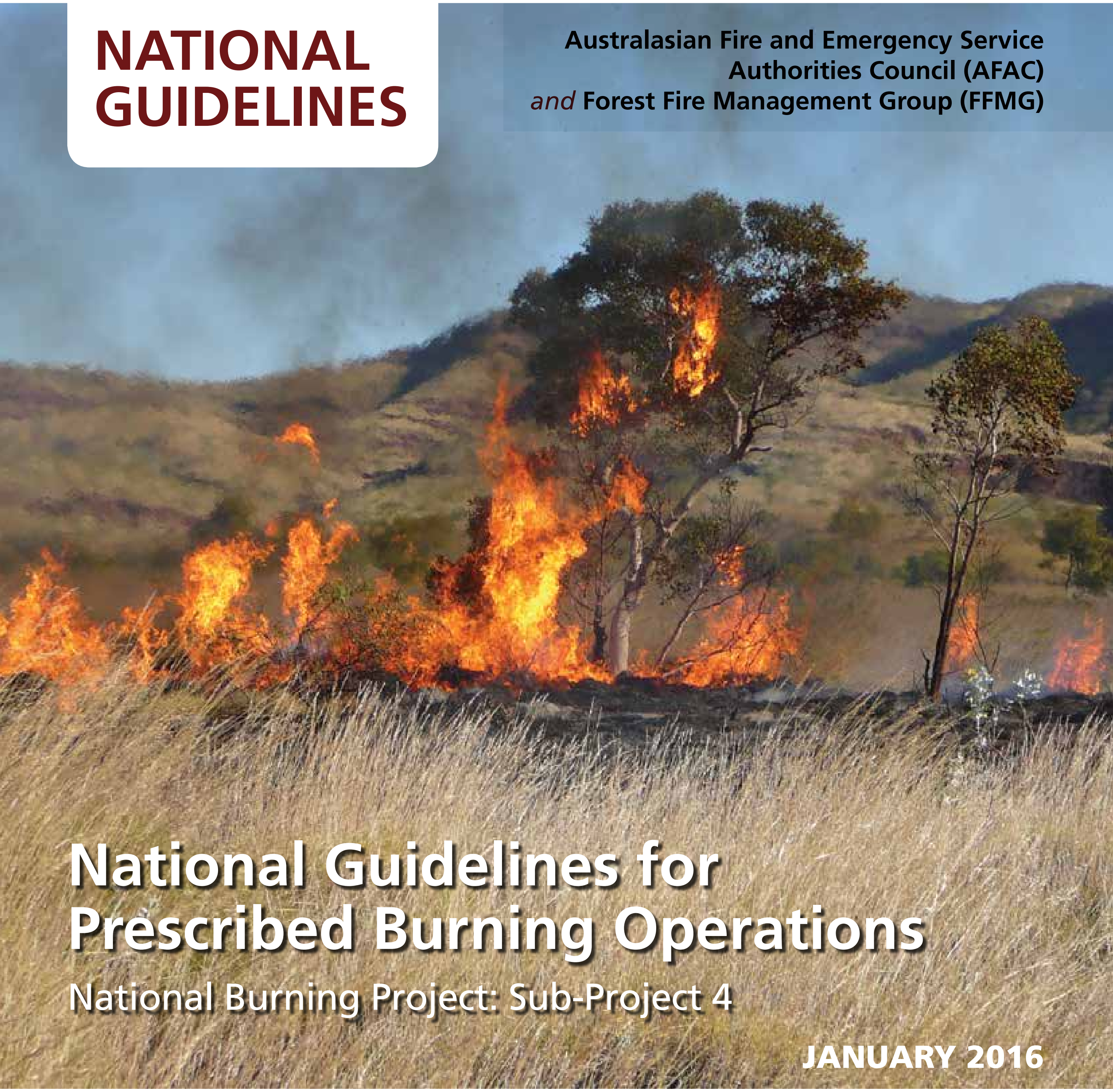
NATIONAL BURNING PROJECT

NATIONAL GUIDELINES

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



National Guidelines for Prescribed Burning Operations

National Burning Project: Sub-Project 4

JANUARY 2016

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1. INTRODUCTION

Preparation of these *National Guidelines for Prescribed Burning Operations* has been undertaken as a component of the National Burning Project. 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 operational planning, implementation, and post-burn assessment phases of prescribed burning. Due to the great variety of operating environments and institutional arrangements around Australia, these guidelines are necessarily at a best practice principles level, establishing a logical and consistent planning and works implementation framework.

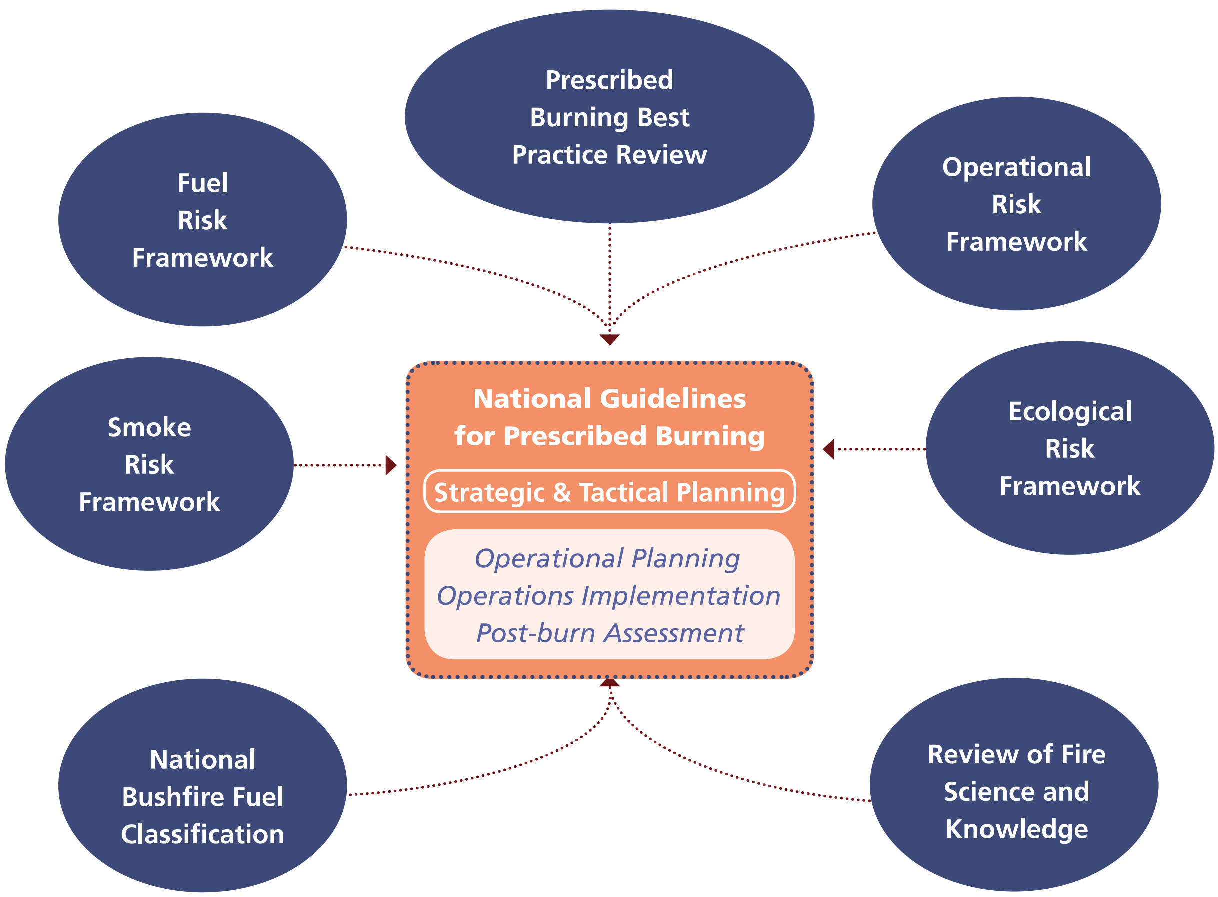
1.1 National Burning Project

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

Use a national approach to reduce the bushfire risk to 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), with a range of important foundation NBP sub-projects (Figure 1).

Figure 1 *National Burning Project – National Guidelines and related sub-projects*



This current project is to develop national guidelines for prescribed burning operations covering:

- Operational Planning;
- Operations Implementation; and
- Post-burn Assessment.

It covers all the operational phases which follow the strategic and tactical program planning phases. The strategic and tactical program planning phases are where the high level landscape priorities are set and candidate burn blocks are identified.

Foundation sub-projects include:

- Development of risk management frameworks for fuel hazards, safety, ecology and smoke;
- A national best practice review of the end-to-end process of prescribed burn planning and implementation; and
- The strategic and tactical planning component of the National Guidelines for Prescribed Burning detailing how the objectives, landscape priorities, burn types and specific burning areas are selected.

1.2 Project objectives

The objectives of this project are to develop national best practice guidelines for prescribed burning, founded on the national burning project work already undertaken. These guidelines will focus on the site-specific operational planning, burning operations and post burn assessment phases of the prescribed burning process. The strategic and tactical program planning phases will be addressed in separate but complementary guidelines.

1.3 Project approach

In commissioning the development of these guidelines AFAC and FFMG member agencies were acutely aware of the very wide range of operating environments, fuel types/characteristics, fire behaviour variability, and operational risk profiles associated with burning in different landscape positions/settings, local climatology and vegetation types in 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. Accordingly, these guidelines identify a planning process, a suite of good practice principles for prescribed burn planning and implementation, and are supported with a range of case studies showcasing how in practice the planning process and principles are applied by agencies to a specific type of burning operation.

1.4 Guidelines development process

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

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

Preliminary development of prescribed burning principles and guidelines: GHD drafted a high-level process framework and principles for prescribed burn planning and implementation to facilitate discussion regarding the structure and detail level of the project outputs.

Preliminary review of prescribed burning principles and guidelines: GHD consulted with AFAC/FFMG's project steering committee to obtain initial feedback on the preliminary draft process framework, principles and guidelines.

Regional case study visits for validation/further development of principles/guidelines and documentation of case studies: GHD visited AFAC/FFMG agency operating centres to conduct semi-structured information gathering focus groups and discussions with local prescribed burning practitioners to obtain validation and improvement feedback on the preliminary principles and guidelines, and to obtain operations-specific burn planning and implementation process and technique detail for development of case studies.

Table 1 Process framework and case study consultations

Location and Date	Case Study	Host/Sponsor
NSW – 2013	Blue Mountains – Complex urban-bushland interface	NSW National Parks and Wildlife Service
NSW – 2013	Young silvertop ash regrowth forest	Forestry Corporation of NSW
Southwest WA – 2013	Tall moist karri forest	Department of Parks and Wildlife
Victoria – 2013 to 2015	Multi-year landscape mosaic burning in forested mountain terrain using natural boundaries	Department of Environment, Land, Water and Planning
South Australia – 2013	Mallee-heath	Department of Environment, Water and Natural Resources
Tasmania – 2013	Buttongrass moorland	Department of Primary Industries, Parks, Water and Environment
NT – 2015	Savanna burning for greenhouse gas abatement	Charles Darwin University
Northwest WA – 2014	Spinifex	Department of Parks and Wildlife
Southeast Queensland – 2013	Moist grassy eucalypt forest	Queensland Parks and Wildlife Service; Brisbane City Council

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Case study documentation and draft guidelines report preparation: Following the regional operating centre visits, case studies were documented in a consistent format for inclusion in the draft National Guidelines, for review by the AFAC/FFMG steering committee (documented case studies to be reviewed by regional staff consulted during the operating centre visits/consultations).

Final reporting: A final report is prepared based on steering committee feedback.

As a foundation for developing national guidelines for prescribed burning, it is appropriate to first identify the key concepts of what prescribed burning is, the purposes for which it is used, and some key matters of operating context that influence its use.

2.1 Background

Deliberate, purposeful biomass 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, despite inter-annual climate variability[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, and provided heat and light for a range of purposes. Today these traditional burning practices only continue in certain areas where their knowledge has been retained, and where traditions involving burning remain a part of contemporary lifestyles. Where knowledge of traditional burning practice has been lost or fragmented, active efforts are being made to restore this knowledge across a number of communities.

There is widespread acknowledgement that Indigenous Australians continuous and frequent use of fire in the landscape shaped the biodiversity of Australia as it existed prior to European settlement. In southern Australia, Indigenous burning practices have been extinguished, in most places, for more than a century. They have been replaced by very different burning practices – different in scale, frequency and timing – instituted by European settlers, and which have been evolving and changing to the present day.

Biomass burning was first applied by those 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 (e.g. land clearing and broadacre 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 widely used by Australian public land management agencies since about the 1970s, with early development of systematic approaches and techniques

[1] There is a significant body of literature examining the issue of traditional Aboriginal burning practices, including a range of 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.

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Source: Office of Bushfire Risk Management WA.

founded in the 1960s. While there has been a history of knowledge sharing and collaboration on approaches and techniques between states and land management jurisdictions over this period, planning and management systems and operational procedures still vary significantly between jurisdictions and agencies, largely reflecting locally autonomous and independent development of practices. Many agencies, communities and land managers may have developed practices in isolation that are tailored to their needs, and may not have had the opportunity to share knowledge and practices that could have beneficial application more broadly.

In many jurisdictions, prescribed burning has never been reviewed in a systematic way and there may be an opportunity to introduce more efficient and effective practices to prescribed burning programs.

Over recent decades there have been many formal inquiries into bushfire management, usually precipitated by high-consequence fire seasons or catastrophic fire events. The most prominent of recent inquiries was the 2009 Victorian Bushfire Royal Commission (VBRC) following the 2009 Black Saturday fires in Victoria.

The VBRC heard evidence and received submissions from a wide range of sources regarding the rationale for, and efficacy of, prescribed burning as one of a suite of tools for bushfire risk management. It convened an expert panel (which included prominent fire scientists, ecologists and land management professionals) to consider and advise on the practice of prescribed burning. The evidence of the expert panel, and from written submissions and oral evidence informed the VBRC's conclusions and recommendations in relation to land and fuel management as outlined in Chapter 7 of the VBRC's Final Report (Parliament of Victoria 2010).

The VBRC's consideration of the role of prescribed burning, and its findings and recommendations largely focussed on public land management. It did not consider in any detail private lands which constitute more than half of the fire-prone land area in Victoria.

The VBRC made some important findings and recommendations including a significant expansion of prescribed burning programs on public land in Victoria, recommending a long-term program of prescribed burning with a minimum of 5% of public land to be treated annually. The merits or otherwise of setting of a quantitative target was at the time, and still remains, the subject of robust debate, and in 2015 the Inspector-General for Emergency Management commissioned a review of performance targets (IGEM 2015) after which Victoria moved to risk-based performance measures to allow more flexibility in terms of meeting bushfire management objectives.

Importantly, from the evidence it gathered, the VBRC (as had numerous inquiries before it) recognised the importance of prescribed burning as a means of modifying fuel loads and distribution patterns in vegetated landscapes, to avoid extreme fuel hazard accumulation at landscape scale stating:

"One of the primary tools for fire management on public land is prescribed burning. The main purpose of prescribed burning is to make people and communities safer by reducing combustible fuel, and hence the risks associated with fire. A secondary purpose is protecting flora and fauna from the consequences of destructive bushfire by preferentially applying prescribed burning in the environment" (Parliament of Victoria 2010).

And then:

"Properly carried out, prescribed burning reduces the spread and severity of bushfire. It makes a valuable contribution to reducing the risks to communities and firefighters by complementing effective suppression and is one of the essential protective strategies associated with making it safer for people to live and work in bushfire-prone areas in the state" (Parliament of Victoria 2010).

This renewed emphasis given to prescribed burning and the expanded programs set across a range of jurisdictions (not just Victoria) has required agencies to review their business delivery systems for the safe management of expanded burning programs and mechanisms to reduce their risk. It has also sparked some innovative thinking and renewed vigour in prescribed burning at the strategic, tactical and operational planning stages. Goals and objectives are also broadening to consider landscape fire risks collaboratively with other agencies and the community, the return to the use of prescribed burning as tool to maintain ecosystem health and heterogeneity (particularly in landscapes homogenised by high intensity bushfire) and movement away from the block-by-block highly constrained and narrow focussed planning systems that have hindered delivery in the past.

