1. INTRODUCTION

In January 1994, eastern New South Wales experienced an extended period of severe bushfire weather. During this time, hundreds of fires consumed over 800,000 hectares, prompting the largest fire suppression operation in Australia's history. Resources were sent from every State and Territory in Australia, and from New Zealand, to assist in suppression efforts.[1] At the height of the fires, Australian television was filled with images of suburban Sydney streets ablaze. When one of these fires burnt through the Lane Cove River Park to within seven kilometres of Sydney's Central Business District, the international media also focussed its attention on Sydney. As Campbell wrote in an article reviewing the media's response to these fires, "nothing is more photogenic or audiogenic than 30-meter flames roaring towards an international city".[2]

The losses sustained during the New South Wales Bushfires were relatively modest[3] in comparison to other major conflagrations in Australia's recent history.[4] However, they provided a vivid demonstration of what the Senate Standing Committee on Industry, Science, Technology, Transport, Communications and Infrastructure recognised in its report ***Disaster Management*** as the 'new problem area' for fire management agencies[5] : the emergence over the last twenty years of a new 'rural' community at the urban-bush interface.[6,7]

The southern Sydney suburbs of Como and Jannali are examples of an urban-bush interface community where the conventional suburb abuts forest or grassland. Half of all homes lost during the New South Wales Bushfires were located in these two suburbs.[8] Most of the houses were perched on a ridge overlooking a forested gully from where the fire struck. In the satellite suburb of Melton, to the west of Melbourne, 14 houses were destroyed in 1985, when a grassfire burnt

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1 Department of Bushfire Services,1994,9

2 Campbell, F.,1994,17

3 Department of Bushfire Services,1994, reports that four lives and 205 properties were lost.

4 The 1983 Ash Wednesday Bushfires in Victoria and South Australia claimed 75 lives and over 2500 buildings.

5 In this paper, the term "fire management agencies" refers to all agencies that have fire prevention and suppression responsibilities, including both rural fire-fighting organisations and public land managers.

6 Senate Standing Committee on Industry, Science, Technology, Transport, Communications & Infrastructure,1994,84

7 Also described as the urban-rural interface, the urban-forest interface, the urban interface, the urban-rural fringe and, in the United States, the wildland-urban interface. Without deciding which term is most appropriate, this paper adopts the term used in the Disaster Management report: the urban-bush interface.

8 Department of Bushfire Services,1994,9

into the western fringe of the town.[9] Where suburbs abut forest or grassland, houses on the fringe are most at risk, as there is not enough fuel to support a fire through the more conventional suburbs.

Fire management agencies also use the term 'urban-bush interface'[10] to describe those low-density suburbs actually sited in the bush.[11] Examples of such communities include areas devastated by the Ash Wednesday Bushfires in 1983 in the hills surrounding Melbourne, such as Macedon, Upper Beaconsfield and Cockatoo. Other examples include those bushland-residential developments found on the fringes of other major cities in southern Australia.[12] These urban-bush communities feature relatively large populations, living in areas of heavy fuel loads, rugged topography, and poor access and egress. A high proportion of their inhabitants are commuters, with little experience of living in the bush, or of fending for themselves in a major fire.[13] More importantly, they frequently have little understanding of how fires behave and how they can be survived.[14] In addition, many people living in these communities resist attempts to reduce fuel loads in order to leave the environment as close to its natural state as possible.[15]

Many writers have recognised the significance of the bushfire threat posed by these communities. The Bushfire Review Committee investigating the 1983 Ash Wednesday Bushfires in Victoria (hereafter referred to as Miller *et al.*) described these communities, living "cheek by jowl with an enormously hostile and dangerous fire environment", as lying at the heart of the fire problem.[16] Cheney describes the urban-forest developments on the fringes of major cities as "certainly the most hazardous areas in terms of economic loss".[17] A recent Western Australian Department of Conservation and Land Management (CALM) report noted that the "urban/rural interface is the most fire-vulnerable part of the Australian (and world-wide) environment."[18]

