At the Crossroads:
A Comparison of Current Social, Scientific and Political Influences on Fire Management in Australia and the USA

Final Report at the World Forest Institute

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Cover Photo: Prescribed burn under Ponderosa Pine, Deschutes National Forest, Sisters Ranger District. Photo courtesy of Maret Pajutee.

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1 Introduction

In recent years, both Australia and the United States have experienced very large, high-intensity wildfires in forested areas, which have impacted dramatically on human life and high-value assets, as well as on forest productivity and environmental values. Whilst the results from this upsurge in wildfire activity are dramatic, there is considerable deliberation and controversy in both countries as to the causes, as well as the proposed actions that can be taken to mitigate the effects of high-intensity wildfires. In addition, there has been increasing recognition of the role of fire in maintaining ecological processes and functions in forest areas, often described in general terms as 'forest health' issues.

Fire management, and particularly fuel management issues, are hotly debated topics in both countries. As a general observation in the US, there appears to be broad agreement and understanding that 70 plus years of fire exclusion – as a result of the 'Smokey-Bear' policy - in large areas of fire-adapted forest, have led to particularly severe wildfires and serious forest health issues. In essence the debate in the US is not that 'something needs to be done' in terms of fuel management and forest restoration, but rather how it should be achieved.

In Australia, the debate surrounding fuel management, and particularly the role of prescribed burning across forested landscapes, continues to raise passions on the application and validity of the technique.

However, the debate in Australia should not be simplified to the extent of categorizing the opposing standpoints as simply 'burners' versus 'non-burners'. As with most complex issues relating to forest management, there are various shades of gray, with considerable room for misinterpretation of the relative positions. Perhaps a more apt description would be those that favour an approach to risk mitigation through a fire-suppression-oriented 'thin-red line' approach, and those that favour broadscale, landscape level fuel treatments using prescribed burning across extensive forest areas.

The former approach emphasises fuel management and suppression activities geared towards asset protection at the wildland urban interface, whereas the latter approach maintains that better outcomes for both risks to human assets and forest health would be achieved by mimicking a pre-European fire regime, which includes maintaining areas of low-intensity fire across forested landscapes.

The practice of introduced fire and/or prescribed burning is generally in decline in forested areas in south eastern Australia due to increasingly restrictive legislation, a lack of resources, funding, and trained staff as well as changing management ideologies.

There are a number of interconnecting factors which influence the extent and application of fuel management techniques in both Australia and the US:

1. Social and Political – The consideration of social and political contexts for forest fuel management and the recognition of the influence of these, often override the following two factors. Addressing these social and political factors often requires the most energy and effort by land managers, where fuel management operations are proposed.

2. Economic – Even where public, political and scientific opinion favours active forest fuel management, the availability of funding and resources can restrict the amount of prescribed burning achieved, despite the best intentions of land managers or the public. There are increasing calls for fuel treatments to be able to pay for themselves (especially in the US), and without this imperative many proposed works are unable to be implemented.

3. Scientific – Research is an important facet of refining the techniques used in forest fuel management. Often individual research results have been used by both sides of the debate to support their position, with negligible consideration of the overall context or multiple objectives of fuel management. Also, it is important for the results of scientific research to be efficiently translated and incorporated into day-to-day forest management, often called 'adaptive' management.

The purpose of this project is to investigate and compare the social, economic and scientific factors in forest fuel management between the US and Australia, with particular reference to prescribed burning. This paper will focus on fuel management issues of the drier forests of the Pacific Northwest in relation to forest areas in south-eastern Australia, particularly the states of Oregon (US) and New South Wales (Australia).

This paper will discuss the influence of the above factors, as well as describe the context and settings for the current environment surrounding application of fuel management in both countries. This is based on information collected through qualitative surveys and direct interviews with a range of land management agency staff, academics and fire research experts. Other content came through direct observation of the processes and results as well as field visits to experimental sites. Research was collected from June 2004 through June 2005 during a one-year Fellowship with the World Forest Institute in Portland, Oregon.

Following comparative analysis and discussion of the situation relating to forest fuel management in both countries, the findings of this report will include of a number of recommendations applicable in the south-eastern Australian context from lessons and experiences in the US.

2 The Current State of the Debate

Précis

This is a background chapter to provide the contextual setting for the report. What are the similarities and differences between the fire management histories and situations in both countries? It also addresses why prescribed burning is so controversial in Australia. What has occurred in the US to recognise the importance of fuels management and promote the practice?

'The after effects of fire in this region are various, but are always evil, without a single redeeming feature'

John Leiberg, 1899 Forest inspector, California (Arno & Allison-Bunnell 2002)

2.1 Current Perspectives on Fire

The incidence and impacts of forest wildfires have had a long and protracted history in both Australia and the US, even prior to the period of European settlement in both countries. Forest wildfire has and continues to be seen as largely threatening, particularly to ever-growing urban populations. Even the language that is used to describe fire is often dramatic. As reported in the media, fire from one point of view can be destructive, disastrous, or catastrophic. Loss of lives, property, and other assets from wildfire remain realities when wildfire occurs near population centers, and examples in the recent past are still sharp in the public memory. In 2003, the Canberra fires destroyed nearly 500 homes and in the same year in California 2,000 homes were burnt in a single fire.

In general, the public agrees that there is little place for wildfire in urban areas. However, this sentiment still impacts the public's opinion regarding all fires, whether they be prescribed, low intensity, or natural. To complicate matters, in recent years an emphasis has shifted from the impact fire has on human lives and assets to its function in maintaining ecological processes and its purpose and place within the natural environment.

Many opinions exist regarding the role of fire in the natural landscape. Often this issue extends to much larger paradigms of the understanding of the human role within nature and the environment. One opinion is that humans are, and have always been, an integral part of the environment, using available tools to shape and modify the environment for the benefit of man's existence. Another viewpoint maintains that humans were and still remain outside 'mother nature' and that any human impact or activity is viewed as an unnatural disturbance.

The former viewpoint espouses concepts such as management, stewardship, interaction and intervention within the natural environment. Fire is viewed as a management tool used to create change or renewal, and is an essential ecosystem process. There is a place for prescribed burning and some wildfire suppression efforts. The latter position views prescribed fire and suppression of natural occurring fires as interference, intrusion, and meddling with the 'natural' order of things. According to this viewpoint, nature can best manage itself, and should be left to do so without human interference, and attempts to intercede are simply man's attempts to dominate nature.

'…A bitter, fundamental and long-running divide between farmers and foresters on one side and environmentalists on the other….At its core is the fundamental refusal by some to accept that Victoria is a fire-rich environment in which man does not and probably will never have the upper hand.'

John Schauble *The Age* (2004)

2.2 Historical Fire Management in the US and Australia

Extensive parallels exist between the US and Australia in regards to forest fire management. Both countries have a history of indigenous burning, which was predominately eliminated in areas with European settlement over the past few hundred years. Both countries adopted European forestry practices and have since adapted these practices to work with their native landscapes. Both countries have areas of dry forestland that evolved with fire to withstand low intensity burning.

However, during the 1900's the two countries adopted different approaches to dealing with forest fires, resulting in great variation in current day opinion and practice regarding prescribed burning and fuels management. Today, prescribed burning has become very controversial in Australia, yet the US now recognises the importance of fuels management and actively promotes its practice. The following section provides an overview of the historical factors that influenced this split in the road.

Fire Management in the US

In North America, evidence for indigenous settlement and forest development extend back to the last glacial period when the ice sheets retreated north some 11,000 years ago. Burning by North American indigenous peoples was reportedly widespread and extensive (Pyne 2001), and was used for a variety of purposes including providing access and ease of travel, regenerating blueberry, huckleberry and camas fields, protection from summer wildfires, driving game and providing fresh grass regeneration for wildlife (Pyne 1997, Vale 2002). In addition to human caused fires, which would have been used extensively across the landscape, lightning played an important role in adding significantly to the total burnt area in a given year.

With European expansion and settlement into the western areas of North America came an increase in fire activity to clear areas for agriculture. In the late 1800s, new railways became a major source of ignitions. Fire in the immediate post-settlement environment was frequent and extensive, however many of the forests and wildlands remained untamed, and the removal of indigenous peoples to reservation lands with their concurrent fire practices set the fuel scene for the extensive wildland fires seen in the central and western US in the early part of the 20th century. (Arno and Allison-Bunnell 2002)

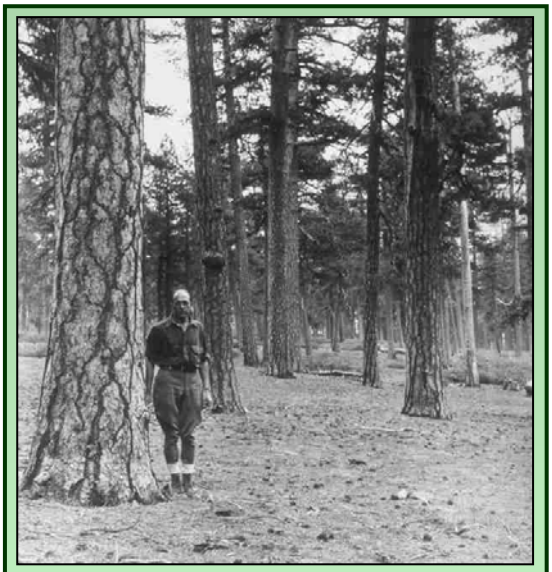
Forestry as a youthful profession in the US had been largely transplanted from northern Europe, bringing with it much of the ideology and concepts regarding fire as a destructive force rather than a renewing or essential process. This was predicated upon northern European perceptions of fire in their environment, an attitude that was ill-suited to the drier forest types in parts of the western US (Pyne 2001).

The catalytic event for fire management and suppression on forest lands was the extensive wildland fires of 1910, which consumed over 3 million acres in northwest Montana and northern Idaho and killed over 80 people. These fires placed great pressure on the recently created Forest Service, which had taken control of managing forestlands only five years previously. The first Forest Service Director, Gifford Pinchot, had earlier in his career begun to recognise the importance of fire in shaping forests and ecological communities, however a great political drive to completely suppress all fires was created as a result of the 1910 experience, and overshadowed all scientific considerations of the role of fire in forest maintenance (Arno and Allison-Bunnell 2002).

Thus the war on fire began. Even early conservation groups, concerned with preserving forest areas in an era of settlement and clearing, justified the crusade against all fire. The Forest Service and federal land agencies were united in a singular purpose, and with increasingly better technology, more efficient firefighting techniques successfully suppressed fire in much of the forest areas in the western US during the mid 20th century (Figure 1, Pyne 1982). Congress even set up specialised funding arrangements to ensure that any and all fire suppression efforts could be paid for. Any distinction between different uses and roles of fire in different forest areas were not widely appreciated (Arno and Fiedler 2005). In 1944, the Smokey Bear campaign was created and still holds the record for the longest running public service campaign in US history.

By the period of the 1970's and 80's the fire prevention message was well-ensconced in the US public psyche. Events like the huge Yellowstone Fires in 1988 and the escape of the prescribed burn which turned into the Cerro Grande Fire which impacted 200 homes in Los Alamos, New Mexico in 2000, only served to reinforce public perception of fire as bad, unnecessary and of course 'unnatural'.

In the US, the unprecedented wildfire seasons of 2000 and 2002 reinforced the message that previous fire suppression and exclusion policies have created significant problems for today's generation of forests and land managers. The introduction of the National Fire Plan (2000), the Joint Fire Sciences Program (1998), the Healthy Forests Initiative (2002) and subsequent Healthy Forests Restoration Act (2003), mark significant recent changes in policy direction on fire and forest management.



There were, of course, a few conflicting opinions regarding fire. In the west in particular, foresters and timbermen pressed for the need for low-intensity fire in place of a fire exclusion policy. One of these was Harold Weaver (above), a forester with the Indian Service in the Department of the Interior in 1930's. Weaver argued that removing fire from Ponderosa (*Pinus ponderosa*) forests had serious consequences for maintaining productive forests (Arno & Allison-Bunnell 2002, OFRI 2004b). But it wasn't until the 1950's and 60's that several scientists in the emerging field of ecology also concluded that attempts to eliminate fire in western forests was a grave mistake. Photo courtesy of OFRI.

Fire Management in Australia & NSW

Records indicate that fire became an important factor in the Australian environment over 50,000 years ago. Similar to the indigenous American inhabitants, the Australian aboriginals used fire extensively often referred to as the art of 'firestick farming' (White 1973 in Bowman 2003). Diaries and records by the early European explorers often indicate that both fire of varying intensities was frequently encountered in the Australian landscape (Cunningham 1806 in Bowman 2003, Ward 2005 pers comm.), however the use of this anecdotal information on aboriginal burning practices is presently subject to considerable debate (Ryan *et al.* 1995, Benson and Redpath 2000, Jurskis 2000, Horton 2003).

The early European settlers in Australia had to adapt to occurrences and extent of fire in the landscape for which they were not accustomed. However, in a similar vein to the early settlers in northwest US, they began to use fire extensively, mainly for clearing and to enhance the green

‘pick’ available for the newly arrived European livestock, and to some degree emulating part of the aboriginal burning practices they had experienced.

The use of low-intensity fire in the 1800’s however, was punctuated by large scale conflagration fires, which caused damage to settlers’ assets in the new colonies. As with the US, fire began to be seen as a destructive force and the fledgling forestry profession also decided that fire exclusion and suppression for the most part was required (Pyne 1998, Cheney 2004).

However, greater threats to forests existed. The timber resource was being degraded by illegal clearing and harvesting in what could best be called a ‘free-for-all.’ In order to protect timber resources, state management agencies were created to oversee public forestland and to impose some degree of regulation (NSW Forestry Act 1916). Fire management and suppression by public agencies, at least initially, escaped the brunt of the public eye.

The major catalyst for rethinking the role of fire in the Australian landscape came with the 1939 Black Friday Fires. These fires in the State of Victoria burnt nearly 2 million hectares of forest and grazing lands and 71 lives were lost. The following Royal Commission of Inquiry into the fires, headed by Judge Leonard Stretton, made a number of recommendations which have affected and shaped land management, forestry and fire prevention and suppression for decades.

> ***‘Where practicable, autumn burning is preferable for protective purposes….It is essential that forest officers who manage fire practices have a thorough knowledge of local forest lore’***
>
> Judge Lenard Stretton (1939)

This recommendation recognises the need for land managers to take responsibility for fire suppression and prevention and the need for locally trained and effective personnel as part of the wider land management ethic.

Australian foresters were unique in recognising early the role that both wildfire and ‘milder’ fire played in the landscape, and they proactively used low-intensity fire to mimic past aboriginal burning practices. These practices began occurring in the 1950’s and were refined during the 1960’s along with considerable research into fire behaviour (Pyne 1998).

As understanding of fire behaviour and fuel dynamics increased, land managers converted the information into practice. Large areas of forest were treated with low-intensity fire through broad scale prescribed burning. Large areas were treated easily using aircraft and incendiary capsules, minimizing intensive ground resources and making the most of the ‘window of opportunity’, when suitable temperature, wind, and moisture conditions could sustain low-intensity fire.

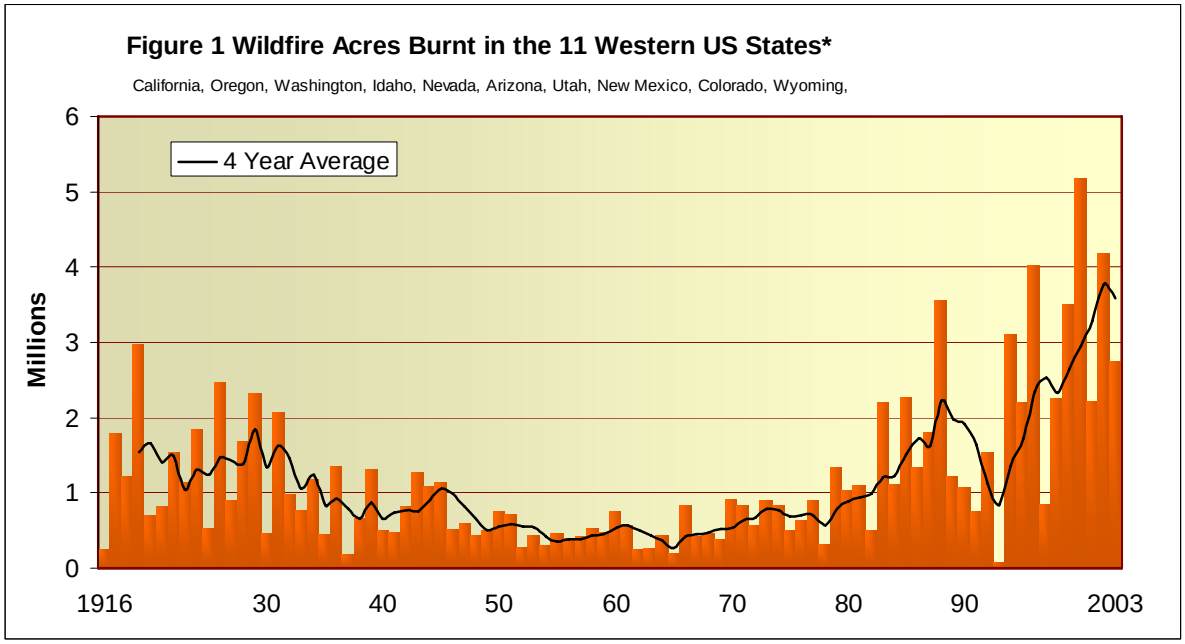
The establishment of conservation agencies, such as the NSW National Parks and Wildlife Service (NPWS) in 1974, saw a shift in focus from multiple-use and timber resource access to preservation and reserve management. Although there was still acknowledgement of the role of fire, a shift occurred in the land management paradigm towards ecological considerations rather than production and protection.

Currently, the practice of treating broad forest areas across the landscape in south-eastern Australia using prescribed burning is waning (State Forests NSW 2002, Cheney 2003, Hodgson 2003, Tolhurst 2003, Hoggett and Hoggett 2004). The principle of permanent preservation

primarily for biodiversity, has called into question the application of broad scale fuel reduction as a valid technique (Whelan 1995, 2002, Gilligan 2002, Good 2002, Ellis *et al.* 2004), as well as increasing emphasis on fire-suppression rather than prevention measures.

2.3 Past Management Leads to the Rising Incidence of Wildfires

Over the last two decades the increasing incidence and extent of wildfires close to population centers in both countries, has given sharp focus to a debate which traditionally was confined to land managers, scientists and the fire management community. As the general populace becomes directly affected through loss of life and assets, as well as the milder effects, such as smoke, increasing focus on wildfire incidence and occurrence becomes a mainstream media event.



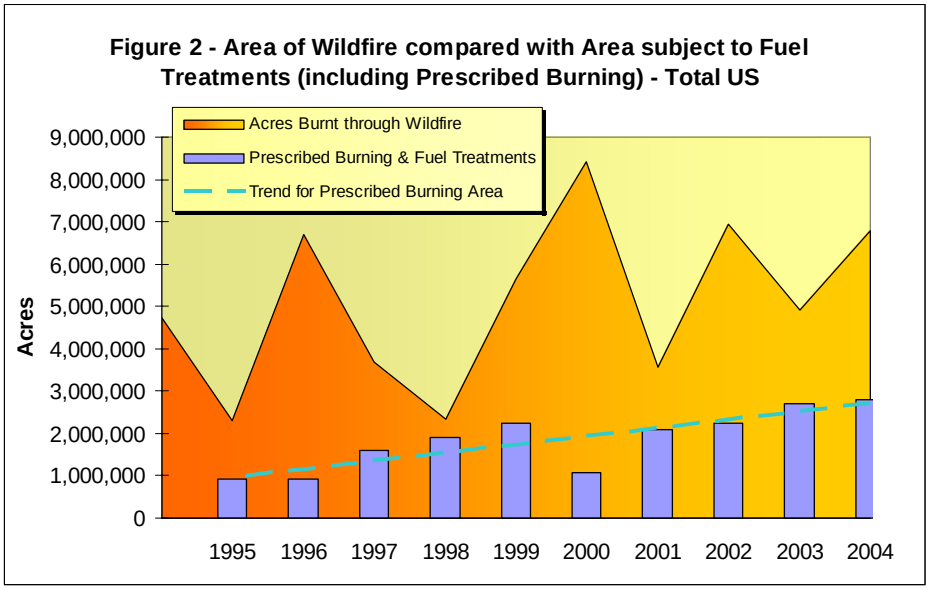
Source: NIFC 2004, OFRI 2004a

The above figure shows the area burnt through wildfire in the 11 western states of the US. The success of the 'war on fire' is evident from the 1920's through to the 1970's, however the longer term effects of vegetation 'thickening', dense crowded forest stands and increased fuel loading did not become evident until the 1980's. The increasing area burnt by wildfire in recent decades is evident and is somewhat disturbing. This is despite advances in fire-fighting technology and better training in suppression techniques.

In Australia, wildfire history is punctuated by intense, large scale events, however, the incidence is again on the rise, particularly in terms of both extent and intensity. It is also important to focus on the regional context of the Australian landscape. In south-eastern Australia, a 45,000 ha bushfire is considered large. The woodlands and savannahs of northern Australia can have total areas of bushfires stretching for well over 20,000,000 hectares in one season (Ellis *et al.* 2004). However, the major population centers and assets are situated in the south-eastern and south-western parts of the country, and so too is the focus on the debate on fire management in forested areas.

2.4 Current Attitudes and Issues Surrounding Fuel Management and Prescribed Burning Practices in Both Countries

The US has begun to move forward from its 'War on Fire.' Smokey Bear has revised his message from 'only you can prevent forest fire' to 'only you can prevent wildfires.' A significant change in public opinion is occurring, albeit slowly, that differentiates between wildfires and low intensity burning. The public is warming to the idea of prescribed burning as a management tool (amongst other techniques), especially in rural communities situated in dry forest areas. In an appropriate context, low intensity burning is viewed as a necessary component for ecosystem health. Figure 2 shows the increasing trend and use throughout the US of prescribed burning and fuel treatments over since 1994.