2.2 Prescribed Burning Definition

AFAC's Bushfire Glossary 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" (AFAC 2012).

Prescribed burning is also referred to as planned burning, controlled burning, prescription fire and prescription burn.

From the key components within the definition it is evident that a prescribed burn should have:

- Defined objectives;
- Specified environmental conditions;
- A specified area of application;
- A timeframe for execution; and
- Specified fire behaviour parameters; specifically rate of spread and intensity.

These key elements form the 'prescription' for a prescribed burn.

For most applications for safe control and delivery, prescribed burning is completed at low intensity (<500 kW/m), to reduce fine fuels[3]. This is not true for all prescribed burns, and in some fuel types such as heath and scrub types, burning involving higher intensities and consuming a high proportion of dead and live fuel and vegetation structure is necessary.

2.3 Why is prescribed burning used?

While the objectives for prescribed burning will vary, they broadly fall into the following two principal categories of burning:

- To modify fuel characteristics (quantity and arrangement) so as to reduce potential fire behaviour and impacts (intensity, rate of spread and spotting potential) when bushfires subsequently occur. This category of burning is commonly referred to as fuel reduction burning or hazard reduction burning; and
- For a specific land/resource management or ecological outcome. While the purpose of these types of burns varies, they are generally categorised as land management and/or ecological burning.

The uses of prescribed burning derive from the range of effects that fire has on the environment in which it is used. Typically, prescribed burning is used to achieve one or more of the following effects:

- Reducing fuel accumulation and altering fuel arrangement in vegetated areas;
- Causing mortality in individual plants not adapted to survive fire at the intensity applied (either whole plants or the above-ground parts), creating an immediate change in the relative abundance of species within a vegetation community and its structure, and changing the growth stage mix. Abrupt and immediate post-fire changes are followed by a continuing change process as vegetation regenerates and post-burn inter-species competition commences;
- Stimulating germination of seedlings or promotion of shoots of plant species with fire-cued regeneration and response traits;
- Alteration of vegetation assemblage structure, opening up structure through removal of combustible biomass and/or creating seedbed conditions favourable to establishment of species which benefit from post-fire conditions;
- Influencing wildlife habitat patterns, food and foraging resources, and local abundance (indirectly through vegetation changes rather than fire-induced mortality);
- Influencing habitat conditions for forest insects, parasites, fungi and pathogens (directly by sanitisation and indirectly by regulating vegetation dynamics);
- Prompting different ecosystem processes and characteristics (such as nutrient cycles and energy flow, succession, diversity, productivity and stability);
- Shaping the physical-chemical environment, such as if some nutrients are volatised, directly releasing mineral elements as ash, and reducing plant cover thereby increasing insolation and soil temperature; and
- Applying specific fire regimes over time to stabilise a vegetation community in a particular state, trigger succession to a new state, or provide an advantage or disadvantage to a particular suite of species.

[3] Principally fuels such as dead grass, leaves, twigs and loose fibrous bark less than 6mm in diameter that ignite readily and are burnt rapidly when cured and dry.

Source: Queensland Parks and Wildlife Service

Land and natural resource managers can take advantage of these fire effects, using prescribed fire to achieve a particular risk and land management objective including:

- Reducing fuel hazards for the reduction of bushfire behaviour (intensity and rate of spread) and risk, thereby improving the potential for containment and control of bushfires;
- Preparing sites to promote natural regeneration or facilitate seeding operations;
- Improving ecosystem resilience through increasing heterogeneity of fuel ages and structural classes and reducing susceptibility to whole stand removal bushfire events;
- Enhancing wildlife habitat (through maintaining productivity of feed resources or creating edges);
- Managing competing vegetation and weeds;
- Disposing of timber harvesting and cut vegetation debris;
- Controlling insects and disease;
- Improving grazing and foraging resource for native and exotic animals;
- Improving forest and woodland access by thinning out understorey vegetation;
- Perpetuating fire-dependent species and communities (through applying appropriate fire regimes for their maintenance or restoration);
- Cycling nutrients;
- Managing endangered species by using fire to create/extend favourable habitat condition; and
- Enhancing the appearance and amenity of vegetated areas.

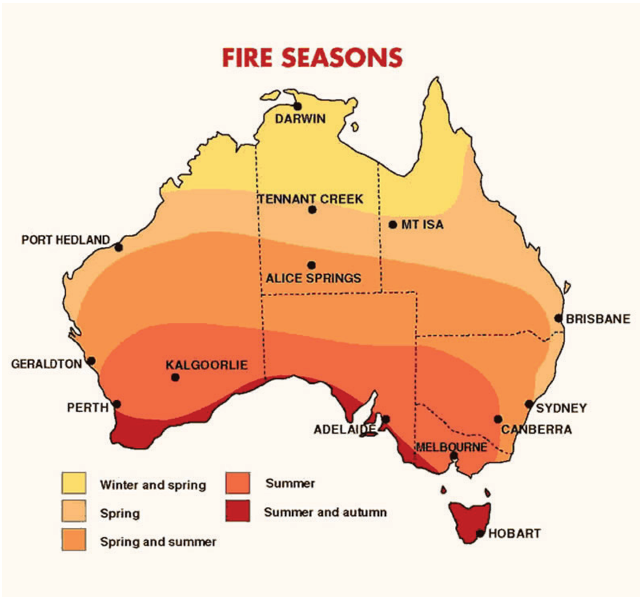
2.4 Physical operating context and challenges

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 include:

- ***Local climate and seasonal drying patterns:*** The timing of fire seasons and characteristics of bushfires changes between climate zones, landscapes and vegetation types. Across Australia the bushfire season grades from winter in the north through to autumn in the south (Figure 2). During these seasons (and sometimes shoulder periods) all climatic zones experience periods of weather conducive to fast-moving, high intensity uncontrollable bushfires. The periods when such conditions can occur can overlap with periods in which prescribed burning is practiced.

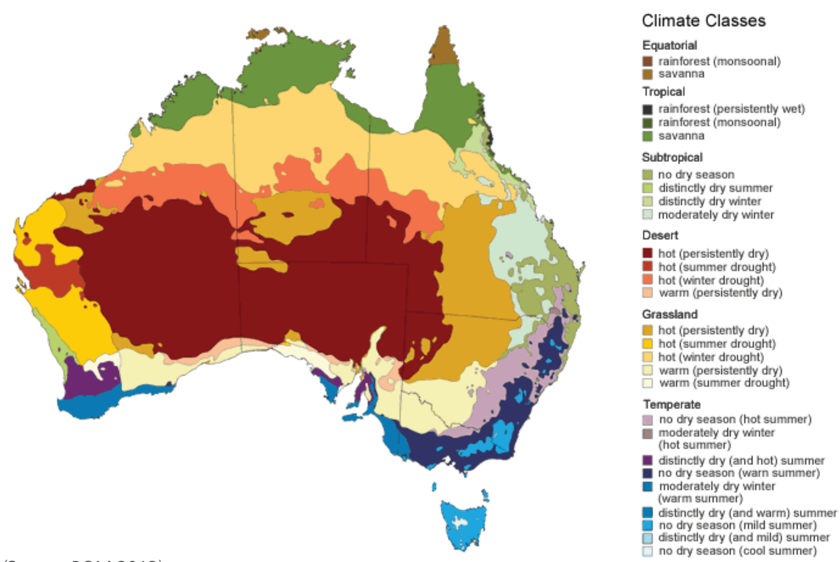
  The most pronounced fire-weather extremes occur in the Temperate and Grassland climate classes of southern Australia (Figure 3), particularly the Mediterranean environment of

Figure 2 *Pattern of seasonal fire occurrence in Australia*



(Source: Luke and McArthur 1978)

Figure 3 *Australian Climate Zones*



(Source: BOM 2013)

southern Western Australia and South Australia (distinctly dry – and hot or warm – summer), semi-arid grasslands and the temperate south east (no dry season – warm summer). Such extremes are experienced more frequently in inland areas away from maritime influences along the coastal fringe, however during severe weather patterns, extreme conditions will extend to coastal locations. The occurrence of severe fire-weather extremes in these areas means the potential for high-intensity fires has been a natural part of the environment for millennia, as have smaller scale lower-intensity fires. The extent to which large high intensity bushfires developed in the landscape historically, and the moderating effect continuous Aboriginal burning across the landscape played in limiting large fire extent, remains the subject of debate.

- ***Landscape distribution of vegetation groups and associated fire ecology factors:*** The broad range of climate classes across Australia, from Equatorial, Tropical and Sub-tropical, though to Temperate, Grassland and Desert, support a wide range of ecosystems (Figure 4). Across this range fire frequency is highly variable, from very rare in some alpine and rainforest areas, infrequent in arid and semi-arid and wet sclerophyll environments, to highly fire-prone, fire-maintained systems such as temperate and tropical grasslands and heathlands, and dry sclerophyll forests and woodlands. While the most dominant vegetation groups within Australia are non-forest types including hummock grasslands, eucalypt woodlands and acacia shrublands occupying more than 41% of the continent (DEWR 2007), high consequence fires primarily occur in eucalypt forest vegetation groups. The diversity of climatic zones, landscapes and vegetation types gives rise to a wide range of historical fire regimes. Accordingly, fire management planning that caters for this diversity is complex.
- ***Landform and landscape access factors:*** The landscape condition and fire regimes of today vary significantly from those in place when European settlement began. Very substantial landscape cover and condition changes have been brought about by settlement and land cover modification for agriculture (Figure 4). Human population distribution and densities far exceed those of any previous times and continue to expand. Correspondingly agricultural, industrial and urban development has extended across and fragmented fire-prone landscapes, increasing the exposure of communities to risk, and the complexity of applying fire management in the landscape.

  Most constructed developments at the urban/bushland interface are susceptible to bushfire. The development of suburbs and growth centres historically has occurred without consistent design and construction measures to improve bushfire resilience for individual structures or entire neighbourhoods. As a consequence the physical delivery of risk mitigation treatments such as prescribed burning have been developed within the systems and capacity of institutions, particularly over the latter half of the twentieth century, with the aim of reducing the adverse impacts of fires on people, assets of commercial value, and natural values. Changes have also occurred within natural areas with an alteration of fire regimes associated with land use changes (through sustained fire suppression practices) and land and fire-use practices that differ significantly from previously established Aboriginal practices (Section 2.1), altering vegetation community structure and flammability.

The results of settlement patterns, changed land use, extinguishment of traditional indigenous burning, and contemporary fire-use and suppression practices are fragmented landscapes and fire regimes substantially different from the pre-European era, and in many areas different to nineteenth and early twentieth century circumstances. While there are no 'benchmark periods' to consider current fire management practices against, there is an increasing recognition that many ecosystems are 'fire-maintained' requiring an ongoing application of fire to maintain diversity and resilience. There is also widespread acknowledgement that areas with a fire regime that is dominated by, or left in a condition that is susceptible to, unplanned high intensity fire on a recurring basis will result in significant impacts on ecosystem health and species decline. Further, leaving the landscape to be impacted by high intensity uncontrollable bushfires (whilst using suppression to limit the extent of those unplanned fires) is a deliberate management action, likely to result in:

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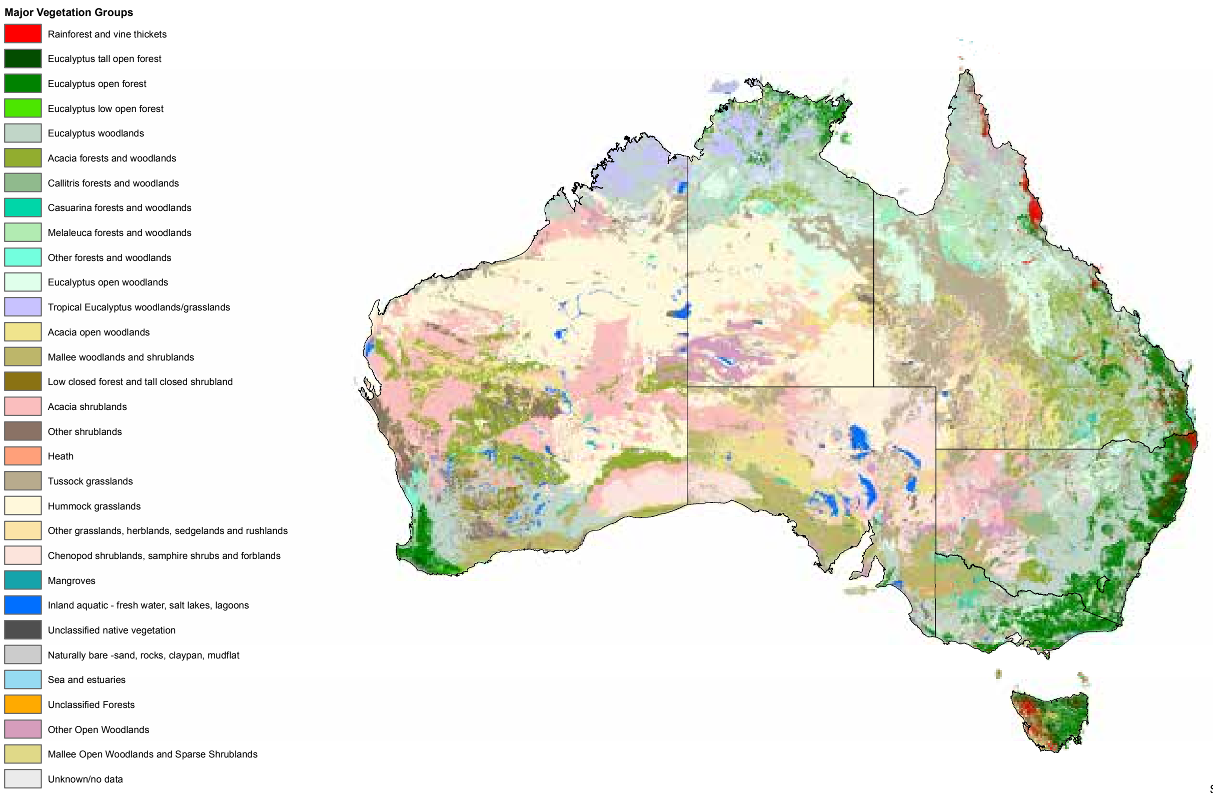
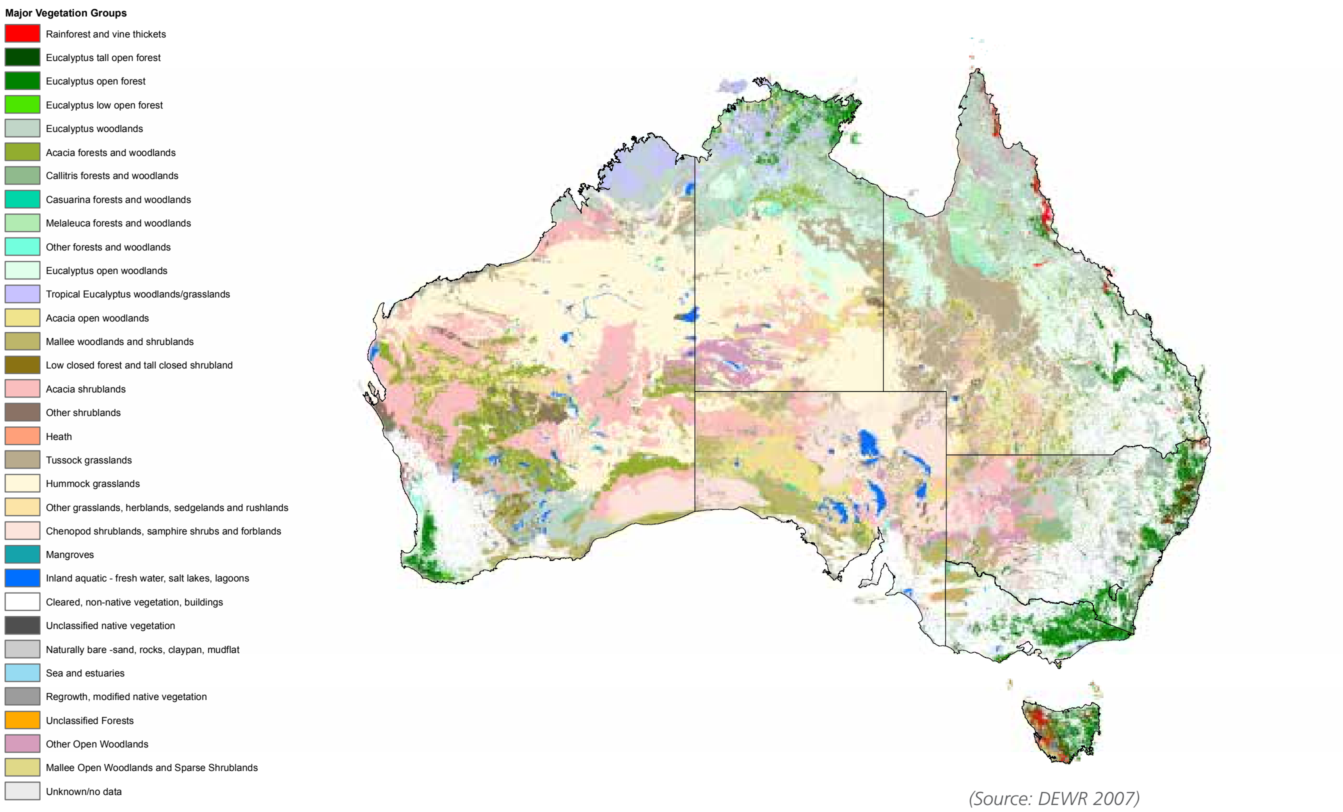
Figure 4 *Pre-1750 and current distribution of major vegetation groups*





(Source: DEWR 2007)

- Significant mortality and potentially permanent loss of plants, shrub and seed stores;
- Adverse and potentially irreversible impacts on those elements designated for protection. The tolerance limits of most species are exceeded in landscapes only serviced by repeated high intensity fires;
- Simplified structure;
- Potentially irreversible damage to soil reserves;
- Reduced capacity to regenerate stand and ecosystem elements (particularly in fragmented reserves);
- Increased risk to human life, property and assets; and
- Reduced resilience of surrounding communities particularly where residual socio-economic impacts result (such as from loss of tourist, agricultural or timber income streams).

