NATIONAL BURNING PROJECT

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

Review of Best Practice for Prescribed Burning

Report for National Burning Project: Sub-Project 4

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An Australian Government Initiative

FFMG

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1. INTRODUCTION

The National Burning Project (NBP) is a multi-year project jointly commissioned by the Australasian Fire and Emergency Service Authorities Council (AFAC) and Forest Fire Management Group (FFMG), with the overarching objective:

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

The NBP comprises a range of sub-projects, a proportion of which will provide preliminary inputs for a Best Practice Guideline for Prescribed Burning. The complementary sub-projects are shown in Figure 1, with those projects for which funding has been approved shaded green. This report is the initial report for the Prescribed Burning Best Practice Review sub-project.

Figure 1 National Burning Project – Best Practice Guidelines Related Sub-Projects

1.1 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 their connection with the land itself – a part of how they cared for the land and 'tilled' their country. They applied fire in the landscape for many purposes, including to modify vegetation cover, composition and condition. From the tropical north to the cool temperate south, Aboriginal people used fire to manipulate landscape condition and their food supply – to promote environments that made preferred food sources more abundant, and made hunting and gathering more convenient. They used fire to keep travel routes unobstructed, as part of hunting practices, for communication, and for spiritual reasons among many other reasons. [1]

Biomass burning was also practiced by European and non-European settlers, particularly those making their living from the land and natural resources. Although European settlers undoubtedly learnt from and adopted aspects of burning practice from Aboriginal people, they often applied fire for different purposes and in different ways (e.g. land clearing and pasture promotion for domestic stock). However, Europeans and Aboriginal people had some common purposes for using fire, including burning around bush-camps and settlements to reduce the risk of being burnt out by bushfires. In more recent decades, there has been an increasing recognition that many ecosystems are 'fire maintained' requiring a particular fire regime to maintain their diversity and resilience – prescribed burning is used to maintain an appropriate fire regime.

Prescribed burning for community and commercial resource/asset protection has been widely used by Australian public land management agencies since about the 1970s, with early development of systematic approaches and techniques 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 fuel reduction programs. The 2009 Victorian Bushfire Royal Commission (VBRC) has proven to be a catalyst for a wide ranging review of prescribed burning practices. Specifically the VBRC recognised the importance of prescribed burning (Parliament of Victoria 2010) (as have numerous inquiries before it) stating:

[1] *There is a significant body of literature examining the issue of traditional Aboriginal burning practice, including a range of studies conducted at regional and sub-regional scales. Among the more comprehensive works on the subject is a recent (2011) book titled The Greatest estate on Earth - How Aborigines made Australia 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.*

"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".

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".

The VBRC convened an expert panel (which included prominent fire scientists, ecologists and land management professionals) to consider the practice of prescribed burning. The evidence of the expert panel informed the VBRC's recommendations for expanded implementation of prescribed burning programs in Victoria. This renewed emphasis given to prescribed burning and the expanded programs set across a range of jurisdictions 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.

This best practice review project is well timed to capture this emerging innovation, as well as any existing practices that may have application across jurisdictions. This project is aimed at reviewing and renewing lead practice in relation to prescribed burning. It is envisaged that this review and report can be used in a collaborative process at a later stage to develop best practice guidelines that will benefit land managers and agencies by providing a degree of interoperability, as well as framework for transparency and accountability.

2. METHODOLOGY

2.1 Project structure

The aim of this project is twofold, with the first component to document the strategic, tactical and operational tools used to deliver prescribed burning programs, and the second to identify examples of innovative practice that could be used to improve business delivery models.

To provide consistency for information collection across National, State and Local Government jurisdictions a framework based on the planning, operational, assessment and monitoring phases to implement a prescribed burning program was used for information collection, workshop delivery and report compilation. This framework is summarised in Table 1 and Figure 2 below:

Table 1 Project Information Framework

Strategic Planning	Identifies the over-arching aims, objectives and performance indicators of landscape level burning programs. It includes the system for how prescribed burns are assigned a strategic value, the basis for allocating priorities and determining locations and dimensions, and decision support tools used in this process.
Tactical Delivery Program Planning	The development of long term and annual burn delivery schedules (1-5 year order of working), stakeholder consultation process, objectives for maintaining values, program oversight and decision support tools applied.
Values Assessment	Consideration of implications of burns on values (environmental, cultural, heritage, community, timber production, commercial, water catchment), risk analysis and setting prescriptions.
Operational Delivery	Risks associated with burning operations and control measures, documentation and communication of operational delivery requirements, burning guides, delivery techniques and resourcing.
Monitoring	Range of monitoring practices including the suitability of conditions, performance against objectives in delivery, remote sensing applications, and broad-scale and long-term monitoring programs.

Information gathering was also divided by northern and southern Australia to reflect the different operating contexts of prescribed burning between the two areas, with the Tropic of Capricorn used as an indicative boundary. Further information of these different operating contexts see Sections 3.1 and 4.1.

Note for the New Zealand context, the southern Australian examples, particularly those from Tasmania may have application.

Figure 2 Review Components

2.2 Project stages

The project was completed according to the following stages:

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

Information gathering and consultation: Identification of the range of information sources, guidelines and templates used by agencies, fire authorities, land managers, research organisations and land owners to plan and deliver their prescribed burning program. A full list of reference information provided by participating agencies is provided in Appendix A.

Workshops: Confirmation of local approaches was achieved at four workshops completed across Australia based around the key components identified (Figure 2). Varying in length from one to three days, the workshops brought together the majority of Australia's fire authorities, land managers and research organisations involved with fire, as well as representatives from Defence, local government, power distributors, not for profit organisations, pastoral industry and the consulting sector (Table 2). Workshops consisted of five sessions based on the project information framework shown in Table 1.

Information analysis and draft report preparation: Following the doctrine review and consultative workshops, information is prepared for preliminary review by the AFAC/FFMG National Burning Project steering committee.

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

Table 2 Project Information Framework

LOCATION AND DATE	PARTICIPANTS	HOST/SPONSOR
Darwin, Northern Territory 31 January – 1 February 2012	AFAC Bush Heritage Australia Bushfires NT Cape York Sustainable Futures Charles Darwin University CSIRO DFES WA Friendly Fire Ecological Consultants GHD Kakadu National Park NT Fire and Rescue Service QPWS (DNPRSR) Reef Catchments Serco Sodexho Defence Services DPaW WA	Bushfires NT/PCS ACT
Melbourne, Victoria 8 -10 February 2012	AFAC ACTESA Country Fire Authority Department of Defence DEWNR SA Department of Environment and Primary Industries Fire & Rescue NSW Forestry Tasmania Forestry Corporation NSW GHD Melbourne Water NSW National Parks & Wildlife Service NSW Rural Fire Service Parks & Wildlife Service Tasmania Parks Victoria Powerlink Queensland Qld Fire & Rescue Service VicForests	Department of Environment and Primary Industries, VIC

Table 2 Project Information Framework continued

LOCATION AND DATE	PARTICIPANTS	HOST/SPONSOR
Perth, Western Australia 15-17 February 2012	AFAC Department of Parks & Wildlife Department of Fire and Emergency Service WA GHD The University of Western Australia	DFES/DPaW WA
Brisbane, Queensland 3 May 2012	AFAC Agforce Queensland Brisbane City Council Department of Transport and Main Roads Ergon Energy Forestry Corporation NSW GHD Gold Coast City Council Moreton Bay Regional Council Nature Conservation Council of NSW Northern Rivers Fire and Biodiversity Consortium NSW National Parks Service NSW Rural Fire Service Powerlink Queensland QPWS (DNPRSR) Queensland Fire and Rescue SEQ Catchments Serco Sodexho South-east Queensland Fire and Biodiversity Consortium Sunshine Coast Regional Council Toowoomba Regional Council	SEQ Fire & Biodiversity Consortium / Powerlink Queensland

3. SOUTHERN AUSTRALIA: PRACTICE REVIEW

In this section, prescribed burning practices in southern Australia are reviewed. For the purpose of this review, southern Australia is considered to be:

- Tasmania;
- Victoria;
- New South Wales;
- Australian Capital Territory;
- South Australia;
- Those parts of Western Australia and Queensland south of the tropic of Capricorn; and
- New Zealand is also incorporated in this section.

The separation of northern and southern Australia in this review is principally due to the significant differences in planning and conducting burning in tropical, monsoon-cycle dominated landscapes (many parts of which can experience very high fire frequency) in contrast with sub-tropical and temperate Australia where planning is generally conducted at longer cycles.

3.1 Operating context and challenges

In considering best practices for prescribed burning, it is necessary to first understand the operating and management context in which prescribed burning sits.

3.1.1 The physical operating environment

Jurisdictions in southern Australia operate across diverse physical environments, landscape types and climatic zones

Landscape types range from alpine, sub-alpine and cool wet temperate and temperate sub-humid areas in the south-east; to semi-arid rangelands and deserts; to Mediterranean climate zone landscapes with typically dry summers and wet winter periods. A wide range of ecosystems are supported, with a highly variable fire frequency, from very low in some alpine and rainforest areas, to highly fire-prone systems such as grasslands, heathlands and dry sclerophyll forests and woodlands. 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 no simple matter.

Jurisdictions in southern Australia are operating in a constantly changing physical environment and with an evolving knowledge base

The timing of fire seasons and characteristics of bushfires changes between climate zones, landscapes and vegetation types. All climatic zones in southern Australia experience periods of weather conducive to fast-moving, high intensity uncontrollable bushfires. The worst fire-weather extremes are experienced in the Mediterranean, semi-arid, cool-wet temperate climate zones of southern mainland Australia. Such extremes are experienced more frequently in inland areas away from maritime influences along the coastal fringe, however during severe weather patterns, extreme conditions can and do extend to coastal locations. The occurrence of severe fire-weather extremes in these areas means that large high-intensity fires have been a natural part of the environment for millennia, as have smaller scale lower-intensity fires. The extent to which distributions of recently burnt areas in the landscape have occurred historically, and have limited the size of high-intensity fires has been, and remains, a hotly debated subject.

There is widespread acknowledgement that Indigenous Australians used fire frequently, and for a range of purposes, and that their use of fire played a central role in shaping the biodiversity of Australia. There is however considerable disagreement in southern Australia on where they used fire, and the frequency and extent of their fire-use. Traditional Indigenous burning practices have been extinguished in southern Australia, in most places for more than a century, replaced by significantly different practices instituted by European settlers – practices which have been evolving and changing over time.

Since the Second World War, fire suppression organisation and capacity has developed greatly, adding to the land management changes. The result of settlement patterns, changed land use, extinguishment of traditional indigenous burning, and evolution of contemporary fire-use and suppression practices are landscapes and fire regimes that are most substantially different from those of pre-European settlement times, and in many areas different to nineteenth and early twentieth century times. In practice, there are no 'benchmark periods' against which to consider current fire management practices – situational circumstances have been in a constant state of change ever since European settlement and still are.

Within the fire-prone landscapes of southern Australia, agricultural, industrial and urban development has taken place at pace. Human population distribution and densities far exceed those of any previous times and continue to expand. The vast majority of developments are adversely impacted by bushfires therefore institutions, systems and capacity has developed, particularly over the latter half of the twentieth century, aimed at protecting people, assets of commercial value, and natural values from the adverse impacts of fires.

3.1.2 The socio-political operating environment

The result of the widely varying opinions on the effectiveness and impacts of prescribed burning, and the somewhat polarised debate surrounding the practice, is that land and fire management agencies often operate in a politically charged environment. Social and political factors may significantly impact the ability of agencies to secure community support for the programs they consider appropriate to the risks, and their ability to gain local support for specific prescribed burn activities.

The place of prescribed burning as one of a suite of tools for protecting people and property, and maintaining natural values can generate debate for a range of reasons. While the panel of experts at the VBRC agreed that prescribed burning is a valid land management tool, within the community there is a very broad spectrum of opinion on the degree to which it is effective and the location and extent of where it should be applied in the landscape[2]. There is also debate relating to the application of 'fire frequency thresholds' and intensity requirements for biodiversity and ecosystem health, and opinions relating to the point at when prescribed burning moves from being beneficial to harmful for a specific burning block. Consideration of the ecological risks associated prescribed burning is to be reviewed as a separate AFAC/FFMG National Burning Project sub project (see Figure 1). Further, at local community scales there are typically a range of different values-at-risk, with conflicts arising when it comes to fire use and timing.

3.1.3 Legislative and policy frameworks

Legislative and policy frameworks differ between jurisdictions. In all jurisdictions, the current frameworks have evolved from earlier frameworks which were not at the time specifically developed to address prescribed fire use. While the legislative frameworks differ between jurisdictions, they have some common elements and derivations. The detail of legislative frameworks has been compiled in a separate FFMG project. The elements and derivation common across jurisdictions are summarised below:

2 *This debate is reflected in the wide and voluminous range of submissions made to numerous recent inquiries into land and fire management, and a polarisation of the debate is regularly played out in the media following major fire events.*

3. SOUTHERN AUSTRALIA: PRACTICE REVIEW CONTINUED

Table 3 Legislative Context

State	Bushfire Risks, Bushfire Events and Emergencies	Management of Forests and Forest Resources	Management of Conservation Reserves	Protection of Flora and Fauna	Environmental Protection and Pollution Control	Specific legislation that influences or mandates prescribed burning
ACT	Emergencies Act 2004	–	–	Nature Conservation Act 1980	Planning and Development Act 2007 Heritage Act 2004 Environment Protection Act 1997	Emergencies Act 2004
QLD	Disaster Management Act 2003 Fire and Rescue Service Act 1990 Land Act 1994 Aboriginal Land Act 1991 Building Regulation 2006	Forestry Act 1959	Wet Tropics World Heritage Protection and Management Act 1993 Nature Conservation Act 1992	Nature Conservation Act 1992 Vegetation Management Act 1999	Environmental Protection Act 1994 Aboriginal Cultural Heritage Act 2003 Torres Strait Islander Cultural Heritage Act 2003 Qld Heritage Act 1992 Sustainable Planning Act 1992 Recreation Areas Management Act 2006	–
NSW	Rural Fires Act 1997 State Emergency Service Act 1989	Forestry Act 1916 Plantations and Reafforestation Act 1999	National Parks and Wildlife Act 1974 Forestry and National Parks Estate Act 1998	Native Vegetation Act 2003 Threatened Species Conservation Act 1995	Environmental Planning and Assessment Act 1979 Heritage Act 1977 Wilderness Act 1987	Rural Fires Act 1997
NT	Bush Fires Act 2004 Fire and Emergency Act 2012 Disasters Act 2008	–	–	–	–	–
SA	Fire and Emergency Services Act 2005 Emergency Management Act 2004 Crown Land Management Act 2009	Forestry Act 1950	Wilderness Protection Act 1992 National Parks and Wildlife Act 1972	Native Vegetation Act 1991	South Australian Water Corporation Act 1994	–

Table 3 Legislative Context

State	Bushfire Risks, Bushfire Events and Emergencies	Management of Forests and Forest Resources	Management of Conservation Reserves	Protection of Flora and Fauna	Environmental Protection and Pollution Control	Specific legislation that influences or mandates prescribed burning
WA	Fire Brigades Act 1942 Bush Fires Act 1954 Emergency Management Act 2005 Fire and Emergency Services Authority of WA Act 1998	Conservation and Land Management Act 1984	Conservation and Land Management Act 1984	Wildlife Conservation Act 1950	Environmental Protection Act 1986	Environmental Protection (Clearing of Native Vegetation) Regulations 2004
VIC	Emergency Management Act 1986 Fire Services Commission Act 2010 Country Fire Authority Act 1958 Public Safety Preservation Act 1958	Conservation of Forests and Lands Act 1987 Forests Act 1958 Land Act 1958 Crown Land (Reserves) Act 1978 Sustainable Forests (Timber) Act 2004	National Parks Act 1975	Flora and Fauna Guarantee Act 1988	Environmental Protection Act 1970 Planning and Environment Act 1987 Climate Change Act 2010	Sustainable Forests (Timber) Act 2004 Climate Change Act 2010
TAS	Fire Service Act 1979 Crown Lands Act 1976 Emergency Management Act 2006	Forestry Act 1920 Forest Practices Act 1985 Public Land (Administration and Forestry) Act 1991	National Parks and Reserves Management Act 2002	Nature Conservation Act 2002 Threatened Species Protection Act 1995	Environmental Management and Pollution Control Act 1994 Aboriginal Relics Act 1975 Historical Cultural Heritage Act 1995 Land Use Planning and Approvals Act 1993	–
C of A	–	–	–	Environmental Protection and Biodiversity Act 1999	–	–
NZ	Fire Service Act 1975	Forest and Rural Fires Act 1977	–	–	–	–

Source: (T.Vercoe 2012 pers comm.)

3.1.4 Governance, management and implementation arrangements

Arrangements for governance, management and implementation of prescribed burning differ between jurisdictions. In southern Australia, differences between jurisdictions arise from current institutional arrangements having evolved along different pathways and timing.

Institutional and governance arrangements for prescribed burning on public lands

The majority of prescribed burning is undertaken on public lands by public land management agencies. These public land management agencies typically are created by legislation pertaining to the management of conservation reserves and forests for timber production (see Table 3).

Agency structures, public land management responsibilities and objectives, and resourcing levels have changed significantly over the past three decades. In general, there has been a significant transfer of land from tenures formerly established for harvesting of timber and other forest resources, to tenure established for biodiversity and environmental values conservation. The result is that the area now managed under conservation reserve tenures is much greater than it was 30 years ago, and the area managed for forestry is significantly less. This has resulted in a change in management intent for significant areas of public land, with a decline in forestry agency resources, and an increase in conservation agency resources (although the increase in the latter is not necessarily equivalent to the decrease in the former)[3].

Additionally, there has been a gradual trend for state governments to divest themselves from the management of timber plantation estates and to commercialise the remaining publicly owned plantations and native forests. The resulting long-term effect is a change in the balance of public good and commercial performance emphasis in management and resourcing priority, contributing to decreases in prescribed burning across former public forestry land tenures. Overall, land management resourcing levels in this period have declined due to changes in land management objectives (conservation and commercial), regionalisation of resources (contraction to larger centres rather than locally based management) and a greater reliance on contractor and seasonal personnel (including for fire management roles). These changes in land management objectives and operational structures have brought with them changes in emphasis for prescribed burning programs.

[3] *The issue of how changes in land tenure and land management objectives have shifted over recent decades and how this has influenced approaches to fire management has been a key subject of many public, industry and professional association submissions to recent fire related inquiries. A key theme has been an observed shift in balance from approaches which incorporate a strong prevention and mitigation focus toward more recent approaches that are much more reliant on suppression. The Institute of Foresters of Australia's submission to the VBRC is one recent example of such analysis, and international fire management expert Stephen Pyne's book The Still-Burning Bush (2006) provides another, placed in a broader international context.*

Prescribed burning on public land tenures generally is subject to the same statutory frameworks as private lands, which include provisions which:

- Control clearing of native vegetation (in some jurisdictions, burning vegetation is considered to be clearing);
- Establish that killing or harming threatened flora and flora is an offence;
- Establish that conducting activities which cause an occurrence of water pollution is an offence;
- Require a form of environmental impact assessment for activities (including prescribed burning); and
- Protect cultural and archaeological sites.

Additional regulatory requirements may also apply to prescribed burning in specific areas, such as in parts of NSW where Integrated Forestry Operations Approvals did apply, adding an unparalleled level of administrative complexity and constraint to prescribed burning operations. Highly regulated air-shed controls, such as in Tasmania, may also significantly reduce the potential for prescribed burning by restricting the number and size of blocks treated, within a relatively small annual prescribed burning window.

Public land management agencies have in-house capacity to undertake prescribed burn planning and environmental assessment process which comply with these statutory requirements, and the delivery of prescribed burning programs. The exception to this is the Department of Defence, a significant public land manager, where these services are contracted out.

Management and implementation of prescribed burning is undertaken in accordance with policies, standards and procedures established by the public land management agency. These can be very extensive, including such things as Codes of Practice, training and competency requirement frameworks, manuals pertaining to the planning and approvals processes for prescribed burn planning at program and site-specific works level, technical guidelines/procedures for implementing burning operations, and a range of decision-support tools, mapping tools, planning templates and record keeping/reporting systems. These planning and implementation approaches and systems are examined in Sections 3.3 to 3.5 of this report.

Institutional and governance arrangements for prescribed burning on private lands

On private lands, the use of prescribed fire is the responsibility of individual land owners and may be supported by rural and to a lesser extent urban fire services. Burning is undertaken on private lands to meet a range of land management objectives including the reduction of fuel hazards near fire-vulnerable assets or dwellings, for a range of agricultural purposes (such as stubble removal, weed control, woody debris removal (piles and windrows), and pasture management) and forestry purposes (such as fuel reduction, reduction of logging slash, to promote forest regeneration or other silvicultural purposes, and fire-vulnerable forest/plantation protection).

Fire services, urban and rural, make a significant contribution to fuel reduction activities including assisting government land management agencies that do not have fire management capacity, and assisting private property owners. This includes addressing environmental requirements on private lands, where it is unlikely that private property owners will have the knowledge and expertise to address statutory environmental protection requirements. By fire services undertaking this role it enables prescribed burning on private land to occur, where previously owners may have been reluctant (or may have completed the activity without statutory approval and/or at risk of legal penalty). In NSW, these process efficiency issues were significant enough to warrant the introduction of a streamlined prescribed burning approval process for both private and public lands, under which a private land owner could apply to a single government agency (NSW Rural Fire Service) to obtain the necessary approvals (via a Bushfire Hazard Reduction Certificate) for prescribed burning. The capacity and requirements for fire services to address such requirements are variable across Australia. Environmental assessment processes are detailed further in Section 3.4.

3.2 Strategic planning

Prescribed burning is not an end in itself, and is undertaken for a range of reasons which may be grouped into two broad categories:

- Fuel reduction burning (where the primary outcome sought is to reduce bushfire risk to human life or assets/values within the potential impact area of bushfires); and
- Ecological burning (where the primary outcome sought is to modify the state or condition of an ecosystem to benefit particular species or communities, or to improve the capacity of an ecosystem to withstand the homogenising impacts of high intensity fires (promote resilience)).

The above broad categories are not mutually exclusive - many prescribed burns will achieve both risk reduction and ecological benefits. Indeed, good strategic planning seeks to maximise the extent to which dual benefits can be achieved.

In order to achieve the desired outcomes, strategic planning is undertaken to work out how best to use prescribed burning as a strategy to achieve the desired results. Strategic planning considers the values at risk from bushfire, how bushfire can impact these values, how prescribed burning can reduce bushfire impacts, how the act of prescribed burning may impact values. Strategic planning generally establishes a long-term, landscape level planning framework, approach, goals and objectives to provide a level of risk reduction for which the impact of the prescribed burning on values is acceptable. Strategic planning differs from tactical planning, the latter being undertaken to devise future works programs to achieve the goals and objectives established by strategic planning, taking specific account of landscape features and condition at the time.

In recent years, some land management agencies have come under great scrutiny regarding the adequacy of their strategic planning, with some being engaged in legal actions through which the rationale and modus-operandi for their prescribed burning has been challenged.

Southern Properties (WA) versus the Department of Conservation and Land Management

One noteworthy example is a recent case brought by a group of wine grape growers in south-west WA against the Department of Conservation and Land Management (now the Department of Parks and Wildlife (DPaW))[4]. The matters considered in this case extend well beyond the issue of whether smoke from prescribed burning affects grapes – under consideration was the broader issue of the extent to which prescribed burning delivers bushfire risk reduction benefits to communities and whether these outweigh the negative impacts to individuals of smoke produced during burning. A key issue arising in the case was the consideration of the strategic importance, necessity and urgency of a burn as an individual event, in contrast to its importance as a component of a strategic program of burns.

DPaW presented their case that the merits and strategic advantage of a burn need to be considered in the context of their contribution to a strategic prescribed burning program. The plaintiffs (group of grape growers) put their case that the necessity and urgency of the burn was not sufficiently high to outweigh the smoke impact risks to neighbouring properties.

DPaW's Director General was cross-examined on the point of the necessity and urgency for the burn to proceed and gave evidence as follows:

> The view that was taken at the time, that I took at the time, was that the necessity of achieving the overall strategic program was the overriding consideration.
>
> Did you have any written advice that conducting DPHB8 burn in the autumn of 2004 was a matter or urgency?---I don't recall being told that that particular burn, or indeed any other, was a matter of particular urgency, but I would take the view that in most circumstances any individual burn is not necessarily a matter of particular urgency; but if numerous burns are not carried out and postponed on that basis, the cumulative effect is to destroy a strategic burning program.

[4] *See the judgement of Murphy J (2010), Supreme Court of W A, in the matter of Southern Properties (WA) Pty Ltd -v- Executive Director, Department of Conservation and Land Management W A in which the legal action seeking compensation for damage to wine-grape crops tainted by smoke from a prescribed burn was dismissed.*

On this point, the WA Supreme Court judge hearing the matter found the following:

> 408 In my view, the words 'necessary' and 'urgent' are capable of creating a misleading impression, in this context, in that they are apt to convey the notion that prescribed burning is done in response to ad hoc dangers as they arise from time to time, rather than as an integrated strategy designed to deal with the systemic risk of wildfire inherent in the landscape and environment of the State generally, and of the south-west in particular. It is correct to say that there was no evidence that absent a prescribed burn on 31 March 2004, there was an immediate and substantial risk that a wildfire would break out in the area of DPHB8. To that extent, the prescribed burn of DPHB8 might, on one view of it, conceivably be described as being neither 'necessary' nor 'urgent' in early 2004. Nevertheless, that characterisation imports an artificial and narrow focus which obscures the broader context in which the large-scale programme of prescribed burning is designed and implemented in Western Australia generally, and in the south-west of the State in particular.

In this matter, it was of significant importance that DPaW was able to convince the judge that the burn was part of an integrated and systematic strategy for bushfire risk reduction. DPaW was able to convey that the benefits of their prescribed burning program accrued broadly to communities living in a fire-prone landscape, and that the potential dis-benefits to a relatively small number of individuals affected by an individual burn do not outweigh these broader community protection benefits. DPaW went to substantial lengths to do this, including providing analysis of the scale and consequences of historical bushfire events, losses and damage prior to implementing a strategically planned burning program, with comparative analysis to bushfire outcomes since the introduction of such programs.

This aspect of the case serves to highlight the importance of the strategic planning phase of prescribed burning, having in place a robust strategic case for burning, and being able to communicate that strategy.

The judge found in favour of DPaW, dismissing the damages claims for smoke damage to grape crops.

The case was subsequently appealed in the Court of Appeal, with the decision upheld by a 2:1 majority.[5] The dissenting judge took a view that has surprised many. He rejected the mainstream ecological science-based view that prescribed burning can be used to promote biodiversity. Of significant concern to land and fire management agencies, and a degree of alarm to the scientific community who have researched aspects of fire ecology over many years, he said *'There is no adequate science to support the stated objectives [of prescribed burning] of promoting biodiversity and optimising the maintenance of forest ecosystems... I would not accept that there is any social utility in prescribed burning for the purpose of promoting biodiversity until there was proper scientific evidence that it had a benefit'.*

5 *See the Appeal Judgement (supreme Court of W A – Court of Appeal) in matter of Southern Properties (W A) Pty Ltd -v- Executive Director, Department of Conservation and Land Management W A in which the Supreme Court judgement was upheld by a 2:1 majority.*

Further he rejected the mainstream view that prescribed burning provides some degree of social utility in the form of protection or risk reduction for communities in bushfire prone areas. He said *'So the question which presumably should be asked, is whether there is any scientific support for the view that prescribed burning provides protection from wildfires. Scientific information to support the claim that prescribed burning protection would have to be based upon observation of the outcome in control areas where no prescribed burning was carried out over many years and the outcome in comparable areas where prescribed burning is carried out. No reference is made in the reasons to any such scientific evidence. Scientific support for prescribed burning is not provided by post hoc ergo propter hoc reasoning that there have been no serious bushfires in recent years like those in the Dwellingup region in 1961 or in New South Wales, Canberra or Victoria because prescribed burning began some time ago'.*

He went further in stating *'There must be a respectable argument open that prescribed burning is damaging to the interests of the community rather than being of social utility'.*

Of particular interest, the dissenting judge offers an opinion on how scientific research should be structured to determine if prescribed burning can provide protection from wildfires. He suggests selection of two comparable landscape areas – one as a control and one for experimental prescribed burning application, with conduct of the experiment over 'many years'. In practice, the complexity involved with operating at landscape scales and over periods of decades, and with a high number of uncontrollable variables within experimental sites, makes application of traditional control versus experimental treatments impracticable.

Firstly, it would likely be impossible to find a landscape scale area in WA where the local communities would accept being the untreated 'control' area in which the experiment seeks to test the hypothesis that the absence of prescribed burning will result in elevated occurrence and severity of life-threatening high intensity fires. Secondly, apart from the difficulties in finding two landscapes with similar topography and vegetation cover proportions and patterns, the experimental results would be influenced not only by prescribed burning but also wildfire occurrence, for which numbers and patterns of occurrence are beyond experimental control. By way of example, from time to time, comparisons are offered between the outcomes of prescribed burning approaches undertaken in SW WA where prescribed burning occurrence and extent are high, relative to some east-coast landscapes where prescribed burning occurrence and extent are by comparison low. Such analyses are frequently rejected by scientists on the basis that factors such as landform, vegetation types and distribution patterns, road networks and climate differ between the landscapes being compared. Absence of any replication offers further grounds for rejection of such an approach as lacking scientific credibility.

The practical realities of large landscape and long time scales, and the number and degree of variables involved, have historically mitigated against the types of experimental methodology suggested by the judge. Landscape scale experiments conducted over decades are also very expensive and require sustained long-term commitment (many decades). The available methods for consideration of prescribed burning effects of wildfire protection are therefore limited to before and after analyses; scaling-up analyses (from local case study to landscape scale), and computer modelling using wildfire spread modelling with different landscape fuel age and distribution scenarios.

The scientific rationale for prescribed burning, and the logic and merits of DPaW's strategic planning which underpins their prescribed burning program has been tested and vindicated.