Traditionally, the cornerstone strategy for reducing the threat of fire for most fire management agencies, is the suppression of fire.[19] Fire prevention strategies are restricted largely to the

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9 Maynes & Garvey,1985,30

10 Or variations of this term (see footnote 7).

11 Campbell, F.,1994,17

12 Senate Standing Committee on Industry, Science, Technology, Transport, Communications & Infrastructure,1994,84; Cheney,1976,259

13 Miller *et al.*,1984,120; Chase,1994,351

14 Krusel & Petris,1992

15 Boura,1994; Miller *et al.*,1984,120; Senate Standing Committee on Industry, Science, Technology, Transport, Communications & Infrastructure,1994,84

16 Miller *et al.*,1984,120

17 Cheney,1976,259

18 Department of Conservation and Land Management,1994,55

19 Whelan,1987,1

modification of the environment to support suppression measures, or to protect forest assets or communities. Limitations of these traditional strategies, coupled with the emergence of the urban-bush interface in recent decades, presents new challenges for fire management agencies. This has meant that some fire management agencies are beginning to agree with the House of Representatives Standing Committee on Environment and Conservation (hereafter referred to as Milton *et al.*) that "community protection involves more than fire prevention and suppression",[20] and are seeking alternative ways of reducing the bushfire threat to complement existing fire suppression and prevention practices.

This report was prepared in response to a recommendation from the Senate Standing Committee on Industry, Science, Technology, Transport, Communications and Infrastructure that Emergency Management Australia conduct a review of major conflagrations to identify key elements of fire prevention and suppression. The first part of this report examines traditional fire prevention and suppression strategies, assessing their relative effectiveness in reducing the bushfire threat. The second part discusses strategies which communities can implement to reduce the threat in urban-bush interface environments and how fire management agencies can facilitate the development of these strategies. The report is based on reviews of all State and Federal reports on major conflagrations which have occurred over the last fifty years, supplemented by information and insights collected by the author in the course of working in the Risk Management Department of the Country Fire Authority of Victoria (CFA). It draws heavily on Victorian experience and research, but this bias is probably legitimate given that Victoria has borne the brunt of Australia's major bushfire disasters. For instance, seventy-two percent of all Australian bushfire fatalities have occurred in Victoria.[21]

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20 Milton *et al.*,1984,21

21 Hickman & Tarrant,1986

2. TRADITIONAL AGENCY RESPONSE TO THE BUSHFIRE HAZARD

2.1 BUSHFIRE AS A NATURAL HAZARD

The traditional view of natural hazards and natural disasters,[22] is that they are defined by extremes in physical processes.[23] Burton and Kates define natural hazards as "those elements in the physical environment, harmful to man and caused by forces extraneous to him."[24] Heathcote describes natural disasters as "extreme physical events greatly exceeding normal human expectations in terms of their magnitude and frequency, and causing significant material damage to man and his works with possible loss of life."[25]

Of course, human communities are not excluded from these conceptions of natural hazard. It is generally accepted that hazard, strictly speaking, refers to the potential for damage that exists only in the presence of a vulnerable human community.[26] As a result it is understood that a natural disaster cannot occur "if the area utilised by humans is not within a flood-plain, astride or adjacent to a geological faultline, along a tropical coastline, or amongst fire-prone vegetation."[27] Similarly, it has been recognised, for example, that the sparse population and limited economic activity of Alice Springs and the Northern Territory, means that the bushfire hazard "does not compare with such areas as the Blue Mountains, the Dandenongs, the Adelaide Hills or the surrounds of Hobart, into which residential development has spread."[28] But as Hewitt explains, while there is recognition of factors like the existence of people and assets in these conceptions of hazard, "the sense of causality or the direction of explanation still runs from the physical environment to its social impacts".[29]

In other words, the focus of research and mitigation activities is firmly fixed on the extent to which variations in the physical environment influence the hazard. Thus, hazards are described according to their physical characteristics, such as their intensity, extent, frequency, periodicity, duration and mobility.[30]

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22 A disaster is the manifestation of a hazard.