Increasingly, prescribed burning is being reintroduced earlier (after the last fire) and more often to fire-maintained ecosystems[4] with the objective of creating and maintaining a fire mosaic across the landscape with a high variability of vegetation growth stages/fuel ages and patchy fire history. This mosaic effect is achieved through progressively applying a sequential pattern of prescribed burns (of different scales) within fire-maintained ecological communities, commencing as early as possible after large bushfires to increase heterogeneity, burning at a variety of frequencies, and varying burn seasons. In the more frequently treated areas, the aim is to create patchy burns through the limiting influence of fuel availability (some sections will have accumulated sufficient fuel to carry a low intensity prescribed burn, others with more discontinuous fuels will not). Fire sensitive species are able to persist to maturity within unburnt patches (and mature specimens may survive even within burnt patches if fire intensity is insufficient to cause mortality), heterogeneity is significantly enhanced, and the integrity of the ecosystem and its resilience to destructive wildfires is also enhanced through reduced fuels and consequently reduced fire intensity and rate of spread potential for unplanned fires.

The mosaic approach has been evolving, and continues to evolve, from previous minimum fire frequency-centred approaches. These approaches typically group a large range of vegetation types into a few large groups and establish a minimum fire interval (a fire exclusion period) based on the vital attributes of individual fire sensitive species – even though the species for which the minimum fire interval is formulated may comprise only a very small component of a vegetation community and may not even be a component of some vegetation types included in a group. In large landscape areas in which fuels have accumulated to near-equilibrium levels, there is increased probability of fire, greater fire intensity, spread and impact severity potential, and reduced opportunity for fire control. The approach of delaying the introduction of low intensity planned burning into fire-maintained ecosystems for lengthy minimum periods that allow high fuel loads to accumulate broadly, can be considered a significant gamble. If the minimum fire exclusion period being attempted exceeds the historical or potential bushfire return interval, a high probability of broad-scale failure arises, with the potential to generate significant irreversible impacts, potentially across large areas. Over the last decade or so, minimum frequency-centred approaches are giving way to approaches that encompass a wider range of considerations, including the degree of growth stage variability desirable within a landscape, and vegetation structure, condition and health considerations.

Across Australia and New Zealand land managers have a responsibility to maintain and enhance biodiversity, productive stands, natural resource values and reduce the risk to communities. Agencies do not have the capacity to exclude fire indefinitely from fire-prone landscape areas. Maintaining a high degree of heterogeneity across the landscape by applying prescribed fire early and regularly can reduce fire intensity and rate of spread of bushfires, reducing high intensity impacts, enhancing control options, reducing the immediate and longer term risk to communities and maintaining ecosystem values.

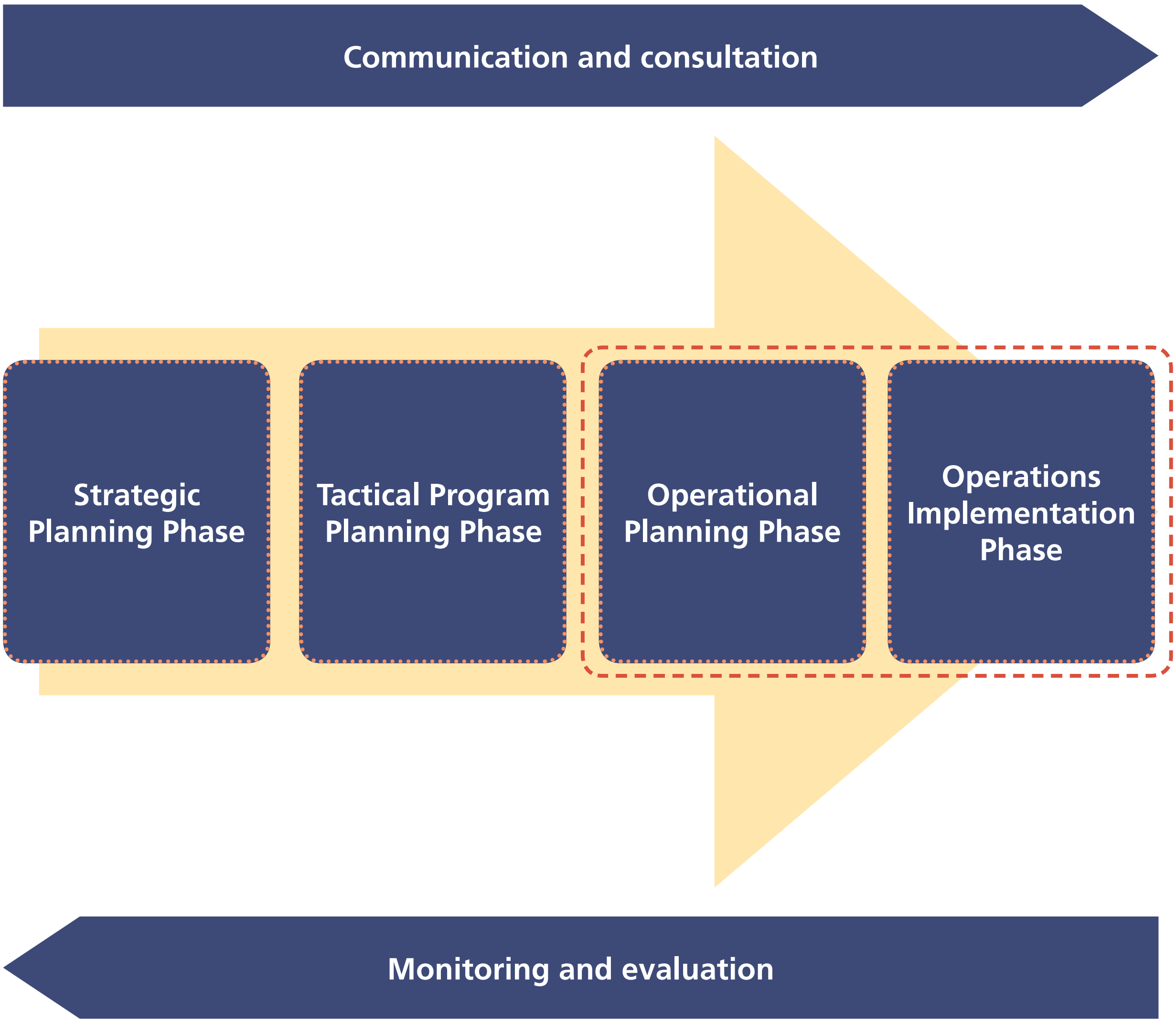
[4] Entire vegetation communities that are fire sensitive or threatened species that have specific requirements may require fire exclusion and protection from potential fire incursions.

3. PRESCRIBED BURNING PROCESS

3.1 Overview

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

Figure 5 *High-level end-to-end process model of prescribed burning*



These guidelines cover the operational planning, and implementation phases and the post-burn assessment component of monitoring and evaluation. Communication and consultation components are integrated within the operational planning and implementation phases.

For context, a broad outline of the focus of strategic planning and tactical program planning is outlined here, but not further discussed. It is intended these phases will be covered by separate guidelines developed in a future project.

Strategic planning phase: Involves the process of assessing bushfire risk in a landscape area, and among other risk reduction programs, identifying hazard management objectives and strategies, and a model of how hazards contributing to the risk will be managed. Strategic planning outputs for prescribed burning programs typically establish:

- Bushfire behaviour modification objectives;
- Which fuel hazard types to treat (fuel-reduce/modify), and which not to treat;
- Different treatment types, objectives and effective dimensions;
- Re-treatment time-cycles or trigger conditions;
- How much of the landscape to treat; and
- The general model for arranging treatments in the landscape to maximise risk reduction benefits and optimise trade-offs.

Whilst primacy of focus is routinely given to managing life and property risk, planning considerations also include planning for biodiversity conservation and land management, which may include identifying areas that are not to be burnt (ever, or for some period of time).

The strategic planning phase should embed a prescribed burning program in an organisation's business/broader program context, establishing the whole-of-organisation mandate and commitment to the program.

Tactical program planning: Tactical program planning is undertaken to organise the delivery of strategic planning outcomes. Based on available options, priorities, resources and seasonal conditions, tactical programs document decisions about the works quantity and scheduling to be implemented over a planning cycle. Tactical program plans typically take the form of annual or multi-year work schedules, often with map-based components, outlining where and when proposed burns are programmed pursuant to implementing strategic planning.

In these national guidelines, the operational planning, operations implementation and post-operation appraisal phases of the prescribed burning process are addressed.

3.2 Operational planning phase

Operational planning progresses prescribed burn planning from the strategy and scheduling phases of strategic and tactical planning (setting location, area, burn type and season) through to the stage where a specific burn activity is planned and ready to implement.

The operational planning phase has three key stages:

3.2.1 Operational planning stage 1 – Burn site and risk analysis

Incorporates analysis of:

- Whether the proposed burn site (in its current state) is consistent with the bushfire management strategy or zoning applying to the land;
- Whether the burn as proposed is reasonably possible and cost-efficient to implement given the site features (access, containment, slope, good neighbour requirements) and fuel conditions, strategic and tactical objectives; and
- The risks associated with implementing the proposed burn, and whether the benefits exceed the potential risks.

3.2.2 Operational planning stage 2 – Deciding the burn execution and risk management strategies

Based on the stage 1 analyses, stage 2 involves deciding or confirming:

- Burn objectives, fuel, weather and fire behaviour prescriptions;
- Burn boundaries and any preparation requirements; and
- All risk controls/treatments required to manage values at-risk during the burn, including:
  - » Notifications, consultations, and hazard warnings;
  - » Resource types/levels to light and control the burn and manage burn crew/public safety risks (from fire and smoke);
  - » Burn organisation, command and control; and
  - » Environmental risk controls/treatments.

The principal output of planning stages 1 and 2 are a ***Prescribed Burn Plan***. The plan documents the information, decisions and action requirements from the planning process in an agency approved Prescribed Burn Plan format. The plan should identify the area to which fire is to be applied and excluded, the management objectives of the planned burn, its timing, desired fire burn coverage, intensity, and rate of spread and the necessary environmental conditions to achieve these objectives. The plan should specify pre-burn preparation actions required, and incorporate necessary maps, operating instructions, and administrative arrangements relevant for burn crews to undertake their tasks safely, and identify burn record keeping requirements.

3.2.3 Operational planning stage 3 – Preparation

The preparation stage incorporates activities necessary to get the burn ready for implementation. Preparations include activities that can be conducted well in advance of implementation such as preparing the burn boundaries/containment lines, checking access to water supplies, providing advance notice to the public and stakeholders, and preliminary organisation of resources for the burn. Preparation stage activities also include monitoring fuel and weather conditions to identify when conditions will become suitable for burning, and it involves the final preparatory activities that are undertaken once a burn date has been scheduled (burn date and time notifications to stakeholders and neighbours; scheduling and mobilising resources and completing readiness actions and checklists).

Outputs of the preparation stage are often in the form of checklists of preparatory actions completed, and an approved burn commencement date/time.

3.3 Implementation phase

The implementation phase is essentially the execution of the Prescribed Burn Plan. In effect, it is the safe and efficient ignition, burning, and risk management execution. It involves a logical sequence of activities including conducting the necessary day of burn checks and briefings, obtaining approval to commence the burn, lighting and monitoring the burn and controlling the risks, actioning burn record keeping and progress reporting requirements, and assessing when to down-scale resourcing, make the burn site safe and demobilise resources.

3.4 Appraisal phase

The appraisal phase involves evaluating the outcomes of the prescribed burn implementation against the planned objectives, reporting the outcomes and identifying lessons learnt for continuous improvement.

3.5 Process model and principles

A process model setting out the work phases involved in planning a prescribed burn, through to implementing it, and assessing the burn outcomes is depicted at Figure 6. The process model incorporates 17 best-practice principles, that when applied through the operational planning, implementation and appraisal phases should facilitate successful and efficient prescribed burning outcomes.

Table 2 provides a simple tabulated list of the 17 best-practice principles for successful and efficient prescribed burning outcomes.

The 17 principles addressed in detail in Section 4 provide the rationale for why each is important, and providing general guidance notes outlining key factors to be considered and the decision points typically associated with each principle.

Section 5 of this report outlines 9 case studies that serve as examples of how best-practice approaches to prescribed burn planning and implementation are applied in a range of different operating environments and jurisdictions.

Figure 6: Process model of prescribed burning: operational

Prior phases

Strategic Planning

Tactical Program Planning

Notes: If these planning stages are done well, the number of risks to be managed during operational planning and implementation stages will be minimised.

Operational Planning Phase
Analysis and Planning Stages

Site and Risk Analysis

Principle 1
Consider the strategic context for the proposed burn and check the proposed burn characteristics are consistent with the strategic intent

Principle 2
Check that prior desktop planning is feasible in practice – consider and assess the operational feasibility of achieving the burn objectives

Principle 3
Potential risks of implementing the burn need to be identified and verified so their management can be planned – identify and assess at-risk values and assets, both within and outside the burn area

Principle 4
Consult with neighbours and stakeholders to identify their issues and requirements

Analyse:

Are the proposed burn characteristics fit for the strategic intent?

Is the burn feasible and can the burn objectives be met?

Burn security risks – are the burn boundaries suitable?

Assets and values at-risk from the burn – social, economic, environment, heritage. Consider fire & smoke.

Neighbour/visitor/stakeholder issues and risks.

Decide Burn Execution and Risk Treatment Requirements

Principle 5
Burn planning needs to be based on well-considered assessment of how fire will behave on the site, and off-site if it escapes – assess likely and potential fire behaviour of the vegetation types/fuel conditions to be burnt – confirm or modify the burning prescriptions

Principle 6
Methodical planning ahead of burn implementation methods & requirements is critical to good operational efficiency – decide and plan burn preparation and contingency plan implementation requirements

Based on the site and risk analysis:

Confirm/decide:

Burn objectives, fuel, weather and fire behaviour prescriptions.

Burn boundaries any preparation requirements.