Prescribed burning strategy - generalisations and subtleties

With regard to prescribed burning strategies, an issue that commonly arises is in relation to the strategic intent of programs. The strategic intent of prescribed burning programs is often generalised to *reducing the extent and severity of bushfires, and to enhance the safety and opportunities for fire containment.*

The extent to which these strategic outcomes are achieved by prescribed burning is often challenged after adverse bushfire events, when some prescribed burnt areas are found to have had a negligible effect on the overall extent of a major bushfire run during the elevated fire danger conditions, and on the loss and damage consequences of the fire. Such situations are often used to present a misleading case that prescribed burning is an ineffective strategy for reducing bushfire risk, with the outcomes observed in some adverse events generalised to be the case in lower fire danger conditions.

Such interpretations of the value of prescribed burning are narrow and misleading. Land and fire management agencies' strategic intent for prescribed burning programs is much broader than the few hours that a fire might make a high intensity uncontrollable run in severe to extreme weather conditions. The value of prescribed burns for facilitating improved suppression opportunities and success probability may be negligible in elevated fire danger conditions, except for very recent ignitions that are small and yet to build up to their potential rate of spread and intensity. However, in recently burnt areas (particularly < 5 years since fire [6]) some reduction in spotting is likely although just how much reduction is not known. During large high intensity fire events, the effects of prolific short to medium distance spotting, and the incidence of long-distance spotting is known to propagate fire across or over low fuel areas thereby negating or substantially diminishing the effect of the burn in reducing fire extent. However, agencies recognise and plan to take advantage of two very substantial benefits accruing from prescribed burnt areas which arise before and after extreme uncontrollable fire runs during more moderate fire danger conditions:

[6] *Research from Project Vesta indicates that while fuel in the surface and near surface layers re-accumulate relatively quickly for the first five years after fire and then the rate change begins to plateau off, bark hazard appears to build more slowly over many years, and hence significant fuel reduction effects of hazard reduction burns (vigorous enough to consume a substantial of bark on fibrous barked trees) may persist for longer in the bark fuel layer than in the surface and near surface layers (15 to 20 years is suggested). Bark fuels are a major contributor to spotting.*

- Fire and land management agencies expect that elevated fire danger conditions may occur repeatedly in the bushfire season, generated by the passage of recurrent weather patterns (e.g. the movement of frontal systems in south-eastern Australia and the movement of the west coast trough in south-west Australia). They understand that a critical risk reduction strategy is to minimise the amount of fire burning or smouldering in the landscape before the onset of such adverse weather conditions. To this end, prescribed burnt areas (and areas burnt by wildfires) are of significant advantage in that they increase the opportunities and success probability for containment and suppression of fires starting in between episodes of elevated fire danger; and
- Fire and land management agencies understand that fires running under adverse conditions will reduce in severity when weather conditions moderate, and opportunities to bring fires under control will return. Areas of low fuel serve to expand the range of conditions in which suppression operations can be safely conducted, and reduce operational difficulty relative to high fuel areas. This increases the probability that fire can be contained prior to the onset of the next bout of unfavourable fire weather hence avoiding further high intensity fire runs.

Therefore to claim that prescribed burning is of negligible value in reducing the extent of loss and damage from adverse fire scenarios is narrow and missing key aspects of their strategic value.

Even during severe to extreme fire dangers, bushfire runs into prescribed burnt areas can have a beneficial effect in reducing the impact area of a fire and enhancing control options. The extent to which such benefits are realised during large high intensity fire runs will depend on the proportion of the landscape treated, and the size and arrangement of the treated areas.

The Victorian Bushfires Royal Commission commissioned a study into the effects of weather, terrain and land use history (prescribed burning and logging) on fire severity patterns in the Black Saturday fires.

The study undertaken by Bradstock and Price (2009) concluded:

In summary, weather was the predominant influence on the severity of these fires in southern Victoria. Fuel age effects produced by patterns of prior fires (prescribed and unplanned) and logging across these landscapes are also important but highly contingent on weather conditions, along with influences of terrain. Young fuel ages produced by prior burning may not enhance the potential for suppression in 'worst case' fire weather conditions in the forest types considered in this study, but could mitigate the potential for propagation of embers. Potential for young fuel ages (e.g. < 10 years) to enhance suppression capacity is considerable in more moderate weather conditions.

That prescribed burning has had limited effect on fire outcomes in some recent major fire event outcomes (e.g. Canberra fires 2003, Black Saturday fires 2009) at least in part reflects that in the fire impact areas, the spatial extent of previously prescribed burnt areas, and their size and arrangement were not at a scale which would be expected to have any significant effect.

VBRC consideration of prescribed burning treatment area targets

The question of how much prescribed burning (proportion of fire prone landscape) would need to be done to have a measurable reduction in bushfire risk without compromising natural values was explored in detail by the Victorian Bushfire Royal Commission (VBRC). The VBRC convened an expert panel of prominent fire and forest ecologists and fire behaviour scientists to consider this and other questions.

If it is sought to significantly reduce the fire impact area of fires running under extreme conditions, the proportion of the fire prone area treated annually with prescribed burning will need to be in the range of 5 to 10% (according to the Victorian Bushfires Royal Commission expert panel [7]). The VBRC noted:

Members of the expert panel considered that the past prescribed burning regime of about 100,000 to 130,000 hectares (1–2%) a year is equivalent to a low level of risk reduction. They thought the strategic distribution and implementation of a prescribed burning regime of at least 5 per cent of the available land would reduce risk. To increase prescribed burning above 10 per cent carries greater risk of adverse ecological outcomes. VBRC Report Vol 2; p 294.

In the context of considering prescribed burn targets, some other matters of strategic importance were discussed with some important observations made and noted in the VBRC report including:

Dr Clarke (ecologist on the VBRC expert panel) clarified that there is some evidence to support the notion that prescribed burning at 5 per cent a year in the dry eucalypt foothill forests would be unlikely to result in undesirable environmental impacts. VBRC Report Vol 2; p 294.

Dr Tolhurst (forest scientist and fire behaviourist) and Professor Adams [fire and forest ecologist] both made the point that a target of 5 per cent across treatable public land was a starting point and the benefits would not be evident for 10 years at least. Mr Cheney [fire behaviourist] said an 8 per cent target for fuel reduction would be more effective. VBRC Report Vol 2; p 294.

Professor Bradstock (fire ecologist) emphasised the importance of what he termed 'the other side of the ledger': there could be ecological benefits from 5 per cent prescribed burning and he pointed to the example of protecting water yield. VBRC Report Vol 2; p294.

[7] *See Chapter 7 in Volume 2 of the Victorian Bushfires Royal Commission Report for a summary of the science examining the effectiveness of prescribed burning for reducing bushfire risk, including a summary of studies commissioned by the VBRC into the effects of prescribed burns on fire behaviour during Black Saturday.*

Panel members agreed in their summary that a state-wide target is useful because it provides a guide to the overall scale of prescribed burning that should be done. The target must, however, take into consideration the fact that each hectare burnt is not of equal 'value' and the location of prescribed burns affects the effectiveness of risk reduction. VBRC Report Vol 2; p294.

Informed by the evidence of the expert panel, the VBRC found:

'... a target of 5 to 8 per cent prescribed burning of public land is necessary for community safety and would not pose unacceptable environmental risks, particularly if priority is given to the dry eucalypt forests referred to by the expert panel. VBRC Report Vol 2; p294.

The VBRC also considered some general characteristics of prescribed burns to maximise their effectiveness for risk reduction, making the following observations:

The panel was unanimous in its view that burning areas smaller than 500 or 1,000 hectares is 'usually of minimal value in reducing the scale of unplanned fires'. Dr Tolhurst indicated that the reference in the panel's summary to burning areas 1,000 hectares in size was not 'just a random number': it is the 'sort of size we are thinking of would be needed to capture the majority of embers falling within three kilometres of a wildfire'. It is not just to achieve a target of so many hectares. Professor Bradstock stated, '... bigger is better and if you are going to push ahead with a more vigorous approach to prescribed burning it is inexorable that you are going to have to achieve that by treating larger slabs of country' VBRC Report Vol 2; p301.

The expert panel's summary noted that ideally a prescribed burn should achieve a burn of 70–90 per cent of the area being subjected to the burn. Dr Tolhurst noted that it should be no more than 90 per cent to allow recovery of the fauna and flora in that area afterwards. Dr Clarke explained that 'patchily burning landscape at a percentage less than 70 per cent' allows animals to navigate through the burnt areas and have necessary cover or resources for recolonising the area after fire. VBRC Report Vol 2; p301.

Mr Cheney explained what needs to be considered when selecting the location of a prescribed-burning block, and said 'the key to a burning program for wide scale protection is to have the blocks strategically located across the landscape in a pattern that, when repeated, large fires are going to sooner or later run into one of these low fuels and be checked, and in the lighter fuels suppression of the fire in subsequent hours or days after the extreme weather will be made much easier and can be done more efficiently'. VBRC Report Vol 2; p301.

Whilst the evidence of the expert panel was given in the context of Victoria, their general observations about extent of burning necessary to optimise risk-reduction effectiveness, and the desirable characteristics of prescribed burn programs have merit in other southern Australian jurisdictions.

Results of a long-term programmatic approach to prescribed burning (SW WA)

In Western Australia, where an approach of treating around 7-8% of public forests in south-west WA with prescribed burning has been sustained since the 1960's, there have been no fires greater than 30,000 ha (and no lives lost in forest fires), and fires larger than 20,000 have been very rare. The annual average for area burnt by wildfires in SW WA is around 20,000 ha, with 95% of fires less than 100 ha, and less than 1% of fires exceeding 2,000 ha. In a 2003 Bushfire CRC study of the long-term impacts of prescribed burning on the regional incidence of wildfires in the SW of WA, Boer and others found, among other benefits, that the extent and incidence of large wildfires was significantly lower than the long term average when the annual extent of wildfire was near maximum and significantly higher when the annual extent of prescribed burning was small (Boer *et al.* 2009).

Fire spread simulations applied to Victorian landscapes (using Phoenix Rapidfire) testing hypothetical prescribed burning programs with the aforementioned attributes indicate large high intensity impact areas can be reduced through such an approach. The spotting models used in the simulations may under estimate the influence of spotting in propagating the fire, and the influence of plume dynamics is absent from the model thus the extent of benefits predicted by the model outputs needs to be interpreted with some caution.

3.2.1 Strategic Planning - drivers and general approach

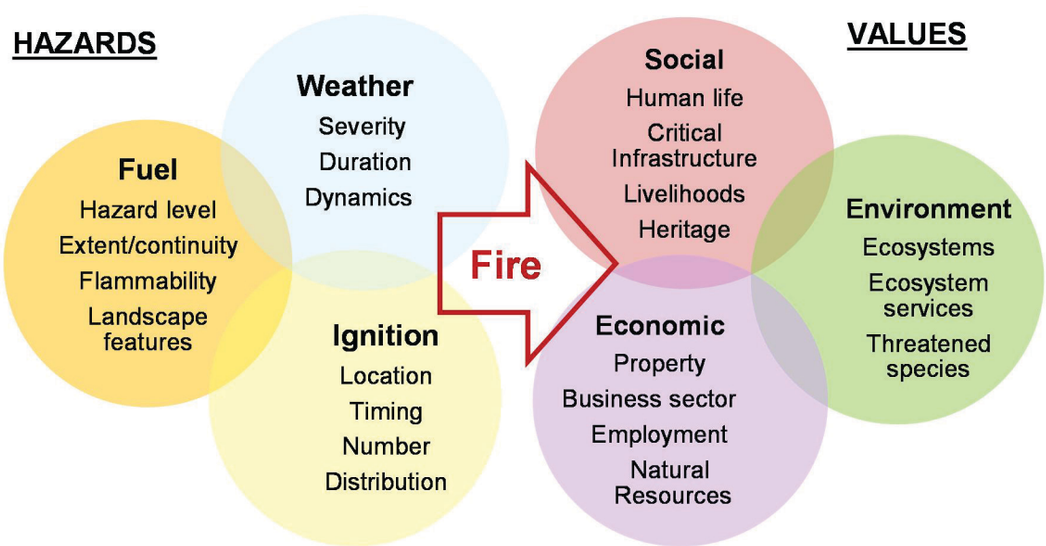
Land and fire management agencies agree that prescribed burning is not a bushfire risk elimination strategy, rather it is one of a suite of bushfire risk reduction strategies. It is planned and carried out in conjunction with a range of other bushfire risk reduction strategies including:

- Risk avoidance programs that avoid fire-vulnerable values being situated in potential bushfire impact zones;
- Prevention programs that seek to reduce accidental, careless and deliberate fire ignition in places and at times which can give rise to bushfires;
- Preparedness and mitigation actions to reduce the impact of bushfire events through hazard management programs such as fuel reduction, increasing separation between hazards and values, and fragmenting hazards so fire propagation is impeded, or programs addressing at-risk values to increase the resilience of people and assets/values, and gearing response readiness levels to the levels of risk anticipated;
- Response actions to suppress a fire before it can impact at-risk values, remove or reduce the exposure of at-risk values through warnings, evacuations/closures, and action to prevent or inhibit fire propagation through hazards or to assets; and
- Recovery programs to restore affected values to their pre-impact former state or an improved state.

Working out the place of fuel reduction strategies among other strategies, and the level of effectiveness desirable and possible, hinges on a risk assessment process which considers how hazards, prescribed burning actions and at-risk values interact. Figure 3 below depicts the elements of bushfire hazard and how these interact through fire with values vulnerable to fire impact. The level of bushfire risk is a function of the fire event likelihood and severity, and the exposure and vulnerability of the at-risk values. The level of risk can be reduced not only through fire suppression (preventing fires emanating from hazards from impacting values) but also by activities which reduce the likelihood and severity of fires, and the exposure and vulnerability of at-risk values.

Across Australia, following the VBRC, there has been an increased recognition of the value of prescribed burning in reducing the risk to lives, community and properties and servicing healthy ecosystems. The risk reduction value of prescribed burning is shown in a study over thirty years where Price and Bradstock (2011) found that historically for every three units of prescribed burning applied, a one unit reduction in high intensity bushfires was provided, and an increase of prescribed burning to 5.4% of landscape areas (annually) would lead to a halving of the extent of devastating bushfires. In terms of life and property protection, this ratio of prescribed burning benefit may be seen as a valuable investment in risk reduction to communities. Considering the greater precision and advances being made in prescribed burning planning and delivery, it would not be unreasonable to expect this benefit ratio to improve further in future.

Figure 3 Hazard and Values considerations in Bushfire Risk Assessment



There are significant challenges involved in the risk assessment process. These include consideration of:

- Potential fire impact areas, attack mechanisms and severity for bushfires which can occur in a wide range of hazard conditions (over-estimates may lead to over-investment in protection, with unsustainable costs, and credibility issues leading to complacency behaviour; whilst under- assessment may lead to the occurrence of preventable losses and damage);
- The at-risk values vulnerable to fire (level of severity and/or frequency and or attack mechanism);
- The combination of strategies optimal for reducing risk (not just fuel reduction);
- The extent, arrangement and degree of fuel reduction in which fuel types is optimal for reducing bushfire risk; and
- The limiting factors in a landscape (physical environment and human induced) which may influence the practicability of undertaking fuel reduction burning.

Risk assessment processes need to be appropriately tailored to the spatial and temporal scales being considered in planning or operations, and the resolution of outputs required. It may not be productive or efficient to conduct fine scale analysis using high resolution data if broad landscape scale outputs in broad risk categories are required. Equally, it will be sub-optimal to use coarse resolution data and analytical methods designed to deliver broad category outputs, to support decision-making which involves fine spatial and temporal scale consideration. 'Horses for courses' risk assessment processes need to be developed and applied.

The planning phases and operating scales most commonly applied to assess bushfire risk and manage fuels at the strategic level involve:

Input information:

- Location of different levels of bushfire hazard (coarse hazard resolution);
- Extent of potential impact zones (and types of impact) extending from areas of bushfire hazard;
- Values vulnerable to bushfire impact and their location in relation to hazard and potential bushfire impact zones;
- Ecologically appropriate fire regimes and objectives;
- Landscape features used to facilitate fuel management; and
- Vegetation/fuel types that can safely, successfully and sustainably support fuel reduction treatments.

Output information:

- Bushfire protection objectives and any fuel management strategies necessary to achieve these (in concert with other risk reducing strategies);
- Fire behaviour modification (and therefore fuel modification) outcome-based zones (or spatial distribution patterns) identification, with quantitative objectives; and
- Treatment cycles and intensity requirements to achieve the fuel management and bushfire risk reduction objectives.

In relation to fuel hazards, these input and output processes typically involve fuel hazard attribute inputs at the following scales:

- Vegetation type data across a landscape, coarsely grouped on the basis of fuel characteristics;
- Fire behaviour characteristics associated with different vegetation types, cover extents, and different landscape positions (and derived therefrom, information about potential fire impact zones associated with fuel hazards in the landscape); and
- Vegetation types suitable and unsuitable for treatment by prescribed burning.

3.2.2 Strategic Planning – good practice examples and innovative practice

There are a range of plan formats which constitute examples of 'strategic planning'. These include the following examples.

Strategic Bushfire Management Plan for the ACT

The ACT Strategic Bushfire Management Plan[8] is a comprehensive plan which contains both strategic and tactical program components. The plan contains a number of strategic elements not commonly found in other strategic plans:

- Robust analysis of fire history (in the ACT and surrounding landscape from where fires come into the ACT), with loss/damage and causal factors analysis, and trend and implications identification;
- Detailed local climate and fire weather analysis, including analysis of inter-annual variation in the occurrence of conditions suitable for prescribed burning;
- Detailed analysis of fuel characteristics in the ACT and fuel accumulation rates, with modelling undertaken to depict how fuel hazards will develop over a 10 year period; and
- The plan identifies different fire-vulnerable 'asset classes' and maps the location and extent of these in the landscape.

8 http://esa.act.gov.au/community-information/publications/sbmp/

Bush Fire Risk Management Planning in NSW

The NSW Bush Fire Risk Management Planning process is applied by local multi-agency consultative Bush Fire Management Committees for a specified regional area, across all tenures. The plan is developed from a model template endorsed by a multi-agency State committee (the NSW Bush Fire Coordinating Committee).

The risk analysis component of the planning process is founded on a risk register, a spatial database application to record assets at risk, maintained by the NSW Rural Fire Service. At-risk assets are grouped into human settlement, economic, environmental, and heritage categories. A structured, consistent process is specified for determining likelihood, consequence and risk ratings for each asset listed in the risk register.

Potential consequence assessment is enabled through a GIS spatial analysis based on a two dimensional matrix of:

- **Threat** - derived using a threat model which has hazard type and associated fuel load assumptions, slope class, and separation between asset and hazard as inputs; and
- **Vulnerability** - rated qualitatively using a three point scale and recorded in the risk register as an attribute of the asset.

A structured qualitative likelihood assessment process is used based on ignition likelihood and the likelihood that fire can spread and reach assets.

Levels of risk in relation to each asset in the risk register are then calculated using a two way matrix combining the likelihood and consequence ratings.

Overall, the NSW Bush Fire Risk Management Planning process has a structured risk assessment process, however the process for identifying what fuel reduction treatments are required in a landscape is focussed principally in Asset Protection Zones, with the designation of Strategic Fire Advantage Zones and works in Land Management Zones being done using guidelines established by the NSW Bush Fire Coordinating Committee. The residual risk that remains after implementation of the treatment is not calculated.

The Bushfire Risk Management Plan and treatment actions are also subject to an audit process.

The NSW risk register tool has been adopted, with some customisation, in Victoria (maintained by the CFA and called the Bushfire At-Risk Register).

Strategic Bushfire Risk Assessment in Victoria

The Department of Environment and Primary Industries (DEPI) is adopting a broader approach to managing bushfire risk consistent with the recommendations of the 2009 Victorian Bushfires Royal Commission and the Code of Practice for Bushfire Management on Public Land.

Strategic bushfire management planning is being implemented on public land in Victoria to identify how fuel management can help to minimise the impact of major bushfires on life and property and maintain the resilience of natural ecosystems.

This is being guided by international standards for risk management (ISO31000) and will involve developing risk-based strategies for bushfire prevention, preparedness, fuel management, response and recovery.

Phoenix RapidFire, a predictive modelling tool, simulates the spread and intensity of a bushfire and is being used in the strategic planning process to inform assessment of bushfire risk, and simulate the likely outcomes of bushfires to evaluate the effectiveness of different fuel management strategies. The software was been developed in collaboration between DEPI, the University of Melbourne, and the Bushfire Co-operative Research Centre.

Victoria has been divided into seven bushfire risk landscapes to implement the strategic planning process. Bushfire risk landscapes are 'bushfire catchments' that reflect where bushfires are likely to start, spread and do damage. Strategic planning at the landscape scale will help to develop bushfire management strategies that respond to how bushfires actually behave.

The seven teams involved in implementing this process will work with communities, stakeholder groups and partner agencies to understand what communities' value and want to protect from bushfire. The costs and benefits of different management strategies can then be weighed up so that Strategic Bushfire Management Plans can be developed.

Fuel management strategies developed through the strategic planning process will inform amendment of the Fuel Management Zoning Scheme and be translated into on-ground activities through the fire operations planning process.

A Monitoring, Evaluation and Reporting Framework is being developed to coordinate and target statewide monitoring programs and research investment to support adaptive management and continuous improvement in strategic planning processes and outcomes over time.

Master Burning Manual – Department of Parks and Wildlife (DPaW) WA

DPaW is responsible for fire management on more than 1.1 million hectares of land and bushfire mitigation across a further 89 million hectares (15% of Australia), with limited resources and budget, but with statutory responsibilities for the protection of the environment, natural and cultural heritage, and community assets. DPaW's Master Burning Manual is a comprehensive framework providing a clear step by step process to plan and deliver prescribed burning underpinned by scientific knowledge.

A key objective is to create, through regular prescribed burning, a spatially and temporally discrete mosaic of vegetation, habitat niches and fuel ages, which is able to mitigate the risks of damaging bushfires to adjacent communities, enhance biodiversity and promote ecosystem resilience.

To do so the manual establishes a hierarchy of planning as follows:

- Landscape Conservation Units (30 000–100 000 ha) – Used as the basis for selection of appropriate fire regimes to maintain heterogeneity;

- Logical Burn Unit (LBU) scale (500–5000 ha) – Defined by logical prescribed burning boundaries prescriptions set are based on the plant vital attributes for the most fire-prone plants (least sensitive) thereby affording protection for the least fire prone (most fire sensitive)[9]. Plant vital attributes are sourced from the FIRERESPONSE database; and
- Fire regime specific species or habitat scale - areas requiring modified burn prescription within an LBU.

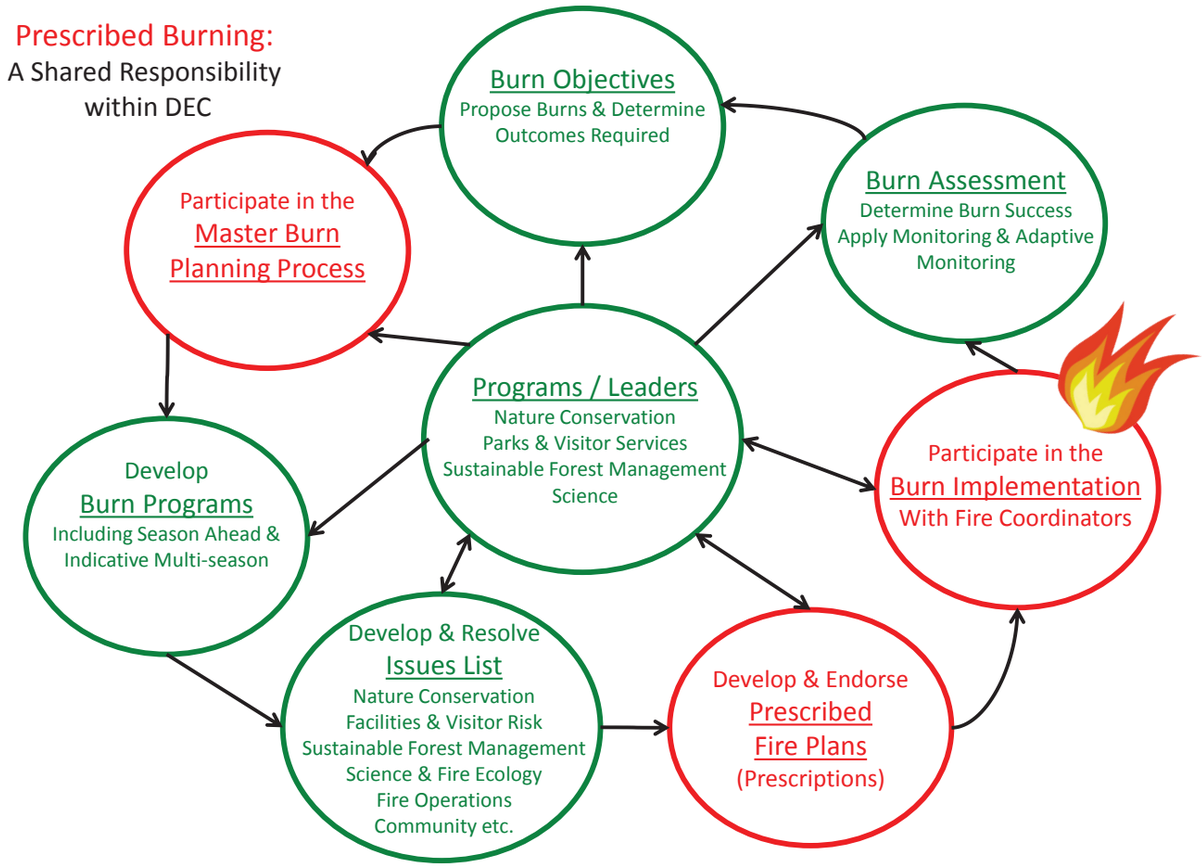
Fire management objectives for a range of forest values including silviculture, ecology, water and research are identified, as well as processes for prioritising burns, individual and functional area responsibilities, review phases, community engagement activities, and data and information protocols.

The manual reinforces DPaW's corporate requirement that all multi-disciplinary teams and individuals have responsibilities in respect to fire management for which they must meet (Figure 4). The corporate level emphasis on shared responsibility has been attributed to the significant improvements made in the regional multi-disciplinary Master Burn Plan preparation process.

There are other innovative strategic planning practices being applied at sub-landscape 'property' scales, including the bushfire planning approach taken across the Defence Estate, and in some Council areas and privately owned conservation reserves.

9 *This is the reverse of the approach applied in many eastern States where minimum fire intervals are set according to the vital attributes of the most fire sensitive species in a community.*

Figure 4 DPaW Prescribed Burning Corporate Responsibilities (Source: DEC 2011)



3.3 Tactical Program Planning

With strategic planning in place, the next phase in the prescribed burn planning process is to undertake tactical planning for the development of works programs that deliver the activities necessary to implement the strategies.

Tactical program planning processes typically take the outputs of the strategic planning phase and develop a works program identifying the locations and extents of different work types, their objectives, proposed sequence and timing. Accordingly, in addition to the processes applied at the strategic planning level they typically involve identification of:

- Different types of fuel hazard (at a resolution sufficient to determine types which can be treated with prescribed fire (and preferred season of treatment) and those types that can't be treated);
- Current and predicted fuel hazard levels within tracts of hazardous vegetation; and
- Identification of spatial patterns of fuel hazard level distribution in the landscape.

In relation to fuel hazards, the above-mentioned processes typically involve fuel hazard attribute inputs at the following scales:

- Vegetation type data across a landscape, grouped on the basis of ecological attributes and fuel characteristics;
- For each vegetation type, the growth stage and fuel age distribution in the landscape – these can either be measured or more usually they are modelled or inferred from time since last fire and fuel accumulation curves; and
- Local fuel drying and wetting cycles do determine best season/timing opportunities for burning.

In addition to the fuel attribute considerations, there are a range of other data and information types that should be considered:

- Objectives of the burn;
- Features suitable for use as burn boundaries;
- Can the burn be contained to its boundaries;
- Resources available to implement the burn program;
- Location of values that are incompatible with fuel reduction burning or for which adverse impacts are likely and will need to be justified in the context of the risk reduction proposed to be achieved;
- Local community/business activity/seasonal incompatibility with burning;
- Weather conditions on the day and four days following the burn; and
- Lighting method and patterns.

The outputs of tactical program level planning are typically maps and/or tabulated work-lists showing where and when works are planned to be undertaken and burn plans.

3.3.1 Tactical program planning process

Deciding where, when and how much to burn in works programs with one to three year time horizons is a very important process involving multiple inputs (as detailed above). It requires detailed knowledge of fire history in the landscape, vegetation type distribution and its current condition (both fuel and ecological health condition), and how well represented the vegetation type and growth stage/condition class is in the broader landscape.

It also requires knowledge gathered through prior burning experience about which vegetation types will burn under certain conditions, how fires spread, behave and persist in the local landscape, and how man-made and natural features in the landscape can be used to contain fire spread to a target area.

Therefore the two most important ingredients in considering these tactical issues are local knowledge of the landscape features, vegetation types and seasonal weather and drying/wetting patterns; and detailed fire behaviour understanding and knowledge of how fuel attributes, weather conditions, topographic conditions and lighting patterns interact to affect fire behaviour.

Historically, agencies have tackled the tactical program planning task by bringing together groups of experienced prescribed burning practitioners with the requisite knowledge to consider the aforementioned information types, and make experience-based decisions on what is possible and will work best. This is still the way tactical planning is done by most agencies today, although advances in GIS technology over the last decade or so have facilitated considerable innovation in the map-based information and analyses able to be considered by burning program planners. Bushfire spread simulators are beginning to emerge as a useful tool available to program planners, especially for consideration of what benefits different management options may provide.[10]

Different program planning processes involve differing levels of community consultation and input. For example, in NSW, active and open community consultation processes are focussed on the strategic planning phase at the time when local Bush Fire Risk Management Plans are prepared and hence consultation at the tactical program planning stage is typically more focussed on neighbours and stakeholders with assets or values with some level of potential exposure to the prescribed burn. In Victoria, the community consultation process is given greater emphasis at the tactical program planning phase, annually at the time when Fire Operations Plans (FOP) are being developed. A period of open public consultation on each FOP is mandated. In the ACT, the five-year Strategic Bushfire Plan contains both strategic and tactical plan components, and has public consultation at the input and draft plan stages.

