FIRE, FOR WHAT PURPOSE?

REVIEW OF THE FIRE POLICIES AND MANAGEMENT PRACTICES OF THE DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

A DISCUSSION PAPER

Environmental Protection Authority
Perth, Western Australia
June 2004

CONSULTATION AND HOW TO MAKE A SUBMISSION

Introduction

The EPA is an independent body set up to advise the Minister for the Environment on environmental issues. The Minister has requested the EPA to review the Department of Conservation and Land Management's (CALM's) fire policies and management practices and to report to her with a view to developing best practice standards. The Minister has specifically requested that the review be as open and consultative as possible with the community, and the EPA is keen to present a fair and unbiased document based on facts.

Purpose

The purpose of the public consultation process is to:

- provide an understanding of the objectives of the review;
- seek public input on the issues discussed in this Paper (see questions in section 2);
- ensure that the community is provided with an adequate opportunity to provide feedback on the review's Discussion Paper;
- facilitate a sound process of public consultation prior to the EPA developing its recommendations and report to the Minister for the Environment.

The public consultation process aims to capture both written and in-person feedback on this review of CALM's fire policies and management practices. The main focus of the public consultation will be to obtain opinions on the acceptability, advantages and disadvantages of the various scenarios discussed. Each scenario involves the choosing of personally acceptable trade-offs in order to gain an overall best outcome.

Document availability

Reference copies of this Discussion Paper are available at council offices/libraries at Albany, Denmark, Walpole, Manjimup, Bunbury, Collie, Harvey, Waroona, Pinjarra, Dwellingup and Mundaring. As well it will be available at the Department of Environment's offices in Perth, Albany and Bunbury and on the EPA's website (www.epa.wa.gov.au). Three consultant reports prepared to inform this EPA review are available at the EPA's website or on request.

Written feedback

Feedback is welcome by mail, fax and email. The EPA is aware that there is a wide range of views on this topic in the community. Organisations and individuals are invited to comment on any aspect of the topic of fire management in the South West. Comments on the options raised in this discussion paper are particularly sought by the EPA. The review and comment period will be for eight weeks, from **23 June 2004** until close of business on **Friday 20 August 2004.**

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1. WHAT IS THE REASON FOR THIS REVIEW?

1.1 Fire Management Policy

The Department of Conservation and Land Management (CALM) adopted a Fire Management Policy in 1987, which was updated in 1997. Since that time, there have been several papers and forums which have updated the content and the direction of the policy. In October 2000, CALM published "*Fire management on CALM lands in the south-west of Western Australia*" which reviewed fire management practices at that time. In 2001 Chris Muller undertook an internal study (Muller 2001), and a public symposium was organised by CALM in April 2002, the proceedings of which were published in 2002 and 2003 in two volumes (CALM 2002, 2003).

CALM is continually reviewing and updating the linkages between research, policy and fire management operations. This work is developing rapidly through CALM's involvement in the Bushfire CRC and the National Disaster Risk Management Studies Program (Department of Transport and Regional Services). One example of these linkages is the involvement of the fire management services with projects delineating landscape conservation units (Mattiske Consulting Pty Ltd and Havel Land Consultants 2002), the fauna distribution information system which has been developed by Christensen, and the more specific projects on fire responses in vascular plant species and fauna species which is being coordinated by Burrows (CALM Science Division). The landscape conservation units link the underlying landforms and soils with ecological vegetation systems (Havel and Mattiske 1998, Havel 2000) and vegetation complexes (Mattiske and Havel 1998). Christensen has also linked the fauna distribution information system with the ecological vegetation systems developed by Havel and Mattiske.

More recently, in September 2003, the Australian Academy of Technological Sciences and Engineering held a seminar at Curtin University, the abstracts and proceedings of which were published (AATSE 2003).

The AATSE proposed several recommendations for Government to consider for implementation. These are likely to be considered by government in combination with the EPA's views and other reviews on CALM fire policies, including that of the Auditor-General, later in 2004. The reviews and symposia have advanced fire management policy and helped to inform the community on matters relating to fire and its management.

With the incorporation in 2000 of ecologically sustainable forest management principles into the *Conservation and Land Management Act 1984* and CALM's focus on conserving the State's biodiversity, CALM's Fire Management Policy needed to be reviewed. A revised draft was released for public comment in early March 2004; the review period closed on 30 April 2004. The draft is appended to this Paper (Appendix 3). The objective of this Draft Policy is as quoted:

> *The Department will manage prescribed fire and wildfires on the lands managed by the Department to protect and promote the conservation of biodiversity and natural values whilst also providing for a sufficient level of protection to human life, community assets and fire sensitive ecosystems. The*

Department will also promote fire management that protects biodiversity on lands not managed by the Department.

Fire management will be planned and implemented in partnership with other landowners and land managers, fire authorities and with the community. The Department will implement an informed and balanced approach to risk management. A variety of fire regimes incorporating different frequency, intensity, season and scale will be applied at the landscape scale on lands vested in the Conservation Commission of Western Australia. (CALM 2004)

With a view to taking recommendations from this review into account, CALM intends to delay finalisation of its policy until after the EPA has submitted its advice on this review to the Minister for the Environment.

CALM's primary concern in every fire management activity is the safety of firefighters and the public, followed by the protection of biodiversity and cultural and property values. In relation to prescribed burns the policy states that fire will be used to achieve a range of land management objectives, all of which are to be specified in individual burn prescriptions. The policy recognises that planning of prescribed burns requires the integration of multiple objectives (and constraints) and must take into account the role of planned fire in the maintenance of biodiversity and in reducing the risk of bushfire. It also notes that fire regimes will include some random bushfires.

The policy requires that the extent to which burn objectives are achieved is to be monitored and recorded and the achievement of fire management objectives is to be subjected to periodic audit by the Conservation Commission.

On fire suppression the policy states, in part, that CALM

will respond to fires on or near Department-managed lands to a degree that is appropriate to the values at risk, the prevailing and forecast weather, availability of resources, the cost of the suppression operation, and likelihood of long term impacts or net gains to the environment. In circumstances where impacts of the wildfire are likely to be low the response may mean observation, rather than active suppression." and *"take control of, or provide assistance ..... in accordance with State and local arrangements between the Department and other fire authorities and land management agencies.* (CALM 2004)

1.2 The EPA's review

On 10 April 2003, the Minister for the Environment wrote to the EPA requesting a review of CALM's fire management policy and practices in its Swan, South West and Warren Administrative Regions. **Figure 1** shows the geographic extent of these regions.

The EPA is an independent body reporting directly to the Minister for the Environment. It is not affiliated with CALM. The Minister wants the public to be fully involved during this review and accordingly the EPA is making it as open as possible to members of the public and is seeking your opinions about the issues raised in this Discussion Paper.

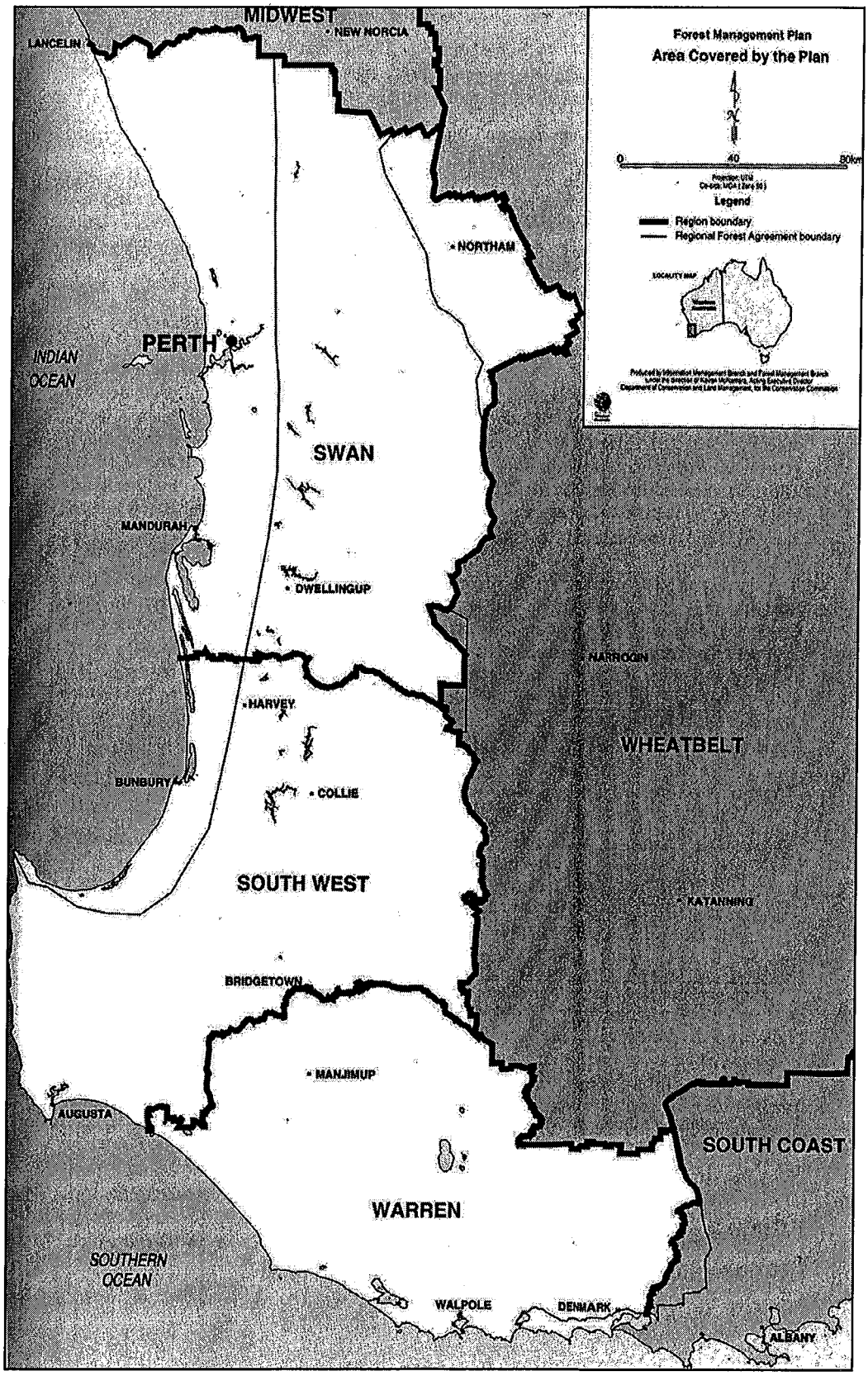

Figure 1. Forest Management Plan regions

The Minister has specifically requested the EPA to provide advice to her in relation to:

The Department of Conservation and Land Management's fire management policy and practices, in the Swan, South West and Warren administrative regions of the Department, in the context of the Department's obligations to manage fire on the lands it manages for the multiple objectives of:

- *protection of human life;*
- *biodiversity conservation and protection;*
- *protection of assets including strategic infrastructure on managed lands;*
- *protection of environmental health; and*
- *the reasonable protection of neighbouring properties and assets.*

The EPA began its review by convening in mid-September 2003 a group representing a broad range of interests to discuss the steps necessary to progress the review, as determined by its terms of reference. Attending the meeting were representatives from the forestry industry, forest conservation and biodiversity interests, government planners, farmers, local government, the insurance industry, and the Fire and Emergency Services Authority (FESA). The group recommended the inclusion of an audit of some of CALM's recent prescribed burns and gave other advice on the conduct of the review. The reference group reached unanimous agreement on the review process and all the proposed steps (discussed below) have subsequently been incorporated into the process.

The agreed process included the EPA seeking views from the general community and interest groups via public information exchange days at various metropolitan and country centres within CALM's Swan, South West and Warren administrative areas. These days were intended to introduce the review, to seek out opinions from individuals on the important issues to be reviewed by the EPA, and to foreshadow a discussion paper to be written and released by the EPA. The information days were advertised in advance and held in Albany, Walpole, Manjimup, Bunbury, Perth and Swan View during November and December 2003. The attendees raised a broad spectrum of views which have been used to inform this Discussion Paper.

The Discussion Paper:

- summarises CALM's fire management policies and practices in the areas for which it has responsibility;
- describes CALM's current practice of prescribed burning;
- discusses wildfires, their frequency, impacts and ways to mitigate them; and
- suggests issues for your consideration to achieve the best possible outcomes for public safety, biodiversity and the protection of assets, both public and private.

There is a wide range of views in the scientific and broader communities and an acceptable balance must somehow be found regarding human health, people's safety, property protection, and management planning (for the forests, woodlands, coastal heath etc. contained within this region) to protect the biodiversity of flora and fauna and achieve ecologically sustainable forest management. The EPA makes no recommendations in this document. It is first seeking your feedback on the range of issues and strategies presented in this discussion paper. Your response to this document will help the EPA to come to a view.

In preparing this paper note has been taken of the valuable information contained in the previous studies and symposia mentioned in ***Section 1.1***, of information and outcomes flowing from studies and reviews held elsewhere in Australia and from specialists.

To help provide specialised information, consultancies were established for three areas:

- an analysis of best practice fire policies and management procedures and a comparison with CALM's;
- a literature review of the effects of fire on biodiversity; and
- a field audit of selected CALM-prescribed burns to review their objectives and whether they were achieved;

The reports prepared by the consultants are available at www.epa.wa.gov.au or on request. Summaries of the main points in these consultant reports, that relate to the terms of reference, are included in the text. The Discussion Paper is on public review for eight weeks from **23 June 2004** and submissions will be welcomed until the close of the review period on **Friday 20 August 2004**. (See the front page for information on how to make a submission).

The EPA will collate and review all submissions it receives in the course of preparing its advice to the Minister for the Environment. Its advice in the form of recommendations will address the terms of reference relating to CALM's fire policy and management practices, as requested in the Minister's original letter to the EPA, and may point to other areas outside the terms of reference that should be given attention.

1.3 Glossary of terms

A glossary has been prepared so that the EPA's use of terms and their meanings in this Discussion Paper are explicit. This is important to prevent misconceptions in their understanding and interpretation. The list of terms is not exhaustive and is derived from a number of formal and informal sources. The assistance of representatives of the 'Bushfire Front', especially Jim Williamson, and the Conservation Council is appreciated. The glossary is included as ***Appendix 1*** to this Discussion Paper.

2. WHAT ARE THE FIRE-RELATED ISSUES FOR CONSIDERATION?

This section summarises issues and management priorities that arise from the discussion in subsequent sections of this review. Given that no single approach satisfies all circumstances, it is important that each issue or option identifies both advantages and disadvantages. The EPA wants to hear what you consider to be the best management approaches and why. If you think that another approach not considered here is better, provide its details and why it should be preferred. Please keep these questions in mind while reading this Discussion Paper and preparing your submission to the EPA.

i) **Should protection of human life be the top priority in all circumstances?** (Sections 4.3, 5.5)

Are there are any situations where protecting human life is not paramount?

ii) **Should private property assets be protected before public property assets (national parks etc) ?** (Section 4.3)

Property may include houses, equipment and sheds, farm fencing, a crop grown on private property, etc. Protection of private property appears to have been a priority for fire management on CALM-managed land in the past, and implies fire exclusion from private land should be a very high priority, irrespective of the consequences to the values of the CALM-managed land such as national parks and nature reserves.

iii) **Should biodiversity (i.e. native plants and animals) and the habitats that support them be protected before property?** (Sections 4.3, 5.5)

This question is raised because the loss of some biodiversity values could be irretrievable whereas property is generally replaceable.

iv) **Should bushfires be left to burn within CALM-managed land and put out only when they threaten property or areas of significant biodiversity (such as those identified in the Forest Management Plan)?** (Sections 5.3.1, 6.1, 6.3, 6.4)

This suggests that bushfires, as opposed to prescribed burns, should be allowed to burn to reduce fuel loads (flammable vegetation). The question also raises the issue of costs and risks associated with fighting wildfires.

v) **Should CALM-managed land be prescribe-burnt at intervals to achieve a relatively uniform period since last burn/ fire?** (Sections 5.2, 5.5)

This raises issues about the level of resourcing to undertake prescribed burns and also the consequences to native plants, animals and ecosystems that are affected by regular fire events. It also requires a decision on the preferred period between burns, which may vary for different native animals and plants, regions, landforms and climate.

vi) **Should the frequency of prescribed burns be determined primarily on biological grounds or on a regular timetable, or should there be a compromise between the two?** (Sections 5.3, 5.4.1, 5.4.2)

The former would require a complex and well planned research programme to address the many variations reflecting the specific needs of different ecosystems and the influence of changing seasons and weather patterns on them.

vii) **Should we apply the precautionary principle when dealing with issues where there is a lack of knowledge of the impacts of a regular and ongoing prescribed burn programme on the full suite of plants and animals?** (Sections 5.4. 5.4.1, 5.4.2)

The precautionary principle requires that decision-makers should err on the cautious side if it is necessary to make a decision without having sufficient information to make a fully informed decision.

viii) **Should prescribed burns primarily occur during the autumn season, and should spring season burns be avoided as much as possible?** (Sections 5.4.1, 5.5)

While there is some evidence to suggest that autumn season prescribed burns are preferable for conserving biodiversity, this is likely to increase the probability of smoke impacting urban communities. It is also likely to lead to reduced areas of CALM-managed land being burnt annually, on average.

ix) **Should CALM set a target for the proportion (and hence, area) of CALM-managed land to be prescribe-burned each year and strive to achieve that target each year?** (Section 5.2)

This could mean that seasonal issues related to biodiversity impacts, smoke issues in urban communities and biodiversity issues about regularity of burns are of secondary consideration to the primary driver of achievement of the target.

x) **Is there a minimum proportion of an area subject to prescribed burning that should not be burned?** (Sections 5.2, 5.6)

As part of its fire planning, CALM sometimes sets targets (generally 10-30 per cent) for the proportion in each prescribed burn area that should remain unburnt. Such mosaic burning is designed to enhance the conservation of biodiversity, leaving 'islands' of refuge for fauna and flora.

xi) **If a target of unburned land within a prescribed burn is set, should that target be actively pursued through fire planning and the burn?** (Section 5.6)

This suggests that fire planning should not rely solely on environmental conditions (soil moisture, vegetation wetness, weather, etc.) to encourage or restrict the burn, but that intervention may be required if the burned proportion is either less than or exceeds the target. This would involve a higher level of field management and staff resources, and hence increased costs.

xii) **How far should fire planning and management be driven by the need to protect harvestable trees or future harvestable trees within CALM-managed land?** (Sections 5.5, 5.6)

These trees are a State-owned economic asset upon which the timber industry is reliant. Their loss through fire damage could have a significant impact on the portion of the timber industry which is dependent on native forest trees.

xiii) **How far should fire planning and management be driven by other uses, such as tourism, recreation, apiary, wildflower picking and access generally?**

xiv) **Should areas around townsites and other important economic assets be subject to frequent burns to establish and maintain a low fuel load, with the aim of providing increased protection from wildfire?** (Sections 4.3, 6.4)

This may lead to a long-term reduction in biodiversity values within this 'buffer area', an appearance of obvious fire effects (scorching), and regular exposure to smoke. Also it should be noted that this may not eliminate the risk, particularly as frequent fires can promote non-native grasses which thrive on fires.

xv) **Should the CALM Act be amended to give clear responsibility for fire management and operations on CALM-managed land to CALM?** (Section 7)

The EPA has been advised that this is a component of 'best practice'. However, the land is controlled by the Conservation Commission of WA, and it has been suggested that the relationship between the Commission and CALM may need to change if CALM's fire responsibilities and obligations are defined in the Act.

xvi) **Should there be a more explicit statutory structure for all fire management, both for CALM-managed lands and for privately owned areas?** (Sections 4.1, 4.2, 7)

This would enable a better understanding of the fire practices employed and which agencies are responsible for what.

xvii) **What responsibility should planning authorities, developers, communities and individual property owners carry for protection from fires?** (Sections 4.1, 4.3, 7)

Many subdivisions are located in or next to high fire risk areas which may or may not be CALM-managed land. Is it reasonable and appropriate to expect CALM to prevent or manage fire from and fire into private property?

xviii) **How important is it to keep smoke from prescribed burns away from communities?** (Section 5.4.3)

This question refers mainly to the discomfort and health effects experienced by some people when they inhale the smoke from fires. Achievement of this goal would be impossible for all communities and may require a no-burn policy in some areas.

xix) **What measures should CALM implement to ensure that communities are informed about intended prescribed burns and have the opportunity to participate in burn planning? (Section 5.3)**

CALM policy is that the community is informed and consulted throughout the planning process. It has been indicated that this is not consistent between CALM regions and districts.

xx) **What areas of research should CALM and others undertake to best inform fire management policy and practices?**

There are shortcomings in our knowledge base and constraints on resources. There is thus a need to prioritise research for best results.

