ECOLOGICAL FIRE MANAGEMENT GUIDELINES

For Native Vegetation in South Australia

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Government of South Australia
Department of Environment, Water and Natural Resources

PREPARE. ACT. SURVIVE. BUSHFIRE READY

Executive summary

Fire is a natural component of the South Australian environment and plays an important role in structuring the biodiversity and ecosystem processes in our native vegetation. To effectively manage these areas, it is necessary to have an understanding of how fire interacts with these environments, including what constitutes appropriate fire regimes. The targeted use of fire for biodiversity management (ecological burning) is still in its relative infancy in South Australia (SA). As such, guidelines for ecological burning that are built on best available scientific knowledge have been lacking.

In this document, Ecological Fire Management Guidelines (EFMG) have been developed for all fire-prone vegetation types which occur in agricultural areas of SA. These Guidelines briefly outline the role of fire and approaches available to manage fire for maintaining and enhancing biodiversity. An approach to develop ecological fire regimes (that is, fire regimes to maintain biodiversity) is recommended. This information will provide land managers in SA with guidance on fire regimes that are appropriate for the maintenance of broad biodiversity values.

The Guidelines identify five aspects of fire regime (interval, frequency, spatial, intensity and season) which need to be managed. Thresholds of potential concern (TPC) are identified for each fire regime element in each Major Vegetation Sub-group (MVS) based on a combination of current knowledge and expert opinion. Estimates for upper fire interval, fire intensity and season have been identified using limited data and all need to be reviewed as more information becomes available.

The EFMG should not be used as prescriptions; instead they define a window of "acceptable" fire regime suitable for the conservation of most species identified in each MVS. The specific guidelines can be applied to all native vegetation within the agricultural zone of SA, but the initial impetus for this document was a need to better inform fire management planning in reserves managed by the SA Department of Environment, Water and Natural Resources (DEWNR).

Implementation of these Guidelines should be through Fire Management Plans (which identify an appropriate system of Fire Management Zoning and determine areas that could be targeted for ecological burning in the landscape) and be part of an adaptive fire management framework centred on maintaining fire regimes which support broad biodiversity and conservation principles. This includes a program of targeted monitoring and research to improve the knowledge used in their preparation and to assess the effectiveness of their application.

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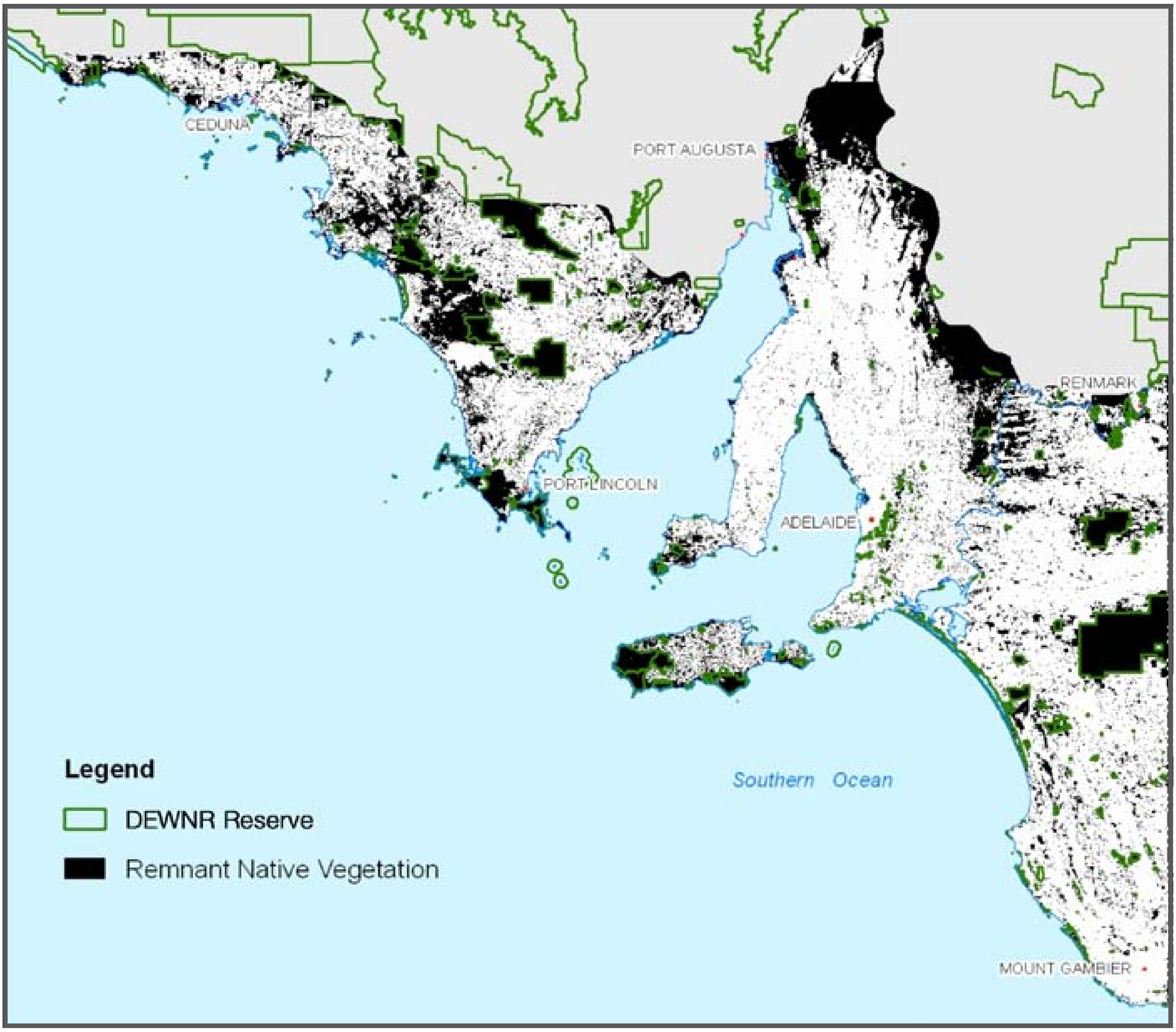
1. Introduction

Fire is a natural component of the ecosystems within the South Australian environment. The ecological effect of fire on the plants, animals and ecosystems within these areas is strongly influenced by fire regime. Fire regimes consist of multiple components that interact across different temporal, spatial and physical scales. Elements of fire regime include the time since the last fire, the time between successive fires, the intensity of the fire, the season in which a fire occurs, and the spatial extent and pattern of the fire (Gill, 1975; Gill, et al., 2002; Gill and Bradstock, 2003). Variation in any or all of these elements can result in differing effects on patterns of abundance and distribution of organisms in fire-prone ecosystems. Careful consideration of the different elements of fire regimes will therefore be needed when managing areas of native vegetation in SA.

The need to manage fire in a way that protects life and property and enhances biodiversity values, is well recognised in South Australia (*Fire and Emergency Services Act 2005*, DENR (2011a)). If fire management of native vegetation is to provide ecologically sustainable outcomes for biodiversity conservation, management decisions need to be based on the best information available and need to look beyond an event-based management perspective to include a broader spatial and temporal view.

This document seeks to synthesise current knowledge of the role of fire in relation to biodiversity conservation and suggest an approach to the management of fire (including the implementation of ecological burning) to assist the conservation of biodiversity in native vegetation in SA. It will define ecological fire management practices and how these will be implemented for fire-prone vegetation types in agricultural areas of South Australia (referred to as SA from here) (Map 1). It is a synthesis of information at a State-level and is based on the flora, fauna and communities which occur in each fire-prone Major Vegetation Sub-group (MVS) (Table 1). The Ecological Fire Management Guidelines (EFMG) will be used to inform fire management in conservation reserves, but are also applicable to other areas of native vegetation in the agricultural zone. This State-level synthesis, by its nature has produced very broad and generic guidelines, which can be further refined where more specific information is available. For example, fire management plans will outline specific EFMG, based on the local flora, fauna and communities, to guide and set minimum standards for fire management to conserve biodiversity in the plan area. This will mean there can be variations in the guidelines between what is recommended for a particular MVS at the State level and what is recommended in the fire management plans. Where fire management plans exist, the ecological fire management recommendations within the plan supersede the broader EFMG in the current document.

Map 1: Agricultural areas of South Australia showing the DEWNR reserve system and areas of remnant native vegetation



1.1. Fire and Biodiversity Management

South Australians live in a fire-prone and fire-adapted landscape. Thus, fire will always be a major environmental, cultural, social and economic challenge for land managers and communities alike. Understanding the relationship between fire events, fire regimes, and biodiversity outcomes, in an environment that involves unpredictable bushfires is a major challenge. The National Fire Management Policy Statement for Forests and Rangelands (FFMG, 2008), prepared by the Forest Fire Managers Group on behalf of the Council of Australian Governments (COAG), outlines agreed objectives and policies for the future management of broad areas or landscape fire in Australia's forests, grasslands and woodlands. The vision for landscape fire management in Australia is:

The effective management of fire regimes to achieve enhanced protection of human life and property, and to maintain and enhance the health of the biodiversity of Australia's forests, grasslands and woodlands.

Fourteen broad National Goals are outlined in this Policy Statement; two directly relate to ecological fire management:

- **Maintain appropriate fire regimes in forest, grassland and woodland ecosystems**. The goal is to manage fire regimes in ways that maintain or, where appropriate, enhance the health, biodiversity and resilience of Australia's forests, grasslands and woodlands.
- **Environmental Impacts of Fire**. The goal is to maximise the environmental benefits associated with the management of appropriate fire regimes and to minimise the adverse environmental effects of fire on key environmental assets such as water supply and air sheds.

Table 1: Fire–prone status of the Major Vegetation Subgroups in Agricultural Areas of SA. Shaded vegetation types have been included in the Ecological Fire Management Guidelines.

MVS_NO	Major Vegetation Subgroup (MVS) 1	Fire-prone
4	*Eucalyptus* forests with a shrubby understorey	Yes
5	*Eucalyptus* forests with a grassy understorey	Yes
8	*Eucalyptus* woodlands with a shrubby understorey	Yes
9	*Eucalyptus* woodlands with a grassy understorey	Yes
12	*Callitris* forests and woodlands	Yes
14	Other *Acacia* forests and woodlands	No
15	*Melaleuca* open forests and woodlands	Yes
16	Other forests and woodlands	No
19	*Eucalyptus* low open woodlands with tussock grass	Yes
21	Other *Acacia* tall open shrublands and shrublands	No
22	Arid and semi-arid *Acacia* low open woodlands and shrublands with chenopods	No
26	*Casuarina* and *Allocasuarina* forests and woodlands	Yes
27	Mallee with hummock grass	Yes
28	Low closed forest or tall closed shrublands (including *Acacia*, *Melaleuca* and *Banksia*)	Yes
29	Mallee heath and shrublands	Yes
30	Heath	Yes
31	Chenopod shrublands	No
32	Other shrublands	No
33	Arid and semi-arid hummock grasslands	Yes
36	Temperate tussock grasslands	Yes
37	Other tussock grasslands	Yes
38	Wet tussock grassland, herbland, sedgeland or rushland	No
39	Mixed chenopod, samphire or forblands	No
47	*Eucalyptus* open woodlands with shrubby understorey	Yes
48	*Eucalyptus* open woodlands with a grassy understorey	Yes
49	*Melaleuca* shrublands and open shrublands	Yes
55	Mallee with an open shrubby understorey	Yes
61	Mallee with a tussock grass understorey	Yes

1. Major Vegetation Subgroups are the Level III-IV classification of the National Vegetation Information System (NVIS), and were for regional scale analysis and mapping of vegetation (ESCAVI, 2003). The commonly used SA Veg grouping of vegetation types is Levels V & VI of NVIS.

The principles used to inform policy making and program implementation in relation to environmental matters are set out in the following documents and agreements:

- Inter-Governmental Agreement on the Environment (COAG, 1992),
- National Strategy for the Conservation of Australia's Biological Diversity (DEST, 1996), and
- No Species Loss (DEH, 2007).

The key principles advocated to guide the conservation of biodiversity in South Australia (DEH, 2007) which relate to fire management are:

1. **In-situ conservation –** Biodiversity is best conserved in-situ where landscapes, ecosystems and ecological processes maintain species in their natural habitats. Complementary ex-situ conservation activities should support in-situ conservation if required.
2. **Appropriate planning** – Biodiversity conservation activities are planned at the appropriate biological, spatial and temporal scales in consultation with government, industries, and urban, rural and Aboriginal communities.
3. **Managing the cause** – It is essential to prevent the introduction of new threats and deal with existing threats at their root cause.
4. **Prevention** – Preventing the loss of biodiversity by dealing with existing threats is preferable to reconstruction and treating symptoms.
5. **Precautionary** – Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
6. **Developing knowledge** – It is essential to develop and share knowledge, and seek and value the wisdom of government, industries, and urban, rural and Aboriginal communities.
7. **Best available knowledge** – The best available biodiversity knowledge should be used in a precautionary way as part of a risk management approach to informed decision making.
8. **Adaptive management** – Biodiversity management must incorporate an adaptive approach that is flexible and inclusive, continually improves by testing and learning, and is based on science where appropriate.
9. **Ecosystem approach** – Biodiversity management will be most effective when we adopt an ecosystem approach that recognises and integrates all components (genes, species, ecosystems) and attributes (components, patterns, processes) of the biodiversity hierarchy, and manages these at appropriate spatial and temporal scales.