All risk controls required to manage at-risk values and objectives, including:

- notifications, consultations & hazard warnings
- resource types/levels to light & control the burn and manage burn crew/public safety risks (from fire & smoke)
- burn organisation, command & control
- environmental risk controls

OUTPUTS

PREPARE PRESCRIBED BURN PLAN

Document the information, decisions and action requirements from the planning process in an agency approved Prescribed Burn Plan format.

The plan should specify pre-burn preparation actions required, and incorporate necessary maps, operating instructions, and administrative arrangements relevant for burn crews to undertake their tasks safely, and identify burn record requirements.

MANAGEMENT/PEER REVIEW & APPROVAL OF PLAN

planning, implementation and appraisal phases

Preparation Stage

Advance preparations

Principle 7
Good, timely preparation for burning enables burning opportunities to be taken when they arise, and contributes to sound risk management – plan and undertake key preparatory requirements for burn/risk control

- Complete boundary and other preparations
- Make advance notifications and public advice
- Give early notice to resources

Monitor fuel and weather conditions

Principle 8
Foresee the onset of burning opportunities and be ready – monitor landscape/fuel drying indicators to determine when suitable burning conditions are approaching

Final preparations

Principle 9
Be well organised for when burning opportunities arise – organise the mobilisation and tasking of resources for the burn with as much advance notice as possible

COMPLETE PREPAREDNESS CHECKLISTS

APPROVAL OF BURN SCHEDULE DATE

Implementation Phase

Conduct burn-day checks and briefing

Principle 10
Base your burning decisions on good forecast information – obtain the latest and most accurate weather and smoke dispersion forecasts

Principle 11
Be well disciplined and organised in scheduling burn components – mobilise resources to burn site; check readiness; brief team and assign clear tasks

Principle 12
Burn timing and ignition location should be based on well-considered knowledge of current and future fuel and weather conditions – monitor site fuel and diurnal weather pattern development on the day of the burn; determine suitable location and conditions for a test fire, obtain ignition approval

Principle 13
Confirm theoretical preditions and intuitive insights with practical field evidence – light a test fire and assess the behaviour

Record decisions and fire behaviour observations

Light and control burn and risks

Principle 14
Exercise good discipline in executing lighting and containment operations but retain flexibility to modify pre-planned techniques where conditions vary from assumptions or change – monitor fire behaviour and always keep in mind the fire behaviour prescriptions for the burn and take action to achieve these

Principle 15
Ensure public safety aspects of the burn are appropriately resourced and managed – execute public safety management requirements as per burn plan and agency procedures

Record & report key issues arising and decisions, weather and fire behaviour

Assess and decide scale-down/patrol

Principle 16
Base decisions for resource up-scaling or down-scaling on well considered assessments of fire behaviour potential and ongoing residual risk – monitor fire burn-out and determine arrangements for crew demobilisation, mop-up and patrol, and treatment of residual public safety risks

Appraisal Phase

Conduct post-burn assessment

Principle 17
Evaluate burn results against objectives to determine if any follow-up works are necessary, and to form part of continuous improvement process, implement post-burn assesment, evaulation and reporting

3. PRESCRIBED BURNING PROCESS

Table 2 *Prescribed burning phases and associated principles*

Phase	Associated Principle(s)	Confirmation of:
Burn Area Analysis Phase	**Principle 1** – Consider the strategic context for the proposed burn and check the proposed burn characteristics are consistent with the strategic intent	Strategic zoning
	Principle 2 – Check that prior desktop planning is feasible in practice – consider and assess the operational feasibility of achieving the burn objectives	Burn feasibility
	Principle 3 – Potential risks of implementing the burn need to be identified and verified so their management can be planned – identify and assess potentially at-risk values and assets, both within and outside the burn area	Site specific risks
	Principle 4 – Consult with neighbours and stakeholders to identify their issues and requirements	Stakeholder and neighbour issues
Operational Planning Phase	**Principle 5** – Burn planning needs to be based on well-considered assessment of how fire will behave on the site, and off-site if it escapes. Assess likely and potential fire behaviour of the vegetation types/fuel conditions to be burnt and confirm or modify the burning prescriptions	Consider fire behaviour potential and decide burn prescriptions
	Principle 6 – Methodical planning ahead of burn preparation and implementation methods and requirements is critical to good operational efficiency – decide and plan burn implementation and contingency plan requirements	Burn plan preparation
Operational Preparation Phase	**Principle 7** – Good, timely preparation for burning enables burning opportunities to be taken when they arise, and contributes to sound risk management – decide and document key preparatory requirements for burn/risk control	Burn control measures and site preparation needs
	Principle 8 – Foresee the onset of burning opportunities and be ready – monitor landscape/fuel drying indicators to determine when suitable burning conditions are approaching	Monitoring for burning window
	Principle 9 – Be well organised for when burning opportunities arise – organise the mobilisation and tasking of resources for the burn with as much advance notice as possible	Team and crews mobilised

Phase	Associated Principle(s)	Confirmation of:
Burning Phase	**Principle 10** – Base your burning decisions on good forecast information – obtain the latest and most accurate weather and smoke dispersion forecasts	Weather forecast
	Principle 11 – Be well disciplined and organised in scheduling burn components – mobilise resources to burn site; check readiness; brief team and assign clear tasks	Timing and scheduling of delivery
	Principle 12 – Burn timing and ignition location is based on well-considered knowledge of current and future fuel and weather conditions – monitor site fuel and diurnal weather pattern development on the day of the burn; determine suitable location and conditions for a test fire	Ignition pattern and spacing
	Principle 13 – Confirm theoretical predictions and intuitive insights with practical field evidence – light a test fire and assess fire behaviour	Test fire
	Principle 14 – Exercise good discipline in executing lighting and containment operations but retain flexibility to modify pre-planned techniques where conditions vary from assumptions or change – always keep in mind the fire behaviour prescriptions for the burn and take action to achieve these	Lighting up
	Principle 15 – Ensure public safety aspects of the burn are appropriately resourced and managed – execute public safety management requirements as per burn plan and agency procedures	Public safety
	Principle 16 – Base decisions for resource up-scaling or down-scaling on well-considered assessments of fire behaviour potential and ongoing residual risk – monitor fire burn-out and determine arrangements for crew demobilisation, mop-up and patrol, and treatment of residual public safety risks	Downscaling resources
Appraisal Phase	**Principle 17** – Evaluate burn results against objectives to determine if any follow-up works are necessary, and to form part of continuous improvement process, implement post-burn assessment, evaluation and reporting	Success factors

4. PRESCRIBED BURNING PHASES AND PRINCIPLES

4.1 Operational planning phase – burn site and risk analysis stage

In order to appropriately plan for the implementation of a prescribed burning operation, a relevant range of information needs to be gathered and analysed – in complex burns the information gathering and analysis process may be considerable. The information required will come from a number of sources including from maps, reports and databases that can be searched in a desktop process, and observations and measurements made during burn-site inspections made to ground-truth information and gain data not available through desktop analyses. Information can also be gathered from neighbours and stakeholders who have an interest and/or relevant knowledge about aspects of the burn and its potential impacts. The information gathered is analysed by the burn planner for the identification of:

- Requirements for preparing for and undertaking the planned burn activity safely;
- Requirements for achieving the burn objectives, and
- The range of burn implementation risks, and the requirements for managing these including contingency risk management, to avoid unacceptable consequences across the Political, Environmental, Social, Technical, Legal and Economic (PESTLE) risk dimensions.

Principles 1 to 4 relate to the initial information gathering and analysis stage of prescribed burn planning.

4.1.1 Principles 1 – 4: Application in Northern Australia

In short interval fire frequency areas such as occur in northern Australia (where fire occurrence can be near-annual in some areas, and where most of the savanna landscape components burn at intervals of less than 3 years), tactical program planning typically occurs in the lead up to and during the early dry season (not on the several years ahead timescales more typical in southern Australia). This is due to the need to take account of the large amount of fire that will have occurred in the last 12 months as well as other unplanned fires as they occur during the current burning season as it progresses. The result is that decisions about burn locations and dimensions, burn site and risk analysis, and stakeholder considerations (importantly also including consideration of traditional owner cultural considerations) are more often made in a seamless continuum together with the burn execution and risk treatment planning components. In fact, these planning activities are often done by gathering together the stakeholders that will plan, execute and potentially be affected by the burn, to consider mapped information about the current distribution of recent fire-scars, and then making decisions about where best to place burns in the landscape (generally to link up recently burnt areas to provide contiguous burnt areas in the landscape which will stop or impede the spread of inevitable unplanned late dry season fires to reduce the extent and severity of their adverse impact). These decisions and discussions about burn location and dimensions flow straight into consideration of operational arrangements and resourcing necessary to get the burn or burns implemented. Thus in northern Australia, the burn planning process is, by necessity, a much shorter-cycle more dynamic process than the more deliberate and staged longer-cycle process applied in southern Australia.

Source: NSW Parks and Wildlife Service

4.1.2 Principle 1

Principle 1

Consider the strategic context for the proposed burn and check the proposed burn characteristics are consistent with the strategic intent.

Why is this principle important?

In many jurisdictions, tactical program level planning for a burn may occur up to three years before the nominated burn year and season. In the intervening period, events may have occurred which could impact the strategic intent of the originally proposed burn. For example, bushfires may have occurred in or near the area, land management activities (e.g. grazing) may have altered fuel conditions and/or local risk, or pre-requisite burns necessary for the proposed burn to proceed or be effective were not undertaken. Any such factors need to be considered so that the burn can be planned to be consistent with the originally envisaged strategic intent.

General guidance notes

The suitability and effectiveness of applying prescribed fire to a locality should be considered within the strategic bushfire risk management objectives and land use management objectives of the area in and around the proposed burn.

Consider what is the strategic context of the burn?

Strategic and tactical program level planning will normally occur prior to the nomination and scheduling of a burn for operational planning. Individual burns will usually be assigned a burn 'type' or be allocated to a particular burning 'zone' which commonly have standard or generic objectives attached. Check that the objectives and general attributes of the nominated burn (e.g. proposed location, dimensions, degree of fuel reduction/modification) are consistent with those of the designated burn type/zone and other 'strategic' intents. For example, are they consistent with the biodiversity conservation outcomes of management plans, water catchment objectives from land use plans, forest productivity outcomes from forest management plans etc.?

Strategic context questions to consider might include:

- Is the burn intended to provide localised protection effects to a specific area or asset? If so, will the proposed burn characteristics (location, dimensions, degree of fuel reduction/modification) achieve the desired level of protection, or are changes required to achieve the desired results?
- Is the burn one of a strategic program of burns, which together with other treated areas is intended to influence the development and spread of subsequent unplanned fires in a landscape area? If so, have the other burns been conducted or scheduled such that the strategic value of the proposed burn can be realised? Or, have recent bushfires altered the strategic value or necessity for the proposed burn? and
- Is the burn intended to facilitate a specific fire suppression objective? If so, will the proposed burn characteristics (location, dimensions, degree of fuel reduction/modification) achieve the desired objectives, or are changes required to achieve the desired results?

Decision point

Decide whether the general characteristics of the nominated burn are consistent with the strategic intent for the burn. If burn characteristics such as burn location, dimensions, orientation in relation to other landscape features and proposed pattern/degree of fuel reduction (or habitat management for ecological burns) are consistent with the strategic intent then continue with planning. If not, decide what changes to the nominated burn characteristics need to be made to improve alignment with strategic intent.

4.1.3 Principle 2

Principle 2

Check that prior desktop planning is feasible in practice – consider and assess the operational feasibility of achieving the burn objectives.

Why is this principle important?

In some cases, tactical program planning for burns may be done at desktop level only, or with only limited ground-truthing of vegetation types, fuel characteristics and burn boundary feature condition. Objectives may have been established through selection of standard prescriptions applying to burning zones/types, and/or applying to a single or dominant vegetation type.

In practice, objectives developed during desktop planning may not be feasible. For example, assumptions about access and burn boundaries/proposed control lines may not accord with their actual condition; vegetation types and their condition in the field may differ significantly from desktop assumptions (or have unexpected levels of variability) with significant implications for planning of the burn. Therefore it is prudent to initially assess the degree to which any burn objectives nominated at the tactical planning stage are achievable in practice.

General guidance notes

Areas identified as suitable for the application of prescribed fire should be examined to determine if and when prescribed burning is feasible and whether prescribed burning objectives can be achieved.

Conduct a desktop review of the proposed burn to scope which matters need to be checked during field inspection.

It is recommended to start with understanding and validating/ confirming the objectives.

This typically will involve field assessment to check the practical feasibility of achieving the objectives, given the nature and constraints of the site.

Key questions to consider may include:

- Are the nominated burn boundaries feasible (i.e. are the boundary features suitable and realistic for containing the burn) – some strategic planning processes are done as 'desktop' exercises using maps, and actual features in the field can turn out to be different to those assumed from map interpretation. Resource requirements to prepare containment lines also need to be considered, including the financial feasibility – if the likely cost of preparing nominated containment lines exceeds available funding, alternative containment options may need to be explored;
- If a burn season or burn treatment timeframe has been nominated at the tactical program planning stage, is this feasible and prudent given expected site and seasonal conditions? Can the burn block be treated in a single-pass burn event, or should burning within the block be staged over a season with multiple ignition events to remove the most problematic fuel types first (such as those with high spotting potential or control difficulty) in advance of other fuel types becoming available? Aiming to burn an entire large block in a single day can be overly optimistic in many circumstances, requiring significant resources and potentially only possible in a very narrow burning window when all fuel types across the block are available or when winds are from a specific direction. It is often the case in burn blocks with significant variation of fuel types and/or topography, that when all target fuels are available across the block, the most problematic fuels are potentially too dry. Burning a block over multiple stages to remove more volatile and exposed fuels earlier or create fuel reduced edges may require fewer resources at each stage, relying on moisture differential of surrounding fuels or fuels burnt earlier in the season for containment. Staging the burning operation into discrete stages may also result in a reduced escape risk; and
- Are the burn success criteria/objectives achievable? If there is an objective to burn a particular proportion of an area (such as 60 – 80%) then the feasibility of achieving this in practice needs to be considered, including what fire behaviour will be required to meet the requirement and if that clashes with other objectives. In this example, consideration of the vegetation types within the block and whether or not they are 'burnable types' and whether the burnable types can all be burnt under one set of conditions or whether multiple stages with different conditions for each stage may be required.

Decision point

Decide whether the nominated burn objectives are practically achievable. Some objectives may not be explicitly stated but still be relevant to consider. Matters for consideration may include:

- The proportion of area to be burnt;
- Degree of fuel reduction proposed;
- Desired fire behaviour parameters;
- Stages of and timeframe for burn to be completed;
- Keeping the burn within nominated boundaries; and
- Achieving environmental prescriptions.

If the burn objectives are achievable, then continue with planning. If not, decide what changes to the nominated burn characteristics might need to be made to achieve the objectives, or whether the objectives may need to be modified.

4.1.4 Principle 3

Principle 3

Potential risks of implementing the burn need to be identified and verified so their management can be planned – identify and assess potentially at-risk values and assets both within and outside the burn area, and identify safety hazards[5].

Why is this principle important?

Appropriate actions to control burning risks and prevent undesirable outcomes will be difficult to plan without rigorous assessment of what the values at-risk and safety hazards are to start with. Values and assets within the burn area, and immediately adjacent (but within the potential ember/heat/smoke impact zone of the burn, assuming it stays within boundaries) must be considered. Additionally values and assets outside the planned impact zone of the burn, but which potentially could be impacted if the burn escaped (under feasible scenarios) also need to be identified to inform contingency planning[6].

Note: Prior to operational planning, the tactical program planning phase may be based on relatively coarse scale information (sometimes from desktop planning process only, other times from limited field appraisal), therefore there is a significant likelihood that at least some fire-vulnerable assets within or adjacent to the proposed burn area may not have been considered, or are not yet known (such as unmapped assets and new flora, fauna or heritage records from surveys). These require identification and consideration at the operational planning phase.

General guidance notes

Identification and documentation of the risk management context of burns including the PESTLE contexts of risk should be initiated as early as possible in the planning process.

To identify and appreciate the risks associated with a planned burning operation, assessment of key risk factors is required, which except in the simplest of operating circumstances, will require field assessment/verification.

