The Burning Continent
Forest Ecosystems and Fire Management in Australia
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Peter Attiwill, Ross Florence, Bill Hurditch & Bill Hurditch
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The Burning Continent
Forest Ecosystems and Fire Management in Australia

Peter M. Attiwill
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Chris Ulyatt
Disturbance of Forest Ecosystems*

The literature on disturbance of ecological systems is very large, and much of it was synthesized in 1985 in a multi-authored book edited by S.T.A. Pickett and P.S. White.1 In their conclusion, Pickett and White state that:

There can be no doubt that disturbance is an important and widespread phenomenon in nature. Disturbance is common to many different systems. It functions or has functioned at all temporal and spatial scales and levels of organization of ecological and evolutionary interest.2

I have just completed a review of more than 500 papers—most of them post-1985—in the international scientific journals on disturbances in forests around the world and on responses following disturbance of forest composition, diversity, structure and composition.3 Major, natural disturbances include fire; hurricanes, windstorms and gap dynamics; ice storms, ice push, cryogenesis and freeze damage; landslides, avalanches and other earth movements including coastal erosion and dune movement; coastal flooding; lava flows; karst processes; droughts, flash floods, rare rainstorms, fluctuating water levels, alluvial processes and salinity changes; biotic disturbances including insect attack, fungal disease, browsing and burrowing animals, invasion by plants (weeds); and disturbance caused by man. The nature of disturbance is frequently difficult to categorize. For example, does a tree break or fall because of wind or

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* This paper was prepared originally for the Forest Protection Society.
because of its own ageing and decay? Wind varies from zero to hurricane force—at what stage do we say it is an external force and not a part of the natural environment? Fires start from lightning strikes, from the normal pursuits of humans over tens of thousands of years and from deliberate arson—how do we distinguish between natural and unnatural fires, and should we aim to suppress all fires? Succession in some of the spruce, pine and fir forests of North America is totally dominated by the events following severe insect attack—what causes these outbreaks, and are the outbreaks natural or should they be controlled?

These and other questions relating to the nature of disturbance are critical to our understanding of ecological processes and to our management of forests. For example, catastrophic hurricanes in parts of the tropics (including northern Australia) are increasingly seen as part of the natural order which preserves heterogeneity of rainforests. This view contrasts with older ecological theories of succession which were preoccupied with the apparent ‘changelessness’ of large trees—with the notion that the natural progression of succession leads to a stable and self-perpetuating end-state. We are now increasingly aware that there is no such end-state. Forests are dynamic in time and space, and, as with other ecological systems, maximum diversity is reached at some level of random disturbance. Disturbance has its own scales of intensity and frequency and so it provides a range of opportunities for plants and animals, each with its own life history and developmental sequence. Through this interaction, and under the range of environmental conditions (soils, climates, and so on) diversity is created and maintained. The ecologists J.D. Aber and J.M. Melillo conclude that:

Disturbance by fire, defoliation, or other agents is an intrinsic and necessary part of the function of most terrestrial ecosystems—a mechanism for reversing declining rates of nutrient cycling or relieving stand stagnation.4

In many natural ecosystems of the world, natural disturbance by fire has been the dominant force determining evolution and development:

The great majority of the forests of the world—excepting only the perpetually wet rain forest, such as that of southeastern Alaska, the coast of northwestern Europe and the wettest belts of the tropics—

our forests to an intensity where no fire-fighting capabilities of any nation could stop them. We have had these conditions in Victoria periodically through European settlement—the Black Thursday fire of February 1851, the Red Tuesday fire of February 1896, the Black Sunday fire of February 1926, the 1932 bushfires (they do not seem to have been named), the catastrophic bushfire of Black Friday, 13 January 1939, and finally, the Ash Wednesday bushfire—so-called because, ironically, it was Ash Wednesday of the church calendar, 16 February 1983.

Fires like these—through European settlement, through aboriginal settlement, and for tens of thousands of years before—have had a major role in determining the composition, structure and function of Australia’s forests, and the forests are no less ‘natural’ because of it. S.G. Taylor writes:

the present equilibrium vegetation [in Australia] has not been ‘isolated in time’ from the pre-Aboriginal native vegetation of the late Pleistocene. It has descended from this late Pleistocene native vegetation through an unbroken sequence of autogenic and allogenic successional responses to human-generated disturbance and other natural agents of landscape change.⁸

We are part of the natural system and our decisions as to how we treat our forests to suppress fires, to protect old-growth qualities, to harvest for timber and other products are management decisions which will have their own consequences for forest development. Management decisions should be based on the best ecological knowledge of how ecosystems function. Natural disturbance and change are fundamental to ecosystem diversity and sustainability; by our understanding of the processes of disturbance and recovery after disturbance, we should be able to accommodate planned management within the framework of natural disturbance. This theme was expressed by T.C. Whitmore, writing about tropical forests⁹:

... [they] are a renewable resource which can be utilized and still retain their diversity and richness for mankind’s continuing benefit; but only if we care to learn enough about how they work, and also, if, as has been repeatedly stated, utilization takes place within the limits of the forest’s inherent dynamic processes.


be prepared to use both prescribed fires and natural lightning fires in landscape management.  

The example of the Mediterranean-type heathland also illustrates a general ecological principle—that maximum diversity is reached at some intermediate level of disturbance. As managers, we should be able to define the size of disturbance, the frequency of disturbance and the intensity of disturbance so that diversity is maintained. If we now switch our attention to disturbance in forests, we can see the whole range of disturbance—some forests regenerate in small gaps created by treefall (many tropical rainforests, for example), whereas other forests regenerate only after extensive disturbance of stand-replacing magnitude. A number of our eucalypt forests fall into this second category, and I will use the fire ecology of *Eucalyptus regnans* (mountain ash) to illustrate the point.

Mountain ash is the world's tallest flowering plant. It forms quite extensive tall open-forests or wet sclerophyll forests in temperate, wet parts of Victoria and Tasmania. It is a fire-climax species; there is no regeneration beneath the forest. Fire of stand-replacing intensity kills the trees and exposes the mineral soil onto which the seeds, protected in small woody capsules from the heat of the fire, fall a few weeks later. The seeds germinate in their millions and competition for survival begins in earnest. By age three years, there may be 60,000 to 100,000 stems per hectare; competition reduces the number to about 2,500 stems per hectare at 10 years and to about 20 at 250 years. Under these conditions, the forest remains even-aged and thus there are extensive areas of even-aged mountain ash. They are often referred to by the date of the fire from which they originated—we speak, for example, of the '39 ash' (the mountain ash forests which regenerated after the 1939 bushfires). Sometimes there may be two, or at the most three, age-classes where subsequent fires have provided the right conditions for regeneration without killing the previously established trees.

Ash forests (mountain ash and similar species including alpine ash, *Eucalyptus delegatensis*, and shining gum, *Eucalyptus nitens*) cover some 480,000 hectares of public land in Victoria (about 10 per cent of the total forested public land). About one-third of the area of ash forest is within parks, catchment reserves and other reserves. The remaining 316,000 hectares has been deemed through the various land-use planning procedures as State Forest, available for the sustained production of high-quality timber; of this, 34,000 hectares is not suitable for timber production and 53,000 hectares cannot be harvested under the prescriptions set out in the Victorian Government's Code of Forest Practices. Thus management of the ash forests for timber production is currently based on a little less than one-half the area of ash forest, the remainder being managed for other benefits, among the most important being high-quality water for the city of Melbourne.

Over the past 30 years or so, the ash forests legislated as available for timber production have been logged by clear-felling and burning, and seed is broadcast over the burned soil—in other words, the silvicultural system is at the intensity of stand replacement. This system has been one of the most successful and we therefore have scattered through the Central Highlands of Victoria small cutting areas, or coupes, of forest which have regenerated following clear-felling and burning, and these coupes form a mosaic of age classes.

Much of my research over the past 10 years has been in ash forest at Britannia Creek between Warburton and Powelltown, Victoria. The forest was killed by the Ash Wednesday bushfire of 1983; the regeneration of this forest has provided a valuable opportunity to study processes of recovery of mountain ash after fire. The study includes recovery of forest on a logging coupe; the coupe was logged over the summer of 1982-1983, one of the worst drought years on record in south-eastern Australia. The Ash Wednesday fire that burnt through the surrounding forest also burnt through all of the logging slash, piled high in the coupe, with tremendous ferocity.

