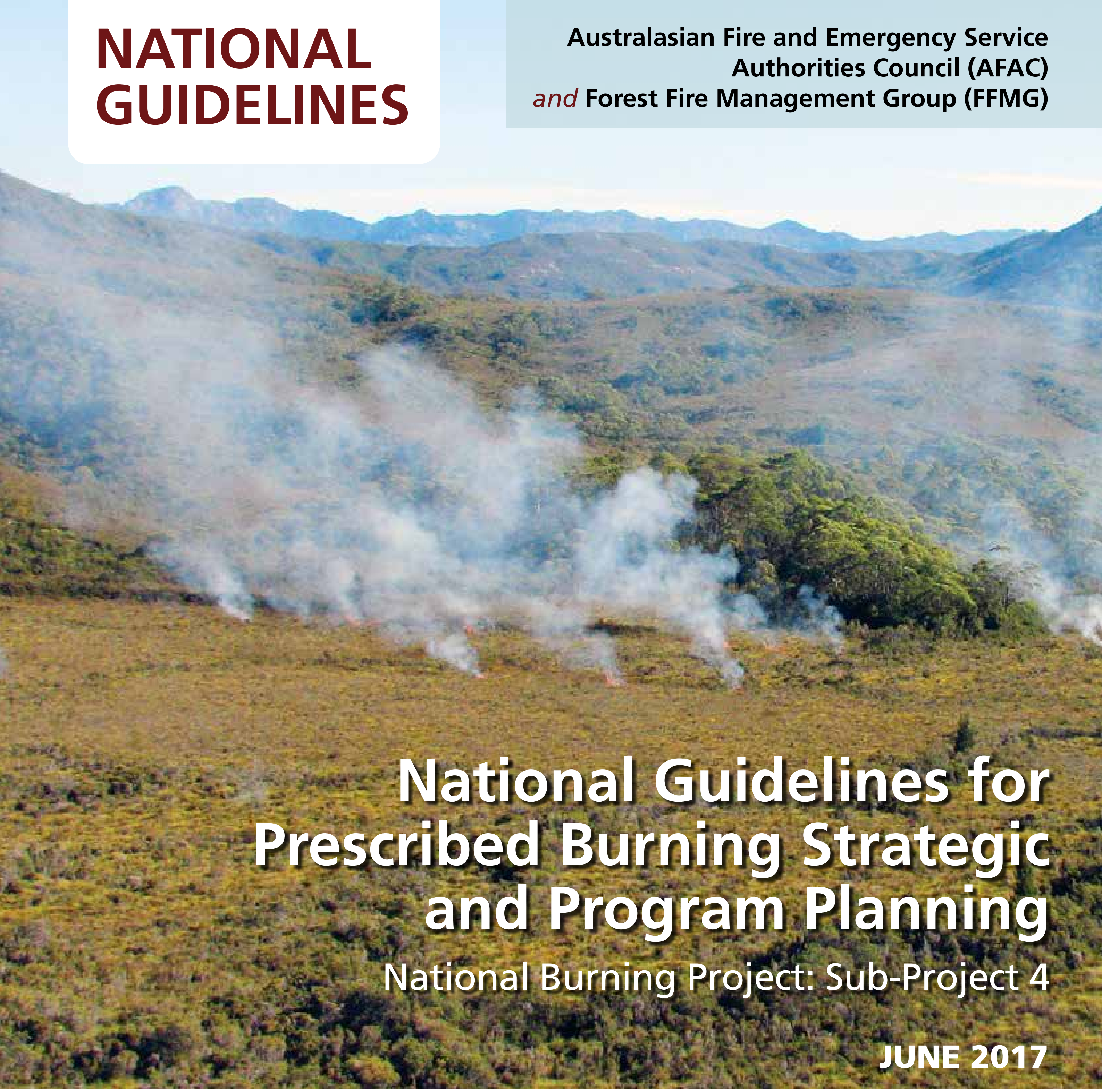
NATIONAL BURNING PROJECT

NATIONAL GUIDELINES

Australasian Fire and Emergency Service Authorities Council (AFAC) *and* Forest Fire Management Group (FFMG)



National Guidelines for Prescribed Burning Strategic and Program Planning

National Burning Project: Sub-Project 4

JUNE 2017

afac

An Australian Government Initiative

FFMG

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ISBN: 978-0-9942589-2-2
Design: Fullpoint Media, +61 3 9376 5370, http://www.fullpointmedia.com.au
Avenue Press, 249 Wickham Rd, Moorabbin VIC, 3189.
Printer: Valiant Press, PO Box 3871, Nunawading VIC, 3131
To be cited as: AFAC (2017) National Guidelines for Prescribed Burning Strategic and Program Planning – National Burning Project sub-project 4. Australasian Fire and Emergency Service Authorities Council Limited (Melbourne: Victoria)

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1. INTRODUCTION

Preparation of these *National Guidelines for Prescribed Burning Strategic and Program Planning* has been undertaken as a component of the National Burning Project (NBP). The guidelines aim to establish a national best-practice framework which can be used as a guide in designing and improving approaches and systems for the strategic and program level planning of prescribed burning. These guidelines complement the *National Guidelines for Prescribed Burning Operations* (AFAC, 2016a). Due to the great variety of operating environments and institutional arrangements around Australia, these guidelines are at a best practice principles level, establishing a logical and consistent planning analysis and implementation framework.

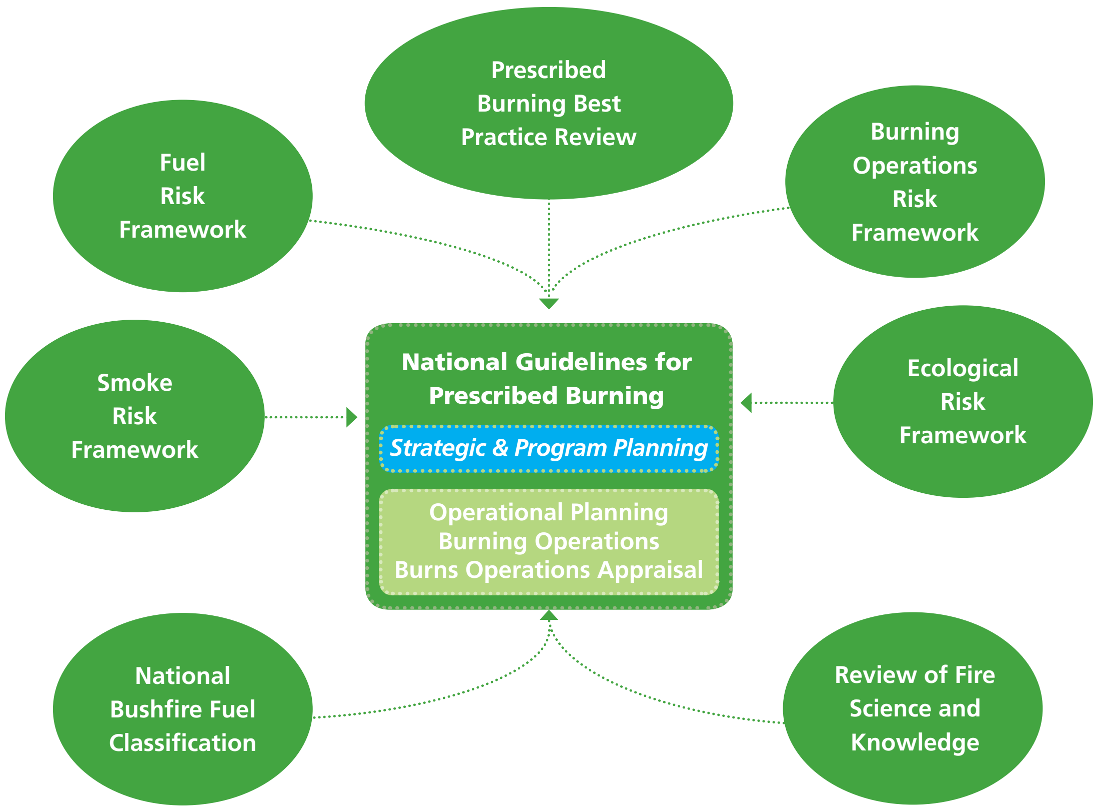
1.1 National Burning Project

The NBP is a multi-year project consisting of a range of related sub-projects (Figure 1) with the overarching objective to:

Use a national approach to reduce the bushfire risk to the Australian and New Zealand communities by the comprehensive management of prescribed burning at a landscape level that balances operational, ecological and community health risks.

The NBP was jointly commissioned by the Australasian Fire and Emergency Service Authorities Council (AFAC) and Forest Fire Management Group (FFMG).

Figure 1 *National Burning Project – National Guidelines and related projects, with this publication shown in blue and other publications in green*



1. INTRODUCTION

This current project is to develop *National Guidelines for Prescribed Burning Strategic and Program Planning* covering:

- Strategic planning; and
- Program planning.

This project covers these strategic and program phases of planning up to the commencement of the Operational Planning Phase and Burn Implementation Phase (already described in the *National Guidelines for Prescribed Burning Operations* AFAC 2016a).

The document draws on the following NBP foundation reports:

- *National Position for Prescribed Burning* (AFAC 2016d);
- *A Risk Framework for Operational Risks Associated with Prescribed Burning* (AFAC 2016c);
- *A Risk Framework for Ecological Risks Associated with Prescribed Burning* (AFAC 2016b);
- *Risk Management and Review Framework for Prescribed Burning Risks Associated with Fuel Hazards* (AFAC 2015c);
- *Risk Management for Smoke Hazard and Greenhouse Gas Emissions* (AFAC 2015b);
- *Overview of Prescribed Burning in Australasia* (AFAC 2015a); and
- *Review of Best Practice for Prescribed Burning* (AFAC 2014).

1.2 Project objectives

The objectives of this project are to develop national guidelines for prescribed burning, founded on the National Burning Project work already undertaken. These guidelines will provide overarching principles and high-level guidance for land management agencies and fire authorities in all jurisdictions of Australia relating to strategic and program planning process.

1.3 National Guidelines overview

In commissioning the development of these guidelines AFAC and FFMG member agencies were acutely aware of the very wide range of operating environments and operational risk profiles occurring around Australia.

This very wide-ranging variability means that national guidelines cannot be of a prescriptive, detailed nature, with specifics of how steps in the burn planning and implementation process are conducted. Rather, guidelines which establish a logical, consistent and robust planning and works implementation process and principles are required that can accommodate this wide-ranging variability in operating conditions.

These guidelines identify a planning process, structured around a suite of good practice principles, for prescribed burn strategic planning and burn program development. Although the principles tend to follow a logical sequential order, agencies could well undertake steps in a different sequence according to their own needs. The sequence of the principles is not in any order of importance.

- **Section 2** of these guidelines outlines the strategic and program planning operating context including an outline of the national and state/territory policy basis for prescribed burning. Noting that each state and territory has its own unique suite of legislative and public policy drivers and constraints for prescribed burning, a high-level overview of the general nature of drivers and constraints is provided.
- **Section 3** considers the purposes and objectives of prescribed burning, addressing objectives such as bushfire mitigation, community safety, ecological, cultural and other land management objectives.
- **Section 4** of these guidelines outlines the prescribed burning process and presents high-level principles of prescribed burning for the strategic planning and program planning phases, as well as a supporting process model.
- **Appendix 1** examines the effectiveness of prescribed burning as a bushfire mitigation tool. Material useful for strategic planners is included, such as how long the effects of prescribed burning lasts in various environments.
- **Appendix 2** considers ways in which ecological management of prescribed burning can be conceptualised.
- **Appendix 3** includes a selection of innovative concepts, tools and ideas that have been utilised by agencies in various parts of Australia, to enhance strategic and program planning decision making.

1.4 National Guidelines development process

The process of developing these guidelines has been structured into stages involving information gathering and concept development, examining case studies, and a number of review stages, as set out below:

1. Inception

- Confirmation of the project methodology, project activity schedule and timelines, agency contacts and communication protocols for gathering participating agency doctrine.

2. Survey

- GHD, in consultation with AFAC, designed an AFAC/FFMG member survey to capture system design level information about how jurisdictions and their fire and land management agencies presently go about strategic planning and program planning relating to prescribed burning.

3. Forum

- GHD, in consultation with AFAC, designed a one-day forum involving AFAC/FFMG member agencies to identify and discuss key factors, processes and constraints involved in designing and implementing approaches for strategic planning and program planning relating to prescribed burning.

4. Concept Development

- GHD prepared a concept model and document framework for national principles and guidelines for the strategic and program planning phases of prescribed burning, for consultation with AFAC/FFMG members, for the purpose of guiding draft report development. GHD undertook consultation with AFAC/FFMG members on the concept model and document framework.

5. Review

- Founded on the survey inputs, national forum and follow-up consultations with AFAC/FFMG member agencies, GHD prepared draft principles and guidelines for the strategic and program planning phases of prescribed burning. These were provided to AFAC's project manager for coordination of AFAC/FFMG members review process and provision of consolidated comments and feedback on the draft guidelines.

6. Final reporting

- The final report was prepared following due consideration of the consolidated feedback and comments received from AFAC's NBP steering committee.

(Source: Department of Environment, Water and Natural Resources South Australia)

2. PRESCRIBED BURNING PLANNING CONTEXT

As a foundation for developing national guidelines for prescribed burning, it is appropriate to first identify the key concepts of what prescribed burning is and the national and state and territory policy settings.

2.1 Background

Deliberate, purposeful burning has a history spanning more than 40,000 years in Australia. For Aboriginal people throughout Australia, the use of fire was central to their way of life and to meet their spiritual and cultural obligations to care for country. The use of fire was their principal means of shaping and managing local environments to sustain a diversity of food sources which were abundant, predictable (in time and space) to locate, and convenient to access and acquire through the year and despite inter-annual climate variability (Gammage, 2011)[1]. Their use of fire also provided safe areas for living, facilitated navigation and ease of travel, was a means of communication, facilitated tracking of animal movement/location and hunting methods, as well as provided light and heat for a range of purposes. These traditional burning practices only continue in certain areas where traditional practices have been retained, and where traditions involving burning remain a part of contemporary lifestyles of Traditional Owners. In other areas, knowledge of traditional practices has been retained in stories, and active efforts are being made to restore this traditional knowledge across a number of communities.

There is widespread acknowledgement that continuous and frequent use of fire in the landscape by Aboriginal people shaped the biodiversity of Australia as it existed prior to the arrival of Europeans. In southern Australia, traditional Aboriginal burning practices have been replaced by very different burning practices – different in scale, frequency and timing – instituted by European settlers; practices which have been evolving and changing to the present day.

Burning was first applied by the early settlers that made their living from the land and natural resources. Although some post-1788 settlers learnt from and attempted to adopt aspects of burning practice from Aboriginal people, their use of fire was often for different purposes and means such as land clearing and broad-acre pasture promotion for domestic stock. Despite these differences, there was universal recognition by both the post-1788 settlers and Aboriginal people of the value of using fire for risk mitigation, including burning around bush-camps and settlements to reduce the risk of being burnt-out by bushfires[2]. Prescribed burning for community and asset protection has been used by Australian public land management agencies since the 1970s, with early development of systematic approaches and techniques founded in the 1960s.

[1] *There is a significant body of literature examining the issue of traditional Aboriginal burning practices, including studies conducted at regional and sub-regional scales. Among the more comprehensive works on the subject is 'The Greatest Estate on Earth – How Aborigines made Australia' (2011) by historian Bill Gammage (Adjunct Professor at the Australian National University) which brings together a wide array of evidence on the subject of how, where and why Aboriginal people modified and maintained Australian landscapes with fire.*

[2] *In response to major high-consequence fire events which occurred in the late 19th and early 20th century, government policies aimed at fire exclusion were attempted but failed. Following the catastrophic 1939 Black Friday fires in Victoria, the Stretton Royal Commission recommended a strategic program of burning selected areas of forest in a controlled way during spring and autumn. Following the Black Friday bushfires, planned burning became an official fire management practice in Victoria.*

2. PRESCRIBED BURNING PLANNING CONTEXT

2.2 Prescribed burning definition and purpose

AFAC's Bushfire Glossary (AFAC, 2012) defines prescribed burning as:

'The controlled application of fire under specified environmental conditions to a predetermined area and at the time, intensity, and rate of spread required to attain planned resource management objectives. It is undertaken in specified environmental conditions.'

Prescribed burning is also referred to as *planned burning; hazard reduction burning; controlled burning; prescription fire; fuel reduction burning; planned fire and prescription burning.*

The physical operating environment and context in which prescribed burning is applied is important as a range of key factors significantly affect the way in which public and private land managers can plan and implement prescribed burning. These physical environment contextual factors are described in the *National Guidelines for Prescribed Burning Operations* (AFAC 2016a).

2.3 National policy basis for prescribed burning

Prescribed burning is used in a coordinated way by land managers and fire services around Australia, and its use is a core element of the FFMG (COAG endorsed) *National Bushfire Management Policy Statement for Forests and Rangelands* (FFMG, 2014) which states:

'Reducing the occurrence, severity and impact of bushfires, and enhancing the resilience of our natural ecosystems by managing fire in our forest and rangelands, are core objectives of this statement.'

The statement establishes four strategic objectives, the first of which is:

'Effectively Managing the Land with Fire:
Fire is used to manage Australia's forests and rangelands to achieve outcomes that involve reduced risk from severe bushfires, and enhance the resilience of ecosystems in the face of climate and other change.'

With regard to using fire for land and risk management, the policy statement commits to future development of a framework that supports effective strategic decision making in relation to managing potential conflicts between competing values and objectives at the expense of longer-term and landscape level outcomes. Importantly it notes:

'In the meantime, land and fire managers will not let the lack of a comprehensive framework for planned fire, or short-term and local risks involved in using fire, unduly constrain the use of planned fire to manage the risk of severe fire impacts.'

2. PRESCRIBED BURNING PLANNING CONTEXT

Consistent with the *National Bushfire Management Policy Statement*, AFAC and FFMG have released a *National Position on Prescribed Burning* (the National Position). AFAC and FFMG member agencies take the position that:

'Prescribed burning is an essential part of bushfire mitigation across the Australian landscape to reduce risk to communities and to maintain ecological health.'

The National Position defines 10 principles for prescribed burning covering each of the following points:

1. **Protection of life is the highest consideration;**
2. **Landscape health is linked to fire and fire management;**
3. **Prescribed burning is a risk management tool;**
4. **Engagement with community and business stakeholders;**
5. **Prescribed burning is done in the context of measurable outcomes;**
6. **Informed knowledge of fire in the landscape;**
7. **Capability development;**
8. **Traditional Owner use of fire in the landscape is acknowledged;**
9. **An integrated approach is required across land tenures; and**
10. **Prescribed burning is carried out under legislative, policy and planning requirements.**

(Source: Department of Environment, Land, Water and Planning, Victoria)

2.4 State or territory policy basis for prescribed burning

Consistent with the national policy direction outlined in Section 2.3, all Australian jurisdictions plan and implement prescribed burning programs, of varying scope, for the reduction of bushfire risks, the enhancement of ecosystem resilience, and to meet other land management objectives. The burning programs conducted in the different jurisdictions are conducted mostly for a similar range of objectives. However, the emphasis given to particular types of burning and the scale of programs, and degree of resourcing applied to implementation of prescribed burning, varies significantly from one jurisdiction to another with the most distinct differences being between northern and southern Australia.

The operating environments vary substantially between and within jurisdictions; therefore the context for prescribed burning programs will differ to suit. This means that differences in emphasis between jurisdictions in the scale and regime of prescribed burning application are to be expected. However, not all of the difference can be explained by operating environment differences alone – the particular history of major bushfire events, the timing and nature of public inquiries that followed, and other institutional and political factors have also influenced the approach and emphasis given to prescribed burning in each jurisdiction.

The mandate for prescribed burning programs in some jurisdictions may come directly from legislation, however in others, legislation simply enables prescribed burning, and mandates arise at the policy level. The legislative framework in each jurisdiction also places various process requirements and constraints on prescribed burn planning and implementation. In general terms, legislation applying to prescribed burning can be considered in two categories:

- Legislation that mandates or enables prescribed burning (refer to 2.4.1); and
- Legislation which establishes constraints for prescribed burning (refer to 2.4.2).

2.4.1 Legislation that mandates or enables prescribed burning

In broad terms mandate-establishing or enabling legislation relevant to prescribed burning establishes some management requirement that either directly mandates that prescribed burning be used, or enables it to be used for pursuing a broader requirement such as for the responsible management of bushfire risk, or for the sustainable management of natural resources. Each state and territory has its own unique legislation pertaining to these matters. Two examples of state and territory legislation that mandate or enable the use of prescribed burning in a bushfire risk management context are:

Northern Territory: *Bushfires Management Act 2016* – Sect 68 (Northern Territory, 2016)

The *Bushfires Management Act 2016* mandates a requirement to establish firebreaks (and makes it an offence not to establish firebreaks) on land within a fire protection zone, and specifically identifies that 'burning' (among other methods) can be used to create firebreaks.

New South Wales: *Rural Fires Act 1997* – Sect 63 (New South Wales, 1997)

The *Rural Fires Act 1997* establishes a general duty for public authorities, and owners and occupiers of land to prevent bushfires, and to minimise the danger of the spread of bushfires on or from their land. Thus, the use of prescribed burning to achieve this duty is enabled. Further, the Act establishes a duty (mandate) for land owners and occupiers and public authorities to undertake 'notified steps' for preventing fires and minimising their spread, and these 'notified steps' include implementing any steps that are included in a bushfire risk management plan applying to the land. The Act directs that bushfire risk management plans must be prepared for all areas where a Bush Fire Management Committee is constituted (which is all rural fire districts and any fire districts (urban) which have a reasonable risk of bushfire) and these plans typically specify requirements to conduct prescribed burning through promulgation of a fire management zoning system. Hence, implementation of prescribed burns, planned in accordance with a bushfire risk management plan, are mandated.

Another form of mandate-establishing or enabling legislation comes in the form of requirements for the management of land and natural resources. Typical examples include legislation applying to public land managed for conservation and/or forestry. Other forms of crown land may also have such requirements. Two examples of legislation that mandate or enable the use of prescribed burning in a land management context are:

Victoria: *National Parks Act 1975* – Section 4 (Victoria, 1975)

The National Parks Act 1975 sets out the objects of the Act. Essentially, for a range of distinct tenure classifications (including National Parks) the Act establishes a general duty that among other things, management of the land areas covered by the Act make provision for:

- '*the preservation and protection of the natural environment including wilderness areas and remote and natural areas in parks';*
- *'the protection and preservation of indigenous flora and fauna'; and*
- *'the responsible management of the land'.*

and in designated water supply catchment areas in National Parks, additionally:

- *'for the maintenance of the water quality and otherwise for the protection of the water resources in those areas'.*

While the objects of the Act do not explicitly mandate any specific fire management activities, in the Victorian landscape context fire management, including the use of prescribed burning, is recognised as an essential component of responsible land, natural environment, flora and fauna and water catchment management. Thus, the Act can be interpreted as enabling prescribed burning consistent with achieving its objects.

Western Australia: *Forest Products Act 2000* – Sect 12 (Western Australia, 2000)

The *Forest Products Act 2000* requires that the principles of ecologically sustainable forest management are applied in the management of indigenous forest products located on public land. The principles of ecologically sustainable forest management specified in the Act include (among others):

- '*that the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making';*
- *'that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations'; and*
- *'that if there are threats of serious or irreversible environmental damage, the lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation'.*

While the principles stated in the Act do not explicitly mandate any specific fire management activities, in the WA forest context, fire management including the use of prescribed burning, is recognised as an essential activity for managing the 'conservation of biological diversity and ecological integrity', and to 'ensure that the health, diversity and productivity of the environment is maintained'. Thus, the Act can be interpreted as enabling prescribed burning consistent with achieving principles of ecologically sustainable forest management.

2.4.2 Types of legislation which place process requirements and/or constraints on prescribed burning

Whilst prescribed burning is mandated or enabled by a relatively small number of legislative instruments, there is a much broader range of legislation which places constraints on prescribed burning. This is because prescribed burns can be large-scale programs or activities which can impact (positively and negatively) a very wide range of values in the built and natural environment as well as social and economic values. The following types of legislation can place process requirements and/or constraints on prescribed burning:

- Legislation establishing environmental impact assessment requirements – in some jurisdictions prescribed burning may fall within definitions of activities or works that require assessment of environmental impacts (as an example the *Environmental Planning & Assessment Act 1979* in NSW). Some, but not necessarily all forms of prescribed burning may require an environmental impact assessment (EIA), with the process for impact assessment typically being in some prescribed form, and depending on the process requirements and assessment outcomes, the assessment may require an approval or consent. Forms of EIA mandated in some jurisdictions may be sufficiently complex that professional expertise in fire ecology and environmental impact may be required to undertake assessments with due diligence.
- Legislation providing for the protection of native flora and fauna and/or threatened species (as an example, the *Flora and Fauna Guarantee Act 1988* in Victoria, and also the Commonwealth Government's *Environment Protection and Biodiversity Conservation Act* 1999 which applies in all States and Territories and applies to a range of other matters in addition to flora and fauna). Such legislation is typically directed to conserving flora and fauna and managing threatening processes. Some make it an offence to harm or kill certain flora and fauna species (in many cases an unavoidable outcome in prescribed burning), and can have application to threatened species populations or ecological communities. They can also mandate the preparation of threatened species recovery plans that can specify constraints or compliance requirements for prescribed burning.
- Legislation providing for the protection of the physical environment, including air, water, land and soils (as an example, the *Environment Protection Act 1993* in South Australia). Such types of legislation are directed to preventing pollution and environmental harm and in some cases nuisance. Some legislation may be more holistic in nature covering a range of physical environment aspects and pollution types, and others may be more specific to particular aspects such as water, air, or soil erosion. As prescribed burning produces smoke which impacts air quality, can result in physical changes to the environment which affect water runoff after rainfall, and can expose soils to erosion, such legislation can affect prescribed burn planning and implementation activities.
- Legislation providing for cultural heritage protection (as an example, the *Heritage Act 2011* in the Northern Territory) is directed to protecting heritage places, objects and sacred sites. Some may be adversely impacted by fire and therefore require consideration during burn planning and some form of protection or avoidance during prescribed burning.
- Legislation which has requirements for the management of workplace health and safety, and also for broader public safety where fire and/or smoke can pose a significant safety hazard, such as for road and traffic management safety, or air safety.
- Miscellaneous types of legislation that may affect prescribed burning. While the broad types of legislation highlighted above are the main types that can generate process or compliance requirements and/or place constraints on prescribed burning, in each jurisdiction there may be many more pieces of legislation that affect prescribed burn planning. There may be requirements for certain permits, licences or notifications.

2.5 Organisational level policy and operating context

Some, but not all States and Territories express a state-level (whole-of-government) prescribed burning policy incorporating quantitative performance measures, and this may also be the case at agency level. In Victoria, the matter of a state-level prescribed burning policy incorporating performance measures has been given deep consideration and development in recent years.

After a number of reviews into prescribed burning, the Victorians set activity based performance measures of burning 5% of the state. Following the Black Saturday bushfires in Victoria the Victorian Bushfires Royal Commission (VBRC) reinforced this target, recommending that Victoria pursue a policy of:

'Implementing a long-term program of prescribed burning based on an annual rolling target of 5 per cent minimum of public land.'

The Inspector General of Emergency Management conducted a further review in 2015, informed by its experience of adopting and attempting to implement Victoria's hectare target-based bushfire prescribed burning policy approach (IGEM, 2015). As a result, the Victorian Government has adopted a revised prescribed burning policy as part of its *Safer Together* bushfire policy for reducing the risk of bushfire in Victoria that is not based on a hectare burnt target. With respect to prescribed burning, the *Safer Together* policy incorporates adoption of a risk reduction (outcome based) target to guide fuel management on public land, maintaining residual risk at or below 70% of the maximum risk no treatment level. It further entails shifting the policy focus from public land in isolation, to a more cohesive approach where land and fire agencies combine their effort to manage fuel loads on both private and public land, based on where and how risk can be most effectively reduced.

Tasmania also has adopted a whole-of-government level prescribed burning policy incorporating quantitative performance measures (at or below 80% of maximum risk) with a program being implemented on both public and private land. In 2014, an eight-year transition was set to reach the performance target.

Western Australia has maintained a consistent prescribed burning policy (for approximately 50 years) for its greater south-west forest area aimed at burning 200,000 hectares per year (about 8% of the forested public land), with the scope of the policy being limited to public land. Other parts of WA do not have a rolling quantitative performance target, although in the Kimberley a fuel age distribution-based system is used to guide a large regional prescribed burning program involving burning in the order of 2 million hectares annually; although the amount varies from year to year depending on the amount of unplanned fire.

In Queensland, land and fire agencies independently develop their own prescribed burning policies and performance measures but coordinate through an inter-agency meeting process for prioritisation of burns in interface zones. In terms of prescribed burn policy performance measures, the Queensland Parks and Wildlife Service (QPWS) has adopted a state-level annual burning target equating to 5% of the terrestrial QPWS-managed land. However this is not intended to be applied evenly across the different regions – in some areas a level significantly higher than 5% is achieved (such as in the Cape parks), and in others (such as parks in more densely settled parts of SE Queensland) a level significantly less than 5% is routinely planned and achieved.

In other States and Territories, prescribed burn policies do not incorporate explicit performance targets of a rolling, quantitative nature. Instead, it is typically the case that a systematic fire management planning process is in place (often an inter-agency planning process), an output of which is a fire management zoning system, for which standards for fuel hazard levels are specified (or in landscape management zones, measures relevant to specific land management objectives). Some jurisdictions may implement an audit process based on a sample of plans to check performance against the zone standards. The amount of area planned to be treated annually

2. PRESCRIBED BURNING PLANNING CONTEXT

(Source: Northern Territory Fire and Rescue Service)

to achieve the fire management zone specifications can vary from year to year, dependent largely on how many postponed or failed burns need to be carried forward from previous years, and on how much those zones have been affected by unplanned fires.

In practice, state or agency-level prescribed burn policies are more nuanced than can be described in summary here. Further, policy approaches and performance measures are rarely static. At the time of preparing these guidelines many jurisdictions are in the process of developing, reviewing or implementing changes to the performance framework and other aspects of their prescribed burning policy.

Also, policy is often considered to be broader than simply the program course of action and outcome metrics pursued. A broader consideration of policy can include such things as the standards and constraints that are applied to the process of implementing the prescribed burning policy. The more commonly encountered types of instrument include:

- Codes of Practice, applying generally to fire management or specifically to prescribed burning, which may establish prescriptive process requirements for the prescribed burn planning process, or select aspects of it;
- Regulatory compliance frameworks and/or minimum standards documents for various things including environmental impact assessment, smoke management, threatened species management, operating licences or permit conditions which cover prescribed burning (such as for forestry approvals), public notification and information requirements;

- Systems, assessment frameworks and prescriptions for such things as determining appropriate fire regimes, ecological condition assessment, and possibly extending to specification of management prescriptions for threatened species;
- Australian or International Standards which may be specified as process compliance standards (such as *ISO 31000:2009 Risk Management Principles and Guidelines* which is widely applied as a standard for guiding the risk management process; or *ISO 14001:2016 Environmental Management Systems* which some agencies have adopted as a framework for managing their environmental performance, including during prescribed burning);
- Safety management systems such as Hazard and Job Safety Assessment processes and Safe Work Methods;
- Land management plans applying to particular reserves, recreation areas, timber production areas, and other forms of public or private land, which may set out specific requirements for the management of environmental and other values connected with the land covered by the plan. They may prohibit some practices (such as use of earthmoving machinery) and provide procedural restrictions (such as to prevent weed dispersal); and
- Stakeholder engagement frameworks and procedural requirements which may establish standards for how planning teams undertake stakeholder engagement.

Other considerations include a familiarity with prescribed burning standard operating procedures, guidelines for various aspects of prescribed burning and the systems (GIS and database) and software that support prescribed burning decision making within an organisation. Training regimes, the level of staff capability and the capacity of the organisation in relation to planning and implementing prescribed burns also needs to be considered at strategic and program planning phase, so that strategic and program planning are commensurate to the type, quantity and complexity of prescribed burning required.