In seeking to optimise the management of fire for biodiversity outcomes, the best elements of these different approaches need to be used to develop and implement ecological fire regimes. This will require careful planning (Fire Management Plans), expert advice (ecologists, fire specialists, and others with specific or local knowledge), and ultimately a land management decision (landowner, land manager or land management agency staff).

1.2. Inappropriate fire regime as a threatening process

Conservation management in the past has placed a high emphasis on obtaining an assessment of and maintaining the so-called 'natural' fire regime of an area. This approach aims to maintain or emulate the fire regimes which occurred prior to human intervention. Fires ignited by lightning are allowed to burn freely, and fires of human origin are suppressed. No goals are set relating to desirable fire regimes using this approach; and it is assumed that lightning alone is sufficient to ignite the required number of fires at the best times. The underlying philosophy is to promote 'wilderness' with minimal human intervention. In Australia, this approach is generally compromised by the influence of Aboriginal ignited fire regimes which have occurred over the past 50,000+ years and the aim to maintain or restore pre-1750 fire regimes is often considered a substitute for 'natural fire regimes'. In northern South Australia, where Aboriginal land management is still practised or has not long ceased, the fire regimes implemented by Aboriginal people can be (and are being) supported or re-introduced.

The fragmented or even relict nature of the vegetated landscape in South Australia's agricultural areas means that the spread of naturally ignited fires has been interrupted. This interruption of fire spread, combined with the loss of most knowledge of Aboriginal burning practices, means that the 'natural' fire regimes are impossible to define, let alone re-introduce across much of South Australia. Changed land use, fragmentation of natural habitats and increasing threats to life and property from continued urbanisation will prevent 'natural' fire regimes from being implemented in these areas.

A more productive approach is to place emphasis on understanding how species, populations and communities respond to fire regimes (Whelan, 1995 p 135). Just as a 'weed' is a 'plant out of place', so fires can be 'in' or 'out' of place in a landscape (Gill, 2005). Ecological effects of fire on species, populations and communities are created by the fire regimes – comprising elements of fire frequency, intensity, season and type (Gill, 1975; Gill, et al., 2002; Gill and Bradstock, 2003). The fire regime at any place is a result of the combination of individual fires that have occurred there, including the characteristics, timing and spatial distribution of each fire. Multiple fire regimes are possible in most landscapes, reflecting differences in the number, size and circumstances (e.g. weather) surrounding individual fires (Kenny, et al., 2004). The limits or thresholds of fire regime tolerated by a plant or animal species in a community will determine its persistence under any given fire regime. If localised fire regimes are outside the suitable thresholds, a species may decline and eventually face local extinction, but may persist where different fire regimes occur in other parts of the landscape. However, when inappropriate fire regimes occur across the majority of the habitat for any given species in a landscape, there is a high chance of extinction of that species from the entire landscape (Kenny, et al., 2004).

The structure and composition of plant communities can be affected by changes in the abundance and cover of the dominant species. Plant communities are also the key elements of habitat for animals. Hence, floristic and structural changes in a plant community caused by fire regime can alter the habitat present for particular animal species.

In the Australian Terrestrial Biodiversity Assessment, the impact of inappropriate fire regimes was assessed as the second most extensive and fourth most frequent threat affecting threatened species, and fourth most extensive threat affecting threatened ecosystems within IBRA subregions across Australia (Sattler and Creighton, 2002).

As the occurrence of fires is generally not predictable, the management of fire, for any objective, is a risk management problem (Keith, et al., 2002). For the goal of conserving and enhancing biodiversity, this becomes a problem of minimising the risk of population extinctions from inappropriate fire regimes (Bradstock, et al., 1995; Keith, 1996).

2. Objectives for ecological burning

The Department of Environment, Water and Natural Resources has a Zoning Policy that outlines the zoning used for fire management planning on DEWNR managed lands (DENR, 2011a; section 3.3). Zoning is derived from:

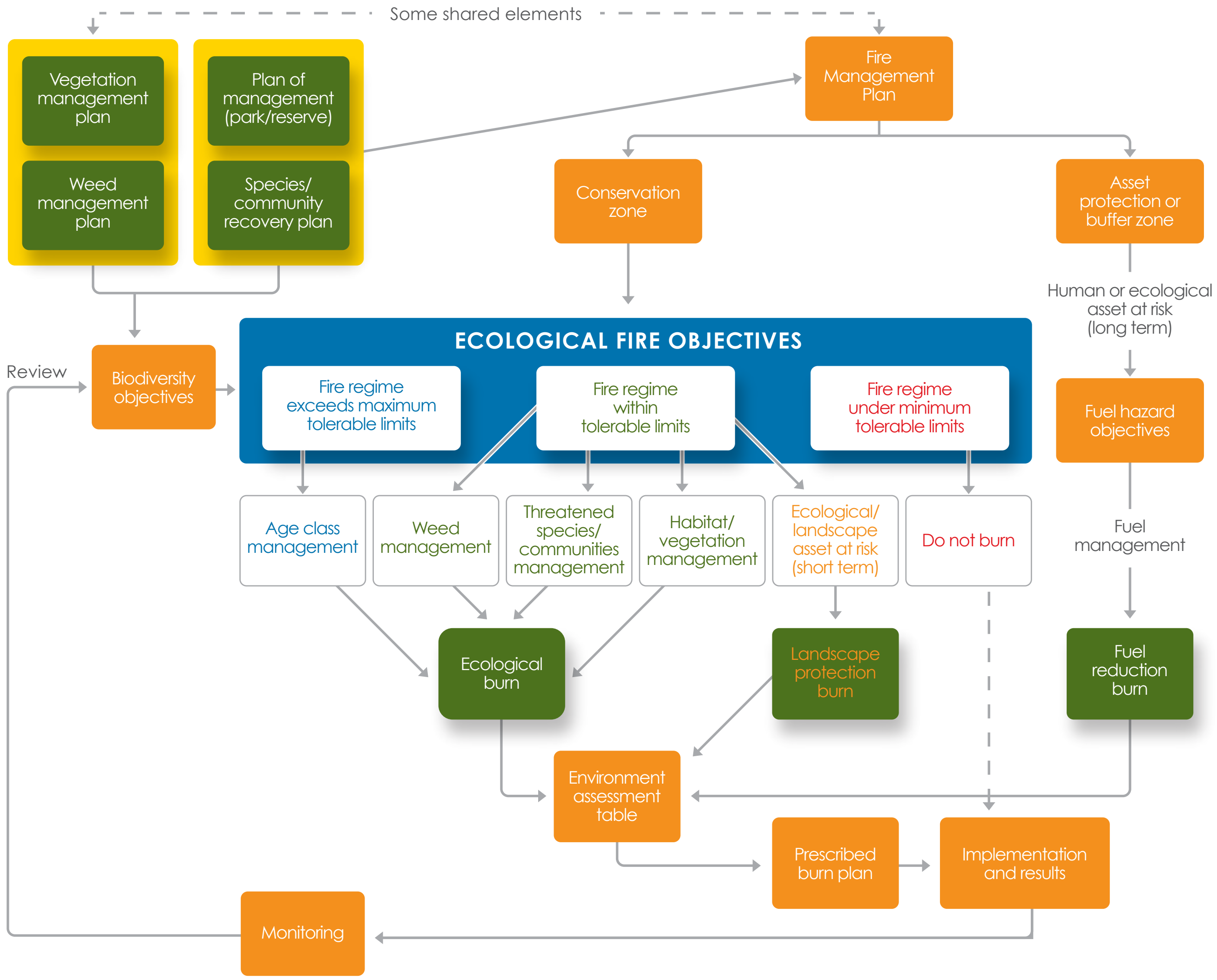
- the level of perceived risk to life, property and the environmental assets, using the *Fire Policy and Procedure for Risk Assessment in Fire Management Planning* (DENR, 2011a; section 3.2)
- the overall fuel hazard, which is assessed using the *Overall Fuel Hazard Guide for South Australia* (DENR, 2011b) in accordance with the *Fire Policy and Procedure for Fuel Hazard Assessment* (DENR, 2011a; section 2.3)
- the activities considered appropriate to mitigate the threat that fire poses to life, property and environmental assets.

Three distinct zones exist: Asset zone (A-zone), Buffer zone (B-zone) and Conservation zone (C-zone) and these are applied according to landscape objectives. A- and B-zones are determined by fuel management objectives for the protection of life and property, whereas C-zones are designated to assist in the conservation and enhancement of biodiversity through the application of appropriate fire regimes, primarily to achieve specified ecological objectives (ecological burning). For more information on zoning, refer to the *Policy and Procedure for Fire Management Zoning* (DENR, 2011a; section 3.3). The objectives for ecological burning outlined in the current document are focused on the C-zones. While fuel reduction is the primary goal in the A- and B-zones, it is important to note that there can still be positive environmental outcomes as part of this process. The decision process and logic flow for prescribed burning in the three zones is illustrated in Figure 1. The decision process for ecological burning in C-zones relies on having an understanding of the maximum and minimum tolerable limits for fire regimes in each particular vegetation type.

The management of fire to maintain or enhance biodiversity is therefore based on accumulating knowledge of flora and fauna species, populations and communities and their response to fire regimes, and then applying this knowledge to fire management practices to maximise biodiversity outcomes. This approach is being used as a sound basis for the management of fire for biodiversity across Australia (Andersen, et al., 2003; FEWG, 2004; Hopkins and Saunders, 1987; Whelan, et al., 2002).

The State-wide EFMG outlined below are used to guide fire management decisions in reserves and native vegetation without a Fire Management Plan. When preparing a new Fire Management Plan, local EFMG (developed from local data) should be developed as part of the Plan and used in preference to the more generic State-wide guidelines, to guide fire management in C-zones for that area.

Figure 1: The 'logic flow' of prescribed burning in fire management.



The EFMG will provide the necessary fire regime estimates which will be an important tool for helping to achieve biodiversity conservation through ecological burning. Ecological burning is the treatment of vegetation in nominated areas by the use of fire, primarily to achieve specified ecological objectives. All prescribed burns where the primary objective is not fuel management are considered ecological burns (DENR, 2011a; section 3.6). Ecological burning should be the most common form of prescribed burning conducted in C-zones. Landscape protection burns however, may be conducted in C-zones for fuel reduction to achieve environmental objectives (see Figure 1). There are four main management objectives for ecological burning in C-zones. It is important to consider that an ecological burn may satisfy more than one of these objectives at the same time. For example, fire could be used to address senescence in a long unburnt site that has allowed weed infestation that negatively impacts on fauna. The objectives are described as follows:

2.1 Vegetation Age-class or 'Mosaic' Management

Various approaches to creating 'mosaics' of different age-classes across a landscape have been attempted (Burrows and van Didden, 1991; Parr and Brockett, 1999; Possingham and Gepp, 1994). Generally, this involves dividing landscapes into blocks and subjecting them to a burning regime, often of a fixed frequency (Bradstock, et al., 1995). The 'mosaic' is provided by burning different blocks in different years, giving rise to a range or mosaic of ages since fire in the landscape. This type of fire management can be attractive, as it is regarded as good for reducing risk by breaking up larger areas of fuel – a compromise between conservation and protection objectives. Unless based on a wide range of ecological data, this approach can lead to declines in non-target species. It can be difficult to implement targeted fire regimes in areas prone to unplanned fires (Whelan and Muston, 1991), unless these are taken into account in the mosaic.

A slightly different version of the mosaic management is the 'ideal' or 'balanced' age-class approach (Avis, 1993; Tolhurst and Friend, 2001; Wouters, 1993). In this case, fire management is aimed at producing a range of age-classes within a vegetation type using ecological criteria of the flora and fauna to determine fire regimes within a mosaic. This involves the use of the best available information on vital attributes of component species to identify those species most vulnerable to changes in the elements of fire regime (Key Fire Response Species or KFRS) (Keith, et al., 2002; Noble and Slatyer, 1980; Noble and Slatyer, 1981; Tolhurst and Friend, 2001; Whelan, et al., 2002). These species are used to develop minimum and maximum thresholds for acceptable fire regimes (Thresholds of Potential Concern or TPCs) that define where biodiversity impacts will exceed acceptable limits based on time since last fire (vanWilgen, et al., 1998). Ideal age classes within each vegetation type are then calculated using the TPC and fire cycle length estimates in a negative exponential distribution model (Tolhurst and Friend, 2001). The ideal distribution derived from the model is compared to the actual mapped distribution of that vegetation type, with prescribed burning allocated to those classes that are overrepresented. The assumption underlying these approaches is that this range of age-classes provides a greater chance of catering for species with unknown requirements – in essence a bet hedging strategy (Bradstock, et al., 1995). The approach is being applied in fire-prone vegetation types in South Africa (Brockett, et al., 2001), Victoria (Tolhurst and Friend, 2001) and South-western Australia (Armstrong, 2003; Burrows and Armstrong, 2003).