One of the assertions used against commercial harvesting of eucalypt forests is that clear-felling and burning cause a loss of nutrients and that this loss is critical to sustained productivity of the forest. One way of testing this statement is to set up a depletion experiment in reverse. That is, we add nutrients and measure the effect of this addition on growth. If the addition of nutrients causes an increase in growth, then it might be argued that the ecosystem is at a threshold of nutrient limitation, and that any depletion of nutrients will result in a decrease in growth. A fully-replicated depletion experiment was set up on the burned and logged coupe at Britannia Creek with additions of nitrogen up to 1,000 kg/ha and of phosphorus up to 500 kg/ha. The maximum rates of addition are much greater than the amounts which could have been lost from the

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ecosystem by harvesting, by volatilization and by leaching following disturbance. Nitrogen and phosphorus were added separately, together, and in combination with all other nutrients known to be essential for plants. There has so far been no net response in forest growth, and so we conclude that logging and burning have not caused a decrease in productivity. We have further concluded that mountain ash is highly resilient to disturbance; the rate of productivity of the forest at Britannia Creek is among the largest reported in the world. It is much more productive than tropical rainforest, and is only equalled by the most intensive tropical tree plantations. Furthermore, there is no evidence of marked change in the composition of the understorey plants in ash forest following clear-felling and burning, and many of the mammal species found in older forests can be found in regrowth forests which have resulted from logging or from burning over the past 50 years. One of the main problems in managing the ash forests for timber production is to provide a habitat which is appropriate for the range of mammals and birds which nest in hollows in large trees. The approach in managing for Leadbeater's possum is to set aside from logging those areas of high habitat quality—areas which have a number of nesting trees together with a dense understorey of acacias on which the possum feeds. The 'Ada River Block', not far from Britannia Creek, includes 6,763 hectares of mountain ash forest, of which about 57 per cent is of harvestable age. Prescriptions under the Code of Forest Practices exclude 33 per cent of this harvestable-aged forest from logging, and recommendations for the management of Leadbeater's possum would exclude a further 9.7 per cent.

From all of this, I conclude that we can manage our forests for all of the benefits they provide within the framework of the changing structure and composition which comes from natural disturbance. We could never expect that this bit of forest will be exactly the same as that bit of forest, no matter what efforts we put into its management. And in any case, what is our yardstick? Australia (or any other country for that matter) has never been covered in old growth forests, tranquil, changeless and eternal—that is romanticism, not ecology. And are we to say that our ash forests are more degraded or less natural now relative to, say, 50 years before the coming of European man? At that time, we presume that huge fires ravaged the Central Highlands of Victoria, and the ash forests which originated from these fires were mostly burned in the devastating fires of 1939. Fortunately, some of these forests which were not burned still remain as magnificent 250-year-old forests in the catchments of Melbourne Water.

Of course, the ways in which we see and value our forests are as much an issue of social attitudes and acceptability of outcomes as they are an issue of science and ecology. In this sense, even conservation means different things to different people. John Passmore's conservationist 'has no doubt that civilization ought to continue ... what the conservationist opposes is not the harnessing of nature for (society's) economic purposes, but carelessness and wastefulness in doing so'. This conservationist is a humanist, believing in the wise use of resources for the benefit of people. Passmore differentiates between conservation—saving natural resources for future conservation through wise husbandry and utilization today—and preservation—saving natural resources from damage, destruction, extinction. The popular image of conservation today is undoubtedly that of saving from and there is no shortage of ecological disasters around the world where saving (species, diversity, habitat) from imminent disaster is desperately needed. Indeed, in the early part of this century, foresters around the world were often titled 'conservators'—their job was both to manage the forests for timber and to protect them from devastation as new frontiers were opened and demands for agricultural lands increased—the very problems that we are seeing today with the destruction of tropical rainforests in places like Brazil.

But forest destruction and the threatened extinction of species and loss of diversity does not follow from well-planned and conservative utilization of forests for the benefit of people; these are disasters which result from greed and exploitation. Many people therefore feel that we have abused Nature and so a new, more spiritual way of thinking has developed—a 'deep ecology' which seeks to right the wrongs. It is 'life-centered rather than human-centered ... an ecology which recognizes the interconnectedness of all life.'

12 And see Passmore's (ibid. page 73) inclusive summary of forestry issues: 'On a particular issue, conservationists and preservationists can no doubt join hands ... But their motives are quite different; the conservation of forests has his eye on the fact that posterity, too, will need timber, the preservation hopes to keep large areas of forest forever untouched by human hands. They soon part company, therefore, and often with that special degree of hostility reserved for former allies.'
Peter Attiwill

How we as a society view our forests will determine the path of conservation—conservation for or conservation from—for the future. My view is that the ecological framework of natural disturbance and the knowledge of its component processes and effects provide the basis on which we can manage our forests as a renewable resource which can be utilized so that the forests retain their diversity and richness for mankind’s continuing benefit.14 We can do this in the ash forests of south-eastern Australia (for example) and include in our benefits the high quality timber it yields—high-quality timber for which there is world-wide demand and which will never be produced economically from plantations. But nowhere in the world is conservative management of forests as a renewable resource more desperately needed than in the wise husbandry of tropical forests for the protection of the forests, its peoples and their cultures.

Concluding Comments

Forests are a renewable resource, and disturbance and change are fundamental to their diversity and sustainability. With the knowledge and understanding of processes of disturbance and recovery which come from ecological research, forest management can embrace both diversity and the sustainable yield of forest products.

The Prime Minister, Mr Paul Keating, recently called for policies of sustainable management of forests and fisheries in the South Pacific region. The thesis of my paper is that we already have the sound basis of ecological research in many of these ecosystems to be able to implement policies of sustainable management. Why do we not hear more of this research from ecologists? We know that most scientists are wary of any political debate about their work. Peters15, however, specifically takes ecologists to task. He writes: ‘Academic ecologists have been trained to approach a (socially relevant problem) by abstracting it; they tend to substitute ‘a pallid, intangible concept for a perfectly good, concrete variable’. I take my conclusion from Peters—ecologists should publicise and analyse the large body of ecological research which has immediate application to sustainable management. Indeed, Peters goes further: he writes that there is a ‘desperate need’ for ecologists to demonstrate that their work is socially relevant and useful. Surely we can do this for renewable resources such as forests and fisheries.

14 Sheldrake (ibid.) would, of course, disagree. He writes (page 180): ‘The knowledge and understanding of the naturalist is generally considered to be inferior to that of the professional scientist. But it seems to me that the opposite is true; the knowledge of the naturalist which comes from an intimate relationship with nature is deeper and truer than the kind obtained by detached mechanistic analysis’. Sheldrake appears to differentiate here between the environmentalist and the ecologist, praising the former and damning the latter with faint praise.

The Ecological Basis of Forest Fire Management in New South Wales

Ross G. Florence
The Ecological Basis of Forest Fire Management in New South Wales

Introduction

The fires of January 1994 in the Sydney region have focused scientific, social and political thinking on the vulnerability of the native forests to fire under extreme weather conditions. This is generating a quest for a better understanding of the relationships between eucalypt forests and fire, and ways of preventing the recurrence of wildfires, or at least ensuring that they may be more readily controlled where and when they do start. Not unexpectedly, the solution most widely advocated is that of periodically reducing the levels of accumulated forest fuels through strictly-managed and relatively mild fires.

Expanded fuel-reduction burning is undoubtedly the most technically- and cost-efficient way of dealing with the problem. However, it is also necessary these days to establish that any use of fire in forest management will be consistent with principles of ecologically sustainable management. This could mean that managed fires of varying intensity must achieve their stated objectives—without affecting, detrimentally, natural species and community patterns, successional and ecosystem processes, or the long-term health and productivity of the forest ecosystems.

Inevitably, people will have widely differing perceptions of the eucalypt-fire relationship, including the role of fire in the evolution of the eucalypt, the reasons for the potential flammability of the present-day forests, and the extent to which managed fire may be justified in ecological and social terms. It is impossible in this paper to address these matters comprehensively. Rather, one ecologically-based perspective of the eucalypt forest-fire relationship is presented, together with an appreciation of ways in which fire might be used in order to achieve a socially acceptable balance between the protection and conservation functions of the forests.
The Origins of the Eucalypt Forests

Some 60 million years ago the Australian continent was still connected to the ancient land mass of Gondwana, and mostly covered by rainforest. It is now mostly covered by eucalypt forests, eucalypt woodlands, shrublands and desert.

During the early stages of continental drift following the breakup of Gondwana, there was a progressive change in climate—sufficient to create widespread vegetational instability, and massive erosion, leaching and weathering of soils. The present-day eucalypt has been seen as an evolutionary response primarily to the decline in soil fertility generated by these events.

