Australian Bushfires: Historical Perspectives and Research Implications

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In a recent paper, Press (1987) described the use of prescribed fire in the management of Kakadu National Park, and he discussed the effects of fire upon flora and fauna and the response of plant species, habitats and fauna to imposed fire regimens in the Northern Territory. One of the aims of the fire management program was to re-establish the past pattern of traditional aboriginal burning and thereby reduce the incidence of damaging wild-fires in the Park during the latter stages of the dry season.

With this in mind, it is interesting to reflect upon the situation which seems to have existed in many parts of Australia before white settlement. The aborigines undoubtedly used fire as a tool, both for hunting and ceremonial purposes; for example Hutchins (1916) reports an early account of aboriginal practices in Tasmania as follows:

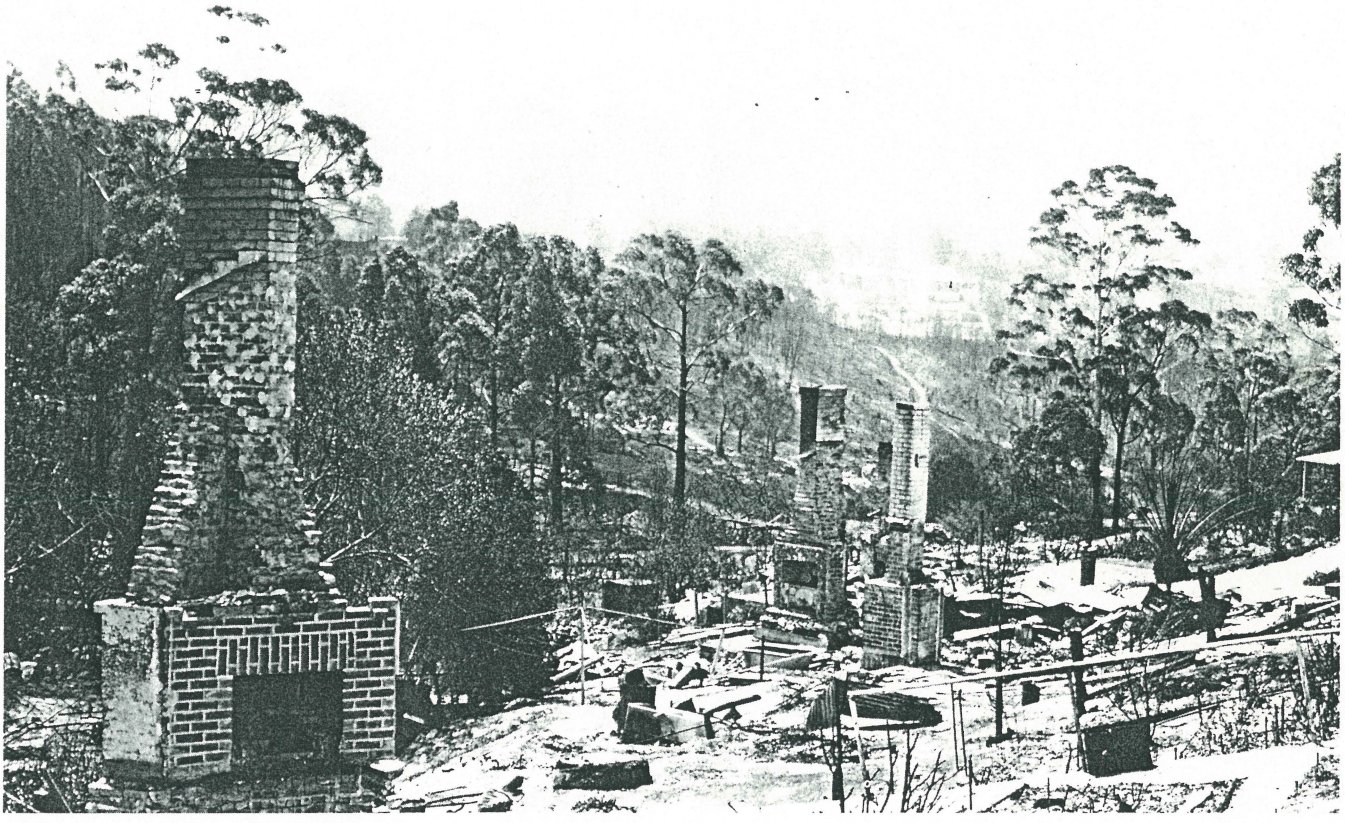
> 'The Tasmanian blacks knew how to obtain fire by twisting a pointed stick in a hollowed out piece of wood, some dry tinder being placed in the hole, — and the use of fire was habitual to them for clearing the forest in order to entice kangaroo and other game to feed in the clearings so made; for cooking their food and cremating their dead.'