23 Hewitt,1983,5

24 Burton & Kates,1964,413; Whittow,1987,307

25 Heathcote,1979; Oliver,1986,283

26 Hewitt,1983,5

27 Britton,1986,254

28 Oliver,1986,300

29 Hewitt,1983,5

30 Oliver,1986,283

An example of the emphasis on the physical environment is the bushfire hazard. While the term 'bushfire hazard' is used in many different ways, and is often used interchangeably with the terms 'danger' and 'risk',[31] fire management agencies typically use the term 'hazard' to describe the condition of fuel.[32] Thus, hazard reduction means the removal of fine fuel. Similarly, the fire danger is said to increase when weather and fuel conditions favour the ignition and spread of a bushfire. Fire danger models incorporating weather and fuel information are used to assist fire management agencies to decide how to deploy suppression forces and whether to declare fire ban days.[33]

When societies focus their disaster mitigation efforts on managing or manipulating the physical environment, the resulting strategies for reducing the hazard frequently involve an understanding of the science of the physical processes, wedded with the development of technology and systems for managing those processes.[34] An example, suggests Salter, is the 'hazard-centred approach' of the United Nations International Decade for Natural Disaster Reduction, where "the forces of nature are highlighted and orientation is to scientific and engineering approaches."[35] These hazard mitigation strategies are generally beyond the resources of individuals and communities, thus the management of the hazard becomes the responsibility of disaster management agencies.[36] Burton *et al.*, for example, explain how the most common strategies for reducing the threat of flooding, such as "the construction of dams, irrigation systems, or seawalls, and the design of monitoring, forecasting, and warning systems with complex equipment ... [are] clearly beyond the scope for individual action."[37]

Similarly, most strategies for reducing the bushfire threat involve the management of the natural environment, and have clearly become the responsibility of fire management agencies. There are many different ways of classifying these strategies. This paper has sought to avoid the debate over the most appropriate definitions for traditional fire prevention and suppression strategies. Instead, discussion of these strategies is divided simply into **Fire Management** and **Natural Resource Management** strategies. The term **Fire Management** in used in this paper to describe traditional fire suppression and prevention activities practiced by both rural fire-fighting authorities and public land management agencies, designed solely to reduce the bushfire threat. Fire suppression attracts the bulk of agency resources. Fire prevention activities are restricted largely to works designed to support suppression efforts, principally the construction of fire breaks and fire access roads, and the provision of water points. These are also referred to as pre-suppression activities.

Another traditional fire prevention strategy is that of broadscale fuel reduction burning, used principally by public land managers to protect public assets and adjoining communities, and to improve suppression capability in the event of fire. This practice is discussed separately under the

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31 Blake,1990,24

32 Luke and McArthur,1978,5

33 Petris,1990,19

34 Hewitt,1983,8

35 Salter,1993,3

36 Hewitt,1983,9

37 Burton *et al.*,1978,219

heading **Natural Resource Management** to reflect the fact that broadscale fuel reduction burning may be used to achieve a range of natural management objectives, in addition to reducing fuel loads.

2.2 ASSESSMENT OF THE TRADITIONAL RESPONSE

Fire Management

The reliance by agencies on traditional fire prevention and suppression strategies is understandable. In some instances there is scope for improving suppression capability by updating equipment, and by re-examining the structures and procedures of suppression forces, but, **for the vast majority of fires, suppression is remarkably effective. The limitations of traditional fire prevention and suppression strategies only become apparent in the event of a major conflagration**. This is significant, for although major bushfires represent only a very small proportion of the total number of fires, they are responsible for the vast majority of death, injuries and damage to property. In Victoria, about 85 percent of the total losses caused by bushfire are the result of just 0.1 percent of all reported fires over one hectare.[38]