The climate began to deteriorate more dramatically around 20 million years ago, and the evolving eucalypt was subject to a new selection pressure—increasing drought. It is one of the more outstanding attributes of this essentially mesophytic plant (that is, one which must transpire water for some part of each day, and hence remain in contact with water in soil) that it has been able to adapt to conditions ranging from the favourable coastal environments to those associated with suitable niches within the shrublands and deserts of the interior.

It is commonly said that the eucalypt evolved in a fire environment—implying, for example, that the lignotuberous habit, the epicormic shoot and thick bark are direct adaptive responses to fire. However, this is not necessarily the case: all of these attributes have biological and adaptive significance in no way related to fire. Nevertheless, fire has long been part of the Australian environment and, as a critical selection pressure, has undoubtedly contributed to the eucalypts' capacity both to survive and respond to intense fires. Fire would have become a common element in the Australian environment perhaps 20 million years ago, accelerating the transition from the increasingly fragile rainforest to eucalypt sclerophyll forests and woodlands. Greater amounts of charcoal in the deposition profiles of Lake George (near Canberra) may be linked with an increasing incidence of fire nearly 2 million years ago, and a further increase early in the Aboriginal era when all fire-sensitive and moisture-demanding plants of the cool temperate rainforest finally disappeared.16


Against this background, many of the attributes of the present-day eucalypt may have their origins in the evolutionary processes which generated its adaptation to a range of environmental stresses: poor soils, drought and fire; and the mosaic of species and communities which characterises the forests may be a product of the 'ecological sifting' of a large number of species by site factors (particularly the nutrient and water status of the soil), and fire.

The emphasis placed on site and fire, respectively, in interpreting vegetation patterns in the Australian forests may always be a matter of personal interpretation. One of Australia’s early foresters (and Commissioner for Forests in NSW) had no doubt about the role of fire in the landscape:

Blackbutt, however, is a fast-growing, aggressive species, wide-rooting, wide-branching and greedy of moisture. In the moist hollows it is beaten out by the jungle invasions, becomes faulty, and gradually falls out. On the slopes it has an advantage over the tenderer jungle trees in its greater hardihood, and this advantage is made binding by the incidence of bush fires. Blackbutt above the sapling stage is fire resistant. It drops limb-stocks, frutious twigs, leaves and bark strips abundantly, and provides ample fuel for the confusion of would-be competitors. By these means it stays the development of succession and establishes itself as a fire subere of some stability, itself regenerate strongly from the ashes of bush fires which have eliminated its competitors.17

While the blackbutt–environment relationship is undoubtedly more complex than this view implies,18 Swain has evocatively demonstrated the way fire has helped mould the Australian vegetation and landscapes.

The Conditions of the Forests at European Settlement

When the Europeans arrived in Australia the eucalypt forests had, by many accounts, a 'woodland structure', that is, large-boled, wide-crowned, widely-spaced trees over an open and largely grassy forest floor. A description from the journal of John White, surgeon with Captain Arthur Phillip, is typical:

After we had passed this swamp we got into an immense wood [Frenchs Forest], the trees of which were very high and large, and a considerable distance apart, with little under or brush wood. The ground was not very good, although it produced a luxuriant coat of a kind of sour grass growing in tufts or bushes, which, at some distance, had the appearance of meadow land.\textsuperscript{19}

It is widely presumed that the open grassy forest floor was a function of regular, light burning by Aborigines—and undoubtedly this was an important contributing factor. However, the forest condition may also be attributed, in a more fundamental way, to the biological attributes of the eucalypt forests, and the natural successional processes within them.\textsuperscript{20}

\textbf{Natural Succession Processes in Eucalypt Forests}

Consider the impact of a single severe wildfire which kills or critically weakens a patch of old-growth trees dominating a grassy forest floor (Fig 1).\textsuperscript{21} Eucalypt seed will fall from the scorched crowns, and eucalypt seedlings will grow rapidly on the burned forest floor. At the same time, the heat of the fire will stimulate the germination of seed of ‘understorey’ species which had persisted in the soil since the last major conflagration—perhaps several decades, or even a century or more before. Wattles, casuarinas and many other species may now be components of a dense stratum of shrubs through which the eucalypts are emerging.

As the eucalypt regeneration gains height, self-thinning (natural mortality) will begin, rapidly at first and then more slowly, and continue until segregation into wide-spaced trees is complete. There will also be a rapid early decline in the density, diversity and cover of shrubs, and eventually, their replacement by a grassy forest floor. While this successional process is quite independent of fire, an occasional light fire may accelerate it. Were a more intense fire to burn through the forest, it might re-stimulate the development of a vigorous shrub stratum. Based on the accounts of the early forests, fires of sufficient intensity to generate a shrubby understorey might have been infrequent events. Possible reasons for this are discussed later.

\textsuperscript{19} Quoted from D. Ryan, ‘The original forest’ [Special wildfire section], Australian Forest Grower, Summer 1993-94, 16, (4).


\textbf{Figure 1:} Successional process in an alpine ash forest. As the stand develops following an intense fire, a complex shrubby understorey (years 0-50) is replaced by an open grassy forest floor (years 50-150). The successional stages restart following subsequent fires.

The rapid break-up of a fire-generated shrub stratum may occur only where there is a complete and strongly competitive eucalypt overwood. Shrubs will be more persistent where the overwood is not complete, or in rocky niches, or where succession to the open forest floor is truncated by continuing disturbance.

This successional model may also be appropriate within wet sclerophyll forests. For example, the density of thickets of fire successional species within the karri forest may reach a peak three to five years after a fire, after which there is a gradual transition to a more open, grassy understorey with occasional clumps of long-lived shrubs.\textsuperscript{22} This transition may take more than 20 years. And within the tall moist mountain ash forests, succession towards more open stands may occur as a fire-generated understorey of \textit{Pomaderris aspera}

\textsuperscript{22} R.J. Underwood, ‘Natural fire periodicity in the karri (Eucalyptus diversicolor) forest’, Forests Department, W.A., Research Paper 41, 1978.
is replaced, over many decades, by tree ferns and a ground stratum of ferns, rather than grasses.23

**Biological Basis of the Successional Process**

The processes by which overstorey trees control the understorey vegetation may be related to those attributes which enhanced the eucalypts' adaptation to low soil nutrients and drying soils in the first place. The eucalypt is very efficient in taking up nutrients when available in an infertile soil, and conserving and recycling them within the tree. Consequently, the leaf litter which falls in large quantities has a very low nutrient content, as has the large component of woody materials (twigs, bark, capsules) within the litter. There are components of this litter which are resistant to decomposition, and when incorporated into the soil organic matter may adversely affect the soil microflora and processes of nutrient cycling.24 Under these conditions there may be insufficient nutrients to maintain all ecosystem components beyond the rapid growth phase, and the shrubby understorey may decline.

The decline of the understorey might also be related to the eucalypts' water use characteristics, and a capacity to compete strongly for soil water in limited supply.25 The trees may dry out the surface soil, and then depend on root systems which can tap water at increasing depths. Unless the understorey species are particularly drought resistant, they may succumb as the rapidly developing stand reaches a point of peak water demand. This may be around 20 to 30 years in stands of fast-growing species, that is, around the point of peak stand volume production.

Yet again, there are claims that eucalypts compete directly with other plants by releasing chemicals from leaves or roots which are inhibitory to those plants.26 This is a common assertion in many overseas countries where eucalypt plantations may have very little understorey, and rows of trees may inhibit adjacent crops. However, for the present, direct chemical competition remains an unproven hypothesis.27

The notion that the eucalypts themselves are substantially responsible for the open grassy condition of the early forests is not altogether new! The Australian explorer and naturalist, Charles Sturt, put it this way:

'It has been obvious to me ... that in New South Wales, the fall of leaves and the decay in timber, so far from adding to the richness of the soil, actually destroy minor vegetation ... Thus it would appear that it is not less to the character of its woods than to the ravages of fire that New South Wales owes its general sterility.'28

It remains impossible to establish the extent to which the natural successional process on the one hand, and burning by Aborigines on the other, contributed to the condition of the forest floor at settlement. However, this is not a question of immediate concern in the context of this discussion. Whatever the processes involved, the important point is this: the present-day forests differ appreciably from those at the time of settlement, and the changes are responsible in large measure for their greater flammability under extreme weather conditions.

**The Impact of Wildfire Following European Settlement**

Few eucalypt forests (and this includes virgin forest in national parks and wilderness areas) can be said to be in a natural condition—where 'natural' refers to the forest condition at European settlement. The forests may no longer have the distinctive woodland structure of the past. There may now be greater structural and floral diversity—incorporating a generally incomplete and irregular upper canopy, residual and often deeply fire-scarred old-growth trees, patches of regrowth trees in varying condition and development stages, a more persistent shrubby understorey, and a greater accumulation of litter materials.

