Chapter 12

fire values

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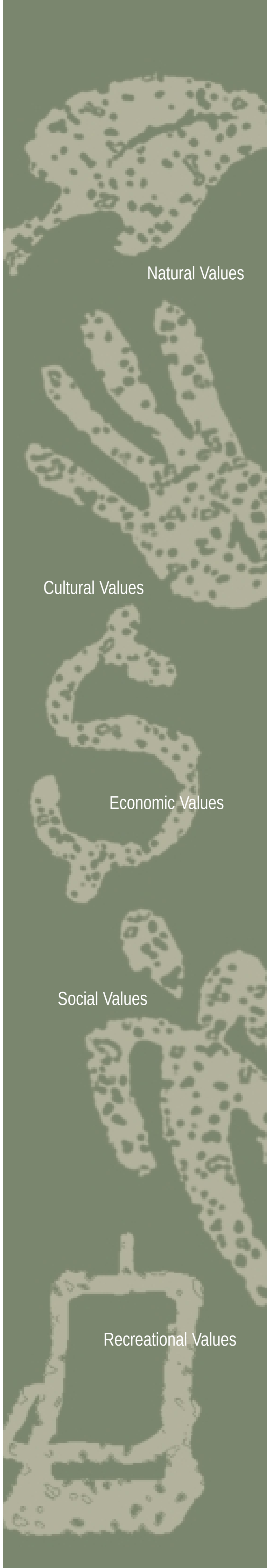
Introduction

Fire management is an integral part of the management of other features and values within Kosciuszko National Park. Fire has influenced, and will continue to influence, the occurrence and distribution of vegetation communities and some species. Similarly, fire can have deleterious impacts on the soils of Kosciuszko National Park, particularly the organic soils of the alpine and subalpine zones.

Fire management in Kosciuszko National Park has always been, and remains, controversial, even though considerable research has been undertaken over the past 30 years on fuel accumulation, fire behaviour, fire effects and impacts. In the late 1940s, wildfire was recognised as a major threat to mountain catchment stability and the operations of the Snowy Mountains Hydro Electric Scheme. In 1951, the Hume-Snowy Bushfire Council was established to coordinate wildfire suppression and to plan and coordinate prescribed burning programs. The council operated until 1985, when its role and functions were passed to the National Parks and Wildlife Service (NPWS).

Fire management in the park has developed since that time, from a very simplistic approach of attempting to suppress all wildfire ignitions together with an annual program of fuel reduction, to an approach based on ecological principles that provide for sound nature conservation, catchment stability and the maintenance of an acceptable level of risk from wildfire impacts on infrastructure, neighbours and park users (Good 1986).

"Fire management is an integral part of the management of other features and values within Kosciuszko National Park."



Vegetation type and fire risk

The boundaries of Kosciusko National Park are generally arbitrary land tenure boundaries. Vegetation and fuel patterns are often contiguous across the landscape, paying no regard to land ownership or reserve status.

The vegetation of Kosciuszko National Park is a complex of vegetation types that vary with altitude, aspect, rainfall and fire history. Each type produces fuel of different rates, levels of accumulation and different presentations of combustible fuel to fire. Bushfire hazard depends largely on the likelihood that high-intensity wildfire will adversely impact on natural or economic assets, and on the capacity to contain potential wildfire in conditions of fuel availability and adverse meteorological conditions across fire-dangerous topography and wind direction.

The complexity of fire in Kosciuszko National Park compounds when the nature of different potentially serious fire seasons is taken into account. A hot dry summer following a high-precipitation winter produces copious grass fuels at lower altitudes, posing a fire intensity hazard in those eastern sections of the park that abut natural or economic assets. However, the high-fuel montane forests and subalpine areas then show green uncured grassland–woodlands or moist compacted fuel beds, forming a barrier to the ignition or spread of high-intensity wildfire.

On the other hand, a summer season that has been preceded by a period of protracted low rainfall presents a quite different hazard regime. The lowland forests and adjacent grasslands have little cured grass fuel and thus have little potential to carry a high-intensity wildfire. In contrast, the higher-altitude forests have beds of deep dry fuel and thus have a capacity to carry high-intensity wildfire under suitable conditions.

Managing fire in Kosciuszko National Park thus presents the challenge of bringing together a complex amalgam of park and regional assessments of vegetation type (and thus fuel accumulation characteristics), topography, asset distribution and potential fire suppression influences. Other management objectives have to be woven into this complex equation, particularly catchment management elements and nature conservation objectives. The biggest problem facing the management of fire in Kosciuszko National Park is oversimplification. Simplistic solutions to complex biophysical problems rarely work and may produce unjustified and potentially dangerous overconfidence. The first step facing fire management planning is to gain an understanding of the vegetation–fuel relationship. A description of this relationship is presented in Attachment 12A.