3.3.2 Tactical program planning tools

There have been significant advances in tactical planning tools available to prescribed burn program managers, coinciding with advances in GIS applications and improvements in ease of use for end users, improvements in the availability and quality of base level data sets particularly vegetation layers, and a commitment by agencies to provide program managers with enhanced scheduling tools to improve delivery. Typically, tactical program tools are comprised of or give consideration to the following:

[10] *DEPI used such an approach to model fire loss outcomes on different management options in the Otway ranges. See the Otway Pilot Study – Interim report titled Future Fire Management Project – Defining and Evaluating Alternative Fire Management Options to Achieve Improved Outcomes for Community Protection, Biodiversity and Ecosystem Services, by Ackland A, Salkin O, Blackett A, Fograty L and Friend G (2010).*

- Fuel management zoning maps and a register of assets at risk (ranked by risk level). Most jurisdictions at the Federal, State and Local Government areas compartmentalise areas by the fuel management intent for that area (fuels are managed to a desired hazard level). These zones generally fall into three broad categories of asset protection, strategic protection and natural/ecological/land management. These areas are generally fixed, or may move based on treatment history (such as in the ACT);
- Establishment and documentation of one to three year prescribed burning programs. This multi- year timeframe scheduling approach has its genesis in the 'order of working' prepared for forestry operations, where fixed compartments are identified and scheduled for harvesting over an extended period (up to a decade). As post-logging burning has historically been linked with timber harvesting operations (for regeneration or disposal of heavy fuels) it is inevitable that long term scheduling has been migrated as accepted practice for burn program managers, including conservation agencies;
- Vegetation and fire history maps with tolerable fire regime analysis. Significant improvements have been made in assembling digital State vegetation layers and it is expected greater interoperability will be possible between jurisdictions through National projects such as the national fuels classification system project being completed for FFMG/AFAC by CSIRO;
- Projected fuel loads for future timeframes if no planned or unplanned fires occur, based on fuel accumulation curves calibrated to local conditions;
- Fire history maps with fire trail and natural containment features and 'burnable vegetation type' analysis;
- Analysis of which fuel management zones will reach their upper fuel load/hazard level thresholds in the planning period; and
- Computerised fire spread simulator outputs showing how a fire will spread under input scenario conditions and the consequential losses (such as house losses), and the residual risk after treatment is applied.

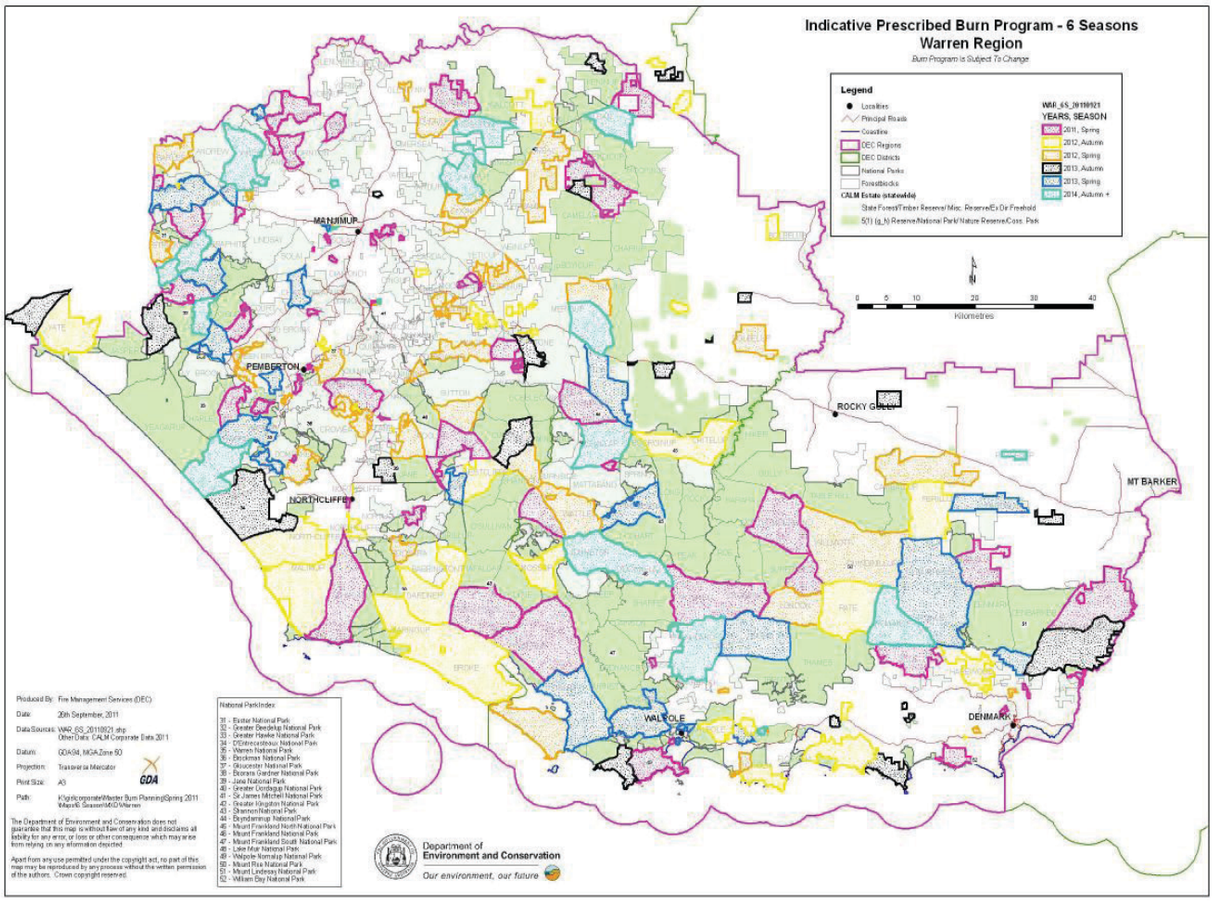
3.3.3 Tactical Program Planning - agency examples and innovative practice

Examples of works programs extending over a three year period include Victoria (DEPI's Fire Operations Plans) and WA (DPaW's Master Burn Plan). These plans are reviewed annually in the case of DEPI, and six-monthly in the case of DPaW.

DPaW Master Burn Plan

DPaW's master burn plans are derived from a spatial database so they can be prepared at State, Regional or district geographic scales. They can also be prepared at different time scales, from three years ahead down to just the next seasons program. Thus differently scaled (in time and area) map-based outputs can be produced to support planning and public notification/consultation processes. In contrast to the DEPI Fire Operations Plans where the opportunity for the public to provide comment on a burn proposal at each year of a three year listing, DPaW's master burn plan has a more focussed pubic consultation phase, where public feedback is sought at the time of a logical bun unit blocks initial listing (three years out from burning delivery). After this time, in the two years up to burning delivery, consultation is targeted to stakeholders that may be directly impacted by the activity.

Figure 5 DPaW Master Burn Plan



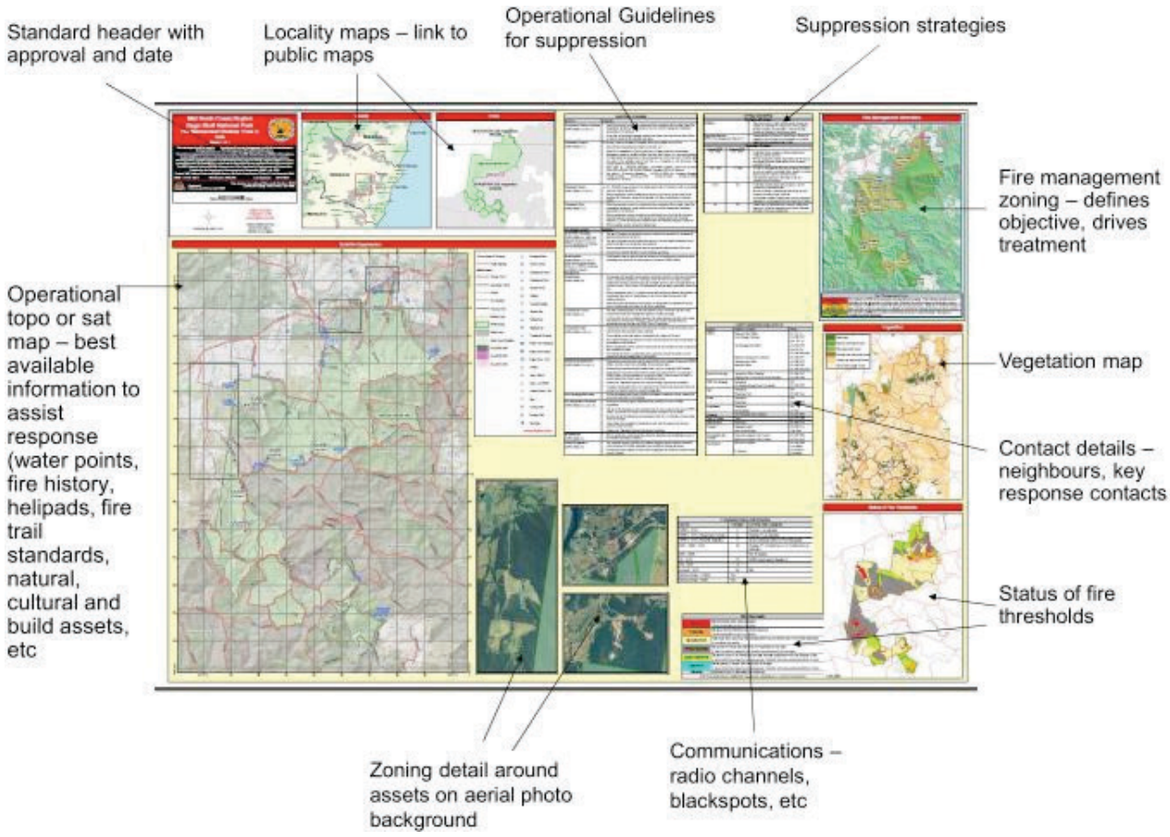
Map Based Tactical Fire Management Plans – NSW National Parks and Wildlife Service (NPWS)

NPWS has been implementing a map based approach for tactical fire management planning for National Parks, Nature Reserves and other areas under its care for more than a decade. These 'strategies' seek to provide a practical and user-friendly tactical plan to convey the fire management intent for a specific reserve to its staff, stakeholders and the community. Information presented includes bushfire prevention, preparedness, awareness and response actions (Figure 6). Recognising the value and utility of this template has seen it used and adapted by a range of land managers including the Department of Defence (applied across more than two million hectares), NSW Sport and Recreation and local government (Moreton Bay Regional Council, Gold Coast City Council,

Sunshine Coast Regional Council, Great Lakes Council). In adapting the template other agencies have incorporated a mitigation works schedule identifying mitigation actions, timing and responsibilities over a five year period.

In South Australia, this has been taken one step further by providing a 'live' on-line 'Fire Management Maps'[11] tool that presents fire management planning information, including prescribed burning intent over the coming 12-18 months. The advantage of this system is that allows the community to zoom in on areas of most interest to them, usually the proximity of burn proposals to their residence or assets.

Figure 6 NPWS Fire Management Strategy (Tactical Plan)



[11] http://www.envapps.sa.gov.au/firemaps/

3.4 Assessment of Environmental Values

During a prescribed burning activity fire is deliberately lit to burn through one or more vegetation communities – the source of the fuel to be burnt. The structure of some vegetation communities (e.g. open dry forests and woodlands) is such that prescribed fire can spread as a low intensity surface fire consuming mostly fine fuels including leaf litter, fallen twigs and bark, grass, dead or cured understorey plant components, and some live plants depending on their combustibility and the intensity of the burn. Some patches of higher intensity fire may occur during a burn due to heavy fuel patches, and slope, aspect, or wind effects. In some other vegetation types (e.g. heaths, shrublands and grasslands) prescribed fire combustion can occur through the full depth of the vegetation structure, including combustion of the live canopy.

In both cases, heat from the fire can impact plants and fauna that cannot relocate out of the path of the fire. Some fire-sensitive species (vulnerable to even low intensity fire), or individuals in vulnerable life-stages may be killed by the burn. However, many plant species impacted by the fire are not killed – for many species immediate impacts are negligible, for others they may be reduced in height or cover but remain alive and capable of recovery, whilst others may be in a dormant state (or suppressed by competition from other plants) and their germination or growth is promoted by the impact of the fire. Where threatened flora species are present in a burn area, and these are vulnerable to being killed by fire of the intensity prescribed, some mortality or adverse impact may be unavoidable, although loss of some individual specimens may not significantly impact populations in every case. For fauna species which cannot take timely avoiding action, or are critically dependant on the pre-burn vegetation condition, or are in a vulnerable life-cycle stage, adverse fire impacts on exposed individuals may be unavoidable. The extent to which the mortality of a few individuals will have any significant impact on populations at landscape scale will depend on a range of population dynamics factors.

For these reasons, fire and land management agencies undertake assessment of how proposed prescribed burning activities will impact the environment. Assessment typically considers not just the impact of the planned burn, but its impact in the context of previous fires (planned and unplanned) so that important fire frequency factors are taken into consideration. Also, the impact of the prescribed burn on future fire occurrence needs to be considered, in particular whether the burn will have a negligible effect on future fire frequency and extent (and is therefore additive to fire load) or whether the burn, as part of a program, is projected to decrease the occurrence and extent of wildfires to the point that the total fire load (planned and unplanned) will be reduced. Seasonal effects and intensity effects also need to be considered. Environmental assessment typically is not restricted to flora and fauna impacts, but also includes any potential effects on other environmental values such as soils and water, and cultural heritage.

Statutory frameworks regulating the scope and form of, and triggers for assessments differ between jurisdictions. Historically, assessment practices have been scoped to the burn site, and the potential for impact on individual species. Further, the consequences of not undertaking the activity, such as subsequent impact by a higher intensity fire burning in more severe conditions have not been considered – this has been a gap because in many Australian vegetation types, fire occurrence is inevitable. Increasingly however, impact assessments are being considered in their broader landscape context, and in terms of their impact on ecological health, diversity and resilience. EIA processes in some jurisdictions are still in transition from site-specific to more landscape oriented approaches.

3.4.1 Drivers and general approach

Since European settlement in the south of the continent, fire regimes have altered dramatically. While Aboriginal people previously used fire across extensive parts of the landscape, and lightning fires burnt without restriction by suppression intervention, the 'fire management' landscape has now changed markedly. Settlement patterns, cessation of Aboriginal burning practices, native vegetation clearing and fragmentation for agriculture and urbanisation, and application of modern agricultural practices across large landscape areas, have together dramatically changed the landscape and how fires occur and spread within it. Further, aggressive action is routinely taken to suppress wildfires, as required by law in most jurisdictions, and as considered prudent given the potential for legal actions and reputation impacts if such action is not taken and fire causes damage. Where contemporary fire response arrangements are in place, a very small proportion of fires, including lightning fires, ever get much larger than a few hectares. A very small proportion of such fires escape control efforts and become large very high intensity fires (this mostly happens in adverse weather conditions).

The success of fire suppression efforts over recent decades across southern Australia has led to significant spatial and temporal changes in terms of how fire impacts the landscape, so that there are now numerous very small fires (successfully suppressed in low to high fire danger conditions), relatively few mid-size fires, and episodic occurrences of large, intense, uncontrollable bushfires (including some fires referred to as mega-fires).[12] A predominantly high intensity fire cycle (of variable frequency) has become established in many areas, whereby following a large high intensity fire, vegetation regenerates and fuels begin a process of accumulation, fire suppression efforts minimise the extent to which small, low to moderate intensity fires can create low fuel patches in the landscape, hence fuel loads build to high levels across a high proportion of the landscape, and eventually a fire starts in adverse conditions in high fuels, cannot be successfully suppressed, and runs in extreme conditions through high fuel loads as a large area high-impact fire and the cycle starts again. In some vegetation types this cycle may not be at odds to historical cycles (e.g. tall wet eucalypt forests), although the cycle may now be shorter than historically, and events may occur across larger areas. However in many vegetation types, particularly grass dominated eucalypt woodlands and dry open forests, the substantial reduction in low to moderate intensity fires in between fires occurring in severe conditions (such as those fires each year which arose from lightning and Aboriginal fire use) is at odds with historical cycles, with adverse consequences for both communities and ecosystems.

[12] *Australia is not alone – similar trends are well documented in north America.*

The large uncontrollable forest fires typically occur in drought affected seasons (or in semi-arid landscapes following seasons of prolific vegetation growth) on days of Very High to Catastrophic Fire Danger, when fire suppression efforts fail. Often the result is growth stage/age class homogenisation of extensive areas of the landscape from a habitat perspective, and the loss of property and sometimes human life. While large individual fires can have disastrous consequences upon the local/regional persistence of some species, it is important not to limit consideration to the effect of a single fire event at a single point in time, but also to consider the effect of the fire as one of a sequence of fires, and what impacts the recurrence intervals may have had (the frequency effects of the fire regime).

The importance of fire as a landscape disturbance factor influencing biodiversity has been recognised through listing inappropriate fire regimes as a key threatening process in various State legislation pertaining to biodiversity conservation , and more recently by the nomination of 'Fire regimes that cause biodiversity decline' as a key threatening process under the federal Environment Protection and Biodiversity Conservation Act 1999. While fire and its effects are a natural disturbance essential for the maintenance and regeneration/germination of many species in almost all southern Australian ecosystems, particular fire regimes can be inappropriate and act as a threatening process when fire is either too frequent or infrequent, is unnaturally excluded from an area, occurs unseasonally or at inappropriate intensities that may interrupt species' life cycles.

Paradoxically, fire as an agent of 'disturbance' is, in effect, a stabilising influence in many ecosystems, with recurrent fire required to stabilise an ecosystem in a particular state, and without which, succession to a different state may be triggered. For example, some grassy woodlands are maintained as grassy woodlands by recurrent short-interval low intensity fire, however if the historic fire interval is significantly lengthened, grassy understorey components may transition to shrubby understorey, the intensity of the next fire event can be substantially higher than the historical fire regime causing mortality or damage to canopy species, and prolific regeneration of shrub species. If a cycle of less frequent, higher intensity fires becomes established this can lead to replacement of the short-interval fire adapted grassy woodland with longer interval fire adapted scrub. In some sub-tropical (and tropical) grassy woodlands, removal of the stabilising short-interval fire regime can promote rainforest invasion, with conversion of grassy woodland to rainforest with continuing fire exclusion. In these examples, recurrent low intensity fire is a stabilising factor, and disruption of the prevalent regime can be considered a 'disturbance'.

Therefore, it is vital that the strategic, tactical and operational planning phases consider the ecological implications of both prescribed burning and fire suppression in the landscape.

Jurisdictions in southern Australia are heeding this imperative and have developed a number of documents (policies, guidelines, manuals) that aim to assist land managers and practitioners to address the ecological implications of burns and thus implement ecologically appropriate fire regimes. Some examples include the following:

- *Fire Policy and Procedure Manual 2011 (DENR 2011)* – South Australia;
- *Planned Burning in Tasmania: Operational guidelines and review of current knowledge (Marsden - Smedley 2009)* – Tasmania;
- *Developing an Ecological Fire Strategy – A Practitioner's Manual (FEWG 2003)* – Victoria;
- *Guidelines and Procedures for Ecological Burning On Public Land in Victoria (FEWG 2004)* – Victoria; and
- *Master Burn Planning Manual 2011 (DEC 2011)* – Western Australia.

Land management and prescribed burning objectives

Prior to considering ecological impacts (both positive and negative) of prescribed burning, either at the tactical program or operational level, it is important to understand the land management objectives, which can vary considerably based on land tenure and use. For instance, the primary objective of water authorities is to manage catchments for sustainable water yields, while maintenance of biodiversity is generally an important, but secondary objective. The Department of Defence is one of the largest landholders in Australia, with a focus on asset protection, sometimes using vegetation as a buffer between assets and residential areas; in such circumstances, fire management for ecological purposes is usually only a secondary or incidental benefit. Conversely, large areas of public land, such as National Parks, State Parks and Conservation Reserves, are managed primarily for ecological purposes.

Associated with land management objectives are the objectives at the operational burn planning stage or for individual burns. Some of the main reasons for conducting ecological burns in southern Australia include the following:

- Reducing the impact of severe bushfires, by increasing fire history patchiness across the landscape, or establishing 'blocker burns' (e.g. DEC 2011);
- Enhancing resilience of ecological communities (e.g. McCarthy 2011);
- Managing an appropriate seral stage diversity (or negative exponential curve) of broad vegetation types;
- Managing threatened species (flora, fauna) populations;
- Maintaining or increasing ecosystem heterogeneity and biodiversity values;

- Managing environmental weed invasions, particularly at the urban interface; and
- Managing shrub invasion into grasslands/heathlands, and the resultant changes to fuel dynamics, fire intensity and fire frequency.

Many of these objectives can underpin the development of ecological risk assessment criteria. An assessment to quantify the ecological risks of a particular burn or burn program is usually undertaken; however, the process differs among jurisdictions from formal to informal, and the level of assessment at the tactical versus operational level.

The level and rigour of environmental assessment at the tactical and operational phase differs in thoroughness between jurisdictions, owing to the quality and quantity of available information, e.g. fire history information, scale of vegetation mapping, extent of threatened species records and the degree of knowledge regarding Key Fire Response Species.

Structuring tolerable fire regimes around Key Fire Response Species

In the south-eastern states, a widely adopted approach has been the use of 'vital attributes' analyses of flora species (including, inter-alia, the method and timeframes for recovery following fire and characteristics of seed dispersal) for the purpose of identifying Key Fire Response Species (KFRS) for particular vegetation groups. KFRS are those species most sensitive to fire within an ecological community. The recovery requirements of KFRS are then used to set a 'tolerable fire interval' to ensure these species, along with the less sensitive species, can repopulate the area. Desired fire regimes are typically expressed in terms of minimum and maximum tolerable time-since-fire thresholds for burning a particular vegetation type.[13]

The method has been criticised in number of quarters as overly conservative and fire-sensitive species centric (Jurskis and Underwood 2007). The minimum tolerable fire interval (TFI) for a vegetation type is usually dependent on the obligate seeding species possessing the longest time to reach reproductive maturity, while the maximum tolerable fire interval is usually dependent on the species that takes the shortest time to senesce and be locally eliminated from the seed bank. The method does not take into account the consequence of interspecific competition processes associated with the fire-sensitive species centred regime – these can be significant for species that are out-competed for space and light resources and which rely on recurrent fire for resource access. Where vegetation groups or divisions are broad (many divisions contain a significant number of vegetation classes or types), and the key fire response of the most fire-sensitive species of the most sensitive vegetation communities within a broader vegetation category are used, unintended and undesirable consequences can arise if minimum TFIs are applied to the more fire- tolerant vegetation classes within the vegetation division.

[13] *For examples see Cheal D (2010) Growth stages and tolerable fire intervals for Victoria's native vegetation data sets. Fire and Adaptive Management Report No. 84; or Kenny B, Sutherland E, Tasker E and Bradstock R (2004) NSW Biodiversity Project Report - Guidelines for Ecologically Sustainable Fire Management.*

Further, by inference, fire intervals outside the maximum and minimum thresholds are intolerable. The intolerance is based on assumptions that mortality rates at each fire event in the fire regime are high, and apply uniformly across a fire-treated area. In practice, low intensity prescribed burns are generally patchy, with the degree of patchiness often increasing as fire frequency is increased. Obligate seeders in unburnt patches are not killed. Further, depending on their fire resilience at particular life-stages, many obligate seeders in burnt patches are not always killed by the passage of low intensity fire – some may be of sufficient height and/or bark thickness to survive the low intensity fire. Some recent studies of frequent fire effects have shown that obligate seeder species, predicted by vital attributes analysis to be vulnerable to a frequent fire regime, have not in fact declined in numbers and some increased.[14]

Also, there are a number of uncertainties, including the lack of complete vital attribute data for many species, and the lack of knowledge regarding soil-stored seed banks and their longevity. While this knowledge remains incomplete, most jurisdictions use the TFI concept as a guide only, with NSW aiming for 50% of a vegetation type to be within the TFI thresholds.

Another criticism of the vital attributes and TFI approach is that it fails to consider fauna. Steps are now being taken to remedy this knowledge gap and integrate fauna into the process of identifying KFRS, and contributing toward development of TFIs (MacHunter *et al.* 2009). However, this is usually only undertaken at the operational/individual burn planning phase, where fauna habitat requirements may be used to tweak the approach, e.g. Mallee Emu-wren in north-west Victoria, where burns are either done in autumn, or exclusion areas are established within a small part of the burn to protect critical habitat. Such approaches may be able to be undertaken in well-resourced states such as Victoria, but are unlikely to be followed in less well-resourced jurisdictions.

[14] *Studies conducted in the Eden Burn Study Area where fire treatments were applied as frequently as every two years over a ten year period showed the persistence of obligate seeders predicted to be vulnerable to elimination under such a regime. See Jurskis, Bridges and de Mar (2003) Fire Management in Australia – the lessons of 200 years. In: Proceedings of the Joint Australia and New Zealand Institute of Forestry Conference, 27 April–1 May 2003, Ministry of Agriculture and Forestry, Wellington/Queenstown, New Zealand, pp. 353–368. See also Penman TD, Binns DL, Shiels RJ, Allen RM, Kavanagh RP (2008) Changes in understorey plant species richness following logging and prescribed burning in shrubby dry sclerophyll forests of south-eastern Australia. Austral Ecology 33, 197–210.*

The pyrodiversity begets biodiversity approach

There is a growing body of evidence linking biodiversity with environmental heterogeneity and appropriate disturbance regimes (e.g. fire) at a landscape scale. As a consequence, some jurisdictions such as WA are now placing their focus on maintaining/enhancing the overall resilience of ecological communities at a landscape scale through patch mosaic burning, rather than focusing on whether individual burns will lead to the localised extinction or population decline of a particular Key Fire Response Species (KFRS). They do not base their burn cycle planning around such species, whose responses to fire are often difficult to predict. However, the notion of 'pyrodiversity begets biodiversity' has been questioned by some on the grounds that certain species need particular habitats associated with long-unburnt stands of vegetation, e.g. hollow-bearing trees, and simply burning to create a patchy environment fails to meet the habitat requirements of all species (Clarke 2008). Some agencies have also expressed concern that while the goal of increasing fire history patchiness (and consequently habitat heterogeneity) across the landscape is beneficial to the majority of species, they are unsure about both the spatial scale of patchiness required to maintain or enhance biodiversity values.

While the focus is shifting toward using prescribed burns to mitigate against the impacts of large landscape scale fire, and concurrently increasing/maintaining ecosystem resilience, there is conjecture surrounding how resilience is defined and measured.[15] Until this issue can be resolved within the scientific community it will be difficult to ascertain whether agencies are meeting program objectives relating to ecosystem resilience. In the meantime, agencies are following a 'learning by doing' approach to varying degrees, whereby learning from burn planning, implementation and monitoring, is fed back into an adaptive management framework.

Emerging issues

In an increasingly regulated environment, some burns are now being referred to the federal Environment Minister for a determination as to whether they constitute a 'controlled action' under the Environment Protection and Biodiversity Conservation Act 1999. Controlled actions usually occur where there is a real possibility that a proposed action may lead to a significant impact upon a federally-listed threatened species or community. So far, Victoria and NSW have never referred any prescribed burns to the Commonwealth, while South Australia has referred some burns, and is currently in the process of seeking approval for a strategic plan to be approved by the federal Department of Environment.

Climate change is also being considered in the context of potential changes to fire regimes, and numerous research projects are underway to determine effects of climate change on biodiversity. However, it was noted during the workshops that detectable changes are only likely to occur over a 50-100 year time frame, while the political and planning cycle is approximately 3-5 years. Therefore, the general conclusion was that while climate change needs to be acknowledged as a factor to be considered, it is more likely to be taken into consideration at the strategic planning level, as opposed to the tactical or operational burn planning level.

[15] *For a recent review and discussion of resilience concepts see McCarthy M (2011) Review of resilience concepts and their measurement for fire management. Fire and Adaptive Management Report No. 90. Department of Sustainability and Environment, Melbourne*

Monitoring

Pre- and post-burn ecological monitoring is considered a vital component of the planned burning process; however, the extent and detail of monitoring, evaluation, reporting and improvement (MERI) frameworks differ substantially among jurisdictions. While some jurisdictions have formal monitoring and adaptive management methods[16] or programs established, there appears to be no formal monitoring procedure or requirement in some other states, which means that performance against burn objectives is difficult to ascertain. In NSW, monitoring is largely ad hoc in nature; however, a monitoring program is currently being developed. At Forests NSW, most monitoring is associated with compliance, rather than achieving burn objectives. A common theme across many jurisdictions is that there are often many objectives for individual burns, including ecological objectives, but the only objective routinely recorded and reported is the burn extent. Another major issue to focus on in the near future is determining a method to measure ecosystem resilience.

3.4.2 Agency examples and innovative practice

Prescribed fire use to promote biodiversity and landscape fire resilience

The Department of Parks and Wildlife in WA (DPaW) plans the application of prescribed fire to achieve biodiversity conservation. In doing so, many of the outcomes required for wildfire risk mitigation are achieved as a collateral outcome. Where these outcomes cannot be achieved as collateral outcomes, specific, targeted operations are undertaken to satisfy this requirement. The WA approach is set out in their Master Burn Planning Manual.

Under the DPaW approach, the south-west of the State is divided into 26 landscape conservation units (LCUs). Each LCU is a mosaic of local ecosystems and landforms repeated in a similar form across a wide area (measured in kilometres). In the south-west these are based on amalgamations of vegetation complexes. In other areas of WA, alternate vegetation/landform classifications may be used.

The fire management objective for each LCU is to maintain a spectrum of age classes for areas treated with fire across the LCU that accord with a theoretical age class distribution that is based on the vital attributes of plant species found within the LCU. Vital attributes of the flora (e.g. time to first flowering and age to senescence) are used to determine the actual shape of the idealised curve and hence the proportion of each LCU that is required in each age class. Over time, planned burning will be used to approximate the idealised curve for each LCU.