3. WHAT ARE THE VALUES OF THE CALM ACT LAND IN THE SOUTHWEST?

The area covered by the three CALM administrative areas of Swan, South West and Warren, extends from Lancelin in the north in a strip 80-100km wide to the south coast at Augusta and eastwards to Albany. It includes a wide range of habitats from karri and

tingle forests, jarrah-marri-wandoo woodlands, to wetlands and coastal heath/sand plains. CALM is responsible for management of a complex variety of land uses covering a range of climates, biodiversity, landforms and soil types. Land uses include proposed wilderness areas (near Walpole), national parks, nature and recreation reserves, State forests for timber production and uses including water catchment. These lands are vested in the Conservation Commission of WA and managed by CALM.

The Forest Management Plan 2004-2013 (Conservation Commission 2004) prepared by the Conservation Commission of Western Australia has been approved as the new management plan for the forest ecosystems of southwest WA. The Conservation Commission's overall objective in the plan is for biodiversity to be conserved, the health, vitality and productive capacity of ecosystems to be sustained, and the social, cultural and economic benefits valued by the community to be generated in a manner taking account of the principles of ecologically sustainable forest management. The Plan considers diversity in understorey vegetation at the landscape scale and proposes the use of prescribed fire to achieve and maintain this diversity.

The Forest Management Plan lists the values of this region as:

- conservation of biodiversity;
- nature-based recreation and visitor experiences;
- timber production on a sustained yield basis;
- water catchment protection; and
- other purpose, being a purpose prescribed by the regulations, such as for minerals, soil, cultural heritage and as a carbon reservoir.

These values are sensitive to the effects of fire and need to be taken into account when fire management and prescribed burning are proposed.

Biological diversity

We are living in the midst of one of the world's richest assemblages of species. The Draft Forest Management Plan notes that Australia is one of *12 megadiverse nations that include some 60 to 70 per cent of all known species,* and that WA *has a very high proportion of the nation's biodiversity. In particular, the southwest is one of only 25 megadiverse 'hot spots' in the world...* (Conservation Commission 2002).

The Forest Management Plan seeks to conserve biodiversity and ecological integrity through the establishment and management of a system of reserves, but recognises that, in order to achieve this objective, the forest areas outside the formal reserves system (which may be used to provide resources such as water, bauxite and timber) need to be managed to control any effects of disturbance on biodiversity within the reserves.

Nature-based recreation and visitor experiences

The southwest of WA is where most of the State's population lives and recreates. There is an increasing demand for the use of forests for State, national and international recreation. Many areas with high recreational values also have high conservation/ biodiversity significance. Forests provide a diverse range of socio-economic benefits, including jobs and revenues, from producing and consuming forest-related products. CALM has 653 registered recreational assets listed throughout the southwest region and in 2000-2001 there were an estimated 4.6 million visits for the purposes of recreation and tourism to land vested in the Conservation Commission (Forest Management Plan).

Sustainable productive capacity
The CALM Act requires that timber production in native forests is conducted on a sustainable yield basis (Conservation Commission 2004). While timber production has declined from earlier levels under this Forest Management Plan, forest-based industries utilising native timber products from State forests will continue to be economically important, with a strong emphasis to add value to the raw product.

Water catchment protection
The region is the wettest part of the southern half of the State and contains many surface water catchments. These provide around 50% of Perth's water supply and a much greater proportion of the supply to the Goldfields and Great Southern Towns Water Supply Scheme. Forest productivity is heavily influenced by soil and water quality and the soil plays an important part in regulating surface and groundwater flows. Similarly the water production is influenced by the forest ecosystems. Therefore the conservation of soil and water is important to the conservation of biodiversity, health and vitality of forest systems (Conservation Commission 2004).

Other purposes

- **Natural and cultural heritage**
  Heritage in forest includes aboriginal and non-aboriginal cultural values and natural values. The Forest Management Plan seeks to maintain these values.

- **Minerals and petroleum, and basic raw materials**
  Recognising that extractive operations provide significant economic and social benefits to the State, the Plan seeks to reduce their impact on CALM lands and to promote subsequent rehabilitation.

- **Other commodities**
  Forests also provide firewood, craftwood, honey, wildflowers and seeds. Bioprospecting, the seeking of potentially valuable pharmaceutical, industrial and agricultural chemicals in native plants, also occurs.

- **Other community benefits**
  Forests are considered to play a major role in buffering climatic changes to the earth's biosphere such as global warming from increased levels of carbon dioxide and other greenhouse gases.

4. WHO IS RESPONSIBLE FOR FIRE MANAGEMENT?

4.1 Fire on Conservation and Land Management Act Land

The Conservation Commission of WA is established under the *Conservation and Land Management Act 1984*. State forests, timber reserves and conservation reserves are vested in the Commission, which prepares management plans for those lands (Conservation Commission 2004). The plans are developed through the agency of CALM in consultation with the Forest Products Commission (FPC) for State forest and timber reserves, and with the Water and Rivers Commission and the Water Corporation for public water catchment areas. The Conservation Commission has a statutory responsibility to monitor and audit management of land in the plans.

The CALM Act deals primarily with conservation and does not directly cover fire management. The Forest Management Plan considers fire within the context of ecosystem health and vitality. The Plan identifies the following objectives in relation to seeking to use and respond to fire:

- optimise the maintenance of forest ecosystem health and vitality;
- promote the conservation of biodiversity;
- control adverse impacts of fire on the social, cultural and economic values of land managed by the Department (CALM) and adjoining land; and
- minimise the risk of smoke emanating from prescribed burns impacting on population centres and other sensitive areas.

The role of prescribed burning in reducing flammable vegetation levels is acknowledged through the wildfire risk to conservation, life, property and other forest values (Conservation Commission 2004).

The *Wildlife Conservation Act 1950*, which is administered by CALM, provides for the conservation of flora and fauna throughout the State. The *Aboriginal Heritage Act 1972* and the *Heritage of Western Australia Act 1990* provide for the protection and management of human cultural heritage.

The *Bush Fires Act 1954* deals with bushfire prevention, control and extinguishment but does not consider biodiversity conservation. CALM has obligations under this Act to respond to fires occurring on or near its land, appropriate to the values at risk. The Act empowers the Fire and Emergency Services Authority of Western Australia (FESA) to perform its duties to, among other things, carry out such fire prevention measures as are considered necessary. It also gives status to local governments with regard to fire prevention measures such as requiring firebreaks and for the creation of bushfire brigades.

The Fire and Emergency Services Authority of Western Australia Act 1998 (FESA Act) establishes an Authority with functions relating to the provision and management of emergency services, and for related purposes. The FESA Act binds the Crown.

4.2 Fire control operational responsibilities

CALM has the lead role in responding to and suppressing fires on the lands it manages. It is supported by staff of the Forests Products Commission (FPC) and the volunteer bushfire brigades of the local government authorities. In all other parts of the State outside of the main urban centres the primary responsibility for fire suppression rests with local government and the associated bushfire brigades. CALM provides operational support where fires are burning on or threatening its lands (CALM 2003). FESA supports local governments and their brigades, technically and operationally, on lands other than those managed by CALM.

Since July 2003 responsibility for coordinating fire prevention programmes on Unallocated Crown Land and managed reserves has been transferred to CALM from the former Department of Land Administration.

4.3 Fires on land adjacent to CALM-managed lands

Increasing numbers of people are choosing to live at the urban/bush interface. Many developments in both urban and rural settings progress ahead of the capacity of local communities to deliver the level of fire services available in established communities. People who live in urban bush areas are at greater risk from wildfires than those in the inner city. How much responsibility should these people take on for their own protection?

A submission from the National Parks Association of Queensland to the Parliamentary Select Committee looking into the 2003 Victorian bushfires stated:

> *In some sectors, there has been a tendency to blame the fires on national parks and other natural areas. Statistics show that more wildfires start outside national parks and burn into them than vice versa. Natural places should not become the victims of fire counter-measures, but rather a more enlightened approach to development surrounding them is needed. The importance of such places and the need for their proper preservation must be recognized.*

Cunningham (2003) commented that hazard reduction burning deep in the heart of natural bushland and kilometres away from urban bushland has little effect on the severity of an urban bushfire. Of much greater importance is the land within one kilometre of the urban interface. This is because the intensity of the fire depends on the fuel available in the area where it happens to be burning, as well as the prevailing weather conditions and the slope of the land. Most damage to houses is caused by the penetration of embers from 'spotting' - embers blown ahead of the fire front on the strong winds which usually accompany major wildfires. Even though the fire may have started a long way from the suburbs, it is still the local conditions that will most determine the extent of any urban damage.

A comment made by Dr Phil Cheney of the CSIRO (2004) is that he was surprised at the depth of penetration of the 2003 bushfire into Canberra's suburbs. It is easy to overlook how much fuel there is in many suburban yards and gardens. In Duffy (one Canberra suburb especially hard-hit by the 2003 bushfire) the damage was not so much from flames or radiant heat but from spotting, which set houses and gardens alight. The fire then spread from house to house. Another observation from the new Bushfire Cooperative Research Centre's CEO Kevin O'Loughlin (2004) is that *houses don't generally burn when the fire front passes-they usually collect embers and burn at a later stage.*

Studies in Kings Park Bushland over the fifty years from 1944-1994 (Dixon and Hobbs 2002, Dixon *et al* 2002) have indicated that a three-year rotation burning regime does not reduce the incidence of wildfire. Instead, it increases nutrient levels, which promotes weed growth. In this respect Kings Park bush varies from most southwest forest areas, which usually do not have a weed problem. Their records indicate that a major wildfire is likely every 10-15 years whatever fire management policy is in place. Kings Park Bushland has endured recurrent arson and wildfires of unknown origin averaging ten fires a year. On the other hand, Tolhurst and Cheney (1999) demonstrated the significant amount of research and understanding used to develop burning prescriptions and to undertake burning operations, one of the outcomes of which was the clear relationship between the nature of fuels and fire behaviour.

Underwood *et al* (1985) described nine case studies from WA forests where the intensity of wildfires was substantially reduced when the fires encountered areas of prescribed burns up to four years old. The reduction in intensity halted the spread of the headfire completely, or allowed direct attack once the fire had spread into the younger fuels. (See also the 2003 Mt Cooke bushfire, section 5.2).

In 2001 FESA published *Planning for Bush Fire PROTECTION* in consultation with the Department of Planning and Infrastructure. The focus of this document is bush fire protection within new land development. It recognises that fire protection must be taken into consideration during the planning phase of land development, and is targeted at *personnel who plan, regulate or provide advice as part of the land development process,* and also to *communities, local government and fire and emergency services personnel and volunteers in fire risk management.* CSIRO guidelines are also available. Failure to follow the guidelines is what caused most of the damage in the 2002 Sydney bushfires (Dixon and Hobbs 2002).

Experience has shown that it is generally not sufficient or practical to add bushfire protection features once a subdivision and related development has been established. The key points made in the FESA document for minimising the impacts of wildfire are:

- identifying bushfire-prone areas;
- ensuring that buildings are not located in highly vulnerable positions and are sufficiently distant from areas of potentially hazardous fire behaviour;
- road layouts and other access features combine fire service access and resident safety;
- water supplies are adequate for fighting a fire; and
- the fire service response is adequate (distance/response times and equipment/staff levels) to meet the building and bushfire risk.

Having taken all these precautions and with adequate emergency backup firefighting services, should communities feel that they are safe against all fire? The EPA understands that, if all the 'right' conditions coincide, nothing will stop a wildfire, except for the strategic removal of any of the three vital ingredients necessary for fire:- fuel, oxygen and heat. Once a fire passes a certain intensity, control is virtually impossible. Thus the key is firstly, fire prevention, and secondly a capacity for rapid response to overcome newly started fires whilst they are still relatively cool and to prevent them from spreading.

This second goal is frequently missed. Resources (often volunteer firefighter brigades) are often stretched and barely adequate to deal with even commonplace scenarios (let alone a really serious situation) and access to areas, especially some in the hills, can take too long.

One or more contingency strategies are thus required. A strategy for protection from wildfires that is favoured both by the Conservation Council (1996) and pro-fire groups is to ensure that strategic buffers are placed around vulnerable communities and properties. Flammable materials within the buffers would need to be minimised. Alternative methods other than fire can also be used. Access to the buffer should be good (i.e. quick) and flammable materials would be kept to a minimum, thus ensuring that any fires which started in the buffer could be quickly extinguished. For maximum effectiveness such a buffer should have all the other measures proposed above (i.e.

community fire education and prevention strategies) in place and rigorously enforced. However, even if the buffer were one kilometre wide, it would not guarantee absolute protection from an out-of-control wildfire once that had passed a certain threshold of intensity.

5 WHY UNDERTAKE PRESCRIBED BURNS?

> *Why should I carry out prescribed burning? All I get is criticism about smoke and destruction of habitat and biodiversity and my staff are vilified.... I would be better off to let the fuels accumulate, have larger wildfires and have my [firefighters] hailed as heroes.*

This is a quote by a former CEO of a government agency (Weekend Australian Magazine 2004). The lighting of fires by CALM on its lands to achieve one or more objectives is a contentious and complex issue.

Fire in Australia is a 'double agent'. It has the capacity to nurture and also to destroy. It has the potential to be a good accomplice, and an enemy if mismanaged. Burrows and Wardell-Johnson (2003) wrote:

> *Fire directly affects plant growth, survival and reproduction. It is the only natural perturbation in the region that can, on the one hand, kill mature plants and on the other, stimulate massive regeneration, virtually simultaneously, across a variety of landscapes and over large areas. Fire consumes both live and dead vegetation, so is a key factor in altering the structure of plant communities.*

After a fire, there are changes to soil moisture, nutrient levels and light intensities at ground level. Particularly the heat and smoke from fire stimulate

> *many plant species to reproduce by enhancing, flowering, seed production, seed dispersal and germination. It also prepares a receptive and nutrient-rich seedbed and temporarily reduces seed predators, herbivores and competition for light and moisture from other plants. Some plants have an obligate dependence on fire for their reproduction and can decline in the absence of fire, ... while others can decline if the frequency of lethal fires exceeds their capacity to reproduce and develop* (Burrows and Wardell-Johnson 2003).

5.1 What are prescribed burns?

'Prescribed burn' is a general term indicating the planned application of fire to achieve specific land management objectives. It is used instead of 'controlled burn', 'hazard reduction', and 'fuel reduction burning' and is preferred to 'pre-emptive burn', because it more accurately describes the process and the objectives. A prescribed burn is planned to be carried out under predetermined (or 'prescribed') environmental conditions within defined geographical boundaries, and at an intensity and rate of spread required to achieve the specified land management objectives.

Quoting from CALM's draft Fire Management Policy (2004), fire is used

> *... to achieve a range of land management objectives, including the conservation of biodiversity; maintenance of ecosystem health and productive capacity; conservation of soil, water and catchment values; conservation of natural and cultural heritage; regeneration and protection of native forests*

and plantations; and protection of human life, community assets, indigenous heritage sites, recreation sites and scenic values. These objectives, and the methods used to achieve them, will be specified in individual burn prescriptions.

Not explicitly stated in the above management objectives is also the need to reduce the 'fuel' (in this Paper, used to describe flammable vegetation material – see Glossary) hazard and enhance or maintain fauna habitat and flora populations (COAG 2004). From the same COAG paper,

Prescribed fires may be of high or low intensity, large or small, regular or irregular, patchy or uniform and be in any season.

CALM's main strategy for achieving its land management objectives is prescribed burning, to reduce the amount of fuel in the forest to a point where, if it is set alight, fires will be relatively cool and more easily controlled. (Fire severity is usually measured by the degree of damage to the forest canopy).

The burns aim *to reduce the amount of bark on tree boles and ... the amount of elevated fuels, including dead suspended fuel material and shrub layers...* (COAG 2004). The surface and near-surface fine fuels are primarily important in determining the rate of spread of the fire; the elevated fine fuels mainly determine the flame height of the fire front; and the quantity of bark fuel affects the amount and distance of spotting ahead of the main fire front (McCarthy *et al* 1999). In the COAG Bushfire Inquiry, Tolhurst and Flinn (1992), studying the Wombat State Forest Fire (Victoria), showed that it can take ten years for elevated fuels and more than fifteen years for bark fuels to reach their respective peaks, while surface fine fuels may be back to long term levels 2-4 years after a fire.

A range of methods has been used to quantify the effectiveness of prescribed burning in modifying fire behaviour and to measure the difficulty of fire suppression. They all make a useful contribution but have limitations (COAG 2004).

Another land management objective which may be sought from a burn is to achieve regeneration of a particular vegetation type. In forestry this has usually been associated with the establishment of seedlings from adjacent trees (such as jarrah or karri) with viable seed in their crowns. Increasingly this term is more widely being applied to burns lit on dry soils and dry fuels with the objective of encouraging regeneration from soil-stored seed. Some plant species require fire, or the smoke from fire, and ashbed, to trigger germination from seed. Some habitats which require fire/smoke as the trigger for regeneration are important refuges for certain native animal species and this habitat regeneration is also a recognised objective.

5.2 CALM's prescribed burn programme

CALM has an annual prescribed burn target in the southwest region of 8% of the area it manages. This equates to about 200,000ha each year. It has fallen short of its target since 1996-7 because the drier weather of the last several years has reduced the number of safe and suitable burning days. This has resulted in a decline in the proportion of the area with reduced fuel loads, from a target of about 40% of its managed area prescribe-burnt within the last five years to about 30% (see *Table 1*). To CALM, this means that its land is increasingly vulnerable to larger, more severe bushfires. CALM wants to

reduce this risk by increasing the annual prescribed burn area to around 250,000-300,000ha, if favourable (moister, cooler) weather conditions permit.

Table 1: Fire history of CALM Act land in the review region

YEARS SINCE BURNT, and DEGREE OF CONTROL		Swan Region		South West Region		Warren Region		TOTALS BURNT	
		Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
0-5	Easy to control. Head attack successful	249,800	34	197,300	27	274,000	29	721,100	30
6-10	Difficult. Head attack may fail; flank attack usually successful	219,500	29	318,100	42	378,000	40	915,600	37
>10	Very difficult. Direct attack usually fails.	272,900	37	234,300	31	289,700	31	796,900	33

Note: The degree of difficulty of control relates to the likelihood of successful attack on head and/or flank fires under the 95 percentile weather conditions. The suppression difficulty is dependent on forest type and fuel structure.
(Data provided by CALM R Sneewjagt, pers. comm.)

Table 1 gives the history of prescribed burns in the southwest region and relates it to the likely difficulty of bushfire control. The table shows that:

- 30% of the southwest CALM Act land in the review region is carrying fuels less than 5 years old, a figure that included the 17,880ha burnt by bushfires in 2003. A bushfire in these areas should be relatively easy to control. (Latest data to 1 May 2004 indicate figure now at 33%);
- 37% of CALM Act land in the review region has not been burnt for between 6 and 10 years and is considered to be more difficult (and expensive) but generally controllable under 95% of the weather conditions encountered. For the 5% remaining, it will be too hot/dry/windy to be able to attack wildfires directly in 6-10 year unburnt vegetation; and
- 33% of CALM Act land in the review region has not been burnt within the last 10 years. Bushfires in these areas are expected to be very difficult to control by direct attack to the head or flank of the fire.

Table 2 provides an indication of how long it has been since areas were prescribe-burnt. Most areas have been burnt in the 7-12 years interval, followed by the interval from 13-18 years. Few have been burnt either in the 1-6 year or in the 25 years and over intervals.

Table 2: Intervals between prescribed burns

YEARS SINCE LAST BURNT	NUMBER OF AREAS BURNT
1-6	3
7-12	53
13-18	31
19-24	13
25 and more	7

Data by R Sneeuwjagt (CALM) for period 1970-2000 as at May 2004

Table 3 shows the areas prescribe-burnt and affected by bushfires since 2001. CALM has received additional funding midway through the 2003-04 financial year to hire 32 additional fire crew to assist in the burning operations during Autumn 2004. The extra personnel and operating budget, combined with favourable conditions, have resulted in a significant increase in the burn areas achieved in 2003-4. As at the end of May 2004, a total of approximately 190,000ha has been burnt, with the prospect of an additional 20,000ha before the end of June 2004 (R Sneeuwjagt pers. comm.).

Table 3: Areas of CALM Act land recently burnt in the review region

YEAR	PRESCRIBED AREA BURNT (ha)	AREA BURNT BY BUSHFIRE (ha)	TOTALS (ha)
2001	74,700	19,000	93,700
2002-2003	144,800	126,000	270,800
2003-2004	190,000 (to end May 04)	17,880	207,880

Data provided by CALM

Whilst numbers provide a guide to burn targets, what is more important to CALM is the location of the burns in relation to community and ecological values. CALM's philosophy is that planned burns in natural areas can be used to minimise the risk of loss of life, property and services and to achieve conservation objectives (CALM 2004). It believes that this method is likely to be more cost-effective and predictable over large areas than using alternatives such as manual, mechanical, chemical and biological methods.

