance or prior dominance of White Box (*Eucalyptus albens*) and/or Yellow Box (*E. melliodora*) and/or Blakely's Red Gum (*E. blakelyi*) trees. In the Nandewar bioregion, Grey Box (*E. microcarpa* or *E moluccana*) may also be dominant or co-dominant. In the woodland state, tree cover is generally discontinuous and of medium height with canopies that are clearly separated.

To be considered part of the listed ecological community remnant areas must also:

- have a predominantly native understorey (i.e. more than 50% of the perennial vegetative ground-layer must comprise native species), and
- be 0.1 hectare (ha) or greater in size and contain 12 or more native understorey species (excluding grasses), including one or more identified important species;

or

- be 2 ha or greater in size and have either natural regeneration of the overstorey species or an average of 20 or more mature trees per ha.

Areas which are degraded to the extent they are excluded from the community definition may still retain important components of the ecological community (e.g. seed bank, soil biota) and/or provide important habitat for fauna (fallen logs, tree hollows, native grasses, paddock trees, bush rocks, rocky outcrops). Consequently, the restoration and management of these degraded areas is important for the successful recovery of the ecological community.

From the National Recovery Plan for White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland (2010). Department of Environment, Climate Change and Water NSW, Sydney.

Local Government Responsibilities

The role of local government in biodiversity conservation is recognised under the 1993 Local Government Act and the Environmental Planning and Assessment Act (1979). Local councils have been required to consider biodiversity issues since at least the commencement of the EP&A Act (in 1980). Since that time, the legislative requirements have become more specific as a result of growing community concerns regarding threatened species and other issues.

Under Section 8 of the 1993 Local Government Act, it is part of each council's charter to properly manage, develop, protect, restore, enhance and conserve the environment of the area for which it is responsible (Fallding et al 2001). The management of Community land is governed by the Local Government Act 1993 and Crown Reserves by the Crown Lands Act 1989. Both Acts require a draft plan of management to be prepared for their community land including parks, reserves and cemeteries.

CROWN LANDS ACT 1989

Crown reserves in New South Wales are subject to the general land management objectives and provisions of the Crown Lands Act 1989, particularly the reserve management provisions set out in Part 5. The Principles of Crown Land Management, as defined in Section 11 of the Act, prescribe the basis for the management and administration of Crown land. Those relevant to Box-Gum Woodlands include:

- That environmental protection principles be observed in relation to the management and administration of Crown land;
- That the natural resources of Crown land (including water, soil, flora, fauna and scenic quality) be conserved wherever possible

Summary of current best practice national guidelines for Box-Gum Grassy Woodlands

The current best practice national guidelines to avoid any detrimental development or management activity in Box-Gum Grassy Woodlands are summarised as follows (from the National Recovery Plan for Box-Gum Grassy Woodland 2010) with the full guidelines provided in Table 4.

These national guidelines apply to Box-Gum Grassy Woodlands in varying states of ecological condition rather than only to sites with very high conservation value native ground-layers, which are the focus of this booklet but many of the principles are overlapping:

- Avoid soil disturbance e.g. cultivation, ripping, excavation, compaction and fertilisers.
- Maintain or improve drainage conditions/existing hydrological regime e.g. avoid directing water run-off (from roads etc) into remnants.
- Control exotic plant introductions and control weeds.
- Avoid inappropriate native tree planting e.g. dense plantings in derived grasslands.
- Ensure ecological connectivity is maintained into surrounding landscape.
- Prevent removal of fallen timber, rocks, standing dead trees, regenerating trees and shrubs.
- Protect from adjacent land use e.g. chemical drift, development.
- Minimise chemical use by using targeted spot spraying, stem injection etc.
- Use strategic grazing, rest during drought and when native plants are seeding, maintain >80% cover.
- Use appropriate burning regimes e.g. in mosaics according to historical occurrence.
- Use appropriate mowing regime e.g. avoid seeding times, mow in mosaics/not too low.
- Control feral and domestic animals and their impacts.
- Exclude commercial apiaries.

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Cover Main image: White Box (*Eucalyptus albens*) woodland in excellent ecological condition; LHS: Researchers and Land Services officers at a very high conservation value site examining ground-layer diversity and condition; Middle: Bulbine Lily (*Bulbine bulbosa*), an iconic Box Gum Grassy Woodland wildflower species; RHS: Landholders, Shire Council staff and others attending a field day identifying and managing Box Gum Grassy Woodlands at Currabubula Cemetery, North Western Slopes, NSW

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