In principle, the maintenance of this fire age-class distribution model for each LCU should maintain the diversity and variability in fire regimes and thereby maintain biodiversity at the landscape level.

16 *For a Victorian example see Cawson, J. and Muir, A. (2008) Flora monitoring protocols for planned burning: a user's guide. Fire and Adaptive Management Report No. 74. Department of Sustainability and Environment, Melbourne*

The WA approach diverges from east-coast approaches at the burning unit level. Landscape Conservation Units are subdivided into Logical Burn Units (the boundaries of which will vary through time) that represent a feasible boundary of the area into which fire is to be introduced under a specific Prescribed Fire Plan. In the southwest they are usually bounded by roads and tracks that serve as functional fire boundaries. In more remote regions of the State they may be the area that is intended to be burnt over a period of years, may be quite large, but may not have a definitive boundary such as a road. This is particularly the case where open edged burning is applied within the LBU over a period of years. When determining the prescription for when and how a Logical Burn Unit (LBU) will be burnt, a fire regime based on vital attributes is devised for the most fire-prone (least sensitive) components that will provide protection to the least fire-prone (most fire sensitive) areas. In most instances the outcome sought is a fine grained, fire induced, mosaic of fire history within the LBU that facilitates a diversity of vegetation structures and therefore habitats, exhibiting a high edge density.

Streamlining environmental assessment processes for prescribed burning

Under authority of the NSW Rural Fires Act, a Bush Fire Environmental Assessment Code is established which sets out the compliance standards for hazard reduction burning (standards which previously were applied by a range of government agencies and through a range of different permits, licenses and approvals). Under the system, an authorised officer assesses an application to conduct a hazard reduction activity and may issue, free of charge, an environmental approval (Hazard Reduction Certificate). An assessment under the Bush Fire Environmental Assessment Code considers the potential impact of a hazard reduction activity on the following environmental factors:

- Threatened species;
- Native vegetation;
- Soil erosion;
- Riparian vegetation;
- Waterbodies; and
- Aboriginal and non-indigenous heritage.

This 'one-stop-shop' approach to environmental assessment for prescribed burning is particularly beneficial for facilitating burning on private lands, where many land owners or managers do not have the technical ecological knowledge to conduct an environmental assessment process. It also applies on most public land tenures, providing a more streamlined and efficient approach to environmental assessment for prescribed burning than was previously the case.

3.5 Operational planning practices

Operational planning advances prescribed burning planning from the scheduling phase (setting location, area, burn type and season) to a site specific delivery phase of defining the method, conditions, containment features, resourcing, risk factors and organisational requirements (notifications, endorsements and approvals).

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[17] format.

The quality of operational planning is one of the most critical requirements for successful and safe operations. There have been past cases where poor quality or deficient operational planning has been a significant contributing factor in adverse operational outcomes including fatalities, serious injuries and substantial property damage. 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 pieces of evidence examined in post-event investigation/inquiry processes. 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.

3.5.1 Operational planning - drivers and general approach

The desired output of the operational planning phase is a plan which documents the information needed by burn managers and crews to prepare for and undertake the planned burn activity safely, achieving the burn objectives and avoiding to the extent possible adverse social, economic or environmental impacts. 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 plan, are the steps taken to compile plan, providing a structured approach to address the range of requirements, issues and risks are foreseen, considered and planned for appropriately.

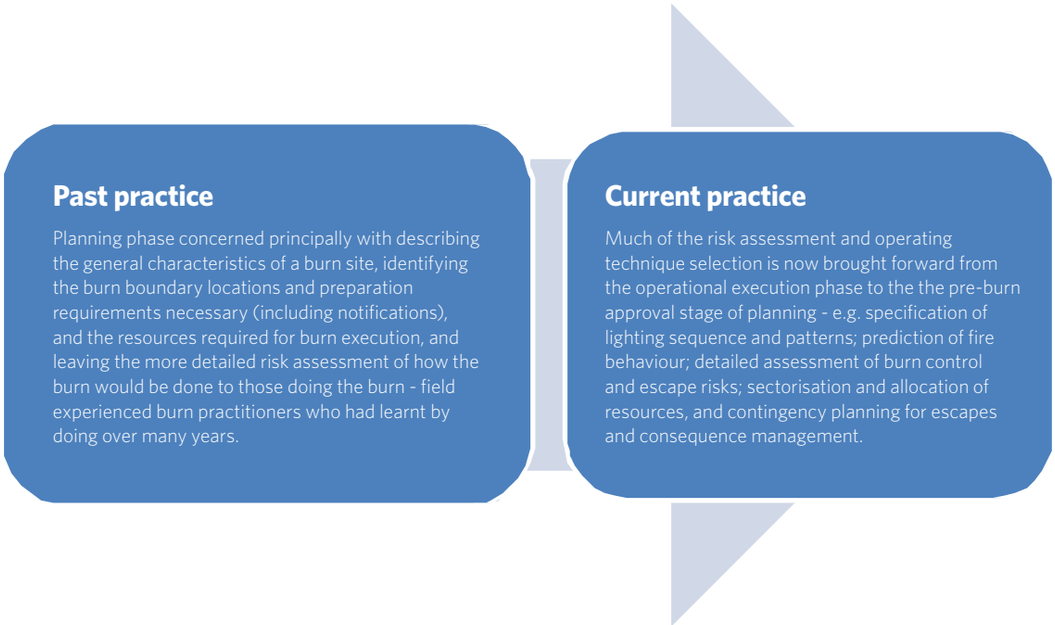
[17] *Situation, Mission, Execution, Administration, Command/Control/Coordination and Communication and Safety*

Depending on scale and site features, prescribed burning operations can be complex with considerable risks to manage. The consequences of a sub-optimally planned and executed prescribed burn can include fatalities, significant scale property loss, environmental harm, and in some cases major legal action and significant reputation damage for the agency concerned. Because prescribed burning is a deliberate action, and implementing agencies are perceived to have choice over timing, degree of preparation and resourcing levels, the public generally have a much lower tolerance for mistakes than for actions undertaken in response to bushfires. Statutes governing fire management typically protect fire fighting agencies and individuals from liability for actions taken in good faith during bushfire control operations, however it is far less common for such protections to extend to prescribed burning. These drivers necessarily result in a high level of caution and risk control being applied to prescribed burning.

Planning practice trends

Accordingly, there has been a trend evident over the last decade or so to increase the degree of operational planning, and in particular the assessment and documentation of risks and the controls to be applied. Many long-term practitioners identify that management expectations regarding how activities are split between planning and execution phases have changed over time and in response to past incidents (Figure 7 below characterises the changes perceived):

Figure 7 Trend in changes to operational planning inclusions



Further, there has been a trend towards increased documentation of the basis of decisions – in particular, the environmental assessment processes for burn approval have become increasingly process-intensive over time.

As a result of increasing inclusions and rigour demands in the planning process, many agencies report that operational plans have become larger, more complex and cumbersome. Some agencies report that current operational plans, with all relevant inclusions, extend to in excess of 30 pages, whereas a decade or so ago, these would have been between 5 to 10 pages. Plan content has got to the point where most content is of little or no interest to the burn practitioner (it is merely hardcopy evidence of decision points earlier in the planning process). Accordingly, a number of agencies have recently been reviewing their planning approach and templates to separate out content which is required principally for recording of decision process, from content which is required to inform actions to be considered and taken by field crews in implementing burns.

Burn plan templates - typical content and coverage

The vast majority of Australian and New Zealand fire and land management agencies which undertake prescribed burning have a planning template. No two jurisdictions use the same operational planning template, and in many jurisdictions, templates are developed at the agency level. However, there are a number of common planning inclusions between jurisdictions. These typically include:

- Burn identification number; agency and management area/unit details;
- Brief description of the burn area (including area, vegetation types/condition, when last burnt, and terrain features) and fuels (using agency system for classifying and rating/quantifying fuel hazard levels);
- Purpose(s) of the burn (e.g. property protection, ecological etc.);
- Burn objectives and/or success criteria;
- Burn prescriptions (these usually cover weather and fuel moisture parameters for the burn, and may extend to desired fire behaviour parameters);
- Environmental prescriptions/conditions;
- Pre-burn preparations requiring to be undertaken;
- Burn area map showing areas to be burnt and areas from which fire is to be excluded, containment lines, identification of the high values and risks within and adjacent to the burn (to be protected), resource organisation and allocation, escape routes and safety zones, public safety control points (e.g. no public access areas, traffic management points), safety hazard locations etc;
- Risk assessment for the burn;

- Resource requirements for the burn;
- Notification requirements (e.g. neighbours, stakeholders and public);
- A lighting strategy for edge and core ignition (some plans may specify standards for these);
- Organisation and communication arrangements during the burn;
- Pre-determined suppression strategies in the event of hop-overs or escapes;
- Operations and safety briefings and checklists;
- Relevant agency endorsements and authorisations;
- Record keeping and reporting requirements; and
- Post-burn monitoring requirements.

Burn planning process

As can be seen, there are many matters to be addressed. The operational burn planning process can be lengthy, especially for more complex burns. In general, the operational planning process can be segmented into the following phases:

- **Information gathering phase** – assembling the 'desktop' and field information necessary for planning. This includes field verification of 'desktop' information;
- **Risk assessment, and work scoping/design phase** – identifying what the risks to be managed are, considering how the burn will be done and the risks managed, what preparations need to be made, what activities will be conducted leading up to and during the burn, and what process and resources are required to undertake these;
- **Preparations phase** – getting preparatory actions undertaken to the point that when seasonal weather conditions become suitable for burning, a decision to burn can be readily implemented; and
- **Readiness phase** – once the day(s) of the burn has been planned, undertaking the remaining readiness action required to implement the burn, such as notifications, and organising resource mobilisation to the burn site (resources for burning and other risk management activities such as traffic management and asset protection).

With these planning and preparedness activities undertaken, authorisations for ignition can be requested and obtained. The authorisation process may entail a risk assessment process (which takes into account the weather forecast for the period of burning and beyond) and preparatory checklists completed to satisfy those with authorisation responsibility that risks have been duly considered, appropriate preparations made and risk controls in place.

Key planning phase decision points and critical paths

The burn planning process can take many weeks or even months to complete depending on site complexity issues. There a some critical paths in the planning process which can have a significant bearing on the efficiency of the planning process.

Burn boundary confirmation and stakeholder consultation

Burns blocks identified in tactical program plans may be identified three or more years ahead of their intended burn year/season, and may have been subject to desktop planning only. Accordingly, it is necessary for nominated burn boundaries to be field-checked to identify their suitability for use as containment lines and access for ground crews, and the extent of preparatory actions required to bring boundaries up to standard for burning. If this is done too far ahead of when burning operations are scheduled, boundary track condition can significantly change (e.g. from adverse weather event impact, user impact, falling trees or regrowth on tracks). If it is left too close to when the burn is scheduled, significant work requirements may be found to be needed which could delay the burn. In some cases, proposed burn boundaries (desktop-mapped) are found to be unsuitable for burn security or not economically viable to upgrade necessitating substantial changes to the burn block design. Assets not previously known to be within the burn block can also generate burn block re-design issues. Further, stakeholder consultation activities, particularly with immediate neighbours, can throw up significant issues to be resolved. Stakeholders, who make no input at the tactical program planning stage, can sometimes raise significant issues at the operational planning stage, or add additional requirements to those raised previously.

Therefore, this phase of burn planning is a critical path for burn planning efficiency. The feasibility of the proposed burn boundaries and stakeholder consultation is best verified early in the planning process, with preparatory works initiated closer to scheduled burning season.

Burn-date scheduling and resource mobilisation

Seasonal conditions can be highly variable, with suitable burning conditions coming early or late in the designated season and in some seasons for very brief periods or not at all. In some locations, the number of days suitable for burning can be limited to just a few days a year. This may be also be constrained by community factors such as tourist events.

These factors make the process of identifying when burning 'windows of opportunity' are approaching and gearing up to take advantage of these, another critical path in the burn planning process. The two key factors are fuel moisture content in the target burning areas coming into the desired range, and the desired weather pattern and conditions coming along at the right time (i.e. not coinciding with times when burning should be avoided for

ecological or smoke impact reasons or control purposes). Tracking seasonal fuel moisture trend development, and forecasting when the necessary fuel condition will coincide with suitable weather, as far ahead as possible, is a key task for maximising efficiency.

Week/day of burn ignition authorisation

Agencies typically have in place systematic burn ignition approval processes. To allow efficient resource mobilisation to burn areas, and timely burn ignition, authorisation processes need to be efficient. Processes need to take account that due to narrow windows of opportunity occurring, requirements for multiple simultaneous burns in a management area may arise, potentially resulting in reduced capacity to respond to escape containment action in the event such arises. Therefore a flexible and nimble authorisation process which can operate across a multiple burn program will normally be required.

3.5.2 Agency examples and innovative practice

NSW Standardised Template for Prescribed Burning

In NSW all four fire authorities (NSW Rural Fire Service, Fire and Rescue NSW, NSW National Parks and Wildlife Service and Forestry Corporation NSW) use a single standardised operational burn plan template. The template is also used by other land managers involved with prescribed burning activities, such as local government. The template replaced previous approaches where each agency had developed its own template of slightly differing design and content. The template is developed in the SMEACS format, in a simple (Level 1) or more detailed (Level 2) format based on the complexity requirements of the burn.

The use of a consistent template provides for enhanced interoperability between fire authorities, particularly on cooperative burns, and using multi-agency incident management teams.

CFA complexity tool

The Victorian Country Fire Authority also assigns a complexity value to its prescribed burns, allowing it to allocate an appropriate of level of planning, approval and control based on the complexity ranking. The CFA's Standard Operating Procedure – Procedures for Conducting a Prescribed Burn or Burn Off (SOP 9.40) provides a weighted matrix to assess the complexity of a prescribed burn and then identify the pre-requisite competency requirements for burn controllers. The SOP also provides standard template(s) based on burn complexity.

Operational Prescriptions Field Guide/South Australian Burn Risk Assessment Tool (BRAT)

The Department of Environment, Water and Natural Resources has recently updated the operational prescriptions used for prescribed burning in South Australia. The guide provides users with a framework to assess fuels (customised to the major SA vegetation groups), weather and previous prescribed burns to assess if conditions are suitable for safe prescribed burning, and document these in an operations plan. The operational guidance is prepared for the following vegetation groups:

- Semi-arid mallee;
- Semi-arid mallee-heath;
- Spinifex grassland;
- Eucalypt heathy open forest and woodland;
- Native grasslands;
- Grassy eucalypt woodlands;
- Coastal mallee;
- Coastal heathland;
- Non-eucalypt woodland and heathland; and
- Woody weeds.

The guide provides users with a vegetation group description, distribution, fire behaviour characteristics for burning, recommended fire behaviour prediction model and prescriptions for a given fuel hazard class, including recommended overnight burning conditions for both bounded and unbounded burns.

The BRAT is a complementary risk assessment tool used to consider and provide consistency in the analysis of risks associated with a specific prescribed burning operation, the associated benefits and potential consequences, and predicted fire behaviour. The tool is similar to the prescribed burning risk assessment tools in use in Tasmania and Victoria. The BRAT gives consideration to the physical dimensions of the block including control lines, available fuel, weather conditions, resources, ignition strategy, assets potentially at risk, and consequences of an escape.

The outcome of this analysis is that a prescribed burn is assigned an overall hazard rating, that is used to identify requirements for burn planning, control, resourcing and approvals.

Prescribed Burning Information Systems

Some agencies have developed online internal web-based fire management systems, including functionality to plan and approve prescribed burning plans, with perhaps the most comprehensive (currently subject to a major upgrade), being the 'Burns and Works' module in DEPI's Fireweb fire management information system. Such systems assist agencies to minimise the potential for duplication or multiplication of data entry, facilitate easier and broader data access, improves reporting and tracking capability and can be used as a community consultation mechanism.

The Burns and Works module of Fireweb allows users to develop the planning inputs required for prescribed burning including definition of a treatment area, identification of sensitive assets and prescriptions, weather and fuel parameters, and notifications required. This information enables the development of an operational burning plan, map and risk assessment, all of which can be maintained in the system for approval. Once entered into Fireweb a burn is spatially referenced and the status of planning identified. Fireweb is only accessible to DEPI and Parks Victoria users and is not used across agencies in Victoria.

NSW has a multi-agency web based fire management information system, called BRIMS. This database is used to log proposed prescribed burning areas, though it does not have the same level of functionality as Fireweb's Burns and Works module.

DEPI Planned Burning tool

The DEPI Planned Burning FBAN tool is a significant development for prescribed burning delivery by identifying on a state-wide basis which blocks are likely to become suitable for prescribed burning in advance based on forecast conditions. This tool uses the gridded weather forecast data provided by the Bureau of Meteorology with MacArthur Leaflet 80 predictions, fuel moisture, and the forest fire danger meter (Mark V) to locate blocks falling within desired burn prescriptions over the coming days. Specifically for up to seven days in advance the tool provides FFDI for gridded locations, and two days before provides headfire intensity projections for a gridded location. Advance notice of favourable conditions allows mobilisation of resources from within an area to complete burns coming online, and if necessary provision of out of area resources to assist in burn delivery. This type of decision support tool is unique in Australia, and previously this analysis was completed through state-wide telephone hookup of regional burn planners based on their best estimate of burning conditions ahead, drawn from a regional non-site specific Bureau of Meteorology forecasts. The rollout of Bureau of Meteorology gridded forecast data provision across Australia, will enable the complementary roll out of this valuable decision support tool developed by DEPI.

3.6 Burning operations practices

The current prescribed burn operating environment in southern Australia has a significant level of administrative, accreditation and delivery constraints that did not exist thirty years ago, requiring elevated levels of resourcing for burn planning and delivery. At the same time as delivery constraints have increased, availability of technology to support operational decisions and practice, standards of equipment, and role-specific training requirements for personnel, have also increased.

Emerging technologies and information management systems, and a move to more long term scheduling of prescribed burning operations in perpetual blocks is enhancing efficiency, and slowly reintroducing the greater flexibility and responsiveness that existed previously, to current prescribed burning operations.

3.6.1 Burning practices - drivers and general approach

Burn supervisors and crew members need to make frequent operational decisions during a burning operation. These involve assessment of highly dynamic environmental conditions require underpinning knowledge and experience to make. Decision making includes (but is not limited to):

- Deciding whether pre-planned burning practices, risk controls and resourcing levels are appropriate to the prevailing situation and conditions on the day, and for the forecast conditions;
- Determining and amending lighting sequences and patterns;
- Devising and altering resource deployment arrangements to maintain burn crew and public safety, burn security, and to ensure burning objectives are met;
- Identifying potential escape risks and escape prevention measures and contingency plans;
- Estimating smoke behaviour and actions required to minimise smoke impacts;
- Tailoring burn containment actions to the current and forecast conditions;
- Deciding when it is safe to downscale resourcing and/or declare a burn safely contained;
- Scheduling post-burn monitoring and patrol arrangements; and
- Downscaling public safety requirements (e.g. traffic control; road closure removal; hazard warning signage).

In practice, management of these operational issues requires considerable underpinning knowledge and experience in how to respond to situations foreseen or arising. Typically decision making at the burn site will involve consideration of the following factors that may affect fire behaviour and burn security:

- Containment lines and specific areas where adjacent fuel hazards may pose risks to burn security (e.g. patches of heavy fuel; roadside windrows; long-unburnt stringybark trees; hollow trees, vegetation types in which fire behaviour can suddenly escalate; heavy fuels in gullies sloping up to containment lines);
- Fire moving between vegetation types and on different slopes and aspects;
- Diurnal fuel moisture cycles will affect fire behaviour, including variation in drying rates on different aspects;
- Changes in wind direction and/or speed during the day;
- Lighting methods, patterns and spacing across different fuel types and topographic positions;
- Under marginal conditions (such as too moist or too dry) selecting where and when to start burning operations to take advantage of diurnal fuel moisture cycles, or deciding not to burn at all;
- Conditions where fire behaviour is sub-optimal to meet burn objectives, and how to increase or decrease fire behaviour whilst maintaining burn security; and
- Fire behaviour resulting from escapes across boundaries in different locations and what suppression resources are appropriate to contain any escapes.

The tempo of operational decision making can be rapid with consideration of multiple options required in compressed time periods. Underpinning knowledge requirements are extensive, with the key knowledge fields being:

- Interpretation of field conditions and weather forecasts to predict weather influences at a burn site;
- Prediction of fire behaviour in a range of different weather conditions, terrain types, fuel type/condition combinations, and different lighting patterns;
- Smoke movement and dispersal in the atmosphere, or ponding in the landscape;
- Safety hazards associated with different vegetation types and burning operations;
- Map reading and navigation in bushland;
- Options to control and/or contain fire spread; and
- Agency requirements for management, command and control, operating practice.

To address the significant capacity issues associated with delivering prescribed burning programs, fire and land management agencies have been investing in technology improvements and competency enhancement projects to improve their ability to deliver programs.

3.6.2 Agency examples and innovative practice

Although this best practice review did not involve demonstration of field practices, agencies did identify a number of technology, decision support tool and procedural improvements they have been pursuing in recent times.

Emerging technology take-up and systems enhancements

Mapping and air navigation technology

With the rapidly increasing availability of competitively priced mobile GPS navigation devices in recent years, agencies have been fitting vehicles used by prescribed burn supervisors with GPS units, loaded up with local agency digital maps and spatial data layers. These make it easier for operational personnel locate their position, and use map formats which they are familiar and which display data relevant to prescribed burning work. DPaW WA have been trialling this technology in some SW districts.

Improved use of air navigation systems has also emerged in recent years with burning boundary limits and ignition line flight paths pre-programmed and downloaded into the aircraft GPS system to facilitate improved aerial operations efficiency (DPaW WA).

On-line forecast weather access

With rapid recent advances in smart phone and tablet computer technology, many options are now available for field operators to have continuous access to Bureau of Meteorology forecast products including MetEye, and/or agency weather data via over-the-web applications.

Advances in aerial burning machines such as Raindance II ignition system

Production of Aerial Incendiary Machines has been commercialised over the last 10 years, providing an alternative to agency customised and built units. Units such as the Raindance II are available and in wide use, not only in Australia but also overseas in South Africa and the US.

Broader use of vehicle deployed flame-throwers and aerial drip torches

Agencies are taking up use of vehicle mounted flame throwers to expedite prescribed burn ignition time and improve efficiency. ACT Parks and Conservation using a Phoenix model flame thrower mounted on the back of a Toyota Hilux tray-back utility. Other options include a range of different drip torch assemblies mounted on ATVs (quad-bikes) such as the TorchRider, Terra Torch and Green Dragon models used in the US.

Aerial drip torch designs have been improved with gel-fuelled drip torches now in use in Tasmania, Victoria and WA. These are particularly effective for achieving ignition in fuels where incendiary capsules may have low success (e.g. logging slash, scrub and some rangeland fuels).

New Generation Fire Tankers

Most fire tankers are designed for fire suppression and made-do for prescribed burning. DEPI is currently designing a new generation tanker fleet that will deliver an increase to operational efficiency, address fire fighter safety and improve user ergonomics. The units will be used for both fire suppression and prescribed burning activities.

Wiltronics fuel moisture meter (ME 2000)

This electronic fuel moisture meter has been commercially available for a number of years and is useful for determining the moisture content of forest litter samples. The units are in widespread use in southern Australia.

Hazard sticks

Use of fuel hazard sticks to determine suitability of conditions in heavy fuels. This simple and long held practice, three pine rods dried to 0% fuel moisture weight of 100 g, is used to provide an indication of when logging slash will burn but the surrounding landscape is not likely to owing to moisture differential. The sticks provides a cost effective alternative to electronic devices (in use in Tasmania).

Decision support tool improvement

QPWS (DNPRSR) Planned Burn Fire Behaviour Tables

This seven step field guide using fuel moisture, wind, fuel load, and vegetation inputs to derive likely fire behaviour to determine if the fire behaviour predicted by the guide matches your burn prescription.

Mallee Fire Behaviour Guide

This step by step field guide was developed by the CSIRO, Bushfire CRC and DEWNR SA to predict if a prescribed burn is able to self-sustain and spread in semi-arid mallee-heath woodlands.

Procedural innovations

An up-scaling and renewed vigour in prescribed burning programs has required not only the development of new technologies but also a return to some practices that may have fallen out of use, and further development of others. Examples include:

- Night burning has been reintroduced in a range of jurisdictions but with limited application;
- Summer burning mostly in sub-tropical areas, and following initial summer rains. Higher humidity can temper fire behaviour, with the higher sun position (with greater canopy penetration) and longer days extending burning periods;

- Greater application of open ended burning, particularly in mid-late Autumn as the end of the burning season approaches. Also, greater use of burning up to recently burnt areas (without the need for mineral earth containment lines at the junction of the current and previous burn); and
- Scrub rolling for heath or low shrubland types, some significant difficulties in terms of community acceptance but very effective in limiting wind driven fires in vegetation types not prone to spotting.

3.7 Monitoring and performance evaluation practices

Monitoring and evaluation is an essential component of both risk and adaptive management processes. Without structured monitoring and evaluation processes in place, prescribed burning system improvement can only be intuitive and ad hoc and lacking a robust evidence base. In the bushfire management sector, monitoring and evaluation frameworks are still emerging, and in the concept phase, although structured approaches have been applied to suppression operations for a number of years in some jurisdictions. For example, a number of agencies conduct structured After Action Review (AAR) processes for bushfire control operations, and collect a range of data typically including numbers of fires, date, origin, area, cause, duration, fuel categories burnt, and loss/damage for various commercial asset classes.

When it comes to prescribed burning, generally monitoring and review processes are less well developed and applied, than for fire suppression activities. Structured AARs are relatively rare, and post-burn data collection is typically limited to some basics such as date of burn, treatment type, ignition methods, total area treated (area encompassed by designated burn boundaries), and a subjective estimate of whether the burn met planned objectives (usually limited to consideration of the proportion of area burnt, and average fuel hazard residual remaining after treatment).

In a risk reduction context, conceptually, evaluation might consider how fuel reduction programs as a whole have reduced risk in a landscape or to particular asset classes or locations within a landscape. This type of evaluation may be conducted intuitively by fire managers in the lead up to the bushfire season (e.g. townships or high value assets that are near areas where negligible or insufficient hazard reduction has occurred [assessed intuitively] are identified as potential trouble spots for the fire season), but are not typically recorded. This is in large part due to there being a lack of readily measurable objectives for prescribed burning programs against which to evaluate performance.

With respect to ecological monitoring, it is not the norm that pre and post-burn flora and fauna surveys are conducted for burns – this would be cost-prohibitive for even the best resourced agencies. In the recent past, ecological monitoring has tended to be done on a 'research project' basis, where fire-effects research

experiments are designed to examine impacts in a few selected sites (typically representing only a very small proportion of the total area burn annually). Even then, such experiments are typically conducted at artificially small scales (not scales at which operational practices take place). This is due to the very high sampling efforts (and therefore costs) that can be associated with sampling over the broad areas operational prescribed burning is conducted across.

3.7.1 Drivers and general approach

To evaluate the performance of a program essentially requires assessment of program results against objectives. For prescribed burning, objectives can be devised at a range of levels. In monitoring and evaluation framework parlance (e.g. Program Logic), these levels are typically categorised into:

- Long-term outcomes level objectives;
- Intermediate outcomes level objectives;
- Immediate outcomes level objectives; and
- Program activities.

Conceptually, an evaluation framework structured according to these categories for prescribed burning might look like:

Long-term program outcomes	Evaluation issues
➢ Reduce* loss of human life ➢ Reduce* property and business loss/damage ➢ Reduce* natural resource and environmental values loss/damage/ degradation *against an historical benchmark level	• Detecting changes in loss/damage trends involves data collection over long periods of time – data collection/ analysis needs to take place over decades of program implementation to identify reliable trends; and • Any identified loss/damage trends would be influenced by other risk reduction programs including fire suppression organisation and capacity, development planning and building design, community bushfire awareness/resilience programs and others, therefore it would be problematic to identify what part prescribed burning has played in influencing the trends.

3. SOUTHERN AUSTRALIA: PRACTICE REVIEW CONTINUED

Intermediate program outcomes	Evaluation issues
➢ Bushfire risks for at-risk values are reduced ➢ Extent and severity of wildfires is reduced ➢ Safety and effectiveness of suppression is improved ➢ Ecosystem health and resilience is improved	Requires: • Comparative assessment of risk, with and without the prescribed burning program, which requires a consistent methodology for risk assessment; • Benchmark data for wildfire extent and severity against which to assess trends over time as programs are progressively implemented and maintained; • Consistent data on how fuel reduced areas have influenced suppression effectiveness and safety; and • Definition of healthy and resilient ecosystems.

Immediate program outcomes	Evaluation issues
➢ Works program planned aligns with strategic goals ➢ Works program is implemented effectively (annual targets met and to appropriate quality standards) ➢ Capacity requirements for implementing works program are sustained	Having in place clear: • Strategic goals; • Measurable program output specifications; and • Measurable program capacity requirement specifications

Program activities	Evaluation issues
➢ Individual work activity components of an annual or seasonal work program are planned ➢ Individual work activity components of an annual or seasonal program are implemented successfully (on time, to work specification, to budget) ➢ Work type specifications are in place and current ➢ Work components of capacity maintenance programs are implemented	Having in place clear measurable: • Work objectives/specifications for each activity type; and • Program capacity requirement specifications.

Long-term (end) outcomes evaluation

At the workshops it was identified that agencies have not historically been able to conduct evaluation at the long-term outcomes scale due to a range of factors, including that consistent programs have not been in place long enough to identify trends, and the outcomes being more relevant to holistic fire management programs than prescribed burning components alone. Of significant interest however, is DEPI's Future Fire Management project, which is using fire simulation and scenario-based outcomes modelling to estimate end-outcome effects of proposed programs – particularly for modelling property and environmental impact differentials between present and proposed states. This approach has significant merit for other jurisdictions but requires substantial spatial data and model assumption/business rule development work to undertake such analysis.