Key risk dimensions to consider include:

1. **Assess asset/value exposure/vulnerability generated risks**
   - Where are fire-vulnerable assets located which are within the burn area, or immediately adjacent[7] and assess what protection options are feasible?
   - Where are fire-vulnerable assets located, which if the burn escaped, under credible weather scenarios, could be impacted by fire and assess what protection options are feasible?
   - What are the smoke-vulnerability related risks of the activity, such as public safety risks to public roads, airports, or sensitive receptors such as hospitals, schools, nursing homes, mine ventilation shafts or agriculture such as viticulture? and
   - What are the environmental and heritage values present, and has the appropriate risk assessment and planning approval requirements been considered? These should be considered early as they may impact work scheduling.

[5] Risk Management Frameworks have been developed by AFAC for fuel hazards, smoke, operations and ecological values.

[6] The importance of contingency planning was also emphasised in the Independent Investigation of the Lancefield-Cobaw Fire (Carter *et al.* 2015).

[7] Sufficiently close such that they can be adversely impacted by fire burning within its designated boundaries, or smoke emanating therefrom.

Source: Office of Bushfire Risk Management WA

Note: Staff tasked with operational burn planning may not have the full range of multi-disciplinary expertise to identify all the assets and values at-risk for a burn. In such cases it will be necessary to access an appropriate range of information sources to identify the suite of risks (such as biodiversity values, cultural heritage, infrastructure assets, land use, amenity values etc.). In any case, accessing local knowledge will be vitally important.

2. Assess the key factors that will affect fire control and burn security risk

Vegetation types, terrain and fuel characteristics are seldom uniform across a proposed burn area – fuel and terrain variability means fire behaviour variability and this needs to be taken into account in planning. Significant consequences to life and property have resulted from prescribed burns where planning has not adequately accounted for variability in fuel types, levels and condition across a burning block.

An appraisal of fuel characteristics and development of burning prescriptions should be based on field-verified information wherever possible. Modelled fuel information and fuel accumulation curves may not adequately account for site variability or variation in accumulation that varies with drought, season and decomposition rates, thus it is recommended they are only used at broadscale planning level (Tolhurst and Kelly 2003). Site fuel assessments do not need to be to research standards but should be appropriate to account for variability across the burn site, different fuel strata and aspects, and assess:

- Overall fuel levels, including levels in each fuel strata;
- Fuel moisture level variability within and adjacent to the burn; and
- Desirable weather parameters for control.

In the weather conditions for which the burn is planned:

- Which fuels will be relatively straight forward to ignite and control?
- Which fuels, due to their type or condition, can be expected to pose difficulties for ignition?
- Which fuels, due to their type or condition, can be expected to pose difficulties for control?
- What, if any, additional controls/measures will be required to deal with the above?
- Which fuels are assumed to be in a condition that will not sustain fire spread in the conditions prescribed (especially any fuels which will be relied upon to limit fire spread for burn control)? and
- Identify control lines which are 'higher risk' due to:
  - » Not being trafficable by vehicles;
  - » That would, in effect (for large burns in particular) be a 'deadman zone' limiting ground access (if fire is burning within the burn area);
  - » Have problem fuels adjacent (such as heavy fuels or fuels with a high potential for spotting across containment lines);
  - » Are not suitable for use as control lines (false assumptions on condition used during tactical program planning or have degraded in condition since); and
  - » Are unformed/not mineral earth (such as control lines relying on moisture differential).

Note: Risk assessment should be based on consideration of expected fire behaviour, and escape scenarios under realistic worst-case weather for the burn period.

3. Assess site-specific potential safety hazards

In addition to the at-risk assets and burn security related risks associated with a site, there may be a range of other site-specific safety hazards[8] to assess during field inspections, including but not limited to:

- The presence of hazardous trees near control lines that if ignited during the burn may be weakened and fall into areas where crews may be working;
- The presence of steep rocky slopes above control lines with loose/falling rock hazards;
- The presence of overhead powerlines in the burn area;
- The presence of unmapped cliffs/drop-offs or old mine shafts in areas where lighting activities will be undertaken;

[8] There are two key dimensions to be considered – safety hazards to burn crew members implementing the burn, and safety hazards to the general public from smoke emanating from the burn or fire if it escapes the burn area.

- Passing traffic hazard areas where lighting will be undertaken along roadsides; and
- Consider public safety dimensions including roads and transport infrastructure/routes potentially impacted by smoke.

Additionally, during field inspections, areas suitable for designation as safety zones should be identified/ confirmed suitable.

4. Assess the broader risk contexts of the burn

Assess other risk dimensions associated with the PESTLE contexts which will affect the burn. Many of these contexts are associated with people and their values and expectations. If these broader risk dimensions are not managed and/ or expectations are not met then risks beyond the traditional burn escape, asset damage, or burn safety dimensions may manifest. Some examples of broader risk considerations may include but are not limited to:

- Assess whether the burn could create or amplify local or current politically sensitivities, such as significant interruptions to major commuter routes or public transport links, or aggravating already elevated and politically sensitive air quality issues;
- Assess whether the burn could generate significant social issues such as smoke impacts affecting smoke sensitive locations/communities/facilities, social events or visual amenity during peak holiday periods;
- Assess whether the burn could result in significant adverse impacts on environmental values such as threatened species, populations or communities, natural resource values, or other ecosystem services such water and air quality;
- Assess whether the burn could significantly impact regionally/locally important economic values such as smoke impacts on viticulture or apiary, tourism, business infrastructure or the like;
- Assess the technical difficulties associated with delivering the burn and contingency management requirements; and
- Consider how the burn could result in breaches of legal Acts and Regulations across the range of risk dimensions.

Identify how the range of risks can be reduced to acceptable levels.

Decision point

Decide the risks which will require control measures to be implemented to manage identified risks.

4.1.5 Principle 4

Principle 4

Consult with neighbours and stakeholders to identify their issues and requirements.

Why is this principle important?

Neighbours and stakeholders may have local or specialist knowledge or insights that can be of significant benefit in operational burn planning. They may also have, or know of, at-risk assets or values potentially vulnerable to impact during the burn, and may have suggestions for how adverse impacts can be avoided or satisfactorily mitigated. Stakeholder issues and requirements require identification and consideration at the operational planning phase (and potentially follow-up confirmation in the preparation phase). In some cases neighbours may be interested in incorporating part of their property into a burning operation, which may provide access to superior burn containment or access options than originally planned, potentially making implementation easier and improving outcomes.

Consideration of and planning for neighbour and stakeholder issues during the planning phase can be far more efficient than dealing with significant conflict issues discovered during the burn implementation phase, and having to undertake hasty or under-resourced protection and management measures while operations are in progress and/or resolving conflicts and/or consequential loss and damage issues after the event.

General guidance notes

Consultation concerning proposed burning programs with community and other stakeholders should be undertaken as early as possible in the planning process:

Source: Bushfire CRC

- Identify neighbours and stakeholders who may potentially be affected by the proposed burning operation and who may have an interest in the burn, as well as stakeholders who are routinely consulted during burn planning;
- Consider scope requirements for consultation and/or negotiation, in particular what is wanted from the consultation and what can and can't be influenced;
- Invite the identified neighbours and stakeholders to identify issues and suggestions for avoiding or mitigating any impacts of concern;
- Document neighbour and stakeholder consultation outcomes, and record any action requirements in the operational burn plan;
- Identify potential partners and collaborators for burn implementation and establish what assistance and resources they are able and willing to provide, and any timing or other operating constraints they may have; and
- Communicate the outcomes of consultation back to neighbours and stakeholders.

Decision point

Decide which neighbours and stakeholders should be consulted, and for what purpose, during the burn planning process and decide which issues raised in the consultation process require actions additional to those already/routinely planned.

4.2 Operational planning phase – deciding the burn execution and risk treatment requirements

The desired output of the operational planning phase is the necessary information to prepare a site-specific Prescribed Burn Plan which documents the information needed by burn managers and crews to:

- Prepare for and undertake the planned burn activity safely;
- Achieve the burn objectives; and
- Reduce the risk of adverse social, economic or environmental impacts, to levels as low as reasonably practicable.

Developing the burn plan will typically involve analysis of information gathered during the desktop, field and stakeholder information gathering stages, and making decisions on how to prepare for and implement operations and manage the identified risks.

The planning process also needs to document data and the basis of key decisions/approvals for the burn, keeping in mind that this may be subject to external scrutiny if adverse unplanned consequences arise from the burn.

As important as the completed burn plan, are the steps taken to compile the plan. Working through the planning process provides a structured approach to address the range of relevant requirements, ensure issues and risks are foreseen, considered and planned for appropriately.

Depending on scale and site features, prescribed burning operations can be complex with considerable risks to manage.

4.2.1 Principles 5 – 16: Application in Northern Australia

In northern Australia there is often less reliance on constructed control lines for burn containment and greater reliance on natural landscape features and recent fire scars. Also, there is general recognition and acceptance by local communities that fire is an inevitable and regular occurrence where they live, and thus there is often a wider acceptance of the need for pro-active application of self-help measures for property and infrastructure protection than may be the case in more densely populated areas in southern Australia less accustomed to experiencing and accepting fire-use in the landscape.

Thus in northern Australia, burn planning processes are typically less complex, detailed and onerous than the often very detailed and deliberate burn operations planning processes applied, by necessity, in southern Australia. The burn planning process in northern Australia is typically scoped principally around considerations of how a burn can be lit (selection of lighting pattern and timing) so it doesn't reach fire sensitive/vulnerable areas/assets, to avoid the need for active on-ground protection of people and assets by ground resources during the burn. This is in contrast to planning for prescribed burns in more densely populated areas in southern Australia, where the occurrence of fire in close proximity to fire sensitive/vulnerable people/assets is less avoidable, and thus there is a substantial planning focus on the actions and resources that will need to be applied on the ground to actively prevent fire-vulnerable assets from being impacted by the burn, and managing those impacts that are not preventable.

4.2.2 Principle 5

Principle 5

Burn planning needs to be based on well-considered assessment of how fire will behave on the site, and off-site if it escapes. Assess likely and potential fire behaviour of the vegetation types/fuel conditions to be burnt and confirm or modify the burning prescriptions.

Why is this principle important?

It will be difficult to properly consider the risks of conducting the burn (achieving the burn objectives and avoiding undesirable outcomes such as an escape) without a sound understanding of what fire behaviour is likely to occur. If fire behaviour is only considered in reference to one dominant vegetation/fuel type within a burn site, then unanticipated 'surprises' may occur when fire moves into vegetation/fuels with different characteristics than the ones considered. This can result in unforeseen burn security or safety problems arising, or not achieving burn objectives.

General guidance notes

The information gathered during desktop review and field inspection should provide the basis for fire behaviour prediction – using the most appropriate fire behaviour prediction models/guides for the vegetation types present (refer to Table 8 in Cruz *et al.* (2015) for guidance on recommended fire behaviour models).

It is important that risk assessments are informed by a well-considered assessment of the fire behaviour expected in the environmental conditions prevailing. If undesirable fire behaviour is predicted, either the nominated prescriptions may need to be changed or the desirable conditions reconsidered.

- Identify the key fuel moisture and weather parameters to get a successful burn result; and
- Identify the range of fuel types and their condition on site and consider how fire will spread and behave within the site.

Fire behaviour predictions should be made for the expected duration of the burn (if multiple stage burning is planned then predictions for each stage will be required).

Decision point

Decide and document the fire behaviour characteristics required in each major fuel type to achieve the objectives of the burn.

Decide and document the environmental conditions (weather and fuel) required to achieve acceptable fire behaviour in each of the major fuel types present.

4.2.3 Principle 6

Principle 6

Methodical planning ahead of burn implementation methods and preparation requirements is critical to good operational efficiency – decide and identify burn and contingency plan preparation and implementation requirements.

Why is this principle important?

Burning is a complex operational task with many dynamic variables and risks involved – prior planning of the key operational requirements is an essential prerequisite for safe and efficient operations. The planning process also places a degree of structure and rigour to the analysis and planning decision process so as to avoid the potential for omission of important procedural requirements. The result of the burn implementation planning process should be a documented work specification (commonly in the form of a prescribed burn plan) which is subsequently used for conveying essential burn preparation and execution information to burn crew participants (who may not be involved in the planning process), and to managers with decision-making responsibilities for authorising (or not) the operation.

Based on the site and fuel characteristics, the burning prescription, the assessment of risks and location/condition of proposed control lines, plan what operational requirements will need to be implemented in preparation for the burn, and executed on the day(s) of the burn to achieve safe and successful implementation of the burn.

General guidance notes:

A comprehensive prescribed burn plan, including a detailed operations implementation plan component should be prepared that specifies burn objectives and work to be undertaken to prepare for and implement burning operations.

A range of different prescribed burn plan templates are used around Australia, tailored to local organisational requirements, operating environments and burning operations types. In general, operational requirements to be covered in the burn plan (or its attachments or associate material) will include such things as:

- A checklist of preparation actions to be completed prior to the proposed burn day;
- Requirements for day-of-burn stakeholder notifications/public announcements (and longer lead-time notifications that may be required by local protocols);
- Resources required for implementing the burn and managing public safety, and the proposed general tasking of resources;

4. PRESCRIBED BURNING PHASES AND PRINCIPLES

Source: Department of Parks and Wildlife WA

- Confirmation of proposed lighting approach – methods, stages, patterns and timing;
- Traffic management and public access control requirements;
- Pre-ignition public safety checks and confirmations;
- Pre-ignition checklists prior to requesting ignition approval;
- Planned arrangements for keeping the burn contained once lit;
- Contingency requirements (such as unexpected fire weather/ behaviour escalation; hopovers);
- Operations map for burn crews;
- Operational briefing for burn crews and support personnel;
- Site hazards and safety management requirements;
- Communications and reporting arrangements for operational management;
- Aircraft management arrangements (if applicable); and
- Forms for recording observed weather, fire behaviour, and key operational implementation information relating to commencement and execution of the burn.

The operational arrangements referred to above are typically documented and contained within the operational burn plan (or associated material) issued to burn crew members, and are also covered in the operational briefing. A number of the key components may be incorporated on a burning operations map such as:

- Containment line locations;
- Site features;
- Safety zones and escape routes;
- Fireground resource organisation information such as sectorisation;
- Location of specific hazards and values-at-risk;
- Lighting sequence and directions;
- Traffic control points; and
- Water points.

A key consideration in operational planning for agencies is the use of operational plan templates suited for use by burn supervisors and crews, prepared simply and with succinct information relevant to the safe burn delivery only. Most agencies typically use a burn planning template and prescribed burn plan preparation guidelines to guide the process and achieve consistency of output within their agency. Templates used vary between agencies although they generally follow the SMEACS[9] format.

The quality of operational planning is one of the most critical requirements for successful and safe operations. The prescribed burn planning and implementation process is essentially a sequence of risk management decisions and actions. Therefore, the basis of decisions taken should be founded upon appropriate consideration of how fire applied in the selected conditions and lighting techniques will behave, the requirements to keep fire contained to the target area, and how it could impact values-at-risk and how adverse impacts can be avoided or reduced to acceptable levels.

The overwhelming majority of prescribed burns proceed accordingly to plan with desirable outcomes achieved. However it is a reality, that in some past prescribed burning incidents, adverse operational outcomes including fatalities, serious injuries and substantial property damage have occurred. Operational planning deficiencies have been a significant contributing factor in some, if not most, of these events. High quality operational planning is a key requirement for successful burning operations.

Further, when a burning operation results in adverse consequences, the operational burn plan is one of the first items of evidence examined in post-event investigation/inquiry processes. Any deficiencies in planning practice will be evident and potentially used against agencies in legal actions should they be initiated.

For all these reasons, and because of the potentially severe consequences that can result from prescribed burning, it is important that operational planning – an important risk control measure – is of high quality.

Decision point

Decide and document, in accordance with agency procedures, the burn preparation and implementation requirements in a site-specific prescribed burn plan.

[9] A model used in emergency management for operational briefings. The acronym stands for topics to cover in the briefing including Situation, Mission, Execution, Administration, Command/Control/Coordination and Communication and Safety.