As is readily apparent from the preceding outline of state legislative and policy frameworks, the amount and breadth of process considerations and compliance requirements is extensive. Planners allocated responsibility to undertake strategic planning for prescribed burning must undertake their task within the bounds of the legislative and policy requirements applicable. For the purpose of these guidelines, the setting of public policy is considered to sit at a level above strategic planning. However, it is prudent that the knowledge and experience gained through implementing strategic planning processes, and delivering the strategic plans, can inform and feed into public policy review. Accordingly, strategic planning teams, whilst bound to comply with legislative and public policy direction, should also be empowered to document issues, constraints and opportunities for improving the planning process outcomes. These insights can subsequently be fed into program evaluation and continuous improvement processes.

3. THE OBJECTIVES OF PRESCRIBED BURNING

While different jurisdictions and agencies may express fire management objectives in subtly different ways, there are four key objective types that prescribed burning strategies address:

- Reducing adverse impacts of bushfires on human life, communities, infrastructure, industries, the economy and the environment; (Section 3.1)
- Maintaining or improving biodiversity and the resilience of natural ecosystems; (Section 3.2)
- To pursue one or more specific land management objectives including but not limited to (Section 3.3):
  - Silviculture and other forestry purposes;
  - Greenhouse gas abatement;
  - Reducing high intensity fire impact risk in designated water catchment areas;
  - Pasture management and/or shrub encroachment mitigation;
  - As part of integrated approaches to weed control; and
- For spiritual, social and cultural purposes on country as part of indigenous burning (Section 3.4).

It is important to note that a single prescribe burn might satisfy several of these objectives. The ideal situation for risk reduction in an ecologically sensitive area is where the fire regime applied to achieve effective fuel reduction also maintains ecological processes and biodiversity (Ellis *et al.*, 2004). The ideal situation is not always possible. Where this is the case, a balance needs to be found between providing acceptable risk-reduction to human life, property and economic assets from unplanned bushfires (or achieving a specific land management objective), and minimising potentially adverse impacts of prescribed fire application on other values held by the community, such as air and water quality, biodiversity and socio-economic values.

3.1 Bushfire risk-reduction strategies pursued through prescribed burning

To achieve bushfire management objectives, there is a range of risk reduction strategies pursued through prescribed burning. In many cases prescribed burning strategies are pursued in concert with other strategies (for example: development planning controls; community awareness and preparedness, reducing asset vulnerability, fire suppression and asset-defence). While risk reduction in the context of places with built structures where people live and work is a primary driver, other important considerations include critical infrastructure such as electricity and water supply, communications networks, road and transport infrastructure among others. The range of prescribed burning strategies selected should be appropriate to the range and degree of risks in a particular location. These prescribed burning strategies can be broadly characterised as follows:

Reducing the potential for bushfires to reach the asset-hazard interface

- Facilitating **improved fire suppression prospects away from the interface** (such as along key strategic roads or trails from which fire containment could be effected) by reducing fire behaviour in those strategic locations, providing for safer and more expeditious fire suppression;
- **To reduce fire behaviour in potentially high-consequence ignition locations** by improving the prospects for successful initial attack before fires reach a size that necessitate larger, indirect methods of containment, requiring many more resources; and
- Slowing the rate at which fires spread and reducing their intensity (and potentially fragmenting fire-

fronts), **thereby reducing the area impacted by high-consequence fire, and reducing the severity of impact**. This can potentially avoid impacts in asset-hazard interface areas by preventing fires from reaching these areas during periods of high-intensity fire spread.

Reducing fire behaviour at the asset-hazard interface

- **To reduce fire behaviour at the asset-hazard interface and where critical infrastructure is located** (particularly reducing bushfire attack mechanisms such as flame contact, radiant heat and ember attack) to improve the prospects of human survival, and property or infrastructure damage-mitigation by both passive and active defensive.

Prescribed burning away from the interface can achieve significant risk reduction benefits, despite the fact that during severe weather conditions fuel reduced areas may not aid fire suppression. The reason such areas can contribute to risk reduction is because they can facilitate fire containment away from the interface before adverse weather conditions eventuate. Fires that are able to be put out before severe weather arrives are prevented from becoming high-consequence fires. Fuel-reduced areas away from the interface can be of significant assistance in this regard. Discussions about the relative merits of fuel-reducing areas immediately adjacent to assets compared with areas further away are sometimes framed in a binary construct; either you invest in close-in defensive strategies or you invest in broad-scale landscape treatments. Such a binary choice construct is not appropriate because fire agencies, in accordance with risk management principles, typically pursue a multi-layered risk reduction approach – not one or the other.

Overlaid with the 'life and property' oriented considerations outlined above are the environmental and ecological imperatives. These are not always mutually incompatible with life and property risk reduction; in fact a high degree of alignment is possible with prudent strategic planning. In particular, burning away from interface areas to slow fire growth and facilitate containment away from the interface can be achieved using ecologically sustainable fire regimes, particularly in dry open grassy forest and woodland communities that have relatively short minimum tolerable fire intervals.

3.2 Maintenance of ecosystem health and resilience strategies pursued through prescribed burning

Fire is a natural component of most Australian terrestrial ecosystems. It plays an important role in maintaining healthy, functioning and resilient ecosystems. A diverse range of ecosystems are supported within Australia– some covering very large geographic ranges and others restricted to small niches. Each ecosystem has adapted to the range of fire regimes experienced at their landscape location over many millennia, noting that those fire regimes were shaped by the particular combination of physical environment features, climate, and fire ignition regimes from both lightning and anthropogenic sources (see Section 2.1). Substantial changes to the physical environment since European settlement, through vegetation clearing and modification, land use change, drastic alteration/cessation of Aboriginal traditional burning practices, increasingly well organised and resourced fire suppression, and new post-European settlement fire-use patterns have all served to alter fire regimes (in many areas substantially) from those regimes to which ecosystems are adapted. This is explored in greater detail in a *Risk Framework for Ecological Risks Associated with Prescribed Burning* (AFAC 2016b).

The nature and degree of fire regime alteration is not precisely known and varies significantly. In some areas a shift has occurred toward large and intense fires. For example, this has occurred across vast areas of tropical savanna where traditional early dry season Aboriginal burning practices have been removed or substantially reduced, and replaced by a regime dominated by very large, higher intensity and impact, late dry season fires. In other areas, a shift has occurred away from regimes with a high proportion of frequent, patchy, low intensity fires, toward regimes with a much higher proportion of less frequent, larger, and high-intensity/high-impact fires. For example, this has occurred in many dry open forest and woodland systems where traditional Aboriginal patch burning practices have been replaced with active fire suppression, and vegetation cover fragmentation and/or modification. The changes in fire regimes in turn can lead to changes in ecosystem structure, composition, health and resilience. For a more detailed overview of these issues see AFAC's *Overview of Prescribed Burning in Australasia* (2015a) – Section 5. Hence in most fire-prone landscapes, land managers are faced with decisions about the degree to which they allow the altered fire regimes to continue, or to which they deliberately set prescribed fires in the landscape in an attempt to restore a fire regime more favourable to maintaining ecosystem health and resilience. Such decisions can be complex and the subject of considerable debate.

With regard to using fire to maintain or improve the resilience of natural ecosystems at a landscape scale, there are three typical scenarios faced by land managers:

1. **Healthy and resilient ecosystems** with high diversity, in which it is necessary to continue applying a suitable variety of appropriate fire regimes for maintenance.

   In such situations the challenge is identifying how the unplanned component of the fire regime is supplemented with prescribed fires. Consideration should be given to where to burn, how often, which seral stages to burn, burn size, mix of season and timings, range of intensities, seasonal climate conditions and weather.

2. A landscape area where a combination of sustained fire suppression and little or negligible prescribed fire leads **to widespread long-unburnt ecosystems** with declining health/condition, structural change and exposure to large, high-impact fire potential.

   In such situations where heavy fuel loads may have accumulated across broad areas, there are two key risks to consider:

   - Sustained fire exclusion continues, potentially with detrimental effects for fire dependent biota, and leading to widespread changes in ecosystem structure and composition.
   - There is widespread risk of a large high-impact fire occurring (should ignition occur and suppression fail) which may also expose habitats occupied by fire-sensitive biota that have edaphic protection from low intensity fires in light fuels, but not from intense fires burning in adverse conditions.

   The significant challenge in this scenario is deciding what landscape pattern of prescribed burning to pursue to best break up the large at-risk area (to achieve the aim of improving ecosystem health and resilience), and how to effectively contain prescribed burns given the broadscale availability of high fuels.

3. A landscape area which is dominated by a large, uncontrollable, **homogenising fire regime** at undesirably frequent intervals (for example, in areas where a combination of arson, careless and accidental ignitions, mostly in dry summer conditions, drives the regime).

   In such situations, decisions may involve introducing yet more fire (planned) into an already adverse fire regime (unplanned) for the purpose of improving suppression/control options, with the aim of restricting the extent of unplanned fires occurring in adverse conditions.

   Other scenarios may arise where particular habitat structures or vegetation growth stages or populations of threatened species are considered vulnerable to an inappropriate fire regime, and therefore a prescribed fire is considered desirable to increase the availability and/or improve the distribution of specific habitat conditions or vegetation assemblage growth stages.

3.3 Burning to achieve specific land management objectives

Prescribed burning can be used to achieve a range of specific land management objectives additional to, or different from, those described in sections 3.1 and 3.2. Such objectives can include:

1. **Silviculture and other forestry purposes.** Prescribed burns can be used to provide favourable seed bed conditions for forest regeneration after timber harvesting by reducing post-harvest debris, and provide an ash-bed favourable for germination of eucalypt seed. Other forestry objectives for burning include reducing fuel loads within timber production areas for the purpose of mitigating unplanned fire damage to timber quality, to prepare harvested plantation sites for replanting, to improve access for harvesting operations, to maintain forest health and for asset protection.
2. **Greenhouse gas abatement.** In tropical savannas, burning projects specifically for greenhouse gas abatement can be established under Commonwealth carbon farming initiative programs. Early dry season burning programs are implemented for the specific purpose of reducing late dry season fire extent. This issues is explored in detail in AFAC's *Risk Management Framework – Smoke Hazards and Greenhouse Gas Emissions* (2015b).
3. Reducing high intensity fire impact risk in **designated water catchment areas**. Some drinking water catchment management organisations undertake prescribed burning programs to reduce the potential for large scale, high-intensity bushfires occurring in catchments they manage, as these can lead to significant catchment degradation and sedimentation of water storages.
4. **Pasture management** and/or shrub encroachment mitigation. Pastoralists undertake burning for a range of reasons including promoting pasture regeneration, inhibiting encroachment by trees and shrubs, providing safe areas for livestock, and to protect their assets from bushfire.
5. Prescribed burning is often used as part of an integrated **weed control program**, coordinated with chemical and/or mechanical treatment of weeds.

3.4 Burning for cultural purposes on country as part of traditional Indigenous burning

Traditional Owners have a range of reasons to undertake burning on their lands and generally as part of their cultural duty to care for country. Such burning does not necessarily need to be done using traditional modes of ignition (for example using the 'firestick'). Traditional Owners often use modern technologies, including aerial ignition techniques, to undertake burning. Traditional Owner burning is discussed in more detail in an *Overview of Prescribed Burning in Australasia* (2015a).

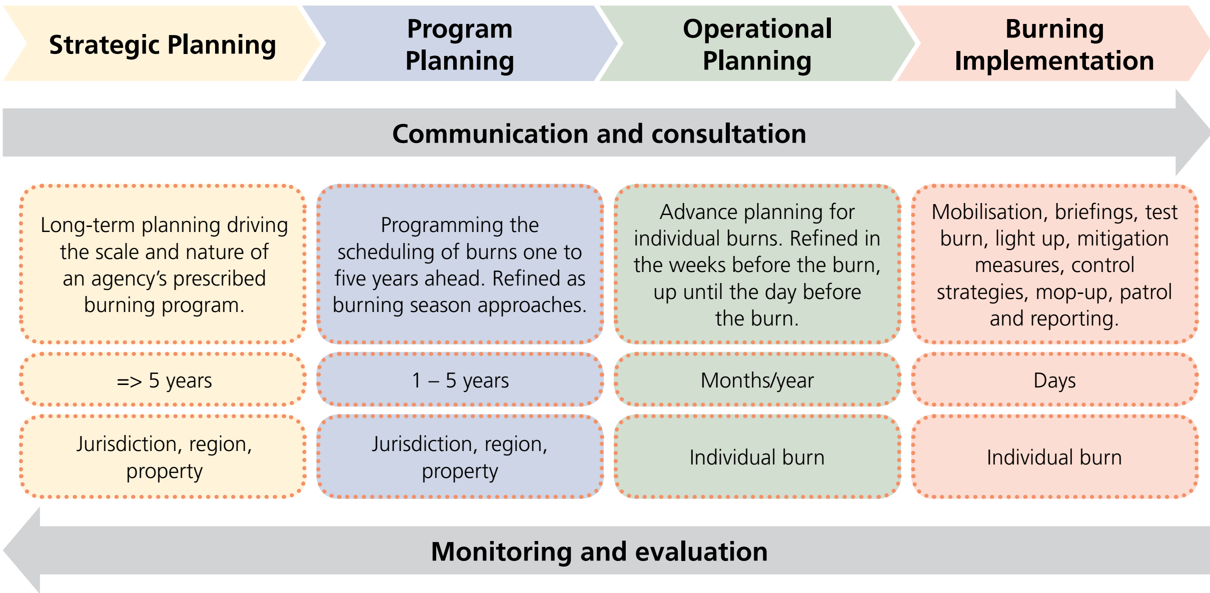
3. THE OBJECTIVES OF PRESCRIBED BURNING

(Source: Office of Bushfire Risk Management, Western Australia)

4. PRINCIPLES FOR THE STRATEGIC AND PROGRAM PLANNING PHASES OF PRESCRIBED BURNING

A general high-level model of the end-to-end process applying to prescribed burning involves four key phases, and two whole-process activities that occur throughout all phases:

Figure 2 *High-level end-to-end process model of prescribed burning*



The planning process and principles in these national guidelines cover the strategic and program planning phases of Figure 2. The strategic planning phase addresses plan scoping as well as prescribed burn strategic planning (as outlined in Section 4.1). The program planning phase covers the development of a program of works directed at implementing the strategic plan (as outlined in Section 4.2).

The strategic planning phase should embed a prescribed burning program in an organisation’s business. The program planning phase provides the framework to organise the delivery of strategic planning outcomes in preparation for the burn operations planning and implementation phases to be undertaken.

Specific principles and guidelines for the operational planning and burning implementation phases are detailed in the *National Guidelines for Prescribed Burning Operations* (AFAC 2016a).

4. PRINCIPLES FOR THE STRATEGIC AND PROGRAM PLANNING PHASES OF PRESCRIBED BURNING

4.1 Outline of strategic planning principles

The strategic planning phase can be segmented into two stages.

The first stage is to consider a range of factors that influence plan scope, commencing with confirming the relevant legislative and policy requirements to be complied with. Decisions made during the **scoping stage** include:

- The geographic area, time period and land tenures covered by the plan and stakeholders necessary to engage during the planning process;
- The planning process to be implemented (ensuring this is commensurate with the planning capability available or to be put in place); and
- Practical program delivery constraints to be considered during the planning process.

These scoping matters are addressed in principles 1 to 4.

The second stage is to implement the selected **planning process**, incorporating a range of key components including:

- Planning and implementing stakeholder engagement activities;
- Conducting risk assessment and evaluation across all risk dimensions;
- Setting of objectives and performance measures;
- Devising the prescribed burning strategy prudent to address the identified risks, including identification of how these prescribed burning strategies work with other bushfire risk reduction strategies; and
- Setting a clear organising framework and strategy specifications for how the strategic plan is to be delivered.

These planning process matters are addressed in principles 5 to 12.

4.2 Outline of program planning principles

The program planning phase involves developing a program of works which needs to consider a range of fire history and landscape condition factors, operational burn program delivery issues and risks, as well as resourcing and timing opportunities and constraints.

A key feature of the program planning phase is that it involves an options and feasibility analysis. Therefore, it is necessary to consider site-specific information to do with the need and priority for burning an area, and the general nature of risks and operational requirements in doing so. Accordingly, program planning is rarely solely a 'desktop' process. It requires detailed condition information at candidate sites (for example, general ecological condition of the sites, fuel hazard levels within and adjacent, the general nature and condition of features that would be used to contain the burns, the degree to which there may be assets at-risk within the burn areas, and some appraisal of potential stakeholder issues). The degree of information required will reflect the need to decide between different options on the basis of priority, feasibility, likely effectiveness of treatment, delivery risk and cost.

Principles 13 to 20 address these program planning process matters.

More finely scaled site information for the purpose of deciding operational delivery method and risk management requirements occurs at the operational planning stage which is addressed in *National Guidelines for Prescribed Burning Operations* (AFAC 2016a).

(Source: Department of Parks and Wildlife, Western Australia)

4.3 Process model and principles for prescribed burn operational planning and implementation

Figure 3 on the following pages provides a high-level process model for the strategic and program planning phases of prescribed burning at a national level. A tabulated version of the principles is also provided in Table 1. Guidelines covering the range of matters typically requiring consideration in addressing each principle are provided in Sections 4.4 and 4.5 (strategic phase, scoping and planning process) and 4.5 (program planning phase).

4. PRINCIPLES FOR THE STRATEGIC AND PROGRAM PLANNING PHASES OF PRESCRIBED BURNING

Figure 3 *Process model: Strategic planning and program planning*

Process model: strategic and program planning phases of prescribed burning

State/Territory Level Policy And Institutional Framework
Legislative/Regulatory obligations; relevant Fire Management Codes of Practice;
Institutional structures and responsibilities

Notes: State-level policy frameworks may provide direction on matters of planning scope, and may prescribe objectives and performance metrics

Strategic plan scoping and planning process

Inputs

- Laws, policies, land/natural resource management plans and bushfire management plans relevant to land and fire management in the planning area;
- Strategic planning guidelines and templates to guide planning teams;
- Available data and information relevant to hazards, at-risk socio-economic and environmental values, fire history, landscape access and containment features for prescribed burn strategy design, and ecosystem condition and the role of fire in maintaining or restoring ecological resilience;
- Traditional owner fire knowledge and collaboration where possible;
- Stakeholder issues, needs and capacity/willingness to collaborate in strategic plan development, promotion and implementation;
- Resources for undertaking the range of planning processes and actions, supported with appropriate training, mentoring and professional development;
- Planning and decision-support tools, and relevant technical guidance.

Strategic plan scoping principles

Principle 1

Strategic planning must comply with relevant laws, policy and agency requirements relevant to prescribed burning – start strategic planning with an up-to-date understanding of relevant legal requirements, policies and objectives.

Key action: Orient team to current policy and organisational requirements

Principle 2

The planning scale (duration and spatial coverage) should reflect regional vegetation growth, fuel accumulation and fire occurrence cycles, and be relevant to how assets and fire prone areas are arranged in a landscape.

Key action: Determine appropriate plan scale and duration

Principle 3

Prescribed burning objectives are not constrained by tenure differences, institutional responsibility demarcations or administrative boundaries – planning scope should address how prescribed burning objectives are to be optimised and managed across different tenures and administrative boundaries, in partnership with all stakeholders.

Key action: Determine land tenures to be covered by the plan and the relevant stakeholders to be engaged in planning

Principle 4

Resourcing capacity, planning systems and capability maturity are key factors influencing the design of a strategic planning methodology – the method selected should be well matched to the available planning capability and area complexity.

Key action: Select an achievable strategic planning model appropriate to the degree of planning area complexity and planning capability

Strategic planning process principles

Principle 5

The needs, concerns and knowledge of relevant stakeholders requires appropriate consideration during planning to maximise plan effectiveness, ownership and support for and commitment to plan implementation.

Key action: Prepare an appropriate stakeholder engagement plan

Principle 6

Strategic plans should contain clear objectives linked to performance indicators and metrics, enabling evaluation of burn strategy delivery and performance.

Key action: Determine strategic plan objectives and performance metrics

Principle 7

Landscape fire risk is highly variable – strategic planning should be based on risk assessment covering community safety, asset and social/economic infrastructure protection, land and natural resource management and the maintenance of ecological resilience.

Key action: Identify hazards and values, assess and evaluate bushfire risks

Principle 8

Prescribed burn strategy options analysis should be based on landscape-level assessment of historical and potential fire paths, considering options for:

- Using ecologically beneficial fire in the landscape to reduce unplanned fire spread, intensity and impact potential, and enhance ecological resilience;
- Maintaining fuel-reduced areas, often adjacent to strategic breaks/trails where unplanned fire suppression is likely to be attempted, enhancing prospects of control before fire can reach vulnerable assets requiring protection; and
- Last line of defence fuel modification options at asset-hazard interfaces to reduce the severity of bushfire attack to people and assets, and enhance the prospects of both passive and active defence during bushfire response.

Key action: Analyse potential fire paths and assess strategic options to enhance fire containment prospects at high risk ignition areas and strategic firebreak

Plan quality assurance and approval: Products of both the strategic and program planning processes should be subject to a suitably rigorous peer review and approval process.

Continuous improvement: Review implementation and performance of previous plans and make adjustments based on lessons learnt and new innovations *locations, and to prevent or reduce fire impacts on at-risk values*

Principle 9

Risk-based fire management zoning or prioritisation systems should clearly specify treatment regimes and specifications for both life and property protection and for maintenance of ecological resilience.

Key action: Articulate a system for applying prescribe burning strategy

Principle 10

Different vegetation types or land management units require different approaches in terms of fire management, and some are not suitable or practical for prescribed burning – strategic plans should articulate management regimes for different vegetation types and/or land management units.

Key action: Identify fire regimes for vegetation types and other areas of land, and any practical constraints for prescribed burning

Principle 11

To optimise the benefits of prescribed burning strategies, other complementary risk reduction actions need to be identified (pursuant to a 'shared responsibility' model), and articulated in the strategic plan.

Key action: Identify complementary strategies for optimising prescribed burning benefits

Principle 12

Clear systems and processes need to be established and agreed for plan implementation, for monitoring and reporting, and program evaluation – these should be articulated in the strategic plan.

Key action: Specify implementation, monitoring and evaluation responsibility.

Program planning process

Program planning principles

Principle 13

Strategic planning assumptions can change by the time program planning is undertaken – check assumptions (especially fire history) and engage local knowledge in the planning process.

Key action: Review strategic planning requirements and assumptions

Principle 14

For a range of reasons, some areas will be a higher priority for burn scheduling than others – using a risk-based approach, consider relevant factors affecting burn priority.

Key action: Prioritise burn scheduling on the basis of risk

Principle 15

Program planning is usually the first stage of the planning sequence at which specific burn locations, boundaries and timings are nominated and thus it can be expected that additional external stakeholder interest will emerge – allow for additional stakeholder engagement activities at the program planning phase.

Key action: Consider stakeholder needs and concerns

Principle 16

There are opportunities to minimise program delivery risk by planning burn sequences that extend on previous burns – consider how risk can be reduced by multi-year and/or multi-stage sequencing of burns.

Key action: Consider implementation risks when sequencing burns

Principle 17

Unfavourable weather, and potentially other factors, can be expected to impact burn program delivery in most years – build contingency into burn programs to allow for a proportion of nominated burn areas being unavailable for burning during the planning period.

Key action: Build contingency into burn programs

Principle 18

Nomination of unrealistic or high difficulty/risk burn areas in a burn program can generate significant operational delivery risks, or a risk that the burn cannot be implemented – nominate proposed burn areas that are within available organisational capability to deliver safely.

Key action: Consider implementation risk and resource capability in selecting burn areas

Principle 19

Most burns will require a degree of site and/or boundary preparation – allow for this in program planning.

Key action: Make allowance for burn site preparation requirements in program planning

Principle 20

Burn program delivery complexity and risk may be strongly influenced by the aggregate works volume associated with burn program delivery – consider cumulative burn security and smoke management issues over the program delivery period as well as for individual burns.

Key action: Consider aggregate operational risks and efficiencies

4. PRINCIPLES FOR THE STRATEGIC AND PROGRAM PLANNING PHASES OF PRESCRIBED BURNING

Table 1 *Prescribed burning phases and associated principles*

Phase	Associated Principles	Key Actions:
Strategic planning	**Scoping**	
	Principle 1 Strategic planning must comply with laws, policy and agency requirements relevant to prescribed burning – start strategic planning with an up-to-date understanding of relevant legal requirements, policies and objectives.	Orient planning team to current policies and organisational requirements
	Principle 2 The planning scale (duration and spatial coverage) should reflect regional vegetation growth, fuel accumulation and fire occurrence cycles, and be relevant to how assets and fire prone areas are arranged in a landscape.	Determine appropriate plan scale and duration
	Principle 3 Prescribed burning objectives are not constrained by tenure differences, institutional responsibility demarcations or administrative boundaries – planning scope should address how prescribed burning objectives are to be optimised and managed across different tenures and administrative boundaries, in partnership with all stakeholders.	Determine land tenures to be covered by the plan and the relevant stakeholders to be engaged in planning
	Principle 4 Resourcing capacity, planning systems and capability maturity are key factors influencing the design of a strategic planning methodology – the method selected should be well-matched to the available planning capability and area complexity.	Select an achievable strategic planning model appropriate to the degree of planning area complexity and planning capability
	Planning Process	
	Principle 5 The needs, concerns and knowledge of relevant stakeholders requires appropriate consideration during planning to maximise plan effectiveness, ownership and support for, and commitment to, plan implementation.	Prepare an appropriate stakeholder engagement plan
	Principle 6 Strategic plans should contain clear objectives linked to performance indicators and metrics, enabling evaluation of burn strategy delivery and performance.	Determine strategic plan objectives and performance metrics

4. PRINCIPLES FOR THE STRATEGIC AND PROGRAM PLANNING PHASES OF PRESCRIBED BURNING

Phase	Associated Principles	Key Actions:
Strategic planning	**Principle 7** Landscape fire risk is highly variable – strategic planning should be based on risk assessment covering community safety, asset and social/economic infrastructure protection, land and natural resource management and the maintenance of ecological resilience.	Identify hazards and values, assess and evaluate bushfire risks
	Principle 8 Prescribed burn strategy options analysis should be based on landscape-level assessment of historical and potential fire paths.	Analyse potential fire paths and assess strategic options
	Principle 9 Risk-based fire management zoning or prioritisation systems should clearly specify treatment regimes and specifications for both life and property protection and for maintenance of ecological resilience.	Articulate a zoning or prioritisation system for applying the prescribed burning strategy.
	Principle 10 Different vegetation types or land management units require different approaches in terms of fire management, and some are not suitable or practical for prescribed burning – strategic plans should articulate management regimes for different vegetation types and/or land management units.	Identify fire regimes for vegetation types and other areas of land, and any practical constraints for prescribed burning.
	Principle 11 To optimise the benefits of prescribed burning strategies, other complementary risk reduction actions need to be identified (pursuant to a 'shared responsibility' model), and articulated in the strategic plan.	Identify complementary strategies for optimising prescribed burning benefits
	Principle 12 Clear systems and processes need to be established and agreed for plan implementation, for monitoring and reporting, and program evaluation – these should be articulated in the strategic plan.	Specify implementation, monitoring and evaluation responsibility

4. PRINCIPLES FOR THE STRATEGIC AND PROGRAM PLANNING PHASES OF PRESCRIBED BURNING

Phase	Associated Principles	Key Actions:
Program planning	**Principle 13** Strategic planning assumptions can change by the time program planning is undertaken – check assumptions (especially fire history) and engage local knowledge in the planning process.	Review strategic planning requirements and assumptions
	Principle 14 For a range of reasons, some areas will be a higher priority for burn scheduling than others – using a risk-based approach, consider relevant factors affecting burn priority.	Prioritise burn scheduling on the basis of risk
	Principle 15 Program planning is usually the first stage of the planning sequence at which specific burn locations, boundaries and timings are nominated and thus it can be expected that additional external stakeholder interest will emerge – allow for additional stakeholder engagement activities at the program planning phase.	Consider stakeholder needs and concerns
	Principle 16 There are opportunities to minimise program delivery risk by planning burn sequences that extend on previous burns – consider how burn program delivery risk can be reduced by multi-year and/or multi-stage sequencing of burns.	Consider implementation risks when sequencing burns
	Principle 17 Unfavourable weather, and potentially other factors, can be expected to impact burn program delivery in most years – build contingency into burn programs to allow for a proportion of nominated burn areas being unavailable for burning during the planning period.	Build contingency into burn programs
	Principle 18 Nomination of unrealistic or high difficulty/risk burn areas in a burn program can generate significant operational delivery risks, or a risk that the burn cannot be implemented – nominate proposed burn areas that are within available organisational capability to deliver safely.	Consider implementation risk and resource capability in selecting burn areas
	Principle 19 Most burns will require a degree of site and/or boundary preparation – allow for this in program planning.	Make allowance for burn site preparation requirements in program planning
	Principle 20 Burn program delivery complexity and risk may be strongly influenced by the aggregate works volume associated with burn program delivery – consider cumulative burn security and smoke management issues over the program delivery period as well as for individual burns.	Consider aggregate operational risks and efficiencies

4.4 Strategic planning principles – scoping

Principles 1 to 4 relate to the initial high-level strategic plan scoping stage of prescribed burn planning.

4.4.1 Principle 1

Principle 1

Strategic planning must comply with laws, policy and agency requirements relevant to prescribed burning – start strategic planning with an up-to-date understanding of relevant legal requirements, policies and objectives

Why is this principle important?

An up-to-date understanding of relevant legislation, policies, plans, agency requirements and systems is a starting point for strategic planning as these may have requirements, a bearing on strategy options, and may also be useful sources of information. It is important to check current requirements as these can change significantly over time. Check relevant agency objectives, standards, procedures and constraints at the time of planning, as set out in such documents as codes of practice, standard operating procedures and land management plans (for lands within the planning area).

General guidance notes

The following list provides a starting-point (it should not be considered exhaustive) for matters to check prior to commencing a strategic planning process:

- Check the requirements of relevant national legislation and policy frameworks that may influence selection of prescribed burning options (refer to Section 2.3). In particular check:
  - Requirements under the *Environment Protection and Biodiversity Conservation Act* (1999), including the terms of any approvals for relevant fire management Strategic Assessments;
  - The strategic objectives and national goals set out in the *National Bushfire Management Policy Statement for Forests and Rangelands* (FFMG, 2014); and
  - The principles set out in AFAC's *National Position of Prescribed Burning* (2016d).
- Check the requirements of relevant state or territory legislation that may influence strategic planning and the selection of prescribed burning options (refer to Section 2.4), including:
  - Emergency management, bushland or rural fire-specific legislation that mandates requirements for emergency or bushfire risk management planning and potentially also may prescribe certain process requirements;
  - Environmental legislation and regulations that typically establish requirements for environmental assessment, protection of biodiversity and the physical environment, and requirements for air and water pollution control;

  - Land and natural resource management legislation and regulations that may establish objectives and/or requirements for the management of particular public or private land tenures (such as National Parks and Reserves, declared Wilderness Areas, public forests or rangelands, Crown Lands, and river catchment areas, etc.); and
  - Heritage management legislation and regulations establishing requirements for protection of heritage values.
- Check relevant state or territory agency polices, strategies, codes of practice, business objectives, standard operating procedures, plans and service delivery charters that may be relevant to prescribed burning; and
- Check the requirements of relevant statutory and other plans of management for lands within the planning area, such as relevant conservation or recreation reserves management plans, forest management plans, catchment management plans.

Persons given responsibility for leading strategic plan development should ensure planning team members are aware of compliance requirements and constraints relevant to their planning activities.

Decision point:

Determine which laws and policy requirements apply to prescribed burning, and check that personnel involved in the strategic planning process understand those requirements.

4.4.2 Principle 2

Principle 2

The planning scale (duration and spatial coverage) should reflect regional vegetation growth, fuel accumulation and fire occurrence cycles, and be relevant to how assets and fire prone areas are arranged in a landscape.

Why is this principle important?

All strategic plans need to have a clear scope, both in terms of the timescale and the geographic area to which they apply.

The timescale of the plan may be influenced by vegetation and fuel accumulation cycles, as well as stakeholder needs such as the timing of agricultural cycles. Short strategic planning timescales can be applied to landscapes where patterns of fuel in the landscape change significantly year-to-year and fire occurrence is high (for example in landscapes dominated by tropical savannas). Alternatively, longer strategic planning timescales can be applied to these landscapes, provided that strategic plans are broad enough to allow flexibility for dynamic, short-period program planning. Where annual changes in fuel are more incremental (such as in the southern forests of Australia) and fire affects a relatively small proportion of the landscape in most years, longer planning cycles are more suitable.