CALM is aware that if an area is burnt too frequently (i.e. at intervals shorter than required for that ecosystem to recover (by re-germinating, growing and seeding) before the next fire occurs) it may cause serious environmental damage and ecological changes. The intensity of the fire is also a significant factor.

CALM's draft Fire Management Policy (***Appendix 3***) indicates that fire may be excluded from representative scientific reference areas and that some biota and ecosystems may also benefit from long periods of fire exclusion. Inappropriate fire regimes in organic substrates like peat bogs (when dry) can permanently alter or disrupt their biophysical characteristics. With any regime designed to systematically remove organic material, fire can become a geomorphological agent by burning the soil, altering water quality by exposing anaerobic soils to air and thereby causing acidification, and threatening other elements of biodiversity dependent on the organic matter/moisture relationship (Horwitz, Judd and Sommer 2003).

This introduces the concept of mosaic burns. Mosaic burns are a pattern of patchiness within a burn envelope where not all the area within the envelope is burnt during a prescribed burn event. Patchiness is an important factor in providing environmental variation at a local level. This gives refuge to animals and plants from which they can move out to re-colonise burnt areas. Fire management at a very local scale may be critical for the survival of some threatened species and ecological communities.

During a prescribed burn the EPA was advised that CALM aims to burn between 65% and 90% of an area, depending on the individual circumstances of each burn area. Patchiness can be achieved:

- by designating fire exclusion zones within the overall burn envelope;
- by burning during times when some forest materials are wetter and less flammable than others;
- through the fire-lighting patterns used; and
- by carrying out burning adjacent to areas with light levels of fuel.

However, soil moisture levels appear to be falling in response to climate change and, all other things being equal, this tends to lead to more intense fires and less patchiness because more areas within the overall prescribed burn envelope are dry enough to burn.

Areas which are not burnt often enough to maintain relatively low levels of fuel are at greater risk of a wildfire which could be much more destructive because of an intensity and speed that are difficult or impossible to control. An example was the Mt Cooke fire, which was started by lightning and burnt uncontrollably for three days in January 2003 south east of Perth in Jarrah forest, at high intensity in timber which had been unburnt for between 7 and 23 years. It was contained along its flanks by forest which had burnt from one to 11 years before and was finally stopped when the headfire ran into areas burnt five years previously enabling firefighters to control the fire by direct attack. Such fires may re-ignite mosaic patterns of more recently burnt (low fuel) areas in their path and hence remove the planned patchiness which is sought to encourage biodiversity within the broader burn envelope. CALM Landsat imagery of the fire shows that the Mt Cooke fire burnt more coolly and in a more desirable patchy mosaic in flanking forest areas to the north which had been burnt one and three years previously.

5.3 Planning and undertaking a prescribed burn

CALM carries out its fire management role in partnership with other agencies, primarily FESA, the Department of Environment, the Forest Products Commission and local government authorities.

The location and timing of prescribed burns is determined by integrating three main considerations:

- the protection of values (via Wildfire Threat Analysis);
- the conservation of biodiversity; and
- forest management (i.e. post-harvesting regeneration burns and regrowth protection burns).

With this mix of objectives, CALM advises that a very wide array of fire regimes and time intervals ranging from 5 to 25 or so years is achieved.

Prescribed burns are carried out by CALM staff to achieve specific land management objectives. The process to define which areas are to be burnt starts with a risk assessment model called the 'Wildfire Threat Analysis'. This considers four risk components (CALM 2003c):

- the location and fire vulnerability of the full range of values;
- the ignition potential;
- the fire behaviour potential; and
- the fire suppression capacity.

The 'values' mentioned in the first point include rural and residential property, threatened ecological communities and species, recreation sites and plantations.

When considering the ideal intervals for prescribed burns, climate change and global warming add complexity. Climatic factors may act either to enhance or to retard ideal burn frequencies for forest ecosystems. Declining winter rainfalls in the southwest of WA for at least the last 30 years mean that forest moisture levels have generally decreased. Less moisture leads to lowered productivity of forest ecosystems (Burrows and Wardell-Johnson 2003), which affects regrowth and recovery rates after fire. The juvenile stages of tree development may lengthen. Drier weather (hence slower growth rates) implies that less fuel accumulates on the forest floor each season, but might extend the time during which vegetation is dry enough to burn, thereby increasing the frequency of wildfires. Higher levels of atmospheric carbon dioxide seem to increase the growth rates of taller trees in rainforest ecosystems and may have a similar effect here too. Species assemblages and fire response patterns could change. These and other factors, with their conflicting effects (and untested combined outcomes) generate uncertainty over whether the currently accepted prescribed burn intervals will be appropriate in the future.

It is desirable that burning prescriptions are drawn up a year or more in advance, to ensure all key factors are checked and firebreaks are put in place. CALM uses a 'Pre-burn Checklist', consisting of two parts which are required to be completed: 'environmental issues' and 'people and property' ***(Appendix 4)***. These are further split into a detailed consideration of the various components. If any of these are likely to be adversely affected by the burn, actions to mitigate those impacts are considered and listed.

It is CALM policy to ensure that the community is informed and consulted at this early planning stage. Various regional offices have different methods of ensuring that those who wish to be involved are contacted. During the course of the various EPA Information Days that were held in southern centres it became apparent that some groups in some communities felt that the degree and timing of these consultations were inadequate. Others had expressed the sentiment that this seemed to be something that used to be done inadequately but that the degree of effective consultation now practised by CALM was good. The EPA employed an independent consultant to review CALM's fire policies and management practices. His findings are discussed in more detail in Section 7. One of the important findings from his review was that he considered CALM's fire planning practices, as outlined in its proforma documentation, to be world's best.

The Pre-burn Checklist is attached to a "Burn Prescription" form ***(Appendix 4)***. The prescription details the primary and secondary objectives (or purposes) of the burn, the burn standards, the conditions under which the burn will be carried out, its precise location, and any specific constraints and considerations (such as neighbouring properties, powerlines, declared rare flora/fauna, heritage sites etc). It contains a list of preparatory tasks, wind ratio conversion factors, an assessment of the fuel levels, edging prescriptions and a record of fire behaviour.

Closer to the time of a prescribed burn (not less than four days and not more than 28 days prior) burn notifications are carried out. All adjoining landholders, potentially affected beekeepers, wildflower pickers, harvesting operators, surveyors and others are notified.

After the burn an assessment is completed. As described in the Fire Operation Manual Instructions, the CALM District Manager arranges a reconnaissance of the burn to examine the results, which are recorded. Details of all burnt areas greater than 10ha, any unburnt pockets larger than 20ha and likely escapes are the key inputs. CALM regards it as essential that patrols are carried out daily until all the burn edges are safe. The post-burn assessment includes a review of the objectives set for the burn.

5.4 Some issues associated with prescribed burns

Prescribed burning is a topic which frequently polarises opinions about how much, where and when it ought to be done. Nevertheless, the EPA understands that there is ground common to most positions:

- an understanding that **some** prescribed burning is necessary. It is the details - the why, how, where, when and how much - over which people disagree;
- strategic buffers should be created around vulnerable communities and properties. Flammable materials within the buffers should be minimised;
- that intense fires are not good; and
- a widely held consensus that CALM is under-resourced (staff and money-wise) for its role as manager of its estate and to fulfil its responsibilities with regard to fire management. This is exacerbated by the reduction over the past several years in equipment and personnel available to fight fires, such as heavy machinery from the logging industry, which was available in emergencies, and the continuing expansion of urban developments and hobby farms into areas adjacent to the CALM Act land.

On this last point CALM has received significant additional funding from the government in 2004. This is $3 million for 2003 and 2004, rising to $5 million in 2005 and $6.9 million thereafter.

While this consensus exists, it is clear that there are also many areas of difference about prescribed burning.

Whilst prescribed burns are used by CALM to achieve land management objectives, including protection of property, infrastructure, regrowth and regeneration of habitat, they do have impacts, such loss of fauna and faunal habitat, alteration to ecosystems, change to soils structure, pollution and loss of visual amenity. The community has an expectation that these impacts are outweighed by the benefits said to accrue from prescribed burns. However, it is apparent from the public information exchange sessions run by the EPA that there is a significant degree of dissatisfaction with the reasons for carrying out, and the outcomes of, many CALM-prescribed burns. The main concerns are with the effects of smoke, the loss of habitat, productivity, aesthetic values and biodiversity from fires (especially from escaped burns) and the counter view by some that more burning is needed to protect vulnerable communities and plantations from destructive and dangerous wildfires.

5.4.1. Windows of opportunity

The window of opportunity for prescribed burns is determined primarily by the weather conditions, which influence soil and moisture levels in the forest. There is evidence (Burrows and Wardell-Johnson 2003) that climate change is occurring in this region and that average rainfall has declined since the 1970s. Reduced moisture levels coupled with warming temperatures will combine to reduce the times when conditions

are considered safe for prescribed burning to take place. Temperatures and winds forecast for the period of the proposed burn must be appropriate before burning is allowed to occur. Too high forecast temperatures, or winds from the wrong direction could result in hotter-than-planned burns doing more damage and possibly getting out of control, and/or smoke drifting over the metropolitan area. As with other forms of atmospheric pollution, for some people there are real health risks associated with the inhalation of bushfire smoke *(see Section 5.4.3).*

An example in March 2004 of a bushfire (not a prescribed burn) near the south coast which subsequently obscured Perth with a smoke haze on the following day illustrates the difficulty of planning and executing prescribed burns to achieve all the objectives set. The smoke from the fire initially tracked westwards and out to sea to the west of Augusta (as forecast), but an incoming low pressure cell concentrated and redirected the smoke, which crossed the coast near Mandurah and affected Perth some 30 hours after leaving the scene of the fire.

CALM carries out prescribed burns in spring and autumn, when weather conditions are mild. The cutoff into winter occurs when conditions become too mild and forest floor litter is too wet, resulting in burns that may not achieve their objectives, nor be cost-effective. Spring burns and autumn burns require different considerations and produce different effects.

Burns in spring coincide with the wildflower season and may adversely affect germination, pollination and honey-making processes, may affect birds by either reducing the nest choices of breeding birds or destroying nests and eggs or chicks unable yet to fly, and have unpleasant visual effects in the forest at the time when recreational use increases in the bush. Advantages of spring burns are that:

- most native plants produce their new leaves in spring and summer visual recovery is usually rapid; and
- the forest is usually much wetter after winter and therefore burns are cooler and more easily controlled.

Conversely an autumn burn:

- will generally have a much longer recovery period because it will not be until the next spring-summer season that burnt-off leaves will be replaced;
- the bush will be dry at the end of summer and more likely to produce a hotter, more difficult-to-control burn; and
- because the material is dry there are more flare-ups (re-ignitions) and more time (extra days) needs to be spent on ground checking to ensure they are properly extinguished and do not spread.

The EPA understands that CALM uses strategies to minimise the adverse visual effects of spring burns (Bushfire Front submission 2003). Measures include:

- lighting burns only under the coolest conditions that will *still provide effective fuel reduction*;
- measuring tree canopy heights as part of the planning for a prescription burn *so as to reduce the risk of scorch*;
- confining burns to one side of a tourist road in the one season, or setting them back from the road edge so as to minimise the visual impacts; and

- *...in the karri forest, burn intensity is kept as low as possible to avoid damage to mature trees.*

With the constraints on when and where prescribed burns may be done, CALM states that it often has difficulty in meeting its annual prescribed burn targets.

5.4.2. Environmental impacts

The EPA sought specialist consultant advice on the role of fire in maintaining and protecting biodiversity. The review by Drs Wells, Hopper and Dixon from the Botanic Gardens and Parks Authority is limited to peer-reviewed published scientific literature pertaining to the impact of fire regimes on biodiversity conservation and in particular on south west Australian studies. The EPA is aware that there is a large body of literature on fire and biodiversity issues that has not been published in edited books and refereed journals and was not therefore considered in the consultant's study.

The consultants reviewed forty-nine papers and book chapters in this study and their key conclusions are as follows:

- most research undertaken in this area is descriptive and short term, establishing pattern and correlation but not causation;
- hypotheses for management of fire to conserve biodiversity are restricted to correlational studies of selected components of the biota;
- no fire regime has been shown to conserve all biodiversity of a region, even at a local scale. Many scientists are of the opinion that no fire regime is optimal for all components of the biota;
- most organisms are fire-tolerant rather than fire-adapted;
- fire-sensitive species are known in all major habitats in the southwest;
- given the above, care must be taken not to yield to the temptation to extrapolate findings with a restricted coverage to other species and areas;
- research conducted to date on fire is insufficient to allow prescriptions to be made for fire regimes to maximise biodiversity conservation;
- research is needed to identify:
  - the interaction between burning and weed invasion, and subsequent influence on biodiversity,
  - the combined impacts of prescribed burns and wildfire on biodiversity conservation,
  - the relationship between fire and rarity in southwest WA,
  - which fire regimes minimise the extinction of genes, species and ecosystems.

In the preparation of this review, the EPA has also noted that the issue of using and managing fire whilst protecting and maintaining biodiversity has been addressed in other recent reviews. The EPA is aware of the structured approach that is being developed and modified linking landscape conservation units with ecological vegetation systems, fauna habitats and plant and animal species. Although this approach is still being tested it appears to provide a rigorous framework for testing linkages of fire regimes in different landscapes with underlying biodiversity values. As well, the EPA notes that there appears to be relatively little documented work on invertebrates with respect to their role in sustaining and supporting forest ecosystems and the effects of fire on them.

Depending on their extent and intensity, prescribed burns have the potential to kill or dislocate fauna (by making them homeless or removing their normal sources of food or cover). Too-frequent fires will not allow some plant species sufficient time to regenerate or produce seed and therefore will reduce species richness (Dixon and Hobbs 2002). By removing or reducing quantities of forest litter, fires expose the ground to air and light, causing it to become drier and the ecology to change (arguably temporarily) in response to the loss of habitat, food and the changed ambient conditions. The ground may be more prone to soil erosion and opportunistic weeds may establish, making the bush more fire-prone. According to a 2002 paper by Pike, regular burning of bushland on the coastal plain has not reduced the fire hazard. Rather, it has promoted the growth and spread of flammable weeds (Veldt Grass, Love Grass, Wild Oats, Freesias and Pelargonium) and increased the hazard by adding to the intensity of fires. The problem thus becomes one of weed management in order to cut the fuel loading. CALM advises that it does not carry out burns in metropolitan area reserves due to the high proportions of weeds and exotic grasses.

In areas frequently burnt by wildfires on the Darling Scarp, Brooker (1995) described how Splendid Fairy Wren populations decreased to 10% of their peak density and concluded that their survival was dependent on linkages to adjacent unburnt areas.

Dell and How (1995) inferred the short term impacts of fire on the fauna of sites in Talbot Road Reserve and on the herpetofauna of sites burnt between three and six years earlier in Kings Park. At the unburnt banksia woodland site at Talbot Road Reserve there were a similar number of individual fauna but nearly double the number of species after the fire in the adjacent burnt area. The burnt woodland had one seventh of the individuals and less than half the number of species after the site was burnt. After the mild 1993 Kings Park fire a sampling grid adjacent to the burnt area showed that many marked individuals moved into the unburnt area as a result of the fire. The burnt area had regained a similar number of individuals and most species (except arboreal ones) three years after the event. By contrast, six years after the hot and extensive fire in Kings Park in 1989, the effect on reptiles was such that species richness still had not recovered. After a fierce fire in Bold Park in 2000, reptiles and frogs displayed very different responses. The reptiles showed a slight decline of species numbers and a large decline of individuals in the year after the fire and probably survived by burrowing. Frogs had the same number of species and an increased number of individuals. (The apparent inconsistency was not explained although it may be that frog predators also died in the fire).

Some ground dwellers escape low intensity fires by climbing or burrowing, but may become more vulnerable to predators if the vegetative cover of their normal habitat (and/or food source) is lost to fire. How (2002) also states that *fire regularly destroys trees that possess hollows and this has a deleterious effect on the occurrence of all hollow-using species....*

The long-term survival of fauna after fire is predicated on linkages and the ability of the fauna to re-colonise areas (Dell and How 1995). Less extensive and milder fires may allow species to move to adjacent unburnt areas, but, referring to areas of urban bushland, they state that the long-term survival and re-colonisation of species has still to be evaluated in situ.

5.4.3. Smoke issues

The smoke from fires (domestic fires, bushfires or prescribed burns) can exacerbate or precipitate health problems amongst susceptible members of the community. There is no distinction drawn between the smoke from a bushfire and that from a prescribed burn as the fires come from the same source and give rise to the same combustion products. The Department of Environmental Protection has stated that during winter in Perth up to 90% of small particles originate from domestic wood smoke (DEP 2004). This review focuses on studies reporting health effects associated with bushfire smoke, where possible in the Australian context. It needs to be emphasised that there is a great deal of toxicological and epidemiological information on individual component compounds of smoke not specifically addressed here.

The smoke from bushfires is a complex mix of particles, gases, such as carbon monoxide, carbon dioxide, oxides of nitrogen, and volatile organic chemicals, such as formaldehyde. Other organic compounds such as polycyclic aromatic hydrocarbons, benzene and dioxins have also been found in bushfire smoke.

All of these substances have been shown to cause harmful physiological responses in laboratory studies of animals and in some cases humans. Some compounds found in wood smoke, such as benzo[a]pyrene and formaldehyde, are possible human carcinogens. Of these substances the most studied are the particles. Particles can cause problems for both upper and lower respiratory systems and when inhaled deeply into the lungs, can damage lung tissue and cause respiratory and cardiovascular problems.

Less attention has been given to the effects of bushfire smoke on human health and the physical and psychological effects on communities subjected to smoke. Some sectors of the human population are more susceptible than others. In many instances these data are not available, especially in rural areas, where perhaps the effects of smoke from fires may be expected to be most apparent. Nevertheless,

> *there is substantial epidemiological evidence that particles arising from the combustion of fuel, including biomass, has health implications for individuals and populations...* and *... In Perth, particle concentrations have been significantly associated with increases in hospitalisations for respiratory diseases and asthma* (Hinwood and Rodriquez 2003).

In response to vocal opposition to smoke over the metropolitan area, CALM's planning for prescribed burns is expected to take into account the potential effects of smoke drifting over the Perth metropolitan area and to schedule burns for those days when the forecast weather cycle is most likely to carry the smoke in another direction. But to have to plan also against its spread over other smaller population centres would be likely to reduce the number of days on which burns could be carried out to an extent that makes it an impractical, and in some areas impossible, exercise.

At the EPA's public information sessions some people said they are prepared to accept the smoke from prescribed burns as a component of country life because they believe prescribed burns are needed to reduce the risk to life and property from a wildfire. Others pointed to the inconsistency between the strategy which aims to keep Perth smoke-free, and the absence of a similar objective for their own southwest communities. The health risks of smoke from a prescribed burn should be balanced against those created by a wildfire which may ensue and perhaps burn out of control in

an area which has been long unburnt and contains high quantities of flammable materials.

It is clear the smoke from bushfires has the potential to impact significantly on the health of individuals and populations. The contribution of bushfire smoke to existing health impacts from other pollutant sources is unknown and it is hoped the work programme within the Perth Air Quality Management Plan will address these questions and provide decision-makers with information on the potential human health risks associated with burning and the significance of these risks. But not all studies on the health effects of smoke have led to the same conclusions as those described above;

> ... *there are many that have not observed any health consequences associated with fire events* (Hinwood and Rodriquez 2003).

More studies are needed, in particular:

- to address physiological and psychological public health effects of smoke if recommending an increase in the amount of prescribed burning, compared to the risks associated with not increasing burning regimes; and
- a focus on both the short and longer term effects of smoke on human health.

Smoke may also generate other effects. For example some recent reports suggest that smoke from fires can taint wine made from grapes (The West Australian 2004).

In 2002 the Air Quality Branch of the Department of Environmental Protection (now Department of Environment) published a document titled *Implementing the Perth Air Quality Management Plan.* The aim was to ensure that clean air is achieved and maintained throughout the Perth metropolitan region. It seeks to achieve this by reducing the emissions of those air pollutants that are causing occasional episodes of unacceptable air quality and by preventing the development of future air quality problems.

While the key contributors to impacts on Perth's air quality were identified as vehicle use and industrial emissions (modified by the prevailing meteorological conditions) smoke from planned burning by CALM was identified as a component at times. It led to the initiative (Initiative 12 in the abovementioned document) to establish smoke management awareness and liaison groups to:

- facilitate community education and information about smoke impacts from planned burns;
- examine smoke management policies, regulations and procedures for consistency;
- promote the development of environmental management plans to incorporate fire hazard reduction strategies for remnant bushland in the metropolitan area;
- develop guidelines and codes for use of fire in horticultural and agricultural practices within the metropolitan area; and
- regulate the use of fire on development sites within the Perth metropolitan area.

