Fire management in Tasmania's Wilderness World Heritage Area: Ecosystem restoration using Indigenous-style fire regimes?

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Summary In many natural areas, changes in fire regimes since European settlement have resulted in adverse impacts on elements of biological diversity that survived millennia of land management by Indigenous people. Some of the rainforest and alpine elements that depend on south-west Tasmania's World Heritage Area have been in decline since European settlement of Tasmania due to an increase in the incidence of landscape-scale fires in the period 1850–1940. Some of the buttongrass moorland elements that also depend on the region are in decline or impending decline because of a decreased incidence and/or size of burns since 1940. Will an Indigenous-style fire regime serve the interests of biological diversity? We examine this question in the context of the fire ecology and fire history of south-west Tasmania. From this assessment we argue that a return to Indigenous-style burning, modified to address contemporary issues such as the prevention of unplanned ignition, suppression of wildfires and burning to favour rare and threatened species may help to reverse trends towards ecosystem degradation in this region.

Key words *south-west Tasmania, fire management, Indigenous burning, World Heritage Area.*

Introduction

This paper refers to the approximately 1.2 million ha of south-west Tasmania's World Heritage Area included in Southwest National Park and Franklin–Gordon Wild Rivers National Park, along with and the part of the South-west Conservation Area that is adjacent to the King River and Cape Sorell. A vegetation map of the region has been published by Kirkpatrick and Dickinson (1984b) and its fire history has been reviewed by Marsden-Smedley (1998a).

Marked changes have occurred in the fire regime of south-west Tasmania since European settlement. These changes have resulted in the spread of fire into fire-sensitive temperate rainforest and alpine vegetation (Kirkpatrick & Dickinson 1984a; Bowman & Brown 1986; Brown 1988; Cullen & Kirkpatrick 1988). Conversely, a trend is also evident towards a reduction in the fire frequency in many buttongrass moorlands which are dependent on shorter fire frequencies to maintain plant and animal diversity (Brown & Wilson 1984; Marsden-Smedley 1993b; Arkell 1995; Greenslade 1997; Driessen 1999). Both changes appear to be reducing elements of south-west Tasmania's biological diversity, with the possibility of major alterations to ecological processes and biological patterning (Kirkpatrick 1994). In this paper we argue that such existing damage and the trajectory towards decline warrant the application of ecological restoration-style management to return these ecosystems to a pre-existing, more desirable state.

An intuitively attractive means of rehabilitating the impacts of inappropriate fire regimes on biodiversity is a restoration of the style of fire regime that prevailed when Indigenous Tasmanians managed the landscape. In this paper we examine the appropriateness of this response in terms of a number of criteria and contrast the fire management regime that emerges from this analysis with six other potential fire management regimes. Before engaging in these analyses we provide a review of the ecology and fire history of south-west Tasmania as necessary background.

The fire ecology of south-west Tasmania

The major terrestrial vegetation types in south-west Tasmania are alpine vegetation, temperate rainforest, eucalypt forest, teatree scrub and buttongrass moorland. Teatree scrub is normally dominated by tall *Acacia, Banksia, Leptospermum* and/or *Melaleuca* while buttongrass moorland is normally co-dominated by sedges and low heaths, in particular the hummock forming Buttongrass (*Gymnoschoenus sphaerocephalus*; Kirkpatrick 1991; Reid *et al*. 1999). Alpine vegetation can be adjacent to any of these lowland vegetation types (Kirkpatrick 1983, 1984; Kirkpatrick & Brown 1987).

These vegetation types characteristically occur in close juxtaposition, with their distributions being related to site productivity and its influence on the probability of fire (Jackson 1968; Bowman & Jackson 1981). A common lowland sequence from less productive and/or more flammable to more productive and/or less flammable sites is: buttongrass moorland — tea-tree scrub — eucalypt forest — rainforest (Jackson 1968).

Below the alpine zone there are few places that could not support any of rainforest, tea-tree scrub or buttongrass moorland, all of which can occur in the full range of sites from highly waterlogged to well drained as well as on the full range of the region's geological types. Eucalypt forest tends not to occur in the most poorly drained sites. This implies that, given the capacity for rainforest to expand and exclude other vegetation groups in the prolonged absence of fire or other major exogenous disturbance, almost all of non-alpine south-west Tasmania could conceivably be covered with rainforest, and a large proportion of the alpine vegetation of the region could be dominated by native gymnosperms and Deciduous Beech (*Nothofagus gunnii*).