Many fire-prone vegetation types often exhibit different 'seral' stages or transition to new 'states' with particular species favouring the different habitats created in the early, middle and later stages of vegetation recovery and re-colonisation following fire (Cheal, 2010). In such communities, for example, grasslands, heathlands and mallee woodlands, when fire regimes become adverse across the majority of the habitat for any given species in a landscape, a high chance of loss of that species from the entire landscape may result. Thus, a mosaic of patches of vegetation representing different seral stages will provide a diversity of habitats for species that are mobile and can move through the landscape.

One limitation of the above approaches is that they are based largely on time since last fire. The underlying effects of the hidden mosaic (Bradstock, et al., 2005) involving prior fire history is not considered and spatial aspects of patch size, shape and position are given less prominence. A third, more targeted approach advocated here in the EFMG also uses vital attributes to calculate TPCs for each vegetation type. Targets are set for the percentage of each vegetation type that should be below, within, or above TPC1 and TPC2 as well as fire frequency limits using available environmental knowledge and expert opinion. Planning for future burning therefore takes into account the distribution of each vegetation type relative to TPC1 and TPC2, previous fire history, and the allowable number of fires in a given time interval as dictated by the life histories of the component species. Historically, the collection of fire history information has been poor in some areas and good in others. Current mapping of new fire scars (particularly in reserves) is now done more efficiently, allowing future analyses to be more robust. New advances in ageing of some vegetation types (Clarke, et al., 2010) will also prove useful in analyses where fire history is lacking, particularly when considering TPC2. Having fire management targets defined as ranges rather than optima offers greater flexibility to deal with uncertainty and potential conflicts between species (Keith, et al., 2002). It is also important to incorporate climate reliability (principally rainfall, especially in semi-arid areas) and the population states across the landscape, not just at a location to minimise the risk of extinction.

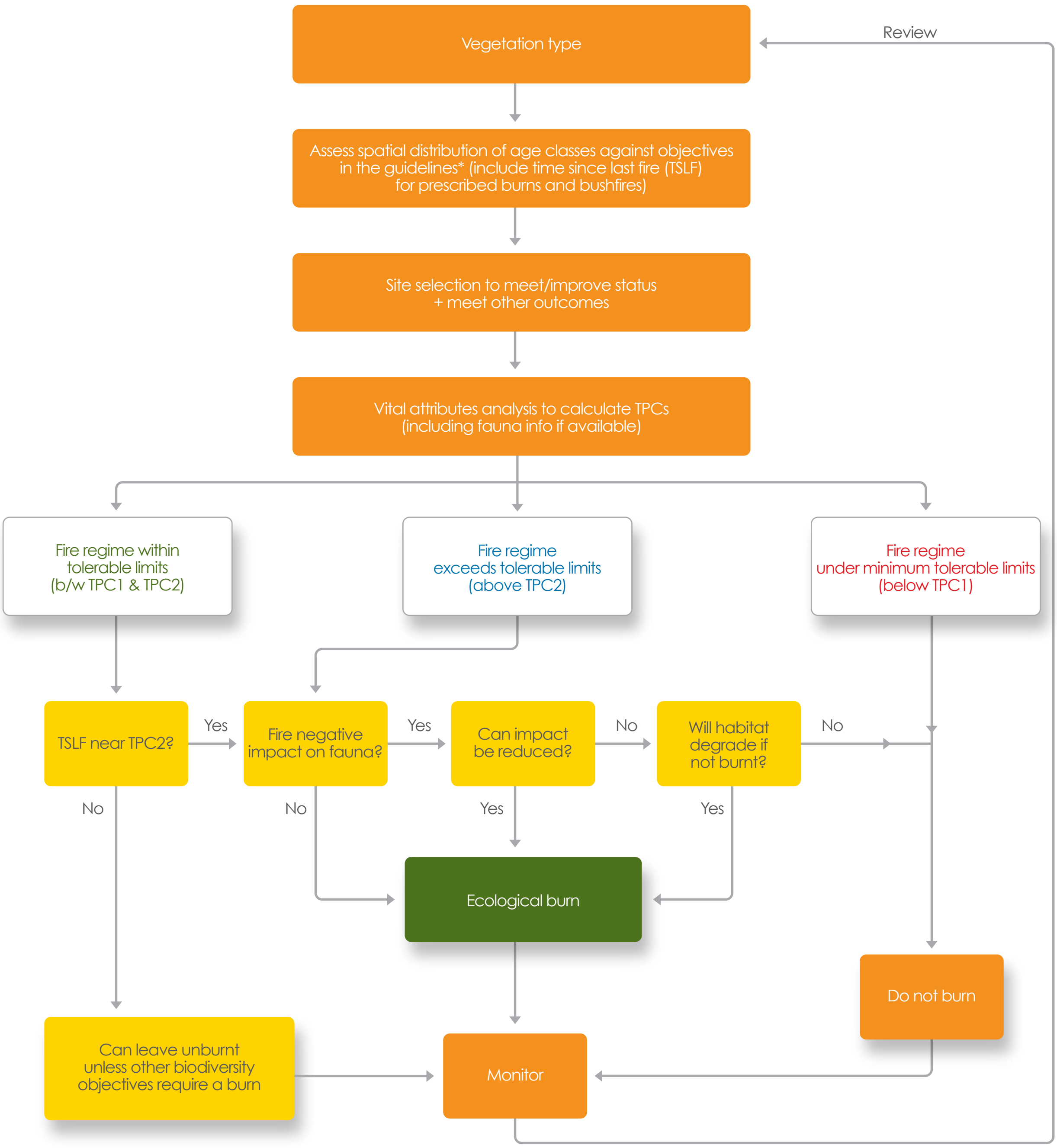
Requirements:

- Ecological burning for age-class management must be planned on a landscape-scale basis and include objectives and assessment for all vegetation communities occurring in the landscape.
- Ecological burning for seral stage management must be planned using appropriate seral stages for the vegetation communities occurring in the landscape.
- Follow-up assessment and if necessary weed and fauna control must occur.
- Monitoring must measure the age-class distribution of the communities occurring in the area and the key indicator species for those communities.

Example

DEWNR Fire Management has developed a GIS based spatial tool that allows the analysis of the landscape in terms of the 'fit' of the EFMG for each MVS. Analyses can be conducted at a range of scales from reserve to large scale landscape applications. Metrics calculated in graphical and tabular format include the percentage of each MVS that occurs below TPC1, between TPC1 and TPC2, and above TPC2. It also allows the mapping of the 'hidden mosaic' by displaying the number of fires that have occurred in the period stipulated in the frequency column of the EFMG for each MVS. This allows for strategic planning of prescribed burning by allowing the combination of time since last fire data with number of fires occurring over a known time period. Parcels of land are then identified as being available to burn or needing to be left unburnt until a specified time into the future. Impacts of the planned prescribed burn program can be analysed in terms of the affects on the distribution of each MVS in relation to the TPC1 and TPC2 figures. The decision process for mosaic fire management is described in Figure 2.

Figure 2: Approach for using fire for "mosaic" management



2.2. Weed Management

Fire can be an effective tool in weed management, particularly against woody weed species. However, weed mortality and impact on weed seed banks can depend to a great degree on the fuel loads present. Fire can stimulate the germination of some weed seeds with hard seed coats (e.g. legumes), while increased temperatures or increased time exposed to heat can lead to mortality. Some shrub species are killed by fire, leaving their persistence to seedling germination while others re-sprout from dormant buds rather than stimulating recruitment.

It is important to note that fire alone will not control invasive plants species, but when integrated with other treatments can be very successful. These additional treatments may be mechanical, biological or chemical and may also include the application of more fire. Each combination of treatments can impact differently on the target species, so weed management using fire needs to be carefully planned and executed (Figure 3).

Requirements:

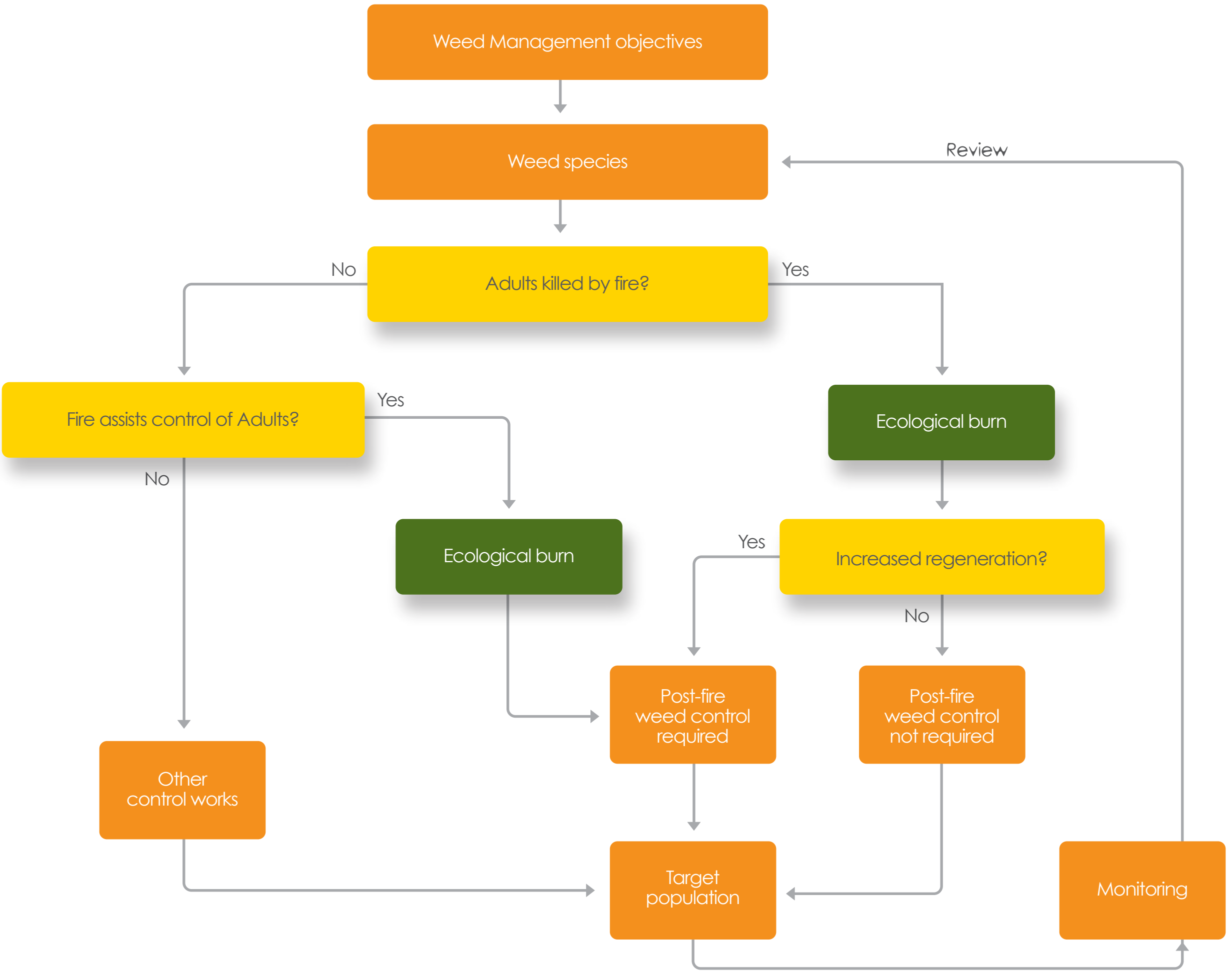
- Ecological burning for weed management must be part of an integrated approach to eradicate or limit the spread of declared &/or environmentally damaging weeds.
- Follow-up assessment and if necessary ongoing weed and fauna control must occur.
- Monitoring must measure the success of the integrated management approach.

Example

Bridal creeper, *Asparagus asparagoides* is a Weed of National Significance (WoNS) that has strong capacity to invade undisturbed native ecosystems. It crowds out native species because of an extensive below-ground tuber system and a dense mat of climbing annual shoots. Usual control methods include herbicide spraying and the introduction of various biological control organisms (Turner and Virtue, 2009). The dense mat of tubers has the capacity to remain in the soil for some years after herbicide treatment (Turner & Virtue 2006), potentially impacting on native species regeneration. It has been suggested that fire is potentially a useful strategy for management of this weed by consuming young annual shoots and increasing the decay rate of underground tubers,

Turner and Virtue (2009) investigated the post-fire recovery of Bridal creeper infested mallee vegetation near Meningie, south east of Adelaide. They monitored plots with no post-fire weed control and plots with post-fire herbicide application. Native species were dominating both the controlled and uncontrolled plots ten years after fire but there were significantly more small native shrubs, creepers and climbers at the herbicide sites. They concluded that fire was an important restoration tool because it promoted the germination of native species, which had a better chance of recovery if there was some form of post-fire control of bridal creeper density.

Figure 3: Approach for using fire for weed management



2.3. Threatened Species or Community Management

Altered fire regimes have been identified as a significant cause for the observed rise in the number of threatened species and communities since European settlement (Sattler and Creighton, 2002). Hence, implementation of ecologically appropriate fire regimes has a significant role to play in the management of threatened species and communities. Target fire regimes have sometimes been prescribed for the conservation of a single species through to communities. Examples include the Ground Parrot (*Pezoporus wallicus*) (Avis, 1993), New Holland Mouse (Wilson, 1993) and Lowland Grasslands (Lunt and Morgan, 2002). In the management of threatened flora, 'fire-free' intervals have been recommend to allow the build-up of the seedbank to ensure sustainable levels of regeneration (Bradstock and O'Connell, 1988; Gill and Nichols, 1989). Keith and Bradstock (1994), Keith (1996) and Bradstock et al. (1995) found that a fire regime directed solely at maintaining a small number of species (in this case dominant shrubs) could be detrimental to co-habiting species, which make a bulk of the floristic diversity. A single fire regime (in particular fire frequency) is unlikely to favour all species in a community, so variation in the fire regime elements within tolerable limits or thresholds may be needed for the conservation of the full range of species.