Evolution of fire management in Kosciuszko National Park

Aboriginal use of fire

Fire 'management' could be considered to have commenced with Aboriginal occupation of the tablelands and foothills of the Snowy Mountains, when annual summer pilgrimages to the high country for 'bogong feasts' and other intertribal ceremonies became part of their summer seasonal activities.

The Aboriginal tribes of the alps areas did light fires in the high country during their summer tribal gatherings, to smoke out the bogong moths and to cook them. No documentary evidence exists on whether wildfires occurred directly as a result of this Aboriginal use of fire but it can be accepted that infrequent fire escapes may have occurred and burnt over small areas of the mountains. Only small areas would have been burnt, as the feasts were predominantly held at or above the tree line where a 'summer green' growing season would have prevailed in all but very infrequent drought years.

The European settlement and grazing era

The introduction of domestic sheep and cattle grazing into the mountains by the early European settlers also introduced a major change in the occurrence, frequency, extent and distribution of fire, producing a very different fire regime to that under which the greater part of the high-mountain vegetation had evolved. This was particularly so in the upper subalpine and alpine zones where much of the summer 'snow lease' grazing was carried out.

The graziers burnt their lease areas toward the end of each summer grazing period, if and when seasonal conditions were suitable. This annual burning aimed to encourage a greater growth of the grasses and herbs (a 'green-pick') in the following spring and summer, and to suppress the growth of 'useless' shrubs. Grazing had a physical impact on the herbaceous grasses and inter-tussock herbs, leading to the degradation of the vegetative cover and subsequent erosion. Unfortunately, however, the regular burning increased the rates of drying of the remnant herbaceous and litter cover, actually increasing the capacity to burn each year and so leading to a greater risk of wildfire. The impact of grazing and burning was most noticeable in the Mount Kosciuszko summit area, where very severe and widespread erosion was evident. The regular and frequent burning of subalpine and montane forests and woodlands to suppress shrub understoreys only exacerbated the snow lessees' shrub 'problem' (Good 1980, 1982, 1998).

The regular low-intensity burning favoured many shrub species, particularly the leguminous species such as *Bossiaea foliosa, Daviesia latifolia, Oxylobium alpestre, Hovea purpurea* and several wattle (*Acacia spp*). These species all produce a high percentage of hard seed that remains viable in the soil for many years as soil-borne seed reserves. The regular burning favoured the regrowth of these species through the heat scarification of the hard seed and through the continual provision of a disturbed or denuded seed-bed suitable to the rapid regeneration of shrub species. This regrowth was at the expense of grasses and inter-tussock herbs. As more and more shrubs established, the graziers had to undertake more burning, the end result being that they were tied into an irreversible cycle of burning and grazing (Good 1982, 1998).

In the 1890s, Helms (1893) and Maiden (1898) both noted the impacts of grazing and burning, but it was a report by Byles (1932) on the condition of the forested areas of the mountains that alerted the scientific community to the detrimental impacts of regular and frequent low-intensity burning on the upper catchments of the Murray, Murrumbidgee and Snowy rivers.

Unfortunately, the concerns of Maiden, Helms, Byles and the scientific community were not heeded and the burning practices continued unabated for another 20 years. This meant that when the removal of domestic stock from the mountain catchments commenced, the catchments were very unstable in terms of vegetative cover and were actively eroding over large areas and dominated by shrubs in other areas. Ironically, a very hazardous fire situation existed at this time, in terms of fire ignition potential, shrub and fine litter fuel levels — a situation created by prevailing burning practices.

The Hume–Snowy Bushfire Prevention Scheme and Bushfire Council

The Snowy Mountains were gazetted as an area of erosion under the *Soil Conservation Act 1938*, but it was only when the proposals for, and the planning, development and construction of, the Snowy Mountains Hydro Electric Scheme commenced that there was 'formal' recognition to the need for better catchment management. Effective wildfire control and suppression were seen as an essential component of this catchment management. The Hume-–Snowy Bushfire Council (HSBC) and the Hume–-Snowy Bushfire Prevention Scheme (HSBPS) were established in 1951 to coordinate the cooperative fire prevention activities of the HSBC's constituent members — local government, the Forestry Commission, the Soil Conservation Service, the Kosciusko State Park Trust (later the NPWS), the Snowy Mountains Hydro-Electric Authority and the rural community. Other interested agencies and organisations joined the HSBC in later years.

The HSBC's fire prevention programs were based on the following (HSBC Fire Management Plan, circa 1970):

> Experience in eastern Australia shows that the control of major forest fires and mitigation of damage in dangerous fire seasons can only be accomplished by burning back from, or steering fires into natural barriers, or fuel reduced areas of sufficient size to moderate extreme fire behaviour and give suppression a chance of achieving its objective .(HSBC Fire Management Plan, circa 1970).