Intermediate outcomes evaluation

Some work has been undertaken evaluating how prescribed burning programs have effected wildfire extent and severity over time. Work undertaken in WA, pursuant to a Bushfire CRC project by Boer at al. (2009) undertook a form of prescribed burning program intermediate outcomes evaluation. Further, recent greenhouse gas emissions reduction programs (e.g. West Arnhem Land Fire Abatement project) in the NT rely on assessment of avoided emissions from fire management practices applied. This involves assessment using remotely sensed fire scar data of area burnt trends over time to determine how prescribed burning is reducing overall area burnt (combined prescribed and wildfire).

Immediate outcomes and program activity monitoring and evaluation

Most monitoring and evaluation effort applied to prescribed burning programs is at the level of identifying whether planned activities are being conducted, and the extent to which annual works programs are being implemented.

In some jurisdictions, annual State-wide area targets may be set for prescribed burning (e.g. In south- west WA an annual target of 200,000 ha on public lands has been in place for many years; more recently Victoria has adopted a target of 395,000 hectares and is in a transition phase to reaching this target). Typically, a State target may be broken down into management area targets (e.g. region/district) with these not necessarily aligned with risk. Evaluation of program activities is on the basis of assessing works achieved against targets (at State and Regional/sub-Regional level). Such approaches are often challenged as not being on a sound consideration of risk.

In NSW, no State or Regional area burnt targets are formalised or set. A fuel management zoning system is implemented with zoning arrangements/patterns being documented in local Bushfire Risk Management Plans (at local Government or clusters of Local Government scale). Fuel load (or hazard score) thresholds are set for specified zones. Vegetation type and local fuel accumulation rates need to be analysed to determine what treatment cycles will be necessary to maintain fuel management objectives in each zone. Such analysis is not commonly undertaken in the plans, and therefore there is negligible transparency of what treatment cycles and annualised treatment areas are needed in the planning area to effectively implement the plan.

The NSW planning approach is an asset-centred approach in that prescribed burning effort is focussed to relatively small areas at the urban-bushland interface, immediately adjacent to assets in what are called Asset Protection Zones. While burning works in the broader landscape are also planned and conducted, these are driven by tolerable fire interval requirements of Key Fire Response Species. In practice, burning intervals applied in the broader landscape tend to be closer to maximum TFIs than minimum TFI's resulting in relatively low volumes of burning being undertaken. This approach attracts criticism from a number of quarters because it is perceived not to address issues of how to reduce bushfire extent and severity in the landscape. As currently applied in NSW, prescribed burning is undertaken on around 1 to 1.5% of public land annually, which is not considered sufficient to have any significant impact on wildfire occurrence or extent, although may be effective in reducing house losses (Price and Bradstock 2011; Gibbons *et al.* 2012).

The development of a national framework of performance indicators which includes coverage of prescribed burning is a work-in-progress being undertaken by AFAC and FFMG working groups at the present time. The outcomes of this work will have a strong influence on what monitoring and evaluation framework can be established for prescribed burning.

3.7.2 Agency examples and innovative practice

Monitoring

DEPI's Monitoring Programs

Since 2006 DEPI has invested in developing fire and biodiversity monitoring protocols and collecting monitoring data. The number of sites involved is extensive and continues to grow. The objective of these monitoring programs has been to increase understanding of the landscape scale effects of bushfire management so that refinements can be made to the way bushfire is managed to protect life, property and the environment. The monitoring has been delivered through the following major programs:

- Pre and post fire flora monitoring (since 2006) – monitoring the effects of planned burning on flora species to improve predictions about their response to fire;
- Landscape fire and environmental monitoring (since 2009) – monitoring the effects of planned burning on flora, fauna, habitat, fuel hazard and fire severity to better quantify the outcomes of landscape mosaic burning;
- Hawkeye (since 2010) – monitoring and modelling the long-term effects of planned burning and bushfires on biodiversity on public land in Victoria;
- Planned Burn Severity Mapping (since 2007) – trial and development of methods for mapping planned burn extent and severity.

DEPI has identified that a more efficient and effective approach to monitoring, evaluation and reporting is required that is better aligned to policy drivers and operational needs. A draft Monitoring, Evaluation and Reporting (MER) Framework for bushfire management on public land is being rolled out as part of a risk-based approach to bushfire management. The current monitoring approaches are also being reviewed and realigned to meet the priorities identified in the MER framework.

Examples of long term ecological research and monitoring projects:

Bauple State Forest, Queensland - long term fire monitoring plots - Located in Bauple, a State Forest, north of Gympie Queensland, this project was set up in the 1950's with the majority of experiments starting from the 1970's, with regular burning to evaluate the impact on silvicultural practices, which evolved into an ecology and fire study.

WA long term forest project (Forestcheck) – Forestcheck is an ongoing integrated monitoring program designed to provide information about trends and changes in biodiversity associated with forest activities. Forestcheck focuses on a wide range of organisms on multiple sites within the Jarrah forest. Science Division began monitoring in 2002 and now there are 48 plots monitored across 5 separate locations.

Wombat Fire Effects Study, Victoria – The Wombat State Forest is located 80km northwest of Melbourne, Victoria and was home to a multidisciplinary study. The study began in 1984 to investigate the effects of repeated low-intensity prescribed burning in mixed eucalypt foothill forest. The study includes various aspects of fauna, flora, soils, tree growth, fuel management and fire behaviour.

The Eden Study Area South Eastern NSW – The study area was established in 1986 to research the impacts of prescribed burning and timber harvesting at an operational scale. The study consisted of 18 coupes ranging in size from 8 to 56 ha with an average size of 32 ha. Each site was allocated one of six possible experimental treatments. 12 vegetation plots within each coupe were randomly located in order to record the changes in understorey vegetation over time. Measurements were taken in 1986 and then approximately every 5 years after that.

4. NORTHERN AUSTRALIA: PRACTICE REVIEW

In this section, prescribed burning practices in northern Australia are reviewed. For the purpose of this review, northern Australia is considered to be:

- Northern Territory; and
- Those parts of Western Australia and Queensland north of the tropic of Capricorn.

The reason for separating northern and southern Australia in this review is principally due to the significant differences in planning and conducting burning in tropical, monsoon-cycle dominated landscapes (many parts of which can experience very high fire frequency, often on an annual basis) in contrast with sub-tropical and temperate Australia where planning is generally conducted at longer cycles.

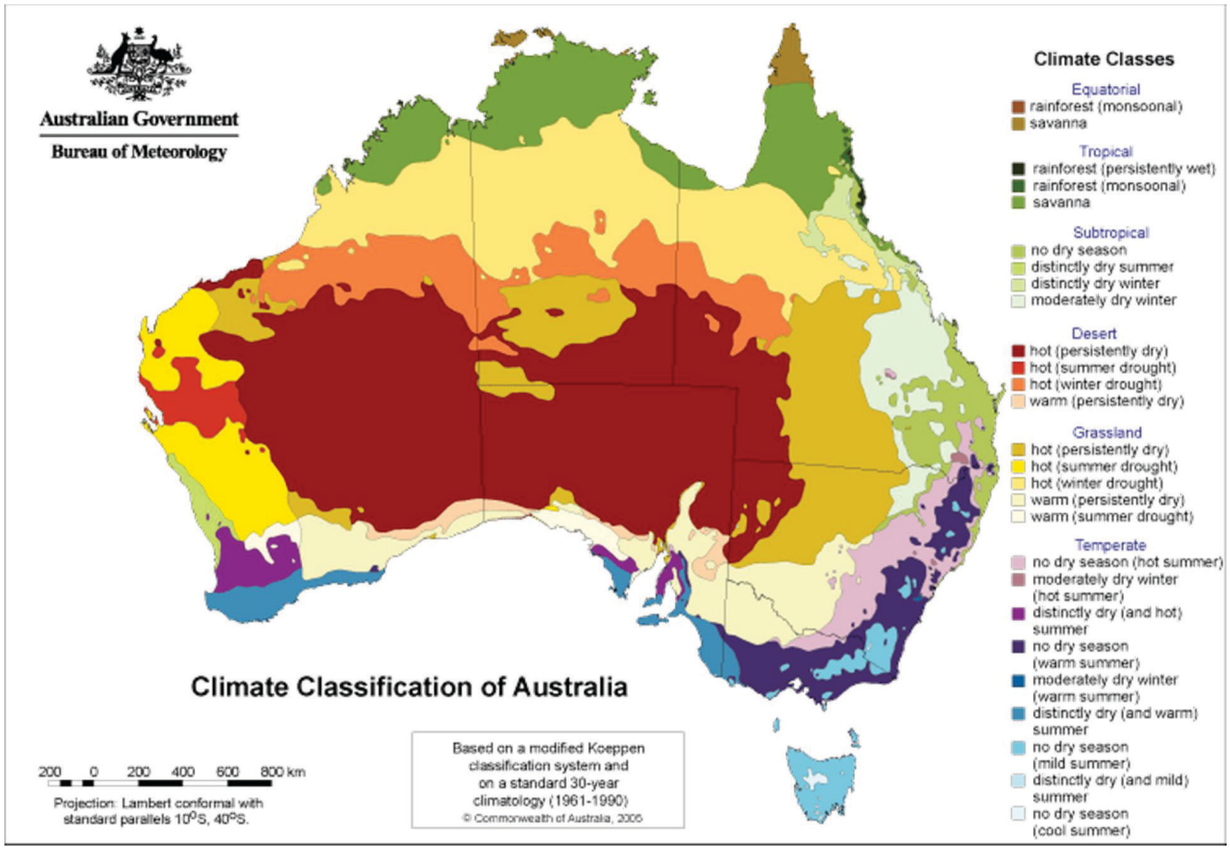
4.1 Operating context and challenges

The climate of northern Australia grades from north to south, from equatorial, tropical, sub-tropical, through to grassland and desert (see Figure 8). The influence of the monsoonal wetting and drying cycle is the strongest influence on this climate, fuel abundance and its availability for burning.

Characteristically April to October is dry (later in east Arnhem and east Cape York), with increasing humidity and clouds building up in October – November, followed by storm rains commencing in late November/early December and peaking in January. While timing varies seasonally and geographically, the early dry season is always cooler than the hotter late dry season.

In the Australian context peak fire weather in northern Australia occurs in winter and spring (late dry season) in the equatorial and tropical parts, and in spring in the sub-tropical, grassland and desert areas. Fire frequency is greatest in the northern part of this region where grass fuels build up and become available to burn annually, declining to an inter-decadal large fire cycle in semi-arid and arid regions associated with wetter conditions of strong La Niña events (such as 2010-11).

Figure 8 Köppen Climate Classification of Australia



Source: BoM (2012)[18]

The northern Australia fire operating context is characterised by:

- Where rainfall is predictable large parts of the landscape will carry fuel that is able to carry annual fires with a reasonable predictability, with fuels aged three to five years old as an aspirational goal that is rarely achieved;
- An environment where if fire is not managed effectively, it can be an annual feature in all parts of the landscape including those elements sensitive to fire (monsoon rainforest, mesophyll to notophyll vine forest, sandstone and obligate seeder vegetation communities, threatened fauna habitat features). Too frequent fire regimes, particularly intense late dry season fires, can result in the contraction of fire sensitive communities such as monsoon rainforest (Russell-Smith and Stanton 2002) and changes to vegetation structure and species composition (particularly fauna with specific feeding, roosting, nesting or habitat resources enhanced by patchy early season fires);

[18] http://www.bom.gov.au/iwk/climate_zones/map_2.shtml

- Rapid and prolific annual plant growth, particularly grasses, linked to the availability of annual wet season rains. Fuel accumulation can be rapid in vegetation types where grass species predominate, with availability increasing through the dry season as grasses cure. Bushfires are rare during the wet season and early dry season due to ground moisture and insufficient curing, although some species are able to carry fire during the wet season;
- In semi-arid and arid areas the large fire interval is much longer (decadal and inter-decadal) reducing land managers exposure and experience of large fires;
- Large areas are relatively remote, sparsely populated, with limited road infrastructure (restricted further during those areas impacted by the wet season) and fire fighting resources, with little opportunity to undertake rapid initial attack of bushfires outside the main urban centres;
- Very limited control options to suppress large late season fires, requiring fire managers to reduce late season fire likelihood through strategic fuel reduction burning in the early dry season over large areas;
- Areas not treated by prescribed burning are likely to be burnt by lightning or people in the late dry season. Untreated areas in creeklines can act as 'wicks' that in the late dry season may burn and breach strategic fuel reduced areas;
- Grass curing varies with landscape position and species, requiring fire managers to adopt a multi- stage approach to fuel management throughout the year. Curing varies with species and landscape position with upper slopes curing first followed by lowland valleys curing later;
- The wet season (and the sub-seasons within it) and the early dry season provides opportunities to apply varied burning prescriptions according to site conditions, landscape position and vegetation condition. However in parts of east-Arnhem and eastern Cape York burning may not be possible as late as August. The fire season officially commences on 1 July and fires burning after this date are officially classified as bushfires;
- In the wet-tropics and sub-tropics an absence of fire leading to vegetation changes in species composition (such as rainforest expansion), structure (including a 'shrubbing up' of the landscape at the expense of grassy woodland communities) and impacts on species requiring fire maintained grassy ecosystems (such as Golden-shouldered Parrot);
- Introduced species such as gamba grass (*Andropogon gayanus*) buffel grass (*Cenchrus ciliaris*), para grass (*Urochloa mutica*) and mission grass (*Pennisetum polyachion*) can out compete native grasses, maintain higher fuel loads, extend into areas that naturally would not have carried fire, cure later in the season and act as ladder fuels for canopy fires; and

- Complete consumption of vegetation cover can create significant impacts on soil and terrestrial carbon release. Burning of the Northern Territory savannas in 2005 contributed 4.7 million tonnes of greenhouse gas emissions (35% of annual NT emissions) with late season burning identified as a significant source of greenhouse gas emissions. Limiting late season bushfires through early dry season prescribed burning has the potential to reduce greenhouse gas emissions, as early dry season fires can have 50% of the emissions of late dry season fires (Russell-Smith *et al.* 2004).

Jurisdictions in northern Australia are operating in a constantly changing physical environment and with a well-established traditional knowledge base

The distinct wet and dry season cycle in northern Australia is naturally conducive to supporting large scale fires, burning at higher intensity over large parts of the landscape, on an annual basis in the north and less frequently moving south. However the presence of fire sensitive vegetation communities and fauna within this fire prone landscape, and the ability for Aboriginal people to live within this landscape, may suggest that historically late-season fires burning large expanses were not a common feature of the landscape. Historical and traditional owner knowledge documented in a range of sources, outside the scope of this report, indicates that fire within the landscape was carefully and artfully applied by Aboriginal people in order to manage for positive outcomes on their lands. This managed fire regime of small to medium scale continuous and purposeful mosaic burning shaped the environmental and natural values of northern Australia over thousands of years.

Changes in traditional burning regimes commenced with the arrival of European farmers and graziers and a reduction in traditional land management practices for a range of reasons. The differences between traditional fire regimes and the fire regime up until recently, are summarised by Russell-Smith (2000) as follows:

- Traditional burning that extended across northern Australia is now primarily restricted to areas of higher precipitation (Kimberley, Top End and the Gulf) and outside pastoral areas;
- Burning has shifted from generally the early-mid dry season to the late dry season burns;
- Burning has moved from a purposeful objective based application of fire to an uncontrolled regime determined by wildfire where environmental values and vegetation health can be compromised; and
- Traditional burning that created habitat and fuel heterogeneity, has been replaced by a greater frequency, higher intensity, and more extensive fires, or rarely burnt pastoral land.

Current and future approaches to fire management in northern Australia at the landscape scale are seeking to embed the principles of traditional fire management, modified to address current constraints (less people living across the landscape, built infrastructure) and taking advantage of current technologies (aerial lighting, satellite information).

4.2 Strategic and tactical planning

As for southern Australia (Section 3.2) prescribed burning in northern Australia is applied for a range of reasons and can also be grouped broadly into burning for hazard reduction, primary production, conservation and cultural heritage. The objectives of strategic and tactical planning are primarily how prescribed burning can be used to mitigate impacts on values potentially at risk (Figure 3). Strategic planning seeks to establish long term landscape level approaches, goals and objectives to achieve a risk reduction through prescribed burning. Tactical planning then seeks to identify works and activities required to implement strategic approaches, goals and objectives.

4.2.1 Strategic planning – drivers and general approach

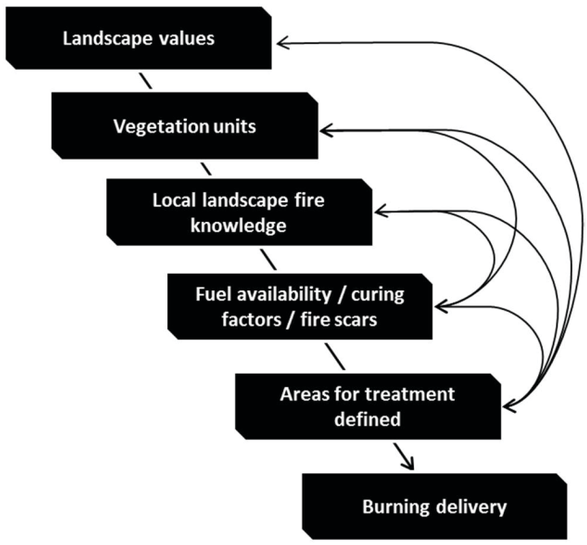
As identified in Section 3.2.1 prescribed burning is not a bushfire risk elimination strategy, and complements a range of risk reduction approaches. The risk assessment process considers how hazards, prescribed burning actions and at-risk values interact (Figure 3). The level of bushfire risk is considered as a function of the likelihood of a fire event occurring and the consequence of that fire on the at-risk values (based on their exposure and vulnerability). In northern Australia the likelihood factor for fire occurrence without mitigation actions is significantly higher than southern Australia, and in most areas would be rated as almost certain or likely. While the consequence rating, if considered in the context of life and property, would be lower than southern states for a range of factors including:

- Reduced occurrence of very high intensity fires;
- Greater community exposure to and familiarity with fire due to the large amount of fire in the landscape annually;
- Lower proportion of persons or assets at risk; and
- Greater awareness of the requirements to implement mitigation actions.

The overall objective of strategic level burning is to break up fuels within the landscape through early dry season burning, preventing annual late dry season fire runs into sensitive areas or from being able to develop into a significant size and homogenise the fuel landscape. Price *et al.* (2012) found that prescribed early season fire can reduce late dry season bushfire by a direct one to one replacement, with significant ecological and greenhouse gas emissions benefits. In semi-arid areas, while fires are also an annual feature, they will only impact broad parts of the landscape irregularly (decadal to inter-decadal) coinciding with wetter years, creating challenges for the up-scaling of resources to address landscape scale fuels prior to curing and a less predictable treatment window available.

The scale of burning requires a more flexible strategic and tactical planning approach than is applied in southern Australia. While the steps may be similar, their timing and the iterations may occur at different intervals. Determination of clearly defined treatment area may not be made until the day of the burning operation after consideration of a range of factors (Figure 9), differing from southern Australia where the 'areas for treatment defined' stage may occur as much as three years from the date of burning (Section 3.3).

Figure 9 Indicative northern Australia burning area approach



Strategic planning usually starts at the property level working outwards using an assets-at-risk approach based on a priority of life, community, cultural and environmental values, pastoral operations and then mining infrastructure. The major consideration is the consequences of fire and the recovery time to that asset rather than a straight financial estimation of value. This includes values on property and those outside the planning unit.

While 'vegetation fire frequency intervals' are used as a framework to prioritise, schedule or exclude prescribed burning in southern Australia, the frequency and reach of fire in northern Australia does not permit the fitting of such rigid intervals to discrete elements of the landscape. However consideration of sensitive landscape communities (sandstone communities, obligate seeders, rainforest) and fuel types within vegetation units is a significant strategic planning input, and agencies have prepared guides and made recommendations for different vegetation and ecosystem types.

The setting of strategic objectives is developed around the strong reliance on 'remote' tools (remote sensing) and delivery mechanisms (aerial ignition) for operational burning program delivery, and to replicate the 'on-ground' stewardship and mosaic objectives of traditional burning. The scale of burning undertaken, and limited resources available significantly limit the potential for on-ground planning and delivery actions. Limiting large late season fires is achieved through linking previously burnt areas (fire scars) as strategic fuel reduced breaks within the landscape. While local landscape fire knowledge held by traditional owners and land managers can assist in providing an indication of historical fire runs and behaviour, it must be complimented by remote sensing fire scar information to set strategic burning priorities. As such remote sensing tools, such as the North Australia Fire Information (NAFI) tool, is an essential component to set strategic objectives and use for tactical planning in northern Australia. It enables fire managers to set objectives for the:

- Protection of sensitive landscape values;
- Fire behaviour modification (though fuel modification) in specific areas; and
- Fuel mitigation treatments.

4.2.2 Strategic planning - agency tools and innovative practice

There are a range of frameworks and approaches to document strategic approaches in northern Australian jurisdictions, with some agency examples and innovative practices identified as follows:

North Australia Fire Information

The overwhelming feedback from northern Australia fire practitioners is the critical role remote sensing technologies play for program planning, delivery and monitoring, specifically the North Australian Fire Information (NAFI) website (http://www.firenorth.org.au)[19]. The NAFI website is public map based information source for:

- Identifying new and tracking current fires: Daily fire information shows 'hotspot' locations of active and recent fires, with a notification option for remote land managers of fires burning on their lands;
- Sourcing previous fire scar information to assist in planning: Fire history from 2004- present (fire location (fire scar), frequency and time since burnt) including the ability to upload fire history that may not be captured by the system (such as wet season burning);
- Maintaining situational awareness of conditions: Fire weather including lighting strikes;
- Cadastral and topographic information; and
- Monitoring and planning as part of carbon offset fire abatement projects such as the West Arnhem Land Fire Abatement (WALFA) Project.

Served over the web, its accessibility is tailored to suit a range of audience needs (Government land managers and fire services, traditional owners and rangers, pastoralists, private conservation managers and the public). The site serves thousands of maps per day during the early and late dry season indicating the critical role it plays in operational fire management. Collectively NAFI saves the jurisdictions and users which it serves, considerable savings in costs (relative to if its products were required to be sourced independently, or in its absence non satellite substitutes were required). NAFI's products are provided free on its website, equitably making information available to a broad range of potential users.

West Arnhem Land Fire Abatement (WALFA) Project

The WALFA project is an innovative approach to strategic fire management where financial credits are provided for the reduced greenhouse gas emission provided by burning in the early dry season compared to the higher emissions that would result from higher intensity late season fires. As well as the climate change mitigation benefit of the project, significant social, economic and cultural benefits have resulted for the communities on whose traditional lands the project is run.

[19] *NAFI website is complimented by similar remote sensing websites such as Landgate Firewatch [http://www.landgate.wa.gov.au/], Sentinel [http://sentinel.ga.gov.au] and Long Paddock [http://www.longpaddock.qld.gov.au/]. Underpinning base climate and weather information is sourced from the Bureau of Meteorology [http://www.bom.gov.au].*

The WALFA project provides for strategic collaboration to set landscape burning objectives involving partner communities, community ranger groups, other partners and Government representatives.

Annual tactical planning, conducted in at the start of the dry season, seeks to target areas for burning to meet strategic objectives for the coming season. Maps are prepared for target areas, identifying key firebreaks and each partners responsibilities.

DFES – Guidelines for the development of a Remote Indigenous Community Strategic Fire Management Plan (FESA 2010)

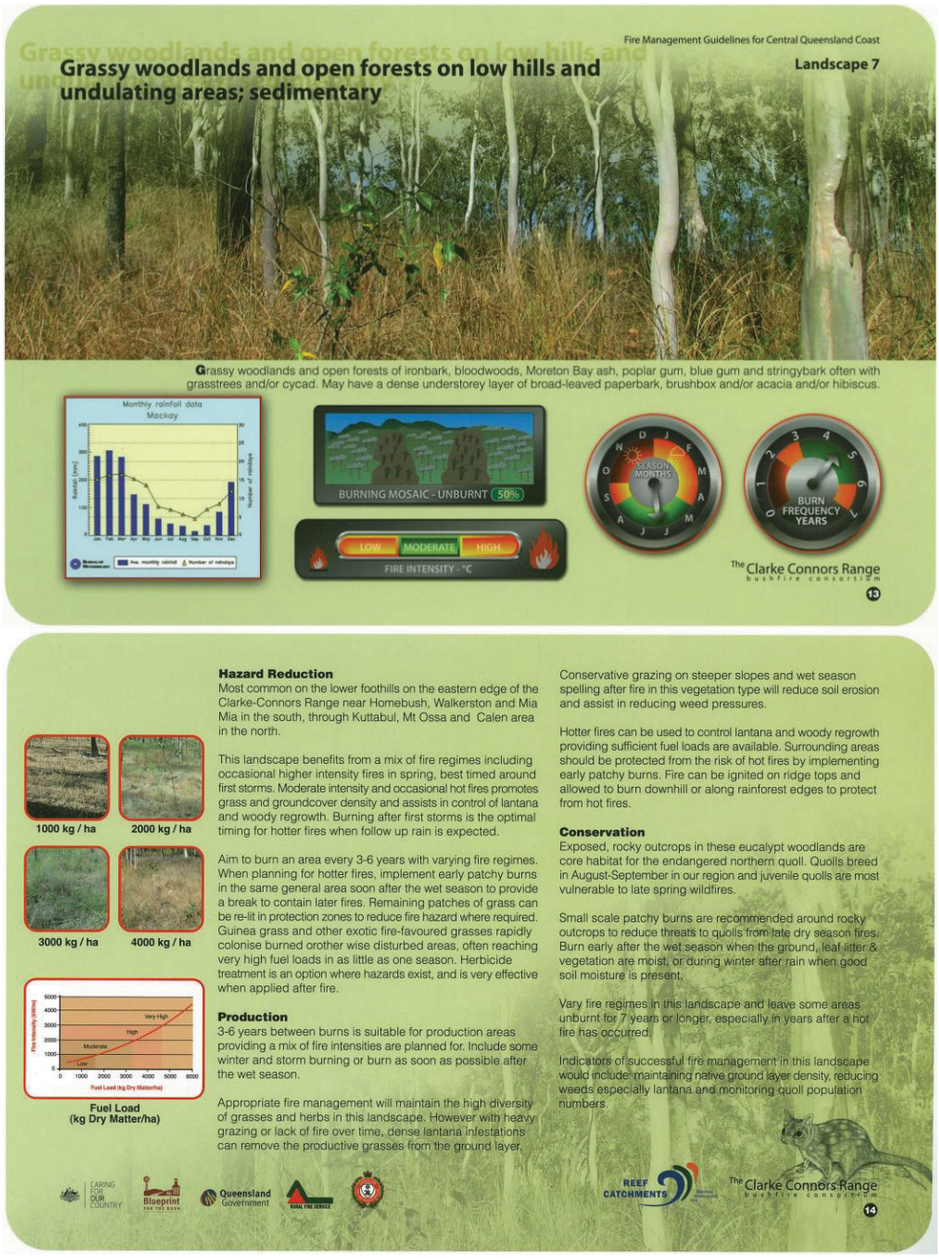
These guidelines provide a structured framework to document fire management approaches on and adjoining remote Indigenous communities. Based on a stepped approach this framework seeks to capture community fire and landscape knowledge through consultation and appraisal phases and community endorsement of the finalised draft.

Reef Catchments Fire Management Guidelines

The large areas being prescribed burnt on an annual basis requires cooperation between adjoining land managers to generate a landscape scale solution to fire management. This may require bringing together land managers and owners with their neighbours who are initially perceived as having contrasting fire management objectives to their own.

Reef Catchments is a not-for-profit natural resource management organisation that has prepared, in partnership with the QFRS and other government and non-government stakeholders, fire management guidelines that seek to provide a consistent approach for primary production and conservation objectives. Prepared as a glossy A4 ruggedized plain English document, these guidelines have proved to be a very useful tool in harmonising strategic approaches and agreeing on areas for prescribed burning across tenures. Guidelines are prepared for landscape vegetation associations (Figure 10), species of conservation significance (such as Northern Quoll) and problematic weed species (such as Lantana).

Figure 10 Regional Fire Management Guidelines – Landscape Profile Example



Regional Fire Management Plan – Pilbara

The Department of Parks and Wildlife (DPaW) has prepared regional fire plans broadly based on biogeographic regions across Western Australia, including for the Pilbara. The regional fire management plan is prepared for a five year period, and as identified in the plan, is prepared as a dynamic document to provide overarching guidance to land managers in planning and delivering operational programs.

The plan provides:

- General characterisation of the landscape and DPaW lands;
- Overarching objectives, strategies and success criteria for the region divided by funding, biodiversity, protection, knowledge and community engagement themes; and
- Specific objectives, strategies and success criteria for discrete landscapes (fire management areas) within the Pilbara, and including defined management approaches and targets for each vegetation type.

QPWS (DNPRSR) and the Northern Territory conservation agencies also prepare regional and/or reserve based fire management strategy document detailing management intent for conservation reserves and public lands under their care.

4.2.3 Tactical Planning – drivers and general approach

As identified in Section 3.2.3 tactical planning processes seek to incorporate the overarching and objectives from the strategic planning phase to identify the scale of the works program, general areas and treatment methods. However because fire frequency is so high in parts of northern Australia, tactical planning can only realistically occur once the previous fire season is complete and satellite imagery has revealed which part of the country has burnt and what has remained unburnt. Identification of a specific area to be treated is generally not possible to define beyond an annual or sub-annual timeframe.

Tactical planning also seeks to identify:

- Landscape features suitable for use as a burn boundary;
- Resources available to implement a burn program;
- Location of values incompatible with prescribed burning for which adverse impacts are likely; and
- Local community / business and tourist activity / pastoral and agricultural activity / seasonal incompatibility with burning.

The tactical planning phase in northern Australia incorporates a significant proportion of operational planning work, that in southern states would be completed during the operational planning phase. As flexibility needs to be allowed for in burn program delivery, tactical burn plans are the key documents for burn delivery and approval.

The tactical planning tools and outputs usually have a heavy emphasis on mapping to assist in plan development, review, consultation and delivery.