The geographic scale selected ideally should encompass both the areas where high-consequence fires can start, and the areas to which they can spread – it is best, where possible, to avoid selecting planning area boundaries where significant at-risk areas are within the planning area, but the locations from where the highest consequence fires may come are outside the planning area boundary. Ideally also, the plan scale used should facilitate provision of analyses and outputs that are meaningful for those exposed to risk within the planning area. Selecting a good balance of these scoping parameters is key to creating an effective and relevant strategic plan which maintains its currency and provides appropriately-scaled detail for stakeholders, enabling key people important to its success to be informed and engaged.

4. PRINCIPLES FOR THE STRATEGIC AND PROGRAM PLANNING PHASES OF PRESCRIBED BURNING

General guidance notes

Selection of planning timescales

In areas such as tropical savanna dominated landscapes, where tropical grasses replenish on an annual cycle, and a high proportion of a planning area can be expected to burn in any one year, planning cycles may be short. In these highly dynamic systems, a short planning cycle such as a single Early Dry Season period can be appropriate; otherwise information important for program planning can quickly become out of date. Alternatively, if strategic planning is done at an objectives and principle level, they could be of longer timescales, and allow flexibility for short timescale program planning.

In more temperate climate zones where fuel accumulation is more incremental over multi-year timeframes, and the rolling annualised average of area burnt by unplanned fires is a relatively small proportion of the landscape (perhaps in the range of 1 to 5%), a longer planning cycle can reasonably be adopted, five years being a reasonable and commonly used planning period. The longer the period selected, the greater the potential for significant change to occur within that period, increasing the potential for uncertainty and potentially creating plan redundancy in the process. Selecting a longer planning scale may be appropriate in systems where change is slow, predictable or episodic. Review points can be built in to provide opportunities to review the plan if major change events occur, and assist in maintaining the currency of information.

For strategic planning systems which incorporate a multi-layered and potentially extended review and approval process, selecting a sub-optimally short planning scale may generate an unnecessarily repetitive and inefficient consultation, review, approval and administrative workload. Selecting a longer planning scale, with facility for periodic feedback or set review points built into the system, can allow for ongoing continual improvement over a longer planning period, without the need to re-enter into a formalised consultation, review and updating process.

(Source: Department of Environment, Water and Natural Resources. South Australia)

Selection of planning spatial scales

The heterogeneity of fuel types and vegetation, and the complexity of their arrangement in the landscape, will influence the choice of area to be covered by a plan. A very complex and highly variable landscape is likely to require a very complex strategy. Otherwise, if the inherent complexities are not appropriately considered, then the strategy developed may become so broad and general that it loses value and meaning for many stakeholders. In such circumstances the planning area may have to be sub-divided into logical sub-plan areas where more finely scaled sub-planning is applied. Selection of planning scale should consider:

- Logical landscape/landform units, within the bounds of which larger scale fire events tend to be confined;
- Land tenure breakdown across an area and the stakeholders who need to be involved within it. The planning extent selected should as far as possible suit the needs and capacity of those partners who are essential for the plan's successful preparation and implementation;
- The location and distribution of assets and other values within the plan area, and the locations of fire hazard areas that may impact upon these;
- The scale of landscape fuel units (such as covering an area based on some similarity of fuel types). Relatively homogenous landscapes can be large in central Australia where a spinifex grassland fire may exceed 10,000 km^2 (Allen and Southgate, 2002). In coastal regions, particularly in areas broken up by urban development with a range of complex small-scale fuel units, much smaller planning areas may be relevant;
- If the planning area being considered accommodates the stakeholders likely to be involved in its implementation; and
- The degree to which the area and scale is a practicable size for strategic burn scheduling and delivery.

Decision point

Select a strategic planning timescale which is relevant to the fuel and fire dynamics in the planning area and manageable for those participating in plan development to maintain appropriate involvement.

Select a strategic planning geographic area coverage that is appropriate for the degree of landscape complexity and accommodates the full extent of most fire scenarios that can occur.

4.4.3 Principle 3

Principle 3

Prescribed burning objectives are not constrained by tenure differences, institutional responsibility demarcations or administrative boundaries – planning scope should address how prescribed burning objectives are to be optimised and managed across different tenures and administrative boundaries, in partnership with all stakeholders.

Why is this principle important?

It is common for fires to cross land tenures and administrative jurisdictions such as local government and state or territory government boundaries. Fires which start in rural or bushland areas can end up in urban areas and vice versa. Biodiversity and environmental values associated with vegetated areas (which provide both the fuel for bushfires and habitat for flora and fauna) also occur across tenure boundaries and their sustainable management often requires a strategic, cross-tenure planning approach. Furthermore weeds, pest animal populations and pathogens can also cross tenures and their spread can be influenced by the local regime of planned and unplanned fires.

The main opportunities for bushfire risk reduction through reducing fuel hazards are often on different land tenure(s) from where the most severe consequences of the risk are likely to occur. Accordingly, to optimise bushfire risk mitigation and other outcomes, cooperative planning within and between agencies, land owners and managers, brigades, potentially affected business owners and other stakeholders is important.

Collaborative planning approaches not only project unity of purpose and direction to the community, they facilitate sharing of knowledge, mutual understanding of different objectives, capabilities, and perspectives, sharing of resources and equipment, as well as promoting a shared understanding of the risks and collective ownership of overall program objectives and outcomes.

General guidance notes

Most States and Territories have either adopted or are moving towards cross tenure strategic planning models, particularly for bushfire risk reduction.

Strategic planning systems are likely to be more effective where all the stakeholders involved work in partnership on an ongoing and consultative basis to develop shared understanding and ownership of the risks, and to develop a complementary suite of strategies to mitigate the risk. In order to develop and maintaining trusted partnerships between land owners, government agencies, individuals and property managers, it is important to recognise the potential for differences in:

- The objectives for which the land is being managed;
- Access to resources;
- Availability and capacity of stakeholders with some, despite being willing, unable to contribute as equally as other partners; and
- Language, culture or depth of knowledge about fire management issues.

Recognising and accommodating these differences within the strategic planning framework is necessary to make it as easy as possible for all partners to contribute to successful cross tenure outcomes.

Strategic planning is as much a community and/or stakeholder engagement process as it is a technical fire management process. For example, in Tasmania, Fire Management Area Committees with agencies and local stakeholders working cooperatively, develop shared understanding of risks and values. And having built trust through this process, they work well collaboratively to address the risk. The inclusion of private land in burning programs is leading to greater risk reduction, and more and better conversations in the community about fire risk.

More about stakeholder engagement is covered in Principle 5.

Decision point

In considering the land tenure and agency involvement-related scope of the strategic planning process, identify the range of key stakeholders that would ideally need to be involved to obtain maximum benefit from strategic planning. Decide which stakeholders to involve as active collaborators in the planning process, which to involve for identification of specific concerns and needs, and which to consult regarding analyses and options. Selection of the stakeholders to be consulted will be substantially influenced by the spatial scale of the strategic plan.

4.4.4 Principle 4

Principle 4

Resourcing capacity, planning systems and capability maturity are key factors influencing the design of a strategic planning methodology – the method selected should be well-matched to the available planning capability and area complexity.

Why is this principle important?

There are many different strategic planning methodologies and tools that can be applied to strategic planning for prescribed burning programs, component parts of which are discussed under Principles 5 to 12. Some planning methodologies are more data-dependent, complex fire-simulation technology based, costly and human resource hungry than others. In any jurisdiction there may be a significant difference between what can be done with existing people, systems, data and technological capacity, and what might be desirable to do in a less resource-constrained environment. Pragmatically, agencies need to select a strategic planning methodology that its available data, systems and people are able to deliver now or within a short timeframe. There may be times when agencies seek to scope out more aspirational strategic planning approaches that can deliver substantially improved and value-for-money prescribed burn program planning outcomes. These may also require scoping of capability development requirements for incorporation into agency budget submission processes. In the past, opportunities to pursue capability improvements have also arisen from internally or externally driven performance improvement reviews that often follow high-consequence events.

Prescribed burning strategies may stand alone, be part of a more general bushfire management plan (that includes a range of strategies to mitigate bushfire risk, of which prescribed burning is just one), or form one component of a more general land management plan (dealing with a variety of land management issues within the one landscape). Irrespective of the planning context under which a prescribed burning strategy is undertaken, this principle considers the component concerned with planning prescribed burning.

General guidance notes

The strategic planning methodology selected needs to be based on a balanced consideration of the:

- Data and information available for the landscape area selected;
- Key analytical and strategy outputs desired;
- Competencies, human resources, tools, systems and guidance required and available to complete various components of the planning methodology; and
- Confidence in the process by stakeholders, and their ability to understand the outputs.

There is a range of analytical methods which can be incorporated in a strategic planning methodology, to undertake the key planning components such as risk assessment, fire path and behaviour analysis, and treatment options analysis. These range from relatively low technology, knowledge and intuitive experience-based approaches through to the use of structured, repeatable computational approaches using bushfire simulation-based methods and automated multi-criteria analyses.

There is nothing wrong with using analytical approaches at either end of this spectrum, or somewhere in between, provided the assumptions and limitations are clear to those developing and implementing the planning methodology and the resulting plan, and that the methodology used is appropriately matched to resources and skills of the planners available. Importantly also the community needs to be able to understand and trust the planning outputs, which generally requires that they have confidence in the planning methodology.

Fire simulators using science-based and operationally tested fire behaviour models can be used to determine where optimal prescribed burning treatments can be applied in the landscape, to mitigate bushfire impacts. These have the advantage that very large numbers of scenarios can be tested using a consistent and repeatable method. The use of such modelling approaches generally requires the availability of trained fire behaviour analysts (FBANs) who have access to, and training in how to operate the selected fire behaviour simulator, as well as a range of fuel and weather input values in order to produce spatial outputs of potential fire spread and impact. Like all modelling processes, the reliability of the modelled outputs will have a strong dependency on the quality and currency of input values sourced from spatial data layers.

Those participating in the strategic planning process need to be aware of the uncertainties associated with modelling, particularly in relation to vegetation and fuel assumptions. The key point here is that to use fire simulation-based planning methodologies, significant investment may be required to assemble and validate (and subsequently maintain) the spatial datasets required to run a fire behaviour simulator.

Where the effort and cost involved in assembling suitably reliable fuel datasets to support detailed analysis using fire simulators is prohibitive, a simpler approach to considering fire paths and impact potential will need to be adopted. Methods can be as simple as using vegetation and fire history maps, giving consideration to 'what if' questions incorporating ignition locations and fire weather scenario assumptions, and using subject matter expert fire behaviour knowledge and local experience to intuitively predict where and how fires will impact. In many cases, particularly in less complex landscapes, a simple subject matter expert and local knowledge-based approach to considering potential fire paths, behaviour and impacts and the options for mitigating these may be just as suitable as using a more complex and mature computer modelling based approach to analysis.

The prospects of success in uptake of a strategic plan by its stakeholders are improved where the stakeholders understand, trust and accept the premises and assumptions on which the strategies and proposed actions are founded. Planning methods which adopt relatively simple and logical methodologies are likely to require less effort to gain stakeholder trust and acceptance. In the case where a planning approach involves relatively complex modelling components, and such elements as multi-criteria analyses of trade-offs, then it can be expected that substantially more effort may need to be put into stakeholder engagement activities. Accordingly, another dimension to considering strategic planning methodology selection is to consider the resources available to participate in community engagement activities to explain the methods used so the stakeholders can develop confidence and trust in the methodology.

Decision point:

Decide and agree on a strategic planning process and methodology that is understood by the planners and the outputs of which can be understood and trusted by all stakeholders, in a format that will encourage their input and involvement.

4.4.5 Outputs from the strategic plan scoping process

The output from applying principles 1 to 4 is:

- Gaining a refreshed and current understanding of the relevant legislative and policy requirements applying to the prescribed burn strategic planning process;
- A decision on the geographic area and timescale to be covered by a strategic plan (or suite of plans);
- Confirmation of the land tenures to be covered in the plan and identification of the relevant stakeholders and the manner in which they will be engaged in the planning process, and the governance arrangements for plan development; and
- A decision on the approach and methodology to be used to undertake the planning, and the resources required to do so.

4.5 Strategic planning principles – planning process

Principles 5 to 12 relate to the process of strategic planning once the initial scoping phase is complete.

4.5.1 Principle 5

Principle 5

The needs, concerns and knowledge of relevant stakeholders requires appropriate consideration during planning to maximise plan effectiveness, ownership and support for, and commitment to, plan implementation.

Why is this principle important?

Stakeholders can provide knowledge and insights of critical value to the strategic planning process, including on locally important matters that may be unknown to agencies involved directly in strategic planning. They will often identify key values or issues of great importance to them that will require specific management in the design, development and delivery of strategic burn planning.

Stakeholders can also provide valuable support and enthusiastic assistance for prescribed burn planning and delivery and can be key opinion shapers in local communities. Equally, they can provide stubborn resistance and objection, and can stymie burn program implementation if they feel their concerns have been unreasonably dismissed or ignored. Landowners can prevent access to land desirable for inclusion in burning strategies for broader community protection. For these and many other reasons, it is critical and advantageous to undertake genuine stakeholder engagement processes at appropriate points through the planning process, to identify concerns and resolve issues early, and strengthen community support and ownership of the resulting plan. Pursuing a goal of having an engaged community supportive of a shared responsibility approach to fire management is only achievable with well-planned stakeholder engagement.

General guidance notes

From the start of the strategic planning process, a stakeholder engagement strategy should be developed. The stakeholder engagement process should be appropriately scaled to the scope and scale of the strategic plan being developed. In general, the matters requiring consideration in developing a stakeholder engagement strategy include:

- Identifying who the key stakeholder groups are for engagement and what their key points of interest are likely to be – a process to register interests may be worthy of consideration for some planning situations;
- Deciding what levels of engagement will be appropriate for different stakeholder groups. Consider using a four-level framework comprised of the following (IAP 2017):
  - **Collaborate** – for those who may be active partners in the strategic planning process and prescribed burning delivery;
  - **Involve** – where specific stakeholder involvement is actively sought to ensure concerns and needs are understood and considered in the strategic planning process;
  - **Consult** – broader engagement to obtain feedback on analyses and alternatives, typically from the public; and
  - **Inform** – to provide interested parties and the general public with information to assist them to understand issues and decisions.

- Identifying the stages in the strategic planning process at which different stakeholder engagement activities would be beneficial;
- Deciding the most appropriate methods by which to engage with different stakeholder groups. Different methods will be appropriate for different groups and different levels of engagement;
- Determining what information, and in what form, will be optimal to provide as part of stakeholder engagement activities. Such matters as providing some context of bushfire risks in the planning area, how different prescribed burning strategy options can reduce risk (as well as the consequences of how not pursuing prescribed burning strategies will affect risk), and the likely impacts of prescribed burning program implementation and how the risks arising (including smoke risks) can be managed;
- Considering how input gained from stakeholder engagement activities is to be captured and considered; and
- Determining what resources are required to undertake the program of engagement activities, having considered and identified what the most efficient approach will be given the resources available. This includes consideration of how stakeholder organisations may assist.

It is advisable to develop a documented stakeholder engagement plan. This is a necessity for planning areas involving a wide diversity of stakeholder groups and where the potential for stakeholder differences of understanding and opinion is high.

Decision point

Decide what approach will be taken to engage communities and stakeholders in the strategic planning process. Document stakeholder engagement and management requirements.

4.5.2 Principle 6

Principle 6

Strategic plans should contain clear objectives linked to performance indicators and metrics, enabling evaluation of burn strategy delivery and performance.

Why is this principle important?

Management by objectives is a key fire management principle as emphasised in the *National Bushfire Management Policy Statement for Forests and Rangelands* (FFMG, 2014), and is a key management principle more generally. If objectives are not expressed in measurable terms, or are not established in conjunction with relevant measurable performance indicators, then program performance and cost-benefit cannot be evaluated.

It is desirable that high-level performance indicators are in a form that can be understood by communities or stakeholders who have an interest in understanding what the strategy is aiming to achieve, and whether program objectives are being met. It is also desirable at the strategic planning phase, that a system of performance indicators be developed that allow performance to be assessed at long-term outcomes level, intermediate outcomes level, immediate outcomes level and activity implementation level (refer to AFAC's *Objectives, Monitoring and Evaluation Framework for Prescribed Burning*, 2017a and *Prescribed Burning Performance Measurement Framework*, 2017b).

4. PRINCIPLES FOR THE STRATEGIC AND PROGRAM PLANNING PHASES OF PRESCRIBED BURNING

General guidance notes

As identified in the *Review of Best Practice for Prescribed Burning* (AFAC, 2014), in the past clear objectives linked to performance indicators and metrics have not always been part of strategic planning for prescribed burning. The performance indicators and metrics vary depending on the objectives being pursued.

Bushfire Risk Reduction

Typically, plans for prescribed burning for bushfire risk reduction have provided broad objectives such as reducing the extent and severity of bushfires, but in many cases have not provided more specific objectives for risk reduction, or even how much prescribed burning activity is required. In many jurisdictions an output of the strategic planning process has been a fire management zoning plan (with different treatment specifications applying to different zones). However, this system has often been applied in a way that lacks transparency in terms of identifying the rate or amount of fuel reduction treatment required annually relevant to the zoning system. Thus it is difficult for agencies, communities or stakeholders to determine whether the strategies are being delivered according to specification.

In the absence of clear program performance metrics, in the aftermath of high-consequence fires it is common for stakeholder groups to call for clear, unambiguous performance measures for bushfire risk reduction, often directed to measuring prescribed burning activity rather than outcomes such as change in risk (risk outcomes being more difficult to measure than activities conducted). However, activity-based performance measures often come in for criticism (whether true or not) as groups may perceive that an agency seeking to meet activity-based targets may choose to plan and conduct works in such a way that the target is most easily achieved within allocated budget (low difficulty or cost burns that treat large areas), but which may not be well directed to reducing risk.

Commonly used activity based metrics include:

- Number of burns conducted (often categorised into different burn purposes, or types, or fire management zonings);
- Area treated (in most cases, area reported as treated is the area within the planned boundaries of each burn, not the proportion of the area actually burnt); and
- Proportion (%) of a management area that has been fuel-reduced within a specified timeframe (this can be for prescribed burns only or also include area burnt by unplanned fires), which may be used in lieu of an explicit area measure.

Another burn spatial arrangement approach used in Western Australia by the Department of Parks and Wildlife is application of a spatial metric that no fuel older than five years old (since last burnt) is located more than 10 km from fuel which is less than five years old. This means that fires in fuels older than 5 years may only have a maximum uninterrupted fire run of 10 km before they run into a low fuel area. The intention is that a fire run in heavy fuels will rarely be able to run through a low fuel area into another high fuel area before night suppression in low fuels can be successfully carried out.

The alternative performance metrics to activity-based measures are outcome-based measures. In terms of bushfire risk reduction an outcome-based measure would normally be expressed in terms of risk. Conceptually this is more difficult than reporting activity-based output, and is difficult for communities to understand. Having previously used a prescribed burn activity-based performance metric, following a review by the Inspector General of Emergency Management in 2015 (IGEM 2015) the Victorian Government replaced the activity-based measure with a risk-based measure. A ‘residual risk’ concept has been adopted whereby at state level, the residual bushfire risk is measured as a proportion of Victoria’s maximum potential bushfire risk.

Victoria's approach to quantifying bushfire risk is described in *Measuring Bushfire Risk in Victoria* (DELWP 2015) which in essence entails the use of computerised fire simulation technology (using Phoenix RapidFire) to:

- Model bushfire impacts on property assuming a maximum risk scenario with fuels assumed to be at the upper end of their potential range across the landscape, using a Catastrophic weather scenario representing a fire danger index of 130; and
- Using the same weather scenario, model bushfire impacts on property based on a "modified fuel scenario", factoring in areas of reduced fuel where recent fires have occurred and prescribed burns have been undertaken, and where prescribed burns are proposed to be undertaken.

Using the approach, a 'residual risk' target can be selected which expresses the desired level as a percentage of the modelled loss under the maximum risk scenario. Presently in 2017, Victoria has adopted a target that the modelled level of property loss should be no more than 70% of the loss attributable to the maximum risk scenario. As the residual risk target is a state-level target based on state-wide modelling, the actual residual risk at any particular location can be quite different to the modelled state-wide risk; in some areas higher and in other areas lower.

Other simpler risk assessment systems, not involving technically complex spatial fire modelling, can be considered. Often, risk assessment at specified locations is undertaken by assessment of risk likelihood and consequence to give a risk rating. This can be done assuming an unmodified fuel scenario, and then reassessed using assumptions that a proposed fuel reduction program is applied. The reassessed risk may reduce the risk rating to a lower category than the unmodified scenario. This method has the shortcoming that it is a subjective method, being the opinion of the risk assessor(s), and that it is problematic to scale outputs up from individual assets or clusters of assets to a strategic planning scale. In terms of setting risk targets, the *As Low As Reasonably Practicable* (ALARP) concept is widely used in risk management, which acknowledges that there may be limits to how far risk can be reduced taking into account the cost of treatment in relation to the degree of risk reduction benefit gained.

ALARP is a standard adopted by, and defined in the Work Health and Safety (WHS) Act 2011 (in Section 18). In practical terms it means that firstly consideration must be given to what can be done – that is, what is possible in the circumstances for ensuring health and safety. Having considered what can be done it is then necessary to consider whether it is reasonable, in the circumstances to do all that is possible. This means that what can be done should be done unless it is reasonable in the circumstances to do something less. In considering what is reasonably practicable, the WHS Act 2011 identifies the relevant matters to be taken into account are:

a. The likelihood of the hazard or the risk concerned occurring;

b. The degree of harm that might result from the hazard or the risk;

c. What the person concerned knows, or ought reasonably to know, about:

   I. The hazard or the risk; and

   II. Ways of eliminating or minimising the risk.

d. The availability and suitability of ways to eliminate or minimise the risk; and

e. After assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

Additional to the choice of performance metrics, there is the matter of program target selection – selecting how much fuel reduction to do, or how much risk reduction to do. This remains a politicised and hotly debated matter in all jurisdictions, and there are substantial differences in approach between jurisdictions. The policy context and institutional arrangements for bushfire risk management varies between jurisdictions, as does the physical landscape context, and therefore it is problematic to make comparisons of performance metrics in one place with those of another. At a general level for Australia, prescribed burn program treatment rates can range from less than 0.5% of a bushfire prone landscape annually (typically in landscape locations with substantial operating context constraints), to more than 20% of the landscape annually as occurs in landscapes subject to Carbon Farming Initiative savanna burning projects in the Northern Territory. As outlined in Appendix 1, long term studies at landscape scale of the relationship between prescribed burning treatment rates and unplanned fire extent, have shown a strong inverse relationship, with total annualised area burnt dominated by unplanned fires where treatment rates are low, and the reverse where prescribed burning treatment rates are high. In interpreting such studies, it is important to consider the physical environment and operating context factors which also influence the outcomes.

The most immediate outcomes of prescribed burning programs that can be measured are the changes in fuel which have been achieved. So for immediate outcomes metrics, indicators relating directly to fuel are usually used.

A longer term aim of fuel reduction is to reduce fire behaviour, both in terms of fire extent and fire intensity and rate of spread. Identifying whether or not this outcome is actually achieved in practice has to wait until unplanned fires occur to see how the reduction in fuel, achieved through prescribed burning, affected the size and intensity of unplanned fires (unless a modelling approach is taken in which actual unplanned fires that have encountered fuel reduced areas are modelled to determine what their impact area and severity would have been if the fuels were not reduced). Fire extent and severity metrics may take years of monitoring before detectable changes, such as annualised averages for area burnt by unplanned fires or the severity of unplanned fires, can be detected. There is also the complicating factor that other fire management strategy changes such as fire prevention and suppression programs can be expected to influence outcomes, so not all change in fire extent and severity can be validly attributed to prescribed burning.

The aim of reducing unplanned fire extent and severity is to reduce adverse impacts in the form of human fatalities and injuries, property loss and damage, other economic losses and costs, social impacts and environmental impacts. The more severe of these impacts typically only occur from fire events during extreme weather scenarios, which at any particular location may not occur for many decades or centuries. These outcomes are difficult to measure and draw valid conclusions from given that there several contributing factors involved such as community education programs, land use planning and development control strategies, among others.

Ecological health and resilience

As outlined in AFAC's *Risk Framework for Ecological Risks Associated with Prescribed Burning* (AFAC 2016b) the most widely used metric applied by Australian fire and land managers for determining appropriate ecological fire regimes (particularly at the strategic and program planning levels), is fire intervals. This frequency-based approach is referred to variously using different terminology in each jurisdiction, for example – *Tolerable Fire Interval* TFI (VIC); *Inter-fire Interval* (QLD); *Fire Interval Threshold* (NSW); and *Threshold of Potential Concern* (SA). The appropriate fire intervals-based approaches mostly consider the frequency element of fire regimes only. TFI metrics have considerable limitations (discussed in detail in Appendix 2) and should not be used in isolation of other measures or without checking the current and actual condition of fuels and ecosystems. Nor should they be used as a formula for applying fire in the landscape. Other emerging performance measures for ecological outcomes that are harder to derive and understand, but give a much greater indication of ecosystem resilience include:

- *Vegetation Growth Stage Structure* – Vegetation Growth Stage Structure (GSS) analyses are based on the premise that a mix of vegetation growth stages and habitat structures across a landscape will optimise biodiversity, and hence enhance ecosystem resilience (DELWP 2015); and

(Source: Department of Environment, Water and Natural Resources, South Australia)

- *Geometric Mean Abundance* – the Geometric Mean Abundance of species in a community is an index of the relative abundance of species and provides a measure correlated with community viability (DELWP 2015).

Summary

In the end, decisions about what system of performance metrics to adopt, and what performance targets to pursue are effectively risk management decisions made by individual jurisdictions and/or land management agencies. However, AFAC's Prescribed Burning Performance Measurement Framework (2017b) provides guidelines to agencies on a range of nationally agreed performance measures that may be adopted.

Decision point

For strategic planning, the objectives of prescribed burning need to be decided, and linked to a system of measurable performance metrics relevant to the objectives. In mature strategic planning systems, targets in relation to the performance measures should also be decided.

4.5.3 Principle 7

Principle 7

Landscape fire risk is highly variable – strategic planning should be based on risk assessment covering community safety, asset and social/economic infrastructure protection, land and natural resource management and the maintenance of ecological resilience.

Why is this principle important?

One of the core components of a strategic plan is to identify areas of risk, be they risks to life, assets, infrastructure, ecological values, cultural values, amenity or landscapes.

It should be noted that prescribed burning is only one of a number of possible risk management tools, and strategies may be prepared that are much broader in scope than prescribed burning alone. For example, agencies may prepare bushfire mitigation strategies for which prescribed burning is one of a suite of mitigation measures. Alternatively, agencies may prepare land management plans, or ecological resilience plans for which prescribed burning is one component of a broader strategy to manage landscapes.

In most situations, within a selected geographic area across which strategic planning is to be applied, there will be significant variability in the range of risks to be managed, and the degree of risk from place to place and over time. There is likely to be variability in the degree to which prescribed burning can reduce risk. Therefore, to develop a coherent and justifiable strategic approach to using prescribed burning, it is necessary to obtain a sound understanding of the nature of the risks requiring management, and how these vary and interact within the planning area.

General guidance notes

Risk assessment can be undertaken using a variety of techniques, from data/resource-intensive landscape bushfire modelling-based analyses, to asset-oriented likelihood and consequence assessment-based approaches. Also risk assessment can be quite specialised with different risk assessment approaches required for ecological matters or cultural heritage matters. Some agencies require a separate environmental impact assessment process as part of, prior to, or in addition to strategic fire management planning.

The risk assessment approaches selected will need to be tailored to the available data, knowledge and planning systems capability.

In terms of bushfire risk reduction, one approach is landscape bushfire risk modelling implemented by the Department of Environment, Land, Water and Planning in Victoria, and by the State Fire Management Council in Tasmania. These approaches use a fire simulation program to predict potential fire spread and impact from selected ignition points across the landscape, under selected weather scenarios. This enables the identification of assets at risk of impact from fires starting from a range of different ignition locations and weather conditions. Different prescribed burn treatment strategy options can then be developed for evaluation, and the bushfire modelling re-run to assess the predicted effectiveness against the base-case. Such approaches also allow identification of the residual risk remaining, assuming implementation of a selected strategy.

Examples of risk assessments which involve asset-oriented likelihood and consequence assessment-based approaches include those used in NSW and WA, and by the Country Fire Authority (CFA) in Victoria. Rather than generating modelled fire run scenarios, assets in bushfire prone areas are recorded in a risk register and classified according to their type. Based on a range of criteria, assessment is then made of the potential bushfire impact consequence and likelihood for each asset or cluster of assets. Their level of risk is then determined as a function of their consequence and likelihood rating. These ratings are used for determining and prioritising risk treatment, including but not limited to deciding where different fire management zones should be placed.

(Source: Office of Bushfire Risk Management, Western Australia)

Other risk assessment process may involve a less structured, more intuitive, landowner/stakeholder experience-informed process of identifying bushfire risk. This is commonly applied in northern Australia. In these situations, the availability of satellite derived fire scar mapping is a critical planning tool.

Ecological risk assessment approaches are often conducted as separate risk assessment. AFAC's *Risk Framework for Ecological Risks Associated with Prescribed Burning* (2016b) contains guidance regarding ecological risk assessment conceptual approaches. At a strategic level, key considerations in proactively assessing the ecological risk dimension of bushfire risk include:

- Identifying parts of the landscape with large contiguous areas that are carrying high fuel hazard levels, which are vulnerable to being burnt by a large, high-impact fire potentially resulting in reducing the diversity of vegetation, seral stages and species;
- Assessing the health and condition of different ecosystems in the landscape, identifying those which would benefit from prescribed fire to maintain their healthy condition and/or prevent them transitioning (potentially irreversibly) to an unhealthy condition or different system;
- Identifying ecological communities that are sensitive to fire and consider ways to mitigate the risk of fire entering into these areas (including using prescribed burning in nearby areas); and
- The relative conservation values of the ecosystems under consideration. In particular, which ecosystems are rare or threatened in the landscape, and which are currently well conserved or poorly conserved within protected areas.

- The needs of individual species that require additional fire regime consideration beyond what would normally be applied at an ecosystem level, because:
  - They are rare and threatened or otherwise significant species who's habitat can be significant impacted by inappropriate fire; and
  - The species has some specialised requirements that need special planning considerations.

Also, fire strategies may highlight other key values that are at risk, such as Aboriginal or European heritage places or items, such as scar trees, rock-art site, sacred sites and historic artefacts that may be present within the planning area. The risk management approach in these cases may involve discussions with subject matter experts with regard to the particulars of risk management treatments.

Environmental considerations such as potential impacts on water catchments or impacts from pests, weeds or erosion may form part of strategic planning considerations. Or alternatively, opportunities to use fire to manage weeds, or the need to avoid prescribed burning due to weed invasions (e.g. Gamba Grass), may be highlighted.

Decision point

Identify assets and values within the planning area. Decide what form of risk assessment is to be applied (in conjunction with deciding what capability is required to undertake it), or what existing risk assessment can be used.

4.5.4 Principle 8

Principle 8

Prescribed burn strategy options analysis should be based on landscape-level assessment of historical and potential fire paths.

Why is this principle important?

It is environmentally, socially and economically desirable to avoid, as far as practicable, very large scale high-intensity fires which cause widespread and severe impacts. Such fires are typically weather dominated; however, the widespread availability of contiguous heavy fuels substantially increases fire intensity and therefore the physical impact of such fires.

High-consequence fires often (but not always) start some kilometres away (and potentially tens of kilometres away) from the area of highest consequence impact. Recent examples include the fires which impacted Canberra (2003, ACT/NSW); the Wangary fire (2005, SA); the Black Saturday fires in Victoria (2009, VIC); the Dunalley fire (2013, TAS), and Yarloop fire (2016, WA). While low fuel areas immediately adjacent to settlements, urban interface and high-vulnerability natural/agricultural resources can reduce risk at a localised scale through reducing fire behaviour at the interface, low fuel areas further away from interface areas can provide enhanced opportunities for fires to be contained before they reach high-vulnerability areas or assets. They may also slow or restrict fire growth to an extent that a fire does not reach vulnerable areas or assets during severe to catastrophic conditions. Accordingly, opportunities to use ecologically beneficial fire in landscape locations intersecting with potentially high-consequence fire paths, and maintaining low fuel areas adjacent to strategic breaks and trails located where defensive firefighting can be used to prevent fire spread to high-vulnerability areas, provides a multi-layered risk reduction strategy. Fire suppression strategies implemented by firefighters frequently seek to use defensive indirect strategies (backburning) to prevent unplanned fires from reaching high-vulnerability areas during adverse conditions, so taking reasonable steps (such as providing reduced fuel areas to work from) to improve their success prospects can provide significant value.