In the early years of the HSBPS, the Bushfire Council developed proposals for fuel reduction burning over more 70% of the park (later up to 93% with the inclusion of the Byadbo lands, previously managed by the Monaro Bushfire Prevention Association). The only area excluded from the planned burning program was the alpine area above the treeline. Prescribed burning blocks of 6000–10 000 acres (2500–4200 hectares) were identified across the park and burning was arbitrarily implemented in several blocks each year, so that all blocks would be burnt on a 7–15 year cycle, with the aim of reducing the fuel loads on each block to below 10 tonnes per hectare. This program took no cognisance of the probability of wildfire ignition and there was no assessment of the relative potential for impact on park infrastructure, natural values, conservation objectives and the lives and property of neighbours and park users.

The annual burning program continued through the 1950s, 1960s and early 1970s; all but a few blocks were burnt at least once, with many burnt two, three or more times. This program continued until it was questioned by fire managers and ecologists from the NPWS and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). The NPWS subsequently took a greater role and responsibility in the planning of fire mitigation (including prescribed burning) programs.

While the objectives of the HSBPS may have been based on acceptable premises, the three decades of fuel reduction burning had as great a detrimental impact on the forest and woodland vegetation, and the soil stability of the park, as the many years of grazing. Ecologists from the NPWS and CSIRO argued that the very regime that was being implemented by the HSBC to 'protect' the catchments was resulting in catchment degradation, not in catchment stability. This was due to a lack of understanding of the complexities of fire physics in mountain environments; in particular, the relationship between fire behaviour, fuel types and fuel structure, fuel accumulation rates, flammability and the range of ground vegetation cover needed to prevent soil instability and erosion. Many individual burning blocks covered a wide elevation range and included varied topographic features, so that acceptable prescribed burn fire behaviour (rate of spread and intensity) could not be achieved across a block. Instead, areas of no burn and areas of crown scorch usually resulted (Good 1986). A number of major wildfire events also occurred as a result of burns in blocks of widely varied elevations and micro-climatic and topographic environments.

In 1981, a review of the management arrangements was undertaken. An assessment of the HSBC's fuel reduction records indicated that the council's objectives for fuel reduction burning had been achieved on less than 10% of the total block area and that no assessment of the success or otherwise of any year's program had been undertaken to form a basis for planning of further burning in following years. There was no instance where the burning program had any influence on the outcome of subsequent wildfire suppression operations. In 1982, the HSBC agreed to a timetable for the transfer of responsibilities to the NPWS. This transfer was completed in 1986 and the HSBC was subsequently dissolved. The NPWS significantly upgraded its fire management capacity to facilitate the transfer. This included the hiring of professional fire management and support staff and equipment, supplemented by a program of fire management training. A fire management plan was subsequently prepared within the framework of the park management plan in 1998. The plan was prepared in consultation with communities around the park. NPWS is also a member of the bushfire management committees that cover the shires around and including Kosciuszko National Park, and has cooperative arrangements with Victoria and the Australian Capital Territory for cross-border management of fire.

Fire management objectives, planning and programs

The main objectives of the Kosciuszko National Park Fire Mmanagement Plan are to protect human life and property; and to conserve the park's natural and cultural features, catchment values and recreational opportunities.

The fire management plan identifies, and contains management strategies for, areas of bushfire risk and areas requiring protection from fire because of their natural and cultural values. It includes strategies to reduce the risk that bushfires will damage residential areas, recreational areas and assets within Kosciuszko National Park, or spread from the park to neighbouring townships and property. Examples of strategies to reduce risk include:

- prescribed fire or slashing to reduce or modify fuels;
- maintenance of trails for fire access;
- active fire investigation of illegal fire events; and
- training and education programs to increase awareness of issues related to fire.

The plan identifies environments, vegetation communities and animal habitats where a lower fire frequency is needed to protect biodiversity and catchment values. Fire management within the park is ecologically based, with a basic objective of excluding fire from most vegetation communities for between 15 and 50-plus years.

Subalpine woodlands

A very high level of protection from fire is desirable in alpine, subalpine and frost hollow areas, moist forests and river valleys of the park. This is a very specific objective for the subalpine woodlands. The structure of the subalpine woodlands was dramatically changed over the many years of grazing and as a response of the vegetation to the poorly planned and implemented 'prescribed burning programs' of the HSBPS. At the time of writing, the greater part of this snow gum woodland remains in a young-age condition, existing as a dense mallee form of woodland (Good 1980, 1986, 1998). This is in contrast with the very small remnant areas of old-age snow gums that are still in very open woodland communities, with large-diameter single-trunk trees at a density of less than 50 per hectare. Research by Barker (1989), Banks (1982, 1989) and Good (1982) indicates that the number of trunks per tree has increased in regularly burned areas, from one to three trunks per tree to up to 40, with the number of trees per hectare having increased from under 50 to 6000–7000 per hectare.