Not only were fires kindled in this way by drilling, or by rubbing, but hot coals were sometimes carried; and our earliest Australian inhabitants made considerable efforts to keep their small fires alight.

It is now considered that aboriginals came to Australia some 50 000 years ago, or perhaps even earlier, and analyses of sedimentary pollen cores from different locations suggest marked changes in the types of vegetational cover over extensive areas of the continent from about that time. Although the subject remains controversial, the implication is that aboriginal fires were responsible for this dramatic shift in the character of the early forest lands.

At all events, the widespread application of fire by the natives is not in question, and they were undoubtedly skilled in its use. Indeed, the admirable 'technology' developed by the aborigines while living in harmony with a harsh environment is increasingly becoming recognised. One of the earliest to comment upon the impact of fire on the Australian landscape, was the Surveyor General of New South Wales, Major Thomas Mitchell (1848), in his *Journal of an Expedition into the Interior of Tropical Australia*:

> 'Fire, grass, kangaroos, and human inhabitants, seem all dependent on each other for existence in Australia; for any one of these being wanting, the others could no longer continue. Fire is necessary to burn the grass and form those open forests, in which we find the large forest-kangaroo; the native applies that fire to the



Damage to Tasmanian houses in the Hobart fire of 7 February 1967.

grass at certain seasons, in order that a young green crop may subsequently spring up, and so attract and enable him to kill or take the kangaroo with nets. In summer, the burning of long grass also discloses vermin, birds' nests, etc., on which the females and children, who chiefly burn the grass, feed. But for this simple process, the Australian woods had probably contained as thick a jungle as those of New Zealand or America, instead of the open forests in which the white men now find grass for their cattle . . . . . The omission of the annual periodical burning by natives, of the grass and young saplings, has already produced in the open forest lands nearest to Sydney, thick forests of young trees, where, formerly, a man might gallop without impediment, and see whole miles before him. Kangaroos are no longer to be seen there; the grass is choked by underwood; neither are there natives to burn the grass, nor is fire any longer desirable there amongst the fences of the settler.'

It is abundantly clear that large areas were burned regularly, a fact which Mitchell (1839) had referred to earlier in *Three Expeditions into the Interior of Eastern Australia:*

'All the country beyond the river was in flames, and indeed, from the time of our arrival in these parts, the atmosphere had been obscured by smoke. . . . . Fires prevailed extensively, at great distances in the interior, and the sultry air seemed heated by the general conflagration.'

Despite such widespread burning there was little evidence of the fierce type of bushfire prevalent today. Indeed, at a British Empire Forests Conference, Kessel (1925) remarked that 'the flora of the virgin (Australian) forest carried a less severe fire and the black fellow showed considerable discrimination in his use of the firestick'.

Again, Newland (1921) made the same point, in an address to the S.A. Royal Geographical Society. Referring to South Australian Aborigines, he stated:

'There is another remarkable characteristic of the aborigine, common, I think, to all the tribes where the nature of the country requires it: the care taken by them to prevent bush fires. In my long experience I have never known any serious bush fire caused by the blacks; and the condition of the country, and the growth of the trees and bushes, such as sheoaks, pines, and acacias and a score of other kinds of trees that bush fires always destroy, were, when the white man arrived, flourishing in the perfection of beauty and health . . . . . Much of all this is gone now by the white man's destroying hand in the march of civilisation. Much the same kind of timber and foliage covering portion of the country round Adelaide bore evidence of long exemption from devastating fires, and I think it may be stated to the credit of the Australian aborigine that such was case over most of the continent when the white man assumed possesion.'