During the 1983 Ash Wednesday Bushfires in Victoria, for example, it was found that the fire-fighting forces were overwhelmed and that controlled response was impossible.[39] Furthermore, it was reported by experienced fire-fighting officers that even "if the available fire-fighting resources in areas such as Cockatoo, had been multiplied many times they would have been powerless to control the unstoppable fires".[40]

In the Inquiry examining the Western Districts Fires of 1977, Barber observed that on extreme fire weather days "once a fire gets away from an early attempt at suppression, no firefighting organisation on earth can prevent the fire spreading and causing immense loss".[41] This experience was similar to that recorded by the Judicial Inquiry investigating the Hobart Fires, which concluded that "when the main fire burnt strongly at about noon on this day it was impossible to do anything".[42]

To understand the limitations of suppression forces requires an understanding of fire intensity. Fire intensity is a measure of the rate of heat release per unit length of fire front, usually expressed in kilowatts per metre (kW/m). The greater the intensity, the more difficult it is to suppress a fire, the more damage it will inflict, and the more vulnerable a community in the path of that fire will be.

Maximum intensities at which suppression forces are able to control the forward spread of a fire by direct attack have been estimated at 4000 kW/m,[43] although it is suggested that it might be as high

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38 Loane & Gould,1986,1

39 Miller *et al.*,1984,51

40 Miller *et al.*,1984,143

41 Barber,1977,80

42 Chambers & Brettingham-Moore,1967,29

43 Luke & McArthur,1978,28

as 10,000 kW/m for grassfires.[44] By contrast, it has been observed that major conflagrations burn at intensities of 60,000 kW/m or more,[45] and cannot be stopped by traditional suppression forces.

Similarly, many fire prevention strategies fail in the event of a major conflagration. One of the most common fire prevention strategies is the construction of firebreaks to assist suppression efforts. A study assessing the effectiveness of firebreaks at stopping low-intensity fires, (an empirical study in the Northern Territory), found the probability of a firebreak stopping a fire decreases with increasing fire intensity.[46]

This finding concurs with the experience of high-intensity major bushfires where firebreaks have little impact on the forward spread.[47] During the Ash Wednesday Bushfires in Victoria, it was noted that even major natural firebreaks such as four-lane highways had no impact on the run of the fire.[48] During the Western District Fires of 1977, McArthur *et al.* observed that almost without exception the "firebreak system failed to have any influence on the suppression of fires during the period of their major run."[49] The evidence they collected following the fires suggested that "burnt firebreaks 20-40 m in width are not effective in halting the headfire once the fire danger ... is in the extreme range"[50] Based on the experience of the Dwellingup Fire in Western Australia in 1961, Rodger noted that "roads and tracks and even firebreaks up to five or ten chains (100-200 m) in width will be of little assistance in halting a fire."[51]

Despite these limitations, traditional fire suppression and prevention strategies may still be very effective at averting major conflagrations. For instance, an extremely effective suppression strategy on a bad fire day is to extinguish outbreaks of fire quickly, before they become too intense to control.[52] This was recognised as early as 1961, in the aftermath of the Dwellingup Fires. Rodger reported that:

> "speed is essential to efficient fire suppression ... A fire must be tackled as quickly as possible no matter where it occurs. If not, then when it does have to be attacked, the burning conditions may be so severe and the face of the fire of such magnitude that, for the time being, it will be impossible to control it."[53]

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44 Packham,pers.comm.

45 Wilson & Ferguson,1984,231

46 Wilson,1988

47 Firebreaks can, however, be effective for achieving other objectives, such as providing a control line to enable firefighters to stop the side spread of the major fire or to undertake tactical fuel reduction works ahead of a bushfire.