The young-aged woodlands (about 50 years) provide little opportunity at this time for any planned ecological burning for vegetation and habitat manipulation. Until the majority of the snow gum community reaches an old-age class (> 100 years), it will not be possible to plan fire regimes that are appropriate to its long-term conservation. An appropriate fire regime would allow the creation and maintenance within the community of the age, species and structural diversity that would provide optimal habitat for the suite of fauna species which use the subalpine woodlands (Parks 1975; Good 1982, 1986).

Similarly, a long period without fire is necessary to allow the dense understorey shrub communities to senesce and to be replaced by a stable grass understorey. Research indicates that this cycle of shrub growth and senescence will occur over a period of 50–70 years, so a further fire-free period of at least 20–30 years is still required for this to take place.

A subalpine woodland with a grassy understorey provides for a greater decomposition rate of the annual litter fall and higher fuel moisture conditions, resulting in a low fire ignition potential in all but the driest years. In this situation the fuel levels may well be above the perceived hazardous level of 10 tonnes per hectare, but are not in a flammable condition. Fuels levels as such in the subalpine woodlands and upper montane forests do not equate with high fire danger or high fire ignition potential or probability. This low fire ignition probability is enhanced by the fact that the growth season in the high country is summer; hence a 'summer green' exists in most years, which itself reduces the chance of fire ignition and occurrence (Good 1982).

Alpine ash communities

A number of other specific ecological fire management issues have been identified and need to be effectively addressed in any fire management planning. One of these is the specific fire regime required for the fire-sensitive alpine ash (*Eucalyptus delegatensis)* communities. This species requires a high-intensity fire once in its lifecycle, at a frequency of about 100–150 years. Such a fire kills the adult standing trees but provides a disturbed and litter-free seed-bed for the germination and growth of the large soil-borne seed reserves and for the seeds released from seed capsules during the passage of the fire. The exclusion of fire from these forests for many years, to allow the species to mature and set seed, is an objective of current fire management, even if it demands the loss of some conservation values in small areas of other communities surrounding the alpine ash forests (Good 1980).

Cypress pine and white box woodlands

Other issues are the cypress pine (*Callitris spp*) and white box (*E. albens*) woodlands of the lower Snowy River, the black scrubs (*Acacia sylvestris — Eriostemon spp*) of the Byadbo area, and the cold-air drainage grasslands valleys in the north of the park. Also, in that part of the park, fire management has to take account of the potential impacts of any fires on the limestone cave systems at Yarrangobilly, where smoke and ash may discolour the cave formations and impact on cave hydrology (A Spate, Optimal Karst Management, pers comm, 1996 and 1998).

Catchment issues

Catchment issues, particularly catchment hydrology and stability, also require specific consideration. During the many years of fuel reduction by the HSBPS, catchment soils were regularly exposed to potential erosion as a result of the reduction of fuels (litter and herbaceous cover) below a level that provided for soil protection and stability. Catchment research in the 1970s and 1980s (Costin 1970; Good 1982, 1986) indicated that most soils on moderate to steep slopes required from 10 to 25 tonnes per hectare of organic matter (litter etc) to provide for stability, so there is an obvious conflict between fuel reduction programs and catchment management over much of Kosciuszko National Park.

This 'conflict' in objectives can be noted from Table 12.1 where data for three major soil groups in the Snowy Mountains indicate that, on slopes in excess of 15 degrees, fuel loads in excess of 10 tonnes per hectare are required to reduce post-fire soil erosion. As prescribed burning for hazard fuel reduction is generally based on reducing fuel loads to below 10 tonnes per hectare, an obvious catchment management and fire management conflict has to be resolved as part of the planning and implementation of prescribed burning in these significant mountain catchments (Good 1982, 1986).

While the need for, and application of, fuel reduction burning in the montane and subalpine zones has been questioned and is now not widely applied, prescribed burning in the lower elevation forests and woodlands has not been challenged in the same way. It should be challenged, as these woodlands, particularly the white box woodlands, yield very little litter with the maximum fuel loads seldom accumulating above 9–10 tonnes per hectare. Hence the maximum levels of fuel in these woodlands are below the 10 tonnes per hectare quoted as necessary for fuel reduction programs.