5.5. Other considerations in determining prescribed burn strategies

The first known attempts at prescribed burning in WA are sometimes called "firestick farming." It is a term applied to the burning of the bush as practised in the past by Aboriginal people. It may have been a way of encouraging a more open countryside by the growth of grasses for the purposes of travel and to facilitate the hunting of gamefoods, such as emus and marsupials. The point about firestick farming is that the

technique is usually described as having been planned and used for specific purposes, and skilful, to the extent that the fires were thoughtfully lit, and were controlled. It is believed that some areas may have been burnt frequently while others may have had fire excluded from them (Burrows and Wardell-Johnson 2003).

The purposes for lighting fires have changed. Having clear fire management objectives for the conservation of biodiversity is of key importance (Burrows and Wardell-Johnson 2003) in assisting with the development of fire management plans and standards. While many, or most people, would assign the highest priority to the protection of human life, there is considerable discussion on the relative importance of the other four elements recognised in the terms of reference of this review, i.e. biodiversity, assets including strategic infrastructure on managed lands, environmental health and neighbouring properties and assets. An approach suggested by Burrows and Wardell-Johnson, (2003) is that conservation agencies should first

> *develop fire regimes that aim to protect and maintain biodiversity, and then undertake a systematic wildfire risk analysis to determine the threat posed by the regime to life, property and other community values.*

The fire management regime could then be modified where the risk of wildfire is unacceptable.

Addressing one term may mean there will be compromises in attempting to protect another. For example, the protection of environmental health in this context requires keeping the smoke from prescribed burns away from human populations because of the documented adverse effects of smoke on human health *(see Section 5.4.3).* CALM aims to burn only on days when the weather forecasts are such that the resultant smoke will drift away from the Perth population. In practice, this means that the air quality in other towns in the southwest may be disadvantaged to favour a smoke-free Perth. This leads to a reducing window of opportunity in which to conduct these burns (due to factors such as geographically spreading metropolitan populations, increasingly vocal complaints about smoke from them and climate changes reducing moisture levels in the forests and affecting weather dynamics). Thus less prescribed burning is now completed annually than in the past (Muller 2001) and less than CALM's annual target of 200,000-250,000ha to prevent flammable fuel build-up from reaching the point where a wildfire in it would be very difficult to bring under control.

CALM believes that, in order to protect the conservation estate in the best way possible in the long term, it is necessary to carry out prescribed burns, at intervals which vary depending on factors such as ecosystem types (flora and fauna), climate, when it was last burnt (either via prescription burn or other causes such as lightning, accidental escapes and arson) and its proximity to populations and properties that need to be protected from fire. CALM normally carries out most burning in spring because that is when the right conditions present most often. CALM recognises that different ecosystems need different fire regimes (frequency and timing of burns) and in an ideal world would take these variations into account in the planning of its burns. Constraints, in the form of limited resources, restricted 'windows of opportunity' and excursions from predicted weather conditions may conspire against prescribed burns taking place in the optimum year and season.

Previously, CALM has stated that, in order to catch up with its calculated annual prescribed burn quota, it needs to plan enlarged annual burn programmes covering

250,000ha to 300,000ha. However, this fire season, greater amounts of appropriate burning conditions and opportune weather has been available, and has allowed more burning than usual to be undertaken. The additional funding also allowed more staff to be deployed in burning operations. At the time of writing this Paper, CALM is confident that its stated 8% of its estate (or about 200,000ha) annually burnt is adequate. (The amount burnt by wildfires is also taken into account each year but wildfires may or may not burn areas which are planned to be prescribe-burnt). CALM regularly proposes total prescribed burning programmes for the southwest area which are larger than can be practically achieved under the abovementioned constraints. This is to provide a choice of areas if the preferred burn area turns out to be unsuitable because of unfavourable weather (or other) constraints. The alternative is for a greater degree of forbearance from all sectors of the WA community in tolerating the smoke produced by prescribed burns when the climatic conditions blow smoke across it.

The Conservation Council of WA states that CALM has a set 'fuel load' of 8 tonnes per hectare in jarrah forest and 17 tonnes per hectare in karri forest. CALM (and other published research across Australia) has confirmed these figures (pers. comm. R Sneeuwjagt) as being the maximum levels under summer conditions for direct attack on the headfire to be realistic, beyond which it becomes difficult and dangerous. The Conservation Council further states that these fuel loads are reached in 5-7 years in jarrah forests and 6-8 years in the karri and that this sets the frequency of prescribed burns that CALM plans to attain, in both 'production forests' and conservation reserves. However, CALM states that the time that it takes for fuel to reach these levels varies depending on the canopy density and productivity of the forest stand.

> *For example a jarrah stand with 25% canopy takes 10 years to accumulate 8t/ha, whilst a 60% canopy cover requires only 5 years. Stands in the east of the forest (lower rainfall) take 2 or 3 years longer to reach 8 tonnes than those in wetter sites in the western sections of the jarrah forest.*

The Conservation Council has raised the concern that young jarrah and karri trees are fire-sensitive until they are 15-20 years old and shouldn't be burnt before then. CALM advises that the decision-making process to determine prescribed burn intervals is more complex than simply responding to overall fuel loads and that young regenerating Karri forest is not burnt until it has had its first thinning, after about 20-25 years.

A conservative approach to ensure that there is ample viable seed to enable adequate regeneration after successive fires is to allow a minimum fire-free interval equivalent to the juvenile period of the slowest-maturing species (Burrows and Wardell-Johnson 2003). A sustained regime of fires at frequencies greater than the conservative interval is likely to lead to a decline in some obligate seed species and instead benefit short-lived herbs and some grasses, leading, in time, to a change in the species assemblage and possible repercussions for the dependent animals.

Wilderness areas deserve special mention. From CALM's draft Policy on Identification and Management of Wilderness and Surrounding Areas (2003b), wilderness can be loosely described as areas that are:

- remote from settlement and access routes;
- substantially unmodified by modern technological society;
- sufficiently large and remote to make the long term protection of its biodiversity and natural systems practical;

- where ecological processes remain essentially intact; and
- where opportunities exist for solitude, inspiration and self-reliant recreation.

Fire management activities within areas surrounding wilderness have the potential to affect wilderness values. CALM (2003b) lists the following strategies for proposed wilderness areas:

- wherever possible, ground-disturbing activities required for fire management (e.g. construction and maintenance of access roads, firebreaks, fuel-reduced buffers and water points) will be conducted outside of a wilderness area;
- prescribed burning within wilderness areas may be carried out for the protection and maintenance of ecological values; and
- where life, property and natural resource values are threatened, wildfire pre-suppression and suppression techniques will be used, subject to the availability of resources.

5.6 Auditing of prescribed burns

As an outcome of a planning meeting on the conduct of this review ***(see section 1.2)***, the EPA committed to a field audit of some prescribed burns, to verify whether established processes were followed and the outcomes of the objectives set by CALM for the burn were met. Three prescribed burns were selected by the EPA. The selection was representative of the different forest types, coastal plain woodland and ecologies and sought to establish how the various objectives and constraints stated by CALM in its planning of the burns were handled. A field audit of these burns was carried out by the consultant firm URS Australia.

From discussions with the CALMfire manager, URS understands that the regional burn planning process is the way in which, for each proposed burn area, biodiversity and asset protection values are weighed in order to determine burn locations, timing and objectives. The scope of URS' review primarily related to comparing objectives with outcomes of the nominated burns and excluded the assessment of regional planning of burns and the biodiversity impacts of burns. The latter topic was the subject of a separate consultancy (see *Section 5.4.2*).

The prescribed burns audited were:

- High Hill Road 415585a (Swan Coastal District) in banksia-tuart woodland north east of Joondalup (2521ha), for the main purpose of providing strategic protection to an adjacent pine plantation. Last burnt in 1991;
- Cornwall W007 (2948ha, Wellington District) north east of Harvey in jarrah-marri forest, to provide protection for introduced Noisy Scrub Birds. Last burnt in 1993; and
- Bramley BS031 (1227ha, Blackwood District) immediately east of the town of Margaret River and north of the river, for the protection of the township, last burnt in 1991.

A section of the audit on community consultation found that the levels varied according to the particular interest levels of the neighbouring communities in the recent past but was appropriate for the three burns. Possible implications arising from the approach to consultation are:

- failure to challenge the assumption that there will be no interest in a burn programme in an area may result in loss of opportunity for public consultation where interest levels have changed either through increased awareness or new residents in the area;
- failure to keep records of public consultation, such as minutes of meetings, may impact on CALM's ability to demonstrate that appropriate public consultation has occurred in the event of legal or community action.

The audits showed that the burns had, to a great extent, met their set objectives, though instances of incomplete records were not uncommon. URS considered that the most significant of the Objectives and Standards not achieved was an unburnt pocket along a creek line on the edge of the Cornwall burn, which is thought to have resulted in a wildfire of around 45 hectares. The most common omissions were incomplete or unauthorised documents, and data not having been signed off as verified.

The audit also indicated a high reliance on the experience of personnel managing the burn to determine if the weather conditions were appropriate on and throughout the day of the burn. Personnel in the aircraft dedicated to the burn assisted with visual reports. This places a high responsibility on the field staff and emphasises the importance of having experienced practitioners. The scope of this audit excluded a review of the adequacy of training and competency assessment systems, but URS recommended that CALM conducts periodic reviews of its training and competency systems.

The Manager CALMfire reported that for each burn, there are primary and secondary objectives, which arise out of the regional planning process and drive the prescriptions for each burn, the primary objective having the greater influence over the burn prescription. From review of the documentation of the three burns audited, the primary and secondary objectives were only apparent to the auditor for one burn. The Manager CALMfire was subsequently able to identify the primary objective for each of these burns from prior knowledge of the burns.
CALM's main objectives for the burns were:

- achievement of fuel reduction;
- protection of man-made assets;
- maintenance/enhancement of biodiversity/ecological values;
- scorch height;
- containment of burn within designated boundaries;
- no unburnt pockets on edges of burns;
- vehicles to remain on existing tracks;
- mop-up to meet internal standards; and
- increase in water yield.

Not all of these objectives were stated for all the burn areas.

Some of the findings of the audit are summarised below.

Achievement of fuel reduction
Field observations during the audit indicated that litter, trash and dry shrub fuels were generally reduced to a very low level by the burn. A remote sensing technique (Landsat) to measure post-burn fuel levels or the distribution of fuels is being refined by CALM but requires further development and ground-truthing. Percentages of burnt

areas from the Landsat imagery were provided to URS and have been included in the audit report. In general, CALM aims to burn about 65-90% of a prescribed burn area in a mosaic pattern each time it is burnt. Preliminary information from CALM data indicates that often this figure is at the upper end of the range sometimes because unburnt patches within the burn envelope may subsequently catch alight.

Maintenance/enhancement of biodiversity/ecological values
CALM states that biodiversity is enhanced by the creation and maintenance of mosaics of burnt areas of different vegetation types and ages, at various scales. In the auditor's opinion the burns have achieved this mosaic of vegetation ages. Burn areas were aerially viewed in the days immediately after the burns to identify any large (>20ha) unburnt areas on the perimeter of the burn envelope. None was found.

Discussions with the Manager CALMfire indicated that multi-disciplinary meetings are held after each burn programme in each district or region to assess the achievement of objectives, including issues of interest to the Nature Conservation group. Minutes of one post-burn meeting were sighted. However, minutes of meetings for the three burns audited were not available. Species diversity was not assessed as part of this audit, nor was the extent to which the mosaic was represented on various parts of the landscape within the burn area.

Burns contained within designated boundaries
URS considered that burn escapes (or hopovers) which are limited to approximately 1ha were acceptable, provided there are no special ecological values or assets in the area. Based on this consideration, the auditor noted there were hopovers at both the High Hill Rd and Bramley burns and that the largest was 1.5ha.

No unburnt pockets on the edges of burns
Two of the three areas met the criteria of no unburnt pockets. The Cornwall burn did not. An unburnt creek line crossed the eastern boundary of the burn and may have been the cause of a wildfire which was reported five days after the burn was carried out and burnt about 45ha. Discussions with CALM personnel and review of CALM documentation indicated that patrol and mop-up were carried out on the two days following the burn, and CALM personnel reported that aerial surveillance was carried out up to three times per day over the following three days until the wildfire was detected. Interviewed CALM personnel reported that it is standard practice to investigate only those incidents that involve high value assets or ecological values.

Vehicles to stay on existing tracks
No newly formed tracks were seen during the audit.

URS concluded the inconsistent use of the terms Objectives and Standards, and the inconsistent use of Primary and Secondary Objectives across CALM districts results in difficulties in identifying the Primary Objectives and therefore assessing whether they have been met. As the Objectives form the basis for the prescription preparation and are also used for briefing burn crews on the purpose of each burn, it would be prudent to ensure that the Objectives, and the order of their priority, are very clear. URS made the following suggestions for improvements to burn implementation:

- greater efforts should be made to ensure that records are complete. In the absence of completed records CALM may be unable to demonstrate that its management was appropriate in the event of legal or community actions.
- record and retain the minutes of meetings of multi-disciplinary team review of burn programmes, and include all of the burns in that programme.

The URS report concluded that CALM has been very successful in executing the burns to reduce fuel loads and suppress hopovers while causing minimal damage to retained vegetation. Twenty one out of twenty six objectives were met from the three burns, only one of which has had a discernable negative impact to date (wildfire escape from Cornwall). Improvements could be made by ensuring that all Districts have access to the current versions of forms (e.g. the Burn Prescription form) and that there is common understanding of the use and purpose of the Primary Objective.

5.7 Resourcing

Because of the great increase of wildfires in 2002/3 (see Section 4) CALM overspent its budget by $6.95 million and its total expenditure (of $11.15 million, excluding normal time payroll costs) was almost three times greater than the average cost for the last five years. For comparison, the State of Victoria's equivalent Departments of Sustainability and Environment, and Parks Victoria, spent $131 million on fire suppression (CALM 2003c). CALM states that United States and Eastern States land managers have

> *found that failure to implement prescribed burning programs has resulted in huge recurrent expenditures to contain wildfires, large infrastructure replacement and economic and productivity losses, and the need to recommence prescribed burning at much higher costs....* (CALM 2003c).

Reviews of heavy firefighting machinery in WA's southwest (CALM 2003c) revealed a significant reduction in the number of contract machines available to the Department for fire control, largely as a result of downsizing the hardwood timber industry, a trend which is continuing. During the 2002/3 fire season there were two occasions when there were not enough bulldozers available at short notice in the Swan Region. CALM has stated that, had these been available in the early stages of the Mt Cooke wildfire in January 2003, the fire may have been contained to an area of less than 100ha, instead of the 18,000ha which were eventually burnt. The cost of suppressing that fire was $964,000 (CALM 2003c).

CALM relies on the provision of support from local bushfire brigades to varying degrees, depending on the area.

The resources required to carry out prescribed burning programmes, whilst under financial constraints, need to be balanced against the huge costs of fighting wildfires.

Generally speaking, the smaller and more tailored the prescribed burning patterns are to the ecosystems and terrains, the more it costs to carry them out. Irregular burn shapes and requirements to exclude sections within the burn envelope add significantly to ignition and subsequent control costs. This factor may be responsible for the percentage of burnt area within the prescribed burn envelope often exceeding the minimum quoted target of 60-65%. This stage of the burn can necessitate frequent visits to the burnt area and takes away staff from other duties.

The need to minimise smoke impacts means that some burns need to be done under more hazardous conditions, such as during easterly and north-easterly winds (which are characteristically hot and dry). Also, in order to take advantage of the windows of opportunity, burns may need to be carried out on weekends and after normal hours when cost factors are higher.

6. WHAT ARE THE CONSEQUENCES OF BUSHFIRES?

Although this review is predominantly about CALM's prescribed burns and their effects, it would be incomplete without also considering wildfires and their consequences in such a fire-prone country as Australia. Fires can regenerate vegetation, recycle nutrients, create and maintain habitats, and can also kill, injure and destroy. A major factor in planning prescribed burns is to reduce the frequency and intensity of wildfires and their impacts on biodiversity, humans, wood resources and property.

'Bushfire' or 'wildfire' are terms meaning an unplanned fire. In the southwest of WA there are on average 350 bushfires annually started on CALM Act lands (CALM 2002) and the trend seems to be towards an increase in their incidence. The average area burnt by bushfires each year in CALM-managed lands is around 15,000ha and the usual variance is from around 5000ha up to 45,000ha (pers. comm. R Sneeuwjagt). The 2002/3 bushfire season in the southern half of Western Australia was one of the most severe experienced in over 40 years (CALM 2003c). In the southwest forest region in 2003, CALM attended 549 bushfires, which burned about 140,000ha, of which 126,000ha were lands managed by CALM. The area burnt by bushfires in 2002/3 was an eight-fold increase in the average over the previous ten years.

6.1 Causes

Bushfires may be started by lightning, arson or accidents, and include forest fires, scrub fires and grass fires. Of the total of 656 wildfires that affected CALM-managed lands during 2002/3 lightning caused 42%, deliberately lit accounted for 26%, accidents for 6%, escapes for another 7% and unknowns from private lands were 19% (CALM 2003c). From the same report escapes from CALM-lit burns amounted to 1% of all wildfires. Over a six year period there has been an increase in deliberately lit fires (arson). Because these are more prevalent in near-urban areas they are more likely to cause significant property damage and risk human life.

One summer thunderstorm can start dozens of fires in a short time and over a large area. According to CALM (2003c) widespread lightning activity in the 2002/3 season caused 275 fires in the southwest forest region (five times the average) and up to 42 simultaneous bushfires, which were spread between Geraldton and Albany. When this happens the resources of firefighters are often spread very thin in trying to put out or control all these fires. Sometimes, with little time to gather all the facts, critical decisions have to be made as to which fires to attend, in what order, and which to leave to burn out on their own. CALM advises that the existence of strategically-located areas which have been recently burnt and so have reduced flammable material levels may help the decision process, enabling a lower priority to be given to fires burning into such areas.

Fire detection on CALM-managed land is based on a combination of thirteen lookout towers and eight aircraft. The towers in the southwest area are staffed from November to April each year. During the 2002/3 fire season the aircraft flew a total of 3640 hours (CALM 2003c).

CALM states (2003c) that rapid response enabled 75% of the bushfires in the 2002/3 season to be contained to less than 10ha and 87% of them to less than 100ha. CALM reports that a large proportion of these fires was kept small because they burned into low fuel and recently burnt areas and that, were it not for the presence of previously burnt low fuel buffer areas or because of favourable wind changes, a number of communities could have suffered severe wildfire damage. These included Ravensthorpe, Augusta, Toodyay and Lancelin.

There is also an increase in deliberately lit and accidental fires with the latter often attributed to the greater numbers of people recreating in the bush. However, some recent fires (at Gingin in 2002 and Mount Barker and Tenterden in 2003) have resulted from falling or arcing power lines.

The spatial distribution, frequency and intensity of fires is governed by variables such as:

- changing climatic patterns influencing the number, timing and distribution of thunderstorms;
- the flammability (or fuel load) of the area - the amount of flammable materials such as forest litter, and their moisture content;
- the location of the lightning strike - for example, the topography of the area and the ecosystem type (e.g. the presence of peat bog);
- ambient temperature, wind speed and its direction at the time and in subsequent days;
- human causes such as arson and accidents; and
- barriers to propagation, for example rivers, bare outcrops and in recent times, clearings, roads and fire prevention measures.

The speed with which firefighting teams can access a fire may have a big bearing on the eventual intensity and size of a fire.

Because of the relatively random nature of lightning it would be unwise to assume that all parts of the State, including the southwest area under consideration in this review, have burnt equally frequently. Due to the interplay of these variables some areas would have burnt more often and others less than the average. It is even possible that some 'islands' may have burnt only rarely. Parts may have burnt relatively slowly and coolly (enabling some animals to outrun or burrow to avoid the flames), while other areas may have been totally consumed, resulting in high animal mortality.

6.2 Effects

Assuming that lightning has been a part of the landscape from pre-human habitation times, it is reasonable to accept that fires caused by lightning are a natural part of ecosystem processes. This is not to imply that such fires are necessarily beneficial, especially nowadays when the community expects agencies like CALM to consider the protection of lives and property. As more people move into semi-urban areas and hobby farms on the edges of the metropolitan area and country towns this is becoming

an increasingly difficult issue to manage. At best any fire is a mixed blessing. Aside from the risk it poses to humans, property and infrastructure, it can damage or kill plants and animals. By opening up the forest canopy intense crown fires can encourage new growth, but also reduce the moisture content of the soil and change the balance and quantities of micro-organisms within.

Water quality and quantity is also influenced by fire regimes. In correspondence from Water Corporation to the EPA it was stated that very hot fires (such as some bushfires) can have adverse consequences for water quality and quantity and that reduced prescribed burning can be deleterious for water quantity.