4.2.4 Tactical Program Planning – agency examples and innovative practice

Eco Fire

The EcoFire project is a strategic approach for tactical fire program planning across the Kimberley involving public and private conservation reserves, private and Aboriginal pastoral holdings and unallocated crown land across an area of more than 4.5 million hectares. Managed through a multiple partner steering committee coordinated by the Australian Wildlife Conservancy the program seeks to shift burning from a regime of late dry season fire to early dry season prescribed fire. While cross tenure objectives and targets are presented in an annual Regional Burn Plan, the program seeks to maintain flexibility to:

- Take into account variability in fuel availability for 'safe' burning;
- Allow for multiple passes where necessary to establish a fire break; and
- Adjust planning to take advantage of a change in conditions or personnel and equipment availability.

Synchronising the annual burning program under the Eco Fire partnership has resulted in an expansion of early season burning, a reduction in late season burning extent and impacts on sensitive assets and greater efficiency through shared resourcing in burn program delivery.

Kakadu National Park Arnhem Land Plateau Fire Plan

The plan sets the overarching approach for fire management and monitoring within the Kakadu National Park, using principles of traditional fire management, to maintain and enhance the parks natural and cultural values. A specific driver of the plans development was to reduce the impacts to fire sensitive communities on the Arnhem Land Plateau, and provide the framework for the delivery of the stone country burning program. The endemic flora and fauna of this area is of international significance, and recognised in its World Heritage Listing.

The plan provides the framework to promote the use of fire, capture non-sensitive traditional knowledge and provide an additional framework for knowledge transfer, sets priorities for the landscape, identify key assets for risk mitigation activities, assist with setting cross tenure objectives and facilitates consistency in approach.

The plan also provides the overarching strategy for tactical planning such as the stone country burning program. To reduce the potentially severe consequences of late season fires on high ecological value species and vegetation, strategic breaks and weak points are identified for treatment with responsibilities defined.

Litchfield National Park – Annual Fire Report and Annual Fire Action Plan – Northern Territory Parks and Wildlife Service

This document incorporates an analysis of the success of the previous season and the priorities and objectives for the coming season, including:

- Previous seasons performance analysis;
- Success in implementing previous seasons prescribed burning;
- Running comparison of early dry season to late dry season fires;
- Maps of fire history;
- Coming season burning program;
- An action plan of key tasks, objectives, actions and responsibilities;
- Schedule, prioritisation and details of prescribed burns;
- Stakeholder and radio communications contact details;
- Maps of proposed breaks and aerial runs, and indicative burning blocks; and
- Planned burning assessment sheet.

This format of providing the previous season(s) overview with the current season objectives and schedules provides the context for the upcoming program, and serves as a very effective continual improvement tool to benchmark the upcoming seasons performance against this previous effort.

4.3 Environmental Impact Assessment (EIA) general approach

In this section the approach to considering environmental management imperatives and impacts of fire regimes in northern Australia are examined.

4.3.1 Drivers and general approach

Key Drivers

The majority of northern Australian ecosystems effectively function as 'cultural' landscapes, in the sense that they have been maintained by traditional Aboriginal burning practices for thousands of years.[20] This is most pronounced in parts of northern Australia that have distinct wet and dry seasons and where in recent decades, fire regimes have been dominated by more extensive, less controlled, higher intensity late dry season (LDS) bushfires. This is most likely due to changes in climate, reduction of Traditional owner traditional burning practices due to the depopulation of country, loss of traditional knowledge and slow social disintegration within some Aboriginal communities, and active fire exclusion in some pastoral areas to protect grazing country. Fire frequency and extent has also increased due to the increase of fuel reduction burning for protection of people and property.

Large, landscape-scale LDS bushfires are generally regarded negatively by ecologists[21], as they tend to homogenise the landscape from a habitat perspective, and may even cause localised species extinctions over time (Russell-Smith *et al.* 1998), e.g. depletion of vegetation cover can lead to increased feral predation on small mammals and reduced food resources for granivorous birds. Large LDS bushfires are also regarded as undesirable by land managers as they are difficult to control and pose the greatest risk to life, property and cultural assets.

Consequently, there is generally a strong agreement and desire by northern Australian land managers to reduce the extent of large, high intensity LDS bushfires. This is the primary focus of prescribed burning efforts, and is accomplished by undertaking as much low intensity, early dry season (EDS) prescribed burning as possible, in a bid to minimise the spread of LDS ignitions, which are usually caused by lightning or humans. Recent evidence from western Arnhem Land suggests that EDS prescribed burning can substantially reduce the extent of LDS fires through a direct one-to-one replacement. (Price *et al.* 2012)

[20] *For discussion of Aboriginal burning regimes in tropical Australia see Bowman, D.M.J.S. (1998) Tansley Review No. 101. The impact of Aboriginal landscape burning on the Australian biota. New Phytologist 140: 385-410, and Cook, G.D., Jackson, S. and Williams, R.J. (2012) A revolution in northern Australian fire management: recognition of Indigenous knowledge, practice and management. In: Flammable Australia: Fire Regimes, Biodiversity and Ecosystems in a Changing World (Eds R.A. Bradstock, A.M. Gill and R.J. W illiams), pp.293-305. CSIRO Publishing, Melbourne.*

[21] *For examples see Russell-Smith, J., Ryan, P.G., Klessa, D., W aight, G. and Harwood, R. (1998) Fire regimes, fire-sensitive vegetation and fire management of the sandstone Arnhem Plateau, monsoonal northern Australia. Journal of Applied Ecology 35:829-846, and Kutt, A.S., Felderhof, L., VanDerW al, J.J., Stone, P. and Perkins, G. (2009) Terrestrial ecosystems of northern Australia. In: Northern Australia Land and Water Taskforce Full Report, pp. 1-42. CSIRO Sustainable Ecosystems, Canberra.*

The primary ecological reason for this approach is that the implementation of numerous 'small', patchy burns across the landscape helps to maintain habitat heterogeneity and variability within vegetated landscapes (e.g. time since fire), which is generally considered beneficial for the persistence of most species. (Bradstock *et al.* 2005). Therefore, a major challenge for land managers lies in maintaining fuel levels at different seral stages across the landscape, especially given the high flammability of many northern Australian ecosystems, which can burn on an annual basis. This has been a particular challenge in recent years with consistent record wet season rainfall leading to prolific grass growth, a circumstance that might not change in the near future according to climate change predictions for increased annual wet season rainfall in north-central and western Australia (Williams *et al.* 2009).

One of the major considerations of the environmental impact assessment component of prescribed burning is the objective of the overall burning program. In northern Australia, burning objectives are often vastly different according to land tenure and/or land managers. For instance, in National Parks such as Kakadu, burning is undertaken for a range of ecological reasons, including fuel reduction (to reduce the spread of LDS bushfires), threatened species management, weed control and maintaining a variety of seral stages. In addition, burning within National Parks can be for protection of assets (both ecological and infrastructure) and tourists. Another focus of prescribed burning is where targeted burning is used to prevent fire intrusion into potential ecological values at risk (e.g. sandstone country, cypress woodlands, areas supporting threatened obligate seeders, vegetation types with narrow ecotones such as monsoon vine thickets and rainforest), by burning back from the identified values, or linking up recent fire scars by burning to stop LDS fires running into these sensitive areas. Pastoralists also burn for different reasons, including strategic fuel reduction (as storm burning to promote green pick in the early wet season, or maintaining sufficient and appropriate levels of grass for livestock grazing), and reducing woody vegetation thickening and woody weeds (Partridge 1992). Furthermore, Traditional Owners burn for reasons such as 'cleaning up' country, maintaining 'healthy' country, spiritual reasons, caring for country, or for hunting and bush food maintenance (Whitehead *et al.* 2003).

In addition to the factors mentioned above, other drivers exist that have the potential to impinge upon the ecological objectives of prescribed burning in northern Australia. For example, pressure is exerted on land managers by the tourism industry, in the sense that "tourists don't like to see burnt landscapes". Neighbours may also influence burn plans, via the threat of litigation (whether real or implied) and the need to minimise the risk of wildfire spread onto private property by implementing fuel-reduced zones along property boundaries.

Finally, the fact that prolific and high biomass introduced plant species (e.g. Gamba Grass and Grader Grass) can dramatically alter fuel dynamics and subsequently fire regimes (e.g. intensity, frequency, extent), is increasingly becoming a key ecological consideration in the burn planning process.

Despite the broad goal of increasing EDS prescribed burning to minimise LDS bushfires, there is growing evidence that suggests high fire frequencies across much of northern Australia are contributing to the decline of certain plant species (Bowman and Paton 1993) and fauna groups such as small mammals (Legge *et al.* 2008).

However, fire intensity also plays a crucial role in determining the impact of fire frequency upon various faunal groups, with most groups benefiting from frequent low intensity fire (Table 4), although there are exceptions such as Black-footed Tree Rat and Brush-tailed Possum, which do not respond well to fire frequencies > 1 in 3 years, irrespective of fire intensity. This is one of the most pressing problems facing land managers as they attempt to implement ecologically appropriate fire regimes.

Table 4 General response of characteristic groups of fauna found in savanna landscapes to different fire regimes (Russell-Smith *et al.* 2002).

FAUNAL GROUP	FIRE REGIME			
	Infrequent or no fire	**Frequent low-intensity fires**	**Frequent intense fires**	**Occasional wet season fires**
	Occasional, potentially at intervals > 5 years	*Patchy early dry season fires at intervals < 3 years*	*Extensive late season fires at intervals < 3 years*	*Patchy low intensity fires*
BIRDS				
Fruit-eating birds	Increase in abundance, diversity	Good diversity	Decrease in abundance, diversity	No effect
Seed-eating birds	Decrease in abundance, diversity	Good diversity – best regime	Increase in some species, Decrease in others (e.g. finches) given poor access to seeds, and habitat changes	Increase in some species (e.g. partridge pigeon)
Insect-eating birds	Increase in abundance, diversity	Good diversity	Decrease in abundance, diversity	No effect
	Occasional, potentially at intervals > 5 years	*Patchy early dry season fires at intervals < 3 years*	*Extensive late season fires at intervals < 3 years*	*Patchy low intensity fires*

Table 4 General response of characteristic groups of fauna found in savanna landscapes to different fire regimes (Russell-Smith *et al.* 2002). continued

FAUNAL GROUP	FIRE REGIME			
	Infrequent or no fire	**Frequent low-intensity fires**	**Frequent intense fires**	**Occasional wet season fires**
	Occasional, potentially at intervals > 5 years	*Patchy early dry season fires at intervals < 3 years*	*Extensive late season fires at intervals < 3 years*	*Patchy low intensity fires*
MAMMALS				
Tree-dwelling mammals	Increase	Good diversity	Decrease	No effect
Terrestrial mammals	Reduction in grazing species, increase in some species (e.g. rodents, quolls)	Good diversity	Decrease in some species (e.g. rodents, quolls)	No effect
REPTILES				
Lizards	General increase in ground dwelling lizards (e.g. skinks) given greater litter, but decrease in dragons	Good diversity (and good for frill-neck lizards)	General decrease in ground-dwelling lizards given loss of litter, increase in dragons	No effect

General approach

The general approach to ecological impact assessment at the individual burn or burn program stage is much more intuitive and less formalised in the NT, when compared with the other northern Australia jurisdictions, WA and Queensland, which follow more structured approaches, e.g. five year plan in WA.

In Queensland, the environmental assessment is completed at the strategic level stage, rather than individual pre-burn environmental assessments. Ecologically appropriate fire regimes are determined from the regional ecosystem database (online) where vegetation types with similar fire characteristics are grouped together. Where there is a species recovery plan[22], fire requirements are incorporated into the operational plan prescription (e.g. Northern Bettong).

The approach in northern Australia differs markedly from the southern states in that private landholders actively manage a large proportion of the land mass using prescribed fire. Consequently, because a substantial proportion of the prescribed burning is undertaken by private land managers (e.g. pastoralists, Traditional Owners), a specific focus on burning for particular threatened species or to maintain threatened vegetation communities is often lacking. Instead of a strong focus on burning within designated Tolerable Fire Intervals (TFIs), as is the case in southern states such as Victoria, the northern Australia approach appears to be more landscape focused with the primary goal to reduce the extent of large high intensity LDS bushfires.

This approach is somewhat tempered within National Parks and private land managed for conservation purposes (e.g. Bush Heritage), where specific ecological considerations are more likely to be factored into burn planning. For example, at Kakadu NP, ecological assets are identified as best as possible prior to using fire as a management tool. Practitioners actively attempt to exclude fire from 'stone' country where obligate seeding Key Fire Response Species (KFRS) are known to occur, so that these areas experience lower fire frequencies, thus providing the necessary time for KFRS to reach reproductive maturity and set seed. In some areas of public land in the NT characterised by savannah woodland, there is an aspirational goal to 'hold' country for three years without burning, but this is often difficult, due to burning by Traditional Owners and unplanned wildfire caused by lightning strikes. Agencies are also trying to integrate fire and weed management as best as possible, as this is rapidly becoming a major issue, particularly for species such as Gamba Grass in tropical savannas and Buffel Grass in the arid interior, which have led to substantial annual increases in understorey biomass and fuel loads, and consequently, an increase in the potential frequency and intensity of fires.

The approach in northern Australia differs to the more arid climate of central Australia, where large landscape scale fires usually only follow years of above average rainfall, which promote grass growth, thus creating a ground layer of vegetation that can carry fire (Allan and Southgate 2002). Generally in central Australia, prescribed burning is conducted annually, to manage for seral stage diversity. However, after big wet years, the prescribed burning focus shifts to undertaking more strategic burns to reduce the extent of large fires in the landscape.

Owing to the desire to prevent the spread of fire into adjacent private property, many Parks (in Queensland) are managed so that the edge of the Park is maintained in a fuel-reduced state, while the core is managed for conservation values. This is essentially a risk management approach to minimise the risk of spread to adjoining private land. It also protects the parks from the more common problem of fires spreading into the park from the adjacent land.

[22] http://www.ehp.qld.gov.au/wildlife/threatened-species/recovery_conservation_plans.html

Monitoring

Pre- and post-burn ecological monitoring is viewed as crucial, particularly by public land managers. While some areas, e.g. Kakadu NP, have an informal process whereby learning is fed back informally through formal studies (Edwards *et al.* 2003) and incidental records, and then reviewed every five years, overall, there appears to be no formal monitoring procedure or requirement in the NT and Queensland.

Consequently, learning from burning is generally via research published in the scientific or grey literature, anecdotal observations, or ad hoc monitoring, but as is often the case, the feedback loop between researchers, managers and practitioners could be improved to facilitate better ecological outcomes.

4.3.2 Agency examples and innovative practice

EcoFire Project

As mentioned in section 4.2.4, the EcoFire Project in the Kimberley region of WA has already achieved positive results in that the extent of mid-to-late dry season fires has decreased across a 5M ha area, unplanned fires are now much smaller in size, and the dispersion of burnt and unburnt vegetation is considerably 'grainier', i.e. there are now more small patches spread more evenly throughout the project area. In addition, the changed fire patterns have led to an enhanced grass and shrub layer, and consequently, many animals (e.g. small mammals, quail and button-quail, finches) that depend on the grass and shrub layer have increased in abundance.[23]

WALFA Project

As mentioned in section 4.2.2, the WALFA project provides an outstanding example of an innovative approach to strategic fire management. While the primary purpose of the project is to provide financial credits for reduced greenhouse gas emissions associated with EDS burning compared to high intensity LDS burning, a major side benefit is the positive ecological outcomes, with wildfire abatement likely resulting in reduced impacts on biodiversity. Evidence is accumulating which suggests that patchy, more traditional fire regimes are leading to more structurally heterogeneous landscapes, which are likely to have far less impact on biodiversity (particularly long-lived obligate seeding plants such as Cypress Pine, *Callitris intratropica*) than the frequent high intensity wildfires experienced in West Arnhem Land in recent decades prior to the WALFA project.[24]

[23] http://www.australianwildlife.org/AWC-Sanctuaries/Mornington-Sanctuary/EcoFire-Project.aspx.

[24] http://savanna.cdu.edu.au/information/walfa_achievements.html

4.4 Operational planning practices

In this section, the approach taken to operational planning in northern Australia is discussed.

4.4.1 Drivers and general approach

As with southern Australia operational planning addresses the requirements for the physical delivery of a prescribed burn (Section 3.4). In northern Australia however a significant proportion of the operational planning work is completed in the tactical phase due to the differing operating context (Section 4.1) compared to southern Australia. While some land management agencies use a burn planning template, as used in southern jurisdictions (based on the SMEACS[25] format), others use the tactical planning document to guide burn program delivery, supplemented by an operational map. In either case these documents have common planning inclusions between jurisdictions (as detailed in Section 3.4.1) including:

- Desired outcomes and success criteria;
- Notification requirements;
- Organisational structure for delivery;
- Fire behaviour parameters; and
- Post burning assessment.

With the paperwork component completed, operational planning moves into an ongoing appraisal, risk assessment and light up approval stage comprised of:

- Constant review of grass and curing factors;
- Ongoing liaison and dialogue with other land managers, traditional owners and fire authorities;
- Review of remote sensing (NAFI), weather (Bureau of Meteorology) and grass curing sites (such as Aussie Grass)[26];
- Confirmation of landscape features that can burn used for containment of burns. Linear firebreaks can be difficult to hold prescribed burns on, and while chain created breaks can be very effective, they are subject to a high level of scrutiny. Landscape features include previously fuel reduced areas (by bushfire or prescribed burning), areas with elevated moisture or uncured or heavily grazed cattle pads;

25 *Situation, Mission, Execution, Administration, Command/Control/Coordination and Communication and Safety*

26 *Aussie Grass http://www.longpaddock.qld.gov.au/about/researchprojects/aussiegrass/index.html*

- Ongoing risk assessment and appraisal of weak points that will need treatment and strengthening to prevent escape or to protect sensitive or exclusion areas (that can be completed in advance through spraying, scrub rolling and/or small area patch burning). This includes ground based burning around sensitive sites, such as in WA where DPaW flies in traditional owners to undertake ground based burning around cultural sites, in advance of aerial burning;
- Ongoing review of the readiness of resources and personnel;
- Final corrections to operational maps; and
- Authorisation for ignition, including completion of preparatory checklist or risk assessments.

4.4.2 Agency examples and innovative practice

DPaW Fire Scar and Operations Maps

To key tool used by DPaW to guide the delivery of burning operations is the preparation of operations identifying broad areas intended for prescribed burning (Figure 11), that can be cross referenced to post burning fire scars and aerial ignition run map (Figure 12) to provide a very useful and simple means to evaluate burn success against intent.

Visual Fuel Load Guide for the Kimberley Region

The Visual Fuel Load Guide has been prepared by DFES for the ten biogeographic regions of the Kimberley to assist land managers, pastoralists and other stakeholders in assessing the potential risks from fuels. The guide provides a non-destructive and rapid methodology to estimate fuel loads. It provides a simple means to create awareness of the different levels of fuel on a property, and fuel load information that may trigger the need for treatment.

This guide compliments other guides prepared by DFES to assist land managers in administering their fire management programs including:

- Grass Curing Visual Guide for Western Australia;
- Guidelines for the Development of a Pastoral Station Bush Fire Management Plan;
- Guidelines for the Development of a Remote Indigenous Community Strategic Bush Fire Management Plan; and
- Guide and Tables for Bushfire Management in Western Australia.

Figure 11 Mitchell Plateau Operational Map (Source: Hartherley 2009)

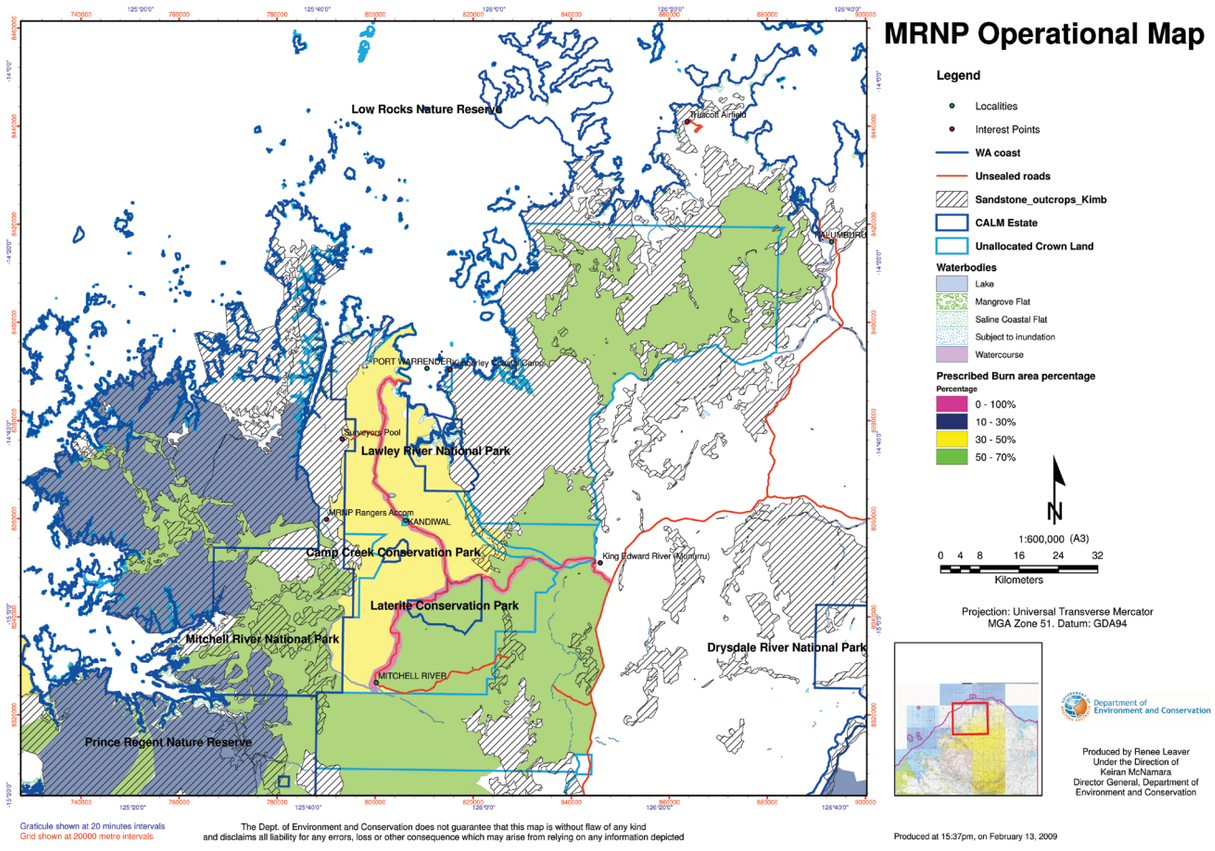
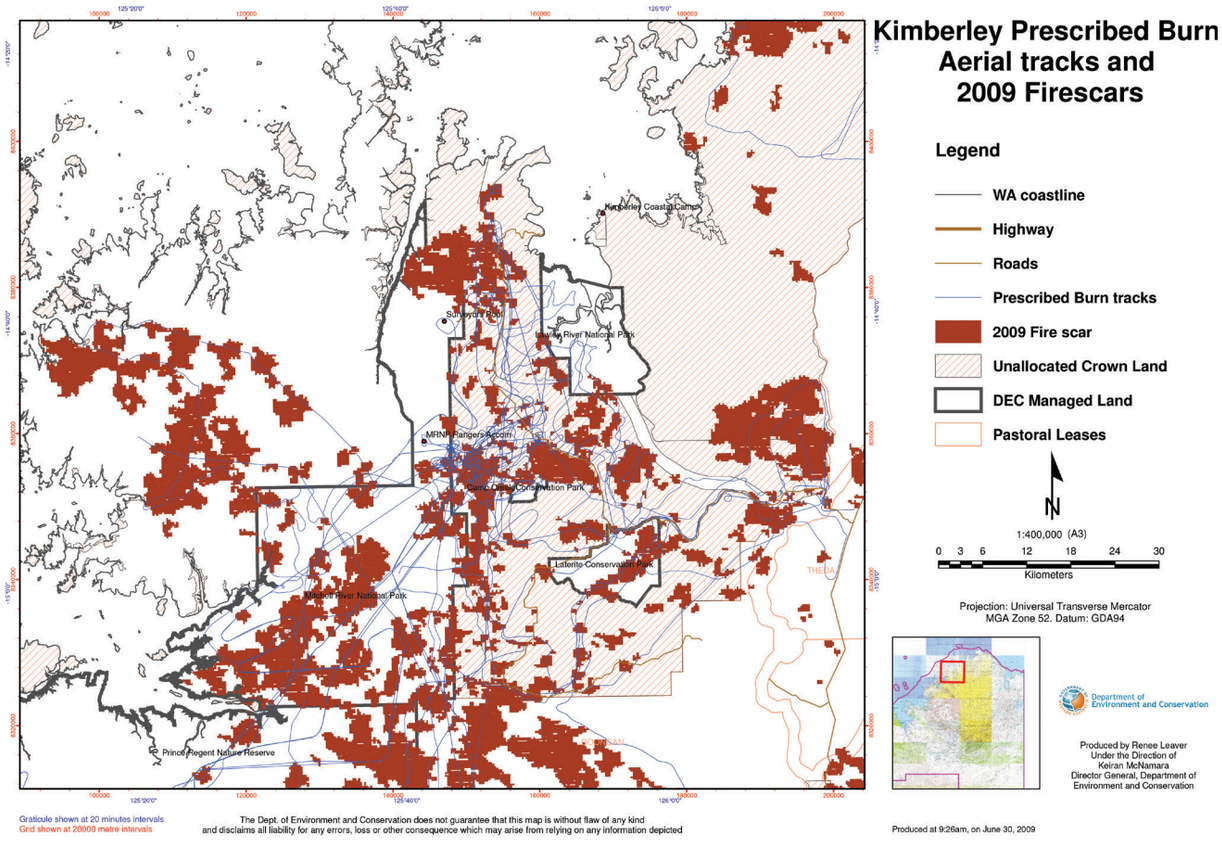


Figure 12 Mitchell Plateau Fire Scars and Tracks (Source: Hartherley 2009)



4.5 Burning operations practices

This section outlines some of the burning practices applied in northern Australia.

4.5.1 Drivers and general approach

As identified in previous sections the northern Australia fire environment is characterised by a significant amount of fire within the landscape annually, declining in frequency and extent moving south, and within the wet tropics. If fire is not applied by prescription in the early dry season, it will burn as bushfire in the late dry season. The volume of prescribed burning completed annually requires a very efficient burning operations program, that is, as recommended by northern Australia, maintained comparatively free of the administrative constraints that apply to burning operations in southern Australia. Burning approval is largely at the tactical level, allowing once the burning season commences significant flexibility, permitting decisions to light up areas to be made at relatively short notice and with a relatively low level of resources. For example lighting up areas by persons on their way home and allowing moisture differentials in fuels and overnight humidity increases to temper or put out fires is still applied in northern Australia, a practice that was also once undertaken in southern Australia but has largely disappeared or is no longer permitted.

In northern Australia there is also the opportunity to tap into and apply existing traditional owner knowledge, that is not available in southern Australia where a loss of traditional Aboriginal fire knowledge has occurred. In recent times there has been a renewed emphasis on facilitating access to and applying traditional fire management knowledge, and structuring opportunities for broader knowledge transfer. In northern Australia, despite pauses in the delivery of traditional burning in parts, significant traditional fire management knowledge has been retained and is being passed on by communities. Indeed the involvement of, and input from, Indigenous communities in prescribed burning programs is now a key input in burn planning and delivery. Further opportunities to expand information transfer and understanding are sought through the introduction and expansion of Indigenous ranger programs, joint management arrangements, cooperative burning programs and formal and informal consultation with traditional owners at the strategic, tactical and operational phases. DPaW WA flies in traditional owners to complete ground based burning of sensitive areas and for cultural and societal purposes in advance of broad area aerial application.

Prescribed burning is acknowledged as the best way to train and gain experience in fire management, and the high level of burning undertaken in northern Australia can quickly produce very experienced fire practitioners in a range of fuel types. This development of experience through prescribed burning also serves as an important disaster mitigation strategy, by building and maintaining the currency of fire practitioners, to be able to respond to better manage bushfire emergencies. Although in semi-arid and wet tropics regions the infrequency of landscape level fires can limit opportunities to gain experience.

The major and emerging constraints to burning operations delivery are similar those experienced in southern Australia:

- Lack of knowledge, experience and therefore confidence of new staff to deliver programs;
- Increasing costs of training and accrediting staff, and procedural or administrative requirements. This may include training and competency requirements to participate in burning operations for staff and traditional owners (particularly an issue in remote locations);
- Information transfer and knowledge loss through retirements;
- Competing work and program objectives;
- Political or societal factors. Community pressures, particularly from persons not previously exposed to or understanding fire, particularly in population centres where there is a high influx of tree- changers that may not understand the need for prescribed burning or its extent. There is also pressure from parts of the tourism industry to reduce prescribed burning;
- Challenges faced by volunteer fire services including aging and declining rural populations available to volunteer and a decline in recruitment;
- Decline in use of fire in the sugar industry and parts of the agricultural sector has resulted in a decline in fire use in parts of the landscape (Queensland wet tropics and sub-tropical areas); and
- Lack of funds, particularly as planned burning occurs at the end of the financial year when funds can be under pressure, and fire suppression operations occur at the start of the financial year potentially eroding operational budgets.

4.5.2 Agency examples and innovative practice

In addition to early dry season burning the following innovative burning practices are applied:

- Storm burning in advance of a forecast storm during October to January to assist in specific objectives such as removal of overabundant woody species. This timing is targeted for when a particular woody species has broken its dry season dormancy. Note this is different to wet season burning (see below).
  Graziers, particularly on Cape York, favour storm burning to early dry season burning due the benefits in reducing thickening (particularly species such as Melaleuca viridiflora) and early promotion of some pasture species;

- Wet season burning (WSB) is also used to target specific species that may have become over- abundant due to changes in anthropogenic fire regimes. Native spear grasses (Sorghum spp.) are believed to have become more widespread due to changes in fire regimes, and WSB is practiced in areas highly stocked with spear grass to reduce its dominance. With its seed germinating in the early wet season, WSB will remove the germinating spear grass crop, removing the seed source and the species for a number of seasons, and creating an area where the fuel hazard is primarily leaves. To have enough fuel to be able to undertake WSB the area must be held over from burning through the previous dry season; and

- Burning in the wet season build-up period in Kimberley under a northerly wind. This burning in undertaken during the build-up (October – November) following initial rains but before the full onset of wet conditions that would preclude broad area burning.