4. PRINCIPLES FOR THE STRATEGIC AND PROGRAM PLANNING PHASES OF PRESCRIBED BURNING

General guidance notes

Landscape assessments about where fires that could result in high-consequence impacts could start and how they would be likely to spread in adverse fire weather conditions can be made using either modelled fire simulations or local knowledge and experience about high-impact fire paths. Computer modelling approaches are certainly useful, however, if such systems are not available, local fuel and fire knowledge and experience-based approaches to fire-path assessment can be highly instructive. A combination of the two is optimal. In fact, knowledge of how fire behaves across landscape features in the planning area (e.g. the effect of slopes and uphill runs of fire increasing risks to uphill values) is essential.

Having identified potentially high-consequence fire paths, developing multi-layered, in-depth strategies for how prescribed burning can be used in conjunction with other strategies can maximise the opportunities to prevent or mitigate high-consequence outcomes from unplanned fire events.

Conceptually, prescribed burn strategies for mitigating bushfire can be considered across three scenarios:

1. **Identify locations where high-consequence fires can start and escalate**

   It is preferable, where possible, to prevent fire reaching high-vulnerability areas; far preferable to attempting to undertake defence of settlements and urban interface areas against oncoming fire fronts in adverse weather conditions. The first defensive opportunity therefore is in the location where potentially high-consequence fires can start and where their early growth stages can escalate. In such areas where there are substantial expanses of fire-prone vegetation with high to extreme fuel loads which are treatable using prescribed burning, burn locations of greatest benefit to slowing or restricting fire growth in its early stages can be identified. Ridges and slopes are examples of areas that may be selected for placement of ecologically beneficial burns to limit early-stage fire growth. Such strategies can serve to improve remote area firefighting team success because the initial attack fires that remote area crews encounter are smaller and less intense than they would otherwise be. In certain circumstances it may serve to reduce fire spread so that fire does not cross strategic fire trails before crews arrive to implement indirect containment strategies. While all of these advantages will not always arise, particularly for fires that start during severe to catastrophic fire weather when fire containment in remote areas is highly unlikely to be attempted, those fires which start on days preceding such weather (as commonly occurs with lightning events) may have significantly improved prospects of being contained and controlled before the adverse weather arrives.

2. **Identify features which can be useful in containment of high consequent fires**

   The second defensive opportunity is to identify those roads, fire trails and man-made or natural breaks in fuel, strategically located in, or through, potentially high-consequence fire paths, which would likely be used to effect indirect containment of unplanned fires to prevent them spreading to high-vulnerability areas. During indirect firefighting operations, the time available before the onset of adverse weather is often insufficient to implement containment strategies without time-pressure. So fuel adjacent to such trails that is in a condition which facilitates expeditious backburning strategies can be highly valuable. They are also safer to work in, have lower risk of losing control of defensive backburns, and broaden the range of weather conditions in which backburning can be safely executed. Accordingly, selection of burn areas which enhance the fire suppression success value of strategic trails and fuel breaks is a valuable component of the prescribed burning strategy development. A synopsis of the supporting fire science is provided at Appendix 1.

3. **Reduce fire behaviour at the interface**

   These first two strategy components enhance the prospects of preventing fires reaching high-vulnerability areas in adverse conditions. This outcome is not always feasible, particularly in situations where a fire can start in adverse weather and spread to high-vulnerability locations before conditions moderate. Thus in such situations the last line of defence is fuel reduction closely adjacent to high-vulnerability areas. In such areas, reduction of the overall fuel hazard to low – moderate levels can serve to significantly reduce the intensity of fire arriving at the interface. Reducing flame heights in these interface locations, and particularly avoiding crown fire at the interface, reduces the degree of ember lofting and the size of embers that are lofted and carried downwind. A relatively low energy fire approaching through forest with a sparse shrub understorey, with a grass or compact surface litter bed dominated fuel, and with low bark hazard (fibrous bark charred by previous prescribed burns) has significantly less ember attack potential than a long-unburnt forest with near-continuous shrub understorey providing ladder fuels into tree crowns, and with abundant bark and suspended dead fine-fuel ember sources available for ignition and lofting by a high-energy fire. Accordingly, use of prescribed burning to maintain low to moderate fuel levels in interface areas is an important last line of defence strategy. The depth of fuel reduced areas at the interface will also be an important consideration.

A well designed multi-layered, in-depth bushfire risk reduction strategy will seek to take advantage of the three defensive layer opportunities defined above, noting that prescribed burning away from the interface in potentially high-consequence fire path locations can utilise ecologically beneficial fire to service multiple objective.

The foregoing discussion has focussed on prescribed burning strategy principally in relation to identified fire paths. A broader landscape focus is also prudent. Most public land tenures have fire management objectives that include the maintenance of ecological diversity and resilience, and their ability to deliver ecosystem services (for example, biodiversity maintenance, water yield/quality and erosion mitigation, and carbon sequestration). Increasingly, large private landowners are recognising the need to pursue similar aims on their land. For Traditional Owners such objectives have, for millennia, been an intrinsic part of their connection to land and are embedded in cultural obligations to care for country with fire.

In today's fragmented landscapes where remnant vegetation may exist as relatively small reserves (relative to their pre-1750 distribution) within substantially modified landscapes, situations can and do occur where all, or a very high proportion, of a reserve can be burnt out in a single high-consequence fire event or convergence of multiple fires. Appropriate action to avoid or limit such occurrences is ecologically desirable.

The strategic use of prescribed burning to break up large contiguous expanses of old, heavy fuel accumulations serves to reduce the extent and impact of fires burning in severe weather conditions. Appropriately prescribed burning can have significant ecological benefits by increasing the heterogeneity of vegetation growth stages and habitat structural diversity in the landscape. This provides more regeneration opportunities for species that take advantage of time-limited post fire conditions, reducing irreversible decline risk for species vulnerable to inappropriately long-interval fire regimes, and increasing habitat structure and composition variety for fauna. The need to use prescribed fire in landscape areas dominated broadly by old heavy fuels is given even greater importance where sustained active fire suppression has been applied and thus has contributed significantly to reducing fire regime heterogeneity and increasing fire risk in the landscape.

Some general considerations for integration of ecologically beneficial fire in prescribed burning strategies include:

- Burn more flammable fire-maintained parts of the landscape (such as grassy ecosystems requiring a shorter return interval) more frequently, and frequently enough to prevent replacement of grassy systems by shrub dominated systems;
- Burn less frequently flammable parts of the landscape less regularly (such as wetlands, rocky outcrops, drainage lines) or not at all if they require no fire. Burning fire-adapted systems adjacent to fire-sensitive areas can help maintain the effectiveness of natural edaphic process at protecting these fire-sensitive areas based on their position in the landscape, as these areas are often naturally protected from lower intensity fire but not from high intensity fire;

4. PRINCIPLES FOR THE STRATEGIC AND PROGRAM PLANNING PHASES OF PRESCRIBED BURNING

(Source: Department of Parks and Wildlife, Western Australia)

- Vary season, frequency and interval across the landscape – with infrequent hotter fires to favour regeneration of those species requiring hot burns (this requires careful consideration as unplanned fires of greater intensity than those prescribed may already be servicing this requirement);
- Disperse burnt patches through the landscape to create a heterogeneous fuel age/vegetation growth structure distribution; and
- Reduce the connectivity of older fuel patches where this is high.
- Where modelled fire simulation systems are available, different strategy options involving integrated, multi-layered strategies can be tested to optimise burn placement selection.

Decision point

Decide how the landscape assessment process will be implemented to identify potentially high-consequence ignition areas and fire paths. Identify where in the landscape ecologically beneficial fires should be planned for the maintenance of biodiversity and ecosystem resilience, where possible locating these so they also have benefits for reducing other risk dimensions. Identify the key strategic locations in the landscape where features such as roads, strategic fire trails, and other man-made and natural fuel breaks would facilitate defensive firefighting in the event of fire threats to high-vulnerability areas in the landscape. Decide where prescribed burning should optimally be placed to facilitate control of fires before they can reach high-vulnerability areas. Decide where prescribed burning can be used to provide last line of defence next to high-vulnerability areas.

4.5.5 Principle 9

Principle 9

Risk-based fire management zoning or prioritisation systems should clearly specify treatment regimes and specifications for both life and property protection and for maintenance of ecological resilience.

Why is this principle important?

Strategic planning needs to provide understandable, practical direction in relation to how burning strategies are intended to be applied so that program planners can readily interpret what is required for implementation of the strategy. This is usually achieved via a fire management zoning plan, although other prioritisation systems are possible.

Vague strategies, such as those that lack clarity on the fuel, timing and/or ecological condition criteria that should trigger selection of areas for inclusion in a burn program, run the risk of not being implemented effectively. Therefore, it is important to provide clear criteria for determining what attributes indicate that a site should be selected for burning, thus enabling the strategic plan's intent to be reflected in the program planning phase. Where it is intended to seek general public stakeholder views and input on a proposed strategic plan, strategies will need to be expressed using concepts and language that can be readily understood by the general public.

General guidance notes

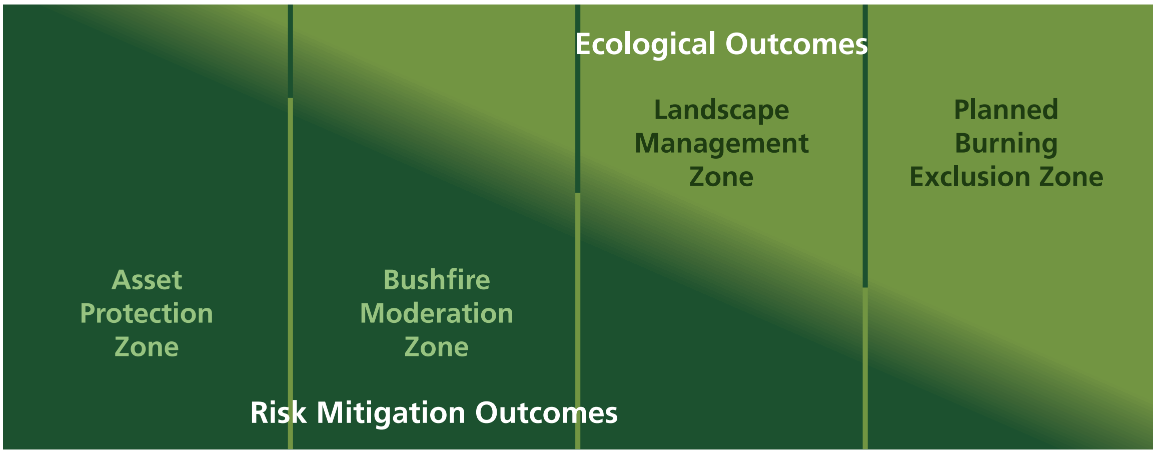
Nearly all jurisdictions use fire management zoning concepts to depict where different fuel management treatments and specifications are to be applied. Commonly used zoning concepts include:

- '*Asset Protection Zone*', also known as '*Asset Zone*', '*Protection Zone*', '*Hazard Separation Zone*', '*Defensible Space*' or similarly named concepts. While the subtlety of the concepts used varies, in general these are intended to be applied in the immediate vicinity of assets which are vulnerable to fire impact, effectively being a last line of defence, and will generally require the greatest degree and frequency of fuel modification and reduction. They are generally relatively small in size providing localised protection (in some cases zone widths are in the tens of metres, in others they may be larger with widths measuring in the hundreds of metres and in some places exceeding 1 kilometre in width). They tend to represent a very small fraction of the broader landscape (often being of insufficient size to be discernible on landscape scale maps) but are usually the most resource-intensive and therefore costly to implement due to their close proximity to communities or identified assets. Sometimes the zone concept extends to the protection of natural values, though it is usually reserved for built assets.
- '*Bushfire Moderation Zone*', also known as '*Strategic Fire Advantage Zone*', '*Strategic Fuel Management Zone*', '*Wildfire Mitigation Zone*', '*Bushfire Buffer Zone*' or similarly named concepts. These zones vary slightly in their intent, scope and application. In many jurisdictions they can be used to supplement A*sset Protection Zones*, and are generally intended to substantially reduce the behaviour of a bushfire, although generally not intended to stop fire spread under all conditions. The degree of desired fire behaviour reduction is generally to minimise the potential for crown fire development, absorb ember attack from approaching fires and reduce ember attack to nearby assets, and facilitate fire suppression from an adjacent pre-existing control line. While the purposes for which they are applied vary, they are commonly placed next to *Asset Protection Zones*. They may also be placed adjoining roads or strategic fire trails where planning indicates these are preferred locations for fire containment away from the immediate vicinity of communities. They are also applied in locations that have a high incidence of human-caused fire ignition, and in locations considered of high strategic value in reducing fire growth and escalation

potential of fires starting in areas where it is considered there is significant potential they could become a serious threat to community safety.

- '*Landscape Management Zones*', also known as '*Land Management Zones*', '*Conservation Land Management Zones*', '*Conservation Zone*', or similarly named concepts, noting that in some jurisdictions this category is split into sub-types applicable to a specific type of land management. Generally, this zone is applied to any bushfire prone areas which are not in one of the previously described zones, nor designated as a *Fire* or *Prescribed Burn Exclusion Zone* (see below). *Landscape Management Zones* generally allow prescribed burning to be used (subject to any statutory and regulatory requirements), allowing for land managers to pursue their specific land management objectives. This includes burning to maintain ecological resilience and other more specific ecological purposes, but also for a range of other objectives such as water catchment protection, forestry, livestock pasture management and others.
- *Fire* or *Prescribed Burn Exclusion Zones* – these are applied where planners consider it would be inappropriate to use prescribed burning, and in some areas this extends to excluding (or attempting to exclude) all fire including unplanned fires.

Figure 4 *Fire management zones, Department of Environment, Land, Water and Planning. Victoria*



With regard to the above zoning systems, *Asset Protection Zones* typically have the clearest and most prescriptive specifications in terms of dimensions and descriptors of fuel characteristics to be achieved and maintained. For those in which prescribed burning is used as the method of fuel management, maximum fuel specifications may be specified, or a maximum or indicative treatment interval/cycle specified (typically not exceeding five years).

Bushfire Moderation Zones are often less prescriptively specified. Some jurisdictions use overall fuel hazard category limits, others may specify indicative treatment cycles. Where these exceed five years and extend closer to 10 years, the fire behaviour reduction benefit in terms of facilitating improved fire suppression prospects may be marginal.

In the *Landscape Management Zone* fuel specifications or treatment cycles are typically left open to the land manager to decide. This means that in strategic planning, land managers will need to define what approach they decide to undertake in this zone, to guide program planners. In the past, specifications for landscape management zones have often been vague or too broad. The common consequence of unclear guidance at the strategic planning level is that little gets planned at the program level because of the lack of directional clarity. The requirements of *Landscape Management Zones* can be expressed through sub-zones such as '*Conservation*', '*Sustainable production*' or '*Rehabilitation*'. Ideally each of these would come with clear and detailed fire regime/management requirements. The fire regime requirements for *Conservation Zones* will vary for each vegetation type or group, and it is important to specify fire regime requirements for each.

Whether a jurisdiction uses a fire management zoning system along the lines of those described above, or an alternative system, the key point is that strategic plans need to be clear on how the zoning or prioritisation system is intended to be applied so that program planners can plan accordingly.

More information on applying zoning strategies is available on page 93.

Decision point

Decide how the system of fire management zoning or other prioritisation system is to be applied through the strategic planning process and provide clear direction about treatment intervals and/or the fuel and ecological condition triggers (for each fire management zone or subzone) that indicate a site should be selected for burning in a burn program.

4.5.6 Principle 10

Principle 10

Different vegetation types or land management units require different approaches in terms of fire management, and some are not suitable or practical for prescribed burning – strategic plans should articulate management regimes for different vegetation types and/or land management units.

Why is this principle important?

Many Australian ecosystems are adapted to a regime of fire (fire-adapted), while others do not require fire or are damaged by fire (fire-sensitive). Also, there are some areas where burning is not technically feasible within contemporary policy and technical constraints, and there are other places where the opportunity to burn safely and in a way that all objectives can be met, is highly constrained. Further, there may be areas of land within the planning area, such as production areas, where fire should be avoided or prescribed fire is required to support production processes, rather than as a risk reduction process.

General guidance notes

The concept of fire regime describes the general pattern of fires that has occurred, or is desirable to occur, in an area over space and time. A fire regime includes consideration of fire frequency, fire extent, fire season, fire intensity, fire patchiness, and the ongoing combination of these factors (AFAC 2016b) as described below:

- Fire frequency is the period of time between fire events, but is sometimes expressed as the number of times fire has occurred over a particular period. Fire frequency is heavily influenced by the concept of tolerable fire intervals, but be aware that this concept has significant limitations as discussed in Appendix 2;
- Fire extent is the area burnt by a fire. Fire extent affects the mosaic pattern of a fire at a landscape level, reflecting that different parts of the landscape have been targeted for prescribed burning at different times;
- Fire patchiness is the pattern of burnt and unburnt fuel within the footprint of an individual burn, reflecting the in-burn mosaic or micro-mosaic of a fire;
- Fire season is the time of year that a fire occurs. Some ecosystems will have preferred seasons for fire, many will have a season in which fire is not recommended, but often some variation in fire season is desirable, so that the benefit to or impact on different species is balanced. Sometimes it is important to

avoid a particular season or month of burning due to the presence of endangered, vulnerable or rare species that may be vulnerable to fire at that time, for example, because they are nesting; and

- Fire intensity. Low intensity fires are usually recommended for prescribed burning, because most species have recovery or survival responses for these kinds of fires. However, in some instances high intensity fire is desirable (e.g. to rehabilitate an area by reducing overabundant trees, to remove certain weed species, or because certain species are present that require sufficient heat to stimulate seed germination). Often the higher intensity fire does not need to be programmed since it is likely to occur at some stage without planning as a result of bushfire.

Support for determine suitable fire regimes for vegetation types or land management units can be gained through:

- Agency guidelines or databases that provide information on recommended fire regimes for ecosystems or groups of similar ecosystems;
- The local knowledge of experience fire practitioners;
- A literature review of relevant scientific research; and
- Engagement with stakeholders that have specialist management knowledge regarding the land area concerned.

Management decisions regarding each vegetation or land management unit need to be nuanced based on the practical constraints of the planning area. It needs to be understood that the fire regime recommended via guidelines may not apply in a given situation, and a decision to apply a different management regime may be taken because:

- It may be determined that treatments to reduce fuel other than prescribed burning (such as mechanical removal of fuel) are more suitable or practical in some areas, especially adjacent to assets;
- The ecological condition of the area differs from what might be regarded as a healthy condition, and some sort of different regime is required in order to rehabilitate the area;
- The ecological condition of the area may have deteriorated to the extent that it is no longer practicable to return it to health and therefore a decision may be taken to not attempt prescribed burning;
- The area may be transitioning to a different ecosystem due to changed fire conditions over many years. A decision may be taken to either let this area transition or attempt to return it to a previous condition utilising prescribed burning. Some consideration of the practicalities of rehabilitating this area is required, as well as considering how well conserved different ecosystems are within the region. If an ecosystem is rare or threatened, this gives greater impetus to attempt to return it to health;
- Areas within the planning area may contain a different assemblage of vegetation than indicated by maps. Alternatively, a single mapping unit may contain variation within it and may not be fine enough to pick up localised vegetation differences. For example, ridgeline areas may contain grass dominated understoreys while slopes contain shrubby understoreys. It is desirable to treat the grassy ridgeline with a different fire regime to more shrubby areas;
- The management regime is directed toward some sort of production outcome such as logging, and therefore the fire regime needs to be optimised toward commercial outcomes; and
- Some areas are not suitable for prescribed burning (see over).

4. PRINCIPLES FOR THE STRATEGIC AND PROGRAM PLANNING PHASES OF PRESCRIBED BURNING

For a range of reasons, some bushfire-prone parts of the landscape cannot be treated with prescribed burning. A few among the many reasons include:

- Some vegetation types have fuel characteristics which make it too risky or technically difficult to burn them in a reliably controlled way at low intensity (for example some tall wet sclerophyll forest types that are difficult to burn at low intensity, and only attain a condition conducive to fire spread when landscape fire risk is high). These vegetation types may cover substantial areas in some landscapes;
- Some widespread agricultural land use or production systems may be incompatible with using fire within that system (such as some rangelands used for livestock grazing where controllable fire is possible only when there is continuous grass cover, but such grass cover events are rare and the fuel is the food source for livestock);
- Some ecosystems are sensitive to fire and benefit from fire exclusion (although it may often be beneficial to burn in fire-prone systems adjacent to such ecosystems, to reduce the risk of unplanned fires penetrating and adversely impacting fire-sensitive systems);
- Some threatened fauna and flora may have habitat requirements for long-unburnt mature to over-mature vegetation growth stages, which may be rare at the time of planning and therefore need protection from types of fire that would alter the specific habitat requirements;
- Fire sensitive timber plantations that may suffer adverse timber quality impact from even low intensity fires – these may cover substantial areas in some landscapes; and
- Some vegetation types are unable to be burnt at low intensity and thus can be very difficult to control. These may pose intolerable risks for prescribed burning when they occur in close proximity to vulnerable assets (for example, some tall heath types with sparse ground fuels, which only sustain fire spread through the vegetation canopy in windy conditions). Alternative risk reduction methods may need to be considered in such areas.

For a range of reasons, there are times of the year when it is not possible or practical to undertake prescribed burning. A few, among the many reasons include:

- Times when seasonal conditions or weather patterns preclude burning – too wet, too dry, or too risky (in some landscape areas, the opportunities to safely and effectively conduct prescribed burns may be very limited);
- Peak times of local economic activity when there is particular sensitivity to smoke or fire, when it is prudent to avoid prescribed burning so as to avoid intolerable impacts on those peak activity periods (examples may include peak tourism times when smoke-sensitivity is heightened, or agricultural production stages such as the veraison period for wine grape production); and
- Times of the year when the resources needed for prescribed burning may have restricted availability due to other requirements (such as peak crop harvesting periods likely to preclude volunteer burn crew availability in some agricultural areas, or fire season shoulder periods when burn crews may be required for fire suppression).

Identifying these prescribed burning strategy constraints is important so that stakeholders can understand the operating context to which prescribed fire can be used in the landscape, and the limitations to reducing bushfire risk through prescribed burning in some landscape locations. For example, in landscape areas dominated by vegetation types which are untreatable using prescribed burning, such as tall wet sclerophyll forests that will only burn in dry summer conditions when burning may be too risky, it will be important to acknowledge these limitations so that stakeholders may appreciate the heightened importance of other risk reduction strategies in those areas.

While the operating constraints need to be acknowledged, it also needs to be made clear that failure to achieve all bushfire risk management objectives can arise if the application of prescribed fire is avoided altogether (especially if its use is avoided even in ecosystems adapted over millennia to human application of fire), or applied at ineffectual spatial and/or temporal scales, whilst maintaining a strong fire suppression-oriented program. The unintended consequence can be to create fire regimes with little variety or heterogeneity, with sustained fire suppression facilitating widespread fuel build-up across landscape areas. Fires igniting in or ahead of adverse weather conditions can become uncontrollable, creating the potential for large, severe and potentially catastrophic fire events with very highly adverse consequences for life and property protection and land management objectives.

Increasingly, it is near impossible to exclude fire from natural areas for extended intervals. Managing large tracts of land in a way that results in large areas with very high fuel levels (with low fuel areas only present at a very small scale) increases the potential that, when unplanned ignition and subsequent bushfires do occur, their extent, intensity and impact has the potential to be maximised. Thus it is important to articulate what the likely consequences are for the no treatment scenarios, as these may carry significantly higher risks than those perceived to arise from the use of prescribed burning.

Decision point

Identify fire regimes for different parts of the landscape. Identify the practical constraints that affect prescribed burn strategies, and identify areas that should be excluded from the plan, or included but in which fire will not be directly applied.

4.5.7 Principle 11

Principle 11

To optimise the benefits of prescribed burning strategies, other complementary risk reduction actions need to be identified (pursuant to a 'shared responsibility' model), and articulated in the strategic plan.

Why is this principle important?

Prescribed burning is only one of a suite of strategies that can be used to achieve a desired objective e.g. reduce bushfire risk, and/or maintain or enhance biodiversity. Often, strategic plans integrate the achievement of objectives across a wide range of strategies, and prescribed burning may be only one part of a bushfire management plan.

If prescribed burning is the only bushfire risk reduction strategy carried out, then risk may not be appreciably reduced in situations where homeowners, for example, allow leaf litter to accumulate on roofing, gutters and decks, allow fire prone garden plants in close proximity to their house, or store flammable belongings on open verandas. In these situations the benefit of any prescribed burning in adjacent bushland and landscape areas may be negated as burning can reduce but rarely eliminate ember attack.

Thus it is important that strategic planning integrate the achievement of objectives across a range of strategies. It is also important to make clear the limits to which prescribed burning, together with other complementary strategies, can reduce risk, identifying the nature of residual risks particularly in severe fire weather. If these matters are not made clear, then individuals may make poor, potentially unsafe decisions based on false assumptions that prescribed burning has eliminated or is able to reduce their risk more than it can.

Appendix 1 examines the evidence supporting the use of prescribed burn in consort with other fire risk reduction strategies.

(Source: Bushfire and Natural Hazards CRC)

General guidance notes

Be clear on the range of risk reduction strategies that can be taken to achieve the objectives of a strategic plan, be they bushfire risk reduction objectives, land management or other objectives.

Planning should include assessment of fire behaviour potential in worst-case conditions, at the locations where values and assets are vulnerable. Document how prescribed burning is expected to contribute to risk reduction, but also document the expected residual risk, so that people are aware of what other strategies are required in addition to prescribed burning, to manage their risk. Identify what complementary risk reduction measures can be taken by others. There may be a range of different stakeholders with different complementary actions to take.

Decision point

Identify who the major stakeholders are in the planning area, and what risk reduction actions they need to take to maximise the risk reduction effectiveness of prescribed burning. Decide how to incorporate advice relating to shared responsibility identification within the plan.

4.5.8 Principle 12

Principle 12

Clear systems and processes need to be established and agreed for plan implementation, for monitoring and reporting, and program evaluation – these should be articulated in the strategic plan.

Why is this principle important?

A plan can only be effective if it is implemented. Accordingly, within a strategic plan it should be articulated how the plan is to be actioned over the period to which it applies. This can be as simple as making clear who is responsible for leading or taking actions required by the plan, by when or on what cycle, and with which collaborators or supporting parties. This also facilitates monitoring and reporting on implementation of the plan as there is clarity around who needs to do what, by when. Plans that are not clear in this regard run the risk of falling short in their implementation because responsibilities and action timeframes are not sufficiently clear.

General guidance notes

Strategic plans may be written such that various matters requiring action arise throughout the body of the plan. Unless the various matters requiring action are collated together into a consolidated 'action plan' or 'implementation plan' within the plan, or an appendix to the plan, it can be more difficult than it should be for those with action responsibilities to find out what they need to do and by when. This is particularly the case when people or parties not directly or personally involved in the strategic planning process are required to take implementation actions. It is generally good practice to provide an implementation plan or summary of required actions within the plan.

Additionally, there is the matter of what monitoring and reporting process is to be applied to ensure the strategic plan is being implemented as intended. This can be as simple as putting in place a periodic reporting requirement under which those listed in the plan as responsible for undertaking planned actions report on the progress of their actions, and whether there are any impediments or issues identified that may adversely affect implementation over the remaining life of the plan.

There are internet-based systems that provide a means for those with implementation responsibilities to enter completed activities as they go, so near-live progress monitoring is facilitated.

Decision point

Decide and document responsibilities for various actions necessary to implement the plan. Decide and put in place an appropriate implementation, monitoring and reporting framework to provide transparency around implementing the plan.

4.5.9 Outputs from the strategic planning process design

The outputs from applying principles 6 to 12 are:

- The strategy for engaging with relevant stakeholders: to work with *collaborators*, understand the concerns and needs of those prudent to *involve*, to receive input and potential options from those wanting *consultation*, and *informing* the broad stakeholder community of the decisions and outcomes;
- Selection of the methodology to be used to conduct the key components of the strategic planning process, including:
  - The framework of objectives and performance metrics (at both outcome and activity level) that will be used in the strategic planning process;
  - The method for assessing risk, for which the prescribed burning strategy is intended to reduce; and
  - The strategy and system through which prescribed burning will be applied in the landscape to reduce identified risks and manage landscapes, whether they be for life and property, particular land or ecological management objectives. The output is commonly in the form of a map-based zoning system (noting that there are other systems that can be considered as discussed in these guidelines). It is very important also to decide the best way to deploy the system (where, when, how much, how often, what dimensions and arrangement) to reduce risk.
- The implementation strategy, including identification of actions, additional to prescribed burning, that need to be taken by others to realise the full benefits of risk reduction achievable via the prescribed burning program; and
- The monitoring and evaluation strategy to be employed to evaluate program effectiveness and identify future opportunities for improvement.

Appendix 3 contains a range of innovative concepts, tools and ideas developed by various Australian state and territory agencies to assist with strategic planning decision making.

4.6 Program planning principles

As identified in Section 4.2, the program planning phase operationalises the prescribed burning strategy, and usually consists of an annual (in northern Australia) to three to five yearly (southern Australia) burn program (work schedule) listing the work types, amounts, sequencing, and (approximate) timing to implement strategic level objectives.

The following section details the eight principles (Principles 13 – 20) associated with this phase.

4.6.1 Principle 13

Principle 13

Strategic planning assumptions can change by the time program planning is undertaken – check assumptions (especially fire history) and engage local knowledge in the planning process.

Why is this principle important?

The strategic plan may have been prepared a number of years prior to when a burn program is being prepared, and therefore it is possible that some important assumptions about landscape fuel hazard condition and other risks may have changed. Accordingly, a check of the major assumptions in the strategic plan, particularly those things which can change to a significant degree or in short time scales, should be made prior to the development of the burn program.

General guidance notes

There is a range of important assumptions about landscape fuel hazard condition and bushfire risk which have the potential to change between strategic planning and program planning. Such matters for consideration may include:

- A large bushfire, or several significant bushfires may have occurred since strategic planning, significantly altering the state of fuel hazard and risk distribution in the planning area;
- Significant fuel and/or ecological condition changes may have occurred from causes other than fire, such as recent logging, introduction of grazing, weed invasion or proliferation, or unforeseen increases in understorey fuels (especially near surface and elevated fuels) which may preclude low intensity prescribed burning;
- Significant land use changes such as new urban developments across areas that were previously bushfire prone vegetation, or large tracts of previously grazed grasslands which have been planted with timber plantations, or irrigated agriculture areas which have reverted to dryland agriculture; and
- Cyclone-impacts, major storm or flood events which have caused changes to fuel hazard levels and fuel distribution.

Where the risk and/or fuel profile has changed significantly since the strategic plan was prepared, the objectives in particular areas may no longer be valid. In particular, recent major bushfire events can impact objectives such as:

- Previously long unburnt landscape areas identified in the strategic plan as areas requiring prescribed burning to diversify post-fire growth stage distributions may no longer require planned fire, or need less than originally planned, if a recent bushfire has impacted the area;
- Opportunity to re-introduce prescribed burning into an area that was previously unable to be safely prescribed burnt due to high fuel and risk levels;

- Opportunity to utilise the low fuel levels after a major bushfire to introduce a pattern of low-intensity mosaic fires to begin to establish heterogenic fuel and vegetation growth stages;
- Treatment of specific areas or zones to achieve a risk reduction benefit already achieved by unplanned fire; and
- The proportion of a specific zone that is due to be treated.

The occurrence of extreme climate cycle events may also significantly influence program planning for a particular year, for example:

- A long term drought which has resulted in removal or substantial reduction in grass fuels, and extremely dry woody fuels;
- A long term drought which has changed the availability of fuels and the expected response of ecosystems to fire;
- A long term drought resulting in the landscape becoming destocked (of grazing stock and exotic and native herbivores) followed by rains which result in abundant and well connected grass fuels; or
- Sustained above average rainfall periods which result in abundant and well connected grass and shrub fuel across the landscape.