Table 12.1 Fuel loads required to reduce post-fire soil erosion, for three soil types on slopes up to 30 degrees

	Soil type				
	Podsolic		Solodics		Solodised
	Red	Yellow	Red	Yellow	Solonetz
Slope class (degrees)	**Litter loads (tonnes per hectare)**				
< 2	2	2	3	3	3
2–5	2	3	4	4	4
6–10	3	4	5	5	6
11–15	4	5	6	7	8
16–20	8	10	10	12	12
21–25	12	12	14	14	16
26–30	16	16	18	18	20
> 30	> 20 tonnes per hectare				

Source: Based on data from Good (1986)

Fire management planning must also identify:

- the risk of certain wildfire scenarios occurring;
- the 'life and property' under threat of impact from fires that may occur regularly in any one area /site;
- the impact of these fires on the native vegetation; and
- the potential of regularly burnt areas to impact on catchment stability and to favour alien plant establishment.

The potential sources of high-intensity fire ignitions, and their potential and history of spread into and out of the park, also need to be identified and quantified through a hazard risk assessment process that the NPWS has developed (Good 1982, 1986). These areas are or will be the sites and areas where fuel reduction burning should be undertaken for the protection of life and property. This currently amounts to an area of approximately 30,000–40,000 hectares, or approximately 7% of the park. This contrasts with the area that the HSBPS regularly attempted to burn for fuel reduction: an area in excess of 500 000 hectares, or about 80% of the park.

Other areas within the park have been identified for prescribed burning but the proposed burning is for ecological purposes (vegetation and habitat manipulation), not for fuel reduction. The integration of weed and exotic plant management is an essential part of this fire management.

Prescribed burning — a social as well as a management issue

All land management agencies have an obligation to undertake ecologically sound fire management planning and tohe implementation of effective wildfire mitigation programs. The greater part of fire management is based on the management of fine litter ground fuels, this largely being achieved through the application of prescribed burning (planned application of low intensity fire). Prescribed burning, also referred to as hazard fuel reduction burning, protection burning and controlled burning, is the planned application of fire under a prescribed set of weather conditions; the prescribed or defined outcome is an effective measure of protection against the adverse impact of high-intensity wildfire.

The principles of prescribed burning are well founded but unfortunately the application of such burning is often poorly planned and executed. This has resulted in many fire escapes, resulting in uncontrolled wildfire, excessive scorch height of the overstorey vegetation, and many cases of unacceptable impacts on native flora and fauna and catchment stability.

As a result, the increasingly widespread application of prescribed burning, particularly in nature reserves, national parks and other protected natural areas, has been criticised and is of continuing concern to many professional and community interest groups alike. These concerns arise mainly from the lack of detailed data on the impacts of prescribed burning on the native biota. A greater concern is that prescribed burning is often implemented for 'fuel reduction' with little or no quantification of the actual fuel loads at the time; nor of the fuel structure or the rates of decomposition of litter and hence the rates of fuel accumulation following a prescribed fire. Similarly, little or no quantification of the hazardous nature of various fuel complexes is evident in most prescribed burning plans, the assumption being that fuel loads exceeding 10 tonnes per hectare all pose a high fire hazard. Even where such fuels pose a high hazard in terms of their potential high intensity if they were to burn in a wildfire, the risk of such a fire occurring is seldom assessed.

Therefore, the natural area land management program that is potentially most significant continues to be implemented with little or no knowledge of the very component of the environment that managers are endeavouring to manipulate, modify or reduce.

One of the unfortunate social consequences of the debate on prescribed burning is that it tends to overshadow and thus negate discussion on the development and implementation of other effective fire protection policies and measures (Leaver 1988). Specific areas prone to high-intensity wildfire can be accurately predicted, so it is possible to preclude developments and investments in these lands, by using restrictions similar to those applied in areas subject to other natural hazards such as flooding and landslip. As long as the community is diverted by the seemingly effective panacea offered by prescribed burning, the need for effective measures is ignored. Such measures could include:

- strategic fuel reduction (including prescribed burning) in areas where it can be effective;
- exclusion of residential and other asset development in fire prone lands;
- making assets fire resistant;
- ensuring that those involved in fire management have a basic understanding of fuel dynamics and fire physics;
- Ignorance about fuel dynamics and fire physics can have tragic consequences; and
- One of the most dangerous misconceptions about the impact of reduced fuel loads on fire behaviour is that rate of spread of wildfire is reduced in extreme conditions. This is not the case.

Often too many eggs are placed in the prescribed burning basket. If the program is designed to reduce remote forest fuel loads then the practical reality is that in many years, a burning program is not practicably achievable because of weather conditions and, when achievable, the impacts are often as bad as the wildfire that was to be excluded by the practice.