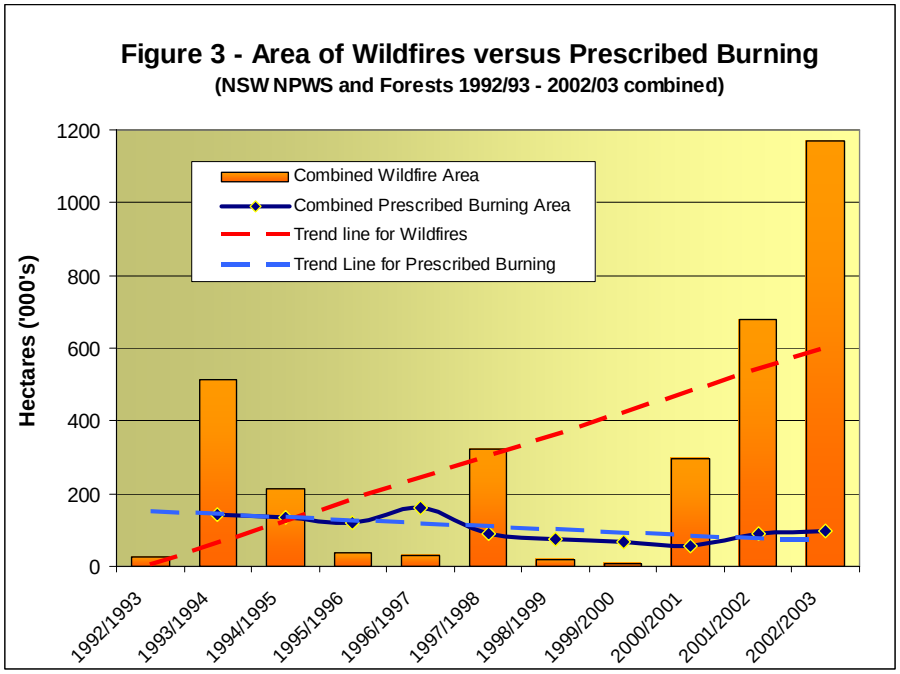


Source: HFI 2002, NIFC 2005

However, prescribed burning can not be examined alone as a fuel treatment. The primary public concern is that, due to the current state of dry US forests, most need to be mechanically thinned before prescribed burning can occur. Many conservation groups are concerned and skeptical that harvesting of any sort, even to improve forest health, may open the door for other types of harvesting (Sierra Club 2003). The distrust between the timber industry, conservation groups and the agencies charged with forest management in the US, is such that numerous lawsuits occur to prevent harvest operations even when in the best interest of the local community (Friends of Metolius 2004). Thus prescribed burning alone does not attract a high level of controversy or attention, but the issue of mechanized thinning does.

In contrast, south-eastern Australia (and particularly NSW) is moving in the opposite direction to the US. Public attitudes towards prescribed or 'controlled' burning have changed over recent decades. Prescribed burning was traditionally practiced as a mitigation and prevention measure by forestry agencies, in order to primarily protect the timber resource for which they were charged with managing. Figure 3 shows the trend in prescribed burning areas treated in NSW over the past ten years for the forest land management agencies (SFNSW and NPWS). Prescribed burning was utilised to a much greater extent over broad forest areas during the 1960's - 1980's.

The rise of the political clout of conservation groups has challenged the idea of prescribed burning as a practical fire management tool (Wilderness Society 2003, NCC 2004). This arises from a deep distrust of forestry agencies, where any traditional operations could be allied with timber harvesting, and a paradigm shift which effectively states that frequent prescribed burning can often have significant (or worse) effects than individual wildfires (National Parks Association of NSW 2002, Whelan 2002, NCC of NSW 2004).



Source: Jurskis *et al.* 2002, NPWS 2004 Annual Reports, SFNSW 2004

This adds to a widespread public perception that prescribed burning can constitute a serious environmental threat in south-eastern Australia, although it appears to be based on misunderstandings of prescribed burning and extrapolation from observations of wildfires (Jurskis *et al.* 2002). The debate has been sustained in the scientific literature and research fields as well (Whelan 1995, McCarthy and Tolhurst 2001, DSE 2002, Cary *et al.* 2003, Horton 2003).

The positions taken are often diametrically opposed, and generally consist of forestry interests, graziers, landholders and sometimes local bushfire brigade volunteers versus conservation NGOs, conservation agencies, government bureaucracies, and some urban-based politicians (Schauble 2004). Much of the scientific literature deals with the effects of 'fire' *per se* on individual species or micro components of the ecosystem, where as land managers, must not only take these factors into account, but also wider 'public good' parameters, including protecting local communities from wildfire.

3 Fire Regimes & Changing Management – What Do We Want Our Forests For?

Précis

Ask anyone, scientist, student, politician or businessman, what the role of fire should be in forested landscapes, and their varied answers will no doubt involve some implicit value judgement, often only a vague notion of what is 'good for forests' as well as what 'forests are good for.'

So how do we define 'what is good for forests?' and 'what do we want from our forests?' These questions are critical to how we respond to whether prescribed burning should have a role in forest management. This chapter examines these questions within the context of current scientific knowledge and public sentiment.

3.1 Looking to the Past—If Trees could Talk

One approach to understanding the role of fire is to ask how fire affected the forest landscape throughout history. Dendrochronology, and newer scientific methods of examining tree morphology, allow us a peek into the past lives of forest stands and the fires they have withstood through time.

Analysis of previous forest fire histories has been conducted in both the US and Australia, with varying results, but common themes. Arno & Fiedler (2005), Agee (1993) and others have found that in the drier forests of the Pacific North West, fire was a regular visitor, and was responsible for the long term maintenance of species and sustainable forest structure. Such evidence can be seen from tree ring and fire scar analysis (as shown in Figure 4). Arno and Allison-Bunnell (2002) have shown that fire intervals in Ponderosa pine forests were fairly regular and occurred every 27 years on average.

Figure 4: Tree Ring analysis by Arno, Agee and others – shows that fire was a regular visitor prior to European settlement of the inland western Ponderosa Pine forests. Photo courtesy of author.

Recent studies though by Ward and Lamont in Western Australia on *Xanthorea* grasstrees or Bulga, have shown more precision (Ward *et al.* 2001). Through a non-destructive sampling technique by removing the charred outer stem of the Bulga, fire history (including lower-intensity fires) becomes discernible. This method shows regular fire intervals of 3-4 years for open woodlands and dry sclerophyll forest types prior to European settlement of the area.

This new technique for determining fire regimes could potentially be examined for application other areas in

Australia, as grasstrees are a fairly common element in particularly drier forest and woodland landscapes (Lamont *et al.* 1999, Ward pers comm. 2005). Application of this technique could be more problematic in eastern Australian states, as effects from European settlement date for over 200 years, and different species of grasstrees also exist.

It is now generally accepted that indigenous peoples on almost every continent, used fire in the landscape for a variety of reasons (Pyne 1982, Flannery 1994, Vale 2002). It is often the extent and derivation of man's role in promoting fire and the effect on vegetation that is debated (Flannery 1994, Benson and Redpath 2000, Jurskis 2000, Horton 2003). Bowman (2003) has stated that aborigines traditionally managed for a few core species, but none-the-less managed to preserve the biodiversity we see today in Australian forests.

Aboriginal burning could have conceivably occurred in most areas of the country. Fires were lit for ceremonies, hunting, camping, warfare, clearing access routes, protecting food resources and encouraging regeneration and of course, by accident, as wandering tribes carried with them the glowing coals for the next night's camp (Bowman 2003). In any event, the numerous lightning strikes that occurred would have only added to the mosaic of burnt-to-unburnt patches across the landscape, at a whole range of varying sizes and regimes. This effect still is occurring in the northern and western drier areas of Australia (Cary *et al.* 2003).

3.2 Defining 'Forest Health'

Our perspective on the proper role for prescribed fire is largely influenced by a somewhat nebulous notion of what is good for forests. For scientists, the concept of 'forest health' was only recently developed, though its application in the US and Australia differ.

In the US, the concept of 'forest health' has been expounded since the late 1960's from

Forest Health in the Urban Parks Context

The following example illustrates changes in forest health, within Canberra Nature Park (Gossan Hill). This area is a dry sclerophyll forest consisting of Red Stringybark (*Eucalyptus macroryncha*) and the predominant shrub layer (seen here) consists of Native Cherry (*Exocarpos cuppressiformis*).

***Exocarpos* is a hemi-parasite from the Family Santalacae, which attaches its own roots to its host trees thus depriving it of nutrients. It spreads underground though root suckers as well as by seed. Although a component in normal healthy forest populations, it rarely reaches more than 10-20 stems per hectare, however, in this situation stem counts of both adult and juvenile *Exocarpos* range in 100's of stems/ha.**

The effect of increasing *Exocarpos* encroachment on the dominant forest species is dramatic, as combined with other stress factors, such as drought, the majority of the forest canopy has been affected – with many Red Stringbybarks dead or dying. Fire could be used to control *Exocarpos* densities when young, however after a long fire interval (in this case over 30 years), many of the juveniles have reached adult status and could only be killed through moderate to high-intensity fire. This is unlikely to be implemented on the urban/nature park interface (due to public concerns), so alternative methods for restoring previous forest structure to these areas may need to be employed. Information on the appropriate application of fire regimes in these situations is scant and presents issues problems for land managers, where maintaining the amenity and ecological value of the parks is the primary objective (Lhuede pers comm. 2004). Photo courtesy of Nick Luede

various forest ecologists in the US, but really only found a mainstream path during the 1990's and into the current decade.

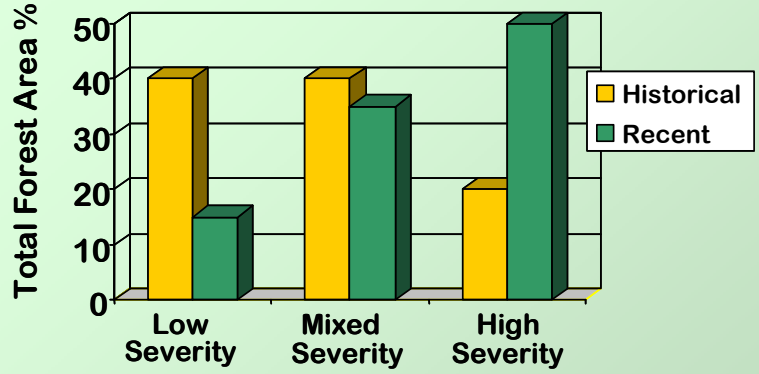


Figure 5: The above graph shows the broad change in fire regimes from historical pre-1900 times compared with the proportion of forest areas burnt under the current fire regimes in US western inland forests. There has been a decrease of low-severity fire regimes, with a corresponding increase in high-severity stand-replacing fire. Research in Western Australia and Victoria tends to indicate that more frequent, patchy but lower severity fires regimes more common prior to European settlement in certain Australian forests (DSE 2002, Lamont *et al.* 2003), reflecting a similar trend (after Arno and Allison-Bunnel 2002).

The term 'forest health' is somewhat of a misnomer as the definition of what constitutes a healthy forest is a value judgement depending on the observer and desired outcome for the stand. As an example, decline or death of 10% of forests for timber production purposes may be unacceptable and deemed 'unhealthy', whereas in old growth stands 25% of the standing timber may be dead or dying and this may be acceptable in terms of the desired outcome (Arno and Allison-Bunnell 2002).

Perhaps a better way of describing forest 'health', is to define it as the maintenance of historical ecological functions appropriate for the seral stage of the forest, without compromising future sustainability. This acknowledges the dynamic nature of the forest, its capacity to change with time, as well as recognising the historical context (Agee 2005 pers comm.).

Species composition can and does change with time, along with forest structure. However, if increasing encroachment from off-site species, such as White fir and Douglas-fir in Ponderosa pine forests, increases fuel loads and flammability to the extent that wildfires will potentially eliminate all species from the site, this can be defined as 'unhealthy'. The US Forest Service has used the evidence of previous fire regimes to determine 'Forest Condition Class' across much of the US (Figure 6).

Table 1: Number of trees per acre in 1900 and 1991 in a dry-site forest in Montana. No harvesting has occurred and the last frequent fire episodes date back over a century.

	1900		1991	
	Ponderosa	Doug Fir	Ponderosa	Doug Fir
Small Trees (< 100 yrs)	6	19	122	1,010
Large Trees (> 100 yrs)	17	13	24	25

(reproduced from Arno and Allison-Bunnell 2002)

The term 'healthy forests' is also used in the context of disease, insect pests and other pathogens that can infect and kill the dominant forest types. The current issues are not that these diseases and pests – like spruce budworm – should not be part of the forest. They are an integral part of ecological processes. The issue is that, due to overcrowding and stagnating dense stands, these afflictions are more widespread and prevalent than recorded in the past. If this is due to human

interference (via fire exclusion) then this could be regarded as 'unnatural', or at least at variance with the historical fire regime (Table 1, Figure 5).

The problems associated with forest health are not limited to the US, however recognition of disruption to ecological functioning has not been as widespread in Australia. Although the symptoms of dieback and other diseases in Australian forests have been recognised and studied over the past few decades (Florence 2005), the role of fire (and particularly low-intensity fire) in maintenance of forest health and ecological processes has only recently been identified and researched (DSE 2002, Jurskis *et al.* 2002, Tolhurst *et al.* 1992, Tolhurst 2003b, Jurskis 2004).

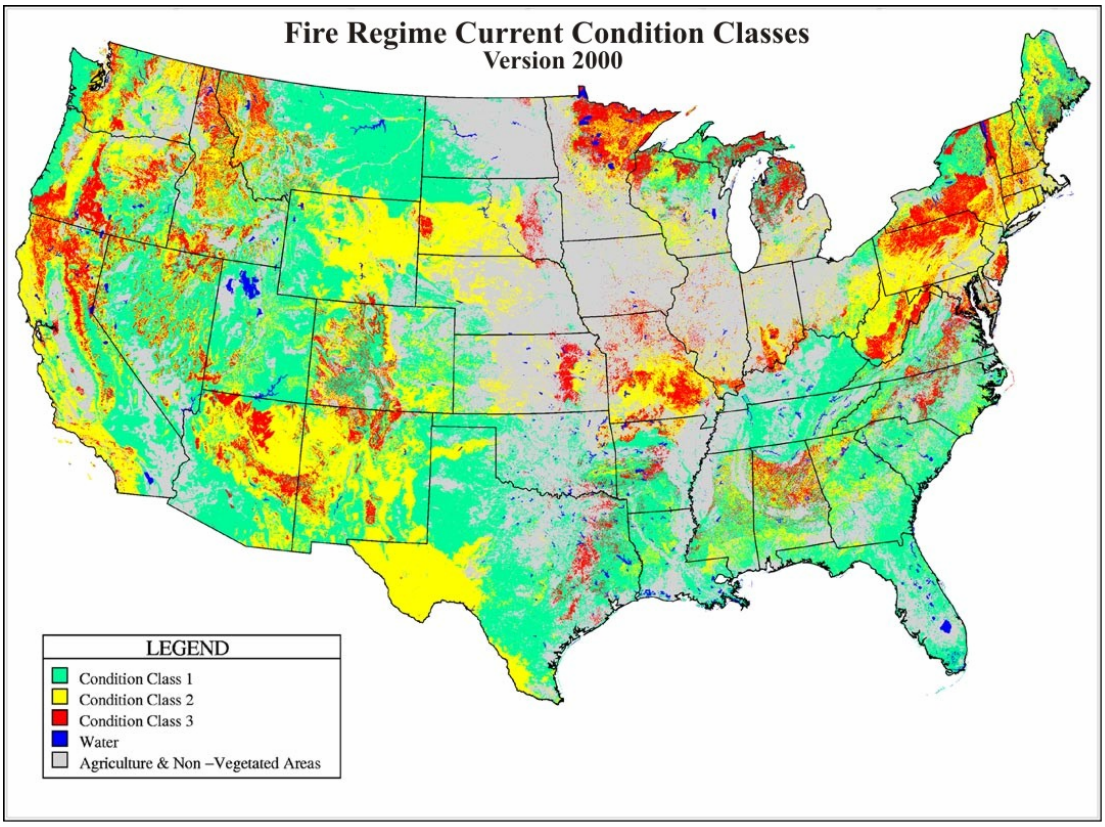


Figure 6: Current Fire Regime Condition Class across the continental United States.

Fire Regime Condition Class	Description	Potential Risks
Condition Class 1	Within the natural (historical) range of variability of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances	Fire behavior, effects, and other associated disturbances are similar to those that occurred prior to fire exclusion (suppression) and other types of management that do not mimic the natural fire regime and associated vegetation and fuel characteristics. Composition and structure of vegetation and fuels are similar to the natural (historical) regime. Risk of loss of key ecosystem components (e.g. native species, large trees, and soil) are low
Condition Class 2	Moderate departure from the natural (historical) regime of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances	Fire behavior, effects, and other associated disturbances are moderately departed (more or less severe). Composition and structure of vegetation and fuel are moderately altered. Uncharacteristic conditions range from low to moderate; Risk of loss of key ecosystem components are moderate
Condition Class 3	High departure from the natural (historical) regime of vegetation characteristics; fuel composition; fire frequency, severity and pattern; and other associated disturbances	Fire behavior, effects, and other associated disturbances are highly departed (more or less severe). Composition and structure of vegetation and fuel are highly altered. Uncharacteristic conditions range from moderate to high. Risk of loss of key ecosystem components are high

Source: USDA Forest Service 2002

3.3 Seeing the Forest for the Trees

Although the broad concept of 'forest health' is less developed in Australia than in the US, many ecologists and scientists in Australia employ a more narrowly-focused approach to defining what is 'good for the forest', by answering in terms of what they believe forests are good for, namely, providing ecological biodiversity. One of the approaches involves the use of so-called 'filters.'

Recent conservation targets and recovery plans in NSW (NSW NPWS 2005) for biodiversity involve the metaphor of filters – which are conservation strategies that are designed to 'catch' elements of biodiversity so that ecosystems and the species within them do not fall between the 'mesh' and disappear. Filters are usually grouped as either fine or coarse. Coarse filter conservation strategies seek to preserve biodiversity by maintaining the variety of ecosystems across the landscape. The theory behind this approach is that ecosystems that are managed to preserve their natural composition, structure and function will retain the vast majority of species that evolved within these or similar ecosystems (Agee 2003).

Fine filter approaches are species or population specific plans that are designed to capture elements that have slipped through the coarse filter. Fine filter strategies targeted as saving small ecosystems, or even one particular endangered species, are critically important to longer term conservation strategies, however they can effectively clog the coarse filter strategies, with commensurate detrimental effects (Agee 2003). The focus on individual ecosystems and their unique characteristics usually reinforces a 'no-disturbance' mentality, a version of the 'Precautionary Principle' (Rio Declaration 1992). This can present significant problems for the land manager, as it can not be applied over large areas, the interactions between ecosystems are unknown and attempting to preserve them results in enormous costs, or more usually management paralysis (Hoggett and Hoggett 2004).

Many in the conservation and scientific community in Australia, have focused on the fine filter approach, and based much of their hypotheses, interpretation and recommendation for caution in the application of low-intensity prescribed burning on the life-cycle analysis of individual species (Good 1985, 2002, Whelan 1995, York 1999, 2000, Bradstock 2002, Lindenmayer 2003). This may seem a prudent and cautious approach, however this is still grounded in the 'minimal' or 'no-disturbance' preservation philosophy.

In addition it should be recognised that wildfires in themselves are a coarse filter, and wildfires do not care about boundaries (human or ecological). Wildfires simply follow the laws of physics and fire behaviour (Pyne 2002).

Also, undertaking prescribed burning is akin to being a 'little bit pregnant', in reality either you are or you are not. Similarly, you either undertake the activity of prescribed burning, or not. There are modifiers, such as weather and fuel conditions which can mitigate physical effects, such as patchiness, scorch height, and fine fuel consumption. However the fundamental approach to prescribed burning is one of fire applied as a coarse filter across the landscape.

Most land managers recognise that there will be changes in species composition and/or distribution as a result of any disturbance, and it is impossible to maximise the habitat potential for every single species on every hectare of land. If there is a primary goal for conservation outcomes, it is that species should be conserved across the landscape, and although individuals or small populations may die-out at one particular location, they may fact be flourishing nearby (Jurskis *et*

al. 2002). The context in this case must consider whether the fine filter should be applied at 1 ha, 100 ha or at 10, 000 ha resolution. Thus biodiversity and ecosystem health must be measured at a broad landscape level to have much meaning in terms of conservation outcomes. Similarly, the argument would be that active management must be applied at a broad level if working towards outcomes is to be achievable (Agee 2003).

Also, the stochastic nature of wildfires, that always have, and will continue to occur throughout the landscape, should be taken into consideration. These can not be predicted and provide further diversity in terms of the fire regimes when allied with low-intensity fire applications.

Even the best of conservation intentions can result in some unexpected consequences, as demonstrated by the situation occurring with the northern spotted owl in dense forests, which were historically more open and less suitable in terms of habitat (see side panel).

In the Australian context, many forest management agencies could face the dilemma of trying to create forest conditions to suit one particular threatened species, only to find that another has become rare or endangered as a consequence.

Decisions on forest health, desirable conservation outcomes, and through them fire management, then become much more value-orientated from societies' point-of-view. Management must then take account of how society sees the value in what they are doing (or not doing), and adjust practices accordingly. This is further discussed in Chapter 5.

The Northern Spotted Owl Dilemma

It is now generally well accepted that there have been significant changes to structures of the drier forests of the Eastern Cascades over the past century, due mainly to human influences, including fire exclusion, timber harvesting, and subsequent changes to the previous historic fire regimes.

The iconic northern spotted owl is also found in these forests, albeit in lower densities than on the western side of the Cascades. Interestingly, the frequency of detection and fecundity rates of spotted owls seem to be correlated with stand condition class in these forests. In forests with a typical structure more akin to historical conditions (grassy and open), spotted owl frequency and fecundity is low. In modified forest areas (with much greater stand densities, vertical structure and consequently 'ladder' fuels) spotted owls are found in greater numbers with greater fecundity.

Spotted owls in the latter case may actually be off-site (with a major but 'unnatural' range expansion) and have benefited from the current stand conditions, which reflect a modified traditional habitat. Agee (2005 pers comm.) maintains that given the previous extent and condition of drier eastern forests, spotted owls were probably always there in low numbers, with commensurately lower fecundity.

Unfortunately, due to the size, extent and greater intensity of wildfires in these modified forests, the favourable habitat for spotted owls may decrease as much as 2/3 over the next 100 years (the time frame for the NW Forest Plan). These areas will regrow over time but as far as the NW Forest Plan is concerned, they will be lost from the pool of available habitat. Ironically, measures intended to help spotted owl populations have resulted in less available habitat, not more.

Another factor in this mix, is the invasion of the barred owl, which seems to replace spotted owl populations in forest areas where it has invaded. The barred owl originated from the east coast of the US and made its way through Canada to the west coast. This may constitute the greatest single threat to continuing spotted owl populations. Photo courtesy of USDA FS.