Local knowledge, fire history, current fuel hazard profiles, ecosystem condition and other information should be cross-checked to determine if they still reflect the intent of the original strategic plan objectives. If they do not correspond, document this variation and preliminary revised objectives for updating the strategic plan and providing justification for the burn program selected.

Decision point

Decide if the risk profile and the prescribed burning objectives for the strategic planning area are still current and if not use local knowledge and updated datasets to guide selection of prescribed burning areas.

4.6.2 Principle 14

Principle 14

For a range of reasons, some areas will be a higher priority for burn scheduling than others – using a risk-based approach, consider relevant factors affecting burn priority.

Why is this principle important?

Further progressing the risk-based approach to planning applied during the strategic planning phase, it is also important that a risk-based approach is implemented at the program planning phase. The risk evaluation step provides a starting framework for prioritising risk control works such as prescribed burning – higher rated risks are normally a higher priority for control action than lower-rated risks. Agencies tend to have documented approaches for assigning risk to burns. These are often influenced by the values at risk, type of burn, complexity of burn and fire management zone among other matters.

However, with the intention of ensuring that limited resources are applied in the most effective and efficient way, there are additional matters beyond the risk rating that need to be considered. Such matters include considerations about:

- Operational feasibility and efficiency. For example, areas in close proximity may be scheduled together or in sequence for more efficient use of prescribed burning and fire control line preparation resources;

- Resource requirements and costs for treatment and what operational limitations these might impose;
- Fire history considerations with regard to triggers for treatment within fire strategies (e.g. is the area overdue as compared to recommended fire regime);
- Seasonality considerations with regard to safety (e.g. seasons favourable to prescribed burning conditions) and the requirements of ecosystems and species (e.g. ecosystems or species may have guidelines about seasons that are preferred or that should be avoided);
- The current condition of fuels, vegetation communities and landscapes; and
- Smoke considerations including consideration of cumulative smoke impacts on airsheds, communities, community events and smoke sensitive locations.

These matters are appropriate to consider at the program planning stage when site selection and treatment options are being considered.

General guidance notes

The program planning phase essentially involves:

- Considering the objectives and planning outputs developed during the strategic planning stage (typically maps identifying different management zones, each of which should have criteria for deciding whether or not burning treatments within the zone are necessary or desirable); and
- Analysing and prioritising burning program delivery options and deciding what program of works will best achieve the objectives during the program period with the available resources.

Different burn selection decision criteria will be relevant for different burning objectives.

Burn prioritisation considerations to meet public safety and property objectives

In relation to public safety and property risk reduction objectives, risk assessments conducted during the strategic planning phase (or upon which the strategic plan is founded if conducted separately) are a key input (but not the only input) to deciding priorities. In a public safety and property risk context, bushfire risk assessments are typically based on assessing the potential consequence of bushfire impact, and the likelihood of impact occurring. The consequence and likelihood ratings are then typically combined through a two dimensional matrix to give a risk rating. Some lower levels of risk may be considered tolerable, but other higher levels of risk are often identified as requiring treatment, with the priority for treatment increasing according to the risk rating. Areas assessed to have extreme risk levels are typically the highest priority for risk reduction. In considering burn priority for inclusion in a burn program, for areas identified as at the upper levels of risk, an assessment needs to be made regarding what combination of burns to apply in different zones to optimise risk reduction. This may not be as simple as limiting consideration to treating an Asset Protection Zone. While such a treatment can reduce risk, it may not reduce risk to as low as reasonably practicable (ALARP – see Principle 6). There will often (but not always) be additional options beyond the Asset Protection Zone that are both reasonable and practicable, so it is important to consider and assess these.

The process for deciding what landscape arrangement of burns to nominate in a program is similar to the multi-layered planning approach outlined in Principle 8, except that at the program planning level it is additionally necessary to consider how much and what pattern of burnt areas are currently in place, so that new areas can be nominated which augment the existing situation. Other things being equal, at-risk areas that have relatively little in the way of fuel reduced areas in the direction from which bushfires are likely to come will normally be a higher priority for treatment than areas that already have a reasonable level of risk reduction in place.

Burn implementation feasibility is another important consideration. There will be circumstances where it may be more effective to plan a lower number of larger but less difficult and less resource-intensive burns than to pursue a program with a larger number of small but difficult and resource-intensive burns. There will be other situations where the former approach is not technically feasible (e.g. where there are large expanses of untreatable vegetation types or problematic terrain), and thus the latter approach is preferable. With regard to considering burn feasibility factors, there will be site-specific stakeholder needs, concerns and collaboration opportunities to be considered (see Principle 15), and considerations for reducing delivery risk that also require analysis (as outlined in Principle 16).

Burn prioritisation considerations to pursue ecological resilience maintenance objectives

When it comes to prioritising burn areas for achieving ecological objectives, there is a range of issues to consider. It is rarely a case of making decisions based solely on whether candidate burn areas are within or outside tolerable fire intervals for a vegetation type/group. There are many other issues to consider, including (among others):

- For a particular vegetation type, at landscape level consider what proportion of that type is in different seral stages/time-since-fire classes, and how those are distributed in the landscape. If seral stages/time-since-fire classes are disproportionately biased to the mid-range to maximum fire interval (or longer) then there may be a case for selecting areas for ecologically beneficial burning to increase seral stage/habitat diversity. Where in the landscape to plan such interventions can be influenced by the current distribution pattern of different seral stages/time-since-fire classes, burn feasibility considerations, as well as consideration of where ecologically beneficial burns may best be placed to support other objectives such as public safety and property risk reduction and breaking up large contiguous tracts of vegetation with a high degree of time-since-fire uniformity;
- A second and related consideration is in terms of both the current ecological condition and burn treatment feasibility. Some vegetation types may, as a result of long absence of fire, have attained a condition which is too difficult/risky to treat with prescribed burning and/or may have reached a condition such that it is doubtful that a burn could restore a healthier condition, and at worst may exacerbate it. In the same planning area there may also be areas where the same vegetation type is in a relatively healthy condition but would benefit from burning to prevent it transitioning to a less healthy or different state. Although in risk assessments the former situation (advanced degradation) may be rated as a higher ecological resilience risk, treating the latter (relatively healthy state) may achieve better ecological outcomes and be a more prudent use of limited resources. As an example, such situations can often arise in forests or woodland types which in their healthy state have open, diverse grass/herb-dominated understoreys, but which in the sustained absence of fire may undergo transition to an increasingly dense shrub (and potentially invasive weed) dominated understorey with an increasingly prolific seedbank. In such a case, a focus on prioritising burning to areas with healthy, diverse grass/herb-dominated understorey condition to maintain their health will often be a better strategy than prioritising burning effort to areas in poor condition (in an attempt to reverse shrub domination and ecosystem decline and transformation but inadvertently allowing the healthy systems to transition to less healthy states). As identified in *A Risk Framework for Ecological Risks Associated with Prescribed Burning* (AFAC 2016b), a simple and useful example of how condition of ecological condition can be used in program planning decision making in Queensland is outlined in *Planned Burn Guidelines – Southeast Queensland Bioregion of Queensland* (DNPRSR, 2013); and
- It may be the case that in the planning area consideration needs to be given to the specific fire regime requirements of a particular threatened species. For example, flowering rates in some terrestrial orchid species which occur in native grasslands or open grassy woodlands have been found to decline with time since fire, as native grasses attain increasing levels of site occupation. Should such species have a

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(Source: Queensland Parks and Wildlife Service)

small population, and their distribution is restricted to relatively small areas, then to enhance ecological resilience of such a species, it may be important to plan and conduct prescribed burning in a portion of the sites they occupy, particularly if the fire regime prevailing across its limited distribution is relatively uniform and unfavourable. In a planning area there may be a range of flora and fauna species which have particular habitat requirements that can be manipulated by fire, which require specific consideration in burn program planning.

For more detailed guidance on assessing ecological risks, refer to AFAC's *A Risk Framework for Ecological Risks Associated with Prescribed Burning* (AFAC, 2016b).

Burn priority considerations to meet land management objectives – Savanna burning example

Tropical savannas are one of the most fire-prone ecosystems on Earth. Fire frequencies are often high. Changes in landscape fuel condition are highly dynamic arising from annual grass replenishment cycles, rapid drying cycles and high rates of fire occurrence in the landscape arising from both prescribed and unplanned fires. Accordingly, the distribution of recently burnt areas in the landscape can change rapidly from month to month during the dry season, and even at weekly timescales changes can be significant toward the end of the Early Dry Season during which most prescribed burning occurs.

Accordingly, program planning in tropical savanna landscapes is not like the relatively static process often applied in southern Australia where annual or seasonal burn programs are planned many months ahead of implementation periods. In savanna systems planning is dynamic and an iterative process that commences before the Early Dry Season and continues throughout it. The process entails ongoing monitoring of burn scar mapping (produced from satellite imagery and updated daily) which is used to determine the arrangement and age of burnt patches in the landscape. The burn planning thought process essentially involves assessing how prescribed burning can be used to link up already low fuel areas in the landscape (and/or areas not yet in a condition ready to burn), such that joined-up low fuel patches can be created in the landscape which can serve to limit the spread of unplanned fires when they start later in the dry season. In simple terms, the process is akin to a join-the-dots process where the dots are low fuel areas, and prescribed fires are used to link these together in a way that provides a labyrinth of recently burnt corridors, buffers or patches within the broader fire-prone landscape, with the aim of limiting the spread of subsequent unplanned fires.

Additionally, in consideration of managing the more fire sensitive parts of savanna landscape areas, features such as sandstone country vegetation communities are selected for burning early in the development of the dry season, soon after they are dry enough to burn so that they are burnt by relatively mild patchy fires; as opposed to fires that result later in the dry season when conditions support hotter, larger, less patchy, higher intensity and impact fires.

Thus in the savanna land management scenarios referred to above, program planning is a dynamic and strategic process in which prescribed fire interventions are planned iteratively as the burning season progresses, to maximise the likelihood that Late Dry Season fires will encounter recently burnt areas, thereby reducing their spread and impact.

Burn prioritisation to meet other land management objectives

Prescribed burning is undertaken to achieve a diverse range of land management objectives not limited to those discussed specifically above. Some of the more common land management contexts include forestry (to meet timber value protection, forest health, and silviculture objectives), native pasture management and livestock protection, catchment management for water quality and erosion/water storage sedimentation mitigation and burning as a component of integrated weed control programs.

In each different case, guidance similar to that provided for public safety and property protection applies. Risks evaluated as part of risk assessments provide a sound starting point for prioritisation – what are the key risks to be addressed through burning, and what were the outcomes of risk evaluation? From this risk-based foundation, the feasibility and effectiveness of available burn options (and combinations of options) can be analysed to identify those which offer the greatest effectiveness in terms of risk reduction outcomes and which are feasible to implement, within the resource availability and environmental constraints.

Decision point

Considering the particular prescribed burning objectives being pursued and the management zone system (if any) specified in any relevant Strategic Plan:

- Consider levels of risk identified during risk assessment, in combination with considerations about actual and planned fuel hazard distribution patterns in the landscape, analysis of the feasibility and effectiveness of candidate burn options, and consideration of program delivery capability constraints and likely seasonal condition outlooks; and
- Using decision criteria for burn prioritisation (as identified in strategic planning), decide what the highest priorities are for candidate burn area inclusion in the burn program for the period.

4.6.3 Principle 15

Principle 15

Program planning is usually the first stage of the planning sequence at which specific burn locations, boundaries and timings are nominated and thus it can be expected that additional external stakeholder interest will emerge – allow for additional stakeholder engagement activities at the program planning phase.

Why is this principle important?

Engagement with stakeholders at the local level in relation to the location and timing of a specific burn is an opportunity to:

- Obtain local knowledge;
- Determine if there are opportunities for local stakeholder participation (such as extending a burn area);
- Provide stakeholders with site specific understanding of how overall strategic goals and objectives are implemented; and
- Allow them to be part of, and create trust in, the decision making process.

It is also an opportunity to find out what specific local concerns or needs require consideration in developing a burn program.

General guidance notes

As identified in Principle 5, stakeholder involvement in the strategic planning process, using a stakeholder engagement strategy, is a means to identify key stakeholder groups and their points of interest, based on a four-level framework of *collaborating*, *involving*, *consulting* and *informing*. The key external stakeholders for site-specific burn options under consideration for inclusion in a burn program are generally not those that were formally involved in the strategic planning process. Accordingly, such stakeholders can be expected to have varying degrees of familiarity with the strategic planning outcomes, including many that may have none. Stakeholders for candidate burn areas being considered for inclusion in a burn program may include:

- Private landowners, public land managers or infrastructure owners;
- Adjoining primary industry, plantation, commercial or other land management individuals or groups;
- Traditional Owners;
- Other parties with fire management interests including fire agencies;
- Local municipalities;
- Conservation groups; and
- Other industry or local interest groups, e.g. tourism operators or associations, and Landcare groups.

Naturally, those landscapes with a large proportion of urban and peri-urban vegetation interface have the greatest potential for stakeholder interaction relative to rural or remote areas, and this interaction has to be managed practically and efficiently to an extent that does not impact on overall program delivery.

Engaging locally with stakeholders about particular candidate burn areas where they may have an interest presents an opportunity for information exchange (such as how prescribed burns and bushfires may have behaved at that location in the past and lessons they have learnt based on this experience). It also provides an opportunity to explain how prescribed burning areas are contributing to overall program objectives and goals, and establish if there is anything the stakeholders can contribute or offer to the program in a shared responsibility approach (see Principle 11). This interaction may also identify where minor adjustments can be made to the program, either adjusting the areas nominated or slightly altering the timing, to better take account of broader community activities such as those important periods for primary production or peak tourism periods. Although any adjustments have to be considered within the context of overall program objectives and burn delivery, any adjustments should not prevent or critically alter the program schedule.

Where stakeholders understand how and why a strategic burn program is being implemented, trust can be developed, and as some of the uncertainties about how and why a particular burn is being delivered are better understood, stakeholder concerns about delivery or impact risks may be reduced. Gaining the trust of key stakeholders through a shared responsibility model, and generating stakeholder confidence in the approach through delivering the program in accordance with the specified objectives, are key factors in gaining acceptance of the prescribed burning program when it reaches the operational delivery phase.

Decision point

Decide how the interaction with key stakeholders regarding candidate burn areas for inclusion in burn programs can be managed practically and efficiently to provide for mutual information sharing and participation in a shared responsibility approach, to an extent which still enables efficient overall program delivery.

4.6.4 Principle 16

Principle 16

There are opportunities to minimise program delivery risk by planning burn sequences that extend on previous burns – consider how burn program delivery risk can be reduced by multi-year and/or multi-stage sequencing of burns.

Why is this principle important?

In some cases, the operational risks of burn delivery can be reduced at the program planning phase through sequencing a series of burns so that the following burning blocks on the schedule adjoin an already fuel reduced area, reducing the extent of heavy fuel areas along the burn perimeter. This can serve not only to reduce control risk, but also to reduce the resources that may be required to manage each burn in the sequence.

General guidance notes

An area that is potentially suitable for nomination as a candidate burn area may contain or directly adjoin a range of fuel types of varying risk profiles or fire behaviour characteristics. This mix of fuel types and the potential associated implications for burn security, particularly if the burn is scheduled as a single pass burn operation, may give rise to implementation issues or result in the burn being deferred, potentially with knock-on effects for other burns. There are two broad scenarios in which this may occur:

- **A landscape with high fuel hazard extending across much of it, where a sequence of burns can be planned over successive years.** In planning the sequence of these burns, the operational delivery risk may be reduced by selecting burning blocks adjacent to the last, with the lowest risk block nominated first. In this way, burns which have at least one boundary in a low fuel condition will provide for improved burn security, particularly if burns are organised in a pattern whereby each burn has the most recent previous burn on its downwind boundary. This can also serve to reduce the resources required for safe burn implementation.

- **A large long-unburnt area that has a variety of vegetation and fuel types within it, which may not be able to be burnt in a single operation.** A proposed burn area may contain a mix of fuel types for which each type may be ready for burning at different times, due to seasonal conditions and drying patterns. Those vegetation fuel types which dry early may be too volatile to burn by the time the remainder of the vegetation fuel types are in a condition suitable for prescription burning. In such situations it may be prudent to schedule a multi-stage burn which first treats the volatile fuel types at a time when the other fuels are unavailable for burning. The remaining fuels can be treated at a subsequent burning stage when they are in a condition suitable for burning, with the more volatile fuels in the burning block having already been treated. This approach can include multiple stages of progressive burning within one block where more volatile fuel types may be treated directly either earlier in the prescribed burning season (such as swamp, wet heath or edges with bark fuels prone to candling) or later in the prescribed burning season after surrounding fuels have been burnt (such as marri-jarrah-karri fuels). A case study of successive burning of tall moist karri forests is available from the National Burning Project website www.afac.com.au/initiative/burning.

In developing a burning program, consideration should be given to multiple stage sequencing of burns which create a risk benefit for the subsequent prescribed burns in the program, either in following days or weeks, later in the season or following years.

Where it is possible to identify and schedule prescribed burning blocks as multi-stage burns (either broken up by days, months, seasons or years) at the program planning phase, this will assist subsequent phases of operational planning and delivery to achieve overall strategic planning, as well as burn operations objectives (see Principle 2 of *National Guidelines for Prescribed Burning Operations* (AFAC 2016a)).

Decision point

Select a logical sequence of blocks or patches that will make, as far as possible, the subsequent burning areas easier to plan and deliver.

4.6.5 Principle 17

Principle 17

Unfavourable weather, and potentially other factors, can be expected to impact burn program delivery in most years – build contingency into burn programs to allow for a proportion of nominated burn areas being unavailable for burning during the planning period.

Why is this principle important?

The delivery of a burn program depends on suitable weather and fuel moisture conditions to enable each burn to be delivered safely and according to the prescription set for the specific burn objective(s). Operational principles and considerations in relation to suitable weather conditions in burn delivery are identified in the *National Guidelines for Prescribed Burning Operations* (AFAC 2016a) (Principles 8, 10 and 12). However, on a year-to-year basis, it is to be expected that periods unfavourable for prescribed burning (such as wet periods or extended dry spells) may impact on the capacity to deliver a prescribed burning program. Also, it might be expected that other factors, such as the availability of sufficient resources or specialist equipment, will impact on the delivery of burn programs. Therefore, the burn program should include contingencies, such as access to extra resources or identifying additional contingency areas in case some areas are too wet or dry (i.e. areas suitable for burning when conditions are wetter than normal, and areas suitable for burning when conditions are drier than normal). This allows a degree of flexibility to be built into the burn program.

General guidance notes

Areas nominated for prescribed burning are generally based on burning under a set of weather conditions favourable for achieving burn prescriptions and security. In southern Australia weather conditions suitable for prescribed burning occur mostly in autumn and spring (but potentially also outside these primary burning periods). In subtropical regions, burning is often conducted in late-winter and early spring and late summer through autumn. In northern Australia, prescribed burning is principally conducted within the early dry season. Across all these areas the burning 'window', or the time period in which fuel moisture and weather conditions are suitable for a safe burn, is usually only of a few weeks duration in any year. In some years it may, owing to various factors, be only a few days long and pass very quickly or alternately be extended and carry into and across winter. Therefore, contingency needs to be built in to the burning program to include a range of burn areas providing options if seasonal conditions turn out to be drier or wetter than normal. Such contingency planning will enable a burning program to continue in the contingency wet or dry weather option areas, according to what conditions the prevailing weather patterns bring.

Examples of wetter weather burning areas may include the burning of:

- Heathland, sedgeland, coastal banksia or melaleuca communities where a higher fuel moisture may be sought so as to not burn peat and surface humus;
- Grassy communities such as ridgelines or valley floors where a higher burning return interval may be required to maintain healthy native grasslands, but where a moisture differential is being used to limit extension into adjoining forest areas where a longer return interval may be sought; or
- Grassy woodland and forest vegetation types where a high level of woody debris is to be retained.

Wet weather may also limit access to complete the prescribed burns, even when conditions otherwise might be favourable.

Dry weather burning areas may include wetter forest types, south-eastern facing hillsides or areas which are suffering from rainforest encroachment/canopy closure, that are rarely dry enough for prescribed burning. To maintain burn security the surrounding fuels should be fuel reduced in advance to limit the potential for escape.

Consideration may be given to including a dry, wet or normal weather categorisation as one of the descriptors in the burn program.

Decision point

Where possible, include in the burn program a range of blocks suitable for normal annual conditions, but also contingency areas to enable some burning to continue where possible, in the event of conditions becoming too wet or too dry. Also consider contingencies such as being able to access additional or external resources where required to continue the burn program in the event that resources become less available than expected.

4.6.6 Principle 18

Principle 18

Nomination of unrealistic or high difficulty/risk burn areas in a burn program can generate significant operational delivery risks, or a risk that the burn cannot be implemented – nominate proposed burn areas that are within available organisational capability to deliver safely.

Why is this principle important?

High difficulty burning blocks may contain a larger number of factors, or even a single very high risk factor, which may contribute to a potential loss of control if not mitigated. Therefore, it is important that the scheduling and planning of complex burns is explicitly considered at the program planning stage, and that such assessment is completed by one or more experienced burn practitioners familiar with the uncertainties associated with burning in such an environment. The consideration of scheduling of higher complexity or difficulty burning areas at the program planning phase reduces the potential for a disproportionately large number of complex burns being nominated in a particular program to a degree likely to exceed capability. It also allows, at the earliest stages, consideration of potential contingency areas or alternative implementation strategies, such as staged burning (see Principle 16), which may reduce the complexity.

General guidance notes

Organisational capability is identified as a key risk control dimension in the *A Risk Framework for Operational Risks Associated with Prescribed Burning* (AFAC 2016c) which identifies the objectives to:

- Maintain resources, equipment, financial allocation and a skilled workforce commensurate to the scale and complexity of prescribed burns undertaken; and
- Assess burn program quantity, complexity and technical difficulty in relation to internal capacity and capability. Decide appropriate technical skill and experience levels and resources required for assigning burn delivery responsibility.

It is desirable to avoid situations in which too many complex burns, in various stages of completion, are in progress at once, as the capability (resourcing, skill and experience levels) to manage such burns simultaneously in the event of any unexpected weather may be problematic. There is a range of factors which should be considered in assessing the complexity and difficulty for prescribed burning:

- The expected fire behaviour at burn boundary locations in relation to the condition of available control lines/features. The more locations there are where predicted fire behaviour is expected to generate resource-intensive measures to control escape risks, the more complex and resource-intensive the burn will be;
- Multiple stage burns requiring ongoing measures between ignition stages to address uncertain edges or fuel types;
- The prevalence of particular burn implementation hazard types, such as potentially hazardous trees requiring management;
- Unfamiliar and/or potentially more volatile fuels along part of a boundary;
- Very large burning blocks that may remain alight or smoulder for extended periods;
- Crews that may be unfamiliar with burning in a certain fuel type and its potential fire behaviour, topographical position and environmental context;
- Limited contingency areas or fallback lines available; or
- Smoke sensitive receptors located in very close proximity (such as hopsitals) (refer to *Risk Management Framework – Smoke Hazard and Greenhouse Gas Emissions* (AFAC 2015b)).

(Source: Adrian Pyrke, EcoLogical Australia)

Consideration of burn complexity and difficulty should not be limited to the area being burnt, but also extend to the adjoining contingency areas. For example, if a simple block is nominated but it adjoins areas of greater complexity and the crew tasked with implementing the burn is only experienced with simple burns, in the event of a burn escape into the more complex environment the crew may not be sufficiently experienced to deal with escape as effectively.

Determining the complexity of a burn in the program planning phase and identifying this complexity in the burn program will assist in subsequent operational delivery phases. Where possible the scheduling should include a mix in the complexity of burn types, in a given year and over the full schedule. Spreading out complex burns across the program with more simple burns assists in subsequent burn planning, resourcing and delivery through the program.

Where the complexity of a burn program exceeds the ability and physical capacity of available resources, cumulative effects may result across the program where prescribed burns may not be able to be delivered or objectives for program success may not be able to be achieved. Therefore, involving those who are responsible for program delivery and execution within program planning and scheduling will assist in making sure the program developed matches the operational capacity to plan and deliver the program.

Decision point

Decide whether the burn program options being considered are within the capacity of those that have to plan and deliver the program, and where possible spread higher complexity burns evenly throughout the program.

4.6.7 Principle 19

Principle 19

Most burns will require a degree of site and/or boundary preparation – allow for this in program planning.

Why is this principle important?

Burn control and security is identified in AFAC's *A Risk Framework for Operational Risks Associated with Prescribed Burning* (AFAC 2016c), as one of the four operational risk control groups for prescribed burning. Selection and confirmation of fit for purpose boundaries, including those around fire sensitive assets, is a key risk dimension for most burns. Consideration of boundary and site preparation activities at the program planning stage will determine if such works are practical, cost effective and suitable. If boundary works are identified as necessary, documenting these specific work requirements at the program planning phase allows sufficient time for their planning, approval and efficient implementation.

General guidance notes

The program planning phase should include a preliminary appraisal of the degree of site and boundary preparation works which are required at both the nominated burn area and annual program level, in order to determine if:

- They can be cost effectively implemented or if alternative boundaries and control lines are required, by extending or reducing the prescribed burn area;
- They are capable of being physically prepared (considering construction, environmental, cultural heritage, legal and other constraints which may exist);
- Nominated boundaries exist in a suitable condition, or can be made suitable for the purposes of the burn; and
- The boundary and site preparation works implemented can benefit multiple burning blocks (over multiple seasons) to create time and cost efficiencies in delivering site preparation works (particularly with machinery).

It should be noted that in northern Australia physical boundary preparation is less reliant on formed firebreaks, due to the scale, frequency and remoteness of burning involved (although fire breaks are required on the boundaries of properties). Burning is more reliant on boundaries created using previously burnt fire scars. This includes previously burnt fire scars established around sites where prescribed burning is to be excluded, although this can be complemented by mechanical works around structures.

Prescribed burns in heathland vegetation types may also be reliant on previous fire scars to act as a boundary to some extent, although they are generally paired with some firebreak preparation works.

Prescribed fire, under the right conditions, can also be used as a cost effective site preparation method around remote settlements and structures, around cultural sites and to limit fire encroachment into fire sensitive communities.

Decision point

Decide and assess at the program planning phase whether the scale of site preparation and boundary preparation works are cost effective, consistent with overall program objectives, can be practically and efficiently implemented on the ground, and are not going to generate significant environmental, social, cultural or other unacceptable impacts.

(Source: : Department of Parks and Wildlife, Western Australia)

4.6.8 Principle 20

Principle 20

Burn program delivery complexity and risk may be strongly influenced by the aggregate works volume associated with burn program delivery – consider cumulative burn security and smoke management issues over the program delivery period.

Why is this principle important?

In some cases, where burn program development is only considered as a list of individual proposed burn areas, rather than the sum of its parts, an overall delivery risk assessment may not take place to assess if the burning schedule in its entirety can be delivered safely and successfully giving consideration to the:

- Resources available;
- Complexity of nominated burn areas and the fuel types involved (and the experience of the available resources to burn these);
- Adequacy of the potential burning window in relation to the number and difficulty of burns to be delivered; and
- Potential for periods of cumulative smoke exposure on potentially sensitive receptors over an extended period.

Where these issues are not considered until the operational burning phases, the potential may exist that an unrealistic or overly optimistic annual burning schedule has been developed which is not able to be delivered, or is delivered but with considerable strain placed on resources and personnel. This elevates the delivery risk and the potential for undesirable consequences to occur. In the case of smoke management considerations, assessing the smoke impact potential of the program in aggregate can help to identify and avoid the potential for planning a group of large burns in a short timeframe, which may generate sufficient smoke to provoke an elevated level of community concern, impact and complaint.

For all the above reasons it is prudent to consider what burn security and control and smoke risks are likely to be generated through implementation of the proposed burn program as a whole over the scheduled implementation period.

General guidance notes

Considering burn program security and control risk in aggregate

A realistic assessment of whether the burning program can be delivered over the prescribed burning period must be made at the program planning phase so as to avoid initiating a program where resources and personnel will be under unnecessary delivery pressure. Where a program commences with an unrealistic workload, these pressures can become progressively amplified and can create the potential for delivery failures during the operational delivery process. Considerations for determining if the overall burn program can be delivered include:

- The need for the program to be adjusted to account for the burn season commencement overlapping with or closely following on from a long and extended bushfire season, where fatigue can become a significant risk factor if personnel are not provided adequate opportunity for recuperation. This is primarily an issue in southern Australia where the burning season can overlap with, or closely follow, the bushfire season. It should be noted that a well-structured burning program will not always be subject to delivery issues following a busy bushfire season. Where the program is structured thoughtfully, this transition between firefighting and burning operations may be relatively straightforward;
- Equipment may require deployment elsewhere, require major servicing or rebuilds during an intensive burning season or become unserviceable; and
- Staff and volunteers require leave and a stand-down period (such as returning to work or primary production activities) from fire management roles.

Burn security issues may result where multiple large burns are in progress, and contingency planning for individual burns has not considered the potential that the nominated contingency resources are not available (because they are already tasked to another simultaneous large burn). In the event that unanticipated levels of loss of burn security do arise during program delivery, this can result in significant program delivery impacts, including the potential for local suspension of the prescribed burning program.

Program sequencing and tempo

The burn program should be structured to allow burning crews to orientate into a prescribed burning program. After an active bushfire season crews may be more ready and able to make this transition, than crews starting following a very quiet bushfire season. In any case scheduling of the simpler burns at the start of the season, where possible, may be the most effective means to start the burn program, and get everybody familiar with procedures, systems and activities before progressing on to more complex burns.

Other initiatives which can assist to reduce complexity and risks associated with overall program delivery include:

- Developing an annual burn schedule which includes a mix of burns of differing technical difficulty;
- Giving due consideration to down-time provision for crews and volunteers during the program. This should factor in periods when volunteers from primary production backgrounds will not be available due to clashes with key primary production phases (such as harvest or major stock movement periods);
- Considering resources that may be available from other areas. For example, resources from other areas may be willing and able to travel and assist with burn delivery to gain experience in prescribed burning, including burning of unfamiliar fuel types. Planning engagement of out-of-area resources at the program planning phase can assist in building up the prescribed burning experience of those personnel, as well as exposing them to new landscapes they may not necessarily have much previous experience in. This can potentially better prepare them for circumstances when they may be called upon to respond to bushfires in these landscapes in the future; and
- Consideration of how best to deliver the burn program efficiently as a whole can prompt thinking to identify ways that burns can be scheduled in a manner that enhances possibilities for combining resources from neighbouring areas for geographically close burns. It may also help to avoid the inefficient scheduling of burns that results in resources being sent on unnecessary long journeys over short periods of time.

Burn program level cumulative smoke management consideration

Scheduling a significant number of large burns within an airshed, either simultaneously or in close succession, can generate sufficient quantities of smoke to attract an elevated level of community concern, impact and complaint. This can be compounded if the time of year that the burns are scheduled is particularly prone to weather pattern occurrence which is not conducive to good smoke dispersion. Impacts can be further amplified if burns are in topographic areas which drain to valleys in which smoke and fog are known to pond and concentrate, especially if there are smoke sensitive receptors present in those locations. In certain circumstances such situations may become political issues, potentially resulting in pressure for suspension of a program or a considerable downscaling, both of which may impact on the capacity to achieve the strategic program objectives. Accordingly, when undertaking burn program planning consider:

- The key program periods when peak smoke volumes are likely to be produced and the potential for poor smoke dispersal conditions to occur at those times;
- The locations where burning is proposed to take place at those peak burning times, and considering these burning locations in relation to where there are known smoke ponding areas and sensitive receptors and infrastructure; and
- On the basis of the above analyses, where the potential for significant smoke management conflicts can be anticipated, consider how program planning can be reconfigured to reduce smoke impact risks.

AFAC's *Risk Management Framework – Smoke Hazard and Greenhouse Gas Emissions* (AFAC 2015b) provides more detailed advice on methods for identifying and managing smoke risks.

Decision point

Assess and decide, at the program planning stage, if the program can be realistically delivered with available resources (both personnel and equipment), within the normal burning season and whether the program needs to be reduced in scale and/or additional resources sourced and engaged. Ensure that consideration of potential cumulative smoke impacts is factored into deciding the location, timing and sequencing of burns in the program.