4.3 Operational planning phase – preparation stage

4.3.1 Principle 7

Principle 7

Good, timely preparation for burning enables burning opportunities to be taken when they arise, and contributes to sound risk management – plan and undertake key preparatory requirements for burn/risk control.

Why is this principle important?

Without planning and documenting what preparatory actions need to be taken to get a burn ready for burning operations, burns can end up getting delayed because they are not ready when suitable burning conditions arrive, or on burn day, burn crews find they have an inadequately prepared burn site (or they may attempt to do both preparatory works and implementation works on the day of the burn without adequate resources to do both) which can compromise burn security and/or safety and/or other objectives.

General guidance notes

Activities specified in the prescribed burn plan to prepare the burn for ignition and treat identified risks should be implemented in readiness for ignition.

Based on the prescription and the assessment of risks and location and condition of proposed control lines, determine what pre-burn preparatory actions will be required, with responsibility assigned to make the burn-site ready for ignition when conditions become suitable.

Preparatory actions and risk controls will typically include such things as:

- Preparing existing control lines for burning operations;
- Constructing new/temporary control lines where there are no existing lines, other than where natural burn boundaries are to be relied upon;
- Where natural burn boundaries are to be relied on for burn containment, confirm that these are in a suitable condition to contain fire spread;
- Providing breaks and protection to fire-vulnerable assets (such as built structures, fences, yards, tanks, bee hives, electricity and telecommunications infrastructure, research sites and equipment, sensitive vegetation communities etc.) within or immediately adjacent to the burn;
- Arranging access to adjacent properties for burning operations and making necessary preparations thereon;
- Upgrade or remedial work to control points and escape routes and safety zones;
- Removing or clearing around hazards (such as rubbish piles or dangerous roadside trees);
- Advising local stakeholders of preparatory actions required by them (such as moving stock to a paddock away from the burn boundary, ploughing a break along a fence line, moving mobile equipment away from burn boundaries etc.); and
- Identifying requirements for public safety (such as road closure and traffic control points).

Preparatory works are typically scheduled in work schedules. Preparation schedules should take account of the requirements of particular burn stages for multiple stage burns.

Decision point

Decide, plan and implement the actions required to undertake necessary preparations for burning.

4.3.2 Principle 8

Principle 8

Foresee the onset of burning opportunities and be ready – monitor landscape/fuel drying indicators to determine when suitable burning conditions are approaching.

Why is this principle important?

In many jurisdictions/areas, the number of days suitable for prescribed burning can be quite limited. Therefore it is imperative to monitor how seasonal wetting/drying trends are tracking to predict ahead of time when conditions are anticipated to be suitable for burning so full advantage of burning opportunities can be taken and efficiencies in resource organisation can be maximised. Wetting and drying trends are seldom uniform in a landscape, therefore monitoring at scales sufficiently fine to allow detection of different areas coming into suitable condition for burning is optimal.

General guidance notes

Seasonal and short term monitoring to identify and forecast appropriate burning conditions (weather and fuel moisture content) should be maintained to facilitate early notification of stakeholders and logistical resource management.

Monitor fuel conditions and weather patterns using a range of means:

- Fuel moisture trends deduced from days-since-rain-based drought index trends (e.g. SDI; KBDI)[10];
- Fuel moisture trends identified from field sampling methods;
- Local vegetation and or soil visual appearance/characteristics-based indicators of drying trends;
- Local knowledge of land owners and forest users;
- Seasonal and four day weather outlooks/forecasts to identify when seasonal/daily weather conditions suitable for burning are approaching; and
- Monitor that all preparatory requirements in the burn plan have been completed so there are no delays to starting when conditions become suitable.

While technology provides useful tools such as modelled KBDI or SDI maps and/or remotely sensed fuel condition maps, these may be produced at coarse resolution and/or using interpolation between distant weather observation locations. Accordingly, there is no substitute for field-validation, and local knowledge of conditions can be highly valuable.

Check any notes in the burning or environmental prescriptions which may call for specific requirements (e.g. burning early in a drying cycle to reduce the consumption of coarse woody debris/hollow logs/trees, or burning on a wetting cycle to minimise potential for delayed re-ignitions).

[10] SDI – Soil Dryness Index; KBDI – Keetch-Byram Drought Index

Care needs to be taken to ensure fuel and soil moisture conditions are within the desired range – resist program delivery pressures to push burn timing into conditions when moisture is still too high or low. Burning when moisture is still too high can result in a poor burn result, which will likely need follow up work which may be made more difficult by the previous poor burning attempt. On the other hand burning when conditions are in the risky-dry range can significantly increase the risk of adverse consequences, either during the burn, or during a continued drying pattern subsequent to the burn. Resist the temptation to burn when conditions are outside locally accepted and tested parameters as this is when many adverse burn incidents occur.

Decision point

Decide when fuel moisture trends are coming into alignment with suitable conditions and when weather pattern forecasts are indicating suitable weather for burning. Based on this monitoring, schedule an appropriate day for burning (if conditions are not suitable, look for opportunities to get burns done in other areas where conditions are suitable).

4.3.3 Principle 9

Principle 9

Be well organised for when burning opportunities arise – organise the mobilisation and tasking of resources for the burn with as much advance notice as possible.

Why is this principle important?

There will often be competing priorities and availability issues for resources. Alternate resources may need to be sought before the burn can proceed. To maximise the prospects of getting access to favoured resources, and having time to make alternative arrangements should first-choice options be unavailable, early communication of resource requirements is essential.

General guidance notes

Short term monitoring and forecasting of resource availability is required to prepare for and take advantage of burning opportunities as they arise.

Resources for consideration:

- Burning/containment crews and equipment;
- Specialist ignition resources if required (e.g. aircraft, vehicle mounted flame throwers, fuel trailers, incendiaries and the trained operators);
- Resources for managing traffic control and public safety (signage placement, stop-go vehicle control point equipment; neighbour calls, people etc.);
- Resources for checking the proposed burn area is clear of people;
- Escape contingency resources;
- Source appropriate weather forecasts for the burn day and following 4 day period; and
- Patrol resources for the following days.

Source: Department of Environment, Water and Natural Resources SA

Double-check resourcing requirement levels nominated in the plan. If these do not seem right, it may be prudent to check the burn site conditions (or at least the burn site map) to consider whether the nominated resourcing is adequate to the task. Additional resources can be difficult to obtain at short notice on the day of the burn should initially scoped resources be found inadequate. If insufficient resources are available for the burn to be safely undertaken and kept within containment lines, then the burn should not be ignited.

Ensure logistic support considerations for the burn are thought through and planned. For example, running out of helicopter fuel, incendiary capsules or drip torch fuel mid-burn can cause significant operational problems as well as compromising work efficiency.

Decision point

Decide and schedule as early as possible a date to commence the burning operation (based on monitoring of fuel and weather conditions) and give required resources as much notice as possible.

4.4 Burning operations implementation phase

4.4.1 Principle 10

Principle 10

Base your burning decisions on good forecast information – obtain the latest and most accurate weather and smoke dispersion forecasts.

Why is this principle important?

General district forecasts are mostly not suitable for burning operations (unless an Automatic Weather Station is located close to the burn site). Weather conditions typically follow a diurnal trend but 'typical' diurnal trends may not eventuate at the burn site, and conditions may differ between the burn site and district forecast location. Prudent burn supervisors consider how weather will affect fire behaviour and smoke dispersion throughout the burn period, and therefore obtain forecast information that provides forecast weather data for time-points throughout the day and following days, and for the specific location.

General guidance notes

Reliable and accurate forecasts and intelligence on weather and fuel conditions is required to make good decisions concerning burn implementation.

Bureau of Meteorology Spot Weather Forecasts are the preferred forecast product of choice for burning. A range of on-line smoke dispersion forecasting tools are available in different jurisdictions although these have a number of embedded assumptions/limitations which need to be understood by users.

Agency prescribed burning procedures may specify standards for obtaining weather forecast information appropriate to task.

Decision point

Decide what weather forecast information sources are most relevant to the burn site, and make decisions about burn implementation based on the best available current and forecast weather information. If the weather for the day/following days is not suitable to achieve burn objectives or would impact the burn being undertaken safely and kept within containment lines, then the burn should not be ignited.

Source: Bureau of Meteorology, Australia

4.4.2 Principle 11

Principle 11

Be well disciplined and organised in scheduling burn components – mobilise resources to burn site; brief them and assign clear tasks.

Why is this principle important?

Having the full complement of planned resources at the burn site on time, and properly briefed and informed is important to facilitate a timely start to operations, particularly if burn-out timing is expected to be late in the day.

General guidance notes

Adequate on-site resources that are competent, capable, briefed and informed are required prior to ignition operation commencing.

Confirming on-site start meeting times with all resources at least the day prior to the burn is advisable. Sufficient time should be allowed for pre-burn site familiarisation and operational briefing.

Ensure identified risk management actions/treatments in the burn plan have been applied and that burn crew members are aware of any actions/treatments they need to take to manage burn risks.

Operational briefings are very important for communicating operational and work-sequence information, work standards, hazards and safety management requirements, and any triggers for specific actions, and ensuring crew members have an opportunity to ask questions/seek clarifications about procedural and safety requirements.

Fire and land management agencies typically use a SMEACS format for briefings.

Decision point

Decide resource mobilisation requirements, and the pre-burn briefing location and timing, and mobilise resources to the burn site for a timely start to operations.

4.4.3 Principle 12

Principle 12

Burn timing and ignition location should be based on well-considered knowledge of current and future fuel and weather conditions – monitor site fuel and diurnal weather pattern development on the day of the burn; determine suitable location and conditions for a test fire, obtain ignition approval.

Why is this principle important?

Selecting appropriate fuel moisture conditions for commencement of burning is one of the most critical dependencies for achieving successful and safe burn results. In all but the simplest of sites, fuel moisture content will be variable across the site (driven by such things as topographic position, aspect and vegetation type/condition) and within the vertical fuel profile. Under prescribed burning weather conditions, fuel moisture content is the principal factor affecting which fuels will burn and which ones won't, and therefore can be used to identify where fire will spread and where it will slow and self-extinguish. Therefore consideration of fuel moisture conditions across the site is important. This needs to be done in conjunction with monitoring of on-site weather conditions. Prediction of fire behaviour requires assessment of fuel moisture, either directly measured or calculated from weather and time of day information.

General guidance notes

A decision to commence ignition operations should only be taken after a review of weather, fuel condition, fire behaviour predictions, resources and preparatory actions at the burn site. Note that the full explanation of the fire behaviour theory (such as fuel moisture cycles), skills and tools (such as the leaf burn test) to support burn planning and implementation are addressed in detail in the training resource kits *PUAFIR513 Develop Complex Planned Burn Plans and PUAFIR511 Conduct Complex Planned Burn.*

Fuel moisture content (FMC) is a key driver of fire behaviour and using diurnal fuel moisture cycles to full advantage will assist in achieving burn objectives. The following general approach and rules-of-thumb can be useful in considering ignition pattern detail and timing:

- Using current and forecast weather information, predict how FMC is expected to trend during the day and whether it will remain within prescription. If so, determine whether conditions will be toward the upper, lower or mid-range of FMC prescriptions. If FMC is predicted to be toward the lower (dry) end of the desirable range, selection of burn timing to avoid peak burning activity at the warmest/driest part of the day may be prudent. Conversely, if fuel moisture is predicted to be toward the upper (moister) end of the desirable range or marginal, selection of burn timing such that peak fire activity coincides with the warmest/driest part of the day may be prudent. Consider how to stage ignition timings on different aspects to optimise results (e.g. plan to burn drier aspects early before FMC bottoms out, and plan to burn sheltered aspects later when optimal FMC is reached);
- Take temperature and relative humidity observations for comparison with forecast trends;
- If available, use direct FMC measurement equipment to monitor FMC trends in different parts of the topography, or use the leaf burn tests;
- Understand the impacts of inversions on fire behaviour and smoke dispersion.
- Be aware, that fire behaviour is also impacted by the level of overnight moisture recovery. Poor recovery means that fuels will continue to be available and the fire will continue to burn overnight. This may mean increased fire behaviour, earlier in the day following.

- Review the weather forecast for the days following the burn. When a deteriorating weather forecast trend is predicted, and in particular if weather conditions significantly exceeding upper prescription limits are forecast, then consideration should be given to deferring burns to a more suitable date. This should be considered in the following situations:
  - » Where the burn prescriptions are likely to be exceeded and burn objectives unlikely to be achieved;
  - » Where there are soft or weak containment lines (or with vegetation immediately inside the containment line which is unlikely to burn during the planned burn but which is at-risk of burning during the conditions predicted in the days following the burn);
  - » The vegetation within the burn area has high spotting potential;
  - » Reliable blacking out of edges cannot be achieved before onset of the adverse weather;
  - » For burn areas likely to contain large unburnt patches within the burn perimeter; or
  - » Where adjoining fuel hazard levels are high.

Decision point

Subject to FMC following desirable diurnal trends, confirm or amend planned lighting patterns, and decide an appropriate time and representative place to conduct a test fire.

Source: Office of Bushfire Risk Management WA

4.4.4 Principle 13

Principle 13

Confirm theoretical predictions and intuitive insights with practical field evidence – light a test fire and assess fire behaviour.

Why is this principle important?

To validate fire behaviour predictions and ensure that actual fire behaviour will be within prescriptions and manageable.

General guidance notes

Ignition operations should only be commenced after theoretical predictions have been confirmed by the lighting of a test fire.

Test fires are an important tool for validating fire behaviour predictions or intuitive assessments. There are some key tips for obtaining reliable test fire results:

- Ensure all planned safety controls have been implemented (addressing both burn crew and public safety), and that ignition authorisation has been received;
- Ensure sufficient resources are in place to effect containment of the test burn;
- Position the test fire in a location where it can easily be contained and extinguished if necessary;
- Conduct the test fire in a location generally representative of conditions across the target areas to be burnt (often an exposed position is selected so that fire behaviour at the upper end of that likely to occur on the site can be observed);

Source: Bushfire CRC

- Use a line ignition (of preferably not less than 20 metres) to evaluate fire behaviour. Test fires using point ignitions will burn with significantly milder fire behaviour than line ignitions;
- Observe the distance in metres covered by a test fire in 6 minutes and then multiply by 10 to calculate fire spread in metres per hour; and
- When evaluating the test fire results, consider how the fire behaviour in other parts of the burn site will differ according to the effects of slope, different fuel characteristics, and wind direction in relation to spread direction.

Decision point

Based on the results of the test fire, decide whether or not to proceed with the burn, and if necessary adjust planned lighting pattern or timing on the basis of the test fire results.

4.4.5 Principle 14

Principle 14

Exercise good discipline in executing lighting and containment operations but retain flexibility to modify pre-planned techniques where conditions vary from assumptions or change – monitor fire behaviour and always keep in mind the fire behaviour prescriptions for the burn and take action to achieve these.

Why is this principle important?

In order to achieve burn objectives and comply with prescriptions, lighting time, types and patterns which deliver the desired fire behaviour need to be executed. Once ignition is commenced, the only way burn crews can manipulate fire behaviour is through adjustment of lighting patterns. Selection and adjustment of the most appropriate lighting patterns for the conditions will be instrumental in achieving the burn prescriptions. As the burn is progressively lit, containment arrangements and procedures need to be applied to ensure fire stays within designated boundaries.

General guidance notes

Fire behaviour should be monitored and ignition type, pattern and timing amended as necessary to achieve burn objectives, or ceased if operational risk is unacceptable.

Downslope burning can be used where it is desired to keep rates of spread, fire intensity and scorch heights low. Downslope burning takes advantage of the moderating effect of downslopes on fire behaviour, and changes in fuel moisture which are typically drier on ridges and moister on lower slopes and gullies.

Upslope burning can be used to achieve more vigorous fire behaviour in areas with higher FMC. In such circumstances consideration needs to be given to what fire behaviour will do as it moves up slope into drier more exposed fuels. Upslope burning takes advantage of the escalating effect of upslopes on fire behaviour.

Spacing of ignition spots can be based on rate of spread predictions so as to result in spot fires converging at a time of day when desirable fuel moisture/weather conditions are in place. Spot ignition patterns take advantage of lower fire intensities on the heel and flanks of each spot (relative to the head). When spots merge junction zone effects will escalate fire intensity at the junction zones, however if spacing is arranged such that merging occurs during mild and declining weather conditions, junction zone fire behaviour can be managed to minimise fire behaviour escalation.