A new consideration for fire management planning — prescribed burning and predicted global warming

An expanded 'commitment' to prescribed burning is also being carried out across New South Wales with little or no assessment for smoke management and public health. For example, almost every year extensive prescribed burning along the New South Wales south coast and escarpment results in a smoke pall extending over the coastal plain with a consequent potential impact on asthmatics and allergy sufferers. Of concern is the more long-term impact of the contribution to greenhouse gas emissions of these regular and extensive fires together with the infrequent wildfires (Good 1998). These contributions have never been assessed or quantified but some guide can be gained from studies of a fire of approximately 40 square kilometres, where some 20 000 tonnes of carbon dioxide were calculated to be released to the atmosphere along with 3000 tonnes of particulate matter. For wildfires and prescribed burning in an average fire year, this would equate to some 5 million tonnes of carbon dioxide, 1.5 million tonnes of methane and 750 000 tonnes of particulate matter being dissipated into the atmosphere.

In comparison to the total emission of greenhouse gases by primary and secondary industries, the contribution of these gases from the burning of biomass during wildfires and prescribed burning is very small: approximately 2% of the total. However, it is important to note that these figures relate only to the burning of the fine fuel components of the fuel complex, and do not include the large fuels (logs etc) whichthat may burn and smoulder long after the passage of a fire front. These fuels could increase the contribution of carbon dioxide by a factor of four or five.

The release of greenhouse gases from biomass burning may not all be detrimental but certainly will require a rethink in terms of prescribed burning and fire management. Carbon dioxide concentrations in the atmosphere are currently around 370 ppm, some 20% higher than they have been in the last 150 000 years (Spate 1994). Research by Gifford (1991) suggests that if the carbon dioxide concentrations in the atmosphere were to double to 700 ppm in the next 20 years, plant growth and yield could be increased by as much as 30–40%.

Other climate models (Pittock and Nix 1986) indicate a possible 0–40% change from north to south of the continent as a response to the gradual movement poleward of the general climatic zones. This would provide for wetter summers and drier winters over central and south-eastern Australia. Another modelled scenario (Wright 1992) indicates a general 20% increase in windiness and a 20% decrease in humidity. If this were to be the case, the measure of possible wildfire occurrence (the fire danger index) would increase dramatically over southern Australia by about 38% and in the south-west by 13–17%. This scenario indicates a possible increase in the occurrence of high-intensity wildfire, while that proposed by Gifford and by Pittock and Nix suggests that the occurrence of wildfires would decline in southern Australia as summer rainfall increases.

Depending on which scenario eventually arises, the contribution of biomass burning could dramatically increase or decrease with the predicted increase in global warming. If the incidence of wildfires decreased, the need for extensive prescribed burning for hazard fuel reduction purposes would be similarly reduced and the total contribution to greenhouse gas emissions would decline. The alternative is an increase in wildfire occurrences and, if current practices are followed, a consequent increased demand for prescribed burning and further increases in greenhouse gas emissions from fire management programs (Good 1998).

Fire management planning and skills in implementation will have to improve greatly if the latter scenario eventually arises. A sound knowledge of fuel complexes, an appreciation of fire behaviour and an understanding of ecosystem processes relative to fire will be essential skills for natural area and fire management personnel, if we are to meet the challenge of fire management and at the same time make a worthwhile contribution to a reduction in greenhouse gas emissions.

The significance of fire management — implications for the plan of management

Fire management is an integral part of the management of other features and values within Kosciuszko National Park and influences the capacity to implement other management strategies and to achieve planned management outcomes. Fire influences the occurrence and distribution of vegetation communities and of some species. The native vegetation in Kosciuszko National Park has evolved over thousands of years, under the direct influence of fire regimes, and all plant species have developed adaptations (survival traits) to enable them to complete their life-cycles and to survive the impacts of high-intensity fire. Many species depend on fire to some degree to assist the release of seed stored in capsules, the scarification of hard seed and the clearing or disturbance of a seedbed suitable for the germination of seed and the growth of young seedlings such as alpine ash (*E. delegatensis*) and leguminous shrubs, *Daviesia*, *Oxylobium*, *Pultenaea*, *Bossiaea* and *Acacia* spp.

Similarly, fire can have deleterious impacts on the soils of Kosciuszko National Park, particularly the organic soils of the alpine and subalpine zones (alpine humus and transitional alpine humus soils). The combination of wildfire and prescribed burning over these soil types reduces the vegetative cover, exposing the underlying soils to drying, breakdown and eventual soil erosion by wind and water run-off. Soil, vegetation and natural wildfire occurrence are intricately linked in a functional ecological system.

Wildfires can enter the park from adjoining lands and escape from the park to neighbouring farmland. The entry and exit sites of fires have been identified and are recognised as points in historical fire paths. These boundary fire sites necessitate intensive park boundary fire management through the implementation of planned burning for fuel level reduction (hazard reduction), but encompass a very small total percentage area of the park. Infrastructure and tourist or recreational facilities should not be developed in these areas.