The seasonal timing of fires is important for many threatened species. For example many orchid species respond well to a fire in their dormant season, but are adversely affected by a fire during their growth season. For these species, it is particularly important to avoid fires early in their season when they are beginning to emerge, but may not be visible to the naked eye. The decision process for threatened species or community management is shown in Figure 4.

Requirements:

- Ecological burning for threatened species or communities must be part of an integrated approach (or plan) to manage species or limit threats
- Any ecological burning must conform with any State or Federal Recovery Plans, and must be in consultation with the relevant recovery team if it exists
- Follow-up assessment and if necessary weed and fauna control must occur
- Monitoring must measure the success of the burn on the target species.

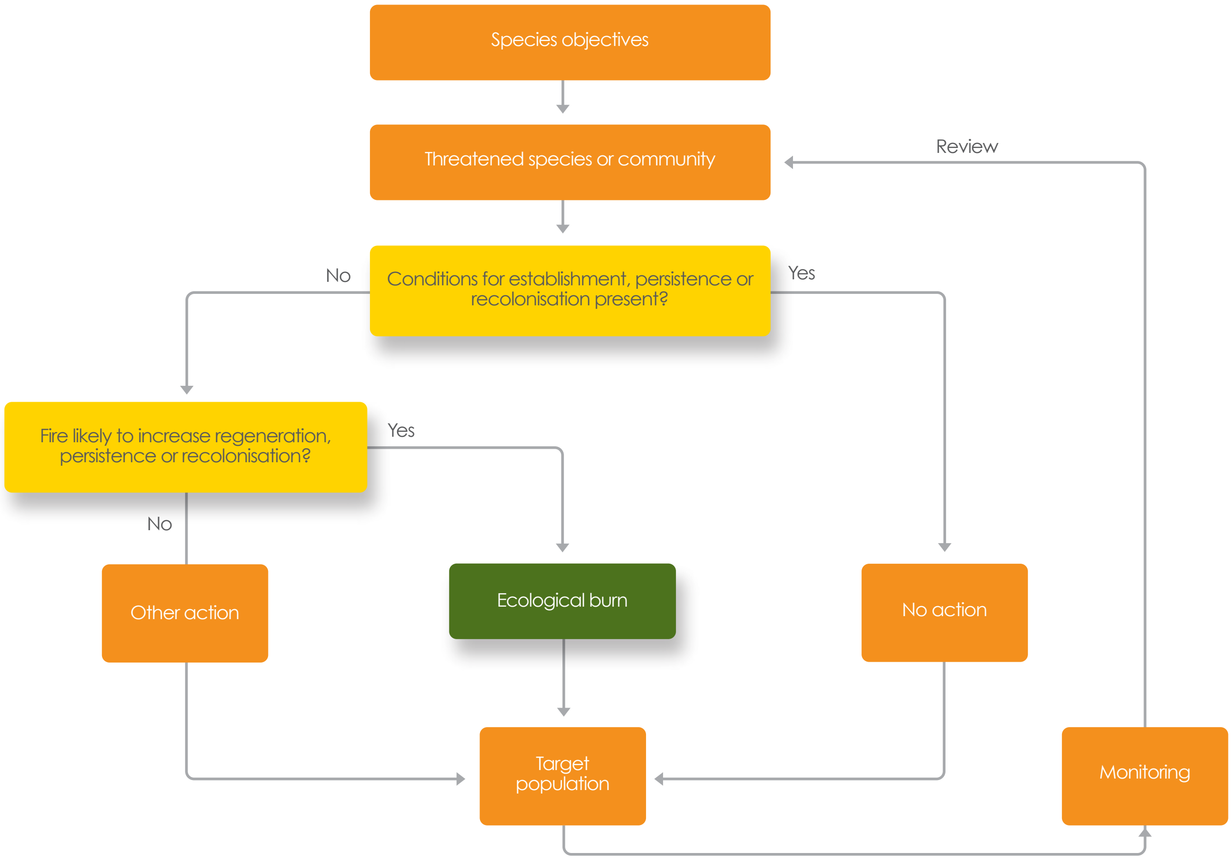
Example

The Small-flowered Daisy-bush, *Olearia microdisca*, is a nationally endangered obligate seeding species that is endemic to fragments of remnant vegetation in eastern Kangaroo Island. Typical habitat consists of open mallee woodland and shrubland with *Eucalyptus cneorifolia* and/or *E. cosmophylla* as the dominant overstorey species (Jusaitis, 1993). *Olearia microdisca* is an early successional species (Davies, 1996; Jusaitis, 1993) with the majority of sub-populations found in areas regenerating from a significant disturbance event such as vegetation clearing or fire. Few *O. microdisca* have been found in late successional vegetation or in areas which are subject to very frequent disturbance (Bickerton and Davies, 1999; Davies, 1996; Jusaitis, 1993). The exclusion of fire from *O. microdisca* habitat has been identified as a key component in the senescence of this species, with anecdotal observations, botanical surveys and small scale scientific trials suggesting that carefully planned burning in long unburnt habitat would be an effective means of encouraging regeneration.

To examine the response of *Olearia microdisca* to fire, a 3.9 ha area of habitat adjacent to Kingscote Airport was prescription burnt and fenced from grazing in October 2003. Five monitoring plots (each 5 x 5 m) were established and surveyed within the burn area. A further five plots were also set up within adjacent *O. microdisca* habitat as control sites prior to burning. All monitoring plots were surveyed in spring 2003, spring 2004 and spring 2005.

High density regeneration of *O. microdisca* from seed was observed throughout the 3.9 ha burn area within 12 months of burning. The number of *O. microdisca* within the monitoring plots increased from an average of 3.6 per m^2 prior to the burn to 1031.6 per m^2 two years after burning. In contrast, the number of *O. microdisca* in adjacent unburnt (control) habitat fell over the same time period from 3.2 per m^2 to 1.0 per m^2 (EPFTWG, 2008).

Figure 4: Approach for using fire for threatened species management



2.4. Fauna Habitat or Vegetation Management

Fauna habitat management for more common species uses the same principles as does threatened species management.

Requirements:

- Ecological burning for fauna habitat must be part of an integrated approach (or plan) to manage species habitat or limit habitat threats.
- Any ecological burning must conform to known habitat requirements.
- Follow-up assessment and if necessary weed and fauna control must occur.
- Monitoring must measure the success of the burn on the target species and their habitat.

Example

The Sandhill Dunnart (*Sminthopsis psammophila*) is a carnivorous marsupial about the size of a large mouse that is listed as endangered under the EPBC and NPWSA Acts. Sandhill Dunnarts have previously been captured at only a few widespread locations in the Great Victoria Desert of Western and South Australia, and the Eyre Peninsula. Recent studies (Churchill, 2001b) have shown that they favour large spinifex (*Triodia* species) hummocks that have started to die off in the centre as nest sites. These only form at 5 – 10 years post fire, and at present only comprise about 5% of the available hummocks. It is believed that altered fire regimes (reduction in Aboriginal burning practices) have resulted in long unburnt patches of the landscape with a high proportion of senescent *Triodia* hummocks that are unsuitable for nesting.

Churchill (2001a) identified the use of ecological burns as a recovery planning measure aimed at promoting the growth of various patches of different age spinifex to secure appropriate habitat for the future survival of Sandhill Dunnarts. In Autumn, 2010, an approximately 150 ha ecological burn was conducted at Yellabinna Regional Reserve in the far west of SA for this purpose. This burn to the north and north-west of a known population will also provide a low fuel buffer for minimising the impact of bushfire.

2.5. Landscape Protection

Landscape protection burns are prescribed burns which primarily aim to reduce fuel hazard across a range of areas in a landscape in order to reduce the likelihood of a whole reserve or large contiguous block of vegetation burning in a single fire event. The short term goal of this form of burn is fuel reduction (for the benefit of broad landscape/ecological values). While this is, strictly speaking, not an ecological burning objective, it has been included in this guideline as it is an objective for prescribed burning which may occur in C-zones. It is important to note that the frequency of burning for landscape protection burns must comply with the EFMG for the MVS that it is conducted in. This therefore, separates this type of fuel reduction burn from those used for A- and B-zones. The decision process for using landscape protection burns is shown in Figure 5.

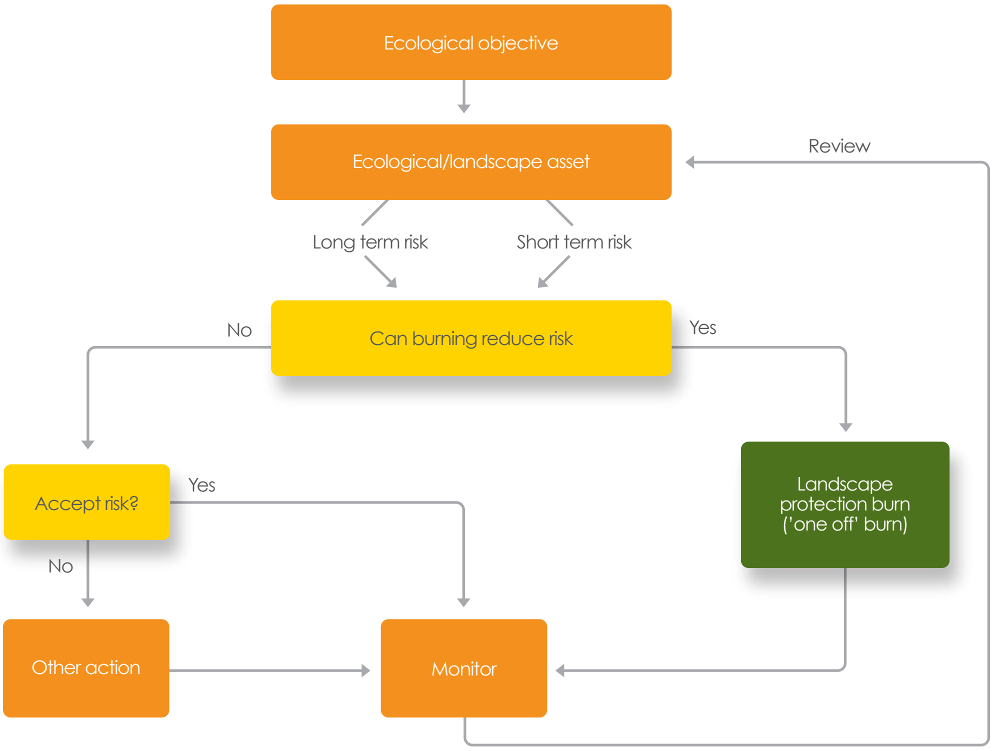
Requirements:

- Landscape Protection burning must be part of an integrated approach (plan) to reduce risk to an ecological asset or limit the spread of fire across a landscape. (i.e. must be based on a risk assessment and management approach).
- Landscape Protection burning must not create a significant imbalance in vegetation age-class distributions.
- Landscape Protection burning must not exceed the appropriate 'ecological' fire regime for the vegetation type(s) which occur within the burn area.
- Follow-up assessment and if necessary weed and fauna control must occur.
- Monitoring must measure the success of the integrated management approach.

Example

Mallee Emu-wrens (MEW) (*Stipiturus mallee*) occur in the more dense vegetation of the mallee and heaths of the Murray-Darling Basin in South Australia and Victoria. Favoured habitats include spinifex heaths, Xanthorrhoea (Yacca) heaths, and spinifex grasslands with a mallee overstorey. A dense layer of vegetation at least 40cm tall seems to be the main habitat requirement of these birds. However, a recent history of relatively large and frequent fires in their preferred habitat has meant they have been declining in South Australia for some time and are now largely restricted to Ngarkat and Billiatt Conservation Parks. Further large scale fires have been identified as a threat to remaining populations of Mallee Emu-wrens. Therefore, landscape protection burns were undertaken in June 2005 to provide a lower fuel buffer near existing Mallee Emu wren habitat in the McCallum block of Ngarkat Conservation Park. The MEW like easterly facing dune slopes and depressions that are dominated by thick *Triodia/Allocasuarina pusilla* and *Banksia ornata* in this McCallum block. The burns were located on flat ground and on the western aspect of dunes, which predominantly run north-east to south-west, to protect the valuable "preferred habitat" of the MEW which is generally on the cooler, heavily vegetated eastern aspect.

Figure 5: Approach for using fire for landscape protection



3. Ecological fire management guidelines

3.1. Methodology

The underlying approach used in determining the SA EFMG is based on those being developed and implemented in Victoria (FEWG, 2004), Western Australia (Burrows & Abbott 2003), South East Queensland (Watson, 2001) and New South Wales (Kenny, et al., 2004).