The advent of the white man, however, changed matters significantly for, according to European tradition, fires had to be suppressed whenever outbreaks occurred: thus, over time, the area burned annually was considerably decreased. But, inevitably, both living and dead fuels (the leaves, bark and twigs on the forest floor) began to build up, until they were in such concentrations that many subsequent fires were disastrously violent and damaging.

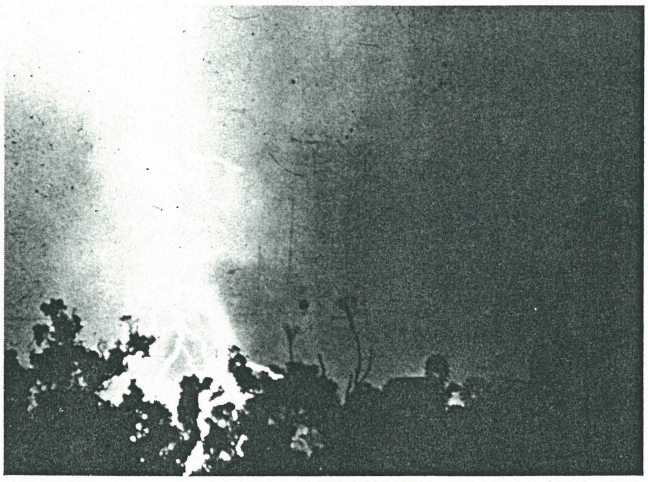
Fire Behaviour and Prescribed Burning

In the 1950s A.R. King was appointed by CSIRO to investigate the bushfire problem. From a study of early Australian literature and journals, he selected many references of the kind quoted above and came to the following conclusions (King 1963):

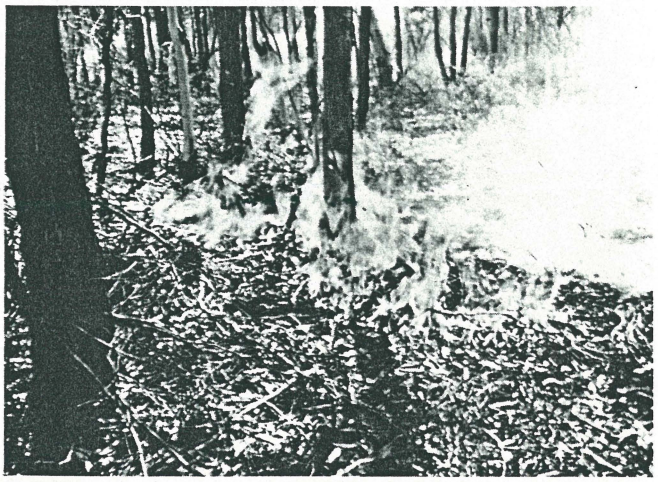
'The evidence seems to indicate that, since colonisation, the forest nature has altered and that the area of bush burned annually has decreased . . . . Most informed persons are of the opinion that the nature of the forest growing at present, even in areas where no trees have been felled, is greatly different from that which existed before colonisation. The general belief is that the forest was usually very open, with almost the appearance of parkland, the trees being widely spaced on ground covered with grass and some little undergrowth. The trees themselves are thought to have been very often immense by present day standards, and to be growing in even aged stands. Most of the forest now is an overstorey of uneven aged trees, standing over dense undergrowth and regrowth, with little grass present'.

King advanced the firm opinion that practices since 'colonisation had produced more severe and damaging bushfires'.

The late A.G. McArthur (1966) had also come to similar conclusions when he wrote:



Lightning strikes can often start fires in grasslands and forests.



A prescribed burn in progress; although the flames are small and slow-moving, most of the forest litter in the wake of the flame-front has been consumed.

'Perhaps in few other countries of the world has a forest association developed to such an extent in an environment of fire as the eucalypt forests of Australia. Large areas of the continent have a particularly harsh climate, which is very conducive to the spread of fire. As a result of climatic and litter characteristics, tremendous areas have been subjected to fires at frequent intervals.

A study of annual lightning occurrence in Australia shows that this cause alone would result in most of the drier areas being burnt frequently. Combined with the extensive use of fire by the indigenous population there is little doubt that most of the drier habitats would be subjected to fire, and only the moister and more sheltered habitats would have a low occurrence frequency.