3.4 Implications of Forest Tenure and their Impact on Fire Management in Australia

'Those that own the fuel, own the fire'
Phil Cheney (2004)

Who owns a given piece of forestland can have serious implications for fire management, because different forest ownership types have different objectives for the forest. Within Australia, and particularly NSW, formal parks and reserves focus largely on ecosystems, biodiversity and wildlife protection, whilst state owned and managed forest estates are more likely to focus on revenue-generating timber and fiber production. The former is more likely to pursue a more benign management style, where some wildfires may be allowed to burn in remote areas, with the idea that it is more 'natural' to allow them to do so. (Conversely, the policies of most fire suppression agencies and volunteer organisations involve suppressing all fires from lightning strikes and other ignitions as soon as possible. In application, this means that where some wildfires 'get away', they tend to burn at very high intensities during the summer months due to fuel accumulation, and much hotter than one would historically see). The latter has significant dollar investments, and thus is more likely to pursue an intensive fire management program that protects its living assets from fire damage that could reduce its future supply of raw material.

Within reserved areas, the network of fire trails and roading may not be as extensive (for valid management reasons), with implications for access to ignitions, and longer response times to lightning strikes. Fire-fighting crews may need to be flown in to remote wilderness areas with no easy ground access. There is increased use and reliance on volunteer fire-fighting resources, as agency personnel are available, but in lower numbers per hectare of managed reserve area compared with production forests. There would be less access to heavy machinery for fire-line construction, and this may be incompatible with general use in wilderness areas in any case. Prescribed burning and hazard reduction are typically conducted at the reserve/urban interface, but not generally across the larger reserve landscape.

In contrast, state-managed forestry lands (especially plantations), typically maintain the highest intensity of fire trails and roading, because such infrastructure is needed for both timber harvesting and fire-fighting activities. These agencies retain their own trained staff for fire-fighting, often with additional summer recruitment, and have the highest availability of heavy plant and machinery for harvesting and roading activities that can also be used for fire-fighting. Little if any prescribed burning is done within pine plantations. Most of the prescribed burning is performed outside the plantation boundary for fire protection purposes. The intensity of fire management and related activity is directly related to the high dollar value of the estate and fire-sensitivity of the pine plantations.

Increasingly, eucalypt (and some pine) plantations for pulp and fiber production are being transferred to a new breed of timberland owners—Timber Investment Management Organisations (TIMOs). These holdings present different issues for fire management. The focus is on providing the greatest financial return for the investors, and expenditure on fire management is often not a primary (or even secondary) consideration. This requires an increasing reliance on the volunteer agencies to perform fire suppression and prevention activities, as company staffing levels may be very low in the field.

TIMOs are more likely to mitigate against fire losses not through increased proactive fire management, but rather by insuring the plantation asset against loss from fire. This results in a devolvement of responsibility for fuel management. Although prescribed burning is not an acceptable tool within the confines of the plantation due to fire sensitivity, the private plantation owner needs to consider the suppression needs of the wider community and manage the fuel loads and ignitions risks accordingly. Simply leaving the responsibility to external fire management organisations would neglect wider community obligations – something public land management agencies have been accused of (Ellis *et al.* 2004). Some private plantation owners have established funding of 'industry brigades' to assist with fire-fighting to address this issue.

3.5 The 'New Zealand' Model of Forest Management

New Zealand aptly demonstrates the implications for forest management when forestlands are increasingly parsed into either conservation areas or intensively managed productive forests.

New Zealand has placed approximately 8 million hectares of publicly owned indigenous (or native) forest areas within formal reserves, and any harvesting of indigenous native timbers now only occurs from 140,000 ha of privately owned native forest areas. Less than 0.1% of New Zealand's total forest production is currently harvested from indigenous forests. The majority of intensive production forestry is focused in an increasingly privately owned (exotic pine plantation) industrial estate (New Zealand MAF 2005).

New Zealand has a mainly temperate, maritime climate, and whilst they occasionally have the odd wildfire ignition they are mostly small and easily contained. Given the rainfall patterns and moist forest types, the conditions for large scale wildfire development do not occur as they do in Australia.

The 'New Zealand' model of forest management removes many aspects of multiple-use forestry within native (indigenous) forest areas. Some off-reserve areas that could be considered as conservation areas within a broader production forestry context would be subsumed into the formal reserve system. Other aspects such as most commercial harvesting for native timber production cease, however there may still be options for small scale 'boutique' removals for specialty timber products. Non-commercial thinning, forest silvicultural improvements, bee-keeping, some grazing of livestock, hunting, mushrooming, mechanised recreation activities and other minor forest products removals or use may still occur in certain circumstances.

Certain states in Australia, including Queensland and the Australian Capital Territory, have already largely moved to the 'New Zealand' forest management model. Other states, such as NSW appear to be moving towards a similar position. This does have wide implications for fire management in forests in these areas, which requires greater investigation and recognition of the implication for this shift in management emphasis.

The management shift away from multiple-use native forest management, towards industrial plantations on one extreme and wilderness preserves on the other, entails a comprehensive rethinking of fire management obligations, ability and responsibilities to the wider community. A commensurate reduction in prescribed burning across the landscape, would give rise to larger, and more frequent wildfires that could affect all landholders, regardless of tenure or position in the landscape.

The risk with this approach in Australia is that forest land management becomes increasingly 'compartmentalised'. Owners and managers concentrate only on their 'patch' without reference or consideration of their neighbours, or to the larger community in terms of fire protection.

Conclusion

Determining the proper role of fire in our forests necessitates a value judgement on what we want *from* forests and *for* forests. Much of the argument still comes back to whether man should interfere with nature or whether we can steward these processes to the best of our ability (Schauble 2004). The reality is that either way, we are making choices. No decision is still a decision. Passive management is also a choice for change (Agee 2002). By focusing on the outcomes we want for the forest, we need to realise we are applying human judgement to ecological processes and then manipulating them by whatever means.

Land managers and ecologists would be far better to view the forest stand in terms of its current forest condition and determine the treatment which best meets the outcomes and objectives sought, and *then* base the applied prescriptions on the objectives to be achieved. Thus, no conversation about the role of fire can occur without a discussion of what we value about, and want from, our forests.

Australians have historically, since the 1960's, managed with the intent of protection from the effects of wildfire (Cheney 2004). But in recent years the trend has been to shift increasing areas of forestland from land management agencies to either conservation agencies such National Parks, or to private timberland investment management organizations.

The implications of this shift in forest ownership for fire management and prescribed burning are significant. Currently, the role of productive native forests within the spectrum of multiple use management contributes significantly to fire management on publicly owned state lands. As more lands move into other hands, we can expect to see a shift towards less active fire management on jurisdictions with fewer access roads, heavy fire-fighting equipment, and trained personnel. The fragmentation of the forest will also complicate fire-fighting for regions or communities, as jurisdictions are divided across different ownership types each with their own interests and budgets.

To some degree, the American example shows us that their discussions have led them to a definition of 'forest health' that sees an active role for low-intensity fire and fuel treatments to manage for multiple benefits, including ecosystem restoration and public safety. However, fragmentation on US forestlands is also occurring rapidly, as more lands shift to TIMOs. Not surprisingly, conservation groups in the US remain concerned about what all this land fragmentation will mean for 'forest health'.

4 Common Misconceptions Concerning Prescribed Burning

'We must count on fire to help in practical forestry...as a servant…
[otherwise] it will surely be master in a very short time'
George Hoxie, 1910 California Timberman (Arno and Allison-Bunnell 2002)

Précis
This chapter discusses the common misconceptions regarding use of low intensity fire and/or prescribed fire as a tool for both fuel management and ecological restoration. The focus is mainly on the Australian context, as this is where most of the controversy concerning influences of prescribed burning exists today.

'There is no correlation between fuel condition and size of wildfires in the landscape'
Roger Good NPWS Fire Ecologist (2002)

Myth 1: All fires behave the same regardless of fuel.

Fact: Fires can range from low intensity fires to high intensity fires and they each have very different effects on the landscape.

Prescribed burns can be defined as '*The controlled application of fire under specified environmental conditions to a predetermined area and at the time, intensity and rate of spread required to attain planned resource objectives' (DSE 2005)*
In the case of hazard or fuel reduction burning, is to reduce forest fuel loads to mitigate the intensity and extent of potentially more damaging high-intensity wildfires.

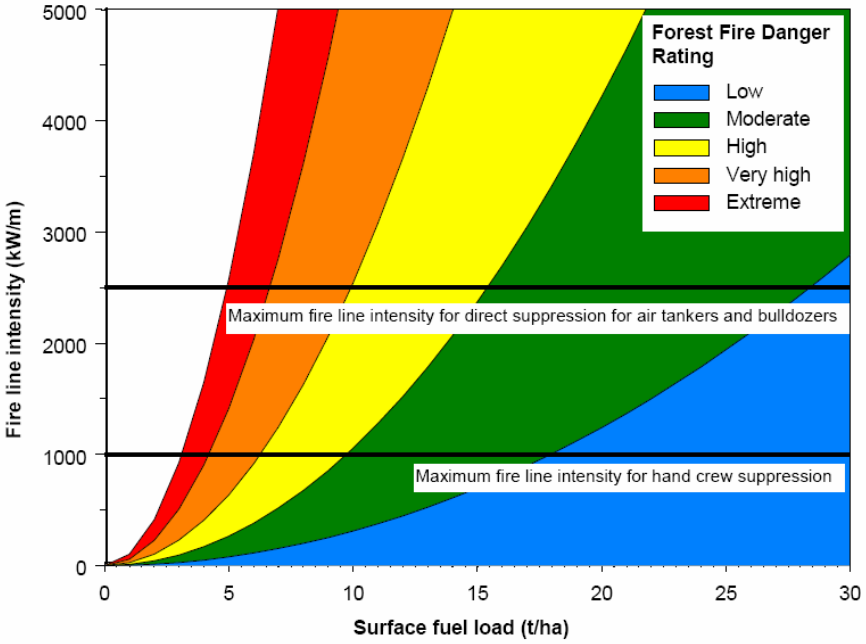


Figure 7 showing suppression potential as opposed to fuel load and forest fire danger rating. There are similar characterizations of fuel load, intensity and rate of fire spread for the same fire danger ratings.
Source : CSIRO 2003, COAG Submission

Much of the scientific research that has been cited and used as examples in prescribed fire management fails to recognise the fundamental difference between low intensity and high intensity fires. Comparisons are often made between fire events without a description of the size, type of burning conditions and seasonality of the burn.

Direct comparisons between prescribed burning and wildfires is questionable, since wildfires tend to burn uniformly where fuel loads are heavy and continuous, especially during severe fire

weather events. (Jurskis *et al.* 2002, CSIRO 2003, Institute of Foresters of Australia 2003, Tolhurst 2003a).

In relation to wildfire occurrence in the US, one of the major issues currently debated is the effect of extreme fire weather conditions in relation to fire size and fire severity. Similar sentiments to those echoed above include '…. In most big fires there is no relationship between the condition of the stand before the fire, and whether it burns or not.' (Portland Oregonian, January 12 1997 as quoted in Agee 1997). In drier forest types, where fire exclusion has occurred over the last century, the problem is one of fire severity and not so much of fire size. Fires in these fire-adapted forest may have traditionally been large but of low severity due to lower fuel levels (Agee 1997).

Prescribed burning for hazard reduction is designed to reduce fire intensity by reducing fuel loads and modifying forest structure, for a given set of weather conditions. This can allow fire suppression crews to mount a direct attack versus a retreat, for example. It can mean the difference between success and failure to contain a fire, as well as providing increased access and safety for firefighters (Rawson *et al.* 1985, State Forests 2002, Cheney 2003).

Some opponents of prescribed burning argue that there is no evidence that this practice can actually mitigate against high intensity fires (Wilderness Society 2003). Most of these comments have focused on severe fire weather and the fact that fine fuel can accumulate quickly in areas where forest underbrush grows rapidly, for example, it may only take 5-10 years to reach pre-prescribed burning levels (Tolhurst *et al.* 1992, Ellis *et al.* 2004).

However, these comments neglect to take into account the effects of prescribed burning on forest structure, and transforming other fuels such as bark, which is responsible for long-distance spotting (McCarthy *et al.* 1998, CSIRO 2003). Prescribed burning does more than reduce fine fuel on the surface. As research in the US and Australia has established, regular prescribed burning affects the vertical distribution of fuels as well as surface fine fuel loads (Tolhurst *et al.* 1992, McCarthy *et al.* 1998, Agee 2002, DSE 2002).

Figure 8: Bulls Ground experimental frequent burning area. Photo courtesy of Vic Jurskis.

The Bulls Ground experiment demonstrates this well. The following picture shows the effects of frequent prescribed burning versus fire exclusion over a period of 20 years, with regular prescribed burns every 3-4 years. The build-up of shrubby material, small trees is evident on the long-unburnt plot on the right, versus the open frequently burned stand on the left.

The scientific evidence (from CSIRO Project Vesta, see Figure 7) indicates a clear correlation between fuel load and intensity, and rate of fire spread, for any given set of weather conditions

Myth 2: Prescribed fires burn with a uniform effect on the landscape.

Fact: Prescribed burning actually enhances can increase patchiness in the landscape and can even be used as a tool to enhance riparian, rainforest and old growth vegetation.

Contrary to many of the assumptions of conservation groups (NSWNCC and ASF 2003, Victorian NPA 2003) and scientific literature in Australia (Good 1985, Whelan 1995, 2002, Lindenmayer 2003), effective prescribed burning can lead to the conservation of riparian, rainforest and old growth communities.

Research in the US (Tomback *et al.* 2001, Agee 2002, pers comm. 2005, Arno and Fiedler 2005, Ward Thomas *et al.* 2002) suggests that prescribed burning will have mostly positive and some negative effects on ecosystems. This is true as long as the prescribed burning program is designed around conserving elements of both burnt and unburnt vegetation in the landscape, in a mosaic fashion. The effects of spatial variability and patchiness are not readily understood, and they counter the claims that prescribed burns uniformly affect the forested landscape and understorey vegetation.

Patchiness is a key attribute of prescribed burning, introducing complexity into fire regimes of both extent and fire intensity (Heemstra pers comm.. 2005). Data from the Eden Burning Study conducted in southern NSW (Jurskis *et al.* 2002) shows that there is high spatial variability or patchiness in the course of five prescribed burns conducted during an 11 year period. The Table below shows the burn frequency of the small assessment plots following the application of the treatments. The variability in patchiness is evident (both spatially and temporally), and an important fact is that one quarter of the plots did not burn at all in the course of 11 years.

Table 2: Frequency of assessment plots according to number of times burnt, Eden Burning Study

No of times burnt	**0**	**1**	**2**	**3**	**4**	**5**
Frequency of Plots %	**24**	**38**	**30**	**6**	**1**	**0**

(Source: Jurskis *et al.* 2002)

In addition, a complex mosaic of burnt and unburnt patches and burn boundaries occurs through the effective use of 'moisture differentials' between mesic vegetation and drier forest vegetation in the mid-and upper slope positions. Typically a prescribed burn is lit from the top slope position and the flames move downhill, thus decreasing flame height and intensity by a factor of half, compared with the same conditions on level ground. Usually, there is a significant soil and leaf litter moisture differential between drier sites in the upper and mid-slope positions (around 8-12%) compared with riparian vegetation (14-20+%). Flames tend to self-extinguish once they reach this boundary – a process which has also been referred to as 'edaphic' control (Jurskis *et al.* 2002, see Figure 9).

Filter strips of retained unburnt vegetation would exist in moister (and cooler) locations, protecting water courses as well as plants and animals in these communities. More complex floristic structures are also left intact in these moister areas. (Jurskis *et al.* 2002)

In comparison, extreme weather and drought during hot summer conditions eliminate these moisture differences, and wildfires tend to burn intensely right through these areas, particularly where fuel loads are continuous and high across the landscape.

The application of prescribed fire, in reality adds another suite of fire regime characteristics that would be missing across the forested landscapes, if fire exclusion (meaning exclusion of prescribed and low-intensity fire) is practiced. If pyro-diversity equates to biodiversity (Martin and Sapsis pers comm.), we should acknowledge the role of both low and moderate intensity fires, and incorporate them into active management.

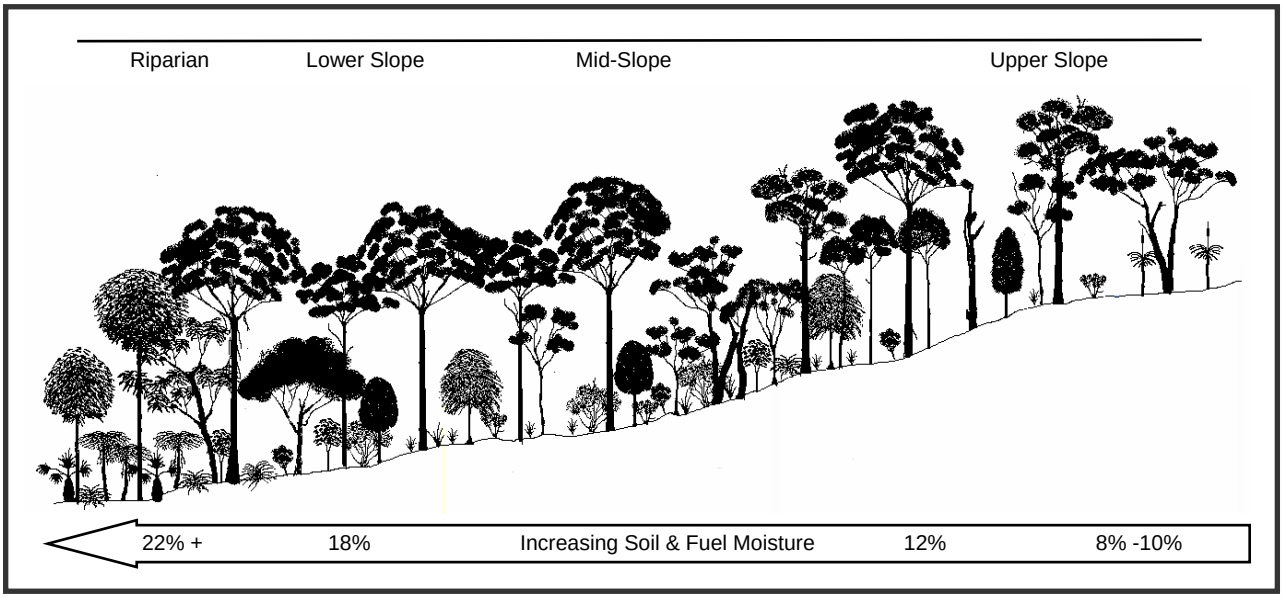


Figure 9: Forest profile diagram showing the typical change in forest structure and moisture differentials with slope.

'No amount of hazard reduction would stopped these fires'
NSW RFS Commissioner Koperberg - News Conference January 2002

'You would need to hazard reduce according to this formula every 9 months 50% of the landscape – that is patently not possible'
NSW RFS Commissioner Koperberg May 2002 –NSW Parliamentary Inquiry into the 2001/2002 Bushfires in NSW

Myth 3: Landscape-scale prescribed burning is not effective and requires too frequent applications to be feasible.

Fact: Prescribed burning is intended to prevent the build-up of fine fuel hazard levels that can result in large-scale high-intensity wildfires, not to stop fire dead in its tracks. As a preventive, long-term measure, prescribed burning can be effective when as little as 3-4% of the landscape is treated annually.

Hazard reduction burning is not aimed at stopping fires dead in their tracks. It is a risk management measure to reduce the likelihood of high-intensity fires. The question is often put –

how much burning should occur in the forested landscape to make a difference for fire suppression?

There are already practical examples, but it is important to note that to have a positive effect on ameliorating impacts from wildfires, as well as providing benefits to fire suppression during low-moderate fire danger risk, as little as 3-4% of the landscape would need to be treated annually as an average (Hoggett and Hoggett 2004). Accordingly, Western Australia has had in place a program for almost 40 years. This kind of long term commitment is essential. Programs must be established and maintained throughout the decades, so that restricted opportunities due to weather and resources can be accounted for.

The table below (Table 3) shows the average amount of prescribed burning undertaken by the two major forest land management agencies in NSW – State Forests of NSW and the National Parks and Wildlife Service, based on the area of their respective estates. There is an obvious difference in the average percentage area treated by each agency, however certain factors should be considered including access, terrain, workforce strength as well as management philosophy in comparing these figures.