A functional approach to fire response based on groupings of species that share critical life history characteristics can provide a means of both understanding and predicting species response to a particular fire regime (Keith, et al., 2007). Tolhurst and Friend (2005) and Whelan et al. (2002) have reviewed a number of different schemes for flora and fauna. The flora vital attributes scheme of Noble & Slatyer (1980; 1981) has the advantage of including both species ecological response and timing factors (Tolhurst and Friend, 2005) and is now being used in at least four other Australian States. It is important to note that there are still knowledge gaps relating to the vital attributes of many flora species. It is therefore necessary to incorporate both scientific data and available expert knowledge into the KFRS selection process. Monitoring of the pre- and post-fire response of the KFRS will therefore be necessary in order to assess if the assumptions and data used in deriving the TPC are appropriate.

3.1.1. Steps to determine Ecological Fire Regime

There are five steps to determine the EFMG for a vegetation type. In summary, the species most likely to be negatively impacted by the extremes of fire regime (Key Fire Response Species or KFRS) will be used to determine the burning thresholds for a community. Research indicates that while all elements of fire regime determine the effects of fire on plant and animal species, long term species survival is affected most strongly by (i.e. in order of significance) fire interval frequency, followed by intensity and season, (Bradstock, et al., 2002). Fire extent is important in the landscape context. This is reflected in the strong focus on fire interval in the current guidelines (and maximum and minimum tolerable fire frequencies). An understanding of the fire regime requirements of the Key Fire Response Species will provide a basis for developing the use of fire as a management tool.

These guidelines define a window of “acceptable” fire regime (in particular, fire intervals) that aims to ensure the conservation of existing plant species. In reality, there is often limited data available on the fire-related requirements of many fauna taxa, so the guidelines are based predominantly on the plant vital attribute information. The process involved in each of these steps is described below.

1. **Identify vegetation unit/s**
2. **Compile species list (flora and fauna) for each MVS**
3. **Identify Rated threatened species (flora and fauna) for each MVS**
4. **Identify Key Fire Response species for each MVS**
    a. **using flora species**
    b. **review using fauna fire response and habitat requirement data**
    c. **review using rated threatened species requirements**
5. **Specify fire regime for each MVS using minimum/maximum fire interval, range of season, minimum/ maximum intensity and extent of most vulnerable Key Fire Response Species.**

3.1.2. Selecting Vegetation Units

Floristic mapping for these guidelines uses a compilation of regional vegetation mapping data that has been stored under the National Vegetation Information System (NVIS) hierarchical classification for Australia (ESCAVI, 2003). Native vegetation survey within SA is conducted at the fine scale levels V and VI within the NVIS System. Examination of the data base (February 2010) revealed 1025 vegetation types for the agricultural zone within SA. The scale of the mapping for these vegetation types was too fine for our goals for fire planning at a landscape scale. We therefore grouped vegetation types within 28 Major Vegetation Sub-groups (MVS) occurring in the agricultural zone of South Australia (Table. 1). These MVS are at the coarser scale NVIS levels III and IV and emphasise the structural and floristic composition of the dominant stratum but with additional types identified according to typical shrub or ground layers occurring with a dominant tree or shrub stratum. Some of the MVS used in the guidelines have a wide distribution across the state and it is likely that there are differences in productivity, and hence flammability within different patches of a particular MVS. For the purposes of this guidelines document, however, the same fire regimes will be applied across all patches of each MVS. Where sufficient local information on vital attributes exist it will be used in the development of fire management plans for regional or smaller scale areas.

Major Vegetation Subgroups that are not likely to be burnt were removed from the list. These were considered as being either too wet or having too low a fuel load to carry a fire. This resulted in 20 MVS for consideration in the ecological guidelines decision process (Table 1).

3.1.3 Compile species list (flora and fauna) for ecological community(s)

Species lists of both flora and fauna within each MVS of interest were compiled from the Biological Database of South Australia (BDBSA), local records, spatial data (SDE), Biological Survey reports and Management Plans. Spatial reliability of species records was set at <1km accuracy to maintain reasonable confidence that each survey record was located within the MVS boundaries. Advice and assistance was also sought from Regional Ecologists, the Bio-Knowledge SA and Spatial Information Services Branch of DEWNR for this task.

3.1.4 Identify significant species (flora and fauna) and community(s) for the area

Rated threatened species have extra legal protection and need to be specifically identified in any analysis. For each MVS, we identified a list of flora and fauna species of conservation significance under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* and the *SA National Parks and Wildlife (NPW) Act 1972* as part of this process. This data was sourced from the Biological Database of South Australia (BDBSA), local records, spatial data (SDE), Biological Survey reports, Management Plans and recovery plans. Advice and assistance was also sought from Regional Ecologists, the Biological Survey and Monitoring and Environmental Information Analyses Sections of DEWNR for this task. Spatial reliability of survey records was set at <1km accuracy to maintain reasonable confidence that each survey record was located within the MVS boundaries.

3.1.5. Identify Key Fire Response Species

Using the available knowledge of plant vital attributes and life histories, the species most susceptible to decline from changed fire regimes need to be identified. These species and their needs in relation to the components of fire regime provide a guide to the acceptable thresholds of fire regime for the community (i.e. the upper and lower tolerable fire intervals, intensities and appropriate season) for the area.

We used the plant vital attributes scheme of Noble and Slatyer (1980; 1981) to classify the flora in each fire-prone MVS into functional fire response categories. The goal of this classification is to aid in the prediction of the fire-related response of the flora to potential fire regimes in each MVS, therefore allowing greater confidence in the use of fire as a management tool. Vital attributes are a functional approach to fire response based on groupings of species that share critical life history characteristics. These can provide a means of both understanding and predicting species' response to a particular fire regime, with the specific objective of being able to predict the changes in plant communities subject to recurrent disturbance. The "vital attributes" approach is not only descriptive, but it also has a quantitative element of time. Assessment of the vital attributes of a plant species involves the determination of three key factors (Table 2):

1. The method of persistence after fire,

The vital attributes classification scheme identifies three particular plant persistence mechanisms that we are likely to encounter following a disturbance (Table 2). These are:

- Propagule-based mechanisms, which include four different seed-related strategies that describe different approaches to seed storage, dispersal, and germination response following fire
- Vegetative mechanisms, which include three different resprouting strategies that describe the different combinations of resprouting response of the juveniles and adults
- Dual mechanisms, which include numerous persistence strategies involving combinations of the seeding and resprouting strategies that either represent a unique response strategy or are considered to be representative of either a seeding or vegetative response mechanism

In reality, there is likely to be a continuum of persistence strategies in some species that can be driven by environmental variation as a result of geographic or climate differences. What we are aiming for in this classification system is to identify the predominant, most typical method of regeneration after a fire.

2. The environmental conditions required for re-establishment

This second group of vital attributes describes three strategies by which propagules (or juvenile vegetative resprouts) are able to establish and grow to maturity (Table 2). It describes whether or not a species requires disturbance, its tolerance of competition, and whether or not there is a need for some pre-conditioning of the propagules before establishment. Essentially, there are those species that:

- Can establish and grow at a site, both after disturbance and at other times, irrespective of competition (T), resulting in multi-aged stands
- Can establish and grow at a site immediately after a disturbance but cannot continue to recruit as competition at the site increases (I). This results in single aged populations with age corresponding with time since last fire
- Require a post-fire delay so that some precondition such as seed dispersal or breaking of seed dormancy may occur (R). These are typically multi-aged stands.

3. The longevity of the dormant propagule store, juvenile and mature plant stages.

The final vital attribute group describes the lifespan of the relevant stages within the plant life history. Three particular life history stages are important here:

- the time that it takes for a species to reach reproductive maturity and begin adding sufficient propagules to the population to be self sustaining
- the lifespan of the reproductive individuals within the population
- the time for all plants and propagules to be depleted so that there is local extinction of that species.

Table 2: Vital attributes categories from Noble & Slatyer (1980)

Regenerative Strategy/Method of Persistence (RS)	
VA Code	**Seedling establishment**
D	Seed dispersed long distances
S	Seed stored, maintains viability for long period, partial germination per disturbance
G	Seed stored, maintains viability for long period, single germination per disturbance
C	Seed short-lived, exhausted after single germination
	Vegetative mechanisms
V	sprouters: all ages survive, all become juvenile
U	sprouters: mature remain mature, juveniles remain juvenile
W	sprouters: mature remain mature, juveniles die
Act like	**Dual mechanisms**
d (δ)	DU or DW: dispersed seed + mature remain mature + juvenile may or may not resprout
s (σ)	SU or SW: Seed store + mature remain mature + juvenile may or may not resprout
g (γ)	GW: Seed store with one germination + mature remain mature + juveniles die
D	SD GD CD VD
S	VS VG
V	VC
U	UC VW
W	WC
Conditions for Establishment (TIR)	
T	tolerant, will establish in presence of adult competition (multi-aged population)
I	intolerant, needs disturbed site with competition removed (single aged population)
R	requires some precondition to be met before establishment, delayed establishment
Relative longevity (m, l, e)	
m	the time taken for a species to reach reproductive maturity (sexual or vegetative)
l#	the longevity of the species reproductive population within the community
E	the time taken to reach local extinction (no reproductive material remains)
Life History#	
A	Annual
B	Biennial
P	Perennial

* note that local extinction is dependent on the seed store as well as the death of mature individuals
# Life History information can be a useful attribute in the absence of species longevity data

To determine the fire regime of a particular species we consider its responses for all three of these factors. Because each factor has a range of potential outcomes there are a number of possible combinations that will lead to a different functional response. Plant functional types (PFT) based on vital attributes are very useful tools for prediction and generalization in ecosystem management, although interpretations need to be tempered by the fact that PFTs may not accurately predict responses of all species across all environments (Keith, et al., 2007).

3.1.6. Assess the fire regime for selection of Key Fire Response Species

Thresholds of Potential Concern are defined as 'the limits of tolerance to a particular fire regime' (Kenny, et al., 2004).

Of particular importance are two TPC relating to **fire interval** component of the fire regime:

- **TPC1** is the lower threshold for fire interval (in years) for a particular vegetation type. That is, vegetation within this MVS will be represented predominantly by early successional species if the inter-fire interval is less than the time specified, and those species that require longer to flower and set seed can disappear from a community.
- **TPC2** is the upper threshold for fire interval (in years) for a particular MVS. That is, populations of some species (eg. obligate seeders) are likely to reduce within this vegetation type if fire is absent for more than the time specified.

If either threshold is breached, plant species of sensitive functional types are likely to significantly decline. In particular, fire intervals between the upper and the lower threshold (Table 2) are predicted to maintain the species complement, whereas intervals shorter than the lower threshold or longer than the upper threshold are predicted to lead to the decline of the KFRS (Kenny, et al., 2004).

Once the vital attributes were established for each of the species in the list (where available) they were used to identify the KFRS. The thresholds of potential concern are first calculated around the interval component of the fire regime. Aspects of intensity, season and extent are then considered in regards to their likely impact on the KFRS.

For fire interval, the use of Vital Attributes for the identification of these species is set out below.

Frequent fires:

Attributes of species most vulnerable to frequent fire:

- G and C; because regeneration is by seed and all seed in the pool is used after a single fire.

Attributes of species potentially vulnerable to frequent fire:

- S, W and γ; because abundance levels or reproductive material will be reduced after a single fire.

Attributes of species least vulnerable to frequent fire:

- D, V, U, δ and σ; because these species should be able to re-establish after 2 or 3 fires in quick succession without loss of abundance.

The species with the longest juvenile period (i.e. time to adequate seed set or reproduction) will be the Key Fire Response species.

Infrequent fires:

Attributes of species most vulnerable to infrequent fire:

- I and R; because only one age class is present so the species may die out without periodic disturbance such as fire.

Attributes of species least vulnerable to infrequent fire:

- T; because this is a multi-aged population resulting from periodic regeneration in the absence of fire.

The species with the shortest extinction period (i.e. time to when regeneration from seed or reproduction is no longer possible) will be the Key Fire Response Species.

Following on from this, there are certain functional groups (of Noble and Slatyer 1980) that are more vulnerable to disturbance. These are summarised in Table 3.

Table 3: Vulnerability to disturbance

Group	Functional type	Disturbance regime resulting in local extinction	Vulnerability to disturbance:	
			Frequent	Infrequent
1	DT ST VT	none	3	3
2	GT CT	frequent (interval < m)	1	3
3	DI	none	2	2
4	SI	infrequent (interval > l+e)	2	1
5	GI	either (m > interval > l+e)	1	1
6	CI	either (m > interval > l)	1	1
7	VI	infrequent (interval > l)	2	1
8	DR SR	none	2	3
9	GR CR VR	first disturbance	1	3
10a	δT σT γT UT WT	none	3	3
10b	δR σR γR UR WR	none	2	3
11	δI	none	2	3
12	σI	infrequent (interval > l+e)	2	1
13	γI	either (m > interval > l+e)	1	1
14	UI WI	infrequent (interval > l)	2	1

1 = most vulnerable (disturbance regime will result in local decline or extinction), 2 = partly vulnerable (persistent disturbance regime likely to lead to local decline or extinction) 3 = least vulnerable (disturbance regime unlikely to lead to local decline or extinction). Critical events are the time to reach reproductive maturity, m, the longevity of the species population, l, and the longevity of its propagule pool, e.