By the provision of fire protection, white settlement has progressively upset the balance between fuel and climate ..... By allowing longer periods of fuel accumulation, fires become progressively hotter and more damaging to the natural habitat. Ecological changes become more significant and, in many cases, irreversible .... Prescribed burning has become a matter of survival for both efficient fire control and the preservation of the Australian landscape.'

By 'prescribed burning' McArthur means the practice in which large areas of native forest are deliberately lit in spring and autumn to decrease the concentration of fuel on the forest floor and so reduce the destructive effects of summer wild fires.

In basic studies carried out subsequently by the CSIRO Bushfire Research Group, thermocouples were used to measure the cambium temperatures of living trees subjected to intense flames (see Vines 1968; compare Gill and Ashton 1968). We found that the effect of ground fires on trees depended upon ambient temperatures, quantities of fuel on the forest floor, time of exposure to heat, fire intensity and the heat tolerance of tree tissues; and we concluded that fire resistance was connected mainly with bark thickness, being largely independent of the moisture content of the bark, its density, or its structure. Thus, fire-sensitive species are generally those with thin bark. Only the bigger trees with thick bark are capable of surviving in really severe fires; but even small trees usually remain undamaged during prescribed burning operaions, when the flames rarely become sufficiently intense to harm them.

It is not possible to make similar measurements of the 'temperature' of fires in grasslands or forests by putting thermocouples in the flames (Vines 1981), although there are many reports in the literature of this having been done. In general such results have little significance, and a more fruitful approach is to determine the effective "blackbody" temperature of bush-fire flames from measurement of radiation intensities. It is then found that very thick flames (for which emissivities can approach unity) yield effective fire-temperatures T_e of about 1200°K, whilst for more average, thinner flames, T_e may not exceed 1000°K (Packham and Pompe 1971). [These fire-temperatures are not to be confused with the actual — and much greater — flame temperatures appropriate to the narrow reaction zone, or luminous flame-mantle, where pyrolysis products from the fuel meet the oxygen from the air; for the measure 'fire-temperature' integrates this flame temperature with that of the cooler vapours which make up the bulk of the reactants.]

Once the effective radiation temperatures of bushfire flames had been determined in this way, corresponding radiation intensities could then be calculated for typical situations encountered in the field. Such estimates are obviously of importance when the safety of people and the protection of structures and vehicles are to be considered; and it can be shown that, in certain situations, objects totally surrounded by flame may be subjected to radiation intensities in excess of 100 kW/m^2. This result should be kept in mind when one realises that rural fire-fighters 2 m away from a line of flame 1 m high encounter heat radiation typically at a level of 2 kW/m^2, the effect of which is to cause unbearable pain on exposed bare skin within 30 seconds. Moreover, an unprotected fire-fighter working a little more than 1 m away from flames just over 1 m high, (when the radiation intensity is

Intense flames from a wind-driven fire.

Damage to trees after a severe fire in an Australian forest. Trees in the path of the fire have been completely defoliated, and bare mineral soil is exposed at ground level.

A fierce bushfire with flames extending into the tree crowns.

roughly 4 kW/m^2), can stand the heat on his bare hands for less than 10 seconds (King 1962).

Fire Prevention and other Research Activities

It is vital to understand the significance of the various parameters which affect fire behaviour on bad days in summer. Some of the more important factors are wind, slope of terrain, ambient temperature, fuel moisture (dependent upon relative humidity, past rain, etc.) and fuel quantity.

And when means of minimising the incidence of devastating wild-fires are considered, it should be recognised that all other factors except fuel *quantity* are more or less uncontrollable. Thus only if fuel quantities in the forest are decreased, is there any hope of reducing the ferocity of fires on bad days. Indeed, the intensity of a fire is approximately dependent upon the square of the fuel quantity (i.e. if fuel is increased by a factor of 10, the resultant fire intensity is increased by factor of 100). Consequently, there is little chance of controlling fire behaviour unless fuels in the forests are drastically reduced; and the cheapest way of achieving such a reduction is by burning the bush intentionally in spring or autumn, when conditions are appropriate to the production of very mild fires which will not get out of hand.