Table 3: Hazard Reduction Areas versus Wildfire Areas 1992-1993 to 2004-2005

	Prescribed Fire Area (total hectares)		Wildfire Area (total hectares)		Total Estate Area (hectares) (change over time)		Prescribed Fire Area (% of annual estate)		Wildfire Area (% of annual estate)	
Year	**SFNSW**	**NPWS**	**SFNSW**	**NPWS**	**SFNSW**	**NPWS**	**SFNSW**	**NPWS**	**SFNSW**	**NPWS**
1992/1993	75,133	No record	4,761	21,772	3,701,587		2.03%		0.13%	
1993/1994	95,424	47,816	131,956	382,897	3,720,707	3,955,318	2.56%	1.21%	3.55%	9.68%
1994/1995	99,915	35,778	126,060	89,112	3,666,302	4,030,559	2.73%	0.89%	3.44%	2.21%
1995/1996	95,395	25,572	23,904	15,192	3,611,576	4,273,545	2.64%	0.60%	0.66%	0.36%
1996/1997	144,226	15,866	17,578	12,670	3,355,140	4,536,513	4.30%	0.35%	0.52%	0.28%
1997/1998	80,105	8,302	87,921	236,152	3,360,870	4,553,084	2.38%	0.18%	2.62%	5.19%
1998/1999	60,275	12,876	4,808	14,195	2,942,076	5,032,551	2.05%	0.26%	0.16%	0.28%
1999/2000	61,478	6,752	824	6,715	2,944,806	5,099,674	2.09%	0.13%	0.03%	0.13%
2000/2001	35,989	19,733	76,498	217,980	2,729,432	5,387,102	1.32%	0.37%	2.80%	4.05%
2001/2002	58,893	31,703	81,903	595,388	2,743,378	5,419,344	2.15%	0.58%	2.99%	10.99%
2002/2003	54,509	42,827	167,112	1,002,068	2,688,539	5,899,882	2.03%	0.73%	6.22%	16.98%
2003/2004	75,540	65,541	7243	38,120	2,644,020	5,948,818	2.86%	1.10%	0.27%	0.64%
2004/2005	35,290	49,478			2,296,150	6,296,818	1.54%	0.79%		
Annual Average	**74,782**	**30,187**	**60,881**	**219,355**			**2.36%**	**0.60%**	**1.95%**	**4.62%**

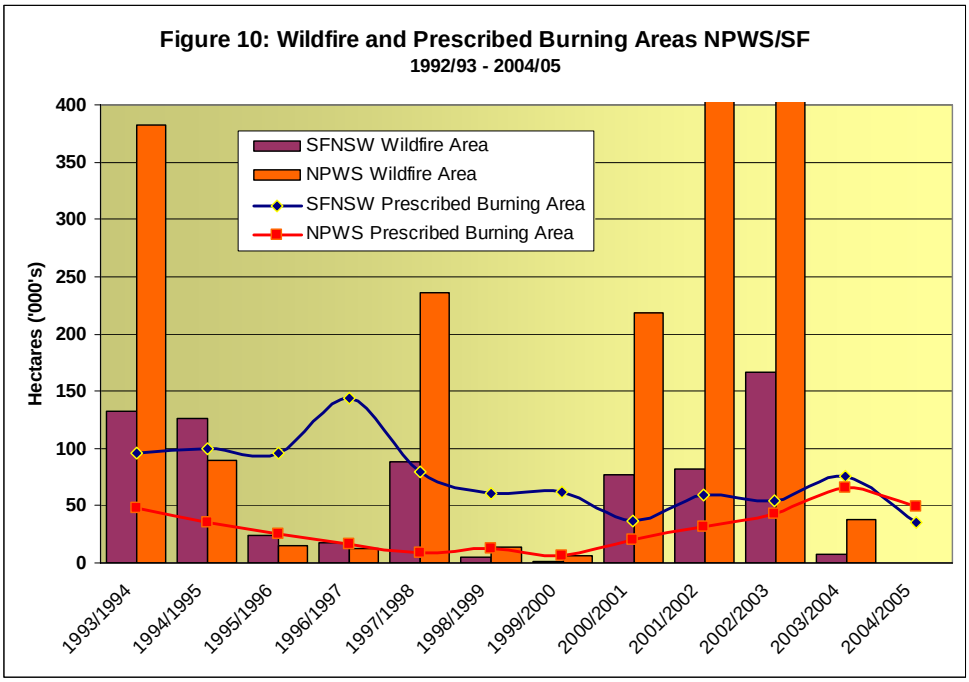
Source: (de Mar in Hogget and Hoggett 2004)

The Institute of Foresters of Australia (2003) has identified 7% annually in drier south eastern Australian forests as a potential target. In NSW Forests NSW achieves on average between 2%-4% annually (although this rate is declining), and reserve managers typically between 0.1%-1.3% (NSW NPWS Annual Reports 1999-2002). This is a difficult goal to generalise, given the huge variety of factors (including forest types, historical fire regimes, prevailing weather conditions, social concerns about smoke). However, by way of example, if a rotational burning regime was used (and it almost never is), a 2% annual burn of areas would take 50 years cover the entire estate.

In reality, possibly 40-50% of the forested landscape would not have fuel management or prescribed burning applied. These include areas of rainforests, riparian strips, rocky outcrops, higher elevation vegetation communities, wetlands, exclusions zones, research plots, fire sensitive vegetation types, regenerating regrowth forests and some formal and non-formal reserves. 10-15% may be treated regularly as part of the 'thin-red line' approach (Hoggett and Hoggett 2004). This leaves approximately 35-50% that could be available for fuel treatments, and could take 17 to 25 years to complete a rotation at a 2% annual average, even if resourcing was not an issue.

Within this context, it should be recognised that not all wildfires are severe or intense, and that wildfire areas may be large but the effect on the landscape and ecology may be minimal. Therefore it is important to distinguish between wildfire intensity (how 'hot' they burn) and their severity (effect on the ecosystem) (Agee 1997). Many wildfires in the Australian context (such as those in Northern NSW in the spring months) could fit into an extensive but low-intensity and low severity category.

Another common misconception is that prescribed burning is undertaken on too frequent a basis, and on a strictly rotational arrangement. This is not correct, as 'frequent' is often ill-defined, and most management agencies would not seek to burn at intervals more frequent than 1 in 5 years (even in dry forests). A more typical operational scenario is to establish an interval of 7-15 years between prescribed burns (outside the urban /bushland interface). Across broad forest landscapes, most land management agencies simply do not have the adequate resources to treat areas more frequently (See Figure 10 to compare hazard reduction are trends for forests and reserve areas in NSW. Data from Table 3).



Finally, much of the available research is based on more frequent application of low-intensity fire, at around 3-4 year time intervals, than would be experienced under 'normal' management regimes (Tolhurst *et al.* 1992, York 1999, Binns 2001). This is deliberate experimental design for a particular research purposes, and thus care should be taken when extrapolating the results and management recommendations to the landscape scale.

Also, most land managers do not institute a fixed rotational burning pattern, most of the assessment is based on previous fire histories, current conditions of stands, how long since the last wildfire, and how much fire sensitive vegetation is in the stand. For example, areas of regenerating

young eucalypts would not have any fire applied until after 15 years of age, and in some forest types such as cypress pine, fire exclusion is the norm.

Key Threatening Process Declaration: 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition.'

NSW Scientific Committee, Schedule 3 (2005)

Myth 4: 'Frequent' prescribed burns (i.e. low-intensity fires) harm biodiversity.

Fact: Frequent high-intensity wildfires are much more likely to harm biodiversity.

A better supposition would be that frequent **high intensity** fire detrimentally affects biodiversity. Much of the scientific literature refers to the potential adverse effects on biodiversity in general (Good 1985, Whelan 1995) of frequent prescribed burning. Many of the objections to prescribed burning practices, are the perceived effects on vascular understorey plants. The results from the Bulls Ground experiment near Port Macquarie on the NSW Central Coast, show some surprising results which contest this assumption (Binns 2001, 2005 pers comm., Forests NSW 2005). This experiment saw multiple prescribed burns undertaken on a small plot scale every three years for twenty years, and then left untreated for a following seven years.

The table below (Table 4) shows that even under experimental conditions, prescribed fires lit every three years on a fixed rotation (which is not standard management practice) increased the total number of vascular plant species, including those unique to each plot.

Table 4: Number of vascular understorey species measured at burnt versus unburnt plots at Bulls Ground – frequent burning study (unpub. Binns 2001)

Total number of Species		**Number of Unique Species**		**Mean No. of Species per Plot**	
Burnt	**Unburnt**	**Burnt**	**Unburnt**	**Burnt**	**Unburnt**
133	126	36	29	68.4	61.8

The species are not the same, and nor would land managers or ecologists necessarily expect them to be. However, the assertion of a large discrepancy and decrease in biodiversity is not apparent based on this research. Of course this may change for different vegetation types, however the focus for this report and ongoing research has been the dry-sclerophyll forests of coastal south-eastern Australia.

Much of the research on fire regimes and minimum return intervals is based on life-cycle analysis of individual understorey species, with an emphasis on obligate seeders that require a certain period of maturity before reaching their flowering and seeding stage (Whelan 1995, DSE 2002).

The table below shows that the number of obligate seeders actually increases in the frequently burnt areas, (contrary to the assumptions in much of the scientific literature) as measured in 1999 (Binns 2001).

Table 5: Number of vascular plant species with contrasting regeneration strategies in frequently burnt and unburnt plots at Bulls Ground (unpub. Binns 2001)

Regeneration Strategy	Only in burnt Plots	Only in Unburnt plots	More frequent in Burnt	More frequent in unburnt
Obligate Seeder	11	2	16	2
Resprouter	20	25	49	54
Total	**31**	**27**	**65**	**56**

Much of the opposition to prescribed burning appears to be grounded in a false belief that fire exclusion will promote the expansion of old growth and rainforest communities across the landscape. These are the desired forest types for many conservation groups. But the irony is that excluding burning can actually have the opposite effect. Lack of human intervention will not 'force' a range of ecosystems into either moist rainforest or old growth across a landscape that may not have supported it historically (Arno pers comm. 2005, Fiedler pers comm. 2005).

It is a fallacy to assume that fire-prone or dependent landscape will not burn given sufficient time. The only constant in any ecosystem is change, and disturbance is an inherent part of any ecosystem (Agee 2002, Shindler pers comm. 2005). Most fire-adapted forests will eventually burn and burn more severely than they would have normally if fire is entirely excluded for some time (Agee pers comm. 2005).

There also appears to be a strong theoretical perception amongst Australian ecologists that, as a general rule, increasing the vertical complexity of a forest structure will result in a commensurate increase in biodiversity. Whilst this concept can hold true in some cases, research both in the US and increasingly in Australia shows that increased forest structures may not either be historical or desirable in the current context (Yaussy 2000, pers comm. 2004, Arno pers comm. 2005).

Ecological interactions are often unknown and difficult to predict. Current accepted wisdom could potentially lead to preventing a treatment at one point in time, however new research may encourage exactly the same practice a decade later (for different reasons). A current example is the re-insertion of downed woody debris into streams and creeks to promote fish habitat, where historically, removal of fallen trees and debris had been encouraged for decades for flood mitigation purposes in the Pacific North West (Dolloff 1994).

Consequently, it cannot be definitively stated that the application of 'frequent' prescribed fire leads to a decrease in biodiversity (Binns 2001, pers comm. 2005, see text box to side).

'In the landscape context, there is no clear evidence from the (Bull's Ground) experiment for a suite of species which has declined as a result of frequent burning. Possible explanations are: no such suite exists; such species were extirpated from the landscape before the experiment began; such species have also declined in unburnt plots as a result of microhabitat changes and would reach optimum densities in an intermediate fire frequency. As a result of the small plot size, which facilitates re-establishment from adjacent, less-frequently burnt areas, results from this experiment need to be interpreted with caution. However it is clear that the effects of frequent burning cannot be assessed without consideration of plant community relationships in the landscape context. The notion that frequent burning invariably leads to decline of biodiversity is clearly far too simplistic for effective fire management, at least in respect of vascular plants.' (Binns 2001)

Myth 5: Prescribed burns deprive the forest soil and floor of nutrients.

Fact: The 'cooler' the fire, the less extensive the organic matter and nutrient loss will be, so prescribed burns may help to offset large scale nutrient loss and erosion by preventing high-intensity fires.

Research performed in a number of states in the US (Yaussy 2000), have shown that in general terms, losses of major nutrients are minimal during low-intensity fires. The most common nutrients to mobilise and volatilise are phosphorous and nitrogen. However this is directly related to the flame front intensity, which is directly related to both the condition of the fuel load (in terms of tonnes and structure) as well as the prevailing weather conditions. It comes as no real surprise, that the 'cooler' or less severe the fire, the less extensive the nutrient loss will be. Some loss of nutrients in the natural system does occur and this background value must also be taken into account. Some experiments have shown an increase in available nitrogen immediately after fire passage, in certain fire regimes, instead of an expected loss (Arno and Allison-Bunnell 2002, Hopmans 2003, Agee pers comm. 2005).

The Australian bush land ecosystem is superbly adapted to changes brought about by different fire regimes. For example, nitrogen-fixing leguminous plants such as acacia are usually stimulated by high fire intensities. Dense germination and regrowth of these species does not usually occur to the same extent following the application of low-intensity prescribed burning (Whelan 1995). The other factor to consider is that these acacias represent a seral stage in the regeneration of forest stands, they often compete with eucalypts for light and water. However as they fix essential nitrogen into the soil profile they are considered largely beneficial.

Prescribed burning can also protect nutrient-rich organic matter on the forest floor. Commonly as much as 30-50% of the fine fuel leaf litter can be retained through prescribed burning, whereas a large high intensity wildfire can strip all the leaf litter and organic soil matter, exposing it to much greater erosive potential from subsequent rainfall (Arno and Allison-Bunnell 2002). Studies in the translocation of nutrients and volatilization have also been done, and this in turn has been directly related to the temperatures to which the soil and sub-soil is exposed (Arno and Fielder 2005). Thus prescribed burning, reaching temperatures lower than experienced in intense wildfires, tend to preserve many nutrients in the system compared to high-intensity fire, and they also tend to stay on-site, available for further tree nourishment, rather than being leached off-site.

Another factor to consider is the amount of water uptake that rapidly growing forests need in order to regenerate after wildfire. As a result of wildfires, the regenerating young replacement stands can remove up to 45-50% of the available run-off that existed in the catchments prior to a wildfire, and the effects can last 30-50 years (Cary *et al.* 2002). Prescribed burning can maintain the forest in an open and grassy condition, limiting the competing understorey and smaller trees, thus allowing for maintenance of reliable run-off and water supply to the catchments.

Myth 6: Prescribed burns make the land more vulnerable to exotic weed invasion.

Fact: Low-intensity fire can help to remove noxious weeds in some cases.

There is a common belief in both the US and Australia, that doing nothing is often better than active forest management. The argument is that prescribed fire creates freshly disturbed areas that become available for exotic weed infestation due to the competitiveness and greater mobility of exotic weeds (usually through airborne or translocated seed sources) compared with native vegetation (Whelan 1995).

Prescribed burning does have an effect on soil and does disturb existing groundcover. This can allow for increased entry of a variety of exotic weeds, however this must be considered in context of the amount of bare and sterile soil available for colonization by weed species after wildfire. In some cases repeated and frequent low-intensity fire can assist in the removal of exotic weed infestation. For example, invasive radiata pine can enter native grassland and forest areas. Frequent burning will kill this fire sensitive species when it is present as seedlings and allow for a competitive advantage of native fire-adapted grasses (such as *Themeda* and *Poa*) and other understorey plants (Cary *et al.* 2003).

Myth 7: All science is good.

Fact: Scientific observations are still subject to interpretation and can be subjective.

Science can often be misrepresented, selectively quoted, or poorly extrapolated from intensive plot-based sampling, to the broader landscape, and fire management as a whole. For example, the development of prescribed burning guidelines in NSW recommending applicable minimum frequencies for broad forest types has been widely adopted in some planning instruments and risk management plans (NSW RFS 2004). However these guidelines were developed using research predominantly conducted on fire sensitive species around the Sydney Basin (Cary and Morrison 1995), which do not transfer well to other (and much more extensive) forested areas in the state. Often the assumptions are based on the 'fine-filter' approach to ecosystem management, using the theoretical minimum burning frequency for the most fire-sensitive understorey species that may occur in a given forest ecosystem. Despite the fact that these species may be extremely localised in their distribution, the resulting recommendations are often broad and extrapolated for a wide variety of forest types.

Individual interpretation may also highlight one aspect, such as decline of a fire-intolerant species, without considering the overall effect of and the need to account for all factors as part of adaptive management (Agee 2005 pers comm.). This is not helpful to land managers, and serves to confuse rather than clarify many issues for them. There are numerous quasi-science related statements which have been made regarding the effectiveness of hazard reduction burning or prescribed burning.

Conclusion

Science also can not make decisions on behalf of the land manager. Science may tell you the potential positive or negative effects of a particular treatment, but it can not tell managers or communities whether it is worthwhile from a social value perspective. These are decisions only people can make with the best information at hand and as best as realisation of the likely implications of any actions.

In much of the inland western US and almost all of the Australian landscape, comparisons have been made as to the effects of wildfire versus prescribed burning. It is important to note, that in these forest ecosystems that the choice is not between burning and not burning, but more towards what type of fire regime and intensity of fire will eventually occur. The question should be not 'if' it will burn, but 'when' and 'how hot'?

5 Perception and Social Dynamics

Précis

Public perceptions can be more influential on the implementation of fire and fuel management than any valid scientific or technical argument. There are numerous factors that can influence public opinion, but gauging them is not straightforward. Assessing, analyzing and ultimately influencing society's views on forest fire management is an important but challenging task if wildfire prevention activities and ecosystem management are to be accepted in the long term.

5.1 The public's role in deciding acceptable use and practice in forest areas in the US

Public sentiment has always been a major factor in land management policies over both forest reserves and production forests, in Australia and the US.

The public scrutiny of land management decisions has a strong tradition in the US, and in particular in the Pacific Northwest, where the 1980s saw frequent (even militant) demonstrations against government decisions to harvest timberlands. More importantly, public pressure has extended to the courts, where concerned citizens and conservation groups have very successfully appropriated the legal system to challenge many governmental policies regarding land management. Issues such as salvage harvesting following wildfire or fuel reduction activities are controversial. Most recently, the current administration's Healthy Forest Restoration Act (2002), where agencies have been directed to improve forest conditions through fuel management activities, has generated considerable outcry from conservation groups. Opposition to the Act and to innumerable other government actions mean that government agencies face a myriad of legal challenges that tie up their budgets and their operations for years. Thus the scrutiny of bureaucratic actions runs high in the current socio-political environment, as questions of trust and credibility are the subject of each decision, and often the courts become the final arbiter of forest policy.

It is only recently that the role of social acceptability has been researched, bringing into focus how land managers incorporate public input and consultation as a valid part of the decision making process. The research confirms that with any natural resource management practice, social acceptability can determine the persistence and longevity of certain practices and policies in time.

Firey (1960) and Clawson (1975) in Shindler (2005) found that the adoption and retention of any natural resource activity depends on the extent to which it is physically possible (consistent with the ecological processes), economically feasible (practices generate revenue or benefits in excess of costs), and culturally adoptable (consistent with prevailing customs and norms).

As public land managers are finding today, regardless of the first two criteria, practices that discount or disregard social acceptance or approval, will either fail or stagnate regardless of their technical or economic merit (Vaske *et al.* 2001). In other words, science and funding matter, but neither more so than politics.

Shindler *et al.* (2002) and Shindler *et al.* (2004) outline several reasons why consideration of the social aspect of public forest management is important.

- Values play a role in decision-making. Despite the virtues of technical and economic information, there are very few management decisions (despite land manager's preferences)

that are limited to 'objective science'. Complex multi-faceted 'trade-offs' can not be decided using science alone. In order to gain public acceptance, decisions must inherently account for public values.

- People have a right to participate in decisions that affect them. As the ultimate owners of public forests and reserves, residents and especially landholders bordering these areas, have legitimate concerns and therefore a stake in their management.

- Simply stated, social acceptability matters in a democracy. We like to think that power ultimately rests with citizens, and that the political institutions will act based on our collective opinions and positions. Although land-management powers may have been delegated to agencies, if their policies are inconsistent with public values, over time this delegated power will be circumvented by the actions of citizens. They can choose to use the court system, politicians or the media to modify, postpone or paralyse the implementation of certain actions designed in part primarily for public safety and benefit.

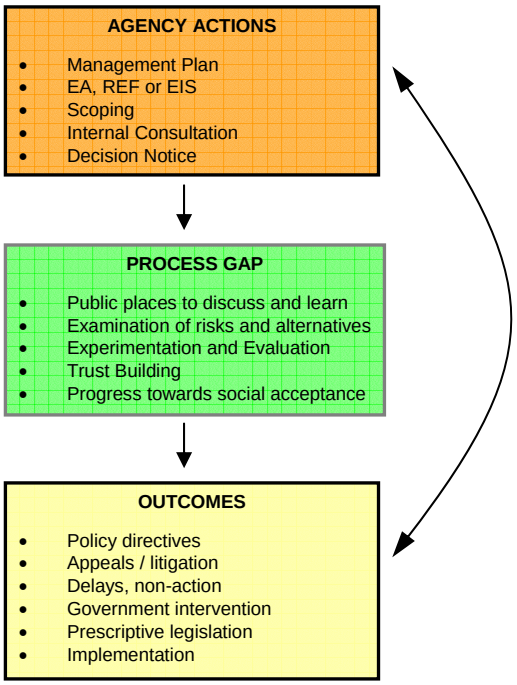


Figure 11: Forest Policy Process Gap
(reproduced from Shindler *et al.* 2002)

Figure 11 shows the current process gap in many land management agency decisions (Shindler *et al.* 2002). Currently agency staff and management have become proficient at the first step, involving formal but rather mechanistic planning processes and actions. Many of these planning processes are simply required to satisfy regulatory and statutory obligations.

Often missing are the in-between steps outlined in the second box of legitimate public process and consultation. These are mostly informal in nature, and most likely to be ignored and undervalued.

These often result in the outcomes described in the third box, where implementation may occur, but only after delays or appeals or changes to legislation. The question arises whether this is conducive to socially acceptable decision making.

Specific examples (including case studies later in this chapter), have shown the value of improving agency staff selection and proper training in public consultation, for successful interactions with the public to occur. In the US, it is widely acknowledged within the forestry educational field, that forestry graduates who find employment with a public agency are more likely to spend time communicating plans and actions to the public than actually practicing field forestry.

5.2 The cycle of public perception in relation to prescribed burning and wildfire events – the role of the media in Australia

There are few if any in depth studies available in Australia on public perceptions towards prescribed burning as a fuel management tool. Most of the information is anecdotal and can at best be deciphered through contrasting reports in newspapers and magazines, as well as individual questioning of focus groups (such as educators on field trips).

The media (as in most countries) is likely to have a key role in shaping public perceptions as well as forest fire issues (Adams 2004). A major problem concerns the mixed messages received by the public via media broadcasts, and the general sensational reporting of wildfire events (Hoy 2004). The media feeds on reports of controversy, disaster and conflict. Such topics and events are deemed 'newsworthy'. However, anecdotal evidence is that even if media in general cover wildfires, the general public often does not care beyond the flaming stage (Agee pers comm. 2005)

The same media treatment is applied to reporting of wildfire events. The larger and more intense the wildfire, the more lives and assets at risk, the more likely the news will be featured in the headlines. This is especially true if there is arson involved. Interestingly, no-one ever hears about the literally hundreds of lightning strikes or other small ignitions that are extinguished every summer, with little or no damage, and even less fanfare. These events are simply not newsworthy, however much their existence adds to complexities of current fire management.

Statements to the effect that '*no amount of hazard reduction would have stopped these fires*' have an enormous impact in the 5-second media grab. These sorts of statements are absorbed at the height of intense activity by a public used to immediate and easily digestible information packaging. Unfortunately, this does not allow for more nuanced information on the role of prescribed burning, how it is conducted, why it should be done or any other factors which might qualify this statement. Constructive dialogue and consensus are rarely, if ever, reported. This means that other avenues must be found to broadcast complex messages with potentially the same degree of positive impact on the public.

There are also statements by prominent scientists who use science as a backdrop but make it easily palatable for public consumption, '*One wildfire can be bad, as the blackened landscape can look awful. But frequent prescribed burning can be just as bad or worse as species will be fundamentally changed as they don't have enough time to regenerate'* (Whelan 2002). This uses some scientific principles as a background to the argument, but again misses the essential point by which fuel management activities are justified on social protection grounds as well as consideration of biodiversity outcomes.

Similar extraneous statements made by opponents of prescribed burning have also been made, but these generally ignore the fact that the problem seems to be the lack of prescribed burning rather than too much (see Chapter 4 and Case study 2).