Fire, weed and exotic animal management programs need to be effectively linked and implemented to achieve the greatest environmental benefits and to ensure weed and exotic animal control programs are successful.

The fire management elements of the plan of management for Kosciuszko National Park should therefore be based on:

- an understanding that inevitable recurrent wildfire has been a feature of the development of the region's vegetation structure for millennia;
- outcomes that are derived from an assessment of vegetation systems and fuel structures, with the principles of combustion physics applied to ensure that these outcomes are valid and achievable;
- a principle that a focus of fire management should be effective measures to minimise the impact of high-intensity fire on natural and human assets;
- an understanding that vegetation in large tracts of the park is skewed to a primary state of succession as a consequence of past fire history and a recognition that the dominant vegetation management objective should be to achieve a more representative range of succession, including areas of old growth vegetation (representing the end result of environmental stability); and
- a principle that achieving catchment protection and stability is a vital conservation function for the alpine areas on both conservation and economic grounds, and recognition that fire management practices should not be undertaken if, on balance, they detract from an objective of catchment protection.

Acknowledgment

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ATTACHMENT 12A: Kosciuszko National Park fuel complexes and accumulation rates.

Extensive fuel sampling across major vegetation associations in Kosciuszko National Park has been undertaken over the past 25 years and the fuel loads depicted in Table 12A1 indicate the sampling results. The fuel load data can be used to generate fuel accumulation curves and generalised fuel models, which can provide a guide to expected fuel loads in the various dominant vegetation communities at other sites.

Table 12A.1 Fuel loads for some forest and woodland communities in Kosciuszko National Park where time since last fire exceeds 25 years

Vegetation association	Fuel weight (tonnes per hectare)			Altitude range (metres)
	Lowest	Mean	Highest	
Eucalyptus delegatensis	28.5	43.5	69.8	1200–1400
E. delegatensis/E. viminalis	24.2	37.1	42.4	1100–1220
E. pauciflora	18.4	28.4	38.2	1000–1400
E. pauciflora /E. dalrympleana	16.5	24.8	35.1	950–1500
E. pauciflora/E. rubida	14.8	24.0	31.2	900–1420
E. dalrympleana/E. radiata	22.0	26.2	30.4	1000–1100
E. dalrympleana/E. fastigata	23.7	27.4	31.0	1000–1150
E. radiata/E. bicostata/E. viminalis	18.8	28.5	37.3	550–900
E. albens	9.0	11.8	14.7	300–450
E. macrorhynca/E. dives	6.4	10.0	16.1	500–900
E. dives/E. mannifera	8.5	12.6	18.2	450–950

Source: Based on data from Good (1982, 1986)

Fuel curves are generated using the modified Olsen model (Walker 1980) which expresses the relationship between litter production and decomposition, and hence the accumulation of dead litter (*X*, in tonnes per hectare) at time *t* (in years) as:

$$X_t = L/kK(1\text{-}e^{-Kt}) \text{ where } L = KX_{max}$$

where *L* is the litter production rate (tonnes per hectare per year), X_{max} is the maximum litter standing crop at equilibrium, *K* is the independent decomposition constant (the ratio of *L* to X_{max}), and e is the base of the natural logarithm. The constants *L* and *K* (and therefore X_{max}) are functions of vegetation community type. This equation yields zero fuel at time 0 and allows the amount of fuel (X_t) to approach equilibrium value X_{max}) as time (*t*) proceeds to infinity. The values of *L* and X_{max} determine the maximum fuel level reached and the rate at which this level is reached.

Caution must be exercised when using this equation to generate fuel accumulation curves for use in planning and implementing fuel management and fuel reduction/prescribed burning programs. The equation makes three unrealistic assumptions that need to be accounted for; it assumes that:

- fine dead litter at time 0 immediately after a fire is always zero; ie all fires effect total reduction;
- decomposition and litter fall are constant over time; and
- fine dead fuel load is the only fuel input.

The first of the above points may be correct for high-intensity fires where there may be a lag period of 1–3 years during which there is little fuel accumulation. On the other hand, fuel accumulations after low intensity fires (prescribed burns) are generally rapid and reach maximum levels again within 3–5 years of such a fire. More importantly, the 8–10 tonnes per hectare fuel load identified in many fire management plans (as the level below which fuels should be maintained in fuel management programs) will in most situations be exceeded in 2–3 years. This can be modelled if the amount of fuel remaining after any fire is known, as it simply decays as a function of the decomposition constant: $X_{rt} = XRe^{-Kt}$ where X_{rt} is the amount (tonnes per hectare) of this residual fuel remaining at time *t* and *XR* is the amount of residual fuel immediately after the last fire. The fine fuel load is thus the sum of X_t and X_{rt} (Kessell et al 1980).