4.6.9 Output from the burn program planning process

The output from applying principles 13 to 20 is a proposed works program that specifies the location, boundaries, proposed timeframe or season, burn type and other general characteristics of each burn proposed to be conducted within the program period. Burn programs may include list-like and map-based components, and also skeletal or draft burn plans. Map products are of high value for undertaking various stakeholder consultation activities carried out as part of the program planning process. It is common to advertise an approved burn program to the public through media such as newspapers or the internet so that the community is well prepared for any potential impacts.

Each of the burns nominated or proposed in the program will typically require further subsequent planning in the form of an operational burn plan, and then implementation. Guidelines for the operational planning and burn implementation phases are provided in AFAC's *National Guidelines for Prescribed Burning Operations*.

Appendix 3 contains examples of map based outputs of the program planning phase as produced by fire and land management agencies.

5. ACKNOWLEDGEMENTS

The project to produce this report was made possible through funding from the Attorney-General's Department.

The report was prepared by Paul de Mar and Dominic Adshead (of GHD) for AFAC, AGD and the Forest Fire Management Group (FFMG). The report was edited by Wayne Kington of AFAC.

The content was generated from input by AFAC member agency staff and key stakeholders and their contributions are highly appreciated. Other valuable contributions, including photographs, were received from other agency staff and their contributions are also recognised.

Front cover photograph was provided by Adrian Pyrke of EcoLogical Australia.

The National Burning Project Steering Committee has worked consistently to ensure the project attracted funding, stayed on track and achieved desired outcomes. Their contributions are also acknowledged. The National Burning Project is managed and supported through the considerable efforts of Greg Esnouf and Deb Sparkes, and earlier contributions by Gary Featherston.

(Source: Department of Parks and Wildlife, Western Australia)

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APPENDIX 1 THE ROLE AND EFFECTIVENESS OF PRESCRIBED BURNING IN BUSHFIRE RISK REDUCTION

Prescribed burning is intended to be used as one of a suite of complementary strategies which together serve to reduce bushfire risk. Complementary prevention and mitigation strategies which work to reduce the vulnerability of assets and values to fire and increase the resilience of individuals and communities are vitally important. Also important are readiness and response strategies which empower communities to prepare for and respond safely and effectively to bushfires when they occur. Prescribed burning needs to be considered a key part of a multi-factorial risk reduction strategy.

The role prescribed burning can play in complementary bushfire risk reduction strategies is by creating modified fuel areas in strategically selected parts of the landscape which serve to reduce fire behaviour when encountered by an unplanned bushfire. By reducing an unplanned fire's behaviour (its rate of spread, flame dimensions, intensity, and spotting) the fire's degree of impact (area burnt, radiant heat impact on assets, range and severity of ember attack, asset damage and ignition, and public safety impact) can be reduced. Importantly also, by reducing fire behaviour, the safety, opportunity and success prospects for fire suppression crews are increased. This may enable a fire to be controlled before the onset of severe fire weather, and/or before it can reach vulnerable assets and communities. Alternatively, it can serve to improve the safety and success prospects for response crews and communities acting to defend lives and assets in fire-impact areas.

Prescribed burns need to result in sufficient changes to fuel characteristics such that fire behaviour is demonstrably reduced to an extent which improves success prospects for the other complementary strategies.

Three key questions which arise from this are:

1. Is prescribed burning effective in reducing or modifying fuels and fire behaviour, and if so to what degree and for how long?
2. Is the nature and degree of fire behaviour reduction sufficient to improve the outcomes of complementary strategies?
3. Can implementation of prescribed burning be done such that its impacts on the environment are either beneficial or tolerable, and at an acceptable cost?

In Australia and elsewhere many decades of scientific research effort have attempted to provide answers to these questions. In considering the breadth of evidence most agencies, practitioners and researchers have come to the conclusion that the answer to the above question is a qualified *yes*.

A response to each of these questions is provided below. The responses are not intended to be a literature review, rather they provide context for the principles identified in Section 4 of these guidelines. A more detailed consideration of the scientific literature is provided in AFAC's *Overview of Prescribed Burning in Australasia* (AFAC, 2015a).

Is prescribed burning effective in reducing or modifying fuels and fire behaviour, and if so to what degree and for how long?

For many decades fire scientists and managers have understood that reducing the amount of fine fuel (<6mm diameter) will reduce fireline intensity. Byram (1959) established that fireline intensity is a function of fuel quantity, rate of spread, and heat yield of the fuel, using the equation:

Fire Intensity (I) = heat yield of fuel combustion (H) x fuel load (W) x rate of spread (R)

If fuel load and/or rate of spread are decreased, fire intensity must also decrease. How this relates to the effectiveness of prescribed burning in different fuel or vegetation types is summarised below.

APPENDIX 1 THE ROLE AND EFFECTIVENESS OF PRESCRIBED BURNING IN BUSHFIRE RISK REDUCTION

Dry open forest systems

McArthur (1962, 1967) studied fire behaviour in dry eucalypt forests and considered that increases in the amount of fine fuel (<6mm diameter) on the forest floor are directly proportional to increases in rate of fire spread. Accordingly, up until the last 15 years or so, most fire and land managers operated on the rule of thumb that if you halve the fuel load you will quarter the fire's intensity, and this was the simple mantra used to support fuel reduction burning in Eucalypt forests for more than 40 years.

From about the late 1980s, Australian fire scientists began to query the role of fuel arrangement in influencing rate of spread and fireline intensity. Many research studies are still continuing to investigate the structure of fuel and its effect on fire behaviour. One of the most comprehensive research projects was Project Vesta, which was the most comprehensive forest fire behaviour research project ever undertaken in Australia, commencing in the late 1990s. It was specifically designed to identify the effects on fire behaviour of different fuel characteristics in dry Eucalypt forests, in fuels ranging from 2 to 22 years since prescribed burning. More than 100 experimental fires were undertaken in four hectare plots under dry summer conditions of moderate to high fire danger.

The results confirmed that the factors affecting fire spread and intensity under particular weather conditions are more complex than fuel load – fuel arrangement is also an important factor. The presence and amount of near surface fuels (grasses, low shrubs, creepers and collapsed understorey, with suspended leaves, twigs and bark from the overstorey) is an important factor affecting fire spread and intensity. Bark fuels were also confirmed to be important for fire propagation by spot fires, and also contributing to fireline intensity during vigorous surface fires and crown fires. Elevated fuels extending above near-surface fuels can also influence fire behaviour via their potential to increase flame heights and invoke crown fire onset. The resulting Dry Eucalypt Forest Fire Model (DEFFM) takes account of fuel arrangement as well as fuel quantity.

Drawing on the advances in fire behaviour knowledge that have emerged from Project Vesta, in the context of prescribed burning strategy McCaw (2013) suggests:

'To significantly reduce potential bushfire behaviour it is necessary to:

- Reduce the depth, quantity and continuity of surface and near-surface fuel which contribute directly to fire spread and flame depth;
- Reduce the height of the elevated fuel layer of understorey shrubs which contribute to flame height; and
- Remove flammable and loose outer bark on tree stems that contributes to spotting.'

In open dry sclerophyll forest systems, in which the majority of prescribed burning effort is applied in southern Australia, low intensity prescribed burning typically removes most of the dead fine fuels in the surface and near surface layer (and in the process much of the live fine fuel), significantly reduces the amount of surface fuel, and may also reduce available bark fuel. The extent of fuel reduction achieved by prescribed burning depends on the amount of fuel present, the conditions under which the burn is conducted and the lighting patterns used (McCaw, 2013). After prescribed burning, fuels burnt in the surface and near surface strata are the quickest to re-accumulate through regrowth of lower strata vegetation, and litter fall from the overstorey.

APPENDIX 1 THE ROLE AND EFFECTIVENESS OF PRESCRIBED BURNING IN BUSHFIRE RISK REDUCTION

The most comprehensive recent analysis of fuel accumulation in dry sclerophyll forest systems is by Gould *et al.* (2007, 2011) from fuel research conducted as part of Project Vesta. They examined fuel dynamics in dry forests with different understorey characteristics – one group of forest sites with a sparse shrub layer, and a second group of forest sites with a dense shrub layer. The research identified that for both surface and near surface fuels the quickest recovery rates are in the first 5 years. After 5 years, combined surface and near surface fuel loads reach 54% (in dense shrub understory sites) to 68% (in sparse shrub understory sites) of the loads they are projected to achieve after 25 years. Based on analysis of the Project Vesta findings in relation to post-burn fuel accumulation, Cheney *et al.* (2012) identified average fuel scores (using the Vesta fuel scoring system[3]) for different age fuels in dry eucalypt forest with shrub understoreys (Table 2).

Table 2 *Average fuel scores for different age fuels in dry eucalypt forest*

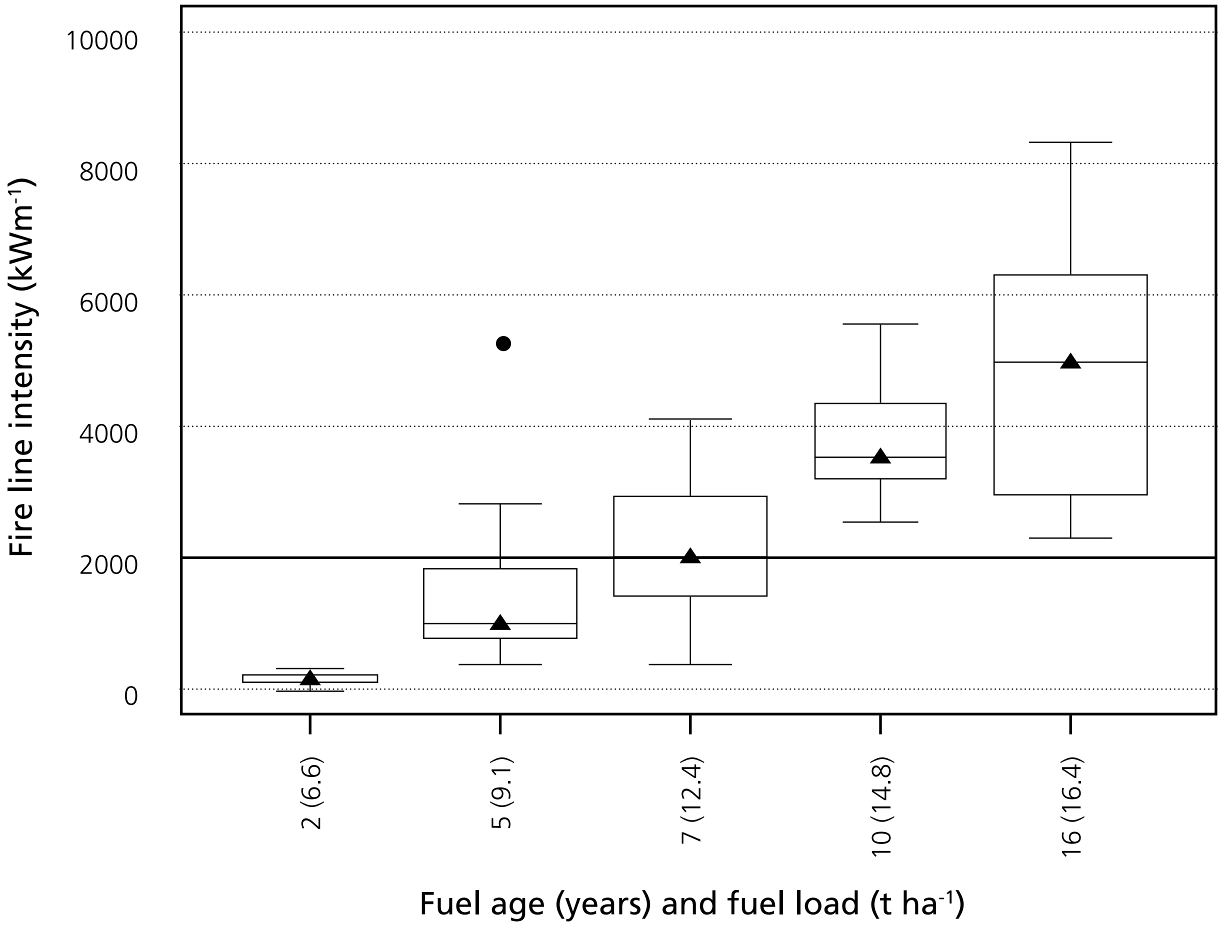
Fuel age (years)	Fuel hazard score and rating		Indicative fuel load (t/ha)	
	Surface	Near surface		
<3	2 (moderate)	1 (low)	Surface: 6 – 10	Near-surface: 1
4-5	2 (moderate)	2 (moderate)	Surface: 6 – 10	Near-surface: 2
6-10	3 (high)	2 (moderate)	Surface: 10 – 14	Near-surface: 2
10+	4 (very high)	3 (high)	Surface: 12 – 16	Near-surface: 3

The results of the fuel accumulation rate research components of Project Vesta are generally consistent with earlier dry open eucalypt forest fuel research in other southern States and Territories, and the results have been widely accepted by Australian fire and land managers.

How a fire will behave in areas effectively treated with prescribed burning will depend not only on how long ago the burn was undertaken; but also the weather and fuel moisture conditions at the time an unplanned fire starts, or spreads into a previous burn area. McCaw (2013) investigated the effects of different fuel ages on fire intensity for the Project Vesta experimental fires. From these experimental fires in typical WA summer conditions, it is clear that fire intensity is substantially lower in young fuel ages relative to older fuel ages (see Figure 5).

[3] The fuel hazard score and rating system is a 5 tier system (Low, Moderate, High, Very High and Extreme). Fuels are assessed in 4 strata (Surface Fuels, Near Surface Fuels, Elevated Fuels and Bark Fuel) and a fuel rating for the combined strata is known as the Overall Fuel Hazard. For further detail of fuel hazard rating systems see Gould et al. 2007 and Hines et al. 2010.

Figure 5 *Fireline intensity relationship to fuel load (Project Vesta experimental fires)*



Fireline intensity of experimental fires burning under dry summer conditions of moderate to high fire danger in eucalypt fuels of different age. The combined load of surface and near-surface fuel for each age class is shown in brackets. Box-and-whisker plot shows the median value (▲), 25th and 75th quartiles (i.e. 50% of cases have values within the box) and dots (•) represent outliers more than 1 box-length from the 25th and 75th percentiles. Horizontal bold line indicates an intensity 2000 kW/m above which the effectiveness of fire suppression using tankers and bulldozers declines markedly. Data for the tall shrub site from Project Vesta experiments (McCaw et al., 2012).

What can be seen from Figure 5 is that relative to the median fireline intensity of summer fires burning in 5 year old fuels during moderate to high fire danger conditions, median fire intensity in 10 year old fuels is 3.5 times higher, and in 16 year old fuels is 5 times higher. Also, the lowest intensity experimental fire in 10 year old fuel was more than 8 times the intensity of the highest intensity experimental fire in 2 year old fuel.

Even at severe, extreme and catastrophic fire danger rating levels, the scientific research-based forest fire behaviour models show that fire intensity is predicted to be many times greater in heavy fuels than in light fuels. However, in all but the most recently burnt fuels the fire behaviour of established fires will still be too high for safe fire suppression in those conditions.

To illustrate the degree of expected differences in fire behaviour between different aged fuels during very high to catastrophic fire weather (conditions worse than those able to be tested in Project Vesta), rate of spread predictions (using the Vesta DEFFM) and fireline intensity predictions are shown for three different fuel scenarios.

Table 3 shows the predicted fire spread rates (based on DEFFM predictions) and fireline intensity (Byram, 1959) calculated for the different combinations of fuel and fire weather scenarios.

Table 3 *Fire behaviour potential analysis, showing predicted rate of spread in m/hr (and fireline intensity in kW/m)*

FDR Scenario	Predicted rate of spread in m/hr (and fireline intensity in kW/m)		
	Fuel age < 3 years	Fuel 6 – 10 years	Fuel 10+ years
Catastrophic	1,030 (5,855)	2,556 (23,775)	8,826 (107,838)
Extreme	813 (4,620)	2,007 (18,668)	6,914 (84,506)
Severe	601 (3,415)	1,475 (13,713)	5,064 (61,919)
Very High	349 (1,982)	840 (7,813)	2,859 (35,003)

Table 3 provides for each combination of fuel scenario and indicative fire weather scenario, DEFFM predicted rate of forward spread (and in brackets – calculated fireline intensity).

What Table 3 shows is that for all FDR scenarios, predicted rates of spread are at least 8 times higher in the 10+ years fuels, relative to the < 3 years old fuel scenario. Predicted fireline intensity is 17 to 18 times greater in the 10+ year old fuels than in the < 3 years old fuel scenario. With the exception of the Very High FDR/fuel < 3 years scenario, all predicted fireline intensities for established fires are well above the 2,000 kW/m threshold generally considered to be the level at which attack with tankers and bulldozers declines markedly. However the differences still have important implications when considered in the context of complementary risk reduction strategies other than fire suppression (see Principle 11).

Grassy systems

Well-executed burns in grassland are very effective at reducing fuel – fire typically consumes the full depth of the grass fuel bed, leaving insufficient residual fuel behind to carry another fire until new grass has regenerated and cured again. However, grassy biomass replenishment in temperate and tropical grassy systems can be relatively rapid, so the benefits of a prescribed burn in grass may only persist for a short period – typically only a year in tropical savanna grasslands, and potentially longer in temperate systems depending on rainfall and land management factors.

In tropical savannas, natural and exotic grass regeneration is an annual cycle, with replenishment in the wet season and return to a readily combustible state in the next dry season. Normally, areas burnt in the early dry season will not be able to burn again until after the next wet season once the new growth has sufficiently cured (although unseasonal weather events can occasionally disrupt this normal cycle). This is the basis upon which savanna burning for greenhouse gas abatement is undertaken, whereupon buffer strips and patches are burnt in the early dry season (EDS) to remove grass fuel, and these burnt patches impede the spread of subsequent late dry season (LDS) fires. Where there is good continuity and depth of EDS burnt buffers, LDS fire spread is stopped at the burnt buffer.

In sub-tropical and temperate grassland areas, fuel reduction in grasslands is more often undertaken by grazing over broad areas, and using slashing or chemicals along linear features. In some areas a combination of grazing and burning may be used. Grazier burning in grasslands may be undertaken to remove dead unpalatable grass which has accumulated over a number of growing seasons, with a desired effect of the burn being to promote regeneration of new live grass growth which is then grazed.

Burning of grass fuels may also be undertaken in areas inaccessible for slashing, and/or where it is also desired to restrict shrub occupation. The length of time before sub-tropical or temperate grassland can carry fire again depends to a significant degree on what land management practices are applied. Graziers often put stock into grassland areas regenerating after a burn as the new shoots are nutritious and attractive to stock. Sustained grazing of the fresh regenerating grass generally slows the rate at which less palatable, cured grass accumulates within the grassland.

In summary, well implemented burning of grasslands is highly effective at reducing fuel, however the benefits for fire risk reduction typically only persist for a year in normal seasons, and potentially longer where undertaken with other fuel modification measures such as grazing.

Heath and shrubland systems

In heaths and shrublands, prescribed burns are typically wind driven and burn through the full depth of the vegetation profile, consuming the overwhelming majority of fine fuels (both live and dead). Prescribed burns typically transform the structure of the vegetation reducing the live vegetation height back to ground level, greatly reducing shrub fuel continuity, and altering the live:dead fine fuel ratio strongly in favour of live fuel. Dead fine fuel in the form of litter (and bark in Mallee) is slow to re-accumulate, although in some systems grasses or sedges may enjoy a period of dominance until shrubs reoccupy the site. The general effect is to substantially reduce fire behaviour potential for at least 5 years in temperate and subtropical heath/shrubland and around 8 years or more in arid/semi-arid systems. Beyond this post-fire re-establishment period, litter, bark and dead woody material begin to increase within the heath shrubland and the effects of the prescribed burn progressively reduce (Cruz *et al.* 2006).

Based on this understanding of how prescribed burns modify heathland fuels, strip-pattern burning with the wind is a commonly used technique in heathlands to create long strips of burnt heath which act as buffers to stop subsequent unplanned burns. While the post-fire heath/shrubland regrowth within these burnt strips is still in its juvenile to early mature growth stage, there is generally insufficient fuel continuity and dead fine fuels to promote and sustain fire spread.

Is the nature and degree of fire behaviour reduction sufficient to improve the outcomes from the other complementary strategies?

<u>Prescribed burn effects which assist fire suppression and active property defence</u>

Dry open forest systems

It is well known operationally, and scientifically well supported, that a low intensity fire burning in light fuel is far easier and safer to control than a fire burning in heavy fuel accumulations (AFAC 2015b). Gill (2008), in considering prescribed burning as a fuel-modification measure, states:

> 'Prescribed burning reduces the fuel load, fuel continuity, loose lower bark of trees and, initially at least, the proportion of dead-to-live fuel contained within the fuel array. Therefore, by definition, the potential fire intensity is reduced. It may then be argued that this in turn increases the chance of controlling the fire, and therefore decreases the chance of the loss of human life and economic assets.' [Gill, 2008; p42]

APPENDIX 1 THE ROLE AND EFFECTIVENESS OF PRESCRIBED BURNING IN BUSHFIRE RISK REDUCTION

McCaw (2013) examined the relationship between fuel age, fire intensity and suppression difficulty (see Figure 5). Using data from the Project Vesta experiments, he showed that for fires burning in summer under moderate to high fire danger, the median fireline intensity remained well below 2,000 kW/m in five year old fuels. 2,000 kW/m is the level above which the effectiveness of fire suppression using tankers and bulldozers declines markedly (McCarthy *et al.*, 2003). More than 75% of fires in five year old fuels did not exceed 2,000 kW/m. The median fire line intensity value did not reach the 2,000 kW/m level until fuels were seven years old.

McCaw's findings are generally consistent with those of McCarthy and Tolhurst (1998, 2004) who identified an overall fuel hazard rating of High[4] to be the maximum level considered to be 'helpful' to fire suppression. They studied a sample of bushfires from across Victoria, occurring between 1990/91 and 1997/98, and conducted detailed examination of 114 fires known to have interacted with areas previously subject to fuel reduction burning (FRB). They also studied a larger sample in less detail; 1,653 fires known to have been influenced by FRB and a further 2,425 fires where previous FRB did not assist suppression. From the data collected, models were constructed for predicting the probability of previous prescribed burns slowing head fire rate of spread, and different fire danger indices, and the probability of different post-burn fuel age assisting fire suppression. The models from the study indicate that on High overall hazard sites, the probability of a previous FRB slowing rates of spread drops to less than 50% once the Fire Danger Index rises to 25 or more (Very High or greater FDR).

At times of Severe to Catastrophic fire danger, fire behaviour in all but the most recently prescribed-burnt areas will reach intensity levels substantially exceeding the limits of effective suppression with tankers and bulldozers, and will mostly also be beyond advisable limits for lighting and controlling backburns. This does not however mean that the risks to public safety and property from fire burning under such conditions are not reduced by prescribed burn-treated areas in the landscape. Firstly, some extreme fire events may be prevented from occurring because unplanned fires in the landscape were able to be put out with the aid of fuel reduced areas, before the onset of extreme weather. If not put out beforehand, such fires could still be burning when extreme weather arrives and those fires can therefore become high-consequence fires. Secondly, the presence of fuel-reduced areas in the path of unplanned fires, before or during extreme weather (particularly during their early spread and growth), can reduce fire behaviour (relative to that likely in heavy fuels). In some circumstances it may result in the fire not reaching some vulnerable asset areas during its extreme weather phase (areas which would otherwise have been impacted if not for the slowed spread). Thirdly, the much lower intensity of fires in light fuel burning during extreme weather are easier and safer to defend assets and people against relative to those burning in heavy fuels. For example, an unplanned fire approaching an urban interface area through a prescribed burn-treated forest with an open understorey with light patchy surface fuels , sparse shrubs, an absence of elevated (ladder) fuels and with charred bark on tree stems is much easier to defend property against than a fire burning in the same weather conditions, but burning through heavy surface fuels, with a prolific, tall shrub layer incorporating suspended litter and bark, and with loose flammable bark on tree trunks providing an abundant source for ember attack.

For most of Australia's major population centres there are only a small number of days of Severe or higher fire danger days each year. On average, population centres within 100 km of the coast have less than three of these FDI 50+ days per year (mostly <2), and inland areas other than in semi-arid zones typically have less than 5 (Lucas *et al.*; 2007). Most importantly, on those days other than the worst 1-3% of days during a fire season, improved fire suppression prospects facilitated by prescribed burning, at or away from asset-hazard interface areas, can assist fire and land management agencies to extinguish or contain unplanned fires before the onset

[4] *The combined surface and near-surface fuel loads associated with five year old fuels in Project Vesta equate with a High overall fuel hazard level.*

of extreme fire weather. This can serve to significantly reduce (but not eliminate) the number of extreme weather fires, which are those that cause the greatest proportion of human fatalities and property loss.

There have been numerous case studies which demonstrate the effectiveness of fuel reduced areas in aiding fire suppression during specific fire events (Billing 1981; Rawson Billing and Rees 1985; Underwood *et al.* 1985, Grant and Wouters 1993; DELWP *et al.*, 2016). A number of these are summarised in AFAC's *Overview of Prescribed Burning in Australasia* (2015a).

In terms of landscape scale studies over multi-year timescales, there are three important Australian studies into unplanned fire interaction with prescribed burns – the previously mentioned study in Victoria by McCarthy and Tolhurst (2004), a study in the Blue Mountains of NSW by Price and Bradstock (2010), and a study in the Warren region of Western Australia by Boer *et al.* (2009). These are discussed in AFAC's O*verview of Prescribed Burning in Australasia* (2015a). Key findings of the studies include:

- The Victorian study (McCarthy and Tolhurst, 2004) found that depending on the management district, between 20% and 50% of unplanned fires will be likely to run into a 'helpful' FRB – with 'helpful' meaning that the burn-treated areas had an overall fuel hazard rating of high or less. For context, the study covered a time period (1990 – 1998) when annual burning programs treated around 1.3% of public land.
- The Blue Mountains study in NSW (Price and Bradstock, 2010) found that 22% of prescribed burns up to five years old were encountered by unplanned fires and that in 62.3% of cases where such an encounter occurred, the unplanned fire stopped; either at the leading edge of the burn (17.9%) or within the burnt patch (44.4%). For context, over the period covered by the study (1990-2007) 0.41% of forested area within the study area was prescription-burnt annually, and the median burn size was 18.9 ha. Over the study period, the annualised area burnt by unplanned fires was nearly 12 times the area treated by prescribed burning.
- The WA study (Boer *et al.*, 2009) demonstrated a strong inverse relationship between the extent of prescribed burning and unplanned fire. During the period of the study, the annual prescribed burn treatment effort was 7% to 9% of the forested landscape. Over the period, unplanned fire occurrence was limited to an annual average area of 16,331 hectares (18% of the total area burnt annually; the other 82% burnt by controlled, low intensity prescribed fire).

In the foregoing sections, the effects of prescribed burning strategies in reducing fuels and fire behaviour and the consequential benefits for improving fire suppression efficacy and reducing unplanned fire extent have been discussed. In rural and peri-urban areas in particular, a key objective of reducing unplanned fire behaviour by prescribed burning is to reduce the impacts of bushfires on assets, whether they be property/economic assets, or environmental assets. Providing bushfire protection for houses is also expected to be beneficial for reducing human fatalities and injuries because historically a high proportion of such impacts have occurred when people have attempted late evacuation from their house, or whilst defending a house, and in some cases while sheltering inside during severe bushfire impact.

One of the few studies conducted examining the effects of previous prescribed burning on asset loss/damage during unplanned fires is by Gibbons *et al.* (2012), looking specifically at the effects on house loss reduction. Their study focussed on the impacts of three large-scale Victorian bushfires which ignited on the same day (7 February 2009 – 'Black Saturday') and burnt out the major part of their final areas under Extreme to Catastrophic fire danger conditions.

Although the study authors had access to spatial data pertaining to prescribed burns conducted over the previous 10 years within the study area, they did not quantify the area treated annually or the proportion of the study area that had previously been prescribed burnt. The study authors did acknowledge that a relatively limited amount of prescribed burning had been undertaken in many parts of the study area.

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(Source: Department of Environment, Land, Water and Planning. Victoria)

The way in which the study considered the contribution of prescribed burns to house loss reduction was to place line transects between sampled houses (499) and the bushfire boundary, with the direction of the transect being in the upwind direction from each house. Along each transect, the proportion of the transect previously subjected to prescribed burning was calculated, and the distance between the house and the nearest prescription-burnt section of the transect was determined. Although quantitative analysis of these measures is very limited in the report, some sense of data distributions within the ranges recorded can be gleaned from the minimum, maximum and mean values:

- Percentage of each transect prescription-burnt up to 5 years ago:
  - Ranged from 0% to 36.4% with a mean of 2.8%. To obtain some proportional context, if the mean value is annualised this amounts to 0.56% of each transect being subject to prescription burns each year – representative of a low prescribed burn treatment rate.
- Amount of unburnt land along the transect upwind from each house (which put another way is the distance measured along each transect from houses to the nearest point of prescribed burning within five years):
  - Ranged from 14 to 40,041 metres, with a mean of 8,848 metres. Interpretation of the 'upwind land not prescribed-burnt' graph in the report identifies that an extremely low proportion of sampled houses had any prescribed burns within 2 kilometres upwind.

Despite these significant limitations, the study found that 15% fewer houses were lost where prescribed burns were conducted 0.5 km upwind from houses relative to houses with prescribed burns 8.5 km upwind.

As a potential alternative treatment to prescribed burning, the study also analysed what difference reducing remnant native vegetation around houses would make to house loss probability. Applying an 'intensive' vegetation clearing scenario within 40 metres of houses (by reducing tree and shrub cover within 40 metres of houses from 90% to just 5%) they found that house loss could be reduced by 43%; that is, every 10% reduction in the cover of native vegetation yields a 5% reduction in house loss. The authors acknowledge that reducing remnant vegetation cover from levels of 90% to 5% within 40 metres of houses is unlikely to be achievable in many locations and will often not be an appropriate or acceptable risk reduction strategy on a range of grounds including cost, health and environmental. Furthermore, it would not be socially acceptable in many urban-bushland interface areas.

The 90% and 5% tree and shrub cover bounds used for the relative risk reduction analysis may be considered extreme, noting that selection of these 'maximised-for-effect' scenario bounds serves to maximise the theoretical extent of risk reduction attributable to clearing around houses and maximise its value relative to other risk reduction methods. Many areas will not have remnant vegetation cover as high as 90%, which was in fact the most extreme value found in the study. The mean value for remnant shrub and tree cover within 40 metres of houses in the study was 30%. Applying the study's finding that for every 10% reduction in remnant vegetation cover within 40 metres of houses there is a 5% reduction in house loss, then reducing cover from the study mean of 30% to 10% cover (still a very low value) will yield only a 10% reduction in house loss. This is less than the amount of risk reduction that the study predicts can be achieved by moving prescribed burns in from 8.5 km to 0.5 km from houses. Accordingly, care needs to be taken in interpreting what the practical implications arising from the study are.

The study's primary author has made the point that the risk reduction effects in the study are additive. Risk reduction may be maximised by applying multiple risk reduction measures in combination (Gibbons pers comm. 20/5/2016). Where some risk reduction approaches are not possible, alternative measures might be applied, potentially in greater measure. The key point is that a suite of measures involving a combination of reducing vegetation hazard adjacent to houses, prescribed burning within close proximity to houses, supplemented by prescribed burning at further distances to reduce the likelihood of fires reaching houses is better than relying on any single strategy.

Grassy systems

In grassy landscapes, areas where fire runs into recently burnt grassland areas will require little, if any resources to suppress. This allows scarce resources to be deployed to other parts of the fire with heavier fuels, thus the overall prospects for fire containment are improved. In the same scenario without the presence of one or more prescribed-burnt (or otherwise fuel-reduced) areas, it can reasonably be expected that the fire will be larger, and have a longer perimeter requiring active effort to contain. Hence fuel reduced areas are a significant advantage to firefighting in grasslands. This is a key principle behind the construction of firebreaks in many grass-dominated rural landscape areas.