48 Miller *et al.*,1984,78

49 McArthur *et al.*,1982,69

50 McArthur *et al.*,1982,70

51 Rodger,1961,54

52 Milton *et al.*,1984,18

53 Rodger,1961,49

An excellent example of the value of stopping or restricting an outbreak of fire before it grows large enough to threaten life and property is the experience of the Victorian Ash Wednesday Bushfires in 1983. Eight major fires burned out of control on that day, taking 47 lives and destroying over 2000 homes, but CFA firefighters were able to extinguish 172 other fires before they were large enough to cause significant damage.[54] There was a similar experience during the Victorian Western District Fires of 1977. The Inquiry into the Western District Fires recorded that of the 68 fires reported and attended by the CFA, 57 were rapidly controlled and did little damage.[55]

Through efficient response and initial attack, and through controlling ignition sources, fire management agencies can also reduce the number of free-burning fires occurring before the onset of dangerous weather conditions.[56] Historically, the large number of fires that have been allowed to burn in the days and weeks preceding the onset of weather conducive to extreme fire behaviour has been a feature of major fires. The focus of the early major fire reports was the control of these free-burning fires, and of the land management practices which gave rise to them.

Stretton, for example, attributed part of the 1939 Black Friday disaster to:

> "the numerous fires which during December, in many parts of Victoria, had been burning separately, as they do in any summer, either "under control" as it is falsely and dangerously called, or entirely untended, reaching the climax of their intensity and joining forces in a devastating confluence of flame on Friday, the 13th of January".[57]

Stretton identified a large number of ignition sources for these fires, but was particularly critical of settlers, graziers, miners and prospectors, whom he described as the most prolific fire causing agents, with the percentage of fires caused by them far exceeding that of any other class. Escapes from burning-off operations by settlers was also the most important cause of the Dwellingup fires (followed closely by lighting strikes).[58] The fires were invariably lit in the days preceding the Dwellingup Fires and escaped later due to the failure of the settlers to keep adequate labour in attendance.[59] The Judicial Inquiry into the Hobart fires found that 89 fires burning on 7 February 1967, started prior to that day from such causes as escapes from incinerators and rubbish dumps, burn-offs lit by landowners without a permit, and fires lit for firebreaks that got out of control.[60]

However, the number of fires being allowed to burn unchecked in the lead up to a 'blow-up' day is no longer as significant as it was. This is possibly a reflection of changing land management practices, tighter regulatory controls on lighting fires, improved suppression capability and fire prevention education.

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54 Country Fire Authority,1983a,3

55 Barber,1977,15

56 Cheney,1976,247

57 Stretton,1939,4

58 Rodger,1961,11

59 Rodger,1961,40

60 Chambers & Brettingham-Moore,1967,17

Natural Resource Management

Since the mid-1960s, broadscale fuel reduction burning has been used by public land managers to reduce fine fuel loads over extensive areas of forest in order to reduce the intensities of subsequent bushfires. Most major fire reports firmly support the practice of fuel reduction burning[61].

The most sophisticated and extensive fuel reduction burning program in Australia is that implemented by the Department of Conservation and Land Management of Western Australia (CALM) for the jarrah and karri forests of south-west Western Australia. It is also possibly the most effective fuel reduction burning program. CALM report that since the introduction of this program, the average size of fires has declined significantly and, since the Dwellingup Fires of 1961, there have been no major property losses, few large fires, few injuries and deaths and many significant 'saves' even under extreme fire weather conditions.[62]

The CALM assessment further corroborates an analysis of the effectiveness of fuel reduction burning programs. This analysis studied a number of case studies and found that the presence of zones in the forest where fuels had been reduced by prescribed burning was an important factor in reducing fire size and improving the ease of control.[63] These case studies included the Western Australian experience of Cyclone Alby on 4 April 1978. On that day, severe winds combined with high temperatures to produce extreme bushfire weather, and 92 fires burned over 53,500 ha. However, the area of State forest burnt was only about 7000 ha. A review of fire suppression operations argued that this area could have been considerably greater "had not many fires burnt into fuel-reduced areas where suppression or mop-up actions could take place".[64]

The West Australian experience is supported by a Victorian Department of Conservation and Natural Resources (DCNR) study of the effect of fuel reduction burning on four bushfires in heath and mallee fuel types in the Little Desert and Grampians areas of Western Victoria. This study found that the fuel reduction burns prevented each of the four fires from reaching a much larger size, thus saving considerable suppression resources and avoiding damage to private property in one case.[65]