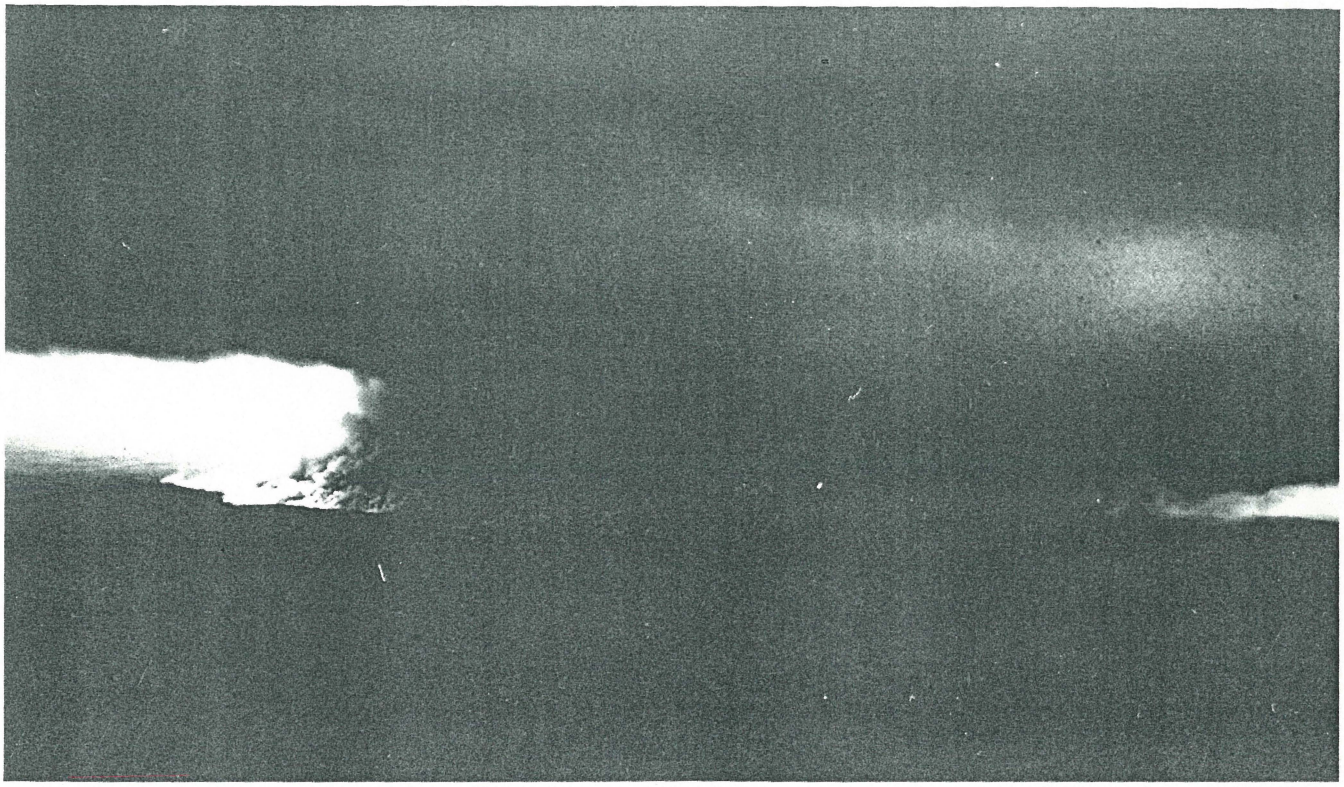
And so we return to the technique of prescribed burning in which the deliberate removal of litter by repeated controlled fires at appropriate times is carried out cheaply on a large scale. Hence the paradox that prescribed burning implies — that destructive summer wildfires can be prevented by having gentle fires in mild weather conditions, in order to remove forest litter over wide areas (i.e. the leaves, bark and twigs which cover the forest floor).

The technique should not be used indiscriminately, for there are some areas in Australia (e.g. snow-gum forests and rain forests) in which fire sensitive species exist, and these must clearly be protected. But there are also vast areas of Australian forest where prescribed burning methods are suitable and, once treated, these then provide buffer zones for those totally protected areas from which fire must be excluded. [It is evident that ecological matters are of particular importance and considerable research is being undertaken in Australia at the present time, in an attempt to find answers to many of the perplexing questions which have been raised; there is, however, no doubt at all that disastrous wild-fires can produce very serious ecological effects over wide areas.]