This condition may be attributed, in the first instance, to the long era of uncontrolled wildfires which followed European settlement.

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28 Quoted from D. Ryan, 'The original forest', [Special Wildfire section], *Australian Forest Grower*, Summer 1993-4, 16, (4).
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As settlement spread out through the coastal forests and along the valleys which penetrate the coastal escarpments and mountain ranges, the surrounding forest was regularly burned to protect the pockets of cleared land from wildfires, to enhance access, to provide relief grazing for stock in dry periods, and so on. Sometimes these became major confabulations which did considerable damage to the forests.

A historical fire pattern has been determined for the snow gum forest through tree ring and fire scar analysis.\(^{29}\) This pattern (Fig 2) suggests that before European settlement there was only limited burning at an intensity sufficient to cause fire scars, probably associated with lightning and the annual Aboriginal visits to the high country to harvest the bogong moths. At this time the forests would have had for the most part a distinctive woodland structure, with a grass-herb ground flora. Europeans began to have some impact on the vegetation from about 1820, and this accelerated between 1850 and 1870 when the fire frequency increased appreciably. Fires were now lit regularly, progressively deepening fire scars, weakening the canopy trees, creating and maintaining a shrubby understorey, and in this way greatly increasing the flammability of the forest under extreme weather conditions. It was not until around the middle of this century that fire control activities began to have an appreciable effect, and the fire frequency declined.

![Figure 2: The frequency of forest fires (of sufficient intensity to scar tree boles) in the snow gum forests of the Southern Highlands—from about 1760 to 1970.](image)


The Ecological Basis of Forest Fire Management

Some perspective of the impact of fire on the forest condition early this century is found in the writings of D.E. Hutchins, a former Conservator of Forests in South Africa, who reported on the status of Australian forestry in 1916.\(^{30}\) He observed that

If there were no forestry in Australia beyond mere fire protection the benefit to the country would be incalculable.... The ravage of fire is the first thing that strikes the forester on seeing the Australian forest.... Every Australian is familiar with the spectacle of the burnt forest, every traveller tells the tale of the monotonous scene of ruin.

The Complete Protection Philosophy and its Consequences

Modern forest services were formed in most States around 1920, and a long battle began to limit the destructive impact of recurrent wildfires, and to bring some semblance of order to a pretty chaotic scene. The forest services adopted a policy of complete protection for their State Forests. Complex fire-break systems were constructed around and within the forests, fire surveillance towers were built, fire attack standards developed, and campaigns begun to change the attitudes of rural landholders to the practice of annual burning of their "rough pastures"—a common cause of forest fires. Despite the considerable scepticism that recurrent forest fires could ever be properly contained, there was a measure of success in reducing the frequency of wildfires.

The complete protection philosophy may, in the event, have been counterproductive. The era of uncontrolled fires destabilised the forests and their natural ecosystem processes, and where subsequently protected from fire there was a rapid build-up in forest fuel loads. This resulted, in turn, in a series of serious and sometimes catastrophic fires, in all States. Possible reasons for the increase in fuel loads and the greater vulnerability of the forests to fire are explored below.

Fuel loads in pre-settlement forests

The amount of litter which accumulates on the floor of the old-growth forest may be appreciably less than that which accumulates at earlier growth stages. Where regrowth develops following a severe perturbation, the forest floor biomass builds up rapidly to a point of

peak fuel energy storage during the forest’s rapid early growth stage. This point may be as soon as 35 years in stands of fast-growing species. Beyond this point there will be a progressive reduction in the forest floor biomass as wood volume production and the rate of crown expansion and litter fall decline, as the shrubby understorey breaks up, and as the litter accumulated at the point of peak energy storage is incorporated into the soil organic matter.

It may be this natural successional process—as much as burning by Aborigines—which limited the build-up of forest floor fuels before European settlement, and hence the frequency of more intense and damaging crown fires.

Fuel loads in the protected forests

As the uncontrolled fires of the post-settlement period damaged the forest ecosystems, the deeply fire-scarred old-growth trees could no longer exert strong site control. Eucalypt regrowth developed either in small patches or more extensively throughout the forests, generating an increase in litter production and hence fuel loads. Fire-stimulated shrubs were now more persistent, constituting a further significant source of potential flame energy.

The concomitant deposition of leaf litter and leaf-bearing branches within the eucalypt forests (particularly during the rapid growth phase) can result in a loosely packed and well aerated forest floor. More oxygen will be available for initiating and maintaining flaming combustion and transferring heat energy than might be the case in other forests with similar levels of litter accumulation. Moreover, leaf litter, twigs and bark held in the shrub foliage can carry fire along tree boles, more readily generating crown fires and long-distance initiation of spot fires ahead of a main fire front. Thus despite the best efforts of the forest services to protect their forests, the stage was set for fires of catastrophic severity.

Given the circumstances of many present-day forests, a more concerted approach to fire management is needed, and this must apply to all forests, irrespective of land tenure. Because few forests are in a ‘natural’ condition (as at the beginning of European settlement), it is unrealistic to argue that forests might be exposed only to natural fire events, or managed on a ‘let it burn’ basis. There is a social imperative to reduce the risk of catastrophic events on all


forests, by reducing the fuel loads they carry, and in this way, better achieving conservation objectives.

This should not be seen, however, as advocacy of indiscriminate or widespread burning of the total forest area. An appropriate management strategy will be that which seeks to balance a number of production, conservation and protection objectives, and this is discussed later. But first, it is necessary to ask whether extended use of prescribed or managed fire will represent an acceptable trade-off between the conservation and protection objectives set for the forests. This question is addressed below.

Responses of the Forest to Managed Fire

Fire can be used as a tool in forest management in a number of ways. Relatively mild fire may be used to reduce the accumulation of forest floor fuels, for example, on a cycle of five to seven years. Fires of greater intensity may be used to reduce the amount of logging debris after harvesting, and create an effective seedbed for regeneration. This may be done only once each 60 to 100 years. And fire may sometimes be used in more specialized ways, for example, to help maintain essential components of habitat for some of the forest wildlife.

There are some people who will reject the use of fire under almost any circumstances. They will not recognize the fuel-reduction fire as an acceptable means of ensuring a safer forest, or the more intense burn as a legitimate means of maintaining its productivity. They will believe that almost any fire must damage forest ecosystems and are prepared to live with the risk of larger conflagrations. However, the impacts of fire are certainly not all detrimental, and indeed, some may be beneficial in helping to maintain dynamic and healthy ecosystems. It is necessary to consider the various ways in which the forest responds to fire in order to develop fire-management strategies and practices which will help balance the objectives set for the forest.

There are many potential responses to fire. Those addressed in this section relate to:

- species diversity;
- ecosystem nutrients;
- stand dynamic and ecosystem processes; and
- the maintenance of wildlife habitat.
Species diversity

The concept of ecologically sustainable management implies that logging and fire will have little detrimental effect on the composition of the forest and the natural plant succession processes. While there will inevitably be some change in the understorey following a fire, the eucalypt forest appears to be well buffered against loss of species diversity.

There has been no evidence of any decline in plant species diversity after several cycles of fuel-reduction burning (either in autumn or spring) in Western Australian forests. Indeed, it is fire exclusion for more than 15 years which reduces above-ground species diversity. Similarly, there were minimal changes in the total species composition of the understorey following harvesting on two East Gippsland forests—with or without fairly intense follow-up slash burning. However, as expected, there were short-term changes in the ground cover and abundance of individual species. It was concluded that from a floristic standpoint, some areas might be burnt and others left unburnt. In a similar study in the Eden area forests (NSW), site factors (particularly aspect) had a greater effect on tree species composition than either logging or wildfire twelve years earlier; and the treatments (logging, wildfire) again affected the frequency of understorey species, but not the presence or absence of those species.

While occasional intense fire may help maintain the diversity and density of understorey plants, the regular fuel-reduction burn might not. Milder fires may not be sufficiently intense to stimulate the germination of soil-stored seed (although this seems to vary with the forest type and soil dryness at the time of the fire), and some of the shrub species which can reproduce vegetatively may progressively weaken and die. Indeed, it will be one of the objectives of the fuel-reduction process to lower the risk of catastrophic fire by creating a more open forest floor in this way.

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32 P. Christensen and I. Abbott, 'Impact of fire in the eucalypt forest ecosystem of southern Western Australia: a critical review', Australian Forestry, 52, 1989, pages 103–121.