Queensland Parks and Wildlife Service's Planned Burn Guidelines (DERM 2012)

A 'how to' plain English guide to assist in burn delivery with a stepped approach identifying factors to be considered before approving the light up of an entire burning block. This includes an initial assessment of weather, dryness and fuel moisture prior to the burn. This is followed up by considerations for the day of the burn from assessment of weather conditions, confirmation of fuel load, calculation of predicted fire behaviour and potential severity, analysis of fuel arrangement, review of identified burn prescriptions and execution and assessment of test burn. This standard operating procedure provides a consistent approach for land managers to appraise on site if the site conditions are suitable to 'go to burn'. This decision support tool assists in providing the justification to commence burning, modify prescriptions or to suspend the operation until conditions are suitable.

5. KEY ISSUES ARISING FROM WORKSHOPS

A number of key issues were raised and discussed during the workshops - these are summarised in this section.

5.1 AFAC/FFMG Best Practice Guidelines development for Prescribed Burning

- There was general support for the development of Best Practice Guidelines for Prescribed Burning, and recognition of their potential value in providing a defendable and consistent model around which to base prescribed burning planning and delivery.
- The guidelines will need to enable flexibility to account for local circumstances and jurisdictional requirements and provide guidance rather than prescription or an audit framework. They should provide for broad consistency across Australia from the large well-resourced fire managers through to smaller agencies, local government, non-government organisations, traditional owners, pastoralists, and energy suppliers.
- Guidelines will need to be simple, not war and peace, otherwise they won't get used. Potentially these should be a suite of separate (but sequentially linked) guideline documents focussing on different stages of the prescribed burn planning and operations process (e.g. strategic planning; tactical program planning; operational planning; burning operations; monitoring and performance assessment).

5.2 Current/emerging issues with the potential to constrain prescribed burn program delivery

- Increasing regulation and constraints may hinder burn delivery without improving program outcomes. This was identified as a potentially emerging issue in northern Australia where there is a very large ongoing annual burning commitment, and in south-eastern Australia where an up-scaling in prescribed burning programs requires enhancement of process efficiency. Increasing constraints include increased documentation requirements, more onerous approval mechanisms, escalating training and competency requirements, and air quality regulatory approaches that reduce opportunities for prescribed burning.
- There is a strong need to gain broader and improved community understanding of the 'social utility' of prescribed burning (in both community risk reduction and environmental benefit dimensions). The social utility of prescribed burning is not as well articulated as it could be by the land and fire management sector, or accepted by communities in many areas. The proportion of the Australian population who work on the land, or make a living from land sector businesses, and understand basic concepts of bushfire risk management is declining. This has the potential to increase the numbers of people inclined to put their individual interests or preferences (in relation to prescribed burning) ahead of the broader social interest (because they don't sufficiently appreciate what that social interest is).

This has the potential to make prescribed burning program delivery increasingly difficult, and makes steady, long-term commitment to programs more challenging.

- Industry group and social demographic group pressure (e.g. from 'tree-changers', tourist industry, wine grape growers) to restrict and constrain prescribed burning needs to be addressed strategically and at an industry-whole of Government level, rather than on a complaint by complaint basis.

- There is significant potential that litigation arising from prescribed burning activities could make agencies and individuals increasingly risk-averse, potentially narrowing the range of conditions in which practitioners are prepared to burn, and thus constraining prescribed burning program delivery. Legal liability limitation for prescribed burning, similar to protections afforded in some jurisdictions to fire suppression operations, may be prudent.

5.3 Potential opportunities to reduce constraints to prescribed burn program delivery

- Continue to move towards longer-term scheduling in tactical planning, identifying prescribed burning blocks up to three years or more in advance in southern Australia, providing greater efficiency in planning and delivery of operations.
- Make improved use of open-ended burning practices in appropriate conditions and landscape locations – move away from the overly risk-averse paradigm of all prescribed burns requiring mineral earth track perimeters. Risk management for open-ended burns can make improved use of controls such as recently burnt areas, landscape features which are natural barriers to low intensity fire spread, and burning on weather patterns which will limit fire spread to desired areas.
- Reduce the potential for site and fire sensitive species-centric environmental risk assessment processes to unnecessarily constrain burning opportunities by adopting ecosystem health oriented approaches where greater emphasis is given to achieving landscape heterogeneity and ecological resilience objectives. Move away from rigid adherence to tolerable fire intervals based on fire sensitive Key Fire Response Species.
- Prescribed burning budgets should be on a multi-year basis so that the seasonality of expenditure can be treated without artificial administrative impediments. This way the balance between good and poor seasonal conditions can be averaged out. This is particularly important in northern Australia where the burning season straddles the financial year end.

5.4 Breaking large, high intensity, high impact fire cycles

- Need to reintroduce controlled fire into areas homogenised by high intensity bushfire as early as possible through a fire mosaic, to re-establish heterogeneity, habitat niches and diversity in seral vegetation stages across the landscape through regular fire. This applies to southern and northern Australian fire operating contexts, where the careful application of controlled fire will limit the potential for high intensity bushfire.
- Recent inquiries and Royal Commission consideration of prescribed burning have focussed on public lands – how to deal with private lands remains the 'elephant in the room' which is yet to be adequately addressed. Breaking large, high intensity, high impact fire cycles requires incorporation of private lands into consideration for landscape fuel management strategies.

5.5 Collaboration and collective support for key planning tools

- Workshops identified the significant and critical contribution that satellite imagery displayed via the NAFI website plays for the northern Australia fire practitioners, land owners and the general public – this vital planning tool needs long-term institutional/funding commitment to continue its availability and improvement in the long term.
- There is value in a number of emerging decision support tools such as DEPI's Future Fire residual risk analysis tools, Fire Behaviour Analyst-developed planned burning suitable conditions forecasting tool, online systems for planning prescribed burns and capturing prescribed burning spatial data. Collaborative arrangements for further developing these tools are worthy of consideration.

5.6 Prescribed burn capacity building and knowledge sharing

- AFAC has many groups and sub-groups but none focussed on prescribed burning. FFMG has an equipment development sub-group, but no group specifically focussed on prescribed burning. Therefore there is no formal inter-agency collaborative/networking group through which those responsible for prescribed burning policy, program and capacity development can share knowledge and experience. 'Lessons learnt' from prescribed burning are not well shared, and lessons from adverse events may not be shared due to legal privilege confidentiality concerns. There appears to be a significant gap in land and fire industry networks catering for prescribed burning.

- Professional development activities and opportunities are biased to emergency fire incident leadership and control, with few activities/opportunities focussed on prescribed burning. With prescribed burning program development and delivery being a very significant program for many agencies (for some agencies, annual prescribed fire output exceeds annualised average for area burnt by wildfire) - this imbalance in professional development focus should be considered and addressed.

6. CONCLUSIONS

1. Prescribed burning is a widely used land and fire-risk management practice in Australia, acknowledged by all AFAC and FFMG member (land and fire sector) agencies as having social utility for both community bushfire risk reduction and environmental values management. It's acceptance is based on an extensive body of fuels and fire behaviour research and fire ecology research.

2. Risk reduction benefits arising from prescribed burning occur:

   - before the onset of adverse fire weather conditions, facilitating improved fire control opportunities and success probability during favourable conditions, so that the number of uncontained or partially contained fires with the potential to make high intensity runs when adverse conditions develop is reduced;
   - during adverse weather, if the extent, dimensions and arrangement of low fuel areas in the landscape are sufficient to slow fire spread for some part of its run, thereby reducing the impact area; and
   - after the main run of a fire when weather conditions moderate, facilitating improved fire control opportunities and success probability, so that fire can be contained before onset of the next bout of adverse weather, thus avoiding further high-impact runs.

3. Benefits of prescribed burning are maximised from committed implementation of strategically developed programs – that is to say the benefits resulting from an individual burn may be significantly diminished if other burns in a program, with which a particular burn is strategically linked, are not undertaken as designed. Sustained commitment to long-term programs is vital.

4. There are relatively few 'before and after' analyses of how prescribed burning reduces bushfire risk at the landscape scale (although there are numerous case studies of individual fire effects), which makes it difficult for land and fire management agencies to communicate benefits and gain community support for programs (the possible exception is south-west WA). This is a key gap, and an important opportunity to be pursued. Use of credible fire spread simulators to assess the potential risk reduction benefits of different prescribed burning program options has significant benefit potential whilst outcomes based analyses are developed.

5. In southern Australian jurisdictions, prescribed burning policy and performance targets are focussed on public lands – how to deal with private lands remains the 'elephant in the room' which is yet to be adequately addressed. Breaking large, high intensity, high impact fire cycles requires incorporation of private lands into consideration for landscape fuel management strategies.

6. Due to the great differences in operating environments, climate, and scale of fire occurrence between northern and southern Australia, different approaches to burn program planning and delivery are necessary. In northern Australia, a highly flexible approach to strategic/tactical burn program planning is required

that can accommodate the continuous changes that occur in burnt and unburnt patch distribution in the landscape as the dry season develops. Strategic and tactical planning is a process that progresses continuously through the burning season. Northern burning practices need to be capable of implementing large volumes of burning in a relatively short burning season (focussed on the early dry season). In southern Australia, more deliberative processes can be applied, and are generally required, due to the higher population density and greater distribution of human settlements and other values through fire prone landscapes. While the different operating environments require different approaches, there is much that fire managers in the south can learn from fire managers in the north in terms of maximising flexibility in program design and delivery.

7. Done properly, strategic planning for prescribed burning is a complex process founded on a proper risk assessment process examining how fire can start, spread and impact values (of varying degrees of exposure and vulnerability). Agencies can expect difficulty in gaining acceptance for prescribed burning programs which do not adequately identify and link:

   - the bushfire risks which the burning seeks to reduce;
   - how the burning program will reduce the risk and to what extent (preferably contrasting this with the risk profile associated with no action); and
   - what potentially negative and positive consequences the prescribed burning activities may have and how the negatives will be minimised.

   Sound strategic planning will address each of these planning dimensions.

8. Without sound strategic planning, the resources and effort expended on prescribed burning may be sub-optimally and even poorly directed, and the risk reduction benefits perceived to accrue by agencies and communities not achieved. Strategic planning involves identification of such things as what the performance objectives or success criteria are for programs, what proportion of a landscape should be burnt to achieve these, which vegetation types should burning be focussed in, what treatment cycles should be applied, what arrangement of treated areas in the landscape and treatment area size will optimise risk reduction, and what residual risks remain to be addressed through other complementary risk management strategies. These are challenging questions, are politically sensitive, and require a high degree of political and organisational will to pursue.

9. Tactical planning is pursued to implement strategic plans. It needs to take account of current fuel age distribution patterns in the landscape, and knowledge of features which can be used as burn boundaries, in order to optimise selection of where burning activities can be best placed for maximum risk reduction effect. It is therefore dependent on robust vegetation and fire history data, and mapping of roads, tracks and natural features in the landscape which can be used to contain burns. It requires good technical knowledge of how fire treatments can be applied so that resulting burning works schedules are realistic and achievable. It also requires sound local knowledge of burning constraints (including ecological) and potential conflicts with local land owners and businesses so as to avoid, to the extent possible, conflicts over burn location, extent or timing. Good tactical planning can maximise efficiencies for the operational planning phase, whereas poor tactical planning can generate major issues for the operational planning phase, resulting in program delivery inefficiency. Teams with high levels of burning competence and experience, and good local landscape and issues/values knowledge are required to undertake effective tactical planning.

10. Operational planning is undertaken to identify the methods by which a burn should be conducted and in what conditions, what preparatory works may be required, what operational and ecological risks may arise from the burn and what control measures are required to manage these, what notifications and stakeholder consultations are required, what resources will be required to execute the burn, and what command, control and communication arrangements are to be put in place for the operation. Operational planning is the stage at which the first phase of detailed operational risk management planning is undertaken and decisions regarding the range of actions and resourcing requirements to manage these are made. Good operational planning enables efficient burn operations execution, whereas sub-optimal operational planning may generate problems and risks for assigned burn crews to deal with, potentially with inadequate resources to manage the actual risks arising in the field.

11. Conducting burning operations involves many operational activities, often occurring at high tempo over a short period of time, applied in a controlled manner . At their core, they involve checking and verifying that pre-planned arrangements are appropriate to the conditions in the field; safely mobilising and executing the pre-planned arrangements; selecting and applying ignition practice which delivers the prescribed fire behaviour; managing perimeter control so the burn remains within planned boundaries (during and after ignition); implementing risk controls to maintain public and road safety; responding to fire behaviour escalations or escapes and other incidents such as fallen trees as they occur; assessing burn progress/ conditions and deciding when it is appropriate to scale down operations and when it is safe to declare the burn out. These operational activities require skilled, experienced operators, able to assess, anticipate and respond to changing conditions and risks, and able to apply fire in the landscape to achieve desired fire behaviour. Prudent investment in burn supervisor and crew competency is vital.

12. Prescribed burning is a complex task carrying many inherent and dynamic risks. Unforeseen events and human error cannot be eliminated – from time to time adverse events will occur, and heavy scrutiny of such events is certain, particularly where loss of life and/or major property damage arises. Therefore, it may be of significant benefit to agencies to be able to demonstrate that their prescribed burn planning and operating practice is aligned with a national approach and in line with industry best practice benchmarks.

13. The substantial changes to historic fire regimes that have been brought about by the cumulative effects of land use change, altered burning practices, and long-term fire suppression have become increasingly well recognised, and the need to use fire to manage for environmental values is gaining wider acceptance. A change in approach to considering environmental values is underway, from one where, in the past, decisions about burning were considered at burn-site scale and may be driven by the requirements of the most fire sensitive species, to a more contemporary landscape oriented approach in which considerations of diversity of ecological communities, reintroduction of heterogeneity and diversity of seral stages, and resilience to large scale disturbance events or threatening processes are the driving considerations. There is more work to do on developing consistent and accepted definitions and objectives before these emerging concepts can be mainstreamed.

14. Practices for prescribed burn planning and operations are variable across Australia and New Zealand. There is no single jurisdiction or agency which is leading best practice in all facets. Rather, different jurisdictions/agencies are developing improved practices and innovations in different aspects of planning and operations. While there is some collaboration occurring, much development and innovation effort happens in isolation. There is much to be gained from improved information sharing and collaboration on projects and tool development for prescribed burn planning and operations. This report highlights many of the leading developments and innovations happening in prescribed burn planning and operations that may provide the foundations for future development of best practice guidelines.

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8. REFERENCES

Ackland A, Salkin O, Blackett A, Fograty L, Friend G (2010) Otway Pilot Study – Interim report Future Fire Management Project – Defining and Evaluating Alternative Fire Management Options to Achieve Improved Outcomes for Community Protection, Biodiversity and Ecosystem Services (DSE).

ACT Emergency Services Agency (2009) Strategic Bushfire Management Plan for the ACT. http://esa.act.gov.au/community-information/publications/sbmp/,accessed December 2013.

Allan GE, Southgate RI (2002) Fire regimes in the spinifex landscpaes of Austalia. In: Flammable Australia: The Fire Regimes and Biodiversity of a Continent (Eds RA Bradstock, JE Williams, AM Gill), pp.145-176. (Cambridge University Press: Melbourne).

Boer M, Sadler R, Wittkuhn R, McCaw L, Grierson P (2009) Long-term impacts of prescribed burning on the regional extent and incidence of wildfires – evidence from fifty years of active fire management in SW WA; (Bushfire CRC: Melbourne).

Bowman DMJS (1998) Tansley Review No. 101. The impact of Aboriginal landscape burning on the Australian biota. *New Phytologist* **140**,: pp. 385-410.

Bowman DMJS, Panton WJ (1993) Decline of *Callitris intratropica* R.T. Baker & H.G. Smith in the Northern Territory: Implications for pre- and post-European colonization fire regimes. *Journal of Biogeography* **20**, pp. 373-81.

Bradstock RA, Price OF (2009) Report to the Victorian Bushfires Royal Commission: Fire Severity Patterns in the Victorian Fires of February 7th 2009: influences of weather, terrain and land use history. (VBRC: Melbourne).

Bradstock RA (2008) Effects of large fires on biodiversity in south-eastern Australia: disaster or template for diversity? *International Journal of Wildland Fire* **17**,: pp. 809-822.

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

Cawson J, Muir A (2008) Flora monitoring protocols for planned burning: a user's guide. Fire and Adaptive Management Report No. 74. (Department of Sustainability and Environment: Melbourne).

Cheal DC (2010) Growth stages and tolerable fire intervals for Victoria's native vegetation datasets. Fire and Adaptive Management Report No. 84. (Department of Sustainability and Environment: Melbourne).

7. REFERENCES CONTINUED

Clarke MF (2008) Catering for the needs of fauna in fire management: science or just wishful thinking? *Wildlife Research* **35**, pp. 385-394.

Cook GD, Jackson S, Williams RJ (2012) A revolution in northern Australian fire management: recognition of Indigenous knowledge, practice and management. In: Flammable Australia: Fire Regimes, Biodiversity and Ecosystems in a Changing World (Eds RA Bradstock, AM Gill, RJ Williams), pp. 293-305. (CSIRO Publishing: Melbourne).

DEC (2011) Master Burn Planning Manual 2011. (Department of Environment and Conservation: Perth).

DENR (2011) Fire policy and Procedure Manual. (Department of Environment and Natural Resources: Melbourne)

DERM (2012) Planned Burning Guideline – How to Assess if Your Burn is Ready to Go. First Edition (Department of Environment and Resource Management:Brisbane).

Di Stefano J, York A (2011) *R*elationships between disturbance regimes and biodiversity: background, issues and approaches for monitoring. Fire and Adaptive Management Report No. 91. (Department of Sustainability and Environment: Melbourne).

Edwards A, Kennett R, Price OF, Russell-Smith J, Spiers G, Woinarski J (2003) Monitoring the impacts of fire regimes on vegetation in northern Australia: an example from Kakadu National Park. *International Journal of Wildland Fire* **12**, pp. 427-440.

FESA (2010) Guidelines for the development of a Remote Indigenous Community Strategic Fire Management Plan. Bush Fire and Environmental Protection Branch. (FESA: Perth).

Fire Ecology Working Group (2003). Developing an ecological burning strategy - a practitioner's manual. (Map Info ver.) (Department of Natural Resources and Environment and Parks Victoria: Melbourne).

Fire Ecology Working Group (2004) Guidelines and procedures for ecological burning on public land in Victoria. (Department of Sustainability and Environment: Melbourne).

Gammage, W (2011) The Greatest estate on Earth - How Aborigines made Australia, (Allen and Unwin: Sydney).

Gibbons P, van Bommel L, Gill AM, Cary CJ, Driscoll DA, *et al. (*2012) Land Management Practices Associated with House Loss in Wildfires. PLOS One **7**, (1). e 29212.

Gould JS, McCaw WL, Cheney NP, Ellis PF, Knight IK, Sullivan AL (2007) Project Vesta – Fire in Dry Eucalypt Forest: Fuel structure, fuel dynamics and fire behaviour. (CSIRO and DEC:WA).

Hartherley E (2009) Kimberley Early Dry Season Burning Program 2009. Regional Fire Coordinator Kimberley Region (Department of Conservation and Environment: WA).

Jurskis V, Underwood R (2007) Fire management: what has changed? In: Growing Forest Values.Proceedings, Institute of Foresters of Australia and New Zealand 3-7 June 2007, pp. 225-232. (Institute of Forestry Conference: Coffs Harbour).

Jurskis V, Bridges R, de Mar P (2003) Fire Management in Australia – the lessons of 200 years. In: Proceedings of the Joint Australia and New Zealand Institute of Forestry Conference, 27 April–1 May 2003, pp. 353–368. (Ministry of Agriculture and Forestry: Wellington/Queenstown, New Zealand).

Kenny B, Sutherland E, Tasker E, Bradstock RA (2004) NSW Biodiversity Project Report - Guidelines for Ecologically Sustainable Fire Management. (NSW National Parks and Wildlife Service: Sydney).

Kutt AS, Felderhof L, VanDerWal JJ, Stone P, Perkins G (2009) Terrestrial ecosystems of northern Australia. In: Northern Australia Land and Water Taskforce Full Report, pp. 1-42 (CSIRO Sustainable Ecosystems: Canberra).

Legge S, Murphy S, Heathcote J, Flaxman E, Augusteyn J, Crossman M (2008) The short- term effects of an extensive and high-intensity fire on vertebrates in the tropical savannas of the central Kimberley, northern Australia. *Wildlife Research* **35**, pp. 33-43.

MacHunter J, Menkhorst P, Loyn R (2009) Towards a process for integrating vertebrate fauna into fire management planning. Arthur Rylah Institute for Environmental Research Technical Report Series No. 192. (Department of Sustainability and Environment: Melbourne).

Marsden-Smedley JB (2009) Planned burning in Tasmania: operational guidelines and review of current knowledge. Fire Management Section, Parks and Wildlife Service (Department of Primary Industries, Parks, Water and the Environment : Hobart).

McCarthy M (2011) Review of resilience concepts and their measurement for fire management. Fire and Adaptive Management Report No. 90 (Department of Sustainability and Environment: Melbourne).

Parliament of Victoria (2010) 2009 Victorian Bushfire Royal Commission: Fire preparation, response and recovery – Volume II. pp. 332 – Session 2006-10.

7. REFERENCES CONTINUED

Partridge I (1992) Managing native pastures: a graziers guide (Queensland Department of Primary Industries: Brisbane).

Penman TD, Binns DL, Shiels RJ, Allen RM, Kavanagh RP (2008) Changes in understorey plant species richness following logging and prescribed burning in shrubby dry sclerophyll forests of south-eastern Australia. *Austral Ecology* **33**, pp. 197–210.

Price OF, Russell-Smith J, Watt F (2012) The influence of prescribed fire on the extent of wildfire in savannah landscapes of western Arnhem Land, Australia. I*nternational Journal of Wildland Fire* **21** pp. 297-305.

Price OF, Bradstock RA (2011) The influence of weather and fuel management of the annual extent of unplanned fires in the Sydney region of Australia. *International Journal of Wildland Fire* **20** pp. 142-151.

Pyne S (2006) The Still-Burning Bush (Scribe Short Books: Melbourne).

Rossiter-Rachor NA, Setterfield SA, Douglas MM, Hutley LB, Cook GD (2008) *Andropogon gayanus* (Gamba Grass) invasion increases fire-mediated Nitrogen losses in the tropical savannas of northern Australia. *Ecosystems* **11**: pp. 77-88.

Russell-Smith J, Ryan PG, Klessa D, Waight G, Harwood R (1998) Fire regimes, fire-sensitive vegetation and fire management of the sandstone Arnhem Plateau, monsoonal northern *Australia.Journal of Applied Ecology* **35**, pp. 829-846.

Russell-Smith J, Stanton JP (2002) Fire regimes and fire management of rainforest communities across northern Australia. In Flammable Australia (Eds RA Bradstock, J Williams, AM Gill), pp. 329-350. (Cambridge University Press: Cambridge).

Russell-Smith J, Start T, Woinarski J (2002) Effects of fire in the landscape. In: Savanna burning: understanding and using fire in northern Australia (Eds R Dyer, P Jacklyn, I Partridge, J Russell- Smith, RJ Williams), pp. 29-49. (Tropical Savannas Cooperative Research Centre: Darwin).

Russell-Smith J, Edwards AC, Cook GD, Brocklehurst P, Schatz J (2004) *I*mproving greenhouse emissions estimates associated with savanna burning in northern Australia: Phase 1 Final Report, (Tropical Savannas Cooperative Research Centre: Darwin).

Russell-Smith J (2002) Pre-contact Aboriginal, and Contemporary Fire Regimes of the Savanna Landscapes of Northern Australia: Patterns, Changes and Ecological Processes. In: Australian Fire Regimes: Contemporary Patterns (April 1998 - March 2000) and Changes Since European Settlement (Eds J Russell-Smith, R Craig, AM Gill, R Smith, J W illiams). Australia State of the Environment Second Technical Paper Series (Biodiversity). (Department of the Environment and Heritage: Canberra). http://www.ea.gov.au/soe/techpapers/index.html

Sharp BR, Bowman DMJS (2004) Patterns of long-term woody vegetation change in a sandstone-plateau savanna woodland, Northern Territory, Australia. *Journal of Tropical Ecology* **20**, pp. 259-270.

Supreme Court of WA (2010) Southern Properties (WA) Pty Ltd -v- Executive Director, Department of Conservation and Land Management WA, http://www.austlii.edu.au/au/cases/wa/WASC/2010/45.html accessed December 2013

Supreme Court of WA – Court of Appeal (2012) in matter of Southern Properties (WA) Pty Ltd -v- Executive Director, Department of Conservation and Land Management WA http://www.austlii.edu.au/cgi-bin/sinodisp/au/cases/wa/WASCA/2012/79.html?stem=0&synonyms=0&query=title(southern%20properties%20) accessed December 2013

Victorian Bushfires Royal Commission (2010) Final Report Volume II - Fire preparation, response and recovery, Parliament of Victoria.

Whitehead PJ, Bowman DMJS, Preece N, Fraser F, Cooke P (2003) Customary use of fire by indigenous peoples in northern Australia: its contemporary role in savanna management. *International Journal of Wildland Fire* **12**, pp. 415-425.

Williams RJ, Bradstock RA, Cary GJ, Enright NJ, Gill AM, Liedloff AC, Lucas C, Whelan RJ, Andersen AN, Bowman DJMS, Clarke P, Cook GD, Hennessy K, York A (2009) Climate Change, Fire Regimes and Biodiversity in Australia: Complex Interactions and Effects. (Department of Climate Change: Canberra).

APPENDIX A

AGENCY SUPPLIED DOCTRINE

Prescribed burning information supplied by project participants.

Source Jurisdiction	Agency	Document title
Qld	DERM	DERM (2012) *Planned Burning Guideline – How to Assess if Your Burn is Ready to Go.* First Edition, Department of Environment and Resource Management, Brisbane.
WA	FESA	FESA (2010) *Guidelines for the development of a Remote Indigenous Community Strategic Fire Management Plan.* Bush Fire and Environmental Protection Branch, FESA Perth
ACT	ACT Gov	ACT Government (2009) *Strategic Bushfire Management Plan for the ACT.* A plan for the bushfires and reduce their consequences: Version Two Government and community of the ACT to work together to more effectively suppress bushfires and reduce their consequences: Version Two
ACT	ACT Gov	ACT Government (2009) *Strategic Bushfire Management Plan for the ACT.* Factors contributing to bushfire risk. Supporting information: Part One.
ACT	ACT Gov	ACT Government (2009) *Strategic Bushfire Management Plan for the ACT.* Bushfire policy and management framework. Supporting information: Part Two.
ACT	TAMS	TAMS (2008) *ACT Parks, Conservation & Lands Prescribed Burning Guidelines (Draft).* Territory and Municipal Services.
ACT	ACTF	ACTF (2012) Smoke Management Guidelines for Prescribed Burning. Schedule 2. Australian Capital Territory Forests.
AUS	CSIRO	Roxburgh, S. (2010) 'Fire and carbon risk management in tall temperate forests'. *AFAC/Bushfire CRC Conference – Darwin 8-10 September 2010 Session* – Fire and Carbon Sequestration.
AUS	CSIRO	CSIRO (2012) Impact of smoke from prescribed burning and wildfires on rural communities in Southern Australia.

Source Jurisdiction	Agency	Document title
AUS	IAWF	T. D. Penman, F. J. Christie, A. N. Andersen, R. A. Bradstock, G. J. Cary, M. K.Henderson, O. Price, C. Tran, G. M. Wardle, R. J. Williams and A. York (2011) Prescribed burning: 'how can it work to conserve the things we value?' *International Journal of Wildland Fire 2011, 20, 721–733*
AUS	IAWF	Kochi, I., Geoffrey, D., Patricia, C. and John, L. (2010). *The economic cost of adverse health effects from wildfire-smoke exposure: a review. International Journal of Wildland Fire 2010,* 19, 803–817.
AUS	DECCEE	DECCEE (Undated) Carbon Farming Initiative – Draft Methodology for Savanna Burning. Australian Government Department of Climate Change and Energy Efficiency.
AUS	AFAC	AFAC (2011) *Scope and Framework for an Australian Fuel Classification.* A Report for the Australasian Fire and Emergency Service Authorities Council.
AUS		Gibbons P, van Bommel L, Gill AM, Cary GJ, Driscoll DA, *et al.* (2012) Land Management Practices Associated with House Loss in Wildfires. PLoS ONE 7(1): e29212. doi:10.1371/journal.pone. 0029212
NSW	BFCC	BFCC (2008) *Annex B to Bush Fire Coordinating Committee Policy* No. 1/2008. Bush Fire Risk Management Planning Guidelines For Bush Fire Management Committees. Bush Fire Coordinating Committee.
NSW	NPWS	NPWS (Undated) Level 1 Prescribed Burn Plan Guidelines.
NSW	NPWS	NPWS (Undated) Level 2 Prescribed Burn Plan Guidelines.
NSW	RFS	RFS (2006) *A Guide for Councils, Planners, Fire Authorities and Developers.* Planning for bush fire protection.
NSW	RFS	RFS (Undated) *Standards for low intensity bush fire hazard reduction burning (for private landholders).*

Source Jurisdiction	Agency	Document title
NSW	RFS	RFS (2006) *Planning for Bush fire Protection.* Determining Asset Protection Zones. Appendix 2.
NSW	RFS	RFS (Undated) Classification of Vegetation Formations.
NSW	RFS	RFS (Undated) *Application Instructions for a Bush Fire Hazard Reduction Certificate.* NSW Rural Fire Service.
NSW	RFS	RFS (Undated) *Before You Light That Fire.* NSW Rural Fire Service.
NSW	RFS	RFS (2008) *Bush Fire Risk Management Planning Guidelines For Bush Fire Management Committees.* Annex B Rural Fire Service, Bush Fire Coordinating Committee.
NSW	RFS	RFS (2006) *Bush Fire Environmental Assessment Code for New South Wales.* NSW Rural Fire Service.
NSW	RFS	RFS (Undated) *Bush Fire Environmental Assessment Code.* Conditions For Hazard Reductions and Aboriginal Heritage. NSW Rural Fire Service.
NSW	RFS	RFS (2005) *Bushfire Safety Publication – Controlling Bushfires.* NSW Rural Fire Service.
NSW	RFS	RFS (2008) *Bush Fire Risk Management Plan, Bush Fire Management Committees. Annex A* Rural Fire Service, Bush Fire Coordinating Committee.
NSW	RFS	RFS (2008) *Exhibition and Approval Process for Draft Bush Fire Risk Management Plans – Annex 1.* Rural Fire Service, Bush Fire Coordinating Committee.
NSW	RFS	RFS (Undated) *Standards for Asset Protection Zones.* NSW Rural Fire Service.
NSW	RFS	RFS (Undated) *Standards for Low Intensity Bush Fire Hazard Reduction Burning (for private landholders).* NSW Rural Fire Service.