Heath and shrubland systems

In heath and shrubland systems, recently burnt areas can and do stop many fires from spreading. In early stage regeneration areas which have sufficient fuel to carry fire again, fire spread can be significantly slower than in late and over-mature systems which have higher dead fine fuel loads, a higher degree of fuel continuity, and potentially longer distance spotting potential. Accordingly, recently burnt areas in heath and shrubland systems can be a significant advantage for fire response. The creation of low-fuel areas using strip-burning is undertaken with the intent of breaking up large expanses of long unburnt heath and shrubland, to reduce the potential for large scale fires which can burn-out an undesirably high proportion of conservation reserve areas in a single event, with adverse ecological consequences.

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Prescribed burn effects which assist other fire risk reduction strategies

There are important bushfire risk reduction strategies, other than fire suppression, which are also assisted or complemented by prescribed burning.

Building construction standards and asset protection zone widths:

- Standards applied through government regulation and bushfire protection guidance are typically based on assumptions of unmanaged fuels. *AS 3959-2009 Construction of Buildings in Bushfire-Prone Areas,* which is central to all bushfire-related development planning and building construction regulation in Australia, assumes fuel loads for forest and woodland are 35 and 25 tonnes per hectare respectively. If prescribed burning is used to manage fuels in areas flanking high bushfire risk assets, the actual radiant heat levels to which assets will be exposed during a bushfire will be much less than assumed by the regulations and factored into such things as building construction standards and asset protection zone specifications. This can serve to amplify the effectiveness of the bushfire protection measures applied through regulations. Most importantly, the benefits of reduced fire intensity will be of particularly heightened value in areas built before such regulations were introduced and applied.

Community/individual bushfire survival planning outcomes

- Fire and emergency services around Australia strongly encourage people living in bushfire-prone areas to prepare *bushfire survival plans* to pre-plan actions in the event that severe to catastrophic fire danger is forecast and a bushfire occurs. The pivotal decision in these plans is to decide whether to leave early for a safe place, or to 'prepare, stay and defend'. For the many people that decide to prepare stay and defend, their degree of safety and prospects of success will be enhanced where the asset they are defending is adjacent to areas systematically and effectively fuel-reduced using prescribed burning (relative to areas where no fuel reduction is undertaken).

Evacuation strategies employed during fire response

- During bushfire emergencies, one strategy implemented by response agencies, for public safety reasons, is to recommend evacuation of areas at significant risk of bushfire impact. When evacuations occur, capacity to defend property from bushfire attack in evacuated areas is limited as responders are prioritised to managing public safety, and residents are not present to defend property. In such situations, built areas where adjacent bushland areas have been fuel-reduced by burning (or other means) will be exposed to lower levels of radiant heat (and potentially also ember attack) than untreated areas.

Can implementation of prescribed burning for bushfire risk be done such that its impacts on the environment are either beneficial or tolerable, and at an acceptable cost?

It is important to note that the answer to this question depends on the scale and design of the prescribed burning program and the practices used to implement the program.

The question of environmental impacts associated with delivering a state-wide prescribed burning program on public land (including lands set aside specifically for nature conservation) was of interest to the Victorian Bushfires Royal Commission (VBRC, 2010). The VBRC convened an expert panel of prominent fire ecologists, fire scientists and fire program managers to consider this and other questions. The fire ecology experts on the panel provided evidence that a prescribed burning program predominantly in dry eucalypt foothill forests, with a treatment rate of 5% annually, would be unlikely to result in undesirable environmental impacts and further offered that it was possible that such a program could have environmental benefits. The fire ecology experts qualified that increasing the treatment rate above 10% per annum carries a greater risk of adverse ecological outcomes. The expert panel qualified that any such program would need to strategically target prescribed burns to maximise risk reduction, assessing the most appropriate prescribed-burning regime for each region or habitat type, and considering the appropriate level of burning in particular regions.

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Most, if not all, fire and land management agencies have legal obligations to ensure the environment is given due consideration in prescribed burn program decision making, and that as far as reasonably practicable, fire management programs are applied in a way that avoids a significant impact on the environment. Such obligations arise from the Commonwealth Government's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in respect of threatened species and ecological communities among other matters, and various state/territory legislation as discussed in Section 2.4. Land management agencies typically have mandated requirements to conserve, protect or enhance biodiversity. Legislation under which some fire and emergency services may operate may have explicit requirements to exercise their functions having due regard to the principles of ecologically sustainable development (for example this is a requirement of the *Rural Fires Act 1997* (NSW)).

In relation to a prescribed burning program, the questions of what environmental impacts are tolerable and what cost is affordable cannot properly be considered without also considering the unplanned component of the historical fire regime[5] because the two are inextricably linked. Holistic consideration of impacts and costs in this way has not been a mainstream practice in Australia and can be considered a matter of relatively recent inquiry and effort to develop and test new conceptual approaches (for example through current projects under the National Burning Project and Bushfire and Natural Hazards Cooperative Research Centre research program).

In considering what the landscape-level environmental risks of a prescribed burning program might be, the most challenging issues for fire and land management agencies has been to consider the potential impacts on biodiversity. However, the environmental issues are not confined to biodiversity. In 2012, the Department of Environment, Water and Natural Resources in South Australia considered the environmental impacts of their prescribed burn policy and program in a formal and structured way, pursuant to seeking a strategic assessment under the *EPBC Act* of their prescribed burning policy and program. Such assessments are directed to considering impacts on Matters of National Environmental Significance (MNES). MNES relevant when considering prescribed burning include:

- Listed threatened species and ecological communities;
- Migratory species protected under international agreements;
- RAMSAR wetlands of international importance;
- World heritage properties; and
- National heritage places.

Assessing the impacts of a prescribed burning program on biodiversity values, including but not limited to threatened species and ecological communities, is generally done in two stages:

1. Firstly, a fire regime-level assessment at broad vegetation community level, by considering the extent to which the burning regimes which need to be applied to achieve the requisite fuel specifications set for different fire management zones are able to be applied in conformance with a framework of *tolerable fire intervals* (TFIs) for a range of coarsely grouped vegetation groups (see discussion about limitations of using TFIs in Appendix 2); and
2. Secondly, to more directly consider threatened species, populations or ecological communities, a threatened species assessment may be undertaken, typically by identifying those that may potentially

[5] *The concept of the fire regime—the frequency, intensity, seasonality and type of fire—is now recognised as central to our understanding of the ecological impacts of fire, for defining risk to people and property, and for mitigation and management decisions. To understand fire regimes, we need to acquire, summarise and interpret information describing fire history and intensity across the landscape.*

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(Source: Department of Parks and Wildlife, Western Australia)

be sensitive to, and potentially negatively impacted by the fire frequencies planned to be applied, even though these may be within the tolerable intervals for the broader vegetation groups within which they occur. Typically, flora species that are most susceptible to frequent fire are those where the adults are killed by fire, regenerate solely from seed in a single germination pulse, have a long juvenile period without seed available, and have limited seed dispersal (DEWNR, 2012).

In practice, when considering the potential for adverse biodiversity impacts to arise from a program, the main interval of concern is the minimum TFI. In theory, if all the burns in a program are able to be implemented without applying burns at intervals that exceed the minimum TFI then at landscape-level, the program is generally considered unlikely to have an adverse impact (unless the proposed regimes are identified as having a negative impact on particular fire-sensitive threatened species or ecological communities).

It is not uncommon in a burn program, that some areas will be identified for application of a prescribed burning regime that will exceed the minimum TFI. Mostly this occurs where management zones in close proximity to vulnerable assets/communities require burning at intervals shorter than the specified minimum TFI, in order that fuel specifications for the zone can be maintained. The risks to be weighed up in deciding what is tolerable are risks to nearby life and property on the one hand, and risks to ecological values in the area where a TFI is to be exceeded on the other. Questions of scale and degree will be important – if the ecological values to be impacted are well represented at the broader landscape level then the impact may be low. However, if the ecological values to be impacted are rare and confined to small areas of which the area to be treated represents a substantial proportion, then the ecological risks may be high. When considering the impact of a program, it is generally potential impact at the population level and over the long term that are considered.

TFI conflict situations are not limited to intensive treatment zones. Other TFI conflict situations in the broader landscape can arise, such as in areas where the predominant vegetation type, or types, belong to one or more broad vegetation groups which have a particularly long minimum TFI. In these situations, strict conformance to the TFIs will often mean that heavy fuel loads can accumulate across broad landscape areas before the minimum TFI has been reached (particularly if prevention and suppression of unplanned fires is generally successful over timeframes similar to or longer than the minimum TFI). Broadly distributed heavy fuel loads can expose that landscape to the risk of large high intensity fires when suppression cannot succeed, and such fuels may also have reached a point where low intensity burning is no longer a practical possibility, or burning them may have untenable implementation risks.

The following approach is generally applied for the purpose of ensuring the environmental consequences of using prescribed burning for risk reduction are tolerable:

- Management zones in which the most intensive prescribed burn treatments are applied (for example Asset Protection Zones (APZ) in which the highest frequency and least patchy burns are planned) are generally restricted to a very small proportion of the landscape in the immediate vicinity of fire-vulnerable assets. Typically, at jurisdiction level scales, such zones may occupy less than 1% of burn-treatable landscape area, and mostly less than 0.5%. In well-managed burn programs, operational methods and burn-specific prescriptions are applied to minimise the environmental impacts of these burns as far as reasonably practicable. The small, more intensively treated areas are not without ecological value – they can provide habitat for those flora and fauna which prefer frequently burnt vegetation, which in many cases may be in limited supply elsewhere in the landscape.
- Management zones other than APZs, implemented principally as part of a bushfire risk reduction strategy (for example Bushfire Moderation Zones), are mostly treated at frequencies falling within the tolerable fire interval range, but towards the minimum interval end of the range. In well-managed programs, operational methods and burn-specific prescriptions are applied to minimise the environmental impacts of these burns as far as reasonably practicable. However, some landscape areas may be dominated by long minimum TFI vegetation types. Where this occurs, it may be necessary to make management decisions which consider whether conforming to TFIs across the landscape is a higher ecological and property risk than using prescribed burns at intervals less than minimum TFI in strategic locations to reduce the risks associated with leaving fuels to accumulate to very high levels across wide landscape areas.
- Management zones which are implemented principally for the pursuit of ecological objectives, are by definition intended to be beneficial for the environment. The intervals, fire intensity, season and patchiness-related prescriptions applied can cover a wider range of possibilities than for burn-types intended principally for bushfire risk reduction. Operational methods and burn-specific prescriptions are applied to minimise potentially adverse impacts of these burns as far as reasonably practicable. However, even in these areas, although they may not be common, TFI-conflict issues may arise for consideration if the minimum TFIs identified for broadly occurring vegetation types allows the broadscale accumulation of very heavy fuels in the landscape.

- During planning, exclusion of prescribed burning is often identified for ecosystems identified as adversely impacted by fire. Additionally burning strategies may be targeted to adjacent areas for the purpose of reducing the prospect of fire-sensitive areas being impacted by unplanned high-intensity fires.

There is a key point emerging from the foregoing discussion. When considering whether the landscape-scale impacts of a prescribed burning program are tolerable or not, it is important to consider what unplanned fire risks may arise if a burn program is applied whereby burn intervals conform to TFI frameworks of the sort commonly used by fire and land management agencies in Australia.

The scale and nature of prescribed burn programs considered to have tolerable ecological impacts differs between jurisdictions. Across the dry sclerophyll forest dominated region of south-west WA, an aspirational annual program scope amounting to approximately 8% of the forested area is considered desirable. In dry sclerophyll forest dominated regions in other parts of southern Australia different annual prescribed burning program scopes are considered desirable, mostly being within the 1 to 3% range.

The concepts covered in the next section regarding the use of fire to manage ecological risks are also relevant to considering questions of burn program impact. Ecological risk management concepts are further expanded upon in AFAC's *Risk Framework for Ecological Risks Associated with Prescribed Burning* (AFAC 2016b).

APPENDIX 2 PRESCRIBED BURNING STRATEGIES FOR ACTIVE MANAGEMENT OF ECOLOGICAL RISKS

There is a substantial body of ecological knowledge from research, reports and various guidelines used to guide fire management in Australia, from the strategic planning level down to site-specific management of a particular species (AFAC 2016b; Gill, 2008). A generally desired state is a landscape in which 'appropriate fire regimes' prevail. In practice however, the identification of what constitutes an 'appropriate fire regime' can be technically challenging and elusive, as fire regimes have multiple elements to be considered including fire frequency, intensity, seasonality and size/patch dynamics.

Much guidance material on the subject of managing the ecological risks of fire, intended for land and fire program managers, is articulated to guide 'avoidance of inappropriate fire regimes'. For example, AFAC's *Risk Framework for Ecological Risks Associated with Prescribed Burning* (AFAC 2016b) provides tabulated information providing examples of 'inappropriate fire regimes' and their adverse impacts. Fire regimes include all fires – planned and unplanned. The examples of inappropriate fire regimes provided are:

- Too frequent, or too infrequent;
- Too intense, or not intense enough;
- Too large, or too small;
- Too much late dry season fire in northern Australia (essentially too big and too intense);
- Fire outside of the 'natural fire season';
- Too much fire in autumn (principally directed to prescribed fire in temperate southern Australia);
- Mosaic 'grain' size too large (lack of patchiness); and
- Lack of diversity of frequency, season and intensity.

In relation to the fire regimes identified above, land and fire managers need to consider the major drivers of inappropriate regimes in each case in order to consider what strategies may be appropriate to address them.

Drivers of inappropriate fire regimes may vary from place to place, however, there are some common themes that can be considered which are shown in Table 4 (beginning next page).

Fire and land managers seeking to pursue strategies to use ecologically beneficial burns to prevent inappropriate fire regimes, or restore more appropriate fire regimes, will need to consider the extent to which both appropriate and inappropriate fire regimes are occurring in the landscapes they are managing. In areas where fire regimes are appropriate, they will need to identify the prescribed burning strategies necessary to maintain that situation. In areas with inappropriate regimes they will need to consider whether it is practicable to restore an appropriate regime.

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Table 4 *Drivers of inappropriate fire regimes*

Inappropriate regime	Regime prevalence and major regime drivers
Too frequent **[temperate southern Australia]**	Public land managers generally adopt and apply a system of minimum *tolerable fire intervals* (which establish guidance in the form of thresholds for what is too frequent for different vegetation communities). These are by design inherently conservative (see discussion in the previous section), and further, deliberate application of 'too-frequent' fire on public lands is mostly limited to Asset Protection Zones in the immediate vicinity of assets (although it may also be necessary in some parts of the broader landscape, to break up large expanses of heavy fuel). This typically represents a small fraction of the landscape, in locations where the risk to human life necessitates the frequency of risk mitigation. In circumstances where particular rare or threatened ecological communities confined to small niche areas happen to overlap with Asset Protection Zones, alternative methods to burning can, and often are pursued in these restricted areas. The much more common scenarios for too frequent fire are areas where people apply unauthorised fires (through arson or ill-considered fire use) at times when fires are not able to be controlled and at frequencies exceeding minimum intervals, and/or where bushfires are occurring too frequently (usually due to human ignitions). In practice, it is not realistically possible for professional land management agencies to apply 'too-frequent' fire at anything but highly localised scales – claims that this occurs are typically not supported by evidence. Even in south-western WA where scientifically based prescribed burning has been applied systematically at a greater frequency than other parts of temperate southern Australia (at a rate of 6 – 8% annually), fire intervals are longer, by a comfortable margin, than specified minimum intervals (AFAC, 2015a). No other temperate southern state comes anywhere near south-west WA's proportional rate of burning, and none, including south-west WA, even come close to being in the too-frequent category on anything but small localised asset protection scales.

APPENDIX 2 PRESCRIBED BURNING STRATEGIES FOR ACTIVE MANAGEMENT OF ECOLOGICAL RISKS

Inappropriate regime	Regime prevalence and major regime drivers
Too infrequent **[temperate southern Australia]**	In temperate southern Australia, when it comes to inappropriate fire regimes on the basis of fire frequency, it is too infrequent fire that is the more prevalent issue. Since European settlement, fire regimes have been substantially altered by a combination of: • Elimination of traditional Aboriginal fire use across southern Australia, and disruption in many other places; • Systematic and unprecedented effort and resources applied to fire suppression (which whilst it serves to reduce localised fire impact on life and property, also serves to greatly limit the area burnt at Low to High fire danger levels, with the majority of unplanned area being burnt now being by uncontrollable high intensity and impact fires burning in Very High to Catastrophic fire danger levels when suppression efforts fail); • Land use change and management that involves mostly small scale or negligible planned fire use, and in many cases prevents ecologically beneficial fire spread in the landscape except in exceptional circumstances (such as broad acre rangeland grazing which essentially reduces cured grass cover in the landscape, which prior to this grazing was the means by which fires spread across rangelands). Rangeland fires are now rare and confined to seasons when exceptional grass growth is beyond the capacity of livestock to graze down; • Minimum fire interval prescriptions in broadly grouped ecosystems that, in practice, exclude prescribed burning (for example – high altitude woodlands in the Victorian high country where the minimum fire interval is 50 years; and grassy wet sclerophyll forests in NSW where the minimum fire interval is 25 years, in which time it is typical for dense shrub occupation to have occurred or prolific shrub soil-seedbanks to have accumulated which will result in dense shrub understorey development after the next fire); • Compared to levels widely considered likely to have occurred prior to European settlement, relatively low levels of prescribed fire use in many landscape areas, ranging from about 0.5 to 3% of public land in south-east Australia (and less on most private land), often focussed mainly in urban-bushland interface areas; and • Public land management agencies (and private land owners) whose resourcing levels are only sufficient to make incremental steps toward burning on a scale that would restore a more sustainable mix of fire frequencies.

APPENDIX 2 PRESCRIBED BURNING STRATEGIES FOR ACTIVE MANAGEMENT OF ECOLOGICAL RISKS

Inappropriate regime	Regime prevalence and major regime drivers
Too intense **[temperate southern Australia. For a Northern Australian perspective, see 'too much late dry season fire']**	An issue overwhelmingly associated with unplanned fires (prescribed burns considered to be in the too intense category are rare, and mostly associated with escaped burns). Areas where a fire regime has been inappropriate on the basis of being too intense are predominantly in low fire frequency areas that have accumulated very high or extreme fuel hazard levels, which are then subsequently burnt by a bushfire spreading in adverse weather conditions. Other such situations are where arson or careless/reckless fires lit in the peak of the fire season are driving the fire regime. Too intense fire is overwhelmingly an unplanned fire issue.
Not intense enough **[temperate southern Australia]**	Examples of this regime are challenging to identify, and probably rather limited in occurrence. Conceptually, the regime is proposed to apply in areas where prescribed fire use is at an intensity insufficient to trigger germination of seeds that require soil heating to cue germination, or burns of insufficient intensity to remove resource competition. In the former case, if recurrent burns have been of insufficient intensity to trigger soil-heating cued regeneration then it is highly likely those burns will have been patchy and a subsequent unplanned fire will cue regeneration. In the latter case, if a prescribed burn was not intense enough to remove resource competition (normally this would be associated with an infrequent regime) then the prospect of a more intense unplanned fire during the fire season remains. Unlikely to be a widely prevalent regime.
Too large **[temperate south; see too much late dry season fire for northern Australia]**	An issue overwhelmingly associated with unplanned fires (prescribed burns considered to be in the too large category are rare, and mostly associated with escaped burns). Prescribed burns are typically in the tens to hundreds of hectares' size range and larger ones in the low thousands of hectares. However, unplanned uncontrollable fires are commonly in the thousands to tens of thousands of hectares range with larger ones in the hundreds of thousands of hectares range, and occasionally in the millions of hectares.
Too small **[temperate south; see too much late dry season fire for northern Australia]**	The reference to inappropriate regimes on the basis of 'too small' is on the basis that prescribed burn size is too limited. If not addressed by a deliberate decision to increase the size of burns in fire-prone areas where this is possible, then an unplanned fire, potentially large and intense, is likely to eventually correct (and potentially over-correct) for the burn size deficiency. In theory, such a regime seems most likely to prevail in interface areas, and is unlikely to be a significant adverse regime at landscape scale (not to be confused with lack of burning or fire exclusion which is a different problem discussed under too infrequent).

APPENDIX 2 PRESCRIBED BURNING STRATEGIES FOR ACTIVE MANAGEMENT OF ECOLOGICAL RISKS

Inappropriate regime	Regime prevalence and major regime drivers
Too much late dry season fire [Northern Australia]	This is an unplanned fire driven regime resulting from a lack of strategically planned prescribed burning. Early dry season savanna burning projects for greenhouse gas (GHG) abatement have proved that regimes of 'too much late dry season fire' can be remedied with restoration of early dry season burning. Various partners including Traditional Owners and Parks and Wildlife in WA, have made significant progress in positively altering unsustainable fire regimes in the Kimberley since 2008. This program has primarily focussed on landscape-scale early dry season burning for biodiversity conservation outcomes. However, there remains an unplanned late dry season fire problem across vast areas not subject to well-managed EDS burning programs.
Too much fire in autumn	A significant proportion of prescribed burns in southern Australia are conducted in Autumn, principally because weather conditions are generally more stable at this time than in spring (which is often windy), and the risk of re-ignition in subsequent adverse weather is lower going into winter than going into summer. Most high-consequence burn escapes are associated with spring burning. The question arises as to how much autumn burning constitutes an 'inappropriate fire regime'? There is no clear answer to that question. In practice ecological burning guidelines suggest aiming for variety, such that burning in any particular location is not always in the same season, and that burn cycles which involve a change of season periodically are advisable.
Mosaic 'grain' size too large (lack of patchiness)	Traditional Indigenous burning is identified to have been associated with significantly smaller 'grain' size and heterogeneity than most contemporary prescribed burning approaches, with the possible exception of some continuing traditional owner burning in remote Aboriginal settlements where burning is still used for hunting bush tucker and cultural reasons. As public land management agency people who implement prescribed burns live in towns and cities, and not on Country as Traditional Owners did, it is unlikely that a reduction in 'grain' size will be achieved in many areas.
Lack of diversity of frequency, season and intensity	Diversifying prescribed burning frequency, season and intensity may be an aspirational goal that is difficult to achieve in many areas. It is more easily achieved where people live and work on Country, such that fires can be lit opportunistically as weather allows and working within a fine scale mosaic of burned patches. However, such burning approaches are problematic to implement in current work systems that require detailed documented planning, multiple-stage review and approval systems, and in circumstances that people are not often on Country to take opportunities when they arise.

APPENDIX 2 PRESCRIBED BURNING STRATEGIES FOR ACTIVE MANAGEMENT OF ECOLOGICAL RISKS

Understanding the assumptions and limitations for using vital attributes-based fire interval guidelines for ecological burning strategy development

As outlined in AFAC's *Risk Framework for Ecological Risks Associated with Prescribed Burning* (AFAC 2016b) the most widely used metric applied by Australian fire and land managers for determining appropriate fire regimes (particularly at the strategic and program planning levels), is fire intervals. The frequency-based approach is referred to variously using different terminology in each jurisdiction, for example -*Tolerable Fire Interval* – TFI (VIC); *Inter-fire Interval* (QLD); *Fire Interval Threshold* (NSW); and *Threshold of Potential Concern* (SA). The appropriate fire intervals-based approaches mostly consider the frequency element of fire regimes only (the best example on an exception being the South Australian Ecological Fire Management Guidelines (DEWNR, 2013) which provide guidance parameters for fire interval, spatial arrangement, frequency, intensity and season). Some, but not all systems may make allowance for whether the most recent fire has been a low intensity prescribed burn or an unplanned fire which has burnt at an intensity and coverage higher than that normally associated with low intensity burns. For those TFI systems that provide for some differentiation in fire intensity, this is in essence an adjustment to compensate for conservative theoretical assumptions inherent in the TFI approach. Devised to consider only fire frequency, the approach makes two key assumptions:

1. It is assumed that each successive fire burns over the location/point under consideration. While this assumption may be necessary for theoretical analysis of how successive fires of different intervals impact particular species, at a practical application level it can be a problematic assumption because within a mapped fire boundary (commonly the resolution at which fire history is recorded), very often not all areas within the boundary are burnt. Additionally, post-fire assessment methods rarely capture reliable information about which patches were burnt and unburnt. In forests, particularly those with relatively patchy fuels, and in which a low intensity burn has been applied at a scale representative of practical operations (tens, hundreds, or low thousands of hectares), in the vast majority of operational circumstances only a proportion of the area within the fire boundary is actually burnt; in many cases a low proportion. This is well-known both operationally and scientifically, and is not a major matter of contention. It has been confirmed in numerous operational scale prescribed burning effect studies (such as the Eden Burn Study in NSW and the Wombat Forest studies in Victoria), and yet the way the TFI approach is commonly applied (i.e. that all the area within a burn perimeter is burnt) assumes fire outcomes that rarely happen in practice. When considering application of TFI concepts to operational situations, it is invalid to assume all areas within a prescribed burn boundary have been burnt, and it is also incorrect to assume this for many bushfires.
2. The second key assumption is that there is 100% mortality of obligate seeder plants subject to the fire, including mature reproducing specimens. Leaving aside the issues about fire not killing any plants in the unburnt patches within fire boundaries, this assumes that the fire will be intense enough to kill all plants within the burnt patches. This will be true for plants that have their above ground biomass consumed by the fire and do not resprout from below ground, but for those not consumed by the fire, survival will depend on whether their live tissues can survive the heat to which they are exposed during the burn. Low intensity fires have relatively low and short duration heat energy output, and many plants, including many woody obligate seeder shrub species with sufficient outer bark thickness to protect their cambial tissues, can and do survive low intensity fires. This is true of many obligate seeder species that are assumed in the TFI conceptual approach to be killed by fire.

The consequence is that while TFI theory suggests those obligate seeders that take longer to reach maturity than the prescribed fire intervals applied will be eliminated from repeatedly low intensity burn treated areas, in practice this has not been found. In multi-cycle frequent burning experiments at realistic operational application scales such as conducted during the Eden Burn Study (NSW) (in which low intensity prescribed burn experimental treatments were applied at two yearly (five cycles) and four yearly (two cycles) intervals in

(Source: Queensland Parks and Wildlife Service)

dry sclerophyll forest with a shrubby understorey), the TFI derived predictions are that slow maturing obligate seeders would be depleted with local losses of species occurring after as few as two successive fires (Kenny *et al.* 2004). This did not happen, and in fact all species present in the unburnt control plots also remained present in both the two year and four year burn treatment plots. It is noteworthy that the two year cycle treatments were an 'extreme case' experimental treatment, not actually intended to be taken up broadly as an operational practice. The persistence of obligate seeder species in the frequently burnt plots is because the frequent low intensity burns were patchy, with successive fires often not burning over the same ground as the previous burn, and in those patches that were burnt, the low fire intensity was such that many mature obligate seeder specimens were not killed by the fire.

As highlighted in AFAC's *Risk Framework for Ecological Risks Associated with Prescribed Burning* (AFAC 2016b) a third and important issue in the way TFIs are developed is that broad vegetation group classifications can cover quite diverse groups of ecosystems. The minimum fire intervals set for the broad vegetation groups are typically set to accommodate the requirements of the most fire sensitive species in the most fire sensitive ecosystem within the group. This can result in quite sub-optimal minimum fire intervals being recommended and applied to ecosystems that are adapted to and favoured by more frequent fire intervals than those determined for their broad ecological group classification.

As also noted in AFAC's *Risk Framework for Ecological Risks Associated with Prescribed Burning* (AFAC 2016b), the TFI approach does not consider the effect of inter-species competition within an ecosystem. Vigorous species, which in the sustained absence of fire can extensively occupy a site in the period following fire, can choke-out species strongly disadvantaged by the dense competition.

Accordingly, it needs to be recognised that the TFI approach to differentiating between appropriate and inappropriate fire regimes has inherent, highly conservative assumptions built in. Further, the minimum tolerable fire intervals, particularly forests with understorey formations classified as shrubby, often set minimum thresholds that result in fuel levels of ‘High’ or greater to accumulate, which typically facilitate abundant seedbanks to accumulate, such that the next fire (planned or unplanned) may trigger a dense shrub regeneration. The result is often significantly denser understorey shrub layers than existed prior to the TFI thresholds being applied, particularly where previously a shorter interval fire regime was prevalent (Tasker and Watson, 2016).

For these and other reasons, land managers and scientists in many regions have practical difficulty with, and are opposed to, simplistically and rigidly applying minimum fire interval concepts. As concluded in AFAC’s *Risk Framework for Ecological Risks Associated with Prescribed Burning* (AFAC 2016b p25):

Not properly understanding or considering all the components that contribute to appropriate fire regimes, for example, by focussing solely on fire interval, is itself a risk that is quite widespread.

Guidance in relation to the other non-frequency elements of fire regimes tends to be in terms of aiming for variety. For example, varying the season of burning, varying the patch size between burns and degree of patchiness within burns, and achieving growth stage variability within a landscape. When it comes to intensity however, prescribed burns in forests are overwhelmingly low intensity (limited by prescriptions for control and risk management). Unplanned fires tend to be dominated by large-scale high intensity fires (in part because the low and moderate intensity fires are minimised in area by active fire suppression, and thus the majority of area burnt is by uncontrollable fires which are mostly of higher intensity).

Health Indicators

A broader approach which goes beyond frequency threshold considerations is to identify the extent to which a landscape is in a diverse, healthy, resilient state and what, if any, prescribed burning is needed to maintain that condition. If an area is in an unhealthy and/or potentially in a low resilience state, then the need is to identify what, if any, prescribed burning strategy might be required to improve health and/or resilience. Such ‘health indicator’-based approaches are discussed in AFAC’s Risk Framework for Ecological Risks Associated with Prescribed Burning (AFAC 2016b), and DNPRSR’s Planned Burn Guidelines Southeast Queensland Bioregion of Queensland (2013). In landscape areas where prescribed burning is deemed desirable, to optimise burn benefits, in the process of considering ecological burn location consideration can also be given to the degree to which such burns would also potentially provide life and property protection benefit. The option with the greatest combined benefit can be selected.