It should be noted that these thresholds are a guide only, and that repeated burning at the upper or lower threshold is not recommended. We advocate that variation in the burn interval between TPC1 & TPC2 is used to promote better biodiversity outcomes for a range of species with different vital attributes across repeated fires.

More than 2 fires in an MVS within a period of x years, as per the EFMG table 4, can severely impact on some species and habitats (significantly more than one or two fires) and are to be avoided, if possible. This will be indicated with "Y' in the EFMG table if this applies to the MVS and an "N" if this does not apply.

3.1.7. Intensity

This 'Key Fire Response Species' approach is also used to determine the window (min. & max.) of fire intensity and season appropriate to a vegetation type (i.e. either low or very high intensity fire, fire in a particular season). For some MVS there is a need to avoid more than 2 successive fires of low intensity, as this may result in the decline of some species. A moderate to high intensity fire at least every 3rd fire event (in the same area) may be desirable in these communities. This will be indicated with "Y' in the EFMG table if this applies to the MVS and an "N" if this does not apply.

For some MVS there is a need for medium to high intensity fire to regenerate some species. Consideration needs to be given to ensuring that communities with these species are burnt with moderate to high intensity fire at least once in the regeneration cycle. This will be indicated with "Y' in the table if this applies within the MVS and an "N" if this does not apply. Changes in intensity can also have an impact on the expression of the vital attributes for different species. For example, the adults of a species with a σ vital attribute exposed to increasing burn severity may lose their ability to persist through the disturbance (changing from σ – S) and with more extreme disturbances the seed pool may also be destroyed (changing from S – 0).

3.1.8. Season

Many plants and fauna are more vulnerable to fire impacts during particular seasons (spring, summer, autumn, winter) or climatic cycles (periods of 'drought' and 'wet years' in arid and semi-arid areas). This is indicated in the tables with 'season' for example referring to 'spring' or 'during & following drought' or 'same season'. Fires during these periods indicated in table 4 should be minimised. This can include avoidance of fires in the same season across a number of years.

3.1.9. Extent

For biodiversity conservation, the chief concern is the amount of the landscape that is subject to adverse fire regimes (i.e. outside the acceptable fire interval window). Landscape ecology and its application to fire in particular, suggests that the effects of extreme inter-fire intervals (too short or long) on a community will be related to the area affected (e.g. effects could be considered to be less critical if the area affected is relatively small). Decline or extinction of species due to extreme intervals in patches within vegetation may be offset, through recolonisation from other neighbouring patches, subject to more favourable fire intervals. A basic conservative approach is, if more than 50 % of any particular vegetation formation is subject to intervals beyond the appropriate fire regime 'window', then the decline or possible losses of species from the entire landscape may be expected. "Patchy" fires are not automatically beneficial to biodiversity. A range of variation of fire extent is desirable.

Spatially, a minimum of 40% (unless otherwise stated) of the area of a MVS in a landscape (or planning area in the case of a fire management plan) should be between TPC1 and TPC2.

Populations of some species (particularly some fauna) are likely to reduce within this vegetation type if "long unburnt" habitat is not maintained. A proportion of the landscape should therefore be maintained unburnt in each MVS at intervals greater than the upper threshold for fire interval (in years) for the likely oldest seral stage. We have stipulated that 30% of each MVS remains longer unburnt in excess of TPC2.

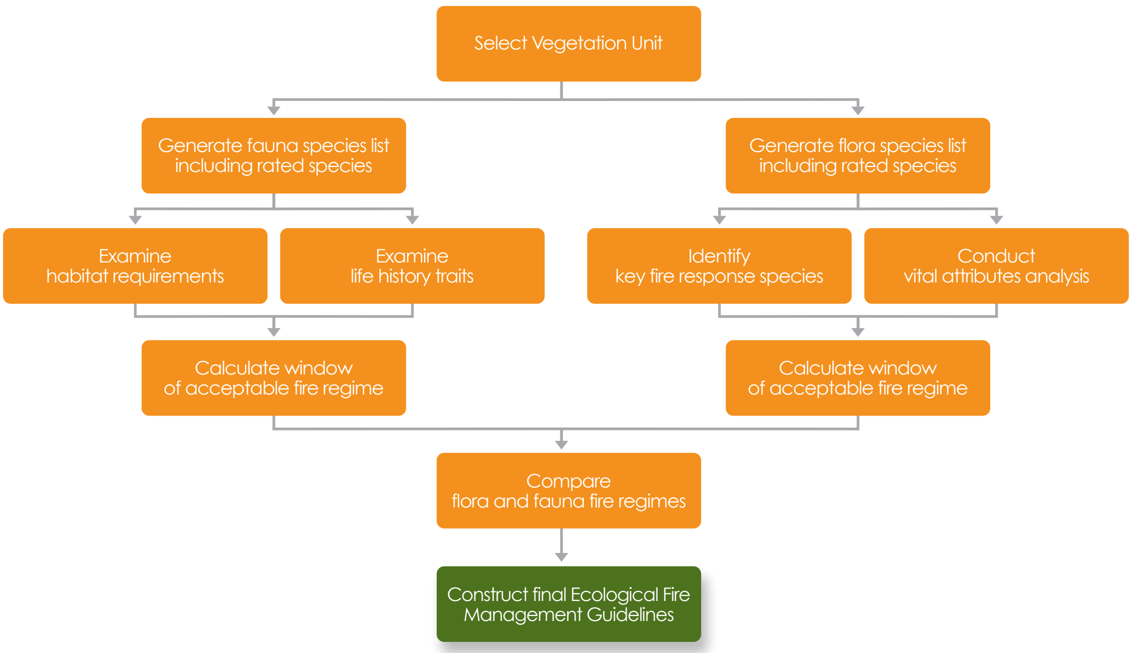
The derived plant-based fire regime thresholds should then be assessed for the potential impacts of known faunal requirements, particularly the requirements of species of conservation significance (Figure 6). No classification of faunal response to fire has yet been developed. Friend (1993), Keith et al. (2002) and Whelan et al. (2002) have identified important life history/ecological elements to determine this for vertebrates and Friend & Williams (1996) for invertebrates. Shelter, food sources and mobility appear as consistent elements in these studies.

This assessment does not occur within the current guidelines but should be undertaken on a regional or 'site by site' basis based on the compiled fauna species list for the area.

These EFMG will be used to guide the fire management practices and assess the impact of any proposed fire regime on the KFRS and TPC to ensure that adequate habitat is available to maintain and enhance biodiversity (i.e. species, populations and communities).

The steps taken in the development of the Ecological Fire Management Guidelines are described in Figure 6.

Figure 6: Approach for determining the ecological fire management guidelines



4. Interpreting ecological fire management guidelines

This version of the EFMG has been developed from an analysis of available data relating to the response of plant species to fire. Ecological Fire Management Guidelines define a window of "acceptable" fire regime which aims to enhance the conservation of existing species. They have been defined for vegetation type, enabling fire managers to strategically plan and manage fire within native vegetation in a way that will ensure the maintenance and enhancement of biodiversity (Table 4) Guidelines for five aspects of fire regime (interval, frequency, spatial, intensity and season) have been determined for all fire-prone MVS within the agricultural zone in SA (where data are available). The upper and lower TPC for a particular MVS have been proposed, as well as recommendations on the management of fire frequency. Fire intensity requirements for species regeneration and undesirable seasonal burning patterns have also been identified (Table 4). A more thorough description of the fire-related information pertaining to each MVS will be included in a subsequent appendix. Here the guidelines for each MVS will be listed individually and include a list of typical vegetation communities, a distribution map, and a list of flora and fauna species of conservation significance under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* or the *SA National Parks and Wildlife (NPW) Act 1972*. An example of the information included in the appendix for each MVS is shown at the end of this document.

Table 4: Ecological Fire Management Guidelines for each fire-prone MVS in South Australia

		ECOLOGICAL FIRE REGIME							
		Interval		Spatial Criteria		Frequency	Intensity		Season
MVS No	MVS NAME	TPC1: Lower threshold in years	TPC2: Upper threshold in years	Inter-fire intervals within TPC1 & TPC2 across more than X% of the extent of this MVS within the planning area	Percentage of the MVS to stay > TPC2	Avoid more than 2 fires within a period of X years	Avoid more than 2 successive fires of low intensity (Yes/No)	Some medium to high intensity fire needed to regenerate some species (Yes/No)	Avoid more than 1 successive fires in season
4	Eucalyptus forests with a shrubby understorey	20	50	40	30	40	Y	Y	Spring or during & following drought
5	Eucalyptus forests with a grassy understorey	5	50	40	30	30	N	N	Spring or during & following drought
8	Eucalyptus woodlands with a shrubby understorey	20	50	40	30	40	Y	Y	Spring or during & following drought
9	Eucalyptus woodlands with a grassy understorey	5	50	40	30	30	Y	Y	Spring or during & following drought
12	Callitris forests and woodlands	15	60	40	30	70	Y	Y	During & following drought
15	Melaleuca open forests and woodlands	15	60	40	30	70	N	N	During & following drought
19	Eucalyptus low open woodlands with tussock grass	5	50	40	30	60	Y	Y	Spring or during & following drought
26	Casuarina and Allocasuarina forests and woodlands	20	50	40	30	60	N	N	During & following drought
27	Mallee with hummock grass	20	50	40	30	60	Y	Y	During & following drought
28	Low closed forest or tall closed shrublands (including Acacia, Melaleuca and Banksia)	15	40	40	30	50	Y	Y	Same season
29	Mallee heath and shrublands	20	40	40	30	40	Y	Y	Spring or during & following drought
30	Heath	15	40	40	30	50	Y	Y	Same season
33	Arid and semi-arid hummock grasslands	10	50	40	30	60	Y	Y	During & following drought
36	Temperate tussock grasslands	3	10	40	30	20	N	N	Autumn
37	Other tussock grasslands	3	15	40	30	20	N	N	Autumn
47	Eucalyptus open woodlands with a shrubby understorey	20	50	40	30	60	N	N	During & following drought
48	Eucalyptus open woodlands with a grassy understorey	10	40	40	30	40	Y	Y	Spring or during & following drought
49	Melaleuca shrublands and open shrublands	20	60	40	30	70	N	N	Spring
55	Mallee with an open shrubby understorey	20	40	40	30	40	Y	Y	Spring or during & following drought
61	Mallee with a tussock grass understorey	10	40	40	30	50	N	N	During & following drought

5. Implementation of ecological fire management guidelines

As discussed previously, the implementation of these Ecological Fire Management Guidelines in native vegetation in South Australia will be achieved through Fire Management Plans following designation of C-zones in fire management zoning. The fire management aims for these areas is to manage appropriate fire regimes to meet the reserve management objectives and provide for the conservation of species, populations, habitats, wilderness areas or cultural heritage values. The C-zone is the default zone for all natural areas within the reserves. Natural or cultural heritage features, which require special fire regimes, will also be identified as C-zones.

Fuel hazard management is not the primary focus for the C-zone. Prescribed burning can occur provided the fire regimes applied are consistent with those in the appropriate Ecological Fire Management Guideline unless otherwise specified in the Fire Management Plan.

5.1. Management objectives for Conservation Zones

The conservation objectives for C-zones are:

- to assist in the conservation of species, populations, habitats or cultural heritage values through the application of appropriate fire regimes
- to manage fire to meet the reserve management objectives

Standard reserve management objectives include:

- to manage fires to meet the ecological fire requirements of species and communities that may be at risk from inappropriate fire regimes
- to minimise the risk of any block or multiple blocks burning in a single high intensity bushfire
- to provide refuge areas for fauna during a large bushfire, either within a block or in adjacent blocks
- to minimise the negative impacts of fire management and suppression activities on conservation values.

Individual Fire Management Plans may also identify other reserve-specific management objectives.

5.2. Strategies for achieving objectives in C-zones

Fire management for areas within the C-zone should aim to meet fire interval, season, intensity and extent estimates in the EFMG for that MVS.

In particular:

- areas in the C-zone should not be burnt at intervals less than the minimum threshold estimates for that vegetation type stated in the appropriate EFMG
- the area of each vegetation type outside of the TPCs (particularly below the Minimum Tolerable Fire Interval) should not exceed the TPC set out in the EFMG in the plan area.

Prescribed burning for Ecological Management within C-zones must:

- plan to maintain the appropriate EFMG for the vegetation type(s) which occur within the burn area
- have explicit ecological and burn objectives
- have specific monitoring established to:
    - assess that burn objectives are achieved
    - assess that ecological aims are achieved
- collect additional vital attribute data to contribute to refining ecological fire regime estimates.

Prescribed burning for landscape protection or broad-area fuel reduction can occur within C-zones, but should attempt to maintain the fire regime limits as listed in the appropriate EFMG. There may be situations where a proposed burn is outside the fire regime limits but is considered necessary to provide positive environmental benefits to adjoining areas that outweigh the risks of burning outside the EFMG. In this case, it is necessary to complete an Ecological Burn Rationale form (DENR, 2011a; section 3.6) that is used to assess the overall objectives and ecological merits of the burn.