Orientation of ignition lines in relation to wind direction and/or slope can be used to achieve different proportions of the target area being burnt by backing fire, flanking fire and head fire. Advantage can be taken of wind direction to assist or retard fire spread and intensity depending on what is required. A backing fire (against the wind) can be used to slow the progress of fire across a burn area, and a running fire (with the wind) can be used to promote fire spread and intensity where this is desirable.

Choice of location and timing of ignition can be used to have fire burn in to particular areas at desired times. Where lower-than-average fire intensity is desirable, single spot ignition at a point just down wind or up-slope of where low intensity is required can be used so that fire burns through the area in its early development stage (when it burns well below its potential rate of spread), and the area is subject to backing or flanking fire behaviour. Choice of time (at a time during the day (or night) when conditions are at the milder end of suitable burning conditions) can also be used to moderate fire behaviour in particular locations.

Where lighting is to be done in two or more stages, achieving desired burn depth/intensity on downwind containment lines will be important for ensuring containment of subsequent burn stages which push fire toward edge-burnt areas.

Whatever lighting patterns are devised and implemented, they should be based on thoughtful consideration of the variability in fuel moisture and weather exposure at the site and how this variability will affect fire behaviour as fire moves within the burn site. The resulting fire behaviour requires monitoring throughout lighting operations to determine what, if any, adjustments of lighting pattern might be required to modify fire behaviour outcomes.

Containment tactics need to be based on assessments of how fire is behaving and moving within the site, and where potential weak-points in burn boundaries may be.

Decision point

Based on observations of fire behaviour as the burn is implemented and how this behaviour compares to fire behaviour prescriptions, decide what, if any, changes to lighting patterns and timing are appropriate to maintain compliance with fire behaviour prescriptions. If fire behaviour prescriptions are exceeded and cannot be moderated to within prescribed limits, then cease further lighting and decide what course of action is appropriate to either contain the burn or resume lighting when conditions moderate.

4.4.6 Principle 15

Principle 15

Ensure public safety aspects of the burn are appropriately resourced and managed – execute public safety management requirements as per burn plan and agency procedures.

Why is this principle important?

Apart from control of lighting operations and maintaining containment, there will be a range of other operational activities to implement to maintain public safety. These may include controlling public access to the burn areas and warning and/or controlling road traffic to manage fire and smoke risks.

General guidance notes

The effectiveness of risk treatments to manage the risks of the burn to public safety should be monitored regularly whilst fire activity and smoke generation are present. Treatments should be adjusted to maximise their

Source: Bushfire CRC

effectiveness as existing and forecast conditions require. Monitor fuel and environmental conditions that could result in an escape, or create conditions where an escape will become more likely, or where smoke will be an issue. Apply appropriate risk treatments – implement a daily risk management plan for burns that remain active over multiple days.

A key action to manage public safety is the placement of warning signage. Warning signage needs to be placed where it can be readily seen, and before observers of the signage arrive at hazard areas.

If the assistance of external agencies is required (e.g. police or road/traffic management authorities/contractors), availability and lead times need to be considered.

Where traffic control points are to be established, traffic controllers need to be appropriately qualified and equipped (according to agency/jurisdiction requirements).

Pre-planned contingency arrangements and trigger points facilitate rapid response escalation to deal with unplanned events.

Public safety management should include consideration of smoke risk management requirements, including consideration of how smoke can move with changes in wind and atmospheric conditions or remain in place for a significant period of time due to an inversion or little wind.

Public safety considerations should include potential impacts to power lines and other utilities.

A key public safety risk commonly associated with prescribed burning is falling trees – falling tree risk prevention and response arrangements require appropriate consideration.

Decision point

Safely and efficiently implement the pre-planned risk management actions required to maintain public safety. Through the course of burn implementation, monitor public safety risks and the effectiveness of pre-planned risk management actions. Make decisions as required to address any changed circumstances or unforeseen risks that may arise.

4.4.7 Principle 16

Principle 16

Base decisions for resource up-scaling or down-scaling on well-considered assessments of fire behaviour potential and ongoing residual risk – monitor fire burn-out and determine arrangements for crew demobilisation, mop-up and patrol, and treatment of residual public safety risks.

Why is this principle important?

As the fire burns-out within the burn boundary, the risk of fire behaviour escalating or escaping will change, and resourcing requirements for burn security and public safety management will also change. How these risks and requirements change as the burn progresses needs to be monitored so that resources surplus to requirements can be released whilst retaining appropriate resources to manage residual risk levels and to provide continued monitoring for changes in site conditions/risk or to remove resources from the area in the event it becomes unsafe to do so due to fire behaviour, wind or storm. Or alternatively, monitoring will enable requests to be made for additional resources to keep the burn within its designated boundaries, to respond in the event of an escape, or unexpected worsening conditions.

General guidance notes

Decisions concerning down-scaling of resources at a burn should be based on the consideration of residual risk to burn security, firefighter and public safety. Residual risk should be monitored and treated, where this is feasible and safe, until acceptable levels of risk for burn security and public safety are achieved. However, where conditions are unsafe for firefighters and other appliances to remain, they should retreat to a safe area. This may occur in the case of unpredictable and uncontrollable fire, lightning storms and high wind events.

Resource up-scaling or down-scaling decisions should be based on fire behaviour and forecast weather predictions.

It is particularly important to consider how conditions may change overnight, in particular giving due consideration to changing wind direction and significant wind change events.

It is also important to consider following-day weather and what time the following day conditions are expected to give rise to fire behaviour escalation.

Ensure those crews remaining at the burn site understand the range and nature of remaining risks, the requirements for managing these, and any triggers for considering further down-scaling or up-scaling decisions.

There is potential for falling tree risks to extend significantly longer than fire and smoke related risks – proper assessment of hazardous tree risks should be undertaken and remedial actions taken before reopening public roads, trails and walking tracks within or around the burn site to the public.

Apply agency requirements for dangerous tree identification and treatment. Be mindful that the risk associated with trees affected by fire operations (burning hollow butts and limbs) may increase as time passes.

Bear in mind that the effects of tree lean and wind are additive to fire damage impacts.

Source: Department of Parks and Wildlife WA

Decision point

A number of critical decision points will arise including:

- When lighting and containment operations start to decline and peak levels of resourcing are no longer required, risk-based decisions on which and how many resources can be released, and what needs to remain on task, will be required; and
- When fire behaviour potential and containment operations declines to a point that continuous attendance at the burn is no longer required, what periodic site monitoring arrangements are prudent? These decisions will be risk-based with particular consideration given to fire behaviour potential, remaining burnt area hazards and weather conditions over the following days.

4.5 Burning operations appraisal phase

4.5.1 Principle 17

Principle 17

Evaluate burn results against objectives to determine if any follow-up works are necessary, and to form part of continuous improvement process implement post-burn assessment, evaluation and reporting.

Why is this principle important?

Evaluation of burn results against objectives is necessary to determine if the burn objectives have been achieved, if any follow-up works are necessary, and to form part of a continuous improvement process. Additionally, it is important to consider whether systems and processes guiding development of the plan and its implementation were effective and able to be complied with in achieving the burn objectives.

If the job is worth doing, it's worth assessing whether the burn has been successful – implement post-burn evaluation. Reporting on the results of planned burns allows others to learn from the burn and assists with the continuous improvement process.

General guidance notes

At completion, prescribed burns should be evaluated. The effectiveness of burn planning processes and burn implementation against burn objectives should be reviewed to facilitate reporting on effectiveness and to contribute to continuous improvement processes.

Post burn assessment processes are often incorporated in agency procedures and commonly use assessment templates.

For all burns, but particularly for large or complex burns, an appropriately scaled after action review process or debrief is part of good risk management practice and is an enabler to continuous improvement processes.

If no standard post-burn assessment procedures are in place, then performance assessment against each of the burn objectives can serve as a reasonable framework for post-burn assessment.

Decision point

Subject to the results of the post-burn evaluation, decide whether any follow-up works needs to be undertaken to achieve objectives, and whether any changes to systems or procedures are required.

5. CASE STUDIES

Case studies that illustrate how prescribed burn planning and implementation is applied in a range of Australian vegetation types, landscape setting and management scenarios are provided on the National Burning Project webpage. A list of the case studies is provided below and a synopsis of each is provided overleaf. The reader is encouraged to follow the link to the full version of the case study online.

Full case studies available at: www.afac.com.au/initiative/burning

Case Study 1	*Bush-urban interface burning in the Blue Mountains of NSW*
Case Study 2	*Burning young silvertop ash regrowth forests in NSW*
Case Study 3	*Low intensity burning in tall moist karri forests in Western Australia*
Case Study 4	*Multi-year landscape mosaic burning in forested mountain terrain using natural boundaries in Victoria*
Case Study 5	*Semi-arid mallee and mallee-heath burning in South Australia*
Case Study 6	*Buttongrass moorland burning in Tasmania*
Case Study 7	*Burning for greenhouse gas abatement in Northern Australia*
Case Study 8	*Burning of spinifex grasslands in the arid interior of Western Australia*
Case study 9	*Burning for eucalypt forest health Southeast Queensland/Northern NSW*

5. CASE STUDIES

5.1 Case Study 1 – Bush-urban interface burning in the Blue Mountains of NSW

5.1.1 Authors

This case study has been prepared by Paul de Mar (GHD) and Richard Kingswood, Glenn Meade, Arthur Henry and Duncan Scott-Lawson of NSW National Parks and Wildlife Service.

5.1.2 Synopsis

The NSW Blue Mountains area is one of the most complex and challenging landscapes in Australia in which to plan and carry out fire management.

With regard to prescribed burn planning and implementation, issues around access difficulty, close proximity to fire-vulnerable urban assets and communities, variable mountain weather, wide altitudinal range effects, a necessity to rely on natural containment lines for remote and some interface burns, and fuel complexity conspire to make prescribed burning a high-risk and resource-intensive operation. However, the alternative risks of not conducting any program of fuel reduction will be accumulation of dry sclerophyll forest and woodland fuels across broad areas including adjacent to fire-vulnerable communities. When fires inevitably occur and escape control efforts under adverse fire weather conditions, community protection difficulty is maximised with catastrophic consequence likelihood increased.

Source: NSW National Parks and Wildlife Service

A major complexity applying to burning in the Blue Mountains is the wide variety of stakeholders that expect consultation and demand (up to 7 days) advance notification. These requirements do not sit comfortably with the need for land and fire management agencies to be ready at short notice to take advantage of the limited and often short opportunities for safe burning in the mountains, in order that they may fully deliver the resource-intensive programs necessary to manage the substantial mountain community fire risks.

This case study steps through the burn planning and implementation procedures undertaken in order to successfully manage the various complexities and risks in order to successfully undertake burning in the Blue Mountains.

5.1.3 Full case study

Case study available at: www.afac.com.au/initiative/burning

5.2 Case Study 2 – Burning young silvertop ash regrowth forests in NSW

5.2.1 Authors

This case study has been prepared by Paul de Mar (GHD) – with incorporation of operational practice components in consultation with Tim McGuffog and Marty Linehan of Forestry Corporation NSW.

5.2.2 Synopsis

Source: Forestry Corporation NSW

Young regrowth forests being managed for timber production and other values can suffer significant damage, timber value degrade, and productivity loss from fires of sufficient intensity to cause excessive stem or crown damage. Therefore forestry organisations may seek to reduce the risk of future tree crop damage by bushfire, through conducting fuel reduction burning in regrowth forests that are suitably resilient to low intensity fire.

While many mature dry eucalypt forest types are resilient to low intensity prescribed burning, the same forests are often vulnerable to damage during their juvenile/early regrowth phase. The issue therefore arises as to when burning can be reintroduced into young regrowth stands, and how the burning can be done so as to avoid or minimise damage. These were challenges faced by the NSW Forestry Commission (FCNSW) in the late 1980's. After a number of high intensity fires that killed extensive areas of young silvertop ash regrowth with adverse environmental, water, and future log supply impacts, FCNSW sought to make greater use of prescribed burning to manage fire risk across the regrowth forest estate. They commissioned CSIRO to undertake research to develop a prescribed burning guide for young regrowth forests of silvertop ash (*Eucalyptus sieberi*) on the far south coast of NSW.

This case study provides a synopsis of Forestry Commission NSW Research Paper 16 – *A Prescribed Burning Guide for Young Regrowth Forests of Silvertop Ash* (Cheney *et al.* 1992) and steps through the procedures surrounding planning and implementing burning in these regrowth forests.

5.2.3 Full case study

Case study available at: www.afac.com.au/initiative/burning

5.3 Case Study 3 – Low intensity burning in tall moist karri forests in Western Australia

5.3.1 Authors

This case study has been prepared by Paul de Mar and Dominic Adshead (GHD) based on interviews and field visits with Department of Parks and Wildlife (DPaW) karri burning practitioners L. McCaw, P. Keppel, J. Bennett and B. Moss.

5.3.2 Synopsis

Source: Department of Parks and Wildlife WA

Karri (*Eucalyptus diversicolor*) forests are endemic to the south west of Western Australia (WA). They are the tallest growing forests in WA, occupying higher rainfall areas, typically on deep loamy soils. Karri forests can accumulate deep litter beds and a tall, dense understorey in which suspended bark ribbons can collect. Hence long-unburnt karri forests, in adverse fire weather conditions, can support very intense and destructive bushfires. Due to its high canopy cover and tall, dense understorey layer, karri fuels are heavily shaded and protected from drying winds and are thus slower to dry out after winter rains than other more open forest types. This means that relative to drier forest types in south west WA, windows of opportunity for safe karri burning are narrow, mostly during summer and early autumn, and have a high degree of technical difficulty.

In WA, prescribed burning is used throughout the forested south west area with the aim of reducing the likelihood of large scale, high intensity, high-consequence fires occurring which are detrimental to public safety, and which adversely affect economic and environmental values. A royal commission, following the Dwellingup fire tragedy in 1961, mandated an expanded prescribed burning program in south west forests as a means of reducing landscape fire risk. The findings of the royal commission remain relevant today, arguably even more so due to the ever increasing numbers of people choosing to settle and live within the forested south west. As karri forests occupy a significant proportion of the forested landscape, particularly in the main karri belt between Manjimup and Denmark, karri forests are necessarily included in strategic burning programs.

One of the many issues with burning karri forest is that by the time the karri is dry enough to burn, other drier forest types in surrounding areas are too dry and risky to safely burn. In pure karri stands and karri-marri mixed forests with tall dense understorey, fuel conditions under which low intensity fire can sustain spread typically don't occur until summer. In most cases, karri burning can only be effectively done in the December to early April period, so great care needs to be taken to prevent burns escaping from karri burning blocks into surrounding dry forest areas where they could develop into uncontrollable high intensity fires under adverse conditions.

This case study follows the approaches used to manage the complexities and risks involved in karri burning in the south west of WA and incorporates relevant components from the Forest Fire Behaviour Tables for WA – commonly called the 'Red Book' (Sneeuwjagt and Peet 2008) and planning practice from the Department of Parks and Wildlife's Prescribed Fire Manual (DPaW 2013).

5.3.3 Full case study

Case study available at: www.afac.com.au/initiative/burning

5.4 Case Study 4 – Multi-year landscape mosaic burning in forested mountain terrain using natural boundaries in Victoria

5.4.1 Authors

This case study has been prepared by Paul de Mar (GHD) and Rob Caddell and Dan Jamieson of the Victorian Department of Environment, Land, Water and Planning (DELWP).

5.4.2 Synopsis

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

DELWP has been pursuing a broadacre landscape mosaic burning (LMB) concept since about 2004, prompted in part by the land and fire management issues arising after the 2003 Alpine Fires which burned more than 1.3 million hectares across the high country in north-east Victoria. It was foreseen at the time that a substantial risk had arisen that if further fires occurred within the 2003 burnt areas before regenerating flora and fauna communities had attained reproductive maturity, then localised species losses could occur. This concern proved prescient as in 2006 the Great Divide fires occurred, which also burnt more than 1 million hectares, including re-burning significant areas burnt in 2003. As a result, the need to pursue landscape mosaic burning strategies to break up fuel within large wildfire-burnt areas gained higher priority in order to reduce the potential for further large areas to be burnt twice at high intensity with an insufficient inter-fire interval.