In addition, public values can change with regard to vegetation and land management, depending on whether they are perceived as an asset (from recreation or aesthetics) or a risk. The experience of ACT Forests (Bartlett pers comm. 2003, Cutrupi 2003, Doherty 2004) showed how initial local resident opposition to proposed removal of Radiata pine stands and associated hazard reduction works adjacent to suburbs in Canberra was transformed into public rebuke for not undertaking this work prior to the January 2003 firestorm.

Typically, public land agencies face a base of either public inertia or apathy towards fuel management. This is normally only altered following a major fire event which may take the form of either wildfire or an escaped hazard reduction burn. The debate and call for increased action usually is relative to the damage sustained to human assets (not biological) following a wildfire event. If the damage was caused by an escaped prescribed burn the path taken is different and usually results in lower levels of fuel mitigation following the event.

If the event is a wildfire and prior fuel loads become part of the debate, the usual response to a post-event investigation is an improved concentration of effort in fuel and risk management. However with time, other issues of public concern, such as smoke and impacts on biodiversity (along with decreases in annual budgets), impede the implementation of fuel reduction, and the cycle begins anew (See Chapter 6.4).

At many of the stages shown above describing the status of public sentiment, there exists opportunities to address, remediate and influence public approval and acceptance. Tackling the issues outlined in the 'Process gap' in Figure 11, are paramount if public acceptance and trust is to be gained and hence the long-term continuing approval for conducting fuel management activities. This does not merely involve the provision of educational and factual material, but allowing for legitimate concerns and alternative approaches to be canvassed.

5.3 Current public perception and acceptance of prescribed burning and fuel treatments – the US experience

As described above, public acceptance is crucial to the successful implementation of any attempted fuel management programs in the long term. This is especially so where local communities exist at the Wildland-Urban Interface (or WUI), where managers in both the US and Australia are attempting to address a broad range of concerns.

There is a stark contrast in many cases towards the issues of fuel management depending on the geographic distribution of the population. As expected, those people living in close proximity and likely to become affected by wildfire have greater concerns about the risks and fuel management treatment options (Shindler 2002). Those based in urban centers unlikely to be directly impacted by the fire, but subject to discomfort from prescribed burning (in terms of smoke and associated health issues) will be less likely to endorse direct fuel treatment options, and acceptance tends to wane with time from a conflagration event. The political influence in many areas is greater from the urban populace which adds increasing difficulty to sustained fuel management treatments over time.

The single largest impact on public acceptance and trust in land manager's performance is the issue of escaped prescribed burns. From incidents like the Cerro Grande Fire in 2000 (near Los Alamos, New Mexico where 200 homes were burnt), to the recent Cascade II Fire in Utah in 2003, escaped prescribed burns tend to polarize public sentiment and draw harsh criticism from local officials and news media. Follow-up surveys of those affected residents showed increased mistrust of land managers. Interestingly, prescribed burning *per se* was not universally disparaged, but still perceived as an acceptable tool for some situations. The greatest doubt was in the agencies' abilities to use them effectively, especially close to urban and recreational areas (Brunson and Shindler 2004, Brunson and Evans 2005).

The challenge in these situations appears to be in regaining public confidence through the judicious use of prescribed fire in low-risk areas, and by publicising the successes (something very rarely done) to off-set the previous negative sentiments. These surveys indicate that eventually, that trust can be regained, but it is a long-term commitment (OFRI 2003).

In the US, a multi-phase national survey is currently underway of fire-prone communities of public perspectives and acceptance of wildland fuel programs on federal forests. This survey is in the form of a mail-survey, with short descriptions of each fuel management practice, and a request for an opinion by respondents. From the completed phase of the survey, the results so far generally show that the majority of the public is in favour of fuel management and public agency practices. At the same time, a number of citizens remain distrustful of the agencies and withhold their full support of manager's actions. Experience from communities adjacent to forest areas indicates that the public will be waiting to see how well these policies play out before making final judgments (Shindler *et al.* 2002).

Table 6: Acceptance of Fuels Management practice – respondents from both Regions showed the most caution regarding prescribed fire.

	Survey of Central Oregon Residents				Survey of Great Lakes Region Residents		
	Prescribed Fires	**Mechanical Vegetation Removal**	**Thinning Trees**	**Grazing**	**Prescribed Fires**	**Mechanical Vegetation Removal**	**Thinning Trees**
A legitimate tool that resource managers should be able to use whenever they see fit	**56%**	64%	73%	60%	**38%**	50%	59%
Something that should be done only infrequently, in carefully selected areas.	**34%**	19%	23%	26%	**44%**	26%	28%
A practice that should not be considered because it creates too many negative impacts.	**5%**	4%	1%	9%	**3%**	3%	1%
An unnecessary practice.	**2%**	3%	1%	1%	**3%**	4%	3%
I know too little to make a judgement about this topic	**3%**	10%	3%	5%	**12%**	17%	9%

(Table adapted from Shindler Toman and Shaw 2004 & Shindler Brunson and Toman 2004)

In addition, a further survey across Oregon commissioned by the Oregon Forest Resources Institute (OFRI) found that an overwhelming 89% of the sample set agreed that it is sometimes necessary to use controlled fire on forestland to reduce the risk of wildfire. A substantial 88% of those surveyed also said it is sometimes necessary to harvest or thin trees to reduce risk of wildfire or improve stand health (OFRI 2003). This suggests a greater public understanding of the forest health issues that emerged after the dramatic 2002 fire season in the US.

These types of benchmarking surveys are an essential baseline to gain information on public perceptions, acceptance and ultimately trust in the proposed fuel management activities undertaken by land management agencies. Forest management agencies in Australia could benefit

enormously from the sort of information these surveys provide and then adapt their public outreach and information provisions accordingly.

5.4 How can public perceptions and attitudes toward the forest and fire management practices be assessed and influenced?

Information and factual knowledge are essential in gaining public support for fuel management practices. Assessing and analyzing the current status of societies' views on any particular forest management activity is only the first step. Education and providing information in an easily digestible and non-partisan way, aids enormously in gaining public awareness and acceptance of forest policy (Davis and Cloughesy 2004).

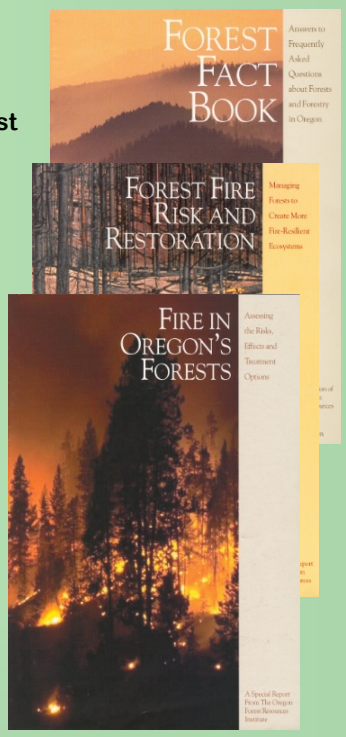
As part of the nation-wide survey on 'Fire management and Forest Conditions' conducted by Shindler *et al.* (2004a & b),(described in Section 5.3 above), people were asked to rate the usefulness of 13 fire information programs in Central Oregon.

For the purposes of the survey, the information programs were depicted either as interactive or uni-directional. Uni-directional information typically involves one-way flow of communication from the agency to the public. In contrast, interactive programs are those that provide for personal contact with agency staff or on-ground learning experiences (Shindler and Ohlsen 2004).

The Role of the Oregon Forest Resources Institute

OREGON FOREST RESOURCES INSTITUTE

The Oregon Forest Resources Institute (OFRI) is a unique organisation created by the Oregon State Legislature in 1991. Its key role is to improve public understanding of Oregon's forest resources and to encourage environmentally sound forest management through training and education programs for forest landholders.



It is primarily a focus and not an advocacy group, although much of the funding comes from revenues obtained through harvesting taxes on forest products producers. OFRI is governed by a board of directors which includes mostly timber producers and small woodland owners. In some conservation group's views this distinctly colours the views of OFRI's mission, however the Institute puts a strong emphasis on collaboration in forest management decision-making (Cloughesy pers comm. 2005). OFRI also relies on close ties with Oregon State University (OSU) Department of Forestry and the Oregon Department of Forestry (ODF) to help ensure its information dissemination and programs are consistent with the best and most up-to-date forest science (Johnson pers comm. 2005).

Fire management has been a central theme for OFRI in recent years, particularly given the overwhelming public concern following the Biscuit Fire in southern Oregon in 2002. OFRI have filled a niche in this respect - increasing public awareness on the role of fire in the landscape and how fire historically shaped the region's forests. Through a variety of publications (right) and field tours involving interaction with federal land management agency staff, they are able to steer and assist the public through a wealth of scientific information & literature, whilst distilling the essential messages on fire and forest management.

As a mechanism for public education, interaction, and information dissemination, OFRI appears to be making good inroads into what has traditionally been the conflict-ridden and difficult field of public opinion, education and attitudes towards forest fire management.

As can be seen in Figure 12 below, the programs deemed most useful by the public were interactive. Interestingly, public meetings run by the government were not viewed very positively. This could be due in part to the traditional meeting format, where although public input is sought, the general opinion is that they are often sterile, rule-bound and one–way exchanges (Cortner *et al.* in Shindler *et al.* 2002). Shindler and Neburka (1997) describe the rather cynical perception in some western communities of this particular type of consultative process – characterising it as the 'three **I**'s' – **i**nform the public, solicit their **i**nput, and then **i**gnore it. This is not a unique situation to the western US by any means. Interactive programs however, can be the most intensive in terms of resources and time on individual agency staff. However as with many efforts in public relations, particularly where trust building is essential - you only get out what you are prepared to put in terms of effort.

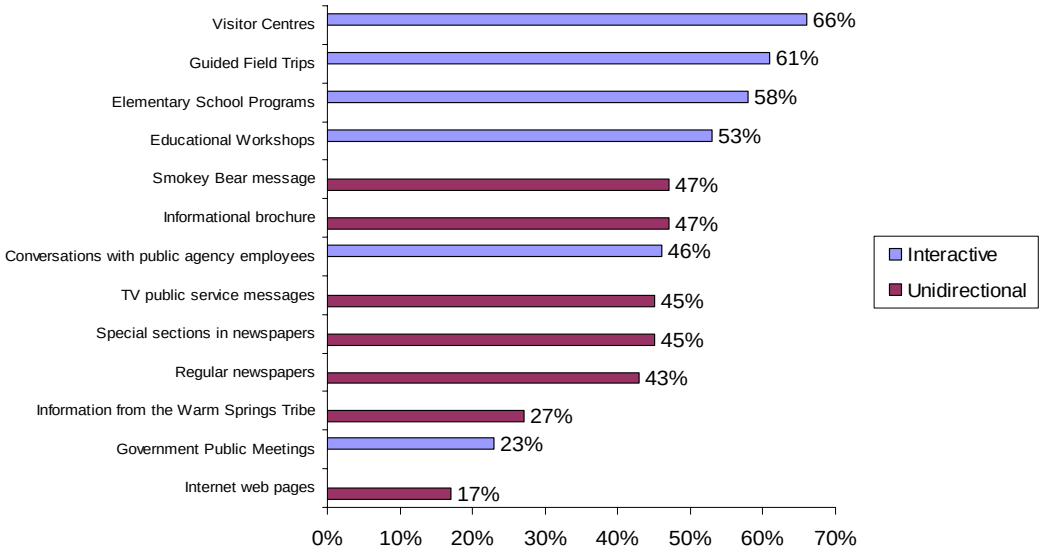


Figure 12: Usefulness of Fire Information Programs in Central Oregon (Shindler *et al.* 2005)

Conclusion

Wondolleck (1988 in Shinder *et al.* 2002) discusses how decision makers often begin with the wrong emphasis by asking first; 'What decision should we make?' Or 'what is the proper allocation of resources in this situation'. Instead they would be better off asking questions as; 'How should we make such a controversial and complex decision?' Or 'Who should be involved, what roles will they play and what information is needed?

Thus the real accomplishment is in identifying stakeholders, supplying them with the appropriate information by which they can base their opinion, and then substantively engaging them in the process. In relation to fuel and forest management, managers need to recognise the incredibly influential role of the public, and the right in free societies for the public to make decisions or value judgments which may be ill-informed, but still represent a decision by the forest owner(s). Building trust between agency staff and the community appears to be the main challenge for most land managers –and often beyond their training. The manager's role then is to ensure that all parties are fully aware of the implications of their decision making – and what it eventually entails – not only for them, but also for the communities to come.

Case Study 1 Friends of Metolius – Active in the Sisters Ranger District (OR)

The USDA Sisters Ranger District of the Deschutes National Forest covers 324,000 acres on the Eastern slopes of the Cascades northwest of Bend, Oregon. Here, prior to 1900, frequent low intensity and mixed severity fires created relatively open mixed conifer forests. As with many other western drier forest areas, fire exclusion has allowed a mixed White Fir/Douglas Fir community to proliferate and form a dense understorey, which in turn, has been more susceptible to drought stress, root disease, insect attack and wildfire than the original forest (Fitzgerald 2002).

Problems have arisen on terms of forest restoration efforts on a number of fronts, not the least of which is the complicated planning processes, changes in guidelines and rules, and legal challenges to any proposed treatments. Much of the controversy/difficulties occur due to the interpretation of the Northwest Forest Plan.

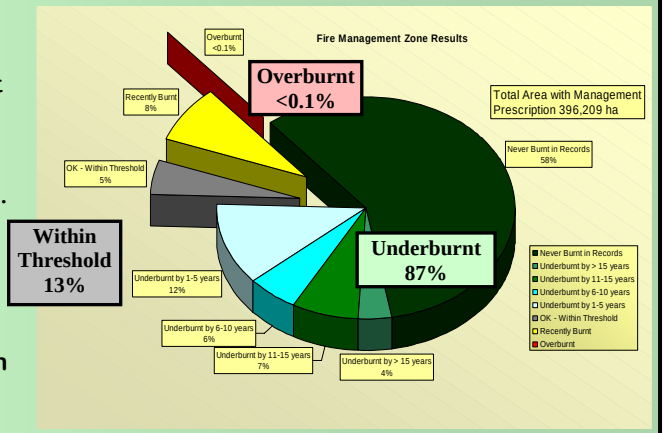
The District was able to engage the 'Friends of Metolius', a local conservation group (based at nearby Camp Sherman) to moderate public concerns about the impacts of fuel treatments in the area. Together with the Forest Service (a traditional adversary), they have established and funded eight demonstration areas, designed to show the 'before' and 'after' situation in relation to thinning, prescribed fire and mowing of various stands (see attached plates and photos). The cooperative exercise has assisted relations between local people and district staff as well as enhancing public understanding of fuel management and forest ecology. The support from the 'Friends of Metolius' has also now included their intervention to a third party conservation group 'League of Wilderness Defenders' legal challenge to the project (Friends of Metolius 2004). This situation is rather unprecedented, where local citizens actually officially support the Forest Service in their attempts at fuel management and restoration ecology.

Other options are being canvassed in terms of wood utilization from these stands, in order to gain some costs recovery from (mechanical) fuel treatments. Progress is developing on the construction of a local biomass generation plant and with the full support of the local community.

Sisters District Ranger Bill Anthony (pers comm. 2004) has personally encouraged community involvement in searching for solutions to local issues. He attributes much of the success to direct community relationships with agency staff and trust building exercises, through collaborative tours and encouraging local resident's input into fuel treatment plans. Much of the impetus for this comes from the community themselves. The local Camp Sherman community was evacuated twice during the B&B Fire complex in 2002 and this has tended to focus people's attention on local forest conditions, risk management and working with neighbouring forest agency staff, instead of against them. Photos courtesy of author.

Case Study 2 - The Canobolas Zone Risk Management Plan (NSW)

A recent development in fire risk mitigation planning in NSW can be seen in the collaborative effort between land managers, fire suppression agencies and community groups in developing the new Canobolas Zone Risk Management Plan (RMP) in October 2004. This area is located around Orange in Central - Western NSW. The Plan arose as a response to the extensive damage caused to surrounding rural lands by the Goobang National Park Fire in 2002.



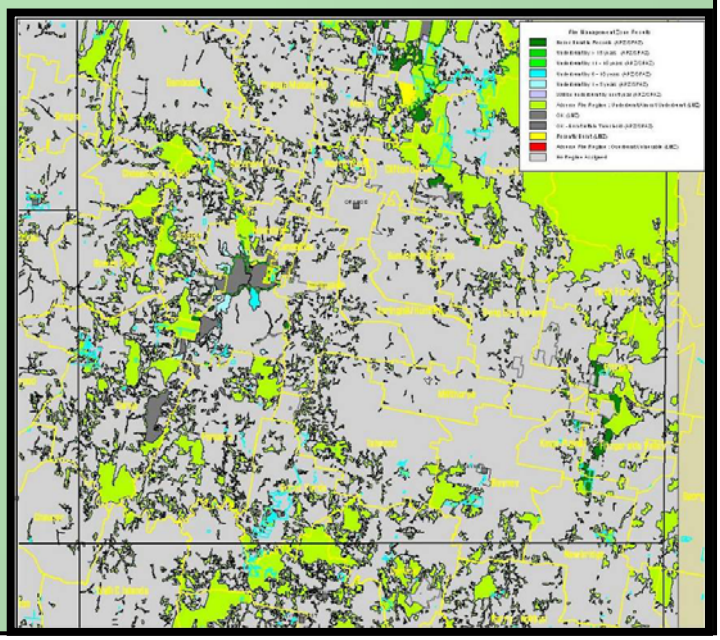
Following a review of the Coroner's findings by the Canobolas Bushfire Management Committee (BFMC) it was recognised that there were broader issues that the existing bushfire RMP and operations plan did not address across the entire Region. The issue was larger than just Goobang National Park and surrounds.

The major catalyst for this approach has been calls from the community that their input into regional fire management has been absent. Fire and land management agencies came under strong criticism that 'local knowledge' has been ignored at all stages in fire management, from risk planning through to operational decision making on the fire-ground. There was a perceived lack of ownership by the community in the decision making process that originally developed the plans across the Zone.The take home message was that all stakeholders in the fire management process must feel that their opinions have been heard and carefully considered. From this basis a further project plan, to involve multiple jurisdictions and community groups was developed, in conjunction with the traditional fire authorities.

Key elements of the plan include a tenure wide landscape approach as well as widespread community and stakeholder consultation, and recognition of some important factors:

- A whole of landscape approach to bush fire management (RMP and Plan of Operations) across Canobolas Zone that is driven by community input and local knowledge.
- Greater opportunity for local brigades, landholders and other stakeholders to have input into the fire management process so that local knowledge can drive and build up to landscape level fire management outcomes.
- Changing the focus of the fire management from reactive (suppression) to proactive (prevention).
- Implement outcomes that flow from this project by training, community education and community consultation.
- Involve all stakeholders.
- Illustrate that community protection and conservation outcomes can and do complement each other in the fire management outcomes across the entire landscape.

The Canobolas RMP also sets some benchmarking targets for treating areas through prescribed burning, following individual analysis of recent burning histories across all tenures. Based on the entire landscape, an annual average target of over 9,400 ha has been set for the region. To this end, the map attached shows large forested areas (highlighted in lime green) which are categorised as 'underburnt'. Further analysis (above) shows that around 87% of the total zone is in an 'underburnt' category. In essence, these areas should have prescribed burning applied to them systematically from now on as they are considered to be outside their maximum fire regime parameters. This could be considered a pre-cursor to the fire-regime condition class mapping approach, now broadly utilised across the US. (NSW RFS 2004)



6 The Political Dimension and Economic Rationalism

Précis

The politics of fire management is largely one of public image and financing. Especially after severe wildfires, government agencies and politicians are under intense pressure to prove they are 'taking action' and 'spending wisely.' However, the dynamics of politics is such that it can be counterproductive to long-term fire management.

This is true in Australia, where land management agencies, long entrusted with fire management on forested lands, find their financial and political support eroding. Their duties are being transferred to volunteer fire-fighting units that, whilst enormously successful at suppressing wildfires, lack the staffing, training, equipment and expertise to provide adequate active fire prevention and management across broad forested landscapes.

'….if we look instead at areas of prescribed burns—which is relatively easy for the service to crank up if we want to go and drop a few incendiaries under mild weather conditions in the Wollemi or Kosciuszko national parks and then get the tally up, it is pretty easy but it is not going to mean an awful lot in terms of our role as a responsible fire manager— whereas….. those burns are, in fact, targeted at the interface where we focus our asset protection rather than chasing some notional arbitrary area tally'

Brian Gilligan, Director General NSW National Parks and Wildlife Service
2 May 2002 (NSW Parliamentary Inquiry into the 2001/2002 Bushfires)

Over 66% of Kosciuszko National Park burnt the following summer.

6.1 Rise of the Australian Fire Suppression Culture

Australia's regional fire-fighting system is envied around the world. It is able to resource a huge volunteer rural fire corps and these state-run groups are often funded through the homeowner insurance industry.

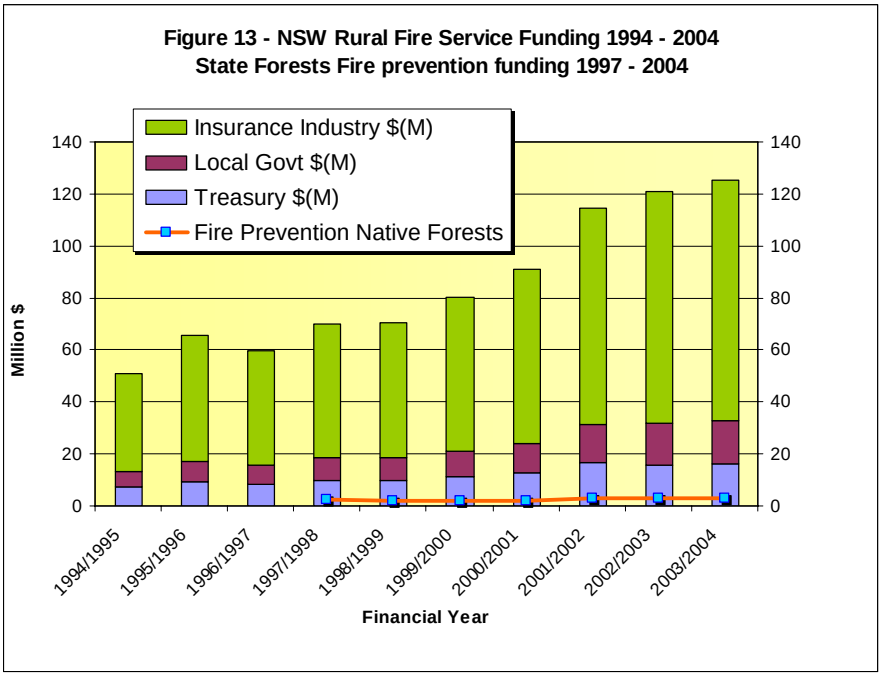
The success of these rural fire-fighting units in suppressing wildfires, particularly in protecting property and lives at the bush/urban interface, is without doubt. However, the increasing reliance on volunteer fire-fighters at a time when support for public land agencies is decreasing, raises some serious questions regarding the nation's ability to implement longer-term initiatives, including broad-scale fuel management via prescribed burns. This has serious repercussions for long-term management of the forest landscape, and for the role that government should play in managing its forests.