5.3. Fauna

A key issue is the need for an approach to developing fire management guidelines to include critical elements of habitat for fauna as well as flora. Currently there are no widely accepted approaches to managing fire and fauna (e.g. a 'vital attributes' scheme for fauna). Some of the ecological and life-history attributes have been identified (Friend, 1993; Keith, et al., 2002; Whelan, et al., 2002) that are important in determining the response of vertebrates to fire, including shelter type, foraging patterns (activity substrate), mobility and breadth of diet. These life history attributes are key characteristics which affect fauna survival and population sustainability and are being included as primary variables in a DEWNR Fauna Fire Response Database[1].

DEWNR is proposing to use the fauna response curve approach of Kavanaugh et al. (2004) as a model for the management of fire in relation to fauna. This approach is to be used to extend the EFMG to better accommodate the fire regime needs of fauna and identify fauna species sensitive to changes in fire regime. Fauna KFRS can then be added to the flora species already identified in these guidelines and used as indicators for ecological fire management. This approach has recently been undertaken by DSE in Victoria following classification of fauna responses during a workshop that combined current knowledge and expert opinion (MacHunter, et al., 2009). It is anticipated that a similar workshop will be used to focus fauna responses from a South Australian perspective.

Until this approach is fully developed and operational, the approach to developing fire regime thresholds using flora, and then testing these against the known needs of significant fauna, particularly threatened species, as illustrated in Figure 6 should be used. Fire management plans will continue to set fire management guidelines for C-zones based on the best available fauna information and expert opinion. Within the planning process specific ecological fire management strategies are currently developed for key threatened species within the planning area.

5.4. Regional and Local Guidelines

These EFMG have been prepared for use across South Australia, particularly where more detailed local guidelines do not exist. Local EFMG should be prepared for fire-prone areas where local data indicates that the guidelines will differ from the State-wide version. DEWNR undertakes this process as part of the preparation of each of its fire management plans. These plan-specific EFMG may differ slightly from the State-wide guidelines as they are based on a narrower set of species which occur in the Plan area.

1. DEWNR Fire Management are establishing a Fauna Fire Response Dataset, similar to that currently maintained for Plant Fire Response and used to develop Ecological Fire Management Guidelines.

6. Adaptive management and ongoing review of the guidelines

Fire management is a complex discipline, involving economic, social and environmental elements in decision-making. Decisions must be made in the face of considerable uncertainty, and often in a short planning cycle. Fire managers can respond to this uncertainty by using risk-based strategies that aim to minimize chances of undesirable outcomes or maximize expected benefits for assessed levels of acceptable risk. Active adaptive management places an explicit value on learning about the effectiveness of management by monitoring its outcomes. The purpose of adaptive management is to acknowledge, deal with and sometimes resolve uncertainty (Holling 1978; Walters 1986)

An Adaptive Management Strategy is being developed by DEWNR for its Fire Management program. This Strategy will address many of the uncertainties around the EFMG through directing priorities, setting of goals/hypotheses, experimental design, monitoring, evaluation, reporting, auditing and continuous improvement processes.

Implementation will commence in the Adelaide Mount Lofty Ranges region, where a significant part of the prescribed burning program is occurring. Implementation of the Adaptive Management Strategy will be extended to the rest of the state based on risk to significant values and available resources.

The Adaptive Management Strategy will include:

- a breaking down of goals into a series of explicit steps (targets), and the assigning of a due date (milestone)for each;
- definition of sensitive, quantifiable, easy-to-interpret, outcome-based performance indicators, to ensure that projects are on track and that targets and goals are being achieved;
- determination/validation of threshold (trigger) values for each indicator of management response should be implemented;
- revision of strategies and re-evaluation of management actions, using new information, especially from monitoring.

For any adaptive management to be effective, the Strategy needs to inform future management plans and actions of the findings from monitoring and of new knowledge gained (both positive and negative).

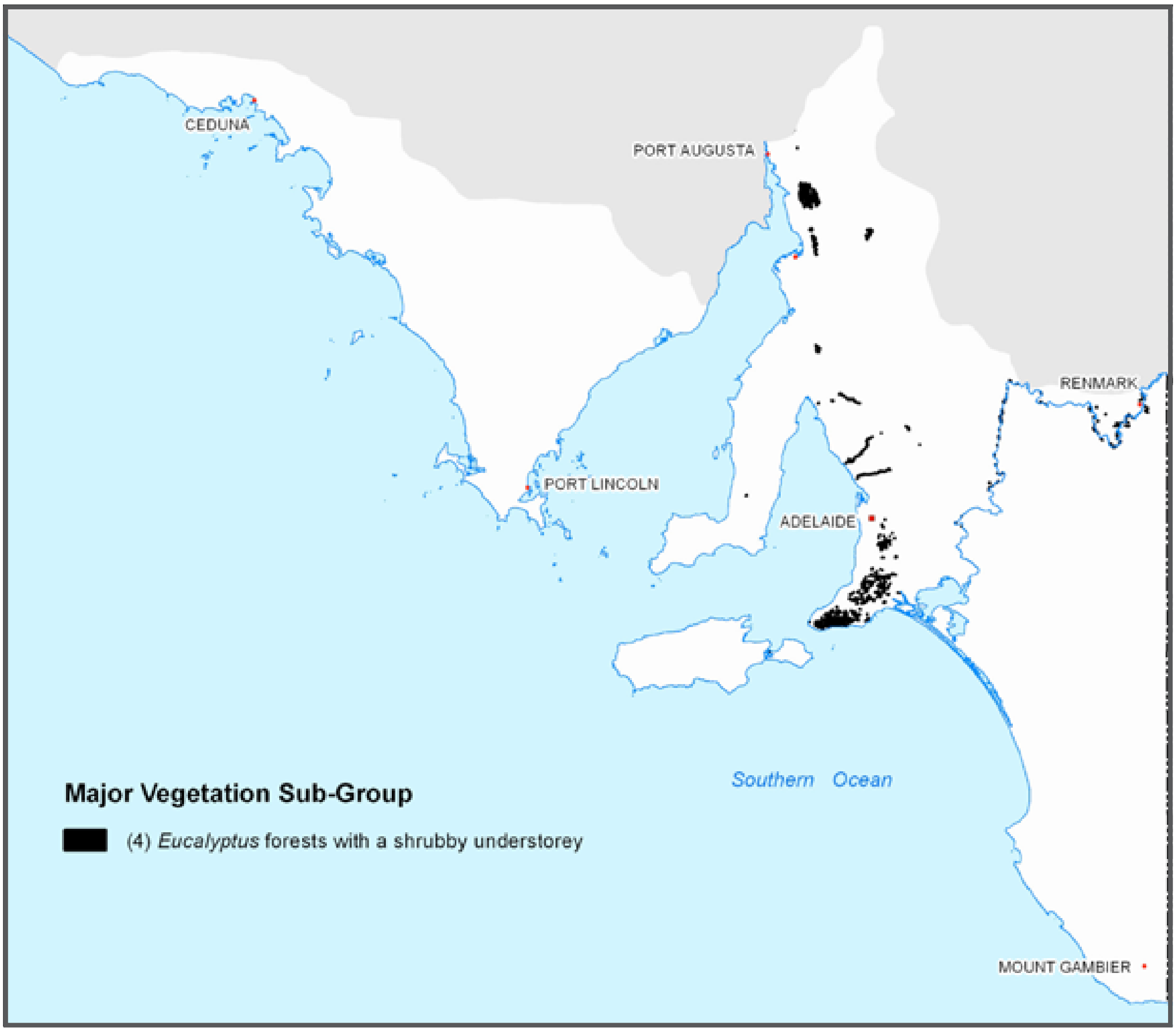
7. Example of fire management guidelines for each major vegetation subgroup

7.1. MVS4 Eucalyptus forests with a shrubby understorey

7.1.1. Description

- These Forests are widely distributed along the foothills and ranges of the Mount Lofty Ranges and the riparian areas of the Mid-North and Southern Flinders areas of South Australia.
- Typical communities include:
  - *Eucalyptus cladocalyx* forest over shrubs
  - *Eucalyptus cosmophylla* (mixed) forest over tall shrubs and low shrubs
  - *Eucalyptus obliqua* forest over tall shrubs and mid ferns
  - *Eucalyptus baxteri* forest over tall shrubs and low shrubs
  - *Eucalyptus camaldulensis* var. forest over shrubs and forbs

Map 2: Distribution of Major Vegetation sub-group 4 – *Eucalyptus* forests with a shrubby understory



7.1.2. Fire Management

Fire regime of high frequency and very high severity fires, flammable for most of the year (possibly not winter), rapid recovery post-fire, much regeneration fire-cued.

Fuel hazard will reach extreme in areas of dense heath understorey and in communities with an overstorey of stringybark eucalypts.

7.1.3. Significant Flora Species

Scientific Name	Common Name	EPBC Act	NPWSA Act
Allocasuarina robusta	Mount Compass Oak-bush	EN	E
Caladenia gladiolata	Bayonet Spider-orchid	EN	E
Caladenia rigida	Stiff White Spider-orchid	EN	E
Caladenia woolcockiorum	Woolcock's Spider-orchid	VU	E
Caleana major	Large Duck-orchid		V
Calochilus paludosus	Red Beard-orchid		V
Correa eburnea			V
Dipodium pardalinum	Leopard Hyacinth-orchid		V
Eryngium ovinum	Blue Devil		V
Eucalyptus paludicola	Mount Compass Swamp Gum	EN	E
Glycine latrobeana	Clover Glycine	VU	V
Lagenophora gracilis	Slender Bottle-daisy		V
Olearia pannosa ssp. pannosa	Silver Daisy-bush	VU	V
Prasophyllum pallidum	Pale Leek-orchid	VU	R
Pterostylis bryophila	Hindmarsh Greenhood	CR	E
Schizaea bifida	Forked Comb-fern		V
Spyridium coactilifolium	Butterfly Spyridium	VU	V
Utricularia lateriflora	Small Bladderwort		V

7.1.4. Significant Fauna Species

Scientific Name	Common Name	EPBC Act	NPWSA Act
Antechinus flavipes	Yellow-footed Antechinus		V
Aprasia pseudopulchella	Flinders Worm-lizard	VU	
Calamanthus pyrrhopygius parkeri	Chestnut-rumped Heathwren	EN	E
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo		V
Ceyx azureus	Azure Kingfisher		E
Cinclosoma punctatum anachoreta	Spotted Quail-thrush (Mount Lofty Ranges ssp)	CR	E
Cinclosoma punctatum punctatum	Spotted Quail-thrush		E
Egernia cunninghami	Cunningham's Skink		E
Eulamprus heatwolei	Yellow-bellied Water Skink		V
Haliaeetus leucogaster	White-bellied Sea-Eagle		E
Hylacola pyrrhopygia parkeri	Chestnut-rumped Heathwren (ML Ranges ssp)		E
Isoodon obesulus obesulus	Southern Brown Bandicoot	EN	V
Manorina flavigula melanotis	Yellow-throated Miner		E
Melithreptus gularis gularis	Black-chinned Honeyeater		V
Notechis scutatus ater	Eastern Tiger Snake	VU	
Petrogale xanthopus xanthopus	Yellow-footed Rock-wallaby	VU	V
Polytelis anthopeplus monarchoides	Regent Parrot	VU	V
Stagonopleura guttata	Diamond Firetail		V
Stipiturus malachurus intermedius	Southern Emu-wren (Mt Lofty Ranges ssp)	EN	E
Strepera versicolor plumbea	Grey Currawong		E
Thinornis rubricollis	Hooded Plover		V
Varanus rosenbergi	Heath Goanna		V

7.1.5. Key Fire Response Species

Callitris gracilis

Eucalyptus camaldulensis var. camaldulensis

Allocasuarina pusilla

Allocasuarina striata

Banksia ornata

7.1.6. Guidelines

Fire Interval	**TPC1:** Lower threshold 20 years
	TPC2: Upper threshold 50 years
Spatial Criteria	Inter-fire intervals within TPC1 & TPC2 across more than 40% of the extent of this MVS
	30% of MVS > TPC2
Fire Frequency	Avoid more than 2 fires within a period of 40 years.
Fire Intensity	Avoid more than 2 successive fires of low intensity
	Some medium to high intensity fire needed to regenerate some species
Season	Avoid more than 2 successive fires in Spring or following drought

8. References

Andersen, AN, Cook, GD and Williams, RJ (2003) Synthesis: fire ecology and adaptive conservation management. In: *Fire in Tropical Savannas: the Kapalga Experiment* pp. 153-164. Springer, New York.

Armstrong, R (2003) *Fire Planning – Integration of Multiple Land Use Objectives*. Australasian Fire Authorities Council Conference 2003, Perth, 2003.

Avis, L (1993) *Fire Management Plan for Coastal Heathlands in Far East Gippsland*. Department of Conservation and Natural Resources, Orbost, Victoria.

Bickerton, DC and Davies, RJP (1999) *A report on the Olearia microdisca regeneration trial at Kingscote Airport, 19/10/99*. Unpublished report to the Threatened Plant Action Group, Adelaide.

Bradstock, R, Keith, D and Auld, T (1995) *Fire and Conservation: imperatives and constraints on managing fire for diversity. In: Conserving Biodiversity: Threats and Solutions* (eds R Bradstock, T Auld, D Keith, R Kingsford, D Lunney and D Siversten) pp. 323-333. Surrey Beatty & Sons, Sydney.

Bradstock, R and O'Connell, M (1988) Demography of woody plants in relation to fire: *Banskia serrata* L.f. and *Petrophile pulchella* (Shrad.) R.Br. *Australian Journal of Ecology* **13**, 508-518.