There is also considerable anecdotal evidence supporting the practice of fuel reduction burning. Fuel reduced areas were observed to be successful in retarding the spread of fire during the Hobart fires,[66] and reducing the destructive effect of the fires in western Victoria.[67] There are also reports from the Otway Ranges Fire on Ash Wednesday that fuel reduced areas were responsible for the survival of some homes, and for enabling firefighters to make a stand.[68]

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61 For example: Stretton,1939,15; Rodger,1961,59; Standing Committee on Forestry,1984,14

62 Department of Conservation and Land Management,1994,57

63 Underwood *et al.*,1985,166

64 Van Diddens,1978,1

65 Grant & Woulters,1993

66 Chambers and Brettingham-Moore,1967,25

67 Barber,1977,71

68 Country Fire Authority,1983b,109-10

Despite these relatively optimistic assessments of the effectiveness of fuel reduction burning, the ability of fuel reduction burning to meet fire protection objectives has been queried in recent years. It has been observed that due to the lack of decomposition agents and the increased litter shed after a fire, fuel loads accumulate rapidly to reach significant levels within 2-3 years.[69] Recent research by Tolhurst *et al.* in the Wombat State Forest confirms that "there is only a short period of as little as two years (spring burns) and about four years (autumn burns) when the litter fuel load is significantly lower in fuel reduced areas than it is in areas that have not been burnt for 30 to 50 years."[70] However, this is not the experience of CALM in Western Australia. They have found that the time taken for fuels to accumulate to levels above which headfire cannot be successfully attacked under average summer conditions, is 5-7 years in the jarrah, 7-10 years or more in the eastern jarrah/wandoo and 6-8 years in the karri forest.[71] Clearly, a better understanding of fuel accumulation rates in different Australian forests is essential to adequately assess the effectiveness of fuel reduction burning as a strategy for preventing major fires.

However, note that Tolhurst *et al.* argue that it is too simplistic to assess fuel reduction burning purely on its impact on litter weights. For example, Wilson has found that 'spotting' in eucalypt forests commonly determines success or failure in controlling bushfires, and that spotting potential depends substantially on the surface texture and condition of eucalypt bark.[72] Wilson also argues that elevated fuels, such as shrub, heath and suspended fuels, can determine how fast a fire will spread and the success or failure of fire control.[73] Tolhurst *et al.* observed that in the Wombat State Forest the structure of elevated shrub and bark fuel is modified for a period estimated to be more than 10 years. As a result, "although a fire burning under conditions of high to extreme fire danger could still burn through an area which had been fuel reduced 4 to 10 years previously, the severity of the fire would be reduced and the ability to control it would be substantially increased."[74]

In responding to recent questions over the effectiveness of fuel reduction burning, a review of CALM's fuel reduction policies found that "the lowered incidence and intensity of wildfires in areas that have been subjected to prescribed burning for fuel reduction is incontrovertible"[75]. The review concluded that:

> "the only practical way to achieve fuel reduction over sufficient area to substantially modify high-intensity fires, and to change the flammability of the bark on the trees and thereby reduce the spotting potential of the fire, is by low-intensity prescribed fire .... Some wildfires burning in fuel reduced areas will still burn at an intensity which will be beyond physical control until weather conditions abate. However, these fires will be less damaging to timber and wildlife values, will develop and spread less rapidly and

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69 Simmons *et al.*,1988; Boura,1994,4

70 Tolhurst *et al.*,1992,41

71 Department of Conservation and Land Management,1994,19

72 Wilson,1992,1

73 Wilson,1993,3

74 Tolhurst *et al.*,1992,41

75 Lewis *et al.*,1994,6

eventually be confined to a smaller area than fires burning in heavy fuels under the same weather conditions."[76]