If they occur at the right time, fires and the associated smoke provide the conditions for some native plant species to regenerate. The pattern of burning can help to create a mosaic of habitats which may aid biodiversity. But there is no single fire regime that suits all flora, fauna and ecosystems. A regime that enables one organism to gain a competitive advantage over others will affect ecological system balance.

The question of whether bushfires should be put out or left to burn is a complex, controversial topic requiring consideration of the interplay of issues such as biodiversity, burning history, ecological values at risk and safety (of humans - firefighters and the public - infrastructure and private property) and is inextricably linked to the core topic of this Discussion Paper, i.e. prescribed burns. A much debated question is whether more frequent prescribed burning reduces fire intensity and hence the risk of fires getting out of control, or, whether less prescribed burning gives rise to more, but possibly less severe bushfires? The EPA has received separate information which claims to show that both more and fewer prescribed burns can be the best strategy. The key appears to rest in the moisture content of the flammable materials.

6.3 Management options and strategies

Numerous strategies are possible, and will give rise to different effects, from a no-intervention policy on wildfires (as is practised in remote areas of the State such as the Pilbara and Kimberley, south coast and arid inland areas), through allowing the fire to run until it reaches strategically placed fuel/vegetation-reduced areas, to a requirement to extinguish all wildfires as quickly as possible (as for example in Kings Park Bush, in the centre of Perth).

Each of these strategies assigns different weightings to the issues depending on the priorities given to the often-conflicting needs of biodiversity, conservation, human safety, human health and the risk to property. Such strategies reflect the range of geographic variation, values and population densities. Much of the CALM land in the southwest has a common boundary with private property assets such as towns, housing estates, industries and farms. Proximity to such areas influences the strategies to be used to suppress fires.

Fire suppression operations can have detrimental effects on ecosystems, including:

- the introduction or spread of dieback diseases by crews and their machinery;
- soil erosion on firelines;
- effects on water quality and quantity;
- removal of or damage to endangered species and habitats;
- scarring of landscape features; and

- intrusion of fireline access into wilderness areas (Sneeuwjagt 2002).

Where fires occur within sensitive areas, an environmental adviser is appointed to provide intelligence to the fire controller and supervisors on the risks of environmental damage and appropriate measures to minimise the impact of fire suppression activities (Sneeuwjagt 2002).

An important consideration in CALM's fire control policy is to minimise undesirable consequences from the effects of bushfire and fire suppression operations and to protect community and environmental values on and adjacent to lands managed by CALM from damage or destruction from wildfires.

6.4 Fire response actions

CALM's field managers are required to develop and implement fire control emergency plans. These provide the basis for decisions on the type of suppression response to be applied to fires within their region. CALM is obliged under common law to pay for damages arising from fire on its land. The extent of this liability depends on the circumstances of each case, but consideration could be given in the courts to the degree of prescribed burning or other fire preparedness strategies employed by CALM prior to the fire.

In the event of a fire the Fire Controller must quickly determine what the fire will do, what it is threatening and what may be affected by the fire suppression actions. The Fire Controller must then assess what the fire organisation can do about the fire, i.e. what resources are available and how soon. In determining the resources needed to respond to fires in the study region, CALM has created nine response cells to protect areas with the highest concentrations of values, and the highest ignition potential. The cells aim to provide an adequate spread of resources to attack fires within one hour of their detection and are linked to the response priority zones discussed below. Personnel and equipment levels are based on the minimum required to rapidly contain a wildfire burning within heavy fuels under severe summer conditions.

CALM relies heavily on the support of local government, local bushfire brigades and, in the metropolitan area, the FESA Fire Rescue service. It has developed a memorandum of understanding with FESA that requires both agencies to work cooperatively on multi-agency fires.

CALM considers that resourcing levels need to rise to cope effectively with the consequences of a drier climate which is leading to a greater incidence of bushfires, fewer windows of opportunity to carry out planned prescribed burning and consequent heavier fuel accumulations which will give rise to more intense, harder to control fires.

An important component of the fire control emergency plan is the identification of response priority zones and appropriate suppression strategies for each zone. A technique called Wildfire Threat Analysis, combining the various factors that affect the 'fire proneness' of an area, is used by CALM to identify the response zones within each of its regions.

Response priority zones are rated in one of four categories according to the urgency and degree of response indicated:

- P Zones or Red Action - for vulnerable settlements, plantations and high visitation sites;
- A Zones – high value, where some preventative measures have been undertaken (prescribed burning, fuel-reduced buffers);
- B Zones – where moderate to low values are at stake, travel time by fire crews is more than two hours. High reliance on fuel-reduced buffers so that wildfires are more likely to be able to be contained;
- C Zones – remote areas with little of community value to protect. The main response involves aerial monitoring and suppressing those parts of the fire that may threaten property or other values.

There are basically three response actions to a bushfire and each of these, or combinations, depending on a range of factors, may be applied by CALM. Factors that help determine the most appropriate response include:

- the size and intensity of the fire;
- the impending weather conditions;
- the 'fuels' ahead of the fire;
- the suppression capability and the likely costs of the suppression action;
- the level of understanding of the role of fire in the particular ecosystem;
- the likelihood of significant long-term damage by the suppression activities; and
- the safety of the firefighters and their equipment.

CALM's response actions are:

Option 1-suppress fires immediately (the direct approach)

In areas where human lives, property, environmental values or timber values are high, CALM considers it needs to limit potential fire damage to the minimum. In the southwest forest region, especially immediately adjacent to settlements and farmlands, there are too many values at stake to allow fires to simply burn out in the hope of cooler or wet weather to put a stop to them (Sneeuwjagt 2002).

The strategy used whenever possible is to attack fires while they are still small. It requires rapid detection, quick mobilisation of firefighting teams to the fire, and direct attack. The fire is extinguished by building an earth firebreak, either on the flame front or, if the fire is too intense, a short distance away and parallel to the fire. Neither of these methods can be used where flame heights are greater than 3-4 metres or the fire intensity exceeds 2000kw/hr - the heat is too great for it to be safe to use bulldozers. Hence this method is most successful where the fire intensity and flame heights are somehow limited. This can be achieved by reducing the availability of flammable vegetation. CALM's experience has shown that, even in severe weather conditions, fires in fuel-reduced areas can be controlled by 'pincer attack' on their flanks and eventually on the headfire (Sneeuwjagt 2002).

Option 2-contain fires within fuel-reduced buffers

This is applied where it is necessary to confine the fire but where, due to its intensity or location, it is not possible or practical to suppress it by direct means. It is often used for large conservation reserves where it is important to minimise the possibility of fires consuming large sections in one hit (Sneeuwjagt 2002).

Most fires burning within or into fuel-reduced areas can be attacked directly and safely contained, even under severe weather conditions (Sneeuwjagt 2002) but the success of this option depends on the proximity and width of these low-fuel zones. In many instances both the direct approach (option 1) and low-fuel buffer options are applied in combination, and sometimes attack on the headfire may be deferred until it burns into a low-fuel buffer.

Option 3-let burn
This option is never considered for the South West region (the area under this review) especially in forests where fires quickly develop in size and intensity and, having become large and intense, can rarely be stopped by firebreaks or fuel-reduced buffers unless they are kilometres wide. However, fires that occur in or near reserves in the more remote parts of State are usually allowed to burn as they rarely threaten human assets. In any case, because of their large size and remoteness, they are usually too difficult and expensive to attempt to control. Where park assets, station homesteads and outlying communities are threatened some suppression action may be carried out in their vicinity.

7. HOW DO WE ACHIEVE BEST PRACTICE FIRE MANAGEMENT?

In the course of its review, the EPA has noted some additional principles and suggestions from various sources that it considers provide some guidance in relation to this review.

Burrows and Wardell-Johnson (2003) stated:

> *There is no fire frequency or season of fire that is optimal for all plant species and communities. Whatever the frequency, some species will be advantaged, some will be disadvantaged and others will be little affected. Variation in the fire interval and season of fire will maintain plant species diversity in a particular community.*
> *Conservation agencies should develop fire regimes that aim to protect and maintain biodiversity, and then undertake a systematic wildfire risk analysis to determine the threat posed by the regime to life, property and other community values. Fire management can then be modified where the risk or threat of wildfire is unacceptable.*

Prof. Rob Whelan in a dissenting report by Michael Organ, MP, to the Parliamentary Inquiry Select Committee into the Victorian bushfires:

> *The complex challenge for land managers is how to protect adjacent property and human lives without compromising biodiversity conservation in the areas gazetted to serve just that purpose.*
> *Development should not be permitted in bushfire prone areas where such development is likely to put lives or property in danger or involve substantial protection and suppression costs including loss of environmental values.*

In order to achieve change for the better in current bushfire practices, the following broad criteria have been suggested as requisites:

- avoiding or minimising undesirable long term environmental impacts;

- appropriately and sustainably reducing flammable material loads in bush areas at risk from fires where they are near communities;
- fire planning and management for private and public land is properly coordinated so as not to jeopardise proper fire management procedures;
- working with local residents to reduce fire risk and improve awareness, fire preparedness and protection, hence the support of the community and the media; and
- local, State and Federal coordination and cooperation.

The EPA sought the advice of a specialist experienced in fire operational procedures and with a background in fire ecology to review appropriate management practices for the southwest of WA and to compare them with those in use by CALM. This review was to benchmark processes rather than to investigate procedures in the field, which was the subject of the field audit discussed previously. The report of the consultant, Mr Athol Hodgson, is available on the EPA's website: www.epa.wa.gov.au

In his review the consultant has explored areas outside the scope of work where he found it necessary or appropriate to do so. This relates in particular to his consideration of land areas outside CALM-managed land.

Hodgson's views are:
- CALM uses fire management procedures that are as good as, if not better than, any other system in Australia;
- CALM fire management procedures need effective legislative backing, which is currently missing. Good legislation signals Parliament's intent to provide WA with 'best practice' bushfire management and provides the administrative frameworks that allow policies to develop, objectives and outcomes to be identified and planned for, and strategies to be applied. It also establishes the accountability of key players and, by association, of the Government of the day; and
- an agency such as CALM cannot deliver 'best practice' fire management in isolation or in the absence of State and regional bushfire policies and management plans.

Hodgson lists the current key policy elements of best practice fire management for southern Australia, particularly for rural lands. In relation to Western Australia, these are:

1) Legislation that:
   (i) requires preparation, approval and regular review of a State Bushfire Plan, Bushfire Risk Management Plans and Bushfire Plans of Operation for the prevention, mitigation and suppression of bushfires across *all rural and urban lands* in southwest WA and for post-fire community recovery;
   (ii) requires CALM to operate within arrangements that ensure:
      - a single controller is in supreme charge of a fire event that involves multi-agency response, and
      - seamless co-ordination and integration of resources responding to multi-agency fire events.
   (iii) assigns to CALM the role of a fire authority and the duty, notwithstanding anything to the contrary in any other Act or law, to carry out proper and sufficient work to manage fires to protect and sustain the health and

biodiversity of ecosystems, regenerate disturbed or degraded ecosystems and to prevent and suppress unplanned fires on all CALM lands.

2) Where the dual objectives of protecting life and high value assets and protecting conservation values cannot both be achieved, management priority on CALM land should be given to protection of life and high value assets.

3) CALM should prepare Fire Management Plans for all CALM lands and integrate the Plans with WA Bushfire Risk Management Plans and WA Bushfire Plans of Operation.

4) CALM should differentiate between unplanned fires that must be controlled and planned fires that are lit to achieve specified outcomes. The former include natural fires caused by lightning that occur at times when they threaten or may threaten biodiversity and other assets on CALM lands and lives and assets on adjoining lands. Planned fires include those lit to reduce fuel loads that increased as a consequence of controlling natural fires and fires lit to maintain the health and biodiversity of ecosystems or for regeneration of disturbed or degraded ecosystems.

5) CALM should continually improve its knowledge base by conducting its own research and development programmes in matters peculiar to its responsibilities and the technologies used to manage fire on CALM lands. It shall also support independent research relevant to bushfire management.

6) CALM should maintain training programmes for all personnel it employs likely to be involved in campaign fires and all similar personnel employed by other Government Agencies operating on its lands to:
   - meet relevant occupational health and safety standards;
   - perform appropriate roles in fire management from base level to incident control of campaign fires; and
   - meet special requirements pertaining to its duty to conserve and protect ecosystems.

   Where appropriate, training programs should be competency-based and provide accreditation recognised by the Australasian Fire Authorities Council (AFAC).

7) CALM should maintain an explicit and routine system to record all fire events on its lands. The system and details recorded shall conform to standards agreed by the Auditor General and shall be made available for independent audit.

8) CALM should identify all values, including intrinsic values, on CALM lands in ways that reflect the value the community puts on them.

From a consideration of these policy elements come the consultant's recommendations:

1. The *Fire and Emergency Services Authority of Western Australia Act 1998* be amended to provide for the preparation and review of a State Bushfire Plan, Bushfire Risk Management Plans and Bushfire Plans of Operation.

2. The *Fire and Emergency Services Authority of Western Australia Act 1998* be amended to provide that, at the request of the Police and Emergency Coordinator or

at their own volition, the Executive Director CALM and the Executive Director Fire Services FESA may, by agreement, appoint an officer of one of the agencies to have the overall control of response activities in relation to any fire in any area and, in the absence of such agreement, the Coordinator may direct one of the Executive Directors to appoint an officer to have the overall control.

3. The *Conservation and Land Management Act 1984* be amended to provide that, notwithstanding anything to the contrary in any other Act or law, it shall be the duty of the Executive Director to carry out proper and sufficient work to manage fires to protect and sustain the health and biodiversity of ecosystems, to regenerate disturbed or degraded ecosystems and to prevent and suppress unplanned fires on all CALM lands.

4. The *Conservation and Land Management Act 1984* be amended to provide that the Executive Director shall maintain an explicit and routine system, agreed to by the Auditor General, to record all planned and unplanned fires on all CALM lands.

5. CALM (i), initiates a program to identify the value the WA community is prepared to put on intrinsic assets on CALM lands and (ii), develops and uses methodology to balance the risk/costs/benefits of prescribed burning versus wildfires.

6. The *Conservation and Land Management Act 1984* be amended to provide that the Minister considers the advice of the Executive Director, CALM before approving Plans involving fire management.

7. CALM's fire management policies be expressed succinctly in the terms listed 2) to 8) inclusive (above) under Term of Reference 1 in the consultant's Report.

8. CALM's fire management strategies be expressed succinctly in the terms listed 1) to 14) inclusive (below) under Term of Reference 1 in the consultant's Report, these being:

1) Prepare for each administrative field area, and keep under constant review, Fire Management Plans (FMP). FMPs shall include objectives for planned and unplanned fires and the holistic operational requirements for both. Objectives for planned fires shall include specific goals identified for the health of and biodiversity in ecosystems and the prescriptions required to manage such fires safely and effectively. Objectives for unplanned fires shall include effective pre-suppression, suppression and post-fire recovery and the operational requirements of each. Performance standards and an annual works program shall be part of each FMP.

2) Arrange for every FMP to be integrated with WA Bushfire Risk Management Plans and WA Bushfire Plans of Operation.

3) Maintain independently or where appropriate with co-operation of other agencies, an initial attack system that is rapid, aggressive and effective and with the capacity to control unplanned fires quickly. When an unplanned fire is not considered to be an immediate threat and initial attack is deferred, the occurrence of the fire and the reasons for deferring control action shall be recorded.

4) Maintain a fire detection system that gives timely warning of fires threatening CALM lands and adjoining lands.

5) Maintain a system of roads, fire trails, airfields and helipads for access and safety of personnel managing fires. The standard of access shall accommodate occupational health and safety expectations of volunteers that may use the access during fire emergencies.

6) Develop and use guidelines to manage smoke from planned burns to reduce atmospheric haze in Perth's airshed.

7) Develop and use guidelines, prescriptions and standard operating procedures to plan and conduct prescribed burning.

8) Conduct and participate in programs to minimize the occurrence of preventable fires.

9) Schedule staff training programs at all competency levels to achieve specific numbers of staff needed to manage planned fire programs and unplanned fires.

10) Organise the total resources of the Agency into an effective and efficient fire authority capable of combating simultaneous fires and integrating with other fire agencies in campaign fires.

11) Rehabilitate and restore disturbance and damage to areas damaged by fire operations.

12) Engage professionally trained teachers and journalists to improve community awareness and understanding of vegetation fires and best practice fire management based on science, experience and accountability.

13) Record, store and periodically analyse weather records necessary for calculation of indices used for research and prescriptions for planned burning.

14) Maintain formal liaison with fire authorities and land management agencies in other States.

9. CALM initiates a research programme to identify the spread and behaviour of fires caused by lightning, including their projected spread and behaviour after their spread was stopped or slowed by suppression actions.

In summary, the consultant believes that Western Australia has benefited from the best fire research programmes in the world for decades and that its strategies are best practice. This knowledge must be continually updated as the focus of land management changes to meet new demands. Whilst in-house research is the quickest way to get findings translated into practice, it also runs the risk of bias. Therefore, ongoing independent research into bushfire management is recommended for CALM, and training programmes for all involved personnel operating in fire management, occupational health and safety and in the conservation and protection of ecosystems, on CALM lands. However, best practice fire management will not be supported by the

community unless it is understood and trusted, and only if it has the support of the community will politicians be prepared to back it.

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APPENDIX 1

GLOSSARY OF TERMS

FIRE, FOR WHAT PURPOSE?

REVIEW OF THE FIRE POLICIES AND MANAGEMENT PRACTICES OF THE DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

GLOSSARY OF TERMS

Arson
Maliciously setting fire to property or vegetation. Arson is a major cause of fires, in recent years ranging from 26% to 46% of fire incidents on CALM-Managed land in the South West.

Back burn (sometimes written **'backburn'**)
A fire deliberately lit to remove the fuel in front of an advancing fire so that it will have reduced levels of fuel and so can be more easily controlled. Not to be confused with 'prescribed burn'.

Biodiversity
A concept encompassing the diversity of indigenous species and communities occurring in a given region. It includes 'genetic diversity', which reflects the diversity within each species; 'species diversity', which is the variety of species; and 'ecosystem diversity' which is the diversity of different communities formed by living organisms and the relations between them. Biological diversity is the variety of all life forms - the plants, animals and micro-organisms - the genes they constitute and the ecosystem they inhabit. (Definition from the National Forest Policy Statement, 1991 glossary)

Burning program
A program that sets out a number of prescribed burns and schedules these for a designated area over a nominated time, normally looking ahead over one fire season (for the coming spring to the following autumn), but can also look ahead 5 years or more.

Bushfire (sometimes written **'bush fire'**)
An unplanned fire in bush. This is a general term, uniquely used by Australians, and includes grass fires, forest fires and scrub fires, i.e. any fire outside the built-up urban environment. Also sometimes known as a wildfire.

Bushfire threat
A term used to describe and analyse the danger that a bushfire poses in a particular place, or to specified values. There are four aspects: (i) the risk of a fire starting, and of it becoming uncontrollable; (ii) the values which will be lost or damaged if a bushfire starts and gets away; (iii) the extent of damage which could be caused; and (iv) the resources which can be brought to bear on a fire and their efficiency and effectiveness.

Bushfire (or Wildfire) Threat Analysis is a structured approach used to analyse the bushfire threat for a particular area or a nominated set of values and calculate a response or determine priorities for funding or action. It is usually the first step in producing a *Bushfire Management Plan*, which sets out the actions to be taken to minimise a threat, mitigate possible damage, ranks actions, allocates responsibility for action, establishes protocols for action in the event of a fire and post-fire monitoring. The Bushfire Management plan should also set up cooperative and command arrangements, and put in place mechanisms for review and updating of the action plan.

Controlled burn
Obsolete term, these days replaced by 'prescribed burn'.

Crown fires
Occur when a ground fire is so intense that whole trees catch fire and all or parts of the upper branches and crown are consumed. In a crown fire, burning embers are sucked up into the

convection column and can be carried down-wind to start new fires called spot-fires. Spotting is generally worse during crown fires but it can also occur to a significant extent in fires burning in surface litter and understorey fuels, particularly if the bark on the trees is very woolly, as in long-unburnt stringybark forests.

The term crown fire is usually applied only in vegetation with both an upper and a lower canopy, as in a forest with trees and a shrub understorey.

Ecologically sustainable forest management
Forest management and use consistent with the principles of sustainability, precaution, intergenerational equity, conservation of biodiversity and ecological integrity and valuation. Each of these principles are defined in the *Conservation and Land Management Act* and also the *Environmental Protection Act.*

Ecosystem
A community or an assemblage of communities of plants, animals and microorganisms interacting with one another and the environment in which they live. (Adapted from FMP 2004-2013).

A terrestrial ecosystem encompasses a particular biota, the soil, rock outcrops, wetlands and waterways and the atmosphere. Different ecosystems may respond differently to external events, such as fire, frost, flood or drought.