The Volunteer Fire Service Agencies

The volunteer fire service agencies (VFSA's) are composed of volunteer fire-fighting organisations in each state. They are organised at the state rather than the federal level. The Rural Fire Service (RFS) in NSW and the County Fire Authority (CFA) in Victoria have 69,000 and 58,000 volunteers, respectively (NSW RFS 2005, CFA 2004). In addition to the large number of volunteers, these organizations also have permanent salaried staff who manage the volunteer force and administer the increasing legislative, planning and community fire protection responsibilities. The primary purpose of these volunteer units is to allow states to call up a rapid response force to combat wildfires.

This force is not full-time, but instead mobilised when needed to fight large scale blazes. Volunteers have separate, professional lives. When called, they serve, and by law cannot be fired for leaving their regular day jobs. The services have been very successful at responding to emergencies. However, traditionally, long-term management planning and implementation remained the purview of state land management agencies.

The VFSA's, have been well staffed and equipped over recent years, with a commensurate rise in funding every year, usually in response to preceding severe fire seasons in each state (Figure 13).



Source: NSW RFS 2005, State Forests NSW 2005

Funding Mechanisms

The Australian fire-fighting system also boasts a unique funding mechanism, whereby, a large majority of capital infrastructure and costs of the VFSA's are borne by the homeowner insurance industry. This occurs in NSW, Victoria and Tasmania, and other states (such as South Australia) have off-set arrangements whereby targeted emergency service levies are directed at homeowners in lieu of higher insurance premiums. (CFA 2005, NSW RFS 2005).

As can be seen from Figure13, the insurance industry funds the majority of capital works, associated administration and non-emergency fire-fighting and prevention activities. In NSW for 2003/2004 this amounted to over $92 Million AUS.

In Victoria for 2003/04, the insurance industry component exceeded $139 Million AUS. This is commonly calculated on a pro-rata amount of total costs. In NSW and Victoria this has been consistently applied at 73% and 77% of total annual revenues for the last 5-10 years respectively.

In NSW, other funding components come from local Government (councils) and State Government, each accounting for 13% of the total RFS revenue. In emergencies, the NSW Government, under Section 44 of the Rural Fires Act 1997, can release additional State funding for extended fire suppression activities. Figure 14 shows the marked variation in emergency funding over the past 10 years, including over $120 million for the severe 2002/03 fire season.

While funding has increased for volunteer fire suppression agencies, the situation and funding mechanism for land management agencies is very different. State funding for fire prevention (traditionally performed by land management agencies) on public lands has been declining. Agencies typically receive either consolidated grants from annual state government budgets, or in

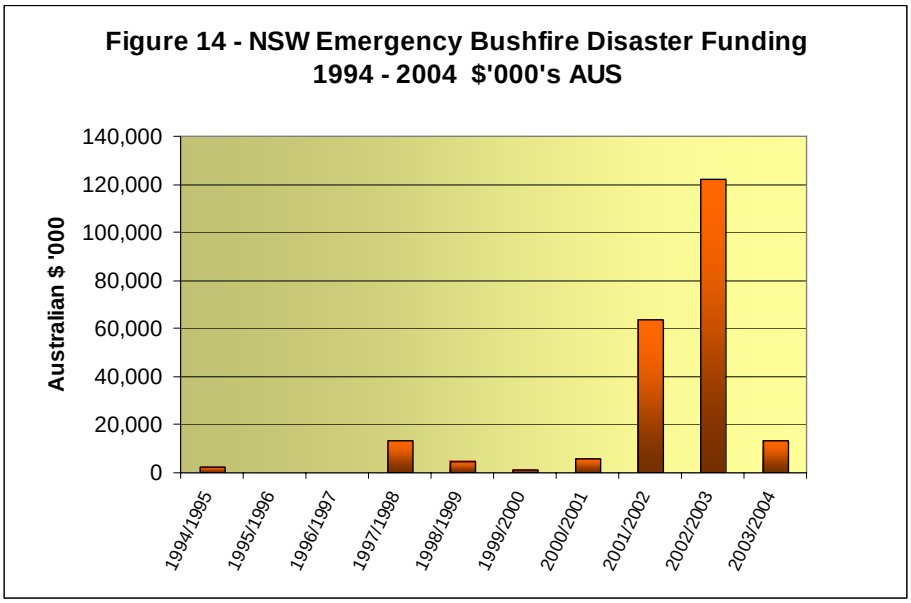
the case of forestry, receipts from timber royalties as part and parcel of business costs. Their fire-fighting budgets are often the first to suffer cuts when there are general budget cut-backs. Plant and machinery are sold off, field-staff downsized and operational expenditure reviewed. The result is declining expenditure on long-term fire planning programs that aim to prevent catastrophic wildfire (Cheney 2003).

6.2 Shifting Fire-Fighting Jurisdiction

Across Australia, there is a trend towards shifting increasing fire-fighting duties, and funding, to the volunteer fire services. This is a major change in the volunteer mission, with important implications. Traditionally, the VFSA's were only called out for emergency fire suppression, not for routine activities and maintenance that requires a longer time commitment. There are serious questions about whether a volunteer fire service can or even should, be asked to bear the burden of daily fire management across most private and public forested tenures.

The attractiveness of this funding and jurisdictional shift is obvious, as it is politically easier for state governments to commit funds to an agency with a focus on community protection than it is to continue funding land management agencies for long-term broad preventative measures, where the benefits are not immediately obvious.

With a large unpaid volunteer component, the VFSA's can apportion more of their funding towards new equipment, capital items and direct fire suppression costs. To the public, this appears to be money wisely spent and well deserved. There is little accounting for the actual costs that the volunteers and their employers bear directly. Their collective contribution is huge. Recent estimates from Victoria put the annual contribution of voluntary fire services at $460 m AUS. Australia-wide, an annual contribution approaching $1,200 million is likely (Ellis *et al.* 2004).



Source: NSW RFS 2005, State Forests NSW 2005

In NSW, recent changes in legislation have given the RFS and other volunteer based services increased powers over private, as well as public land tenures. These new powers extend to requiring private and public landholders to manage fuel risks on their land, and the authority to engage in cost recovery if the landholder or land manager does not comply.

In the Australian Capital Territory, the revised ACT Emergency Services Act (2003) has also given the power to the ACT RFS organisation to undertake any hazard reduction activity on any

land tenure within the Territory. As a result, the volunteer agencies (at least in terms of legislation) now take an increasingly pro-active role in fire prevention on public tenures.

Can a Volunteer Fire Services Agencies Oversee Long-term Fire Management over Broad Forested Landscapes?

As funding for the VFSA's across Australia gains, there has been a parallel decline in funding fire fighting units in traditional land management agencies. Figure 13 also shows how in NSW, funding for the RFS has increased each year, whilst the State forestry organisation funding for fire prevention works in over 2 million ha of native forests (as a small percentage) has remained static (around $2-3 million AUS annually) or declined in real dollar terms.

The question must be asked whether a volunteer fire service agency, created to call up large numbers of unpaid, well but narrowly trained civilians to defend life and property for a short period of time (they have jobs to get back to), could be expected to extend their responsibilities to fire management across huge swaths of public forest land, year-round? Fire suppression is generally a short-term, immediate activity meant to deal with an emergency event. In contrast, fire management involves long-term advance planning to reduce the likelihood of catastrophic fire. The efficacy of such programs has already been discussed in chapters 3 and 4.

Effective fire management on public forested lands demands:

- Full-time field staff, making daily rounds across the estate and familiar with vast landscapes, with capacity to remain 'on-call' or standby stationed in the forest in case of the need for rapid initial attack (Cheney 2003, Jeffery 2003)
- Experienced professional staff with knowledge of the terrain and expertise in regulatory regimes and obligations concerning their estate (Cheney 2003, 2004)
- An organisational culture, as well as comprehensive experience in meeting competing, multiple management objectives (SF 2002, Florence 2003, Forests NSW 2005)
- Ready access to plant (bulldozers) and machinery, normally associated with either timber harvesting or road maintenance, and contracts in place to use them for fire management (IFA 2003, TCA 2003, Victorian Farmers Federation 2005)
- Manning and maintenance of fire detection systems such as fire towers and spotter aircraft (SF 2002, Gray 2003, IFA 2003, Ellis *et al.* 2004, Forests NSW 2005)
- Staff available for long-term mopping up and patrol of existing extinguished fires, not just initial attack and knock-down (Gray 2004, Hodgson 2004)
- Ability to coordinate fire-fighting with day-to-day management tasks (such as timber harvesting, recreation management) in order to minimise impact and disruption to existing activities (SF 2002, Gray 2004, Forests NSW 2005)
- Familiarity with local forest conditions, fuels and fire behaviour in given set of weather parameters and climatic conditions, including major risk and hazard factors (Jeffery 2003, Cheney 2004)
- Ability to undertake rehabilitation and remedial action following wildfire events (NCC 2004, DSE 2005)
- Monitoring capacities to report on outcomes achieved (Florence 1994, DSE 2002)
- Keeping an 'in-house' knowledge base and training people through continuing on-ground experience in the locality they are familiar with (Gray 2004, Hoggett & Hoggett 2004)

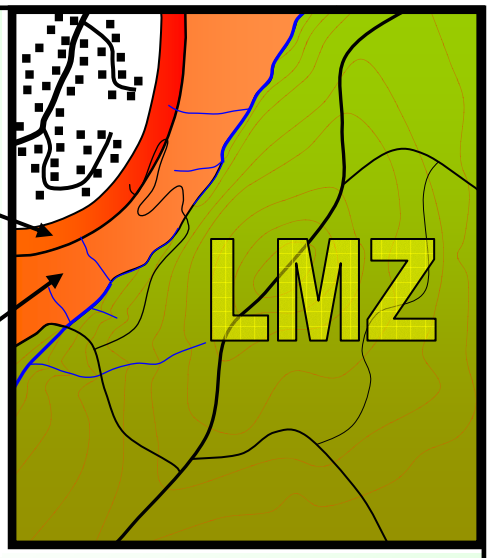
- Control of forest areas on high fire danger days – regarding access and prohibiting certain activities (involving machinery, naked flames) (de Mar 2003, Gray 2004)
- Knowledge and records of historical events and prior prevention measures undertaken in specific forests settings (Ellis *et al.* 2004).

There is no substitute for local knowledge and experienced staff familiar with local conditions (Jeffery 2003, various COAG submissions 2003). No amount of scientific modeling, satellite imagery or theoretical fire interval guidelines can account for more than the combined cumulative experience of seasoned field staff. They can predict weather effects, how ignitions will react to changing circumstances, estimate the combined influences of fuel load, structure and moisture content and can act appropriately (Cheney 2004).

Knowledge of fire behaviour under extreme conditions also comes with practice, not just training. The best practice for any-one starting in the fire game, is through experience only gained through a mentoring process combined with the judicious application of prescribed fire (Cheney 2003).

What is the 'Thin-Red Line'?

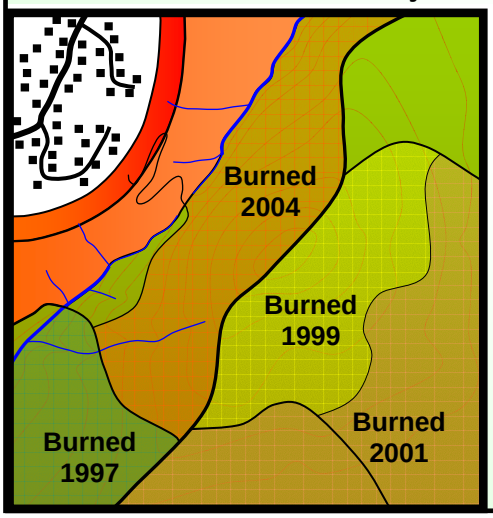
The 'Thin Red Line' refers to the Urban Bushland Boundary (or Wildland Urban Interface WUI) and the specific fire mitigation and risk reduction measures taken to protect lives and assets. There is particular terminology associated with the concept used by fire agencies in their risk assessment, management and planning.



APZ – Asset protection Zone – usually 50 metres or narrower in width – as measured directly from the asset. In this case it may be a suburb, individual house, or usually other structure with tangible $$ value.

SFAZ – Strategic Fire Advantage Zone – essentially a buffer for the APZ, it can extend up to another 500m. Fuel reduction treatments in this zone are usually less frequent and intense.

These two areas can come under specific fire-related regulations, allowing for regular and frequent treatments, such as mowing, mechanical removal or prescribed burning.



LMZ – Land Management Zone – would consist of the majority of area of public and private forested areas, and comes under the agency's or other general environmental planning instruments.

The area of the 'Thin-red Line' interface may only constitute 2-5% of the total forest estate. Protection of human assets from wildfire is essential through the 'Thin-red line' practices, however additional measures (using prescribed burning as the most efficient and effective method) need to be undertaken across the broader landscape. The diagram to the left shows how particular forest areas are prescribed burned on a mosaic basis, in different years, to gain the addition protection benefits for the adjacent communities. Treating the WUI is important - but so is the interior (LMZ) of larger forest areas, where most large wildfires develop.

The less familiar practitioners become with managing low-intensity fire and associated conditions, the greater the opportunity for escapes.

It is conceivable that with sufficient funding, training, and expansion, the VFSA's could ultimately extend their human and technological capital to meet these added demands over public forested lands. There would probably be protracted and a steep learning curve, but it is possible. However, this leads to the bigger question regarding the change in mission of the VFSA's. Is such a shift in mission a good idea? What does this mean for the appropriate role of government in fire and land management?

Should Long-term Fire Management Objectives on Public Lands be Administered by Volunteer Fire Service Agencies?

Over the past three decades across Australia, the traditional 'lead' roles of public forest management agencies in respect to fire prevention and suppression has been overtaken by the VFSA's. As this trend progresses (whereby forestry agencies cede both area and resources), it is accompanied by a shift in both fire management emphasis and culture. For example, prescribed burning programs covering broad areas across forested landscapes are less likely to receive as much attention as 'strategic' actions along the bushland/urban interface (WUI in US terminology). The 'thin-red line' approach to fire management, described above, is not sufficient to meet the diverse objectives of general forest management, which includes balancing the interests of timber production, water catchments, habitat restoration, recreational facilities, aesthetics, and biodiversity conservation alike.

Under this scenario, conflicting interests would most certainly likely arise between volunteer fire agencies responsible primarily for suppression, and land management agencies with long-term goals for amenity, habitat and timber production over the same areas.

Land managers are still in the best positions to know the fuel hazards and associated risks on lands they administer, which fuel reduction strategies work (and which do not) to protect both their assets and the wider public good.

These trends however, tend to further erode the imperative for public land managers to take responsibility for fuel management as expressed in their governing legislation (Cheney 2004). There is a common precept of 'all reasonable care' or 'taking all necessary steps' to prevent fire from both starting and then exiting from one's estate onto neighbouring tenures (NSW Forestry Act 1916, NSW Rural Fires Act 1997). Abrogating fire management responsibilities would further reduce available forest agency resourcing levels, so that an enormous amounts of time would be taken attempting to coordinate between organizations, align potentially competing objectives and decide whose responsibility was the 'fire that got away.'

There is an even more fundamental question regarding this situation, specifically 'what would then be the future role of public forest land management agencies under this scenario?'

Many of the essential capabilities listed on the previous pages would suffer, further restricting the agencies' abilities to meet their other management obligations and legislative responsibilities. This scenario would see increased scrutiny to justify the existence of individual agencies – where as economies of scale (and economic 'rationalism') would demand the combining of sometimes

disparate organisations, with alternate management goals, in the name of increased efficiencies (Florence 2003).

Even if there was no express intent by VFSA's to enlarge their responsibilities across public tenures, the continuing extension of the current situation regarding fire management funding, limiting resources and personnel, as well as increasing planning and associated costs could well see a 'default' situation occur. Land management agencies can increasingly no longer afford fire suppression or treatment work throughout their tenure, and thus become increasingly reliant on outside assistance. Or simply the work doesn't get done. In terms of fire suppression this would be an unacceptable situation, however in terms of fire prevention and fuel treatments, this is continuing to occur (See Chapter 2).

Conclusion

How do we want our public forest lands to be managed in relation to fire suppression and prevention in the future? Current political and policy directions are trending towards a culture of fire suppression at the expense of broader preventative fire activities, and passive rather than active management over extensive forest areas. This shift in emphasis needs to be a distinct decision (with acknowledgement of likely longer-term management implications), made by a well-informed public and their representatives, on whose behalf the agencies perform their duties.

6.3 The Economics of Prescribed Burning and Fuel Treatments

Prescribed burning as a fuel treatment in the broader landscape context has much to offer in terms of 'value-for-money'. It is the most cost-effective option in many circumstances, where local forest fuel conditions make its application feasible. Other fuel treatment options and methods may need to be used where prescribed fire application is not practical, due to environmental (excessive damage to the existing stand) or social concerns (smoke and air quality).

Costs of Fuel Treatments in the Western States of the US

In the 15 Western States of the US there are at least 52 million hectares of forested timberlands. Of this area, there are opportunities for various fuel treatments for forest restoration over at least 28 million hectares. Moderate levels of restoration treatments such as fire or mechanical thinning would be required to begin managing a more 'natural' fire cycle, however over much of these areas, mechanical treatments only can be conducted due to high fuel loadings, the risk of damage from fire, and other factors including smoke management, appropriate weather conditions and lack of resources (USDA Forest Service 2005).

The US Forest Service conducted a strategic assessment of the potential costs and benefits of fuel reduction treatments in these forests (Table 7). Prescribed burning appeared to be the cheapest option with costs ranging from $AUS115 to over $988 average costs running at $300/ha treated ($227US/ha) (USDA Forest Service 2005). Mechanical treatment costs were much higher (see Table 7 below), however some costs recovery could be made if some larger diametre sawlogs were also removed and sold as part of the mechanical thinning operation. For the US forest management agencies, this is where most of the concern and debate over fuel treatments and harvesting occurs in the political and social spheres. More fuel treatments would be cost-effective if some trees greater than 17.5cm DBH were available to harvest for higher value end-products.

Consequently, the biomass volume recovery potential from overstocked stands in the Western US is huge. There are estimates of producing between 8 million to 51 million dry tonnes of

merchantable material annually over the next 30 years from only the essential treatments. Due to the small-diametre of most of the recoverable material, options other than sawn lumber are now being considered. These include using the material for woodchips, orientated strand-board (OSB), medium density fiberboard (MDF) and some of the smallest size material as fuel for biomass electricity cogeneration (USDA Forest Service 2005).

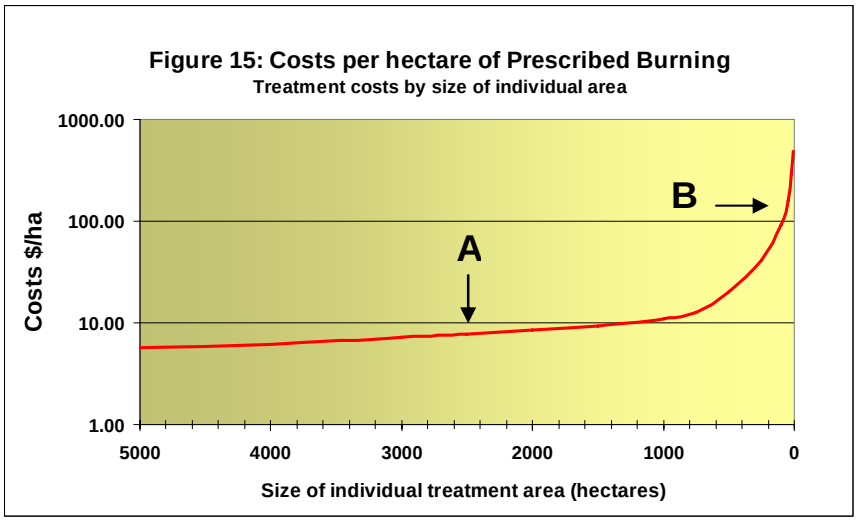
Table 7 - Generic Comparisons of Fuel reduction Alternatives (USDA Forest Service 2005)

Treatment	Cost Range ($US/acre)	Cost Range ($AUS/ha)	Key Benefit	Key Problem	Products
Prescribed Fire	$35-300/ac	$115-988/ha	Low Cost	Restricted Use	No
Mastication	$100-1000/ac	$329-3300/ha	No smoke	Fibre left in woods	No
Cut/pile/burn	$100-750/ac	$329-2470/ha	Low Access	Burning limitations	No

$1 AUS equivalent to $0.75 US

Prescribed burning costs in the Australian forested landscape

Figure 15 below and Appendix 1 shows a general trend indicating that costs associated with prescribed burning increase exponentially, as the individual treatment area size decreases. This occurs most commonly around the urban/bushland (WUI) interface, where average size treatment areas range from 10 to 50 hectares as discrete units. The highest most striking treatment costs occur near large urban areas (such as Sydney northern suburbs) where costs of prescribed burning treatment can run well over $AUS1000/ha (Berry pers comm. 2004).



This is mainly due to the intensity of planning, and concentration of man-hours dedicated towards implementing the burning treatment, whilst ensuring there are no potential 'escapes' or damage to homes or properties as a result of the activity. In contrast, broader forest treatment areas (generally greater than 500ha) can be treated for as little as approximately $7/ha, even taking into account increased staff and resourcing costs.

The use of aerial ignition (using specialised equipment in helicopters or fixed wing aircraft) is a major factor in this cost reduction, and also allows for broad area prescribed burning treatments to be conducted as conditions allow, and maximises the climatic 'window-of opportunity' (Gray 2003)

A sensitivity analysis shows that the individual size of the proposed treatment area has by far the greatest effects on costs on a per hectare basis. The smaller the discrete area to be treated, the greater the cost. Almost all the other individual cost factors and inputs (listed in Table 8) need to increase markedly before any significant effect is recorded on an overall $/ha basis. This

difference is demonstrated by the two points '**A**' and '**B**' in both Figure 15 and Table 8, representing continuous prescribed burning treatment areas of 2,500 ha and 50 ha respectively.