Bradstock, R, Williams, J and Gill, A (2002) *Flammable Australia: The Fire Regimes and Biodiversity of a Continent*. Cambridge University Press, United Kingdom.

Bradstock, RA, Bedward, M, Gill, AM and Cohn, JS (2005) *Which mosaic? A landscape ecological approach for evaluating interactions between fire regimes, habitat and animals*. Wildlife Research **32**, 409-423.

Brockett, B, Biggs, H and van Wilgen, B (2001) *A patch mosaic burning system for conservation in southern African savannas*. International Journal of Wildland Fire **10**, 169-183.

Burrows, N and Armstrong, R (2003) *Managing bushfire in a biodiversity hotspot*. 3rd International Wildland Fire Conference and Exhibition, Incorporating 10th Annual Australasian Fire Authorities Council Conference: Urban and Rural Communities Living in Fire Prone Environments: Managing the Future of Global Problems: Conference Proceedings: 3-6 October 2003, Sydney Convention and Exhibition Centre, Sydney, 2003.

Burrows, N and van Didden, G (1991) *Patch-burning desert nature reserves in Western Australia using aircraft*. International Journal of Wildland Fire **1**, 49-55.

Cheal, D (2010) *Growth stages and tolerable fire intervals for Victoria's native vegetation data sets. Fire and Adaptive Management Report No. 84*. Department of Sustainability and Environment, East Melbourne, Victoria, Australia.

Churchill, S (2001a) *Recovery Plan for the Sandhill Dunnart (Sminthopsis psammophila)*. Government of South Australia.

Churchill, S (2001b) *The Ecology of the Sandhill Dunnart, Sminthopsis psammophila*. Government of South Australia.

Clarke, MF, Avitabile, SC, Brown, L, Callister, KE, Haslem, A, Holland, GJ, Kelly, LT, Kenny, SA, Nimmo, DG, Spence-Bailey, LM, Taylor, RS, Watson, SJ and Bennett, AF (2010) *Ageing mallee eucalypt vegetation after fire: insights for successional trajectories in semi-arid mallee ecosystems*. Australian Journal of Botany **58**, 363-372.

COAG (1992) *Intergovernmental Agreement on the Environment*. Council of Australian Governments Canberra.

Davies, RJP (1996) *Threatened plant species on roadsides: Kangaroo Island, South Australia*. Unpublished report to the Department of Environment and Natural Resources, South Australia.

DEH (2007) *No Species Loss: a Nature Conservation Strategy for South Australia (2007-2017)*. Department for Environment and Heritage, Government of South Australia, Adelaide.

DENR (2011a) *Fire Policy and Procedure Manual*. Department of Environment and Natural Resources, Government of South Australia, Adelaide.

DENR (2011b) *Overall Fuel Hazard Guide for South Australia, Second Edition*. Department of Environment and Natural Resources, Goverment of South Australia.

DEST (1996) *National Strategy for the Conservation of Australia's Biological Diversity*. Department of the Environment, Sport and Territories. Online: <http://www.environment.gov.au/biodiversity/publications/strategy/index.html> Accessed: 21 January 2009.

EPFTWG (2008) *The Eastern Plains Fire Trial, Kangaroo Island, South Australia. Project proposal submitted to the Native Vegetation Council, 16th of June 2008*. Eastern Plains Fire Trial Working Group.

ESCAVI (2003) *Australian Vegetation Attribute Manual: National Vegetation Information System, Version 6.0*. Department of the Environment and Heritage, Canberra.

FEWG (2004) *Guidelines and Procedures for Ecological Burning on Public Land in Victoria*. Fire Ecology Working Group, Department for Natural Resources and Environment & Parks Victoria, Government of Victoria, Melbourne.

FFMG (2008) *National Fire Management Policy Statement for Forests and Rangelands (Draft 2008)*.

Friend, GR (1993) *Impact on small vertebrates in mallee woodlands and heathlands of temperate Australia: a review*. Biological Conservation **65**, 99-114.

Gill, A (1975) *Fire and the Australian biota: a review*. Australian Forestry **38**, 4-25.

Gill, A (2005) *Fire interval distributions and the management of Australian landscapes*. Proceedings of a workshop held 26 September 2003, Albany WA.

Gill, A, Bradstock, R and Williams, J (2002) Fire regimes and biodiversity: legacy and vision. In: *Flammable Australia: The Fire Regimes and Biodiversity of a Continent* (eds R Bradstock, J Williams and A Gill) pp. 429-446. Cambridge University Press, United Kingdom.

Gill, A and Nichols, A (1989) *Monitoring fire-prone flora in reserves for nature conservation*. Perth.

Gill, AM and Bradstock, RA (2003) Fire regimes and biodiversity: a set of postulates. In: *Australia Burning: Fire Ecology, Policy and Management Issues* (eds G Cary, D Lindenmayer and S Dovers) pp. 15-25. CSIRO Publishing, Melbourne.

Hopkins, A and Saunders, D (1987) Ecological studies as the basis for management. In: *Nature Conservation: the Role of Remnants in Native Vegetation* (eds D Saunders, G Arnold, A Burbidge and A Hopkins) pp. 15-28. Surrey Beatty, Sydney.

Holling, C.S. editor. 1978. *Adaptive Environment Assessment and Management.* John Wiley and Sons. London.

Jusaitis, M (1993) *Conservation studies on four endangered plants from Kangaroo Island, South Australia*. Black Hill Flora Centre, Botanic Gardens of Adelaide, South Australia.

Kavanagh, R, Loyn, R, Smith, G, Taylor, R and Catling, P (2004) Which species should be monitored to indicate ecological sustainability in Australian forest management? In: *Conservation of Australia's forest fauna.* (ed D Lunney) pp. 959-987. Royal Zoological Society of New South Wales, Mosman.

Keith, D (1996) Fire-driven mechanisms of extinction in vascular plants: a review of empirical and theoretical evidence in Australian vegetation. *Proceedings of the Linnaean Society of New South Wales* **116**, 37-78.

Keith, D and Bradstock, R (1994) Fire and composition in Australian heathlands: a conceptual model and field investigations. *Journal of Vegetation Science* **5**, 347-354.

Keith, D, Williams, J and Woinarski, C (2002) *Fire Management and biodiversity conservation: key approaches and principles. In: Flammable Australia: the fire regimes and biodiversity of a continent* (eds R Bradstock, J Williams and A Gill) pp. 401-429. Cambridge University Press, Cambridge.

Keith, DA, Holman, L, Rodoreda, S, Lemmon, J and Bedward, M (2007) Plant functional types can predict decade-scale changes in fire-prone vegetation. *Journal of Ecology* **95**, 1324-1337.

Kenny, B, Sutherland, E, Tasker, E and Bradstock, R (2004) *Guidelines for Ecologically Sustainable Fire Management - NSW Biodiversity Strategy*. NSW National Parks and Wildlife Service, NSW Government, Hurstville.

Lunt, I and Morgan, J (2002) The role of fire regimes in temperate lowland grasslands of south-east Australia In: *Flammable Australia: the fire regimes and biodiversity of a continent.* (eds R Bradstock, J Williams and A Gill) pp. 177-198. Cambridge University Press, Cambridge.

MacHunter, J, Menkhorst, PW and Loyn, R (2009) *Towards a process for integrating vertebrate fauna into fire management planning. Arther Rylah Institute for Environmental Research Report Series No. 192*. Department of Sustainability and Environment, Heidelberg, Victoria.

Noble, I and Slatyer, R (1980) The use of vital attributes to predict successional changes in plant communities subject to recurrent disturbances. *Vegetation* **43**, 2-21.

Noble, I and Slatyer, R (1981) Concepts and models of succession in vascular plant communities subject to recurrent fire. In: Fire and the Australian Biota (eds A Gill, R Groves and I Noble) pp. 311-335. Australian Academy of Science, Canberra.

Parr and Brockett (1999) Patch-mosaic burning: a new paradigm for savannah fire management in protected areas? . Koedoe 42(2), 117-130.

Possingham, H and Gepp, B (1994) *Assessment of Fire Regime Options for the Southern Brown Bandicoot Isoodon obesulus in South Australia using Population Viability Analysis*. Fire and Biodiversity: The Effects and Effectiveness of Fire Management, Footscray, Melbourne.

Sattler, P and Creighton, C (2002) *Australian Terrestrial Biodiversity Assessment 2002*. Australian Government. Online: <http://www.anra.gov.au/topics/vegetation/pubs/biodiversity/bio_assess_contents.html> Accessed: 22 January 2009.

Tolhurst, K and Friend, G (2001) *An Objective Basis for Ecological Fire Management - A Victorian Case Study*. In: Proceedings of Bushfire 2001, Joint Bushfire/FRFANZ Conference, Christchurch, New Zealand.

Tolhurst, K and Friend, G (2005) *Variability in fire interval: how important is it and how do we manage for it?* Proceedings of a workshop held 26 September 2003, Albany WA.

Turner, PJ and Virtue, JG (2009) Ten year post-fire response of a native ecosystem in the presence of high or low densities of the invasive weed, *Asparagus asparagoides. Plant Protection Quarterly* **24**, 20-26.

vanWilgen, B, Biggs, H and Potgieter, A (1998) Fire management and research in the Kruger National Park [South Africa], with suggestions on the detection of thresholds of potential concern. *Koedoe* **41**, 69-87.

Walters, C.J. 1986. *Adaptive Management of Renewable Resources*. McGraw-Hill, New York.

Watson, P (2001) *The role and use of fire for biodiversity conservation in Southeast Queensland: Fire management guidelines derived from ecological research*. SEQ Fire and Biodiversity Consortium,

Whelan, R and Muston, R (1991) *Fire regimes and management in south-eastern Australia.* High Intensity Fire in Wildlands: Management Challenges and Options. Proceedings of the Tall Timbers Fire Ecology Conference,

Whelan, R, Rodgerson, R, Dickman, C and Sutherland, E (2002) Critical life cycles of plants and animals: developing a process-based understanding of population changes in fire-prone landscapes. In: *Flammable Australia: The Fire Regimes and Biodiversity of a Continent* (eds R Bradstock, J Williams and A Gill) pp. 94-124. Cambridge University Press, United Kingdom.

Whelan, RJ (1995) *The Ecology of Fire*. Cambridge University Press, Cambridge.

Wilson, BA (1993) *Management and conservation of habitat for the New Holland Mouse in Victoria*. National Estates Grant Program Final Report (Project No. 838) Unpublished.

Wouters, M (1993) *Developing fire management planning in Victoria: a case study from the Grampians*. Department of Conservation and Environment Victoria, Melbourne.

9. Glossary of terms used

Community attribute	attribute of a vegetation community or habitat (e.g. constituent species, structure, constituent physical element) that is integral to that community and is sensitive to one or more element of fire regime.
Fauna life history attributes	attribute of a fauna species or it's habitat (e.g. individual or species behaviour, physical characteristic or habitat structure habitat element) that is integral to that species and is sensitive to one or more element of fire regime.
Fire management	For these guidelines, 'fire management' gives a description of the key fire occurrence and fire management issues relating to the major vegetation sub group (MVS).
Fire regime	The history of fire in a particular vegetation type or area including the frequency, intensity and season of burning. It may also include the spatial arrangement of fire in a given area.
Fire regime element	One of the individual elements which go to make up a fire regime for an area – fire frequency, inter-fire intervals, season of burning, fire intensity (or severity) and the spatial arrangement of fires (mosaic & patchiness)
Flora vital attributes	Attribute of a flora species or its habitat (e.g. individual or species behaviour, physical characteristic or habitat structure habitat element) that is integral to that species and is sensitive to one or more element of fire regime. The Noble and Slatyer Vital Attribute scheme (Noble and Slatyer, 1980; Noble and Slatyer, 1981) is a specific classification of flora vital attribute that is used to model and predict the response of species to disturbances.
Floristics	The study of the number, distribution, and relationships of plant species in one or more areas.
Functional group	A group of species that share similar life history and fire response characteristics
Key Fire Response Species	Those species whose life histories or vital attributes indicate that they are vulnerable to either a particular fire regime. Key fire response species listed for each MVS are those species to use for assessment and monitoring.
Landscape protection burn	A Landscape Protection Burn plans to reduce the likelihood of a whole Park/ Reserve or large contiguous block of vegetation burning in a single large fire event by reducing fuel hazard at strategic locations in the landscape
Major vegetation Subgroup (MVS)	Major Vegetation Subgroups are the Level III-IV classification of the National Vegetation inventory System (NVIS), and were for regional scale analysis and mapping of vegetation (ESCAVI, 2003). The commonly used SA Veg grouping of vegetation types is Levels V & VI of NVIS.
Seral stage	The series of stages in the development of a plant community on a particular site over a period of time.
Significant fauna species	List of significant fauna species and their ratings (national and State)
Significant flora species	List of significant flora species and their ratings (national and State)
Threshold of Potential Concern (TPC)	Point along an indicator scale after which irreversible impact leading to change in ecosystem status occurs.

For further information please contact:

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Phone Information Line (08) 8204 1910, or see SA White Pages for your local Department of Environment, Water and Natural Resources office.
Online information available at: www.environment.sa.gov.au/firemanagement/Home

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