Most rainforest and alpine shrub and tree species will regenerate after fire, with several fires at relatively high frequency being necessary for their total local elimination. However, the re-establishment of Deciduous Beech and native gymnosperms in burned areas is normally an extremely slow process because they are killed by fire, have no persistent seed bank, and have very limited dispersal ranges (Kirkpatrick & Dickinson 1984a). Conversely, under prolonged absence of fire in lowland sites, *Eucalyptus* can be eliminated from an area if the interval between fires exceeds their lifespans. This is due to *Eucalyptus* having no persistent seed bank, poor dispersal mechanisms and its requirement for open regeneration niches which tend not to occur in the absence of fire. The seed bank and dispersal characteristics of most buttongrass moorland taxa are also poorly known. However, canopy closure by overstorey tree and heath species will probably result in the elimination of many species. There seems little doubt that the extensive areas of eucalypt forest, tea-tree scrub and buttongrass moorland in south-west Tasmania are a product of a fire regime frequent enough to prevent the successional process that terminates in rainforest. With a reduction in fire frequency in these areas, buttongrass moorland has been shown to maintain its species richness for at least 50 years without fire (e.g. see Brown & Podger 1982; Jarman *et al.* 1988a; Marsden-Smedley 1990, 1998b), but by the time these moorlands are 100–150 years of age many appear to be undergoing succession into tea-tree scrub (J. B. Marsden-Smedley, unpubl. data). More frequent fires are therefore needed to maintain buttongrass moorlands and to maintain habitat for some animal species. For example, Orange-bellied Parrots (*Neophema chrysogaster*) require fire frequencies of 3 to 12 years between fires (Brown & Wilson 1984; Marsden-Smedley 1993b) while small patchy fires about every 20 years seem to maintain small mammal and invertebrate species diversity (Arkell 1995; Greenslade 1997; Driessen 1999).

Key role of buttongrass moorland in landscape-scale fire dynamics

The most critical ignitions are those that occur when any or all of tea-tree scrub (particularly its fibrous peat layer), eucalypt forest, alpine and rainforest areas are dry enough to burn under the prevailing weather conditions. During most of the year, however, fuel moistures in south-west Tasmania are such that only buttongrass moorlands are dry enough to burn, and fires are therefore limited in their duration by the size of the buttongrass patch in which ignition took place. The probability of fire transgressing the boundary between buttongrass moorland and tea-tree scrub increases with increasing buttongrass moorland fuel. Fires in old buttongrass moorlands burn with high rates of spread and intensities, tend to burn throughout the diurnal cycle and frequently burn into scrub vegetation types where there is a high potential for peat fires (see Marsden-Smedley 1993a, 1998b; Marsden-Smedley & Catchpole 1995a, 1995b, in press; Marsden-Smedley *et al.* 1998, 2000, in press). Thus, frequent fire in buttongrass moorlands in conditions in which other vegetation types will not burn seems likely to lower the probability of the other vegetation types burning at other times. Conversely, an absence of fire from buttongrass moorland for a period sufficient to allow tea-tree scrub to develop should also result in a lowering of the probability of fire in forest and alpine vegetation. The literature (e.g. Brown & Podger 1982; Jarman *et al.* 1988a, 1988b; Marsden-Smedley 1990, 1998b) suggests that this period could vary from less than 50 to more than 150 years, the lower limit relating to buttongrass moorland on fertile soils and the latter to steep, high altitude and/or sites underlain by quartzitic rocks.

The fire history of south-west Tasmania

Pre-human fire history

The time period over which humans have occupied south-west Tasmania is currently the subject of some conjecture. Anthropological evidence suggests a minimum occupation age of about 35 000 years (see Kee *et al.* 1993) but in a recent review based on palaeoecological data, Jackson (1999) proposed that an occupation age of 70 000 years is more probable. Prior to 70 000 years ago, during interglacial periods the proportion of rainforest taxa in the pollen record is much higher that is currently the situation (see Jackson 1999).

Dominance by rainforest taxa would be expected in south-west Tasmania under a regime where lightning was the only significant cause of fires. In the current interglacial, the incidence of lightning resulting in medium- to large-scale fires is extremely low with lightning usually being associated with rainfall, and lightning fires covering very small areas (Parks and Wildlife Service, unpubl. data; see also Marsden-Smedley 1998b).