Much prescribed burning experience gained by DELWP staff is through conducting burns within man made containment lines or using major natural features such as rivers or riparian vegetation in deep gullies, or other physical landscape features with low available fuel. Most planned burning aims to burn-out much higher proportions of a burn unit than will be targeted in an LMB. Therefore, landscape mosaic burns that target a subset of fuel types within the burn unit are largely beyond the experience of most current DELWP staff.

There is the potential for reputational or political issues to arise if an LMB does not meet the burn objective (i.e. burns vegetation in fire-sensitive growth stages that were intended to be avoided, or burns at a higher intensity than specified, or spreads beyond LMB Unit boundaries and impacts communities, assets or built structures). It can be a difficult proposition to defend unbounded burning as this can be seen by some as overly risky. However, the flip-side is that opportunities may be missed to protect the environment and community if improved methods and knowledge are not developed due to risk-averse attitude and behaviour. The imperative is to maximise the chances of success through careful and deliberate burn planning practices.

This case study focuses on the Lake Dartmouth Landscape Mosaic Burn Unit in order to illustrate broadscale, unbounded mosaic burning procedures. It integrates knowledge and operational practice information from a range of sources including DELWP's Landscape Mosaic Burning Planning Guidelines (2009), and burn planning information for the Lake Dartmouth Landscape Mosaic Burn Unit.

5.4.3 Full case study

Case study available at: www.afac.com.au/initiative/burning

5.5 Case Study 5 – Semi-arid mallee and mallee-heath burning in South Australia

5.5.1 Authors

This case study was prepared by Paul de Mar (GHD) and Mike Wouters of the Department of Environment, Water and Natural Resources (DEWNR).

5.5.2 Synopsis

Source: Department of Environment, Water and Natural Resources SA

Semi-arid mallee and mallee-heath dominated vegetation occurs in central and northern South Australia (SA), western Victoria, western NSW and south-eastern Western Australia.

Mallee dominated landscapes typically have low population densities, and modest local capacity for fire suppression. The majority of mallee area burnt is by large, unplanned summer fires, occurring when seasons with abundant fuel conditions, ignition and adverse fire weather coincide. Fire suppression efforts on established fires often have little impact on the eventual fire size and impact area, other than to provide life and property protection at specific locations during the fire. Fire extent and impact are influenced to a much greater extent by the presence of low fuel areas in the landscape which restrict fire spread allowing the arrival of weather conditions that extinguish the fire or facilitate its containment. Low fuel areas in mallee can be created by unplanned fires, prescribed burns, or mechanical treatments. Mallee landscapes also contain 'natural' areas of low fuel, for example lake beds, chenopod shrublands and areas of bare ground.

Prior to the 1980's little prescribed burning was attempted in mallee vegetation. Fire regimes at that time can be characterised as low ignition frequency, dominated by small numbers of large, unplanned summer fire events of moderate to high intensity, often resulting in low seral stage diversity. In some areas of SA mallee, fragmentation significantly affected fire regimes such that they burnt in an 'all or nothing' pattern across isolated blocks.

From the 1980's land management agencies have explored ways to limit the size and impact of unplanned fires that inevitably occur during the landscape drying phases which follow high rainfall years. During these periods, long-term fuel build-ups in long-unburnt overstorey mallee and heath vegetation and short-term growth pulses of ephemerals coincide, maximising fuel continuity and quantity across broad areas. To break up the continuity of heavy fuel accumulation, fuel-breaks are created usually through a combination of mechanical means (e.g. scrub-rolling) and prescribed burning.

This case study is a synthesis of semi-arid mallee and mallee-heath fuels, fire behaviour and burning information documented in reports from SA, Victoria and WA. It incorporates burn operations planning and implementation practice information as well as the relevant fire science on which current procedures are founded.

5.5.3 Full case study

Case study available at: www.afac.com.au/initiative/burning

5.6 Case Study 6 – Buttongrass moorland burning in Tasmania

5.6.1 Authors

The report was prepared by Paul de Mar (GHD) and Adrian Pyrke (Eco Logical).

5.6.2 Synopsis

Source: Adrian Pyrke

Buttongrass moorlands are areas dominated by low growing sedges (the most dominant sedge being buttongrass – *Gymnoschoenus sphaerocephalus*) and heaths. They may be completely treeless or occur in a landscape mosaic with patches containing trees or scrub. They often occur in wet landscape positions with poor drainage, but also on slopes in hilly terrain, and are mostly associated with nutrient-poor substrates such as quartzite, conglomerate and granite. They are one of the most fire-adapted ecosystems to have evolved.

Tasmanian buttongrass moorlands occupy more than one million hectares, approximately one seventh of the island. It is the most common vegetation type in many parts of the west and south west of the State, where annual rainfall exceeds 1000 mm. While it does occur in eastern Tasmania it is confined to creek lines and depressions. It also occurs in other areas of south eastern Australia (South Australia, Victoria, New South Wales) though it is less common there than in Tasmania (Parks and Wildlife Service Tasmania 2013).

Buttongrass plants form tussocks which over time (since the last fire) become increasingly dense. Buttongrass leaves are very fine. As growth from previous seasons dies, the very fine dead grass leaves are retained within the tussock forming what is commonly referred to as thatch. This thatch is held above the wet ground underneath. As a result, dead, very fine fuel (thatch) accumulates, and due to their fineness these fuels can dry very quickly after rain. Accordingly, despite occurring in relatively high rainfall areas and wet landscape positions, there are many days in the year when buttongrass moorland will burn, and they may burn even though the ground below the tussocks is waterlogged. Buttongrass can be burnt under conditions in which other types of vegetation in the landscape are too wet to burn.

Buttongrass moorland mostly occurs in areas remote from human settlements. Some asset protection burning does occur in buttongrass areas around towns, buildings and infrastructure. However, most buttongrass burning is conducted for ecological and strategic landscape reasons – to induce a degree of time-since-fire heterogeneity so as to avoid damaging, large scale higher-intensity buttongrass fires that can and do occur if older growth stages are allowed to accumulate broadly across a landscape.

This case study It is a synthesis of buttongrass burning information documented in Buttongrass Moorland Fire-Behaviour Prediction and Management (Marsden-Smedley *et al.* 1999), Planned Burning in Tasmania I, II, and III (Marsden-Smedley 2011a, 2011b and 2011c), and Parks and Wildlife Service Fire Planning Policy P-055 (DPIPWE 2009). It incorporates burning operations planning and implementation practice information as well as the relevant fire science on which current procedures are founded.

5.6.3 Full case study

Case study available at: www.afac.com.au/initiative/burning

5.7 Case Study 7 – Burning for greenhouse gas abatement in Northern Australia

5.7.1 Authors

This case study has been prepared by Paul de Mar (GHD).

Source: Andrew Houley, Fire and Landscape Strategies

5.7.2 Synopsis

Tropical savannas occupy a high proportion of Australia's tropical north, covering 1.9 million km^2 of land from the Kimberley region in the west, through the Northern Territory to Queensland's Cape country in the east. These savanna regions have annual rainfall of more than 600mm per year, with rainfall restricted principally to the wet season (December to March) producing prolific annual grass growth. A seven to eight month dry season follows during which the landscape progressively dries out, with grasses becoming fully cured and the landscape increasingly primed for fire. This annual monsoonal cycle of wet-season growth, followed by dry-season curing and drying makes tropical savannas the most fire-prone biome on Earth. On average about 20% of Australia's savanna region is burned each year, mostly in the late dry season when widespread dry fuel conditions promote large, intense fires. Fire occurrence in Australian savannas is unevenly distributed, with near-annual fire frequencies occurring in some lower-productivity savanna areas with unmanaged fire regimes, and much lower fire frequencies (decadal or less) in more fertile and intensively managed beef production areas where active land management seeks mostly to exclude fire (Russell-Smith *et al.* 2013).

These large, high intensity late dry season fire-dominated fire regimes have been shown to have chronically deleterious impacts on savanna biodiversity values (Woinarski *et al.* 2011; Russell-Smith *et al.* 2013). They are also contributing a significant component of Australia's greenhouse gas (GHG) emissions. Savanna fire emissions of long-lived greenhouse gasses (methane and nitrous oxide) account for between 2 to 4% of Australia's annual National Greenhouse Gas Inventory (AGEIS; ANGA 2011).

Commercial opportunities to create voluntary GHG emissions offset programs have given rise to the development of savanna burning programs in northern Australia which are restoring more sustainable fire management practices to some savanna landscape areas. These programs are drawing on traditional owner knowledge and skills, together with modern technologies to pursue commercial GHD abatement opportunities, whilst also generating significant social and biodiversity conservation benefits.

One example of GHG abatement savanna burning programs, outlined here in this case study, is the West Arnhem Land Fire Abatement (WALFA) Program.

5.7.3 Full case study

Case study available at: www.afac.com.au/initiative/burning

5.8 Case Study 8 – Burning of spinifex grasslands in the arid interior of Western Australia

5.8.1 Authors

This case study has been prepared by Paul de Mar (GHD) in consultation with Neil Burrows and Ryan Butler (DPaW).

Source: Department of Parks and Wildlife WA

5.8.2 Synopsis

Vast landscape areas of the arid interior of WA (as well as extensive areas of semi-arid and arid lands in Australia generally) are dominated by highly fire-prone spinifex grasslands. For thousands of years, lightning and human ignitions have ensured that fire is an environmental factor that has influenced their structure, function and biodiversity. Spinifex-dominated ecosystems are fire-maintained. Fire burns the above-ground biomass which accumulates in mature and over-mature spinifex grasslands and when rains arrive a regeneration response follows.

European colonisation resulted in a breakdown of traditional hunter-gatherer lifestyles and ended or greatly disrupted traditional burning practices. Prior to the impacts of colonisation, Aboriginal people used fire on a frequent basis, applying a patch burning regime in the spinifex landscapes they occupied. Their use of fire maintained spinifex landscapes in a condition that contained a mosaic of seral stages (stages of recovery from fire), with abundant edges between growth stages, thereby providing an array of habitat niches which supported a variety of food sources that Aboriginal people accessed and depended on. Fire created the conditions which maintained sufficient availability of food sources, and fire was used, among many other purposes, as a tool to facilitate locating, hunting and gathering favoured foods (Burrows and Christensen 1990; Burrows *et al.* 2006; Gammage 2011).

The removal of traditional Aboriginal burning practices from vast spinifex landscape areas reduced the frequency of fire (ignition being limited to lightning and much less frequent and differently-intentioned human caused fires), resulting in a substantial increase in fire size and severity, and obliteration of the habitat heterogeneity associated with finely-scaled mosaics (Burrows *et al.* 2006).

In spinifex-dominated landscape areas where the current unplanned fire regime is comprised principally of very large, high-coverage fires that have burnt in adverse fire conditions, change to a more proactive use of fire is required for biodiversity conservation. In such areas, use of planned burns is the only viable method available to reduce the potential for very large adverse unplanned fires which can otherwise burn through and homogenise previously existing seral stage mosaics, with adverse consequences for biodiversity. Fire management may also be necessary to protect property, infrastructure and cultural values.

This case study explores the planning and implementation of prescribed burning in spinifex areas, drawing upon information from Department of Parks and Wildlife's Prescribed Fire Manual, WA's Spinifex Grassland Fire Behaviour Guide – Mk 2 (Burrows, Liddlelow and Ward 2015), and DPaW's Lorna Glen/Earaheedy Fire Management Plan 2011 – 2015 and annual operations implementation reports (2012 – 2014).

5.8.3 Full case study

Case study available at: www.afac.com.au/initiative/burning

5.9 Case Study 9 – Burning for eucalypt forest health Southeast Queensland/Northern NSW

5.9.1 Authors

This case study has been prepared by Mark Burnham and Dave Kington of the Queensland Parks and Wildlife Service (QPWS), and Dominic Adshead (GHD).

Source: Queensland Parks and Wildlife Service

5.9.2 Synopsis

The principle objectives of the QPWS fire management system are mitigating, as far as possible, the risk to life and property through planned burning, and using planned burning as a tool to maintain functioning and healthy ecosystems. This approach recognises that failure to apply low intensity fire regularly, coupled with an infrequent regime of high intensity bushfire (often occurring during dry or drought periods when ecosystems are most stressed), is a worst case scenario ecologically.

To meet these objectives QPWS uses a Vegetation Condition Assessment Framework (VCAF) to classify a conservation reserve into ecosystem health classes, with the healthiest vegetation communities given the highest priority for low intensity prescribed burning. Treating the healthiest forests first provides the most cost effective means to retain forest values and keep the best ecosystems in peak condition. QPWS is the first state agency in Australia to formally apply this approach, and this case study summarises how it is applied as part of the Burning Block Analysis Phase (Principles 1 and 2) to south-east Queensland conservation reserves.

5.9.3 Full case study

Case study available at: www.afac.com.au/initiative/burning

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Front cover image provided by Roger Armstrong, of the Department of Parks and Wildlife, Western Australia.

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Source: Department of Land Resource Management NT

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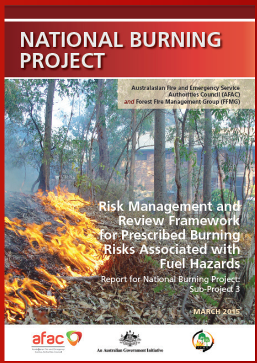

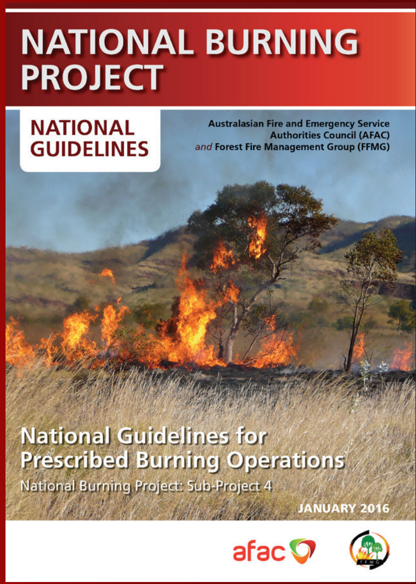

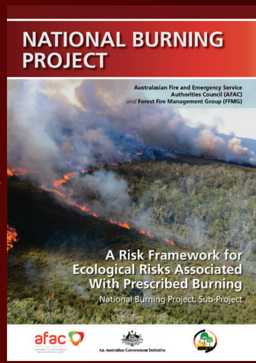

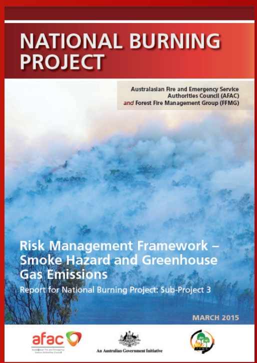

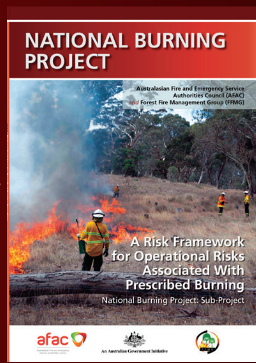

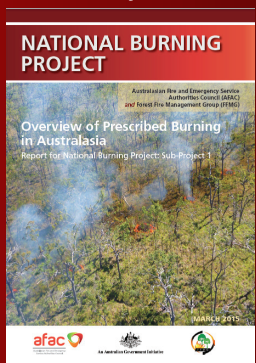

These reports are available at the AFAC shop www.afac.com.au.

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

National Guidelines for Prescribed Burning Operations

National Burning Project: Sub-Project 4

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Prescribed burning is delivered through a variety of processes by agencies across Australia and New Zealand. This allows for regional differences and tailored programs. However, there are underlying principles that should and do support these disparate programs. AFAC has taken on the challenge to develop national doctrine to provide guidance on the principles that underpin all prescribed burn planning and implementation activities. I am confident that the framework and principles identified in this document will be valuable to practitioners, planners and land managers with an interest in undertaking prescribed burning in the best ways possible.

– Gary Featherston,
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