A major effort was also directed towards analysis of the components of bushfire smoke (Vines et al 1971). Thus, the CSIRO Bushfire Group examined particulate concentrations and agglomeration effects, and made further studies of photochemical reactions at the top of the smoke columns in order to find whether dangerous pollutants were present, and also to find whether there was significant loss of soil nutrients in the ascending plumes. No dangerous concentrations of air pollutants have ever been observed at ground level and, even when smoke is mixed with emissions of nitrogen oxides from urban complexes, there is little increase in ozone concentrations, (which remain well below requisite levels), provided the smoke has aged and is more than one hour old, i.e. that more than one hour has elapsed in the transport of the smoke by wind from its source to a city environment (see Packham and Vines 1978).

All these matters are now reasonably well understood. Indeed, the major problem arising from smoke concentrations is loss of visibility in the atmosphere; and prescribed fires are now carefully planned so that any nuisance caused by large-scale burning operations is minimized.

Many of the matters discussed in this article have been studied elsewhere. In America, too, the attitudes of the U.S. Forest Service towards the use of fire have undergone a profound change in the last 20 to 25 years; prescribed burning practices are no longer suspect, and are commonly used in national parks such as Yosemite.



Intense forest fire in Western Australia. Photograph taken as an aircraft began a traverse at 1220 m through the centre of the plume.

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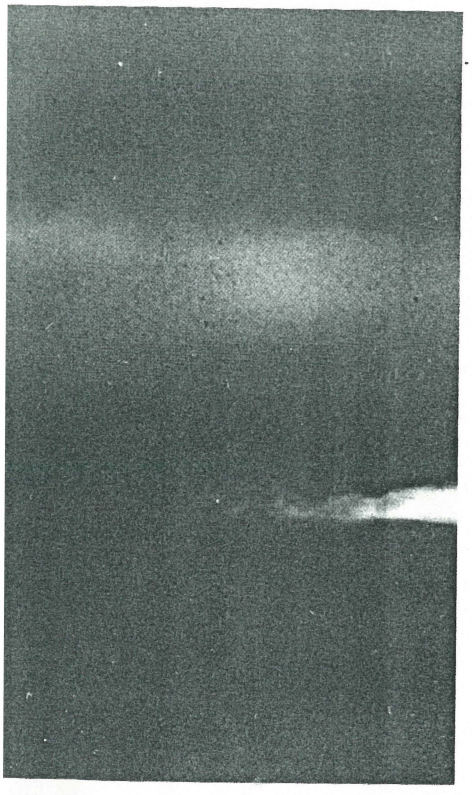

at 1220 m through the centre of the plume.

Indeed, there is nothing new under the sun when we reflect upon the aboriginal practices originally used on the Australian continent over tens of thousands of years. In conclusion, a further historical extract may well be appropriate. It is taken from the Journal of Captain L. Stokes—*Discoveries in Australia; The Voyage of H.M.S. Beagle during 1837–1843,*—and describes an incident when his party was near Albany in Western Australia (Stokes 1846):

> 'On our way we met a party of natives engaged in burning the bush, which they do in sections every year. The dexterity with which they manage so proverbially a dangerous agent as fire is indeed astonishing. Those to whom this duty is especially entrusted, and who guide or stop the running flame, are armed with large green boughs, with which, if it moves in a wrong direction, they beat it out . . . . . The whole scene is a most animated one, and the eager savage, every muscle in action and every faculty called forth, then appears to the utmost advantage, and is indeed almost another being. I can conceive no finer subject for a picture than a party of these swarthy beings engaged in kindling, moderating, and directing the destructive element, which under their care seems almost to change its nature, acquiring, as it were, complete docility, instead of the ungovernable fury we are accustomed to ascribe to it. Dashing through the thick underwood, amidst volumes of smoke — their dark active limbs and excited features burnished by the fierce glow of the fire — they present a spectacle which it rarely falls to our lot to behold, and of which it is impossible to convey any adequate idea by words.'

At a time when ever more complicated technologies seem to be required as we confront increasing global problems, it is salutary to consider that 'primitive' techniques may sometimes prove extremely effective in dealing with the natural world.

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