Source Jurisdiction	Agency	Document title
NSW	RFS	RFS (Undated) *Standards for Pile Burning.* NSW Rural Fire Service.
NSW	RFS	RFS (Undated) *Standards for Windrow Burning.* NSW Rural Fire Service.
NSW	RFS	RFS (Undated) Rules and Notes for Implementation of the Threatened Species Hazard Reduction List for the Bush Fire Environmental Assessment Code.
NSW	RFS	RFS (Undated) Rules and Notes for Implementation of the Threatened Species Hazard Reduction List for the Bush Fire Environmental Assessment Code. Animals – Part 2.
NSW	RFS	RFS (Undated) Rules and Notes for Implementation of the Threatened Species Hazard Reduction List for the Bush Fire Environmental Assessment Code. Endangered Ecological Communities – Part 3.
NSW		Van Loon, P. A. (1977) Bushland Fuel Quantities in the Blue Mountains – Litter and Understorey. Forestry Commission of NSW, Research Note No. 33
NT	AFAC	AFAC (2008) *Fire Risks from the Management of Gamba Grass in Northern Australia.* Australian Fire Authorities Council.
NT	CSIRO	Andersen A *et al.* (2005) Fire frequency and biodiversity conservation in Australian tropical savannas: implications from the Kapalga fre experiment. *Austral Ecology* **30**, pp. 155–167.
NT	BFNT	BFNT (2009). *Desert Fire: fire and regional land management in the arid landscapes of Australia.* Desert Knowledge CRC Report Number 37. Bushfires NT, Department of Natural Resources, Environment, the Arts and Sport.
NT	DNRE	Edwards G, Allan G, Brock C, Duguid A, Gabrys K, Vaarzon-Morel P (2008) 'Fire and its management in central Australia'. *The Rangeland Journal,* **30**, pp. 109–121. (Department of Natural Resources, Environment, and the Arts: Darwin).

APPENDIX A CONTINUED

Source Jurisdiction	Agency	Document title
NT	DEWHA	S Atkins & Winderlich S (ed) 2010. *Kakadu National Park Landscape Symposia Series 2007– 2009.* Symposium 3: Fire management, 23–24 April 2008, Aurora Kakadu (South Alligator), Kakadu National Park. Internal Report 566, February, Supervising Scientist, Darwin.
NT		Tropical Savannas CRC (2007) *Kakadu National Park Arnhemland Plateau Draft Fire Plan.* Tropical Savannas CRC Cooperative Research Centre for Tropical Savanna Management.
NT		Trembath, J. (2011) Litchfield National Park Annual Fire Report and Annual Fire Action Plan January 2011 – January 2012 DRAFT – April 2011.
NT		Overarching Top End Parks Fire Management Plan 2011-2016.
NT	BCRC	Parr, C. and Andersen, A. (2006) 'Patch Mosaic Burning for Biodiversity Conservation': a Critique of the Pyrodiversity Paradigm. *Conservation Biology Volume 20, No. 6, 1610–1619.* Society for Conservation Biology.
QLD	QPWS	QPWS (2003) *Fire Management System.* Volume 1: Planning and Reporting. Queensland Parks and Wildlife Service, Environmental Protection Agency, Queensland Government.
QLD	DERM	DERM *(2011) Possible Fire Management Performance Indicators for Land Management Agencies.* Defining the 5% challenge and are there better options? Department of Environment and Resource Management, Brisbane.
QLD	PWS, EPA	Bushfire Conference, Brisbane (2006) *Life In A Fire-Prone Environment:* Translating Science Into Practice. Parkinfo: A Geographic Information System For Land Managers.
QLD	QPWS	QPWS (2006) *Life In A Fire-Prone Environment:* Balancing Ecological Requirements and Hazard Reduction In Burning Practices - Translating Science Into Practice. Queensland Parks and Wildlife Service Fire Management System.

Source Jurisdiction	Agency	Document title
QLD		Department of Local Government and Planning, Department of Emergency Services (2003) *Mitigating the Adverse Impacts of Flood, Bushfire and Landslide* – State Planning Policy 1/03.
QLD		Department of Local Government and Planning, Department of Emergency Services (2003) *State Planning Policy Guideline 1/03.* Mitigating the Adverse Impacts of Flood, Bushfire and Landslide.
QLD	QPWS	QPWS (2012) Planned Burn Guidelines – How to assess if your burn is ready to go. Queensland Parks and Wildlife Service.
QLD	QPWS	QPWS (2012) Planned Burn – Fire Behaviour Tables. Queensland Parks and Wildlife Service.
QLD	QPWS, GCCC	QPWS (2003) *South Stradbroke Island Conservation Park Fire Strategy.* Fire Management System. Queensland Parks and Wildlife Service.
QLD	DPI	DPI Forestry (Undated) Prescribed Burning Guide. Suggested Ignition Guidelines – Native Forests. Department of Primary Industries Forests.
QLD	QRFS	QRFS (2010) *Instructions for completing the QRFS Prescribed Burn Plan.* Queensland Rural Fire Service.
QLD	QRFS	QFRS (2007) Hazard Reduction Programs – Brigade. Queensland Rural Fire Service.
QLD	QRFS	QRFS (2000) *Standard procedures/guidelines.* Chief Fire Warden/Fire Warden Manual. Queensland Rural Fire Service.
QLD	QRFS	QRFS (2011) *Fire Management Guidelines.* The Clark Connors Range Bushfire Consortium. Queensland Rural Fire Service.
QLD	QRFS	QRFS (2011) *Fire Management Guidelines.* Cape York Peninsula. Queensland Rural Fire Service.

APPENDIX A CONTINUED

Source Jurisdiction	Agency	Document title
QLD	MLA	MLA (2002) *Grazing Land Management – Education Package Technical Manual.* Meat and Livestock Australia.
QLD	MLA	MLA (2010) *Enhancing adoption of improved grazing and fire management practices in northern Australia: Synthesis of research and identification of best bet management guidelines.* John McIvor CSIRO Sustainable Ecosystems.
SA	CFS	CFS (2010) *CFS Fact Sheet:* Information Collection. No. 30. Country Fire Service
SA	DENR	DENR (2011) *Operational Prescriptions Field Guide* Prescribed Burning in South Australia. Department of Environment and Natural Resources.
SA	DENR	DENR (2011) *Operational Prescriptions Field Guide* Prescribed Burning in South Australia: Review of Operational Prescriptions. Department of Environment and Natural Resources.
SA	DENR	DENR (2011) *Overall Fuel Hazard Guide:* for South Australia. Second Edition. Department of Environment and Natural Resources.
SA	DEH	DEH (2009) *Fire Management Plan Billiatt District 2009-2019.* Department for Environment and Heritage.
SA	DEH	DEH (2009) *Fire Management Plan Bookmark Mallee District 2009-2019.* Department for Environment and Heritage.
SA	DEH	DEH (2009) *Fire Management Plan Cape Forbin Integrated Fire Management Plan 2009-2019.* Department for Environment and Heritage.
SA	DEH	DEH (2009) *South Australia Prescribed Burning Code Of Practice February 2009.* Department for Environment and Heritage.
SA	DENR	DENR (2011) *Fire policy and Procedure Manual.* The Department of Environment and Natural Resources.

Source Jurisdiction	Agency	Document title
SA	DEH	DEH (2011) *Fire Management Plan Reserves of the Onkaparinga Valley 2011 - 2021.* Department for Environment and Heritage.
SA	DEH	DENR (2009) *Fire policy and Procedure Manual.* The Department of Environment and Natural Resources.
SA	DEH	DEH (2009) *Fire Management Plan Reserves of the Hills Face Zone, Mount Lofty Ranges 2009-2019.* Department for Environment and Heritage.
SA	DEH	DEH (2004) *Interim Environmental Assessment Table Guidelines.* Department for Environment and Heritage.
SA	DEH	DEH (2010) *Fire Management Plan Reserves of the Lower Yorke Peninsula, 2010-2020.* Department for Environment and Heritage.
SA	DEH	DEH (2009) *Fire Management Plan Ngarkat District, 2009-2019.* Department for Environment and Heritage.
SA	DEH	DEH (2004) *South Australia Prescribed Burning Code of Practice.* Department for Environment and Heritage.
SA	DEH	DEH (2011) *Operational Prescriptions Field Guide – Prescribed Burning in South Australia.* Department for Environment and Heritage.
SA	DEH	DEH (2004) *Risk Assessment – Consequences.* Department for Environment and Heritage.
SA	DEH	DEH (2010) *Prescribed Burning in South Australia: Review of Operational Prescriptions.* Department for Environment and Heritage.
SA	DEH	DEH (2009) *Fire Management Plan Reserves of the Southern Eyre Peninsula, 2009-2019.* Department for Environment and Heritage.
SA	DEH	DEH (2009) *Fire Management Plan Reserves of the Southern Flinders Ranges, 2009-2019.* Department for Environment and Heritage.

Source Jurisdiction	Agency	Document title
SA	DEH	DEH (2009) *Fire Management Plan Reserves of the Southern Foothills, Mount Lofty Ranges, 2009-2019.* Department for Environment and Heritage.
SA	DEH	DEH (2009) *Fire Management Plan Reserves of the South-Western Fleurieu Peninsula, 2009-2019.* Department for Environment and Heritage.
TAS	TFS	TFS (2005) *Guidelines for development in bushfire prone areas of Tasmania. Living with fire in Tasmania.* Tasmania Fire Service.
TAS	TFS	TFS (Undated) *Guidelines for Vegetation Burning*
TAS	PWS, TFS, FT	Marsden-Smedley JB 2009. *Planned burning in Tasmania: operational guidelines and review of current knowledge.* Fire Management Section, Parks and Wildlife Service, Department of Primary Industries, Parks, Water and the Environment.
TSA	TPWS	Taylor, D. and Wallace, L. (Undated) *Bushfire Risk Assessment Model – A Quantified Method of Determining Bushfire Risk Spatially in Tasmania.* Department of Primary Industries, Parks, Water and the Environment, Parks and Wildlife Service, Hobart, Australia.
TAS	TPWS	TPWS (2012) *Northwest Region Strategic Fire Management Plan.* Department of Primary Industries, Parks, Water and Environment.
TAS	TPWS	TPWS (Undated) *Planned Burning Procedures – Process Map.* Department of Primary Industries, Parks, Water and the Environment.
TAS	TPWS	TPWS (2009) *Operational Guidelines and Review of Current Knowledge – Planned Burning in Tasmania.* Department of Primary Industries, Parks, Water and the Environment.
VIC	CFA	CFA (2010) *A guide to retrofit your home for a better protection from a bushfire.* Building and renovation ideas to better prepare your home in a bushfire situation. Country Fire Authority.

Source Jurisdiction	Agency	Document title
VIC	CFA	CFA (Undated) *Preparing your property.* Make your home bushfire ready. Country Fire Service.
VIC	CFA	CFA (2011) *Community Safety Directorate.* Evaluation and effectiveness project.Evaluation report. Country Fire Authority.
VIC	CFA	CFA (1999) *Business planning and Review.* Grassland Curing Guide. Victorian Country Fire Authority.
VIC	CFA	CFA (2011) *Stay and Defend.* Section 05 Defending your property – Stay and actively defend. Country Fire Authority.
VIC	CFA	CFA (2011) *Prepare. Act. Survive.* – Fire Ready Kit – Complete. Country Fire Authority.
VIC	CFA	CFA (2011) *Landscaping for bushfire* – Garden design and plant selection. Country Fire Authority.
VIC	CFA	CFA (2010) *Bushfire Neighbourhood Safer Places, Places of Last Resort* – CFA Assessment Guidelines Country Fire Authority.
VIC	CFA	CFA (2011) *A best practice approach to shelter-in-place for Victoria.* Country Fire Authority.
VIC	DNRE	DNRE (Undated) *Victoria's Native Vegetation Management – A framework for action.* Department of Natural Resources and Environment.
VIC	CFA	CFA (2007) *Building in a Wildfire Management Overlay* – Applicant's Kit 2007. Country Fire Authority.
VIC	CFA	CFA (2010) *Building in a Wildfire Management Overlay* – Applicant's Workbook 2010. Country Fire Authority.

APPENDIX A CONTINUED

Source Jurisdiction	Agency	Document title
VIC	CFA	CFA (Undated) *Building in a Wildlife Management Overlay* – Property bushfire preparation and native vegetation management. Case Study 1. Country Fire Authority.
VIC	CFA	CFA (2007) *Chief Officer's Standard Operating Procedure.* Procedures for Fuel Reduction Burning. Country Fire Authority.
VIC	CFA	CFA (2011) *Prepare. Act. Survive. Section 03* – Your Property, How prepared is it? Country Fire Authority.
VIC	CFA	CFA (2011) *Chief Officer's Standard Operating Procedure.* Procedures Conducting a Prescribed Burn or Burn Off. Country Fire Authority.
VIC	CFA	CFA (2011) *Chief Officer's Standard Operating Procedure.* Procedures for Planning a Prescribed Burn. Country Fire Authority.
VIC	DEPI	Code of Practice for Fire Management on Public Lands (2012). Fire management Policy framework and including principles and program standards for prescribed burning.
VIC	DEPI	Fire Management Manual 2.1 Fire Operations Planning (2010). Step by step guide to developing a Fire Operations Plan.
VIC	DEPI	Fire Management Manual 10.1 Prescribed Burning Operating procedures for prescribed burning.
VIC	DEPI	Guidelines and Procedures for Ecological Burning on Public Land in Victoria 2004.
VIC	DEPI	Overall Fuel Hazard Guide (2010).
VIC	DEPI	Synopsis of the Knowledge Used in Prescribed Burning in Victoria. (Tolhurst, K.G. and Cheney, N.P. 1999)

Source Jurisdiction	Agency	Document title
VIC	DEPI	Step by Step Guide to Developing a Fire Operations Plan and Timeline Guideline 2.1.1.
VIC	DEPI	Relationships Involved in the FOP Development and Endorsement Process Guideline 2.1.2.
VIC	DEPI	Format and Standard Templates Guideline 2.1.3.
VIC	DEPI	Burn Mapping Standards Guideline 2.1.4.
VIC	DEPI	Management of Aboriginal Cultural Heritage Values During Fire Operations Planning on Public Land Guideline 2.1.5.
WA		EcoFire (undated) Restoring the biodiversity values of the Kimberley savannas, Western Australia.
WA	FESA	FESA (Undated) *Evaporative Air Conditioners, did you know?* Fire and Emergency Services Authority of Western Australia.
WA	FESA	FESA (2007) *The Homeowner's Bush Fire Survival Manual.* Fire and Emergency Services Authority of Western Australia.
WA	FESA	FESA (2011) *Prepare. Act. Survive. Am I At Risk From Bushfire?* Fire and Emergency Services Authority of Western Australia.
WA	FESA	FESA (2003) *Rural Urban Bush Fire Threat Analysis (RUBTA).* Fire and Emergency Services Authority of Western Australia.
WA	FESA	FESA (2009) *Winter Burning Guide.* Fire and Emergency Services Authority of Western Australia. Bush Fire and Environmental Protection Branch.

Source Jurisdiction	Agency	Document title
WA	FESA	FESA (2008) *Grass Curing Visual Guide for Western Australia.* Bush Fire & Environmental Protection Branch, June 2008 Fire & Emergency Services Authority of Western Australia.
WA	FESA	FESA (2007) *Visual Fuel Load Guide for the Kimberly Region.* Bush Fire & Environmental Protection Branch, Fire & Emergency Services Authority of Western Australia.
WA	FESA	FESA (2010) *Model Bush Fire Management Plan.* Bush Fire & Environmental Protection Branch, Fire & Emergency Services Authority of Western Australia.
WA	FESA	FESA (2007) *Visual Fuel Load Guide for the Pilbara Region.* Bush Fire & Environmental Protection Branch, Fire & Emergency Services Authority of Western Australia.
WA	FESA	FESA (2010) *Planning for Bush Fire Protection.* Guidelines: edition 2. Western Australian Planning Commission and the Fire and Emergency Services Authority.
WA	FESA	FESA (2010) *Visual Fuel Load Guide for the Denmark Shire.* Bush Fire & Environmental Protection Branch, Fire & Emergency Services Authority of Western Australia.
WA	FESA	FESA (2010) *Visual Fuel Load Guide for the Esperance Plains.* Bush Fire & Environmental Protection Branch, Fire & Emergency Services Authority of Western Australia.
WA	FESA	FESA (2010) *Visual Fuel Load Guide for the Goldfield Region. Part 1.* Bush Fire & Environmental Protection Branch, Fire & Emergency Services Authority of Western Australia.

Source Jurisdiction	Agency	Document title
WA	FESA	FESA (2010) *Visual Fuel Load Guide for the Goldfield Region. Part 2.* Bush Fire & Environmental Protection Branch, Fire & Emergency Services Authority of Western Australia.
WA	FESA	FESA (2007) *Visual Fuel Load Guide for the vegetation of the Swan Coastal Plain including Geraldton Sandplains and Leeuwin Ridge Regions of Western Australia. Part 1.* Bush Fire & Environmental Protection Branch, Fire & Emergency Services Authority of Western Australia.
WA	FESA	FESA (2007) *Visual Fuel Load Guide for the vegetation of the Swan Coastal Plain including Geraldton Sandplains and Leeuwin Ridge Regions of Western Australia. Part 2.* Bush Fire & Environmental Protection Branch, Fire & Emergency Services Authority of Western Australia.
WA	FESA	FESA (2008) *Information Note – Why do we need to manage fuel loads in the urban/forest interface zone?* Fire & Emergency Services Authority of Western Australia.
WA	FESA	FESA (2008) *Information Note – What is a building protection zones?* Fire & Emergency Services Authority of Western Australia.
WA	FESA	FESA (2007) *Kimberley Bush Fire - Burning Guidelines and Firebreak Location, Construction and Maintenance Guidelines.* Fire & Emergency Services Authority of Western Australia.
WA	DAFWA	DAFWA (2009) *Bushfire Generated Smoke Taint in Grapes and Wine.* Department of Agriculture and Food, Western Australia.
WA		Smart, R. (2008). *Report On The Possibility Of Air Pollution From A Biomass Power Station Affecting Neighbouring Vineyards And Wineries.* Smart Viticulture.
WA	DEC	FMSB (Undated) *Armstrong, R. Regional Fire Management Plans.* Fire Management Services Branch.

APPENDIX A CONTINUED

Source Jurisdiction	Agency	Document title
WA	DEC	DEC (2009) *Goldfields Regional Fire Management Plan 2008 – 2013*. Department of Environment and Conservation Government of Western Australia.
WA	DEC	DEC (2009) *Kimberley DEC Regional Fire Management Plan 2008 – 2013.* Department of Environment and Conservation Government of Western Australia.
WA	DEC	DEC (2009) *South Coast Regional Fire Management Plan 2009 – 2014.* Department of Environment and Conservation Government of Western Australia.
WA		Woinarski, J., Russell-Smith, J., Andersen, A. and Brennan, K. (2009). *Fire management and biodiversity of the western Arnhem Land plateau.* Culture, Ecology and Economy of Fire Management in North Australian Savannas.
WA	DEC	Butler, R. and Wall, A. (2010) *Results of Prescribed Burning Program for the Goldfields Region Autumn/Winter/Spring 2010.*
WA		Wall, A. (2009) *Results of Prescribed Burning Program for the Goldfields Region Autumn 2009.*
WA	DEC	Hartherley, E. (2009) *Kimberley Early Dry Season Burning Program 2009.* Regional Fire Coordinator Kimberley Region.
WA	DEC	DEC (2008) *Fire Management Guideline No. E2 Tingle Forest.* Fire Management Services. The Department of Environment and Conservation.
WA	DEC	DEC (2010) *Fire Management Guideline No E8 Southern Forest and Shrubland Mosaic.* The Department of Environment and Conservation.
WA	DEC	DEC (2008) *Fire Management Guideline No. S9 Cypress (Callitris spp.)* The Department of Environment and Conservation.

Source Jurisdiction	Agency	Document title
WA	DEC	DEC (2008) *Code of Practice for Fire Management.* Department of Environment and Conservation.
WA	DEC	DEC (2009) *Prescribed Fire Plan.* Fire Operational Guidelines. Department of Environment and Conservation.
WA	DEC	DEC (2011) *Procedures for Daily Fire Season Teleconferencing.* Fire Operational Guidelines. Department of Environment and Conservation.
WA	DEC	DEC (2007) *Good Neighbour Policy.* The Department of Environment and Conservation.
WA	DEC	Butler, R. (2009) *Boorabbin Post-Fire Burning* GPB022 (Goldfields) & YIL003 (Wheatbelt) 5th-10th June 2009 and 4th September 2009.
WA	DEC	DEC (2009) *Parks of the Leeuwin Naturaliste Ridge and Surrounds Wildfire Threat Analysis - South West Region July 2006.* Department of Environment and Conservation.
WA	DEC	DEC (2011) *Master Burn Planning Manual 2011.* Department of Environment and Conservation.
WA	DEC	DEC (2010) *Prescribed Fire System Review and Development.* Department of Environment and Conservation.
WA	DEC	DEC (2005) *Guiding Principles and Strategies for Fire Management in Landscapes Dominated by Spinifex Grasslands in the Arid Interior of WA.* Department of Environment and Conservation.
WA	DEC	DEC (2009) *Pilbara Regional Fire Management Plan 2008-2013.* Department of Environment and Conservation.

Source Jurisdiction	Agency	Document title
WA	DEC	Butler, R. (2008) *Results of Prescribed Burning Program for the Goldfields Region Autumn 2008.*
WA	DEC	Butler, R. (2007) *Results of Prescribed Burning Program for the Goldfields Region Spring 2007.*
WA	DEC	Wall, A. (2009) *Results of Prescribed Burning Program for the Goldfields Region Spring 2009.*
WA	DEC	DEC (2010) *Bushfire Threat Analysis of the Southwest of the Western Australian Goldfields.* Department of Environment and Conservation.
WA	DEC	DEC (Undated) *Quick Overview of Proposal for Describing Large Area Burns in the Remote Regions.* Department of Environment and Conservation.
WA	DEC	DEC (2010) *Bushfire Threat Analysis Method for Remote Regions.* Department of Environment and Conservation.
WA	FESA	FESA (2010) *Guidelines for the development of a Pastoral Station Bush Fire Management Plan.* Bush Fire and Environmental Protection Branch. Fire & Emergency Services Authority of Western Australia.
WA	FESA	FESA (2007) *Firebreak Location, Construction and Maintenance Guidelines.* Fire & Emergency Services Authority of Western Australia.
WA	FESA	FESA (2011) *Guide and Tables for Bushfire Management in Western Australia.* Bush Fire and Environmental Protection Branch. Fire & Emergency Services Authority of Western Australia.
NZ	DCON	Allen, R., Basher, L and Comrie, J. (1996). *'The use of fire for conservation management in New Zealand'.* Science for conservation: 23

Source Jurisdiction	Agency	Document title
NZ	NZFSC	NZFSC (2010) *Rural Firefighter Exposure to Fireground Gases with Relevance to Physiological Workload and Fire Suppression and Productivity.* Fire Research Report. New Zealand Fire Service Commission Research Report Number 108.
US		North, M., Hurteau, M. and Innes, J. (2009) *'Fire suppression and fuels treatment effects on mixed-conifer carbon stocks and emissions'.* Ecological Applications, 19(6), 2009, pp. 1385–1396 2009 by the Ecological Society of America.
US		*Lower North Fork Prescribed Fire:* Prescribed Fire Review (2012). Requested by the state of Colorado Office of Executive Director, Department of Natural Resources Denver, Colorado.

APPENDIX B

NATIONAL BURNING PROJECT – LIST OF SUB-PROJECTS

The objective of the National Burning Project is to use a national approach to reduce the bushfire risk to the Australian and New Zealand communities by the comprehensive management of prescribed burning at a landscape level that balances the operational, ecological and community health risks.

The project will produce a series of outputs through sub projects that together form a framework. The framework will endure long after the project and future projects will be required to add further elements to, update and refresh the framework. There are elements of the framework that are outside the scope of this project and will be delivered separately by the project partners. The current scope of the framework and the component sub- projects are listed in the table below.

#	Short Title	Long Title	Status as at December 2013
1	**Review Fire Science and Knowledge**	Prepare and publish a review of the fire science, operational experience and indigenous knowledge at a national level for all fire bioregions.	Completed
2	**Analysis of Objectives**	Report on an analysis of the tools and methodologies available to balance competing objectives of burning programs and matching these to users needs.	Unfunded Unplanned
3	**Risk and Monitoring Framework**	Design a management and review framework to manage the major prescribed burning risks. Four risks are currently planned: 1. Fuel Hazard 2. Smoke and CO2 emissions 3. Ecological 4. Operational (safety)	Risks 1 and 2 completed. Risks 3 and 4 unfunded.
4	**Best Practice Guideline for Prescribed Burning**	A review of the end to end processes, practices and systems of prescribed burning jurisdictions, land managers and across a range of burning objectives.	This review report completed. Operational practice guideline underway. Strategic practice guideline planned.

#	Short Title	Long Title	Status as at December 2013
5	**National Bushfire Fuel Classification**	Develop a best practice guide for the classification of bushfire fuels	Underway
6	**National Position on Prescribe Burning**	A nationally agreed position is developed and communicated that outlines the principles for the use of prescribed burning.	Planned
7	**Prescribed Burning Competencies**	Define agreed standards for the tasks associated with the planning and conduct of prescribed burns.	Completed
8	**Develop Training Materials**	Develop training materials for prescribed burning for national application.	Underway
9	**Prescribed Burning Training Delivery**	Investigate the options for national training delivery and mutual recognition frameworks.	Unfunded Unplanned
10	**Resource Optimisation**	Develop processes for the sharing of resource between prescribed burning programs.	Unfunded Unplanned
11	**Performance Measures**	Develop performance measures for prescribed burning and design a reporting framework.	Unfunded Unplanned
12	**National Tool Box**	Provide a means whereby prescribed burning tools can be shared between agencies.	Unfunded Unplanned

APPENDIX C
NATIONAL BURNING PROJECT – LIST OF PUBLICATIONS

The National Burning Project will progressively publish a comprehensive library of reports from the sub-project results. The list of planned publications is provided below:

Title	Description	Date of Report	Date of Publish	Authors	Contri-butors
Review of Best Practice for Prescribed Burning	**A report to scope the development of a best practice guide for prescribed burning by reviewing current practices across Australia.**	Dec 2013	March 2014	de Mar P, Adshead D	AFAC, FFMG, AGD, GHD
Risk Management Framework - Fuel Hazards		30 Apr 2012	May 2014	de Mar P, Adshead D	AFAC, FFMG, AGD, GHD
Risk Management Framework - Smoke Hazards		1 Jul 2012	May 2014	de Mar P, Adshead D	AFAC, FFMG, AGD, GHD
Scope and Framework for an Australian Fuel Classification		30 Jun 2011	May 2014	Hollis J, Gould J, Cruz M and Doherty M	AFAC, FFMG, AGD, CSIRO
Australian Bushfire Fuel Classification - Scope and Objective.		31 Aug 2012	May 2014	Gould J, and Cruz M	AFAC, FFMG, AGD, CSIRO
Australian Bushfire Fuel Classification - Glossary		31 Aug 2012	May 2014	Gould J, and Cruz M	AFAC, FFMG, AGD, CSIRO

Title	Description	Date of Report	Date of Publish	Authors	Contri-butors
Australian Bushfire Fuel Classification – Assessment Methodology		31 Aug 2012	May 2014	Gould J, and Cruz M	AFAC, FFMG, AGD, CSIRO
Overview of prescribed burning in Australasia.	**A review of the science and practice of prescribed burning written to provide background to practitioners and information to interested members of the public.**	30 Jun 2012	May 2014	Poynter M	AFAC, FFMG, AGD, CSIRO (reviewer)
Australian Bushfire Fuel Classification – Case Study Report		2013	May 2014	Gould J, and Cruz M	AFAC, FFMG, CSIRO
National Position on Prescribed Burning		2013	2015		AFAC, FFMG
Prescribed Burning Competencies		2013	2015		AFAC, FFMG
Prescribed Burning Training Material – Assist with Prescribed Burn		2014	2015		AFAC, FFMG, BCRC
Prescribed Burning Training Material – Plan Simple Burn		2014			AFAC, FFMG, BCRC

APPENDIX C CONTINUED

Title	Description	Date of Report	Date of Publish	Authors	Contri-butors
Prescribed Burning Training Material – Plan Complex Burn		2014			AFAC, FFMG, BCRC
Prescribed Burning Training Material - Conduct Simple Burn		2014			AFAC, FFMG, BCRC
Prescribed Burning Training Material - Conduct Complex Burn		2014			AFAC, FFMG, BCRC
Best Practice Guide for Operational Prescribed Burning					
Best Practice Guide for Strategic Prescribed Burning					
Australian Bushfire Fuel Classification - Business Case					
Australian Bushfire Fuel Classification - Implementation					
Review of Prescribed Burn Training					

Title	Description	Date of Report	Date of Publish	Authors	Contri-butors
Report on the options for resource sharing in prescribed burning					
Performance Monitoring and Reporting for Prescribed Burning					

NOTES

Review of Best Practice for Prescribed Burning

Report for National Burning Project: Sub-project 4

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