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Ecosystem nutrients

Some loss of nutrient from a logging coupe is inevitable during an intense slash-disposal fire—through volatilization, particle transfer in smoke, and as ash in wind. The potential seriousness of this generated a brisk debate in the early 1980s and, subsequently, a number of studies on the impact of both harvesting and intense slash-disposal fires on the total ecosystem nutrient pool.

There appears to be a consensus from these studies that nutrient depletion associated with logging and slash-disposal fires might become critical in time, but only after several rotations (and this could mean at least 200 to 300 years), and mainly on soils of low to moderate fertility. Thus there may be no immediate threat to site productivity and sufficient time to assess fully many of the factors relating to forest nutrient for the long term. In any case, potential problems are likely averted by avoiding fire altogether on lower quality sites, and creating seedbeds through a mix of mechanical (tractor) disturbance of soil on some higher quality sites, and fires of moderate intensity on others.

A case study (Box 1) illustrates the outstanding resilience of eucalypt forests which have been burnt by wildfires, salvage-logged, and subjected to a second wildfire of great intensity 8 to 28 years.

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later. The second fire totally destroyed the young regrowth created by the first. While this resilience, of course, does not justify excessive use of fire, or any poor standards of management practice, it may help support the view that where fire is integrated into management in a conservative and well-planned way (including periodic fuel-reduction burning), it is highly unlikely to have an early and adverse impact on the forest ecosystem.

**Box 1: Response of a eucalypt forest to harvesting and two devastating wildfires**

1. In 1980 a very intense wildfire burned through young regrowth in the Eden area of NSW. Some of the regrowth had itself developed following previous wildfires in 1952, 1964 and 1972, respectively, and follow-up salvage logging of the damaged forests. The 1980 fire created a 'scorched earth'—killing the above-ground parts of both the eucalypt regrowth and the understorey over a very large area.

2. There were fears at the time that given the infertile soils of the region, full recovery might not be possible on many sites. However, this has not been the case. Coppice shoots developed from the below-ground parts of trees insulated by the soil, and understorey species regenerated vegetatively or from soil-stored seed.

3. The vigour of the post-1980 regrowth has been impressive. Height and diameter growth of coppice stems has exceeded that of the regrowth stems they replaced, and on one lower quality site (the 1964 regeneration area) the regrowth is no longer in a stagnant condition. The largest coppice stems were over 50cm dbh (diameter at breast height) in 1993 (representing 2.5 cm diameter growth per year), and average diameter growth is in the range 1.5 to 1.9 cm per year. There is a dense and at times diverse understorey, and some faunal species (including the common ringtail possum and bandicoot) are already colonizing the new regrowth.

**Stand dynamic and ecosystem processes**

Some forests seem to become stagnant in the long-term absence of disturbance. This may be due to the limitations imposed by the forest itself on the soil biological condition and processes—as discussed earlier. Fire (often relatively intense fire) may act to stimulate those processes. This may be expressed in two main ways.

The rate at which tree boles grow in diameter can actually be greater for a period after a fire. For example, this was recorded where an experimental spotted gum forest in Queensland was burned for the first time in eight years. An early suggestion of a link between tree growth and fire was that relating 50 years of fire protection in the jarrah forest of Western Australia with loss of tree vigour. Indeed, there has been argument about the appropriate intensity of fuel-reduction fires within these forests. It may take a fire of crown-scorching intensity to improve subsequent crown vigour and stimulate the diameter growth of the tree boles. It would be necessary, of course, in determining a fuel-reduction regime, to take into account the way the more intense fire may damage and reduce the commercial value of tree boles.

The stimulation of the forest ecosystem following a fire of moderate or greater intensity may be related, in part, to a large component of soil-improving (nitrogen-fixing) species within the developing shrubby stratum. These include the ubiquitous wattles. The development of a soil-improving understorey following periodic fire may contribute nitrogen to the ecosystem, accelerate the rate at which the eucalypt litter decomposes, stimulate a more diverse, active and healthy microflora, and, through this, more vigorous tree growth.

The role of a fire-generated wattle understorey may sometimes go beyond this. It has been suggested that the activity of the dieback organism, Phytophthora chlamydom, may be reduced where a moderately intense fire stimulates the germination of the wattle, Acacia pusilla, within the jarrah forest. The wattle may inhibit the disease organism directly, or, through its influence on the soil, generate a more active and competitive soil microflora.

**The maintenance of wildlife habitat**

An intense wildfire may be highly damaging to the forest wildlife; it may take several decades for arboreal (tree-dwelling) mammals to recolonize the forest as the regrowth reaches specific development stages. Nevertheless, in managing the eucalypt forests, fire may be used, in suitable circumstances, to enhance the quality of wildlife habitat.

The role of fire in maintaining habitat for ground-dwelling mammals is well appreciated in Western Australia. For example, while the

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37 C.A. Gardner, 'The fire factor in relation to the regeneration of Western Australia', Western Australian Naturalist, 5, 1957, pages 166-173.
38 P.C. Kimber, 'Increased growth increments associated with crown scorch in jarrah', Forests Department, Western Australia, Research Paper No. 37, 1978.
woylie population may be severely reduced by fire, it will reach stable pre-fire levels only 4 to 5 years after fire; this results from an increase in food supply and emigration from unburnt surrounds.

Tammar wallabies require dense scrub thickets for shelter, and grass and other green foliage for food. These thickets generally degenerate naturally around 25 years of age, and need fires to regenerate them. The Department of Conservation and Land Management has adopted the strategy of using intense autumn burns, on a rotation of 20 years, to maintain thicket patches. Other examples include the use of fire to aid the hollowing of fallen logs which the numbats require for cover and to create a fuel-reduced buffer around areas of significant mardo habitat. The mardo feeds on insects which occur only within a deep litter layer.

The use of fire to create shelter and provide protection from the fox and other predators, and to increase food supply, is undoubtedly relevant to many ground-dwelling mammals in the eastern Australia forests.

Periodic fire may also help maintain habitat for those arboreal mammals which use hollow old trees for shelter and nest sites, but are especially understorey feeders. For example, the wattles may be an important source of food for Leadbeater’s possum, the common ringtail possum and the sugar glider. It should be possible to maintain a vigorous wattle stratum through periodic use of fire of moderate intensity.

The response of the forest to fire—a management perspective

It may be concluded from this section that managed fire will not only be vital in reducing fuel loads within the present-day forests, but may also be used to enhance the biological diversity within the forest, and help maintain dynamic and ecosystem processes. Despite this general conclusion it cannot be claimed that there is a complete understanding of the long-term biological consequences of either regular fuel reduction or more intense burns. Thus, fire should not

only be used in a highly planned and skilled way, but it will also be appropriate to establish procedures for monitoring its long-term effects.

Fire-Management Planning

Modern resource management is essentially about balancing a number of often competing objectives. Thus in projecting a greater focus on fire management (which will incorporate extended use of the managed fire), it is certainly not intended that fuel-reduction burning, or any other use of fire, should override other important objectives of management.

In a broad sense, forest resource management might try to balance three important objectives:

- protection against highly damaging wildfires;
- conservation of biodiversity generally, and environmentally significant forests in particular; and
- the continuing supply of wood to industry.

Because forests have different tenures, and will differ in environmental attributes and significance, no single fire-management regime will be appropriate to them all. Each forest must be considered on its merits, though in the context of a wider strategy for fire protection.

Fire-management planning may be approached at two levels.

The regional level

A regional plan for forestry may be based on a biological resource assessment, and a review of the way the forest is allocated to conservation and production functions, respectively. Multiple purpose objectives might also be determined at this planning level for each of the wood-production forests. Regional assessment is now an essential procedure for establishing security of forest tenure for the wood-using industries.

Ideally, formulation of a fire-management strategy will be part of the regional planning process. The strategy might identify the attributes of climate and weather, topography, access, land ownership, land use, and forest conditions contributing to potential fire hazards within the region. The strategy may be broadly acceptable and fully

effective only where land in all tenures is considered within a single planning framework (national parks, State forests, all other Crown lands, and cleared and forested lands in private ownership). The strategy might identify the responsibilities of all participants, and the contribution each will make to reducing the frequency of wildfires, and containing the spread and intensities of fires where they begin.

The forest level

Fire-management plans for individual forests will be consistent with the objectives and priorities for that forest set at the regional level. It will recognize the particular environmental values of the forest, and explore ways of conserving them—while reducing, as far as possible, the risk of wildfire through fuel-reduction burning. It may be necessary to establish, at the regional level, minimum standards for fuel reduction and other protection activities to apply to all forests.