Fire intensity (also known as **fire line intensity).**
The ferocity of a bushfire. Fire intensity is a function of the fuel consumed and the rate of spread of the fire. It is expressed as the rate of energy release per unit length of fire front.

This is defined by the equation: $I = H \times W \times R$ where:
I = fire intensity measured in kilowatts /metre.
H = heat yield of fuel measured in kilojoules/kg of fuel.
W = dry weight of fuel consumed measured in kilograms /square metre.
R = rate of spread in metres /hour.

Fire Intensity can also be described in terms of rate of spread and flame height.

A ***mild fire*** produces up to 350 kilowatts /metre. An ***intense fire*** produces 2000 or more kilowatts/metre. Mild fires (or low intensity fires) have rates of spread generally below 40 metres/hour and flame height less than 2 metres. In a forest, a mild fire will usually cause little or no scorch to tree crowns. Mild fires are easily controlled, except in peatlands. Intense fires (or high intensity fires) can exceed a rate of spread of 3000 metres/hour and flame heights in heavy forest can exceed 70 metres.

Fire Intensity is affected by:

- the quantity of fuel, its moisture content, distribution and type. For forests, jarrah litter is more flammable than karri because karri litter usually contains more decomposing moister material. ***Forest fuel*** includes litter on the forest floor [despite decomposition, litter may increase annually with leaf, twig and bark fall], understorey, shrubs[scrub], rough bark and heavy ground-fuel such as dry logs which burn behind the main fire front.
- weather conditions, especially high temperatures and strong winds, and predisposing climatic factors such as drought.
- topography. Fires burn more intensely uphill than downhill.

Fire line (also known as a **fire control line** or a **firebreak**)

A natural or constructed barrier such as a graded track or ploughed soil, or treated fire edge free from flammable vegetation, used in both fire suppression and prescribed burning to limit the spread of fire or to provide access for firefighters.

Fire regime

Fires can be viewed as "a single event" of which the most important characteristics are extent, intensity and season of occurrence, or as part of a "fire regime" which describes a series of fires at the same locality. A regime has many variables, including the fire frequency (or interval between fires), extent, intensity, season and distribution across the landscape (patchiness).

Fire risk

The chance of a fire happening that will have an impact on objectives. It is measured in terms of consequences and likelihood. (Adapted from ASNZS 4360:1995).

Fire season

The time of the year when a bushfire can start and will spread. In southern Western Australia generally confined to the spring, summer and autumn months (October to April), and lasting about 5-7 months depending on latitude; in northern Western Australia confined to the dry season (April to October). In general a fire season will extend as rainless months go by. The peak fire season in southern Australia usually coincides with the hottest months at the end of summer (i.e. February and March).

In southern Western Australia, fire seasons become more dangerous if there is a run of dry winters. Dry winters, leading to "drought" dry out vegetation, creeks and wetlands, and cause trees and shrubs to shed their leaves, adding to the amount of fuel on the ground. Climate change, resulting in changed distribution of and a reduction in annual rainfall, will further extend the fire season.

Fire suppression

Fire suppression consists of the many activities connected with restricting the spread of the bushfire, extinguishing it and making it "safe" so that it will not flare up and escape later. The principal activities in fire suppression are locating the fire, arranging rapid movement of firefighters to the fire, attacking and extinguishing the fire edge, and then mopping up the fire edge to ensure that the fire cannot later escape.

Fire triangle

Diagrammatic expression of the three elements that are necessary for a fire to occur:
FUEL - HEAT - OXYGEN. The removal of any one of these will extinguish a fire.

Forest

An area, incorporating all living and non-living components, that is dominated by trees having usually a single stem and a mature or potentially mature stand height exceeding two meters and with existing or potential crown cover of overstorey strata about equal to or greater than 20 per cent.

Fuel

Fire Fuel. Any material such as grass, leaf litter, twigs, bark, logs and live vegetation that can be ignited and sustain a fire. Measured in tonnes per hectare.

Fuel age. The length of time elapsed since fuel was last burnt, usually expressed in years. Depending on climate, weather and soil type, it may or may not provide an accurate estimate of the tonnage of fuel per hectare.

Fuel type. An association of fuel characteristics such as species, form, size, and arrangement that will cause a particular rate of spread, or difficulty of suppression, under any particular set of weather conditions. The following fuel types relate mainly to forest:

- ***Heavy fuel.*** Dead woody material in contact with the soil surface, greater than 25mm in diameter. Also called 'coarse fuel'.
- ***Litter fuel.*** The top layer of the forest floor composed of loose dead sticks, branches, twigs and recently fallen leaves little altered by decomposition.
- ***Surface fuel.*** The loose surface litter on the forest floor. Can consist of fallen leaves, twigs, bark, small branches, grasses, shrubs, tree saplings less than a metre high, heavier branches, fallen logs, stumps, seedlings and small plants.
    - ***Trash.*** The component of surface fuel above the leaf litter layer made up of dead twigs, branches and scrub debris of at least 10mm diameter.
    - ***Fine fuel.*** Dead leaves, twigs and bark less than 6mm thick in the litter layer as well as the green leaves and twigs of shrubs and grasses less than 2mm in diameter, and all less than 1 metre above the ground.
    - ***Elevated fuel.*** Fuels that are suspended above the ground, such as shrubs, bark, seedlings.
    - ***Available fuel.*** The amount or weight of fuel that will be burnt under prevailing weather conditions during a prescribed burn or a bushfire. Available fuel can be less than total fuel, where part of the fuel profile is still damp from previous rain. Measured in tonnes per hectare
    - ***Total fuel.*** The sum of the fuel quantity of litter, trash, scrub and fuels that are available to burn under extreme wildfire conditions. Measured in tonnes per hectare.
    - ***Organic fuel.*** This term is sometimes used to describe subterranean fuels such as peat, or coal seams.

Fuel load. The oven-dry weight of fuel per unit area. Also known as fuel quantity. Expressed as tonnes per hectare.

Hazard
A source of potential harm, or a situation with potential to cause harm. (Adapted from ASNZS 4360:1995).

Mopping up (or Mop up)
The operation carried out by firefighters after a running fire has been stopped. The aim is make the fire edge safe so the fire will not later flare up and escape. Mopping up in forest requires extinguishing all smouldering logs and trees adjacent to the fire line and sometimes felling trees which are alight in the crown and are throwing embers across the fire line. Mop up work should always be accompanied by "patrol", where a fire edge is closely monitored by firefighters for a period (sometimes weeks) after a fire is thought to be extinguished.

Mosaic burn
Prescribed burns carried out to achieve a pattern of patchiness within the burn and where some of the area is deliberately not burnt.

Post-logging burn
A post-logging burn is lit under prescribed conditions for the purpose of achieving regeneration of preferred timber species. In WA, usually seedlings of adjacent jarrah and karri trees with viable seed in their crowns, and to reduce the amount of debris left after logging. This term is also being applied to burns lit on dry soils in dry fuels with the objective of encouraging regeneration from soil-stored seed.

Precautionary principle
Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by:

(i) careful evaluation to avoid, whenever practicable, serious or irreversible damage to the environment;
(ii) an assessment of the risk-weighted consequences of various options.

Prescribed burn
A general term indicating the planned application of fire to achieve specific land management objectives. 'Prescribed burn' replaces the old term 'controlled burn'

A prescribed burn is planned to be carried out under predetermined (or "prescribed") environmental conditions within defined geographical boundaries, and at the time, intensity and rate of spread required to achieve the specific land management objectives. Before a prescribed burn is commenced a "burn prescription" is prepared. The prescription details the objectives of the burn, the conditions under which it will be carried out, and the precise location, and deals with any specific considerations for the particular burn.

Prescribed burning can be undertaken to achieve the following land management objectives:

> ***Fuel reduction*** A fuel reduction burn is nearly always carried out under mild conditions to ensure that no, or minimal, damage is done to the vegetation and associated environment. The following terms are sometimes used interchangeably with fuel reduction burn and mean the same thing: pre-emptive burn, community protection burn; environment protection burn; forest protection burn; hazard reduction burn.
>
> **Regeneration** A regeneration burn is lit under prescribed conditions for the purpose of achieving regeneration of a preferred timber species, in WA usually seedlings of adjacent jarrah and karri trees with viable seed in their crowns. Increasingly this term is also being applied to burns lit on dry soils in dry fuels with the objective of encouraging regeneration from soil-stored seed.
>
> ***Site preparation*** A burn conducted to remove debris from a site before undertaking some other activity or converting to a different land use. Examples are stubble burning by cereal growers before sowing the next crop, or burning debris on a minesite before mining and rehabilitation. Site preparation burns are not usually undertaken with a prescription, and are more properly regarded as "burning off" rather than "prescribed burning."

Risk
The chance of something happening that will have an impact on objectives. It is measured in terms of likelihood and consequences. (Adapted from ASNZS 4360:1995).

Scorch height
The maximum height above the ground to which the leaves of trees or shrubs are browned by a fire. Generally about four times the flame height. In Australia, eucalyptus tree crowns that are merely scorched by a fire tend to recover, whereas trees that are defoliated can take several years to recover or may never recover. Most European and many tropical tree species are not resilient to fire, and even a mild scorching of the crown results in tree death.

Research in WA has shown that scorch height in jarrah forest is generally 5 times flame height in a spring burn, and 9 times flame height in an autumn burn. The difference is due to the greater combustion of bark and woody fuels in the drier conditions of an autumn burn.

Scrub
Vegetation, such as heath and shrubs, that grows either as an understorey or by itself in the absence of a tree canopy.

Spot fire
A new fire occurring up to 10km downwind of a headfire, usually started by a piece of burning bark. Compare with hop over which is a new fire that has started immediately across a fireline and not necessarily at the headfire.

Surface moisture content
The moisture content of the fine fuels in the top 5 – 10mm of the litter bed. It is expressed as a percentage of oven dry weight of those fine fuels.

Wilderness
Land that, together with its plant and animal communities, is in a state that has not been substantially modified by, and is remote from, the influences of European settlement or is capable of being restored to such a state, is of a sufficient size to make its maintenance in such a state feasible, and is capable of providing opportunities for solitude and self-reliant recreation. (National Forest Policy Statement. 1991, p50).

Wildfire
An American term used to describe an unplanned fire. A generic term that may include forest fires, scrub fires and grass fires. Usually referred to in Australia as a ***bushfire***.

APPENDIX 2

TERMS OF REFERENCE OF EPA CONSULTANCIES

FIRE, FOR WHAT PURPOSE?

REVIEW OF THE FIRE POLICIES AND MANAGEMENT PRACTICES OF THE DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

TERMS OF REFERENCE

(1) ANALYSIS OF FIRE MANAGEMENT POLICIES AND PRACTICES OF THE DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

Provide advice on what would comprise the key elements of current "best practice" fire management policy and practice for southern Australia; and particularly South West Australian vegetative and climate conditions in relation to prescribed burns and wildfire.

Provide advice on how this best practice would apply to the Department of CALM's Swan, South West and Warren regions, taking into account the range of ecosystems and climatic conditions in those regions.

On the basis of the above:

- review CALM's current fire management policies and practices applying in its Swan, South West and Warren regions; and
- provide advice and recommendations on changes that should be made to meet best practice standards.

Identify outstanding issues for research or improved knowledge that are necessary to provide the capacity to improve fire management policies and practice in south western Australia on an ongoing basis.

Balance the risk/costs/benefits of prescribed burns versus wildfires.

(2) FIRE REGIMES AND BIODIVERSITY CONSERVATION: A BRIEF REVIEW OF SCIENTIFIC LITERATURE WITH PARTICULAR EMPHASIS ON SOUTHWEST AUSTRALIAN STUDIES

The scope of this consultancy would encompass the following details to be considered and presented in a written report:

Identify the role of fire in maintaining and protecting biodiversity. This would include:

- beneficial effects from prescribed burns, and the extent to which these are influenced by factors such as scale, frequency, seasonality and intensity;
- adverse impacts from prescribed burns, and the extent to which these are influenced by factors such as scale, frequency, seasonality and intensity;
- the effects of wildfire on biodiversity; and
- whether the effects of wildfire are significantly different from those from prescribed burns.

Provide advice on the current understanding of fire management practices which promotes biodiversity protection, including the value of prescribed burns in reducing the impact of wildfires.

Comment on the level of understanding and identify the gaps in information that need to be filled to improve our knowledge of fire effects on biodiversity through research, monitoring and data gathering.

(3) AUDIT OF THREE DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT PRESCRIBED BURNS

The contractor will be required to be familiar with auditing of practices relevant to fire operations and should address the following:

Using information provided by CALM, document the fire management objectives of each prescribed burn event including:

- age since last burnt and fuel levels;
- fire exclusion areas;
- the targeted percentage of the areas to be burnt; and
- the operational details of implementation.

Using information provided by CALM and field inspections where appropriate, determine and document the fire management outcomes of each prescribed burn.

Compare and report on the fire management objectives and outcomes for each prescribed burn.

Document what follow-up was taken by CALM to assess whether the fire management objectives for each prescribed burn had been successfully met and, if not met, what further action was undertaken or planned to achieve the fire management objectives.

APPENDIX 3

DRAFT CALM FIRE MANAGEMENT POLICY

FIRE, FOR WHAT PURPOSE?

REVIEW OF THE FIRE POLICIES AND MANAGEMENT PRACTICES OF THE DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

DEPARTMENT OF
Conservation
AND LAND MANAGEMENT
Conserving the nature of WA

DRAFT
(February 2004)

FIRE MANAGEMENT POLICY

1. OBJECTIVE

The Department will manage prescribed fire and wildfires on the lands managed by the Department to protect and promote the conservation of biodiversity and natural values whilst also providing for a sufficient level of protection to human life, community assets and fire sensitive ecosystems. The Department will also promote fire management that protects biodiversity on lands not managed by the Department.

Fire management will be planned and implemented in partnership with other landowners and land managers, fire authorities and with the community. The Department will implement an informed and balanced approach to risk management. A variety of fire regimes incorporating different frequency, intensity, season and scale will be applied at the landscape scale on lands vested in the Conservation Commission of Western Australia.

2. BACKGROUND

The rationale and the principles upon which this policy is based are provided in the Appendix.

3. LEGISLATIVE BASE

- Sections 33(1)(a)(i) and 33(3)(a) of the *Conservation and Land Management Act 1984* provide for the Department to manage lands to which the Act applies, according to those operations prescribed in management plans or, in the absence of a management plan, in accordance with the necessary or compatible operations provisions of the Act depending on the land category [Sections 33(3)(b) and 33(b)]. Fire management activities are subject to these provisions.

- The *Bush Fires Act 1954* applies to land throughout the State including Department-managed lands. The provisions of the Bush Fires Act do not, however, affect the provisions of the Conservation and Land Management Act, and the Department is generally not bound by the Bush Fires Act.

- Section 56 of the Bush Fires Act imposes a specific obligation on an authorised CALM Act officer to take enforcement actions under the Bush Fires Act (eg. to demand the name and address of an offender, to produce an authorisation to light a fire, and to apprehend the alleged offender without a warrant). Section 39 of the Act provides wide-ranging powers for a bush fire control officer to take necessary steps to extinguish a fire. If an authorised CALM Act officer is present at a fire on or near any Crown land the officer may take supreme control of the fire as if the officer were a bush fire control officer appointed by a local government authority. The Bush Fires Act also provides other powers to designated Departmental officers.

- The *Wildlife Conservation Act 1950* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* provide special protection to threatened species (both Acts). The Commonwealth Act also protects threatened ecological communities. These impose an obligation to conduct fire management activities accordingly.

- Under common law, the Department falls under a duty as an occupier to take all reasonable care to eliminate or minimise foreseeable risks of harm. The Department could be held liable for injury or loss caused by fire which a Departmental employee had negligently lit or negligently failed to control.

4. RELATIONSHIP TO OTHER DEPARTMENTAL POLICIES

The Department's Fire Management Policy is consistent with and recognises the requirements contained in other Departmental policies:

- Policy 3 Management of Phytophthora and Disease caused by it
- Policy 9 Conservation of Threatened Flora in the Wild
- Policy 10 Rehabilitation of Disturbed Land
- Policy 31 Management of Reserves for the Conservation of Nature
- Policy 40 Road Management
- Policy 41 Beekeeping in Public Land
- Policy 49 Radio Communications
- Policy 60 Occupational Health and Safety
- Media Relations Policy
- Public Participation Policy
- Wilderness Policy

5. POLICY

Firefighter and public safety is the first priority in every fire management activity, followed by the protection of biodiversity, cultural and property values.

The Department carries out its fire management role in partnership with other fire management and land management agencies, primarily the Fire and Emergency Services Authority, the Forest Products Commission and local government authorities.

5.1 Use of Fire

- Fire will be used to achieve a range of land management objectives, including the conservation of biodiversity; maintenance of ecosystem health and productive capacity; conservation of soil, water and catchment values; conservation of natural and cultural heritage; regeneration and protection of native forests and plantations; and protection of human life, community assets, indigenous heritage sites, recreation sites and scenic values. These objectives, and the methods used to achieve them, will be specified in individual burn prescriptions.

- Prescribed burning plans will incorporate both nature conservation and protection objectives in order to optimise outcomes. The planning of prescribed burning will require the integration of multiple objectives and must take into account the role of planned fire in the maintenance of biodiversity (for example, by timing burning to achieve regeneration) and reducing the risk of wildfire (for example, by reducing fuel loads).

- A variety of fire regimes incorporating different frequency, intensity, season and scale will be applied at the landscape scale (tens of thousands of hectares). Fire regimes will include some random wildfires.

- Planning for prescribed burns will incorporate the need to address strategic protection from large fires, as well as landscape scale and land management unit scale (several hundred to several thousand hectares) plans that provide for the protection and conservation requirements at each of these levels.

- During the planning process for prescribed burning the Department will consult with traditional owners, the community and specific stakeholders regarding the Master Burn Plan, fire regimes for the conservation of biodiversity, the scope of the proposed burning program, individual burns and burning methods, road and track maintenance and other fuel management treatments. Fire management will also be considered during public consultation on the content of area management plans prepared for the Conservation Commission. Consultation processes will also be used as an opportunity to develop community understanding and support for fire management programs.

- The coordination of prescribed burns will be planned, directed and conducted by qualified and experienced staff. Written prescriptions will be prepared by trained staff, with appropriate input from research scientists, traditional owners and appropriate staff, and be approved by designated officers.

- Each year the proposed annual burn program will be brought to Corporate Executive by the Director Regional Services for endorsement.

- In fragmented landscapes where Department-managed lands are surrounded by extensive urban and agricultural land uses, the planning and application of fire regimes will require consideration of interacting factors such as weed invasion, lack of regeneration of native species, grazing impacts, fire history and size of reserve.

- The extent to which prescribed burn objectives have been achieved will be monitored and recorded in order to continue the process of adaptive management. The achievement of fire management objectives contained in area management plans will be subject to periodic audit by the Conservation Commission.

- Prescribed burns will be managed to reduce the risk of smoke causing detrimental impacts on population centres and other sensitive areas through application of smoke management guidelines. Potential impacts of smoke and ash on water catchments, road traffic, neighbours and visitors, and firefighters will be considered when planning and implementing prescribed burns.

5.2 Fire Suppression

- The Department will respond to fires occurring on or near Department-managed lands to a degree that is appropriate to the values at risk, the prevailing and forecast weather, availability of resources, the cost of the suppression operation, and likelihood of long-term impact or net gains to the environment. In circumstances where impacts of the wildfire are likely to be low the response may mean observation, rather than active suppression.

- The Department will maintain its fire management, suppression and response capability in accordance with sound risk management principles. This requires an adequate state of preparedness and standards of fire suppression relative to the values at risk, and to the difficulty of controlling fires in a safe and cost-effective manner.

- The Department will fully consider the protection of environmental and other values in determining strategies for fire suppression. Where appropriate, fires may be contained within management units defined by existing roads rather than by constructing new firelines around the perimeter of the fire. Where firelines are constructed during suppression operations, they will be subsequently rehabilitated to minimise the threat of soil erosion, weeds or spread of dieback disease.

- To meet its fire suppression responsibilities the Department will:

  - in high risk or high value areas, maintain comprehensive fire detection and fire reporting systems that will give timely and accurate warning of fires threatening community or environmental values. Lower level detection and reporting systems will apply in other areas;

  - maintain an effective and efficient fire-suppression capability of personnel, equipment and aircraft. Resources need to be mobile and personnel must be fit, skilled and well trained;

  - take control of, or provide assistance at fires on or near Department-managed lands in accordance with State and local arrangements between the Department and other fire authorities and land management agencies;

  - develop and deliver high quality training and performance assessment programs for Departmental staff for appropriate roles in fire and incident management.

- The Department will establish working arrangements with other fire authorities and volunteers to provide cooperative and coordinated fire fighting that can deal successfully with the full range of emergencies on or near Department-managed lands.