Table 8: Prescribed Burning Gross and per Hectare costs with individual costing inputs

Discrete Area of Prescribed Burning Treatment	2500 ha	50 ha
Points from Figure 15	**'A'**	**'B'**
Man Hours	224	140
Staff Costs	$6,400	$4,000
Helicopter Costs	$5,610	$0
Planning Costs	$3,300	$1,925
Vehicles and Fuel	$1,549	$877
Sundries	$2,500	$1,200
Total Costs	$19,359	$8002
Costs per Hectare Treated	**$7.74/ha**	**$160.05/ha**

(Source: NSW Forests, NSW NPWS pers comm. 2004-2005)

Australians are in an enviable position in relation to the treatment options available for fuel management in broader forest areas. Our fire-adapted forests will allow for prescribed burning treatments alone, without resorting to the need for mechanical thinning, mastication and other techniques necessary in US forests, to prepare areas for reintroduction of a more historic fire regime.

Pending further investigation of the potential costs and benefits, from both an economic (and ultimately political) perspective, broad landscape-based prescribed burning treatments should be sustained and encouraged. Whilst it is essential to maintain the intensive fire risk mitigation work on the urban/forest interface, a realistic cost/benefit balance needs to be recognised and appropriate funding directed for the optimal benefits to forests, struck between treating only the 'thin-red-line' and the broader forest areas. This might also then better fit the definition of an 'economically rational' approach to fuel management.

One controversial proposal to sustain broader fuel reduction practices in south-eastern Australia, would be for public land managers to utilise a very small portion of the recurrent funding to volunteer fire services from the insurance industry. From the above data, if as little as 3% or $2.5AUS Million of the current contribution was redirected to land management agencies to recognise the value of fire protection, at average cost of $10AUS/ha, it would enable treatment of 250,000 hectares of forest in broad area fuel reduction.

However future funding arrangements are to be organised, one thing is clear. Fuel reduction, hazard mitigation and prescribed burning activities need to continue, and the public and politicians should seek the appropriate economic balance in terms of 'public good' between preventative measures on the 'Thin-red line' and broader fuel reduction actions in the adjacent forests.

6.4 Moving Past the Blame Game: Utility and Limitations of Inquiries and Coronials in Australia

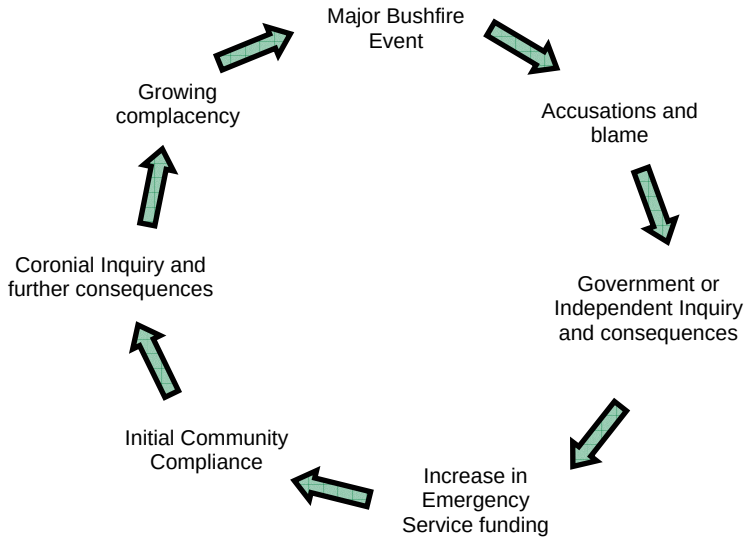
No description of the political process in relation to bushfires and hazard reduction in south-eastern Australia would be complete, without reference to the numerous inquiries and coronials that inevitably follow major conflagration events. Since the late 1930's, the typical political response following major fire emergencies involving loss of life and/or assets has been a series of either official independent or Parliamentary inquiries in conjunction with mandatory coronial

inquests. Whereas coronials are legally mandated as a response to the loss of life (and occasionally assets alone), many other inquiries are politically inspired responses to public concerns. These investigations are seen as a way to show the public that the government is 'taking action,' and (sometimes) holding responsible parties 'accountable.' Often the automatic political response following instigation of an inquiry is to increase annual emergency and volunteer fire service funding (Figures 13 and 16).

Evidently, many such formal inquiries concentrate on allocating (or deflecting) blame, analyzing initial operational responses to the incident, improving emergency management processes or increasing suppression agencies' authority. Their terms of reference and recommendations may also cover fire-fighting infrastructure, planning regulations for home-owner safety, insurance, public awareness and education of bushfire risks, as well as training issues.

Despite the history and number of coronial and other formal inquiries, few if any, have risen to the challenge of addressing a comprehensive solution for better forest fuel management. Most often lacking, is impartial analysis on the fuel conditions that led up to and contributed to the bushfires, and most importantly, concrete, constructive and specific recommendations on the management of forest fuels, in order to prevent a repeat of such events in the future. Occasionally, there are generalised and vague recommendations to 'sustain' or 'increase' the current levels of hazard reduction over forest areas. This is mostly met with generalised and vague responses by the agencies charged with implementing the measures.

Figure 16: The 'Bushfire Cycle'. This can extend between 20-50 years, depending on the location and scale of the event. (Source: Ellis *et al*.. 2004)



In recent inquiry outcomes, caution has been advised in relation to applying prescribed burning on the basis of potential harm to biodiversity (Ellis *et al.* 2004), with an inevitable call for more research into the effects of fire in the landscape. Whilst further research is necessary and laudable, (as exemplified by the recent Bushfires Cooperative Research Centre), this does not give immediate assistance or direction to forest managers who are required to make decisions now.

It is questionable whether an inquiry or coronial procedure is the best method for improving overall fire management performance (Cheney 2003, Ellis *et al.* 2004). Often, essential information is discovered in the process, and ideally should be shared in subsequent joint agency debriefings, but is withheld as the lawyers begin to circle.

Real improvements to agency co-operation, fire management systems and fuel reduction are bound in with the prospective outcomes of a process, which can take months, and often years to conclude. Whilst the Parliamentary inquiry process particularly, may satisfy the political beast, it does little to improve long-term fuel management planning.

In contrast, the US situation is markedly different. The Federal US Government has taken the initiative following advice from its public land management agencies in relation to forest 'health', wildfire mitigation and fuel management. The fact that public forest land is for the most part a federal rather than a state jurisdiction, obviously makes it easier for nationally co-ordinated programs and responses to wildfires, as well as more uniform approach to fuel management.

This also provides a stronger focus on the prevailing and changed forest conditions, with firm responses and commitments to them, in the form of the National Fire Plan (2000), Healthy Forests Initiative (2002) and Healthy Forests Restoration Act (2002). Despite the controversy surrounding the associated politics, these measures do provide a sound basis and clear direction for land managers. The regular General Accounting Office (GAO) reports to Congress have been fundamental in facilitating these changes in management ability, accountability and performance. (Hill 2002, Nazzaro 2005)

Conclusion

Accountability following bushfire events does need to be brought to land management organisations, but not in the form of the fear of blame or prosecution. Two primary factors need to be considered in terms of this accountability; (1) the appropriate discharging of obligations and responsibilities to the wider community on the basis of 'all reasonable steps'; (2) How previous fuel management activities and responses to bushfires were in accord with established objectives and agency goals, performed with due diligence and to the best ability of the organisation.

7 The Future of Fire and Fuel Management

Précis

This paper has attempted to show that the current state of fire management in Australia is at a major crossroads. Common misconceptions about the science of fire ecology, current trends in shifting forest ownership and fire management jurisdiction, prevailing social attitudes about fire, and the politics of funding fire programs are moving fire policy in Australia towards a reactionary and short-term approach to fire. This has potentially serious consequences for the forested landscape, as emergency fire suppression ethos replaces long-term fire management principles.

Social values, science, public attitudes and politics impact how we, as a society, make the decision regarding the proper role of prescribed burning in forest management. This chapter offers recommendations on how we should consider each of these areas, and where specific improvements can be made in relation to fire and fuel management in Australia.

The Precautionary Principle:
'In order to protect the environment, the precautionary approach shall be widely applied by the States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost effective measure[s] to prevent environmental degradation'.

(Principle 15 of the Rio Declaration 1992)

In using the 'classic' interpretation of the precautionary principle (above) in relation to fire, it can be taken to mean that if prescribed fire might have negative effects of any kind of significance, than do not used prescribed fire. However, if the alternative of 'no-action' is larger and more severe wildfires, than some remedial action should be taken, even where some scientific information is lacking.

7.1 Social Values

No discussion of the proper role for prescribed burning can ignore the core questions of what we value about, and what we want from, our forests.

Using fire as a management tool to achieve certain objectives has been in practice for a very long time. Contrary to the common public myth that there was little fire management prior to European settlement, indigenous peoples on almost every continent used fire on the landscape for a variety of reasons.

Any decision, be it to actively manage the land or not, is a choice. Choosing to do little in the way of active fire management, such as reducing fuel build up, does not necessarily mean that the impact will be less. This was well-demonstrated by the Yellowstone Fires of 1980, which erupted after lightning strikes were allowed to burn continually during an extended dry spell, setting off fuels that had accumulated but had not yet been treated. Thus every decision carries with it a set of implicit value judgments that inform our opinion of the role of fire and prescribed burning.

It is critical that decision-makers are cognizant of these assumptions. This is especially true today, when Australian forests are increasingly becoming fragmented, as forestlands are transferred from state land management agencies to parks, and sold off to TIMOs. State land management agencies have the infrastructure (accessible roads) and long-term vision to manage broad landscapes.

TIMOs and parks are less likely to use intensive fire management, as the former weighs financial costs and benefits and the latter philosophically prefers 'benign' forest management. This land shift complicates fire management, as fire-fighting units must coordinate across various ownerships, and they encounter varying degrees of fuel loads, access, and staffing.

Recommendations:
Increase co-operation among public land management agencies, and with private land managers to ensure management on a landscape level. Regardless of land tenure, fire prevention activities and operations are most effective when implemented on a landscape basis as well as defensible boundaries. Much has been achieved in recent years in terms of cooperative fire fighting arrangements. A similar approach to the case study of the Canobilis Risk Management Plan (Chapter 5) would enhance fire prevention across tenures. As wildfires do not respect tenure lines on a map, private landholders, public land managers and fire suppression organisations should cooperate to maximise public good. In terms of public agency structures, a potentially better outcome, in an era of decreasing resources, would be to combine land management agencies (or at least their fire management divisions) with common interests in fire management. Victoria and Western Australia have adopted this approach.

Continue fire prevention and mitigation based on the 'thin red line' for community protection, in combination with broader fuel management across the forested landscape. This approach has occurred in the past and should continue. As Australia is a country prone to wildfires, community and asset protection is best served through a fuel management approach across the landscape. Fire exclusion by 'default', can only lead to larger, more intense, and less manageable wildfires.

7.2 Poor Science, Myths and Misconceptions

Much of the debate around the use of prescribed burning results from common misconceptions about fire ecology and utility.

There are many common myths regarding prescribed burning which often arises from a poor understanding and application of science. Critics of prescribed burning contend that it is bad for biodiversity, requires too frequent burns to be feasible, robs the forest of needed nutrients, encourages weed growth, and harms the ecosystem.

These misconceptions are largely based on a failure to distinguish between low-intensity fires and high-intensity fires, as well as their frequencies, as each have very different effects on the landscape. Prescribed burns are mostly intended to be low-intensity fires with a clear management objective to reduce fuel loads and to prevent the eruption of potentially more damaging high-intensity wildfires. Wildfires, if they occur on untreated lands with heavy fuel loads, tend to burn more intensely, widely and have greater detrimental impact on the ecosystem.

Hence, it is arguably desirable to implement low-fire intensity prescribed burns because they reduce the likelihood of more damaging high-intensity wildfires. Community fire protection and conservation outcomes can and do complement each other at the landscape level. Indeed, the science, particularly emerging from the US, indicates that regular prescribed fire treatments can actually encourage some species to thrive.

Recommendation:
Ecologists, conservationists, managers and politicians need to be careful when citing science as a basis for policy-making. Not all science is good. The science emerging in the US, and much more slowly, in Australia, is that there is a legitimate and necessary role for consistent prescribed burning as an effective fire management tool across the landscape. After years of debate, factions in the US can generally agree on this. Reaching a consensus in Australia is probably the hardest thing to achieve in the current divisive environment. The continuing debate (and entrenched positions) regarding frequent prescribed burning and the perceived impacts on biodiversity has to be resolved before positive progress on this can be achieved. Awareness of the latest scientific research on fire ecology can be helpful, only if it is applied correctly, in context and without bias.

7.3 Public Attitudes

Public policy must balance both science and social needs, and thus understanding the public's attitudes towards fire is essential for developing fire management policy.

Fire in any form is big news. Charred homes and lost lives play out dramatically on television and in papers, and the general public's perception of fire is undoubtedly influenced by media coverage. This raises a critical issue for fire managers. Fire management should include an understanding of how the public perceives fire and prescribed fire, and what methods of communicating to the public work best.

Studies on public attitudes towards fire have been a relatively recent development. But there is sufficient evidence to conclude that even if the science and the economics bear out a certain natural resource policy, failure to garner public support will doom the policy. That is, science and funding matter, but neither more so than politics.

Research in the US indicates that public attitudes depend a lot on where people live. Those living near historical wildfire-prone areas are much more concerned about fire, and more supportive of fuel treatments. Those living in urban areas tend to see only the inconveniences of fire, such as smoke, and are less likely to endorse prescribed burning.

In the US, where there have been a string of escaped 'controlled burns,' the public seems to question the land agency's ability to manage such treatments, more than the efficacy of the treatment itself. This highlights an important issue regarding public attitudes towards any kind of forest management, the issue of trust in public agencies.

Recommendations:
Make education of the public, on the role of prescribed fire in maintaining forest ecology and protecting communities, a priority. The US experience (with the groups like OFRI and the public agencies) has shown that communities can both understand and support fuel treatments that are designed for protecting the community and restoring ecosystem processes in forest areas. south-eastern Australian states can benefit from a similar approach to public education. It is critical to build trust with the public through extensive, consistent communication.

Conduct surveys and other means to determine a baseline benchmark of the public's knowledge and attitudes towards prescribed burning and fuel management. Any

improvements in terms of public understanding of the reasoning behind forest fuel management must have a basis from which to work from.

7.4 Politics

The vagaries of politics often make funding for long-term consistent fire management difficult.

Across Australia, politicians are increasing conservation areas by transferring lands from state land management agencies. There has also been a privatisation move to sell off plantations to timberland investment management organizations. The resulting shift of forestlands has serious consequences for fire management and fire-fighting jurisdiction, as it results in a de facto transfer of fuel management obligations to the Volunteer Fire Service Agencies (VFSA's), well-funded, but primarily part-time, volunteer fire suppression force.

Whilst the VFSA's fire service agencies have been adept at battling fire emergencies, they are not currently set up to implement long-term, fire management regimes across the landscape and land tenures that require expertise, specialised equipment, and familiarity within forested landscapes. That does not mean that over time, with sufficient training, added full-time staff, and funding, that the VFSA's could not become proficient at handling the daily management duties of a long-term fire management program. But it was not originally set up to do so, and in the period of transition, there is a steep learning curve, and confusing state of overlapping management responsibilities between cash-strapped land agencies that have traditionally had fire-fighting authority, and the volunteer fire services.

What emerges is a risky system that discourages land agencies from investing in long-term planning, and program implementation (since they are either static or losing funding, and the VFSA's are gaining funding). This bodes ill for broader fire prevention activities in the forested landscape.

Recommendations:

Society and the government need to discuss whether something as critical as fire prevention planning on public forested lands should be delegated to a largely volunteer fire organisations. At present, without real transparent debate, the VFSA's are being handed new duties and responsibilities for which they were not originally established or intended to handle.

The government must allocate consistent funding for long-term fuel treatments and fire planning. Whether a public discourse results in reaffirming fire management as part of the core business of land management agencies, or is transferred to the VFSA's, stable funding for long-term fire prevention is essential.

One funding option, though controversial, is to appropriate a small amount of the current insurance industry funding for VFSA's for fuel reduction activities on public lands managed by agencies. Given the large amount of 'public-good' benefit derived from public agency land management in respect to fire, and the stagnating and stymied nature of the current funding arrangements, this solution could involve a separate allocation from the insurance industry, whose grants now cover over 70% of RFS and CFA funding. If as little as 3%, or around $2.5 Million AUS of the current contribution was redirected to land management agencies to recognise the value of fire protection, this could, at average cost of $10/ha, treat 250,000 hectares of forest in broad area fuel reduction, or at least provide relief to that level.

This would have the effect of both sustaining long-term funding arrangements for specific activities and isolating an essential community service component from the vagaries of annual budget reviews. It would ensure continuing land management agency support for broader fuel management programs, with greater accountability, as other entities would also be contributing and obviously want to get value for their money. At least the proposal should be canvassed by those that pay the fees, the insured home-owners, who would derive addition protection from the measures.

Although this proposal could be resisted from the emergency services sector, it would also recognise and ensure continuing resourcing to the land managers who continue to manage for community fire protection and welfare from a limited and vulnerable funding base.

7.5 At the Crossroads

To use an old Australian idiom, 'having a go' means to try our best even though the prevailing conditions may present some difficulties not in our favour. As regards fire management and fuel reduction, if land managers and agencies are at least 'having a go' (attempting prescribed burning, improving cooperative arrangements, engaging stakeholders and local community consultation), whilst not immune from criticism, they can point to successes and the valid efforts at active and adaptive management.

Fuel reduction and prescribed burning may not be the panacea, but without it, options are greatly reduced in terms of consequent effects and our ability to suppress and mitigate damage from wildfires. In addition to prescribed burning, we need access to readily available, trained and experienced forest firefighters, maintenance of equipment, rapid detection and response, coordination between agencies and policies in place which allow for the implementation of all of these.

Steve Arno has stated (2005 pers comm.) 'There is an elephant in the living room' in relation to forest fire management but it appears we are more focused on the colour of the drapes than doing something about the elephant!

At this crossroads in Australian fire policy, we have an opportunity to learn from rapidly developing science and social science, and from the experiences of other countries. It is an opportunity worth engaging, as elephants in small rooms tend to make themselves felt!

8 References

1. ACT Emergency Services Act. 2003. Government of the Australian Capital Territory. Available at: http://legislation.act.gov.au.

2. Adams, Paul W. 2004. *Fire and Forest Management in the Public Eye: What the News Media Sees and Reports.* Presentation at: 'Creating Fire-Resilient Landscapes: Improving Our Understanding and Application'. 8-12 March 2004, Medford, OR.

3. Agee, James K. Pers comm. 2005.

4. Agee, James K. 1993. *Fire Ecology of Pacific Northwest Forests.* Island Press.

5. Agee, James K. 1997. *The Severe Fire Weather Wildfire – Too Hot to Handle?* Northwest Science, Vol. 71, No. 2 1997.

6. Agee, James K. 2002. *The Fallacy of Passive Management - Managing for Firesafe Reserves.* Conservation in Practice 3[1]. Society for Conservation Biology.

7. Agee, James K. 2003. *Burning Issues in fire: Will we let the coarse filter operate?* Presentation at 'Proceeding of the Fire Conference 2000: The First National Congress on Fire Ecology, Prevention and Management.' Tallahassee, FL.

8. Anon. *Achieving Healthy Forests and Rangelands: National Fire Plan Performance Update.* 2004. US Department of Agriculture; US Department of the Interior.

9. Anthony, Bill. Pers comm. 2005.

10. Arno, Stephen F. Pers comm. 2005.

11. Arno, Stephen F. and Allison-Bunnell, Steven. 2002. *Flames in our Forest: Disaster or Renewal?* Island Press.

12. Arno, Stephen F. and Fiedler, Carl E. 2005. *Mimicking Nature's Fire: Restoring Fire-Prone Forests in the West*. Island Press.

13. Bartlett, Tony. Pers comm. 2005.

14. Benson J.S., and Redpath, P.A. 2000. *Nature of pre-European native vegetation in SE Australia:* a critique of Ryan, D.G., Ryan, J.R. and Starr, B.J.

15. The Australian Landscape – Observations of Explorers and Early Settlers. *Cunninghamia* Vol. 5(2): 1997.

16. Berry, M. Pers comm. 2004.

17. Binns, D. L. 2001. Bull's Ground Frequent Burning Study Area - Notes for Institute of Foresters Field Day, Wauchope NSW, Institute of Foresters of Australia, NSW Branch. (unpublished data).

18. Binns, D. L. Pers comm. 2005.

19. Bowman, David. 2003. Bushfires: A Darwinian Perspective. In *Australia Burning: Fire Ecology Policy and Management issues*, edited by Cary, G., D. Lindenmayer, and S. Dovers, CSIRO Publishing.

20. Bradstock, R.A. Report of Proceeding before the Joint Select Committee to the NSW Parliamentary Inquiry to the 2001/02 Bushfires, Hansard Transcript 22 April 2002, Legislative Assembly, Government of NSW. Available at: http://www.parliament.nsw.gov.au/prod/parlment/committee.nsf/.

21. Brunson, M. W. and Evans, J. 2005. Badly Burned? Effects of an Escaped Prescribed Fire on Social Acceptability of Wildland Fuels Treatments. *Journal of Forestry*. 103 (3) 134-138 April/May 2005.

22. Brunson, M. W. and Shindler, B. 2004. *Geographic Variation in Social Acceptability of Wildland Fuels Management in the Western United States.* Society and Natural Resources 17, 1-18.

23. Cary, D. G. and Morrison, D. A. 1995. *Effects of Fire Frequency on Plant Species Composition of Sandstone Communities in the Sydney Region: Combinations of Inter-fire Intervals.* Australian Journal of Ecology 20, 418-426.

24. Cary, G., Lindenmayer, D., and Dovers, S. (eds). 2003. *Australia Burning: Fire Ecology Policy and Management issues*, CSIRO Publishing.

25. CFA (Country Fire Authority Victoria). 2004. Annual Report. Government of Victoria. Available at: http://www.cfa.vic.gov.au.

26. Cheney, Phillip N. 2003. *Economic Rationalism, Fear of Litigation and the Perpetuation of Disaster Fires.* In *Australia Burning: Fire Ecology Policy and Management Issues*. Cary, G., Lindenmayer, D., and Dovers, S. (eds) CSIRO Publishing.