The forest plan might create a series of zones where different burning regimes will apply. There may be areas of forest where every attempt is made to ensure complete protection from fire in any form. Where managed fire is to be used, both the frequency and intensity might be varied. There may be a general fuel-reduction zone where standard regimes apply, for example, lightening from roads or trails or from helicopters at five-year intervals. Yet other zones may be scheduled for burning at wider intervals, perhaps at higher levels of intensity. And there may be zones where burning regimes are designed to achieve a number of objectives, for example, to reduce the immediate fire hazard, to help stimulate ecosystem processes, and to maintain shelter and food sources for wildlife.

This planning may be best done by a team representing a range of interests, and including, preferably, a 'champion' for each of the 'key resources' and management objectives (fire protection, timber production, biological resource conservation, water protection and so on). It also must follow that fire-management strategies and regimes should be formulated by skilled professionals, either drawn from all relevant public and private sector institutions, or operating within some independent planning authority.

It is not an objective of this paper to pursue possible administrative arrangements further. Rather, it has sought, primarily, to focus on the condition of the forests and reasons for this, and to project the fundamental and ecologically-based need for a more comprehensive and integrated approach to forest fire management in New South Wales.

Conclusion

This paper has not addressed specific questions of fire management relating to more specialized circumstances—such as the forest-urban interface. Nevertheless, the ecological and fire-management principles, as espoused, will be broadly applicable in most situations. It will be the objectives and priorities set for the forests, and the level of planning and intensity of management needed to achieve them, which will vary from place to place.

It is recognized that in advocating a more comprehensive approach to fire management, including wider use of fuel-reduction burning, there are still inadequacies in the understanding of the eucalypt forests, and the impacts of fire, of varying intensities, on them.

However, it may be inappropriate (and probably dangerous) to delay decisions on more comprehensive fire management until every research 'i' is dotted and every 't' crossed. The resilience of the forest—as expressed in its recovery from the excesses of the past, suggests that any biologically-unacceptable impacts of managed fire may take a long time to develop, and there should be sufficient time to resolve the questions these generate. In any case, where the 'precautionary principle' applies, fire-management strategies and burning regimes might be modified where problems (both social and biological) are perceived to arise. It follows that wider monitoring of the effects of managed fires (including fuel-reduction and regeneration burns), must complement any extension of their use in forest management.
The Politics of Bushfires:
Can We Learn From Past Mistakes?

W.F. Hurditch and W.J. Hurditch
The Politics of Bushfires

Bushfires represent a fundamental contradiction: the best way to fight them is to light more fires. If we fail to grasp this, we risk killing our forests with care...44

Introduction

The divide between city and country in Australia is growing greater every year. What really happens 'in the bush' is becoming more and more of a mystery to city people, even though *Crocodile Dundee* images make us feel as though we understand country Australia. The severe bushfires which gripped New South Wales in January 1994 brought out the worst of fears in people living in some of the most urbanised parts of Australia. The leafy, bushland settings of Sydney's affluent North Shore became nightmare fire traps, and expensive houses gave way to the flames.

As frightening as the experience of such fires is, it is surprising that we haven't learnt to cope with bushfire, and avoid such losses of life and belongings. We have a sophisticated bushfire-fighting system, well-equipped with well-trained personnel. We have laws which require appropriate caution in managing bushland environments. We have a well-recorded history of fire. But Australians continue to suffer substantial losses from bushfires. And the evidence suggests such losses are increasing rather than decreasing with each major bushfire crisis.

This paper analyses some of the factors which shape and direct our bushfire environment. Some of these are natural factors, but more of them are social, organisational and political. The aim of the paper is to inform and stimulate debate on the changes which need to be made if Australians are to live more harmoniously with bushfire in the future.

Australian Bushfire History

Bushfire is an inevitable part of life in Australia. The degree of bushfire threat depends upon the type of dominant vegetation growing, the climatic conditions, and the particular landscape of an area. European Australians are having an increasing direct and indirect influence on the frequency and severity of bushfire in Australia.

In the more densely populated areas, coincident with the right natural ingredients, bushfires are often lit by humans, sometimes intentionally and sometimes accidentally. Indirectly, catastrophic bushfires result from poor management, misguided public policy or sheer complacency.

Although bushfires are a constant element in our history and experience, public attention is turned on Australia’s bushfire problem only when large numbers of people are affected or very large property losses are sustained. The recent bushfires in New South Wales gained national and world-wide attention because of their impact on peoples’ lives—particularly in Sydney (see Box 1).

One particular aspect of bushfires in Australia continues to confound long-term strategic plans. It is the periodicity of fires. Extreme bushfire is not a regular incident. If it were so, and we experienced a damaging fire every year or so, we would be much less complacent, and much more competent to deal with the problem. The less frequent the happening, the greater the calamity, confusion, damage and newsworthiness.

This problem of infrequency was highlighted in the recent 1994 Sydney fires. In that case many of the firefighters and others in the emergency services had never before experienced such extreme conditions. They were either too young or not involved when similar fires last occurred. For example, at Como in Sydney’s southern suburbs, around seventy houses and two lives were lost when the fire jumped 800 metres across a waterway. Few would have been able to anticipate that the fire, which was in fact capable of igniting forest up to three kilometres ahead of the main flames, would get out of control so quickly.

Such a limit to experience poses a major logistical problem for bushfire authorities, since it is very difficult to train for or simulate large, and extreme bushfire events. Every time it happens it is heralded as the ‘worst’ in living memory, and public reaction is usually to demand more of the same solutions which, ironically, failed to prevent such losses of life and property. Public policy on bushfire

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Box 1—Case Study of a Bushfire Region: The Sydney Basin

Sydney has a sordid fire history. Since 1952 hundreds of thousands of hectares of bushland and up to one hundred homes each decade or so have been burnt. While the architects of Sydney’s city skyscrapers can be thankful for the foundation the solid sandstone afforded them, those who have built their homes on rocky outcrops above the bush around Sydney, in the Blue Mountains and on the Central Coast, face a periodic risk from rapidly-moving bushfires which most will only experience once in a lifetime. Such fires have the ability to move at two or three km per hour and areas ahead of the flames can be peppered with thousands of wind-borne burning brands, leading to an exponential rate of bushfire spread. The dry eucalypt forests and heath lands of the Sydney Basin have a particular propensity for bushfire. During the 1994 New South Wales bushfires, although there was fire-fighting activity from Batemans Bay on the NSW South Coast to the Queensland border, the major fires were confined to the Sydney and Central Coast areas of the State. Here, dry, flammable vegetation types grow on shallow, rocky soils derived from the Hawkesbury Sandstone, an area of some three million hectares. The Sydney Basin is broken in the west by deep gorges—ideal bushfire conditions.

Fires in bushland around Sydney are not new. An examination of old newspapers will show that every decade or so damaging fires have occurred. In recent times, widespread fires burnt the outer Sydney bushland in 1977, before an escalation of the urban sprawl into the fashionable bushland setting. That year some 180 buildings burnt to the ground in Leura and that was the most newsworthy occurrence. However the 1957 season occurred over two months, not in one week like the recent one. Since 1957 there were major fires in each decade whenever fuel was allowed to accumulate and the weather was right. For example more than sixty percent of Kurring-gai Chase, with its extensive water frontage, was burnt in October 1971, December 1979 and again in January, 1994.

Elsewhere in the Hawkesbury Sandstone fire environment, the pattern is similar. In a developing fire season, this region is often the first along the NSW coast to experience fires because of its well-drained soils and the influence of low atmospheric humidity on the rapid desiccation of its surface fuels. A vital factor is the high population density.

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management and the administration of services clearly need to be cast independently of the knee-jerk clamour during the aftermath of individual bushfire events.

**Bushfire Behaviour**

Australian scientists are world leaders in the study of bushfire behaviour. Their empirical research and field observations have led to the preparation of tables detailing fire dynamics such as the forward rate of fire spread, average flame height and 'spotting' potential (the ability of the fire to jump ahead of the main fire) which can be anticipated under varying conditions of weather and fuel-load factors.

It is therefore possible to predict bushfire behaviour quite reliably (see Box 2). Predictive tools are particularly useful where controlled fire is used to reduce fuel loads in cooler months. When major outbreaks occur, these predictive tools are essential in organising suppression forces.

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**Box 2—Predicting bushfire dynamics**

Most bushfires behave predictably in response to the particular combination of three main factors: fuel characteristics, ambient temperature and wind. The following examples illustrate the effect of typical combinations of these elements on the intensity and rate of spread of fire in the forest.