The practice of fuel reduction burning seems to sit comfortably with the growing appreciation that fire has been and remains an integral part of the Australian environment, and will never be expunged from it by any agency practice. Robinson *et al.* report that while Australians are yet to be persuaded that fire is an essential process for both conservation and fire management, there is a range of studies which explain that biodiversity is intricately linked to fire regimes.[77] Milton *et al.* note that "fire is an integral part of the natural Australian environment and, along with the climate, has played a significant part in the evolution of Australian flora and fauna."[78] Pyne's fire history of Australia argues that not only is fire connected with the composition and geography of our native vegetation, but it has also been an important factor in shaping the character and lifestyle of both the Aborigines, and the European settlers.[79] The recent review of CALM's prescribed burning policy and practices notes that "today, fire should be considered to be as much a part of our forest and heathland ecosystems as the sun and the rain."[80]

The long-term ecological impact of fire on any particular ecosystem and its components is a function of the fire regime, i.e. the intensity, frequency, and season of the series of fires to which the ecosystem is subjected. While there has been a considerable amount of research into the ecological effect of fire, it has been noted that most of these studies are opportunistic, simply examining the effects of a single fire, rather than the effects of a fire regime. Because these studies are not replicated in time and space, it is difficult to compare the results of these studies of single fires in order to improve our understanding of the impact of various fire regimes on different environments.[81] The study of the relationship between fire regimes and biodiversity for different flora and fauna communities (fire ecology) is clearly an increasingly important research field.

Some people argue that because not much is known about the effect of various fire regimes on specific communities of flora and fauna, fuel reduction should cease until its effects are better understood. Milton *et al.*, for example, agreed with the Australian Conservation Foundation that "the general use of prescription burning to manipulate habitats should not be applied until our knowledge and technology improves."[82]

Meredith responds by observing that although it is easy to become concerned with how much we do not know, "quite often the information required for making management decisions can be provided by a knowledge of the responses of critical indicator species or through the use of theoretical concepts of general application".[83] Moreover, most fire ecologists now recognise that

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76 Lewis *et al.*,1994,9

77 Robinson *et al.*,1994,1

78 Milton *et al.*,1984,1

79 Pyne,1991

80 Lewis *et al.*,1994,15

81 Tolhurst *et al.*,1992,1

82 Milton *et al.*,1984,15

83 Meredith,1988,9

as fire and biodiversity are so intricately linked, a decision not to burn will have as much influence on the long-term structure and composition of an ecosystem as the implementation of any particular fire regime. Instead they advocate the implementation of a range of diverse fire regimes, including fire exclusion, to best maintain biodiversity.[84] This closely parallels the practice of CALM, who have found that "a variety of spring and autumn burns, together with occasional periods without fire, is the regime which is considered to best meet both protection requirements and environmental needs of the forest."[85]

It is significant to note that there is no scientific evidence that the prescribed burning regime applied by CALM in the south-west of Western Australia has any deleterious effect on any plant, animal or ecosystem.[86] Similarly, no plant or animal species has been lost from any study area of the Wombat State Forest in Victoria after either spring or autumn burning during the first seven years of a long term study of the ecological effects of fuel reduction burning.[87]

The importance of the role of fire in maintaining environmental integrity was recently articulated by the Chief of the United States Forest Service in a statement before a United States Senate Subcommittee. The statement claimed that when the ecological state of the forest is dramatically altered by fire suppression and other management practices, the role of insects, disease, and wildfire are likewise altered. It continued that the forest health problem in the United States and the associated high intensity wildfires that the United States have recently experienced, are indicators that the system is not in balance, and that these problems will persist "until we recognise that some actions are necessary to return fire to the environment in a way that achieves desired outcomes, to improve forest health and reduce the risk that fire will damage site productivity or destroy human life and property."[88]

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84 Tolhurst *et al.*,1992,43

85 Department of Conservation and Land Management,1994,50

86 Department of Conservation and Land Management,1994,51

87 Tolhurst *et al.*,1992,41

88 Thomas,1994