27. Cheney, Phillip N. 2004. *'The Green Inferno' – The Politics of Bushfires and Conservation?* Inaugural oration to the Stretton Bushfire Group.

28. Cloughesy, M. Pers comm. 2005.

29. Council of Australian Governments (COAG). 2004. *Report of the National Inquiry on Bushfire Mitigation and Management.* Commonwealth of Australia, Canberra, ACT.

30. CSIRO (Commonwealth Scientific and Industrial Research Organisation). 2003. *CSIRO Submission to the COAG National Inquiry on Bushfire Mitigation and Management in Australia*. Canberra ACT.

31. Cutrupi, R. 2003. Forests viewed with hindsight. *Canberra Times*, 24 January.

32. Davis, A. and Cloughesy, M. 2004. *Opinions and Perceptions of Oregonians about Wildfire and Treatments to Create Fire-Resilient Forests.* Oregon Forest Resources Institute (Unpublished). Survey Results.

33. de Mar, P. 2003. Presentation to the 3rd International Wildlands Fire Conference Sydney October 2003.

34. Department of Sustainability and the Environment (DSE). 2002. *Analysis of Disturbance by Fire on Public Land*, Fire Ecology Working Group, Victorian Government. Available at: www.dpi.vic.gov.au/dse.

35. Department of Sustainability and the Environment. 2005. Code of Practice for Fire Management on Public Lands (Draft in review). Victorian Government. Available at: www.dse.vic.gov.au/fires.

36. Doherty, M. 2004. Residents 'opposed fuel reduction'. *Canberra Times*, 2 June.

37. Dolloff, A.C. 1994. *Large Woody Debris – The Common Denominator for Integrated Environmental Management of Forest Streams. In: Implementing Integrated Environmental Management.* Cairns, J (Jr), Crawford, T.V. and Salwasser, H. (eds.) 1994 Virginia Polytechnic Institute and State University.

38. Ellis P., Kanowski, P., and Whelan, R. 2004. National Inquiry on Bushfire Mitigation and Management. Council of Australian Governments (COAG) Commonwealth of Australia, Canberra.

39. Fiedler, Carl E. Ppers comm. 2005.

40. Fitzgerald, S. A. 2002. *Fire in Oregon's Forests: Risks, Effects and Treatment Options.* Oregon Forest Resources Institute.

41. Flannery, T. M. 1994. *The Future Eaters: an ecological history of the Australasian lands and people.* Reed Books.

42. Florence, R. 1994. The ecological basis for forest fire management in NSW. In *The Burning Continent*, pp 15-34. Institute of Public Affairs, Central Issues Sept. 1994.

43. Florence, R. 2003. *Upgrading Fire management in East Coast Forests: The case for a single forest management authority. Submission to the House Select Committee Inquiry into the Recent 2002/03 Australian Bushfires*. House of Representatives, Commonwealth Government Canberra 2003.

44. Florence, R. 2005. Bell miner associated dieback: an ecological perspective. In press. Aus For 68(4).

45. Forests NSW 2005. Corporate Fuel Management Plan (unpublished).

46. Friends of Metolius. 2004. *Joint Press Release of Sisters Forest Planning Committee and Friends of the Metolius*. Metolius Forest Project Lawsuit.

47. Gilligan, B. 2002. Report of Proceeding before the Joint Select Committee to the NSW Parliamentary Inquiry to the 2001/02 Bushfires, Hansard Transcript 22 April 2002, Legislative Assembly, Government of NSW. Available at: http://www.parliament.nsw.gov.au/prod/parlment/committee.nsf/.

48. Good, R. B. 1985. The Role of Fire in Conservation Reserves. In *Fire and the Australian Biota*. Gill, A. M., Groves, R. H. and Noble I. R. (eds.). Australian Academy of Science, Canberra.

49. Good, R. B. 2002. Report of Proceeding before the Joint Select Committee to the NSW Parliamentary Inquiry to the 2001/02 Bushfires, Hansard Transcript 22 April 2002, Legislative Assembly, Government of NSW. Available at: http://www.parliament.nsw.gov.au/prod/parlment/committee.nsf/.

50. Gray, G. 2004 *Submission to the House Select Committee Inquiry into the Recent 2002/03 Australian Bushfires*. House of Representatives, Commonwealth Government Canberra 2003.

51. Healthy Forests Initiative. 2002. Healthy Forests: An Initiative for Wildfire Prevention and Stronger Communities. US Government. Available at: http://www.whitehouse.gov/infocus/healthyforests/Healthy_Forests_v2.pdf.

52. Healthy Forests Restoration Act. 2003. H.R. 1904-3. US Government. Available at: http://www.healthyforests.gov/initiative/legislation.html.

53. Heemstra, S. 2005. Pers comm..

54. Hill, B. T. 2002. *Reducing the Threat of Wildland Fires Requires Sustained and Coordinated Effort.* General Accounting Office, US House of Representatives, Department Operations, Oversight, Nutrition and Forestry. Publication number GAO-02-843-T.

55. Hodgson, A. 2003. *Submission to the House Select Committee Inquiry into the Recent 2002/03* Australian Bushfires. House of Representatives, Commonwealth Government Canberra.

56. Hoggett, Jim and Hoggett, Aled. 2004. *When Will We Ever Learn?* Institute of Public Affairs, Background Paper. 16 February 2004. Melbourne, Institute of Public Affairs.

57. Hopmans, P. 2003. *Effects of repeated low-intensity fire on carbon, nitrogen and phosphorus in the soils of mixed eucalypt foothill forest in south-eastern Australia.* Department of Sustainability and Environment. Fire Research Report No. 60. Available at: http://www.dpi.vic.gov.au/dse/nrenfoe.nsf.

58. Horton, D. 2003. *Submission to the House Select Committee Inquiry into the Recent 2002/03 Australian Bushfires*. House of Representatives, Commonwealth Government Canberra 2003.

59. Hoy, Anthony. 2004. *In the Line of Fires.* The Bulletin (Newsweek) 15 Dec 2004. Available at: http://bulletin.ninemsn.com.au.

60. Institute of Foresters of Australia (IFA). 2003. *IFA Submission to the COAG National Inquiry on Bushfire Mitigation and Management in Australia*. Canberra ACT.

61. Jeffery, V. 2003 *Submission to the House Select Committee Inquiry into the Recent 2002/03 Australian Bushfires*. House of Representatives, Commonwealth Government Canberra.

62. Johnson, Dave. Pers comm. 2005.

63. Joint Fire Sciences Program. 1998. National Interagency Fire Center, Boise Idaho. US Federal Government. Available at: http://jfsp.nifc.gov/.

64. Jurskis, V. 2000. Vegetation changes since European settlement of Australia: an attempt to clear up some burning issues. *Australian Forestry* 63(3): 166-173.

65. Jurskis, V. 2004. *Observations of Eucalypt decline in Temperate Australian Forests and Woodlands.* Gottstein Fellowship Report: Available at: http://www.gottsteintrust.org/html/reports/report.htm.

66. Jurskis, V., Bridges, B., and de Mar, P. 2002. *Fire Management in Australia: the lessons of 200 years.* Refereed paper (in press).

67. Koperberg, P. 2002. News Conference, as reported by Robert Wainwright, *Sydney Morning Herald* 1 January.

68. Koperberg, P. 2002. Report of Proceeding before the Joint Select Committee to the NSW Parliamentary Inquiry to the 2001/02 Bushfires, Hansard Transcript 22 April 2002, Legislative Assembly, Government of NSW. Available at: http://www.parliament.nsw.gov.au/prod/parlment/committee.nsf/.

69. Lamont, B. B., Burrows, C. L., Colangelo, W., Swanborough, P. W. and Ward, D. 1999. *Grasstrees (Xanthorrhoea spp.) and the fire history of sites.* Paper presented at Australian Bushfire Conference, Albury 1999**.**

70. Lamont, B. B., Ward, D. Eldridge, J. Korczynski, D. Colangelo, W., Fordham, C., Clements, E., and Wittkuhn, R. 2003. Believing the Bulga: a new method for gauging the fire history using grass trees. In *Fire in Ecosystems of South West Australia*. Backhuys Leiden.

71. Lhuede, N. Pers comm. 2004.

72. Lindenmayer, D. 2003. Fire Behaviour, forest management, and biodiversiy conservation. In *Australia Burning: Fire Ecology Policy and Management issues*, edited by Cary, G., Lindenmayer, D. and Dovers, S. CSIRO Publishing.

73. Martin, B. Pers comm. 2005.

74. McCarthy, G.J. and Tolhurst, K.G. 2001. *Effectiveness of broadscale fuel reduction burning in assisting with wildfire control in Parks and Forests in Victoria*. Fire Research Report No. 51. Fire Management, Dept. Natural Resources and Environment, Victoria.

75. McCarthy, G.J., Tolhurst, K.G., and Chatto, K.1998. *Overall Fuel Hazard Guide; Research Report No.47* CFTT- Orbost & Creswick Research Station. Victorian Government. Available at: www.dse.vic.gov.au/fires.

76. National Fire Plan. 2000. US Government. Available at: http://fireplan.gov/index.html.

77. National Parks Association of New South Wales. 2002. *Response to the NSW Summer Bushfires 2001/02 – Burning Questions – Are the Greenies and National Park Management really to blame for bushfires?* Available at: http://www.npansw.org.au/media/bushfire%20burning%20questions.html.

78. Nature Conservation Council (NCC) of New South Wales. 2004. *Bushfire Program and Bushfire Policy Statement 2002.* Available at http://www.nccnsw.org.au/bushfire/context/.

79. Nature Conservation Council of NSW and Australian Conservation Foundation. 2003. *Submission to the House Select Committee Inquiry into the Recent 2002/03 Australian Bushfires.* House of Representatives, Commonwealth Government Canberra.

80. Nazzaro, Robin N. 2005. *Forest Service and Interior Needs to Specify Steps and a Schedule for Identifying Long Term Options and their Costs.* [GAO-05-353T]. 2005. Forests and Forest Health, Committee on Resources, House of Representatives.

81. New Zealand Ministry of Agriculture and Forestry. 2005. *New Zealand Forests Resources.* Fact Sheet – available from: http://www.maf.govt.nz/forestry/forestmanagement/#Indigenous%20Forestry%20Unit.

82. NIFC National Interagency Fire Center. 2004. Wildfire Statistics available from: http://www.nifc.gov/.

83. NSW Forest Act No 55. 1916. Available at: http://www.legislation.nsw.gov.au.

84. NSW National Parks and Wildlife Service (NSW NPWS) 2005. *Threatened Species Recovery Plans* (various). Available at: http://www.nationalparks.nsw.gov.au.

85. NSW National Parks and Wildlife Service 2004. Annual Reports 1999-2002, 2004. Department of Environment and Conservation (DEC), Government of NSW.

86. NSW Parliament Joint Select Committee into the 2001/2002 Bushfires. 2002. *Report on Inquiry into the 2001/2002 Bushfires.* Government of NSW, Legislative Assembly.

87. NSW Rural Fire Service (RFS). 2004. Canobolas Zone Bushfire Risk Management Plan, Canobolas District Bushfire Committee.

88. NSW Rural Fire Service (Various) – Annual Reports 1999-2004. Available at: http://www.rfs.nsw.gov.au/.

89. NSW Rural Fires Act No 67. 1997. Available at: http://www.legislation.nsw.gov.au.

90. NSW Scientific Committee. 2005. *Schedule 3 - Key Threatening Processes.* NSW Threatened Species Conservation Act (1995), Government of NSW.

91. Oregon Forest Resources Institute (OFRI). 2004(a). In *Fire in Oregon's Forests - Assessing the Risks, Effects and Treatment Options*.

92. Oregon Forest Resources Institute (OFRI) (b). 2004. In *Forest Fire Risk and Restoration - Managing forests to create more fire-resilient ecosystems*.

93. Oregon Forest Resources Institute (OFRI) 2003. *Opinions and Perceptions of Oregonians about Wildfire and Treatments to create Fire-Resilient Forests. Presentation.*

94. Pyne, Stephen J. 1982. *Fire in America: A Cultural History of Wildland and Rural Fire.* Princeton University Press.

95. Pyne, Stephen J. 1997. *World Fire: The culture of Fire on Earth.* University of Washington Press.

96. Pyne, Stephen J. 1998. *The Burning Bush: Fire History of Australia.* University of Washington Press.

97. Pyne, Stephen J. 2001. *Fire: A Brief History*. University of Washington Press.

98. Pyne, Stephen J. 2002. *If I Rran the Zoo: A Survey of Wildland Fire in America.* Arizona State University.

99. Rio Declaration on Environment and Development 1992. *Report of the United Nations Conference on Environment and Development – Rio de Janeiro – 3-14 June 1992*. Annex 1. A/Conf. 151/26 Vol 1. United Nations General Assembly.

100. Ryan D.G., Ryan, J.R. and Starr, B.J. 1995. *The Australian Landscape – Observations of Explorers and Early Settlers.* Murrumbidgee Catchment Management Committee: Wagga Wagga NSW.

101. Schauble, John, 2004. Why there's so much heat from bushfires. *The Age Newspaper* Melbourne Australia (Fairfax Press) 5 August.

102. Shindler, B. 2005. *Public Acceptance of Wildland Fire Conditions for Fuel Reduction Practices: Challenges for Federal Forests Managers*. In *Humans, Fires and Forests: Social Science applied to Fire Management (i*n press*)*, USDA Forest Service, North Central Research Station.

103. Shindler, B. and Neburka, J. 1997. Public Participation in Forest Planning: 8 Attributes of Success. *Journal of Forestry* 95, no. 1:3.

104. Shindler, B. and Olsen, C. 2004 *Survey of Citizens Bus Tour of the B&B Complex Fire*, Sisters Ranger District, Deschutes National Forest. Dept. of Forest Resources, Oregon State University.

105. Shindler, B., Brunson, M. and Stankey G. H. 2002. *Social Acceptability of Forest Conditions and Management Practices: A Problem Analysis.* USDA Forest Service Pacific Northwest Research Station. Corvallis, Oregon.

106. Shindler, B., Brunson, M. and Toman E. 2004 (a). *Fire Management on Public Forests and Rangelands: A survey of citizens in Central Oregon: Jefferson and Deschutes Counties.* Dept. of Forest Resources, Oregon State University.

107. Shindler, B., Toman E. and Shaw C. 2004 (b). *Fire Management and Forest Conditions: Public Acceptance in the Great Lakes Region - A survey of citizens in Michigan, Wisconsin and Minnesota.* Dept. of Forest Resources, Oregon State University.

108. Shindler, Bruce A. 2002. Citizens in the Fuel-reduction Equation: Problems and Prospects for Public Forest Managers. In Fitzgerald, S. A. *Fire in Oregon's Forests: Risks, effects and Treatment Options.* Oregon Forest Resources Institute.

109. Shindler, Bruce A. Pers comm. 2005.

110. Sierra Club. 2003. *Forest Protection and Restoration: Debunking the "Healthy Forests Initiative".* Available at: http://www.sierraclub.org/forests/fires/healthyforests_initiative.asp.

111. Stankey, G. H. and Shindler, B. 1997. *Adaptive Management Areas: Achieving the Promise, Avoiding the Peril.* USDA Forest Service, Pacific Northwest Forest Research Station. General technical report PNW-GTR-394.

112. State Forests of NSW. 2002. Submission to the NSW Parliamentary Inquiry into the 2001/02 Bushfires. Report of Proceeding before the Joint Select Committee to the NSW Parliamentary Inquiry to the 2001/02 Bushfires, Hansard Transcript 22 April 2002, Legislative Assembly, Government of NSW. Available at: http://www.parliament.nsw.gov.au/prod/parlment/committee.nsf/.

113. State Forests of NSW. 2005. Annual Reports 2001-2004. Department of Primary Industries, Government of NSW.

114. Stretton L.B. 1939. *The report of the Royal Commission to inquire into the causes of and measures taken to prevent the bushfires of January, 1939, and to protect life and property.* Government Printer, Melbourne.

115. Timber Communities Australia (TCA) (Tasmanian Branch). 2003. *Submission to the House Select Committee Inquiry into the Recent 2002/03 Australian Bushfires.* House of Representatives, Commonwealth Government Canberra.

116. Tolhurst, K. 2003. *Prescribed Burning in Victoria: Policy and Practice.* Paper presented to 'Bushfire Prevention- are we doing enough?' conference. Institute of Public Affairs.

117. Tolhurst, K. 2003. *Effects of repeated low-intensity fire on the understorey of a mixed eucalypt foothill forest in south-eastern Australia.* Department of Sustainability and Environment. Fire Research Report No. 58. Available at: http://www.dpi.vic.gov.au/dse/nrenfoe.nsf.

118. Tolhurst, K.G., Flinn, D.W., Loyn, R.H., Wilson, A.A.G.and Foletta, I. 1992. *Ecological effects of Fuel Reduction Burning in a Dry Sclerophyll Forest; A Summary of Principal Research Findings and their Management Implications.*

119. Department of Sustainability and the Environment. 2002. Forest Research Centre Department of Conservation and Environment., Victorian Government.

120. Tomback, Diana F., Arno, Stephen F. and Robert E. Keane (eds). 2001. *Whitebark Pine Communities: Ecology and Restoration*. Island Press.

121. USDA Forest Service 2002. Fire Regime Condition Class Website, available at: http://www.frcc.gov/index.html.

122. USDA Forest Service. 2005. *A Strategic Assessment of Forest Biomass and Fuel reduction treatments in Western States.* Fort Collins, CO, Dept. of Agriculture, Forest Service, Rocky Mountains Research Station. Gen. Tech. Rep. RMRS-GTR-149.

123. Vale, Thomas R. ed. 2002. *Fire, Native Peoples and the Natural Landscape*. Island Press.

124. Vaske, J. J., Donnelly, M., Williams, D. and Jonker, S. 2001. Demographic influences on environmental value orientations and normative beliefs about national forest management. *Society and Natural Resources* 14: 761-776.

125. Victorian Country Fire Authority (CFA). 2004. *Annual Report 2004.* Country Fire Authority, Government of Victoria.

126. Victorian Farmers Federation 2005. *Submission to the Department of Sustainability and Environment - Code of Practice for Fire Management on Public Lands.*

127. Victorian National Parks Association 2003. *Submission to the House Select Committee Inquiry into the Recent 2002/03 Australian Bushfires*. House of Representatives, Commonwealth Government Canberra.

128. Ward Thomas, Jack, and Irwin, Larry J. 2002. *Policy Conflicts Relative to Managing Fire-Adapted Forests on Federal Lands: The case of the Spotted Owl.* In Fitzgerald, S. A. *Fire in Oregon's Forests: Risks, effects and Treatment Options.* 2002. Oregon Forest Resources Institute.

129. Ward, D. pers comm. 2005.

130. Ward, D., Lamont, B. B., & Burrows, C. 2001. Grasstrees reveal contrasting fire regimes in eucalypt forest before and after European settlement of Southwestern Australia. *Forest Ecology and Management* 150: 323-329.

131. Ward, David. 2003. *The Terra Nullius Fire Hypothesis*. Submission to the COAG National Inquiry on Bushfire Mitigation and Management in Australia. Government of the Commonwealth of Australia.

132. Whelan, Robert J. 1995. *The Ecology of Fire.* Cambridge University Press.

133. Whelan, Robert J. 2002. Report of Proceeding before the Joint Select Committee to the NSW Parliamentary Inquiry to the 2001/02 Bushfires, Hansard Transcript 31 May 2002, Legislative Assembly, Government of NSW. Available at: http://www.parliament.nsw.gov.au/prod/parlment/committee.nsf/.

134. Wilderness Society 2003. *Submission to the House Select Committee Inquiry into the Recent 2002/03 Australian Bushfires.* House of Representatives, Commonwealth Government Canberra 2003.

135. Yaussy, D. A. (ed) 2000. *Workshop on Fire, People and the Central Hardwoods Landscape.* USDA Forest Service Northeastern Research Lab, Richmond, Kentucky. General Technical Report NE-274.

136. Yaussy, D.A. Pers comm. 2004.

137. York, A. 1999. Long term effects of frequent low-intensity burning on the abundance of litter-dwelling invertebrates in coastal blackbutt forests of Southeastern Australia. *Journal of Insect Conservation* 3, 191-199.

138. York, A. 2000. Long term effects of frequent low-intensity burning on ant communities in coastal Blackbutt forests of South eastern Australia. *Australian Ecology* 25, 83-98.

Appendix 1 – Costs and Estimates relating to Figure 15

Example Working:

Treatment Area	Ann. Wage per staff	Cost per Day	No of Days	No of staff	Man Hours
50	52,000	200	2	10	140
	Total Field Staff Costs	4000			
			Helicopter Hours	Helicopter Costs	Incendiaries
	Helicopter	0	0	540	0
			Planning Hours	Costs	
	Planning	2090	38	55	
			No of Vehicle Hours	Costs per hour	
	Fleet and Fuel	877.50	120	$4 + Sundry	
			Estimate		
	Sundries	1200	1200		
	Total grand	8002.5			
	Costs per ha	160.05			

Data sourced from Forests NSW, NSW NPWS 2005

Assumptions and fixed costs:

Average Annual wage (Including on-costs $52,000)

Helicopter Hire rate including Fuel = $540 per hour
Planning costs average = $55 per hour
Fleet Hire and Vehicle Costs = $4 per hour
Planning costs include Crew organisation, fleet coordination, database search, mapping fire history and Threatened species checks as well as post-burn monitoring.
Crew costs include patrol and mop-up
Helo costs include wet hire and incendiary capsules
Sundries include drip-torch fuel, consumables

Area	Costs	Costs/ha	Man Hours	Staff Costs	Helo	Planning	Fleet and Fuel	Sundries
5000	28589.375	5.72	315	9000	10140	4400	2049.38	3000
4000	24435	6.11	280	8000	7680	3850	1905.00	3000
3000	21864.5	7.29	252	7200	6300	3575	1789.50	3000
2500	19359	7.74	224	6400	5610	3300	1549.00	2500
2000	16853.5	8.43	196	5600	4920	3025	1308.50	2000
1500	13908	9.27	168	4800	3690	2475	1143.00	1800
1000	11098.875	11.10	147	4200	1920	2310	1018.88	1650
750	9568	12.76	168	4800	0	2200	1068.00	1500
500	10082.125	20.16	189	5400	0	2090	1142.13	1450
250	10248.5	40.99	196	5600	0	2090	1158.50	1400
100	9208	92.08	168	4800	0	2090	1018.00	1300
50	8002.5	160.05	140	4000	0	1925	877.50	1200
25	7159.75	286.39	126	3600	0	1540	819.75	1200
10	4913.75	491.38	70	2000	0	1375	538.75	1000