APPENDIX 3 INNOVATIVE CONCEPTS, TOOLS AND IDEAS

Strategic Planning

1. Residual risk metrics concept (VIC)

Figure 6 *Drivers of inappropriate fire regimes*

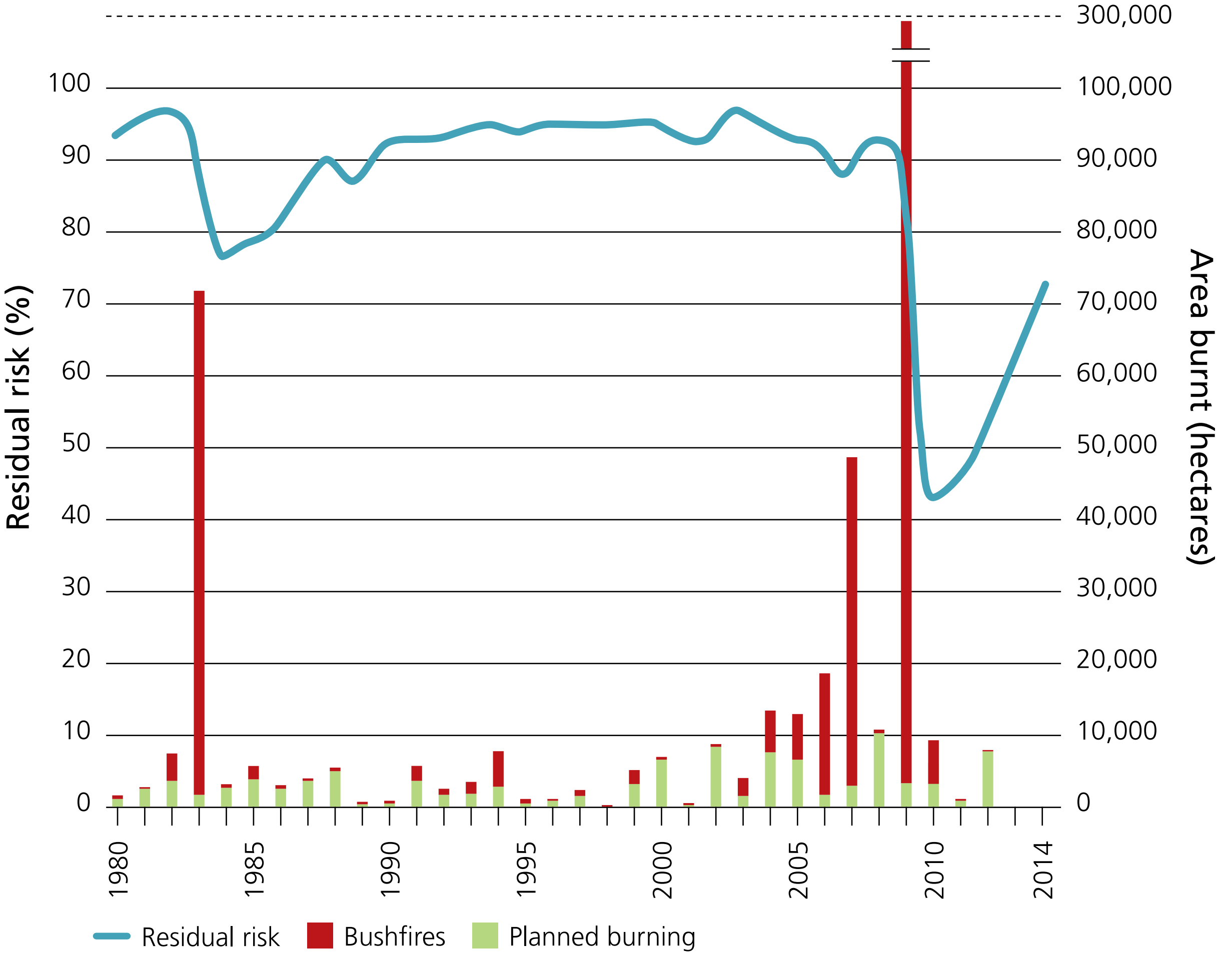
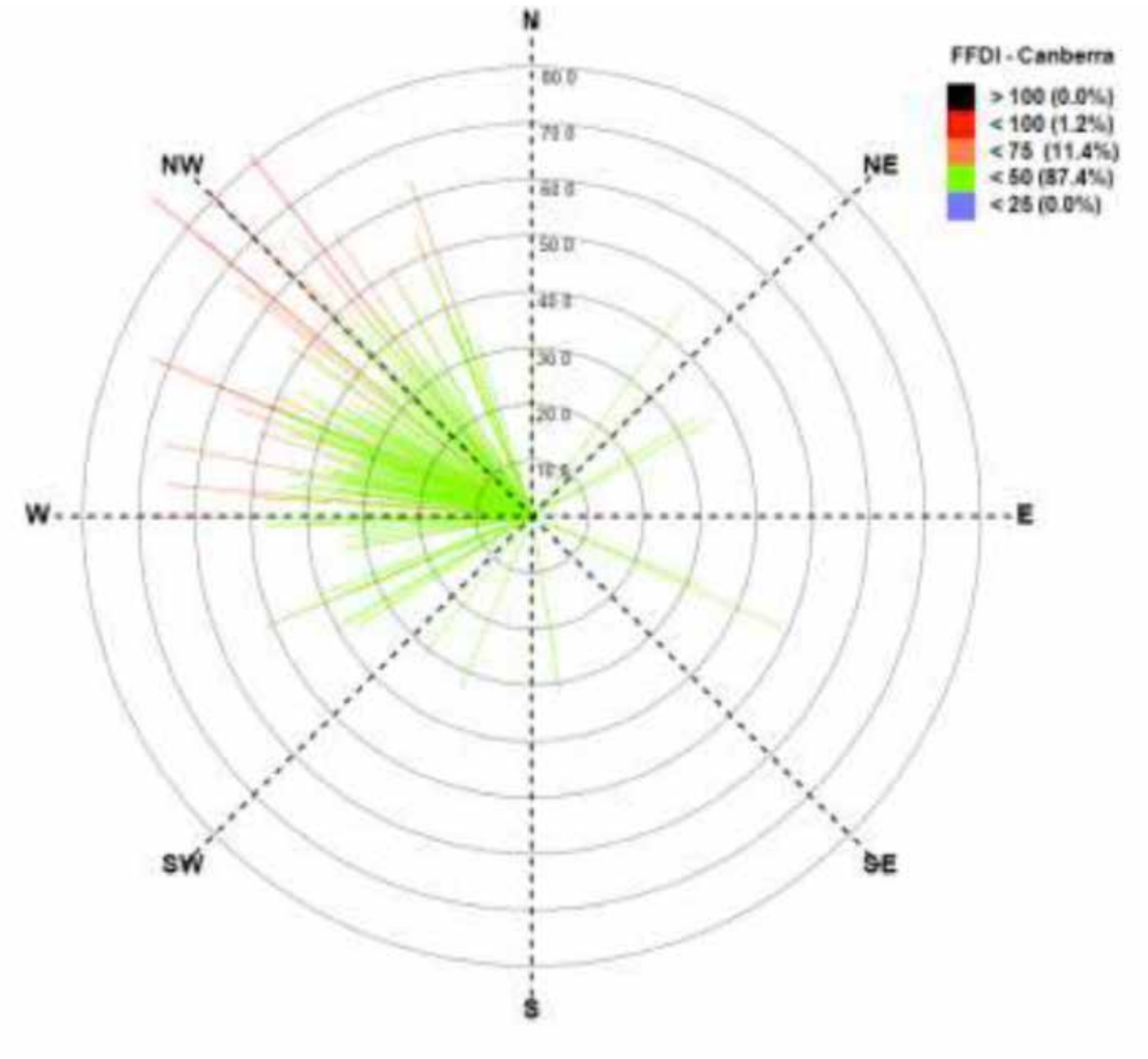


Figure 6 shows conceptually how residual bushfire risk changes through time, influenced by bushfires and prescribed burning program implementation. The maximum risk level of 100% represents "no treatment" including no bushfires, or maximum risk scenario landscape, with all fuels at maximum load. The residual risk profile for a particular program of treatment represents the changing level of risk as a particular fuel reduction treatment is applied through time. (Source: DELWP, 2015)

2. FFDI wind ray plot (ACT)

Figure 7 *FFDI and associated wind ray plot*



The wind ray plot in Figure 7 (from the *ACT Strategic Fire Management Plan* 2014 – 2019) is a very effective way of showing the wind directions associated with different levels of forest fire danger. Occurrence of FFDI exceeding 50 is associated with winds from north-west quadrant. Very High FFDI can occur from any quadrant but is overwhelmingly between north and south-west.

3. Multi-criteria ecological fire regimes guidelines (SA)

Table 5 *SA ecological fire regime criteria*

		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 and following drought
5	Eucalyptus forests with a grassy understorey	5	50	40	30	30	N	N	Spring or during and following drought
8	Eucalyptus woodlands with a shrubby understorey	20	50	40	30	40	Y	Y	Spring or during and following drought
9	Eucalyptus woodlands with a grassy understorey	5	50	40	30	30	Y	Y	Spring or during and following drought
12	Callitris forests and woodlands	15	60	40	30	70	Y	Y	During and following drought

Table 5 presents ecological fire regimes guidelines incorporating multiple criteria covering tolerable fire intervals, spatial criteria (time-since-fire class distribution), multiple fire frequency, intensity and season (DEWNR, 2013).

4. Healthy ecosystem criteria (QLD)

Figure 8 *Extract from Queensland Bioregional Planned Burn Guidelines (Southeast Queensland Bioregion)*

Issue 1: Maintain healthy open forest and woodland

Mosaic burning is critical to maintaining healthy open forests and woodlands.

Awareness of the environment

Key indicators of a healthy open forest or woodland (refer to the photos below):

- Healthy open forest has a grass; sedge; or shrub-dominated understorey (or various mixtures); with a few canopy species of variable sizes (to eventually replace the canopy) and a healthy canopy.
- Lower and mid stratum trees are scattered (e.g. eucalypts, wattles and she-oaks), but **are not** having any noticeable shading effects on ground stratum plants.
- Fallen logs and hollow bearing trees may be present.
- In **shrubby** open forest, shrub layer is dominated by sclerophyllous (hard-leaved) species (e.g. grass trees, banksia, pea-flowers) with healthy foliage.
- In **grassy** or **mixed** open forest, grass clumps and/or sedges are well formed.
- Grassy open forest is easy to walk through or see through.
- Generally few weeds present.

Layers used to describe open forest/woodlands

Canopy: tallest tree layer with an open structure

Mid stratum: (not always obvious) scattered shorter trees, canopy species saplings, tall shrubs and other plants over one metre.

Lower stratum: ground layer of grasses, sedges, herbs, small shrubs and seedlings up to one metre.

QPWS.

Southeast Queensland Bioregion Planned Burn Guidelines: Chapter 1—Open forest and woodland
Issue 1: Maintain healthy open forest and woodland

Figure 8 shows an example of how healthy ecosystem photographs and criteria with descriptors can provide practical specification for guiding ecological burning priority. This planned burn guideline is one of 13 guidelines produced for each Queensland terrestrial bioregion and covering most Queensland ecosystems.

5. Prescribed burn weather opportunity and constraints analysis (TAS)

Figure 9 *Days per year suitable for prescribed burning – Tasmania*

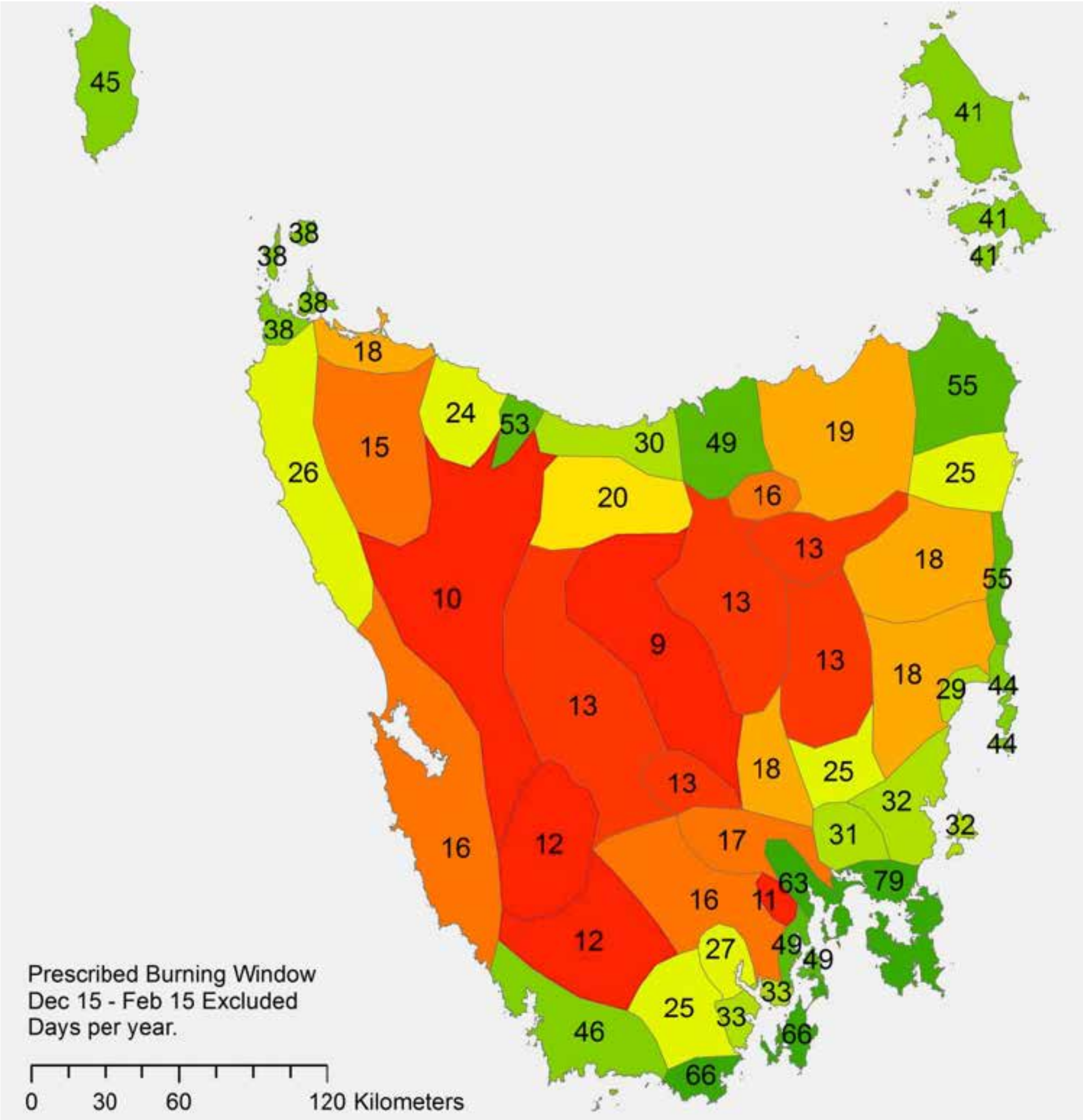


Figure 9 is an extract from Bushfires in Tasmania (State Fire Management Council 2014) providing analysis of the weather constraints on prescribed burn program delivery.

6. Modelling (using PhoenixRapidfire) of high-consequence fire ignition areas assuming maximum fuels (VIC)

Figure 10 *Modelled high-consequence fire ignition area maps*

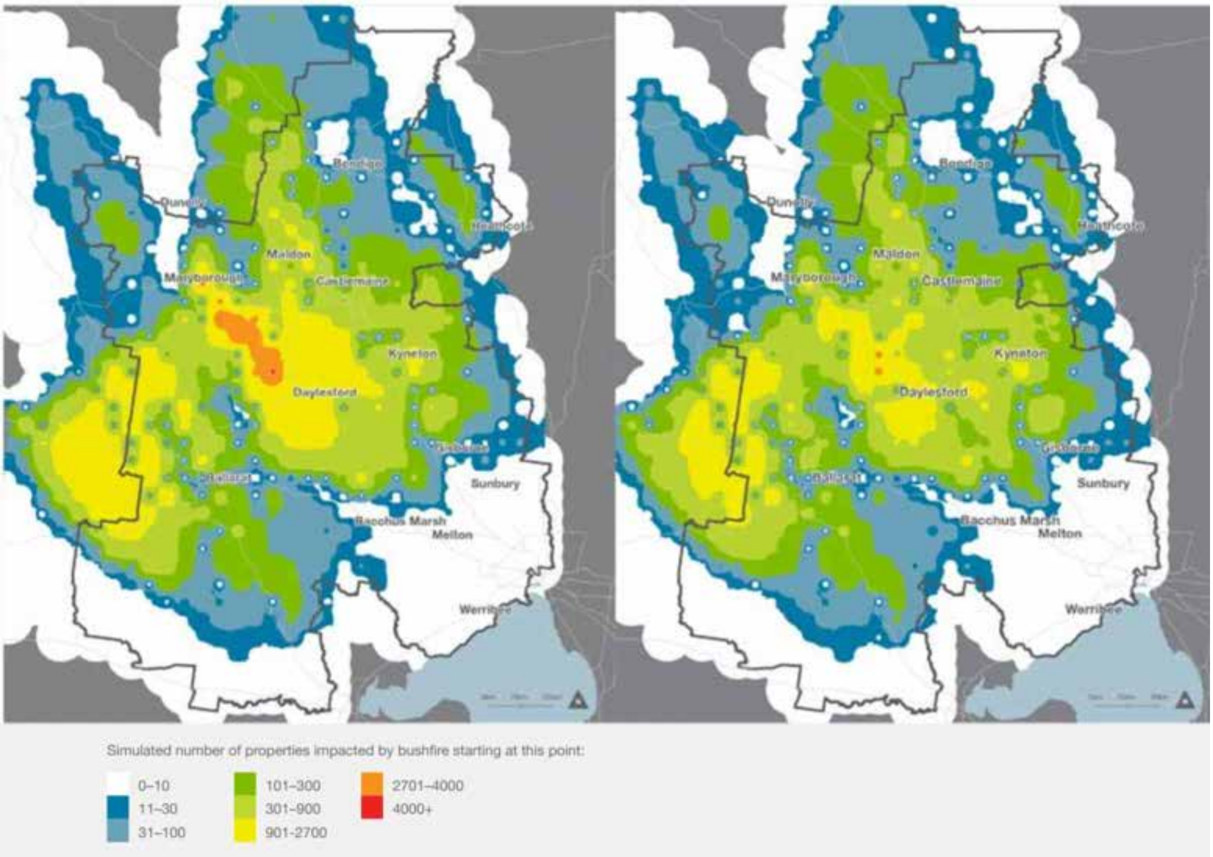


Figure 10 is an extract from the *Strategic Fire Management Plan for West-Central Bushfire Risk Management Landscape* (VIC) showing modelled high-consequence bushfire ignition locations (left panel is maximum fuel scenario; right panel is 2013 actual fire history-based scenario).

7. In-depth fuel management strategy comprised of Asset Management Zone supplemented by a Strategic Fire Advantage Zone (NSW)

Figure 11 *Bushfire risk and fire management zone mapping (NSW)*

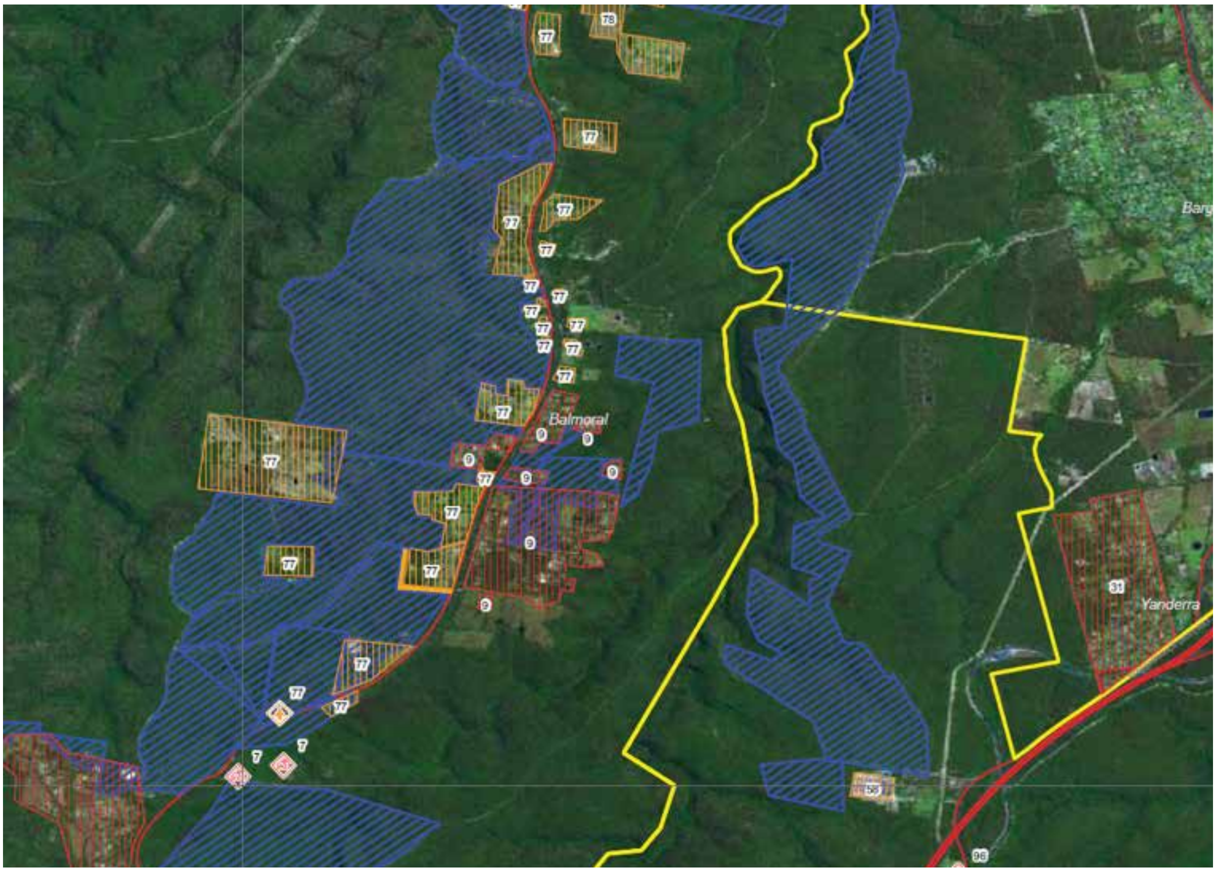
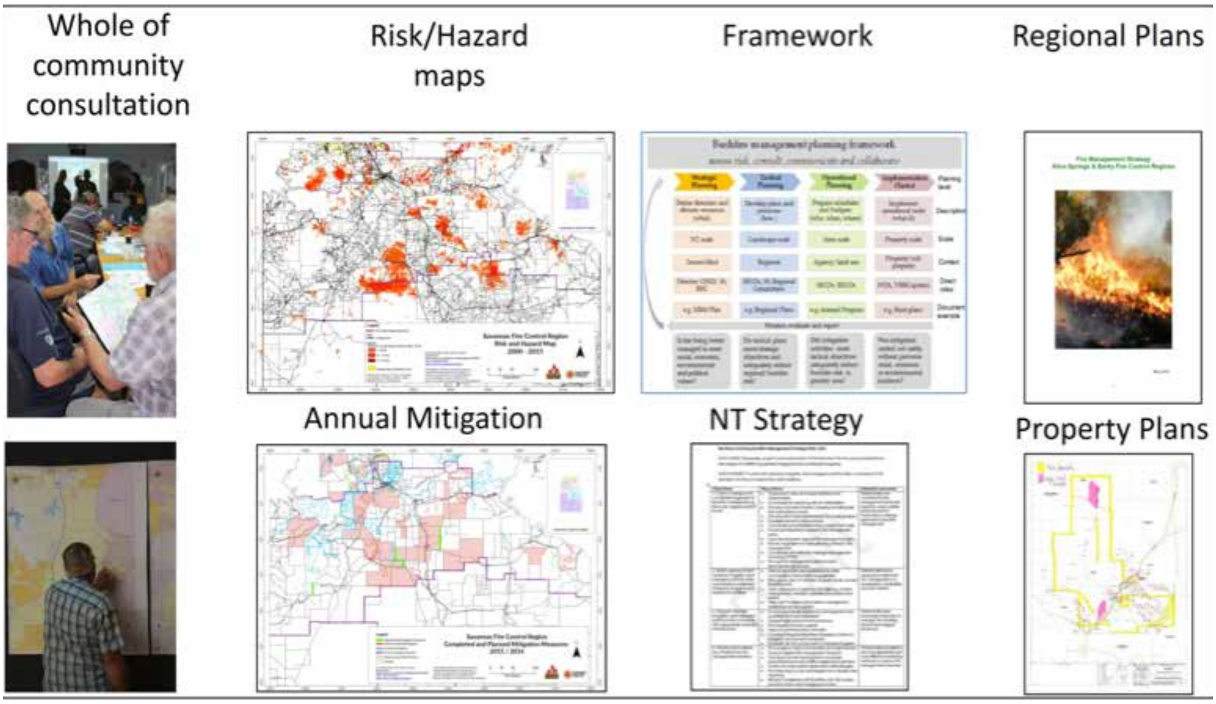


Figure 11 is an extract of bushfire risk and fire management zone mapping from *Wingecarribee Bushfire Risk Management Plan* (NSW). The at-risk life and property assets are identified as red hatching, with immediately adjacent Asset Protection Zones (APZ) depicted in orange hatching, supplemented with Strategic Fire Advantage Zones (SFAZ) depicted in blue hatching. Additionally, beyond the SFAZ is the land management zone in which the land manager may undertake ecologically beneficial burning, potentially placing such burns where they can also provide additional life and property protection benefit.

8. Strategic planning framework based on bushfire risk (NT)

Figure 12 *Northern Territory – developing a new strategic planning framework from scratch*

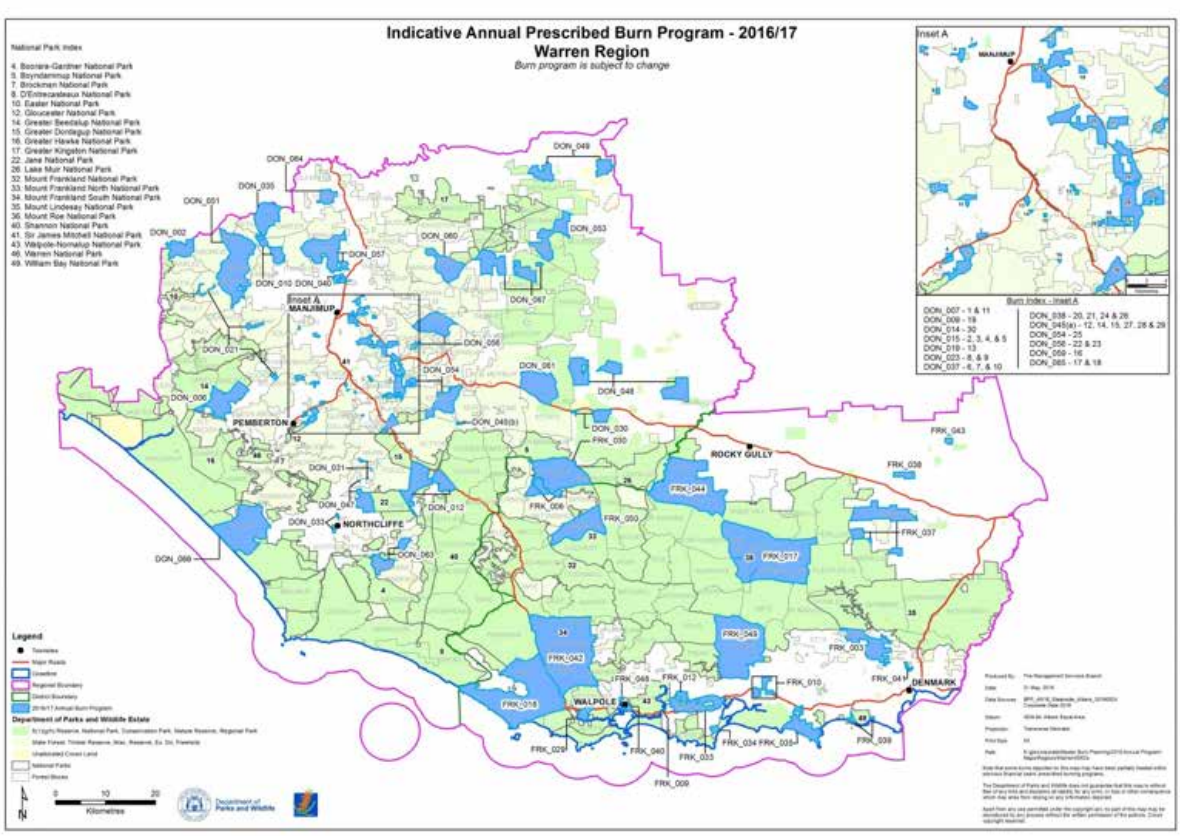


The introduction of the new *Bushfires Management Act 2016* provides the Northern Territory (NT) with a new strategic planning framework based on bushfire risk. Building an overarching framework from top to bottom provided the NT with a unique opportunity to carefully select elements that have been successfully applied in other jurisdictions, and adapt them to unique elements of the top ends large annual burning system, with the latest spatial modelling technology. Key features include a heavy emphasis on land owner and stakeholder consultation and participation, and a well-integrated series of planning steps from a framework, strategy and risk plan, through to preparing regional and property level plans.

Program Planning

9. Master Burn Plan product (WA)

Figure 13 *Parks and Wildlife WA's Master Burn Plan*



Parks and Wildlife WA's Master Burn Plan (Figure 13) is an output of their burn program planning phase. Maps are derived from a spatial database so they can be prepared at state, regional or district geographic scales, and are available over the internet so they can be zoomed in to any preferred scale. They can also be prepared at different time scales, from three years ahead down to just the next season's program.

10. Fire Operations Plan product (VIC)

Figure 14 *DELWP Fire Operations Plan online interactive map*

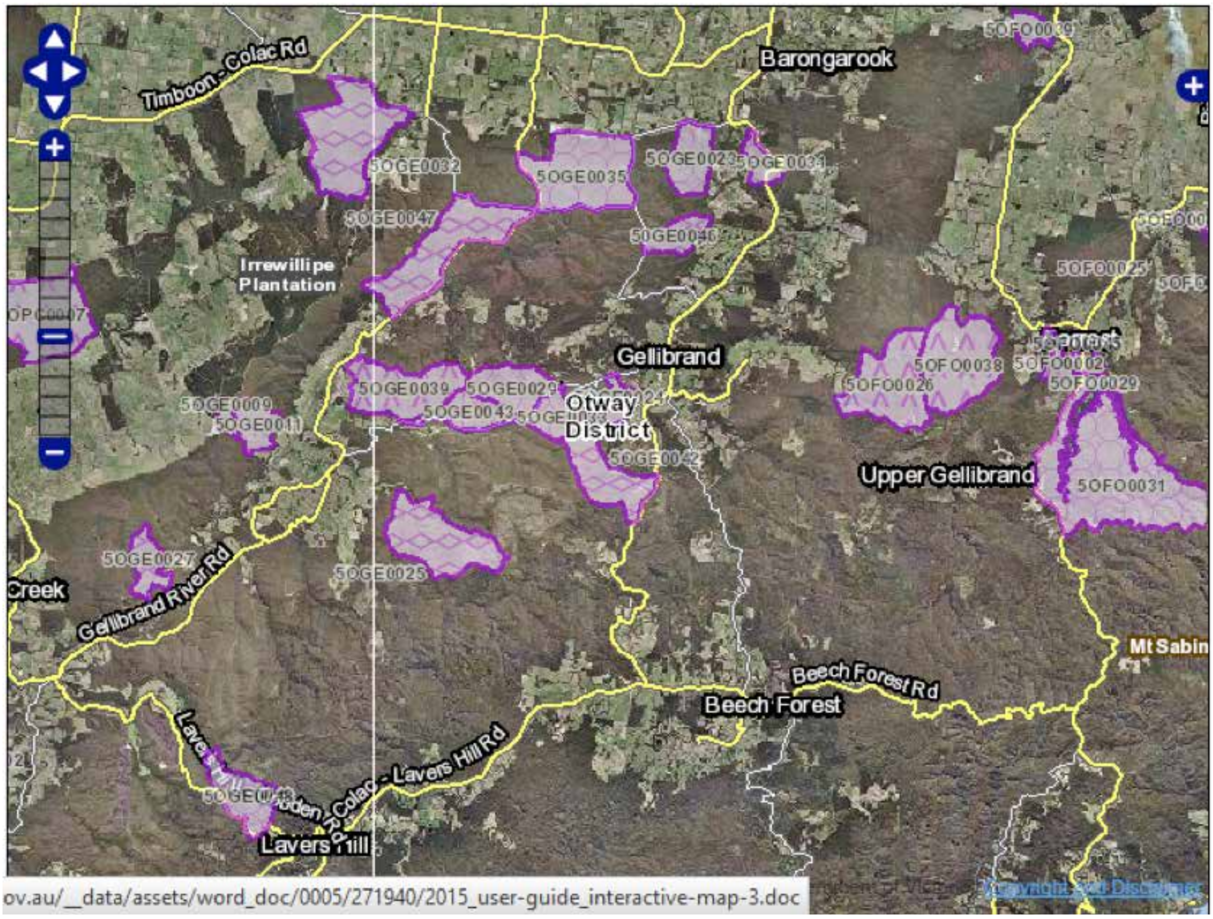


Figure 14 is an extract from the Department of Environment Land Water and Planning Fire Operations Plan online interactive map depicting the location of areas planned for prescribed burning over a 3-year period. Burns are positioned in close proximity to townships, in strategic areas in high-consequence fire-paths, and also in high-consequence ignition areas and locations requiring burning for ecological benefits.

These reports are available at the AFAC shop www.afac.com.au.

Information about the National Burning Project is available at www.afac.com.au/initiative/burning

National Guidelines for Prescribed Burning Strategic and Program Planning

National Burning Project: Sub-Project 4

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Strategic approaches to prescribed burn planning and programming is an important and growing area of proactive fire management in Australia. Due to significant diversity in climate, landform, vegetation, landuse, settlement pattern and historic use of fire, varying strategic planning approaches have evolved across the continent. Despite these differences there are important underlying principles that underpin all prescribed burning in Australia, no matter where or who you are. AFAC and the FFMG, through the National Burning Project, has taken on the challenge of building national guidelines for prescribed burning by developing a set of principles to support practitioners and to assist those reviewing systems, procedures and policy, so that greater consistency can evolve over time.

These National Guidelines for Prescribed Burning Strategic and Program Planning are part of a set that, together with the National Guidelines for Prescribed Burning Operations, build an end-to-end framework of best practice principles spanning strategic planning, program planning, operational planning and implementation phases of prescribed burning.

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