Indigenous fire regimes

Direct observational evidence of Indigenous fire regimes in the study area, although necessarily limited, leaves little doubt that Indigenous people burned buttongrass moorlands (Kelly 1816; Goodwin 1828; Robinson 1829–1834; Calder 1847; Sharland 1861). Given that buttongrass moorland was burned by Indigenous people and that extensive areas of highly fire-sensitive vegetation also occurred in close proximity (Kirkpatrick & Brown 1991; Corbett unpublished), such burning must have either been restricted to times in which escapes into non-moorland vegetation types was unlikely, the burning was so frequent and patchy that the probability of escape into non-moorland vegetation was low, or a combination of both of these options. This latter alternative seems the most likely (Thomas 1993, 1995) and is further supported by the implication that patch burning was employed, although there is no clear indication of specific frequencies and sizes of burns (Marsden-Smedley 1998a). For example, the available evidence strongly suggests that Indigenous burning was performed during wetter seasons and/or following recent rainfall (e.g. see the accounts of Goodwin 1828; Robinson 1829–1834; Sharland 1861) and contemporary fire research indicates that burning under these conditions tends to result in small-scale patchy fires (Marsden-Smedley *et al*. 2000, in press).

From this information, the most likely fire regime utilized by Indigenous people in south-west Tasmania was one of frequent (e.g. on average less than about 20 years between fires) and probably relatively low-intensity fires in buttongrass moorlands, and with the exception of burning for access tracks, few fires in other vegetation types. These fires would have been mostly lit when scrub, eucalypt forest, rainforest and alpine areas were too wet to burn (Marsden-Smedley 1998a, 1998b). This regime would have been analogous to the firestick farming regime proposed by Jones (1969) and is similar to the fire regime currently being practised in northern Australia by Indigenous people (Jones 1995; Andersen 1996). Under such a fire regime, the aim would probably have been to create a large number of small, recently burnt areas surrounded by thicker vegetation. Burning would also probably have been conducted to improve access tracks. The weather and site conditions used to achieve these burning outcomes were probably very similar to those currently being developed for the technique of unbounded patch burning.

European fire regimes

Following the displacement of Indigenous people from south-west Tasmania, the fire regime changed to one of periods of few fires followed by a regional-scale fire. Since the 1830s there have been three such cycles of few fires followed by a regional-scale fire (Marsden-Smedley 1998a), resulting in massive vegetation change (Brown 1988; Pemberton 1988, 1989; Peterson 1990; Robertson & Duncan 1991). These very large fires burned extensive areas of all vegetation types. These cycles of few fires followed by a regional-scale fire reflected periods where the region was more or less deserted followed by attempts to utilize it (e.g. open up the country, expose potential mineral deposits, improve access and/or to make the vegetation more economically productive). Such processes allowed for the development of extensive areas of old buttongrass moorland during the period when the region was abandoned, which in turn facilitated regional-scale fires during the next period of land exploitation, in a context in which lighting fires in wild country was a socially acceptable activity.

Since the 1930s, there has been no decade that has rivalled the peak earlier decades in terms of the area burned (Table 1). In the 1990s there were very few fires and these covered only small areas. During this decade, fire prevention and suppression were the major tactics used by land managers along with very limited area hazard-reduction and ecological-management burning. Between 1940 and 2000 only about a dozen large fires occurred, all of which primarily burned buttongrass moorland, with only limited areas of rainforest, alpine and subalpine vegetation being burned. The majority of these fires occurred in areas adjacent to the coast or access points and many areas were burned several times. As a result, the majority of the region has not been burned since the fires of the 1930s or 1890s (Marsden-Smedley 1998a). This change is almost certainly the result of a reduction in human-initiated fires, as a result of declining social and legal acceptability of unplanned ignition of bush. In the 1980s and 1990s there were several years (e.g. 1980/1981, 1981/1982, 1994/ 1995, 1997/1998, 1998/1999) during which the weather conditions were comparable to the major fire years of 1897/1898 and 1933/1934 (Bureau of

Table 1. Area of different vegetation types and area burned in 1850, the 1890s and since the 1930s

	Moorland and scrub		Wet eucalypt forest		Rainforest		Subalpine and alpine		Total, all vegetation types	
	ha	%	ha	%	ha	%	ha	%	ha	%
Total area	704 179	57.4	225 594	18.4	245 867	20.0	51 562	4.2	1 227 202	100.0
Estimated 1850	>127 000	–	unknown	–	unknown	–	unknown	–	400 000	33.0
Estimated 1890s	690 000	98.0	188 000	83.3	94 000	38.0	26 000	50.0	998 000	81.0
1930s	489 625	69.5	51 161	22.7	59 364	24.1	28 906	56.1	629 056	51.3
1940s	8257	1.2	2158	1.0	356	0.1	80	0.2	10 851	0.9
1950s	71 384	10.1	4755	2.1	5096	2.1	2497	4.8	83 732	6.8
1960s	25 743	3.7	3860	1.7	3739	1.5	394	0.8	33 736	2.7
1970s	92 349	13.1	7835	3.5	4649	1.9	390	0.8	105 223	8.6
1980s	88 947	12.6	8307	3.7	7595	3.1	379	0.7	105 228	8.6
1990s	19 380	2.8	456	0.2	142	0.1	19	0.0	19 997	1.6

Source: Marsden-Smedley (1998a).