From the above, the following very general fuel accumulation models can be generated.

Closed forest communities

Mean litter fall rate	2.8–3.6 tonnes per hectare per year
Mean decomposition rate	0.12 kilograms per year
Maximum fine fuel accumulation	23–30 tonnes per hectare

Open forest communities

Mean litter fall rate	2.2–2.8 tonnes per hectare per year
Mean decomposition rate	0.8–1.0 kilograms per year
Maximum fine fuel accumulation	27–28.5 tonnes per hectare

Woodland (dry to moist)

Mean litter fall rate	0.6–2.8 tonnes per hectare per year
Mean decomposition rate	0.1 kilograms per year
Maximum fine fuel accumulation	6–28 tonnes per hectare

Use of fuels data

Generalised fine fuels data can provide an overview of the status of the potential hazardous fire situation existing in a locality, a vegetation community or across a park or region. These data can also be an input into the quantification of hazard (Good 1986) in terms of potential wildfire behaviour and fire impacts on life and property, or of valuable biophysical features on the lands over which wildfires may burn. It must be recognised that fuel load is not the only factor that contributes to fire behaviour; flammability of the fuels is influenced by the depth and density of the fuel bed (the packing ratio,) and the distribution and groundcover of the fuel bed.

The packing ratio (PR) is the actual weight of fuel per unit volume and can be calculated as:
PR = bulk density (kg/m^3)/average fuel particle size (mm).
The bulk density (BD) is calculated from the total fuel loading and its average depth.
BD (kg/m^3) = total fuel load ($t.ha^{-1}$)/depth (m) x 10.

While the approach above gives a methodology and guide to fuel management and the planning of prescribed burning, the relationships among fine fuel load, surface groundcover, slope and soil stability also need to be considered. A fire frequency (or frequencies) appropriate to the vegetation communities must be identified and considered in terms of maximum post-fire fuel accumulation loads (Good 1980). The relationships among the local weather, micro-climate and fuel accumulation rates and fuel flammability must also be considered. For Kosciuszko National Park, the local weather allows planned burning to be carried out effectively on only a very few days per year (between 5 and 20). As these occur infrequently, fuel loads are generally at a maximum and if such a fuel load was in the order of 35 tonnes per hectare a single effective fuel reduction burn would or should only reduce the fuel load by no more than 15 tonnes, if implemented within 'prescribed' intensity and rate of spread behaviour. If fuel loads in this situation were to be reduced down to 10 tonnes per hectare, which is the stated objective of hazard fuel reduction, higher intensity fires would be needed, or would result. The lack of understanding of this basic fire physics and fire behaviour continues to lead to many fuel reduction burns becoming wildfires. To avoid wildfire intensities would require an area to be burnt two or three times in a short time span (3–5 years) which for all but a few small vegetation communities in Kosciuszko National Park would be unacceptable in terms of vegetation management (Good 1986). It would only be acceptable in the areas or sites designated for the maintenance of continuous low fuel loads, eg near or around infrastructure under threat of impact, or in boundary areas with a quantified history of regular occurrence of fire leaving the park. On the other hand, if only one low intensity fuel reduction burn was to be implemented effectively, only a proportion of the fuel bed would be removed (as noted above), this being the drier upper layer of the fuel complex. This would result in the lower layers of the fuel bed being exposed and these would then dry out (Good 1982, 1986). Hence the fire ignition potential would remain and the heavy fuel load would mean that the potential for a high-intensity wildfire would similarly still exist. One-off fuel reduction burns in these situations therefore do not achieve satisfactory fuel reduction, or if they do, they result in high fire intensities and higher than acceptable impact on the native vegetation and catchment soil conditions.

Where the HSBPS carried out fuel reduction burning in the higher elevation forests and woodlands, a justification for burning was the desire to create a mosaic of vegetation age, species and structure, a justification used particularly post-fire, when planned (prescribed) fire intensities had been exceeded (Good 1986). Unfortunately, where this 'mosaic' was created it was one of areas continually burned, or not burnt at all due to the burning being done in the same season each year (autumn) when only the low dry fuel load areas would burn, leaving the moist heavy fuel areas unburnt. These unburnt areas were to become the sites of fire ignition in several of the prolonged drought years in the 1950s and 1960s, adequately indicating that the fuel reduction programs carried out by the HSBPS were either poorly planned or that the fuel complex, weather and fire behaviour were poorly understood, if recognised or even considered. The actual fire hazard situation was never quantified and hence the fuel reduction program never reduced the fire hazard if one ever existed. Future fire management must be based on and implemented with this understanding.

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