5.3 Wildfire Prevention

- The Department will plan and conduct wildfire prevention activities to minimise the incidence of preventable wildfires (ie. unplanned fires of human origin).

- The Department will, where practical, attempt to identify the origin and cause of wildfires on lands under its control and will investigate fires that result in damage to private or community property. Where regulations have been breached, the Department will take appropriate action to identify and, as appropriate, arrange prosecution of offenders.

- The Department will work closely with the Fire and Emergency Services Authority, Police Arson Squad and local government authorities in developing and implementing coordinated fire prevention programs.

6. POLICY IMPLEMENTATION REQUIREMENTS

- The Department recognises the importance of science and indigenous knowledge to underpin fire management and will continue to promote and support research into fire ecology, fire behaviour, fire information systems and fire control systems.

- In order to promote the efficient, effective and integrated management of fire and fire related activities on lands managed by the Department, a comprehensive set of standards, procedures and prescriptions are to be incorporated in the Department's Fire Operations Manual..

- The need for effective fire management will be recognised in policies and plans prepared by the Department. This includes area management plans prepared for the Conservation Commission for regions, State forest, parks and reserves. Every district will annually prepare a Fire Preparedness and Response Plan and a Prescribed Burning Plan.

- All instructions, prescriptions or guidelines developed for fire management activities undertaken by the Department must be consistent with the fire management principles and operational rationale in the Appendix.

- The Department will provide appropriate awareness and training programs for all staff likely to participate in any aspect of fire management to ensure adequate understanding, knowledge and skill levels to implement the fire policy in an environmentally sensitive, safe and cost-effective manner.

- The Department will use its best endeavours to both consult and involve traditional owners in fire management activities where the objective is to replicate traditional burning practices.

- Departmental staff must meet their obligations under this Policy and the Fire Operations Manual through assigned levels of delegation, approved budgets, sourcing and planning as provided for in the Department's table of delegations, Departmental and other instructions.

- The implementation of this Policy will be subject to both Departmental audit and audit by the Conservation Commission in assessing the implementation of management plans.

7. CUSTODIAN

The Director of Regional Services is the custodian of this Policy.

8. EXECUTIVE DIRECTOR APPROVAL

Approved on .....

by .....
Executive Director

APPENDIX

This appendix outlines the rationale for fire management plans and activities implemented by the Department of Conservation and Land Management. A set of principles to guide fire management is also outlined.

Rationale

- Fires have occurred regularly on most lands managed by the Department. Fires from natural causes (eg. lightning) will inevitably occur. Fires from human activities, either deliberate or accidental, will also occur, but unplanned fires may be minimised by effective public education and awareness, and by enforcement of legislation and compliance management. (Refer Policy 5.1, 5.3.)

- Aboriginal people have inhabited Western Australia for more than 40,000 years and over this period they have used fire as a management tool for hunting, access and spiritual reasons. The landscapes that European settlers and their descendents have come to recognise as being distinctively Australian have been fashioned by fire over many generations. (Refer Policy 5.1, 6.)

- Fire is a natural environmental factor that can have both destructive and beneficial effects. It can regenerate, recycle nutrients, create and maintain habitats, but can also kill, injure and destroy. The impact of fire varies with the frequency, intensity, scale, time of year and the fire sensitivity of the community in which it occurs. (Refer Policy 5.1.)

- Wildfires do not distinguish between land tenures. Fire protection and fire management regimes must involve all State Government agencies with land management or fire management responsibilities, local government authorities and private land managers working cooperatively to achieve agreed fire management objectives. (Refer Policy 5.2, 5.3.)

- Fire has very different impacts on the biota contained in the twenty-six bioregions represented in Western Australia. Fire regimes must be appropriate to the needs of each bioregion. (Refer Policy 5.1.)

- Exclusion of fire from naturally fire prone vegetation over large areas results in the gradual build-up of live and dead vegetation which becomes fuel and increases the risk of large, intense and costly fires. In most vegetated ecosystems, the exclusion of fire for long periods over large areas is difficult to achieve, and may also be undesirable from a biodiversity conservation and community protection point of view. (Refer Policy 5.1.)

- A regime of frequent fires, planned or unplanned, can have adverse impacts on biodiversity for some species and in some ecosystems including riparian zones, granite outcrops, wetland ecosystems and small patches of remnant vegetation. (Refer Policy 5.1.)

- Fire may be excluded from representative scientific reference areas and these provide an important benchmark against which the effects of other fire regimes can be evaluated. Some biota and ecosystems may also benefit from long periods of fire exclusion. The location and size of fire exclusion areas should take account of firefighter safety and other management influences. (Refer Policy 5, 5.1.)

- Planned ignition fires can be used in natural areas to minimise loss of life, property and services, and to achieve biodiversity conservation objectives. This is likely to be a more cost-effective and predictable method of fuel management over large areas than using alternative methods including manual, mechanical, chemical and biological methods.

- Suppression difficulty and damage potential to life and property of a bushfire are proportional to the size of the fire, the conditions under which it is burning, and the rate and amount of heat energy released (fire intensity). The intensity and speed at which fire burns is related to the quantity and structure of accumulated litter, bark and plant material, which is in turn related to the period since last fire. In most vegetated ecosystems, accumulated fuel loads can be reduced by low intensity prescribed fires. This reduces the likelihood of intense fires even under extreme conditions and improves the capacity for firefighters to safely control a fire. Under extreme fire danger conditions, the spread of fire may only be retarded in light fuels. (Refer Policy 5.1.)

- Threshold levels of available fuel quantities or fire intervals have been identified in many major vegetation types which represent the upper limits beyond which fire behaviour in summer conditions will be severe and too dangerous to be suppressed by either ground or aerial fire suppression methods. In situations where a number of fires are burning simultaneously and fire fighting resources are fully committed, the existence of strategically-located areas of reduced fuel provides fire managers with greater flexibility in the deployment of available resources. Fires burning into light fuels may be given lower priority for attention because they are less likely to exhibit severe fire behaviour. (Refer Policy 5.1, 5.2.)

- Maintaining air quality is a major challenge in the execution of approved prescribed burning programs. The need for prescribed fire to conserve biodiversity and to protect community values presents a risk to achieving the standards of air quality regulations in high population areas. This risk can be minimised through the use of sophisticated smoke prediction models. (Refer Policy 5.1.)

- Public understanding of the role and effects of fire, and application of planned fire and fire suppression operations is vital. Effective communication and consultation with the community leads to greater understanding and support for fire management programs, and ensures that knowledge within the community is made more readily available to managers. (Refer Policy 5.1, 5.2.)

Principles for Fire Management

- The vegetation and climate across Western Australia make it highly prone to bushfire. Over millions of years fire has contributed to the evolution of the State's ecosystems. Fire is an important disturbance factor that will continue to influence the biotic composition and structure of all natural ecosystems.

- Plant and animal species and communities vary widely in their adaptations to, and reliance on fire. Species and communities require particular fire regimes for their long-term survival. Such requirements may vary within the ecological and geographical range of species.

- There is no single fire regime that is suited for all flora, fauna and ecosystems. Organisms have developed with a great variety of fire regimes, and thrive in different circumstances. A fire regime that enables one organism to gain competitive advantage will disfavour a competitor.

- Diversity and variability in fire regimes at the landscape level help maintain biodiversity. The application of ecologically based fire regimes that provide for an interwoven mosaic of vegetation and habitats representing a range of fire intervals, fire intensities, seasons and scales will help optimise the conservation of biodiversity. Patchiness of burning is an important factor in providing environmental heterogeneity at a local level. In some instances fire exclusion will be planned. On the other hand, widespread, high intensity fires will periodically remove most of this local patchiness from the landscape. Patchiness can be achieved through applying fire during periods of fuel moisture differential, through the lighting pattern used, and by burning adjacent to light fuels.

- Fire management at a very local level may be critical for the survival of some threatened species and ecological communities.

- Following fire, other factors such as climatic events (eg. drought) and insect attacks often drive ecosystems towards a new transient state with respect to species composition and structure. This may preclude the identification of changes specifically attributable to fire.

- Climate has a major influence on fire regimes, and is one of the fundamental factors determining the distribution of vegetation communities at a regional scale. Some regions of the State have experienced significant shifts in climate over the past three decades and there is an expectation amongst the scientific community that the rate of climate change may accelerate in the future. Fire management should therefore be based on an understanding of climatic trends and adapt to meet changing circumstances.

- All available knowledge including life histories, vital attributes of the native flora and fauna and knowledge of indigenous traditional fire regimes will be used to develop ecologically-based fire regimes.

- Fire management policies and practices should adapt to new knowledge gained through strategic long-term and short-term research and monitoring programs. This adaptive approach to fire management should be flexible to any changes to community values and expectations.

- Fire management planning on lands managed by the Department must address the threats and impacts of wildfire, accommodate the use of planned fire and provide for the achievement of specified land management objectives.

- The response to the threat of wildfire on Departmental lands must consider legal requirements, be thoroughly planned, safe, effective, cost-efficient and environmentally sensitive. All fire management activities, including fire suppression and prescribed burning, must be conducted in accordance with clearly defined procedures that provide for safe work practices and have outcomes monitored and recorded.

- Planning an appropriate response to the occurrences of wildfires must include an assessment of the threat to human life, community assets and services, and natural values, and consider these in conjunction with the management objectives of the area.

- Principles of environmental care must guide all preparedness, suppression, recovery and prescribed burning activities.

APPENDIX 4

CALM 'PRE-BURN CHECKLIST' AND 'BURN PRESCRIPTION' FORM

FIRE, FOR WHAT PURPOSE?

REVIEW OF THE FIRE POLICIES AND MANAGEMENT PRACTICES OF THE DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

CLM 32
(1999)

CONSERVATION AND LAND MANAGEMENT WA
PRE-BURN CHECKLIST

DISTRICT/RESERVE/PARK _____ JOB NO: _____ DATE: _____
LAND TENURE AND PURPOSE _____

PART 1 - ENVIRONMENTAL ISSUES (Page 1 and 4)

The purpose of this checklist is to assist District staff in recognising potential environmental problems in areas subject to proposed burning. It should be completed as the first planning stage for all burns.

ISSUE		YES	NO	IF YES ACTION REQUIRED	TICK	TICK
SMOKE	Airport:					
	City/Town/Settlement:					
	Public Roads:					
GAZETTED WATER CATCHMENTS	Part of Catchment involved			% ( )		
	Water Storage boundary involved			% ( )		
	Ash likely over water					
	Burn approval req. from Waters & Rivers/Water Corp					
WATERWAY	Stream, Lake Name:					
	Significance					
TIMBER PRODUCTION	Current cutting					
	Cut awaiting burn					
	Proposed cutting 0-5 years					
	Any other silvicultural treatment proposed					
	Established Regeneration (State Age)					
RECREATION	Are tourist or major road verges involved?					
	Are aesthetic effects likely? If so, where?					
	Visual Resource Management Zone (VRM)			Number:		
	Walk trail/lookouts involved Eg: Bibbulmun Track					
	Picnic/Campsites					
	Other public use (nominate Eg Tour Operators)					

⇐ CONTINUED ON PAGE 4

PART 2 - PEOPLE and PROPERTY

	Items to be Checked	Complete this portion during preparatory stages				
		(A) Initial to confirm check is completed		(B) Show results and/or action required on check	(C) Is check required just before burn? Yes or No	
		Office	Field		Office	Field
PROPERTY	Buildings					
	Plots					
	Bridges					
	Other					
ADVICE	Burning Notices					
	Low Flying					
	Radio Station					
	Burn Imminent					
	Warning Signs			Ensure Traffic Sign Plan implemented		
	Smoke Management (Written approval rec'd)					
CALM OPS	Research					
	Inventory					
	Surveyors, Monitors					
	Aircraft/Baiting					
SERVICES	Western Power					
	Telstra					
	Shire/CFCO					
	Water & River Corp					
	AgWA					
	Alinta Gas					
	Main Roads Dept.					
	West Rail					
OTHER USERS	Hunters/Fishermen					
	Research/Students					
	Defence Forces					
	Geologists					
	Surveyors					
	Gravel Licences					
	Recreationists					
	Harvesting					
	Wildflower & Seed					

Check Before Ignition			
(D) Initial when check completed for each lighting			
Date of Ignition			

INSTRUCTIONS:

It is important that the planning of prescribed burns be sufficiently detailed to prevent injury to persons or damage to property. Any object or operation within the burn area must be identified before the prescription is prepared and action taken to ensure its protection. Staff compiling the prescriptions must clearly indicate on this form those items which require checking.

Column A: Initial only after the appropriate office and/or field check has been made.
Column B: Briefly indicate result of check or any action required.
Column C: Consider carefully during preparatory stage and indicate whether or not a check is required prior to lighting the burn.
Column D: Enter date of lighting. Where a final check was indicated at "C" initial to confirm check completed. Ensure this is done before lighting commences.

APIARISTS/WILDFLOWER PICKERS DETAILS:

SITE NO	OWNER/LICENCE	ADDRESS	PHONE

OTHER LAND: (Note: Permission to burn other than CALM land must be obtained in writing)

Reserve/Loc Number	Owner/Vested Authority	Purpose	Approval Received		
			Yes/No	Date	Initial

(PLEASE ENSURE PAGE 4 FILLED IN BEFORE SIGNATURE)

SIGNATURES

Prepared by: ______________________

Date: ______________________

District Manager: ______________________

Date: ______________________

Regional Manager: ______________________

Date: ______________________

ISSUE		Yes	No	ACTION REQUIRED	OK	N/A
SCIENTIFIC	Scientific trials/plots					
	Other monitoring sites					
	Reference areas/NPB's					
CULTURAL	Aboriginal/Archaeological sites	*				
	Heritage listing - Registered, Interim, Nominated	*				
	Historical structures (Eg: Bridges/buildings)	*				
	Other					
CONSERVATION	Fragile areas (Caves, dunes, steep slopes, soils etc)	*				
	River/Stream Reserves	*				
	Road Reserves (MRD/Shire approval)	*				
	Known Rare/Endangered Flora/Fauna	*				
	Are there special requirements for flora/fauna habitats?	*				
	Identified diverse ecosystem types					
	Fauna Re-introduction Areas	*				
	Are Recovery Plans for Flora/Fauna applicable?					
	Other Conservation Issues					
DISEASE/ WEEDS/ VERMIN	Within DRA					
	Is a Pc Management Plan required for:					
	(a) Access	*				
	(b) Burn preparation	*				
	Is Dieback photography planned within 5 years?					
	Is Dieback demarcation required?					
	Any noxious weed eradication program/proposals					
	Any vermin control program/proposals					
SPECIAL PUBLIC INTEREST or adjoining CALM land	Nominate:					
OTHER LANDS	Does burn contain other tenure?					
	Is approval to burn required?			If "Yes" enter detail on page 3		
	Any land exchange proposals					

* If YES - Regional Manager Approval required

CLM 386

DISTRICT MANAGERS PRESCRIBED BURN PLANNING CHECKLIST

BURN NO:		SEASON:		BLOCK:	

Conservation comments:			
Signed:		Date:	

Recreation comments:			
Signed:		Date:	

FPC Operations comments:			
Signed:		Date:	

Sustainable Forest Management comments:			
Signed:		Date:	

Fire Management comments:		
Tick Box		All issues raised have been dealt with and incorporated into Burn Prescription.
		Issues raised cannot be incorporated into Burn Prescription. D/Manager to resolve.

District Managers' comments:			
Signed:		Date:	

DEPT. OF CONSERVATION AND LAND MANAGEMENT

BURN PRESCRIPTION CLM 873 (2002)

DISTRICT_____ LOCATION _____ BURN NO-_____

AREA_____ HA PERIMETER _____KM SEASON / YEAR_____

TENURE _____YEAR LAST BURNT _____ STD BURN TYPE _____ BURN BUFFER Y / N

SHIRE _____ ZONE _____ PROHIB PERIOD _____ TO _____

SHIRE _____ ZONE _____ PROHIB PERIOD _____ TO _____

VALUES PROTECTED (%) GP-1_____ GP2_____ GP3_____ GP4_____ GP5 _____ GP6_____ GP7_____

PROG. ALLOC. (%) P24 ____P32____ P42____P43____P _____SHORTCODE _____

VEG. TYPE (CODE) ____,____%,____,____%____,____%,____,____%. BURN % REQD, PROP ____%-, ACT____%

PRIORITY (POINTS EX WTA) 1.____, 1.2____, 1.3____, 1.4____, 1.5____, 2.1____, 2.2____. TOTAL POINTS_____

NOTE: PREBURN CHECKLIST CLM 32 PT 1 MUST BE COMPLETED FIRST.

OVERALL PURPOSES OF BURN (Start with Primary)_____

BURN STANDARDS_____

BURN OPERATIONS_____

COMPILED BY_____ DATE _____ COMMENTS

PRESCRIPTION EVALUATION / APPROVAL (comments , date, signature).

DISTRICT MANAGER or Representative qualified to authorise that the proposal meets all technical, safety and environmental standards:

TECHNIQUES PROPOSED ARE VIABLE?
Relevant District/Region Program Leader has endorsed:

Fire Management Services
MANAGER:

DESCRIPTION OF AREA. ATTACH PLAN (including scale – minimum 1:50000) Use standard legend.

Forest / Vegetation Type(s) and height _____

Average Slopes : Light Fuel _____ Heavy Fuel _____ Aspect _____

Logging tops and other hazards _____

Areas requiring special attention _____

PREPARATORY TASKS Attach CLM 32, Seven way Tests, Neccesary Operations Approval etc.

Edge preparation (Scrub rolling etc) _____

Roadworks _____

Warning signs: (Note: All signs to be erected & removed as per approved Traffic Plan and Signs FPI)

ENVIRONMENTAL (see also attached CLM 32)

DIEBACK. DRA Yes/No____ Permit No_____ Refer Manual, Sections_____. Define Hygiene Requirements:

RARE FLORA / FAUNA _____

WIND RATIO Conversion Factors

Forest type	wind ratio	5-15 km/hr	15-25 km/hr	Forest type	wind ratio	5-15 km/hr	15-25 km//hr
Flats	2.0:1	.2	.1	Sth Jarrah	5.5:1	.8	.6
V. Open Jarrah	3.0:1	.7	.4	Karri 3/6	6.0:1	.8	
Open Jarrah	4.0.1	.8	.7	Karri 4/5	7.0:1	1.0	1.0
North Jarrah	5.0:1	1.0	1.0	Tingle Karri 1/2	9.0:1	1.2	

K 3&6 = KJM,KM, Low scrub K 4&5 = KM, MK, High scrub Karri Regrowth 9.0:1 1.2

K 1&2 = MK, K,

High scrub. Description of terms used in Prescription section of this form.(See Approved Prescribed Burning Guidelines also).

Use Tables 6.14.1. (Northern Jarrah), or 6.14.2 Southern Jarrah or Karri) for 1,2, and 3 below

1 Acceptable Scorch Height : Scorch height that forest type can withstand without incurring fire damage.

2. Actual R.O.S. Range : The actual FROS of the fire. Will be different to FDI and EROSI if fuels and or winds are non standard for that particular forest type. Maximum range - 4 metres / hour

3. Equivalent R.O.S. Index. The FROS of a fire in any forest type with standard fuels for that forest type.

4 Equivalent F.D.I. Range. The same as ROSI when standard wind ratios for the appropriate forest type are used. E.g. North Jarrah 5:1, Karri type 4&5 7:1. (note both have Correction Factors of 1.0 --see Table above) .FDI or Equivalent FDI is obtained by multiplying ROSI times wind correction factor (no slope correction factor).

5. Maximum wind strenghts normally used are 15 km/hr, for forest prescribed burns.

FUEL ASSESSMENT				PRESCRIPTION						
Forest and Scrub Types	Fuel Quantity (from Fuel Assessment Summary Form CLM 872)			Acceptable Scorch Height 6.14 1.or 6.14.2r	Actual R.O.S Range (4 m). 6.14.1.or 6.14.2.	Equivalent R.O.S.I. Range for std fuels: 6:14.1. or 6.14.2.	WIND		Equivalent F.D.I. Range (std forest type) EROSI X wind c.f.	Max Wind
		TOTAL T/HA	AVAIL T/HA				Ratio	C.F.		
	MAX									
	MIN									
	MAX									
	MIN									
	MAX									
	MIN									
	MAX									
	MIN									

EDGING PRESCRIPTION

EDGE N.S.E.W.	OBJECTIVE	Fuel Types	F.D.I.	S.D.I. Limit	Wind speed & direction

CORE LIGHTINGS

IGNITION No	Fuel Type	F.D.I. Range	STRATEGY (Indicate wind direction, AFFs, lighting sequence, patterns, method, timing, fuel moisture contents etc 0	RESOURCES List separately for each lighting.