**Example 1**

A fire in a light fuel load of 10 tonnes/ha in a dry sclerophyll (eucalypt) forest on a relatively cool day would burn at the rate of five metres per hour with a flame height of about half a metre ... a cool and easily controllable fire.47

**Example 2**

A fire in a heavy fuel load of 25 tonnes/ha on a hot, dry and windy day would produce a flame height of 50 metres with a rate of spread in the order of three kilometres per hour. Not including the effect of spot fires ahead of the fire line, such a fire would be impossible to control while the weather conditions lasted. It has been calculated that such a fire has a heat output of such magnitude that every 200 metres of fire edge could provide more than enough power to meet the peak electricity load of Sydney and Melbourne combined.48

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**Bushfire Control Organisation**

In most States of Australia bushfire management and control is organised through a co-operative network of professionals and volunteers. Regions most prone to extreme bushfire, such as the South-West of Western Australia, Central and Eastern Victoria, South-Eastern Tasmania and Coastal New South Wales, have developed well-trained suppression teams organised into local brigades.

Following many decades of locally-initiated, disconnected responses to bushfire control needs, State legislation and centrally-coordinated systems for improved bushfire protection were introduced in the 1970s. These were aimed at co-ordinating the fire fighting authorities in undertaking prevention programmes, planning for emergencies, training and administering funding. Those government authorities with a special land-management role (such as National Parks Services, State Forest agencies, etc.) have special responsibilities under bushfire legislation. For example, in NSW the bushfire protection law provides: ‘It shall be the duty of a council or a public authority to take all practical steps to prevent the occurrence of fires on and to minimise the danger of the spread of fires on or from ... any land vested in its control or management ...’49 The 1980s saw a growing conflict within and between land-management agencies regarding bushfire suppression obligations. Examples and consequences of this conflict are discussed later in this paper.

Organisational models for bushfire management have evolved in response to lessons learnt from past calamities. For example, in New South Wales the current co-operative method of bushfire fighting arose from the ashes of the 1968–69 fire season when ten lives were lost and property-damage records were re-written.

Changes introduced after that devastation included a major drive towards prevention and the introduction of co-operative fire suppression. It is the balance between these two aspects of bushfire management—prevention and suppression—which has excited so much public policy debate since the 1970s.50

49 *Bush Fires Act* (NSW), 1949.

50 'Prevention' refers to management and activity designed to limit the likelihood of major bushfires occurring. Elements of bushfire prevention include controlled or 'prescribed' burn-offs, fire-trail construction and maintenance, surveillance and clearing of undergrowth around houses, etc. 'Suppression' refers to the methods of controlling bushfires once they are alight. Methods of suppression include aerial water-bombing, back-burning and detection and control of spot fires.
Bushfire Suppression

The need for bushfire suppression arose in the early days of European colonisation as the new inhabitants of Australia came to grips with the reality of the fire environment they had adopted. Australia has justifiably been referred to as ‘the burning continent’.51

In looking for evidence of suppression tactics by the original inhabitants of the land, a historical compilation52 shows that in most cases aborigines were cautious in their use of fire—at least in comparison with European thinking. These oldest of our ecologists were clearly aware of its beneficial uses. They availed themselves of fire to such a degree that the entire landscape and floristic make-up of Australia reflects an intense fire history.53 It is thus highly unlikely that there were many examples of today’s high forest-fuel levels in recent pre-European times—or even up to a century ago. Current typical forest-fuel loads are very much a product of our relatively recent fire-exclusion mentality.

In the light of this fire history (and pre-history) we must seriously question whether we should aim at suppressing all fires, especially those that occur in bushland under mild conditions. The inevitable consequence appears to be an increasing number of large conflagrations which are impossible to control. This century, large areas of South-Eastern Australia burnt in 1919, 1926, 1939, 1952, 1957, 1968, 1975, 1982, and 1994. For the State of Victoria, it has been assessed that, in terms of this century’s history, ‘potentially bad fire seasons’ tend to occur about once every 3 years, ‘bad fires’ every 6 or 7, and ‘very bad fires’ every 13 years.54 The ever-increasing area burnt in successive serious bushfires seems to be telling us that something is seriously wrong with the balance between prevention and suppression in current bushfire policy.

But such lessons are very difficult to bring home in the wake of major losses of life and property. The natural reaction of citizens, their leaders and the media is to call for more equipment, more personnel and better suppression techniques—all this despite the scien-

53 See, for example, P.H. Nicholson, ‘Fire and the Australian aborigine—an enigma’ in A.M. Gill, R.H. Groves and I.R. Noble (eds), Fire and the Australian Biota, Australian Academy of Science, Canberra, 1981, pages 55-76.
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In the vast majority of cases the fires either ran out of fuel at the interface with urban developments (or the Pacific Ocean in the case of Royal National Park), or eventually burnt out in the extensive areas of back-burnt bushland. Finally, the weather changed markedly on 10 January with a sharp increase in relative humidity.

**Bushfire Prevention—The Controlled-Burning Option**

Controlled or ‘prescribed’ burning of forest and grassland fuels has been used in many circumstances. For instance, in South-Western Australia, controlled fire is used to maintain particular native vegetation assemblages and dependent fauna populations. Its most common use has been as a means of fire protection: to protect property by affording suppression which may be called for near boundaries and to provide a valuable mosaic of lighter fuels throughout large tracts of forest or bushland. Controlled burning is unequalled as a natural fire-management tool available to the broad-area land manager.

Much of Australia’s vegetation depends upon periodic fire for its regeneration and ecosystem health. Research has shown that regeneration of understorey species in Sydney’s ‘sandstone flora’ is so prolific after intense fires that understorey shrubs can number as many as 50,000 per hectare. About ten years after such a fire the resultant fuel load may be 12 tonnes per hectare, some 5 tonnes of which is suspended in the understorey. This provides a major challenge for fire-management authorities who must make vital decisions and implement action plans to reduce fuel loads using controlled burning between successive bushfire events. Those decisions can mean the difference between a manageable and predictable bushfire and a major, uncontrolled conflagration.

Approvals for the conduct of controlled burns must be given top priority when the optimum conditions of fuel and weather occur.

Broad-area controlled burning as a bushfire-prevention tool is usually supplemented by the maintenance of wide fire-breaks around managed areas. However, fire-breaks cannot be used in isolation because of the spotting capability of high-intensity bushfires up to three kilometres ahead of the main fire. The fire mitigation plan must include both broad-area internal protection and perimeter protection fuel management.

The fire-management technique of controlled burning, based on ecological work in a bushland fire environment, will bring about a notable change in the understorey of the target forest ecosystem if intensive wildfire can be excluded for at least a couple of decades. It is thus important to maintain research programmes to track such vegetation changes. One such study was initiated in 1971 by the NSW Bush Fire Council in the Blue Mountains National Park. It was to be a long-term study stretching over many decades, seen as fundamental to the fuel-management process, and conducted in a highly professional way. The study site was handed over to the NSW National Parks and Wildlife Service in 1980, was partly burnt in the 1982 bushfires, and the study has unfortunately not been continued.

It is unfortunate that the initiatives agreed and adopted over twenty years ago in most Australian jurisdictions have not been continued in the vital area of broad-area controlled burning. Some reasons for its decline are discussed later in this paper. The lesson of its indispensability has been proven in the latest devastating Sydney fires, as well as those of Ash Wednesday a decade earlier. Controlled burning must now be given a new and higher level of political support at least equivalent to that given to the suppression effort, which is always highlighted by authorities and their political patrons after the event.

**Bushfire Control Funding**

Funding methods for bushfire control have varied and evolved in different parts of Australia depending on the balance between local and State government authority, and the varying needs of rural and town protection. In New South Wales, the various local bushfirefighting authorities eventually came under the arm of local government. The town-based fire brigade was instituted by insurance companies for the exclusive protection of insured property.

In any area of public policy, funding obligations and operational accountability should ideally be closely tied. This is not always the case with today’s bushfire control bureaucracy.

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55 See P. Christensen, H. Recher and J. Haase, ‘Response of Open Forest to Fire Regimes’ in Gillingham et al. (eds), op. cit., pages 307-394.
56 See, for example, the works of Attiwill and Florence (this volume).
For example, in New South Wales, the funding basis for bushfire-fighting has recently been changed. The property insurance premium levy component has been increased from 50 per cent to 74 per cent of the total fund, with a corresponding decrease in the rate of contribution of Local Government (now 12.3 per cent) and the State Government (now 14 per cent). Thus, in a $40m annual budget, the State Government’s input has dropped from $10.0m to $5.6m, with a similar reduction for local councils. The increase to be shared by those people who insure their properties is of the order of $10m.

The fact that insurance premiums now contribute almost three-quarters of NSW’s total bushfire-fighting fund raises the question of whether it is proper for the insured people of that State to pay for bushfire control on large expanses of public lands, such as national parks and wilderness areas.

A large slice of the 1994 NSW bushfire effort went to fight bushfires which burnt 250,000 hectares of National Park. However, this land is government land. It is extremely doubtful that a sound case can be made for spending insurance-premium money, or the resources of adjacent local councils and volunteers, on fighting such fires. This question becomes particularly cogent when it is revealed that proven bushfire-prevention techniques had been progressively scaled down in National Park lands over the previous decade.

Another aspect of bushfire-fighting financing worthy of examination is the disproportionate division of funding between city and country. Services in and around major Australian cities usually enjoy much greater government cash support than those in country areas. The difference is not always due to the real or even perceived increased threat of losses of life or property there. It has more to do with political assessments and the role of the media in reporting activity of most interest to readers, listeners and viewers. For example, in country NSW, the Crookwell fire of January 1974 was assessed at that time as damaging property at a rate of $5000-per-minute. In 1994 dollars, this would equate to $15,000 per minute over its three-hour run. This fire hardly rated a mention because there were other fires burning closer to Sydney at the time. If a truly co-operative and equitable bushfire-fighting system is to be implemented, funding formulae must be based on objective risk rather than being driven by media assessments and political etiquette.

The Rise of Green Opposition

Proactive bushfire-management techniques, such as the use of controlled burning as a fire-prevention tool, have been variously criticised since the mid-seventies. Environmentalists have focused on systematic controlled burning because of its alleged deleterious effects on native ecosystems. Some have opposed intervention by such means as being an unwarranted interference in ‘natural’ ecosystems processes, which should be allowed to run their natural course.

From an initial murmuring of discontent, the influence of the green movement in shaping Australian bushfire-management policies has become widespread.

In New South Wales, a well-publicised and co-ordinated controlled burning programme, using aerial ignition, was launched in 1970. In the first year successful burns were conducted in a range of public forest lands along the coastal and mountainous regions. There were three burns in the Blue Mountains in a relatively short time. However, it was not long before environmentalists began to voice objections to this new fuel management technique. The policy of the NSW National Parks Association in 1972 included such a statement as ‘Hazard reduction by low intensity controlled burning is to be generally discouraged because it detracts from natural aesthetic values’.59

Opposition to controlled burning quickly spread to the National Parks and Wildlife Service, largely as a result of lobbying by environmentalists, who saw the Service as their lead advocate in government. Despite the fact that the Service was under an obligation to cooperate with other agencies and the Bush Fire Council in fire prevention methods, by about 1976 it had quietly opted out of broad-area controlled burning. Rather, the Service elected to concentrate on more strategic burning within the Parks, using its own helicopter. Thus, green pressure led to a dismantling of the co-operative approach which had proved so effective in bushfire management since the late 1960s.

The last co-operative aircraft controlled burning operation in the Blue Mountains National Park was in the Colo River catchment in 1976. This later proved effective in blocking the eastward run of 15 km of the flank of the 1979 bushfire.

In the south of NSW, the National Parks and Wildlife Service declined for varying reasons to include any of its areas in the large-scale aerial burning programme from 1976. These ranged from delays in fuel sampling, to the burning of lesser areas with its own helicopter. Collection of annual statistics on the work achieved, as requested by the NSW Bush Fire Council, became increasingly difficult.

Box 4—Bureaucracy and Bushfire Prevention
In the fire-prone Blue Mountains area, west of Sydney, bureaucratic opposition by the National Parks and Wildlife Service to direct bushfire prevention methods resulted in a twenty-year delay in establishing an effective fire control line. A proposal was approved by the Bush Fire Council in October 1973, to have a fire trail surveyed and constructed between the periphery of several lower Blue Mountains towns and the National Park as a ‘final barrier’ for emergency suppression in the fire-prone Blue Mountains area. This was originally proposed as an alternative to fire trails totally within the Park, a concept then entirely acceptable to the Service. Following 47 chronological steps of inaction and stalling, the proposal was finally shelved in 1984.

In 1982, the route had to be rapidly surveyed and cleared as a firefighting line (not properly planned and surveyed as originally intended) and was used successfully against the 1982 bushfire of some 46,000 ha. gross area. The same line was again cleared and used as a backburn fire-line in protecting the towns from the 1994 fire of a similar dimension. Following the January 1994 fires in the lower Blue Mountains, a meeting of all affected parties convened by the local Member of Parliament recommended the trail be constructed as a top priority.

The results of environmentalist pressure on bushfire prevention activities have also been evident in the decline in maintenance of strategic fire trails in National Parks. Several trails, proposed by NSW Southern Bushfire Association brigades, were opposed by National Parks Service representatives on various grounds. The ready availability and the expertise of the Service helicopter was cited as obviating the need to construct a trail for bushfire brigade access. In other cases the trail was opposed because it might allow entry of trail bikes. However the objection many observers regarded as a classic example of bureaucratic obstructionism ended in February 1982 with the preparation of a 93-page document titled Coolumbooka Fire Trail Investigation. This was intended to show why a short fire trail in vacant crown land should not be constructed. The area had also been identified as one for possible reservation as a new National Park. The trail has never been constructed. Thus, suppression would be made to prevail over prevention as a primary strategy.

Ironically, as with the case of the Coolumbooka fire trail, the intent of the fire trail often becomes the last consideration in the analysis of merits. Specific local vegetation occurrences, the possible effect of controlled burning on flora, the predicted soil erosion as a result of controlled fire all become more prominent than the evaluation of the original case: the need to prevent major bushfire losses. And on the human side, the crucial concern of the original submission, the desire of the local bushfire brigade to facilitate the protection of the area, is discarded. Thus the opponents of the fire prevention measures appear to be so intent on highlighting their particular expertise on wildlife, vegetation, soil factors, and the like, that they fail to evaluate the effect of a major wildfire on those very same factors.

A further example of opposition to proven fire-management techniques is with the use of fire-retardant chemicals to limit the spread of bushfires in remote terrain. In 1988, in Kosciusko National Park, a National Parks and Wildlife Service officer refused to grant permission to use fire-retardant mixed in the water of an aerial fire-bomber. In an inquiry before a Coroner at Bombala, evidence was presented to the effect that Phoscheck is equivalent to an agricultural fertiliser, which might increase the growth of native species in areas of National Park, if employed in fire control, and such would be contrary to the Service’s policy.60 Four separate fires, which started within the Park, escaped and damaged at least nine properties in the Bombala area. Yet the exclusion of the fire-retardant, on presumed local environmental grounds, was prominent in the decision-making process.

Conclusion
In Australia there will always be damaging, rapidly-moving bushfires which will affect humans and wildlife, water and ecosystem values. These are a natural part of life on this continent, but their increasing severity and impact can be traced to our 1950s European-based approach to what is a distinctive Australian phenomenon.

60 Fire Inquiry before Coroner, held at Court House, Bombala, NSW, 29 May 1989 to 17 December 1990.
Fostering the concept of fire exclusion by allocating the great majority of our resources into suppression and providing the general public with a false sense of security, will continue to fail at peak times. Television images of masses of equipment, armies of manpower and flights of water bombers offer an immediate political solution, but fuel a recurring misconception in the minds of the Australian public.

In the bushfire equation, there is only one controllable factor: fuel quantity. This must be reduced, and if needs be, modified, in a properly evaluated, planned and co-ordinated manner. Unless this is done, the ferocity of bushfires will never be reduced. If it is achieved, however, bushfire suppression can become cost-effective and a less hazardous occupation for those professionals and volunteers in the front line. A most important aspect of this scenario will be public education.

The morals of funding extensive mitigation works and fire suppression activities on Crown lands, mostly additional to the planned budgets of authorities, need to be critically examined. A government should be financially accountable for its actions. Likewise, a public land management authority should not be able to evade its major suppression costs by sophisticated quasi-ecological arguments based on a limited value-set.

Further, the quest for a better model of bushfire management and administration, following major calamities such as the 1994 New South Wales fires, has brought with it new questions about accountability in long-term land-use planning. With volunteers making up the bulk of the suppression forces on National Parks, the bushfire-management factor must take a much higher profile in government decision-making over the assessment, dedication, funding and management of new national parks and wilderness areas.

Postscript

In the wake of the 1994 NSW fires, a special Cabinet Committee met to consider proposals for changes to bushfire-management laws, practice and administration in the State. The report of the Committee, released on 22 March, places strong emphasis on the establishment of District Fire Committees to plan for and monitor controlled burning operations, and co-ordinate local bushfire management. With respect to controlled burning (referred to in the report as 'hazard reduction') the report recommends, *inter alia*:
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