BURN RECORD

FIRE BEHAVIOUR. Must be completed by Operations Officer after each major lighting.

Date(s) of lighting	Time of lightings - from - to	S.D.I	Strip & spot spacing (m x m)	Actual R.O.S range m / hr	Time strips joined	Comments	Sign

BURN EVALUTION. Assess each Objective- GOOD, FAIR or POOR. If Fair or Poor,explain WHY.

OBJECTIVE	ACHIEVEMENT LEVEL	COMMENT

FURTHER ACTION REQUIRED	ACTION TAKEN DATE	SIGNATURE

IF A DETAILED COSTING IS REQUIRED, USE AND ATTACH BURN COSTING FORM CLM 873 (A)

POST BURN INSPECTION

Attach plan (min. scale 1 : 50000) , showing : Scorch > 1.0 ha, Unburnt pockets exceeding Aerial Burn Security Stds.

Final Ground Inspection. Date(s) _____ Signature _____ Comments _____

Aerial Inspection Reqd Y / N Date _____ Signature _____ Attach plan with comments.

Meets Security Standards?

CLM 871 (1999)

Conservation and Land Management WA

FUEL ASSESSMENT RECORD

Burn No. _____ Sample Line: _____ Date: _____

FOREST/VEG. TYPE _____ TREE SIZE CLASS and HEIGHTS _____(m)

DOM. SCRUB TYPE _____ _____(m)

TOPOGRAPHY _____ ACCEPTABLE SCORCH HEIGHT _____(m)
(Slopes, aspects, ridges, gullies)

SUGGESTED BURN SEASON _____ REC. WIND RATIO _____

Sample Number	Littter Depth (mm)	Trash Height (m)	Trash Density	SCR Structure Type	Scrub Density	Scrub Ave Height (m)	Foliage Dead (%)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
TOTALS	mm	m				m	
AVERAGES	mm	m				m	%
TOTAL WEIGHTS	7.2.1 .....t/ha	7.3.1 + ... t/ha				7.4.1 (Col 1) .....t/ha =	.....t/ha
AVAILABLE WEIGHTS	AFF = ... Total WTxAFF ..... t/ha	AVAIL TRASH TABLE 7.3.1 ..... t/ha		AVAIL SCRUB 7.4.1 Col 3 or 2 ..... t/ha X *FLAMMABILITY FACTOR 7.4.2 .....= ..... t/ha *F/F NORMALLY 1.0 FOR PRESCRIBED BURNING			

AVAILABLE FUEL WEIGHT = AVAIL. LITTER + AVAIL. TRASH + AVAIL. SCRUB = _____ t/ha

REMARKS: (Indicate factors to consider in determining prescription and burn strategy)

_____

_____

_____

_____

OFFICER COMPILING: _____ OFFICER CHECKING: _____

CLM 872 (1999)

Conservation and Land Management WA

FUEL ASSESSMENT SUMMARY

(Attach to Fuel Assessment Record sheets)

BURN NO. _____ AREA: _____ SEASON/YEAR: _____

FOREST/VEG TYPE *(GROUPED)	LINE NO'S	TOTAL WEIGHT (Lt+Tr+Sc)	AVAIL. WEIGHT (Lt+Tr+Sc)	SCORCH HEIGHT	WIND RATIO	VALUES SELECTED FOR PRESCRIPTION Avail Range / Scorch Ht / W Ratio

* Group similar Forest/Veg. types to obtain overall fuel ranges

COMMENTS:

_____

_____

_____

OFFICER/RANGER COMPILING: _____ DATE: _____

APPENDIX 5

HEALTH IMPACTS OF SMOKE INHALATION

FIRE, FOR WHAT PURPOSE?

REVIEW OF THE FIRE POLICIES AND MANAGEMENT PRACTICES OF THE DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

HEALTH EFFECTS OF SMOKE INHALATION FROM BUSHFIRES.

Epidemiological studies require substantial numbers of cases to create a reliable and statistically significant database from which to draw robust conclusions.

The concentrations of substances emitted from bushfires will vary and are influenced by a number of factors, including the type of vegetation, the fuel content and its moisture status, the fire's temperature, and meteorological conditions. The prediction of whether or not someone will experience smoke-related health problems is therefore complex and is also influenced by the extent and duration of exposure to the smoke, its concentration, the person's age, individual susceptibility and factors like their levels of physical activity.

Symptoms from short-term exposure to smoke can range from throat irritation, cough, irritated sinuses, headaches, runny nose, itchy or burning eyes and stinging eyes, to more serious reactions from persons with asthma, emphysema, congestive heart disease and other existing medical conditions. For example in Albury, Victoria a survey was conducted in 2003 to identify health consequences of high levels of pollution due to the bushfires. Overall 72% of people surveyed experienced some health problem associated with the smoke. The most common complaints were eye irritation (55%), coughing (31%), throat irritation (30%), shortness of breath (24%) and headache (18%) (GMAHS 2003).

Inhaling carbon monoxide, carbon dioxide and microscopic pieces of ash or burned wood in bushfires is problematic for people who suffer from respiratory or heart diseases such as congestive heart failure, angina, chronic obstructive pulmonary disease, emphysema or asthma. Also people with vascular complications from diabetes may be susceptible to the effects of fine particles (DHS Victoria, 2003). Older adults are more likely to be affected by smoke, possibly because they are more likely to have heart or lung diseases than younger people.

Children also are more susceptible to smoke for several reasons:-their respiratory systems are still developing, they breathe more air (and air pollution) per kilogram of body weight than adults, and they are more likely to be active outdoors, especially during summer months when smog levels are highest. They also often breathe through their mouths, bypassing the filtering effect of the nose and allowing more pollutants to be inhaled (Ammann, et al. 2001).

Smoke can aggravate existing health conditions. People with heart disease like congestive heart disease might experience chest pain, palpitations, shortness of breath, or fatigue. People with lung conditions like chronic bronchitis, emphysema and asthma may not be able to breathe as deeply or as vigorously as usual, and they may experience symptoms such as coughing, phlegm, chest discomfort, wheezing and shortness of breath.

Fine PM (particulate matter) has been associated with decreased pulmonary function in children and with increased chronic lung disease. Fine PM can also aggravate chronic heart and lung diseases – and has been linked to premature deaths in people with these conditions (EPA, 2003). Woodsmoke fumes, taken from both outdoor and indoor

samples, have shown mutagenic activity in short-term bioassay tests (Pierson, Koenig et al. 1989).

Duclos (1990) evaluated the public health impact of the smoke on the general population during a bushfire that destroyed more than 600,000 acres (272,727ha) of Californian forests in 1987. All hospital emergency rooms located in the six counties most severely affected by smoke or fires were surveyed. The study found that during the period of major forest fire activity, visits of persons with asthma and chronic obstructive pulmonary disease increased in number (observed/expected ratios of 1.4 and 1.3, respectively), as did visits of persons with sinusitis, upper respiratory infections, and laryngitis. A few patients with acute respiratory or eye irritation also visited the emergency rooms. No increase in hospital admissions was found (Duclos, et al. 1990).

Mott et al (2002) assessed the health effects of exposure to smoke from the fifth largest US wildfire of 1999, in California. They found that during the weeks of the forest fire, medical visits for respiratory illnesses increased from 417 to 634 visits (or by 52%) over the previous year. Their survey results indicated that although 181 (62.6%) of 289 participants reported worsening lower respiratory tract symptoms, those with pre-existing cardiopulmonary conditions reported more symptoms before, during, and after the smoke episode.

Several large wildfires occurred in Florida during June-July 1998. To determine whether certain medical conditions increased in frequency during the wildfires, the Florida Department of Health initiated surveillance of selected conditions in the emergency departments (ED) of eight hospitals. For comparison, the hospitals also provided the same information for the same period in the previous year. From 1997 to 1998, ED visits increased substantially for asthma (91%), bronchitis with acute exacerbation (132%), and chest pain (37%). Changes in the number of admissions were minimal (MMWR 1999).

In 1997, the dry conditions that prevailed in Southeast Asia together with land-clearing practices, resulted in the second largest forest fire disaster of this century in Indonesia. The resultant fires generated intense smoke, affecting neighboring countries (e.g., Singapore, Malaysia, Thailand) and the Indonesian islands for several months. Between September 1997 and November 1997 in Indonesia, there were 527 haze-related deaths, 298,125 cases of asthma, 58,095 cases of bronchitis, and 1,446,120 cases of acute respiratory infection reported (Osamu 2002). In South Sumatra, the number of acute respiratory infection cases increased 3.8 times compared with the previous year (Osamu 2002).

In Singapore, Emmanuel et al (2000) studied the potential health effects of the daily measured concentrations of sulfur dioxide, particulate matter (PM10), nitrogen dioxide, ozone and carbon monoxide. Findings showed that there was a 30% increase in outpatient attendance for haze-related conditions. An increase in PM10 levels from 50microg/m^3 to 150microg/m^3 was significantly associated with increases of 12% of upper respiratory tract illness, 19% asthma and 26% rhinitis. There was no significant increase in hospital admissions or in mortality despite particulate levels being substantially raised. This may be explained by differences in the particle size distribution during this particular bushfire (Emmanuel 2000).

Several Australian studies examined the effects of pollution in Sydney from bushfires in January 1994. The first study analysed the proportion of asthma presentations in the emergency departments during the week of the bushfire-compared with the same week 12 months before. The authors found that despite the high levels of bushfire–generated air pollution (the peak PM10 was 210μg/m^3, compared with background levels of about 30μg/m^3) there was no increase (Smith, et al. 1996). The second study measured changes in evening peak expiratory flow rates (PEFR) in children with wheeze. This study of 32 children used a direct measure of PM10, including pollen and alternaria counts, and meteorological factors. The maximum daily PM10 level peaked at 210μg/m^3, which was nearly seven times the usual PM10 level for the rest of January and February 1994. No significant associations were reported and it concluded that the high levels of particulate pollution caused by the Sydney bushfires did not lead to any clinically significant reductions in PEFR in symptomatic children (Jalaludin, et al. 2000).

Johnston and colleagues analysed emergency department presentations for asthma in the Darwin region during the "dry" season, April–October 2000, when bushfire activity is high. They analysed daily 24hr PM10 concentrations in this ecological study, and found that asthma presentations increased significantly (adjusted rate ratio, 2.39; 95% CI, 1.46-3.90) on days when PM10 levels were above 40μg/m^3, compared with days when PM10 levels were less than 10μg/m^3 (Johnston, Kavanagh et al. 2002).

Increased PM levels, from sources other than bushfires, have been shown to be associated with small, but consistent, increases in total mortality from respiratory and cardiac conditions in several studies (Sim 2002). The Australian National Environment Protection Council's target for maximum mean PM10 concentration is set at 50μg/m^3 in a 24-hour period. The Indonesian forest fires in 1997 produced maximum daily PM10 averages of over 1500μg/m^3. During Sydney's Christmas 2001 bushfires, PM10 levels above 150μg/m^3 were sustained for 10 days

Consensus is emerging about the adverse health effects of particulate air pollution. A recent report of the Australian National Environment Protection Council (NEPC) suggests that each increase of 10 μg/m^3 in the ambient concentration of respirable particulates is associated with a 3.0% increase in exacerbations of asthma. This estimate was derived from published studies of the health effects of air pollution in large urban settings where particulate pollution originates from motor vehicles, and domestic and industrial sources.

The DEP is a member of the Smoke Management Liaison Group, which has developed as part of Initiative 12. Smoke management research is listed as an action item, with the aims being to:

- quantify significant emission sources outside the metropolitan region contributing to Perth's air quality;
- undertake studies on weather and smoke modelling to improve burn decision processes; and
- continue to promote and review risk assessment of bushfire impacts, taking into account air quality and other environmental impacts.

Stakeholders for Initiative 12 are the DEP, FESA, CALM, the Bureau of Meteorology, Western Australian Local Government Association, Department of Local Government and Regional Development, Bush Fires Service, the Conservation Commission of WA, Pollution Action Network, bushland conservation groups and the building industry.

NOTE:
References for this appendix are listed under References for the main discussion paper.

APPENDIX 6

LIST OF SUBMITTORS TO THE EPA

FIRE, FOR WHAT PURPOSE?

REVIEW OF THE FIRE POLICIES AND MANAGEMENT PRACTICES OF THE DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

SUBMISSIONS RECEIVED PRIOR TO RELEASE OF THE DISCUSSION PAPER

From:

Sallie Coulson

Peter Robertson, Convenor, Western Australian Forest Alliance

Peta Sargisson, Convenor, Northcliffe Environment Centre (Inc)

Dr Beth Schultz, Conservation Council of WA

Dr Christine Sharp, MLC

Roger Underwood, The Bushfire Front Inc

H J Versluis

Dr. David Ward

David Warnock

SIM Cameron

From: Hill-Tonkin, Janette [jhilltonkin@agric.wa.gov.au]
Sent: Thursday, 27 October 2005 15:33
To: 'keithc@calm.wa.gov.au'; ROBB Malcolm; Beeston, Greg; Dixon, Jim
Cc: Loney, John; Nulsen, Bob Dr; George, Richard Dr; Schoknecht, Noel; Shepherd, Damian; 'kena@calm.wa.gov.au'; Lloyd, Sandy; 'peterm@calm.wa.gov.au'; 'neil.riches@csiro.au'; 'clare.taylor@csiro.au'; 'kenw@calm.wa.gov.au'; Woolnough, Andrew; 'mike.grasby@csiro.au'; 'stuarth@calm.wa.gov.au'; MUIRDEN Peter; Griffin, Ted; Short, Rod; 'timg@calm.wa.gov.au'; 'martin.heller@csiro.au'; SIM Cameron; MILLS Des; 'chriss@calm.wa.gov.au'; 'fwells@fish.wa.gov.au'; 'rtregonning@fish.wa.gov.au'
Subject: Statewide RCM Proposals - further analysis needed by 12 Nov


Inland Aquatic Monitoring Prop...


Marine Monitoring Proposal 27 ...


Terrestrial Monitoring Proposa...


Appendix 1_2 Lead persons for ...


RCM TWGs.xls

<<Inland Aquatic Monitoring Proposal 17 Oct 05.doc>> <<Marine Monitoring Proposal 27 Oct 05.doc>> <<Terrestrial Monitoring Proposal 17 Oct 05.doc>> <<Appendix 1_2 Lead persons for RC Indicators 27 Oct 05.doc>> <<RCM TWGs.xls>>

Dear 'Person Responsible for MfT'

Thanks for your input so far to the Statewide RCM proposals. The attached proposals were submitted to WAMEAC and SOG in the last week and as a result of those discussions we now request your urgent assistance to recast the proposals with a regional split for a December JSC meeting.

We are approaching you as the designated 'responsible person' for an MfT to coordinate input from your related 'Lead Persons' and other Technical Working Group contributers (see attached list of Lead Persons and original TWG contributers) to provide the following two additions to the Statewide RCM analysis for your MfT/s to Bob Nulsen (bnulsen@agric.wa.gov.au) by noon Friday 12 November -

1. Resubmit the results of the budget analysis for your Matter for Target/s in two table formats as per the attached Land Salinity examples. This will give us a regional split of activities/ costs that we don't have for all MfTs.

2. Add into the text for your MfT, numerical details of the current and proposed infrastructure, monitoring activities etc and supporing case as per the last 3 paras on page 7, section 1.1.3 (Land Salinity) of the Terrestrial proposal. We need some very 'hard facts' for the marketing argument that goes with the proposals.

The outcome is that we are now going to prepare 6 proposals - one for each NRM region covering all Matters for Target for 2005/6 to 2007/8. This will allow everyone to see clearly what would be spent in each region on each NRM issue and also assist with our 'point of investment' monitoring analysis.

Please advise in advance if you cannot meet the 12 November timeline. Bob and I are also happy to answer any queries, protests, solicitations etc

Many thanks

> Janette Hill-Tonkin
> Manager, Monitoring and Evaluation
> State Natural Resource Management Office
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> Locked Bag No. 4, Bentley Delivery Centre, WA 6983
> (08) 9368 3191 (office) 0412 788 449 (mobile) (08) 9368 3939 (fax)
>
>
>

Location Id	Region Id	Location Name	Area	Longitude
1	6	Ocean Reef		115.72586
2	6	Swanbourne		115.7525
3	6	Sepia Depression		115.63188
4	6	Rottnest Island		115.54707
5	6	Owen Anchorage		115.75108
6	6	Success Harbour	Fremantle	115.74736
7	6	Cockburn Sound		115.72346
8	6	Minstrel Channel		
9	6	Careening Bay	Cockburn Soun	115.68912
10	6	Warnbro Sound		115.71459
11	6	Shoalwater Bay		115.69328
12	6	Fishing Boat Harbour	Fremantle	115.7446
13	6	Challenger Harbour	Fremantle	115.73844
14	6	Parmelia Bank	Owen Anchora	115.70662
15	6	Fremantle		115.74495
16	6	Yanchep		115.63013
17	4	Geraldton		114.61316
18	9	Albany		117.87185
19	8	Walpole		116.72995
20	4	Leeman		114.97638
21	8	Augusta		115.1571
22	3	Denham		113.53688
23	8	Windy Harbour		116.02366
24	5	Ledge Point		118.72046
25	5	Cervantes		115.067
26	4	Dongara		114.93132
27	2	Onslow		115.11033
28	4	Kalbarri		114.16555
29	7	Mandurah		115.72021
30	6	Quinns Rocks		115.6875
31	9	Princess Royal Harbour		117.89032
33	9	Oyster Harbour		117.95082
34	6	Market Samples		
35	10	Mundrabilla		127.85612
36	9	Cheynes Beach		118.40054
37	10	Esperance		121.88111
38	8	Busselton		115.34398
39	8	Bunbury		115.63466
41	6	Swan-Canning Estuary		115.85196
42	6	Perth		115.86494
43	6	Dalkeith	Swan River	115.79875
44	6	Blackwall Reach	Swan-Canning	115.77661
45	6	East Perth	Swan-Canning	115.88322
46	6	Canning	Swan-Canning	115.85196
47	6	Canning Bridge	Swan-Canning	115.85196
48	6	Deep Water Point	Swan-Canning	123.083
49	6	Beenyup		
50	6	Mindarie		115.71405
51	6	Woodman Point	Cockburn Soun	115.74613
52	6	Beacon Head	Cockburn Soun	115.66775

Latitude
-31.76435
-31.96940
-32.15969
-32.00035
-32.1222
-32.07116
-32.19859
-32.23471
-32.33847
-32.28388
-32.06749
-32.06344
-32.11999
-32.05307
-31.55917
-28.78022
-34.99675
-34.97700
-29.95003
-34.31716
-25.93022
-34.83782
-34.65823
-30.49886
-29.25943
-21.63816
-27.71191
-32.52811
-32.68081
-35.04129
-34.99056
-31.84383
-34.88131
-33.86141
-33.65367
-33.32674
-32.01222
-31.95763
-32.00528
-32.02387
-31.96045
-32.01222
-32.01222
-16.66659
-31.68694
-32.13555
-32.15692

Location Id	Region Id	Location Name	Area	Longitude
53	6	James Point	Cockburn Soun	116.16284
55	6	Mangles Bay	Cockburn Soun	115.69328
56	6	Buchanan Bay	Cockburn Soun	115.68243
57	6	Palm Beach	Cockburn Soun	115.71209
58	6	Jervoise Bay	Cockburn Soun	115.7508
59	6	Garden Island	Cockburn Soun	115.6896
60	6	Cliff Point	Cockburn Soun	122.54268
61	6	Colpoys Point	Cockburn Soun	115.69716
62	6	Becher Point	Warnbro Soun	115.71386
63	6	Minim Cove	Swan River	115.76354
64	3	Monkey Mia	Shark Bay	113.7169
65	3	Taillefer Isthmus	Shark Bay	113.69106
66	3	Useless Loop	Shark Bay	113.41433
67	3	Herald Bight	Shark Bay	113.55051
68	3	Useless Inlet	Shark Bay	113.35369
69	3	South Passage	Shark Bay	113.18297
70	3	Blind Strait	Shark Bay	113.25561
71	3	Cape Bellefin	Shark Bay	113.29787
72	3	Cape Heirisson	Shark Bay	113.36079
73	3	Tetrodon Loop	Shark Bay	113.14044
74	2	Dampier		116.71121
75	6	Market Samples		
76	10	Mundrabilla		127.85612
77	2	Exmouth		114.12364
78	3	Shark Bay		113.55572
79	6	Fish Rocks Bank	Success Bank	115.72993

Latitude
-20.97146
-32.28388
-32.20581
-32.27629
-32.13638
-32.23494
-16.86294
-32.22552
-32.37181
-32.02359
-25.79681
-26.16694
-26.13470
-25.58540
-26.12557
-26.15119
-26.13647
-26.01978
-26.01965
-25.94805
-20.66406
-31.84383
-21.94148
-25.34915
-32.08693