Note: areas burned in the 1850 and 1890s fires are estimates only; area covered includes South-west and Franklin – Lower Gordon National Parks along with that part of the South-west Conservation Area that is adjacent to the King River and Cape Sorell.

Meteorology data; see also Marsden-Smedley 1998b).

It is important to note that if current trends continue (i.e. a regime of few small fires, as occurred in the 1990s), by 2005 about 79% of south-west Tasmanian buttongrass moorlands will be 'old' (i.e. in excess of 60 years) while by 2035 over 99% of the buttongrass moorland in south-west Tasmania will be 'old' (Marsden-Smedley 1998a, 1998b).

Potential constraints on the contemporary application of Indigenous-style fire regimes

While one of the difficulties in applying Indigenous-style fire regimes is the knowledge gaps referred to above, further concerns also need to be addressed.

The potential presence of introduced biota that are likely to produce undesirable consequences under a burning regime similar to that of Indigenous people

Some introduced plants and herbivores have been shown to change the nature of impacts of particular fire regimes in the Top End (Bowman 1998); and cattle in Queensland have increased the penetrability of fire into rainforest (Fensham *et al*. 1994). Introduced plants, such as Giant Sensitive Plant (*Mimosa pigra*) in the Northern Territory floodplains and Boneseed (*Chrysanthemoides monilifera* ssp. *monilifera*) in south-eastern Australia may have had their spread accelerated or their dominance increased with changes in fire regimes (Kirkpatrick 1986; Miller & Lonsdale 1991).

Most exotic flora species found in the study area are confined to disturbed areas (in particular roadside verges) and show little tendency to invade undisturbed native ecosystems. The most widespread exotic species are European wasps, bumble-bees, honey bees, cats, trout and the Cinnamon Fungus (*Phytophthora cinnamomi*). The five animals all seem highly unlikely to influence the impact of fire. The Cinnamon Fungus can gain higher altitudes after forests are disturbed by fire, otherwise being largely unaffected by its incidence (Parks and Wildlife Service 1993). Thus, a re-imposition of the putative Indigenous-style fire regime is likely to reduce the impact of the Cinnamon Fungus if it lowers the probability of forests burning.

The area of remaining vegetation is inappropriate to the scale of the fire regime

If the remnants of a particular ecosystem are not sufficiently large to allow a mosaic of patch burning, taxa such as wind-dispersed herbs that rely on dispersal to recolonize burned areas, or taxa such as the Orange-bellied Parrot that require vegetation in several successional states may become locally extinct (Brown & Wilson 1984). Where only a few stands remain of fire-susceptible vegetation types in a matrix of flammable vegetation, the adoption of a risk minimization strategy might be more appropriate than the re-imposition of the fire regime that prevailed during periods of Indigenous management. For example, the fire regimes utilized by Indigenous people may have occasionally caused the loss of stands of fire-susceptible vegetation, but these losses would probably have been offset by the expansion of other patches. However, in a remnant landscape, any such losses could be critical.

Almost the entire area of south-west Tasmania is covered by native vegetation. While fire-sensitive patches (e.g. rainforest containing native gymnosperms) have suffered a high rate of loss since the 1830s, large areas of all vegetation types remain. Nevertheless, some particularly outstanding remnants of unburned rainforest and alpine vegetation may need more protection than might be provided by a fire regime designed to approximate that of Indigenous people. It may be advisable to conduct hazard-reduction burning in order to reduce the level of fire risk adjacent to these areas.

The vegetation has been segregated into remnants with a variety of management regimes

Such segregation into remnants has occurred in temperate lowland grasslands and grassy woodlands on the mainland of Australia (Lunt 1997). An extreme case is that of the endangered herb, *Lepidium hyssopifolium*, which now largely depends on the survival of large exotic trees on ungrazed roadsides and farmyards (Kirkpatrick & Gilfedder 1998). The reinstatement of an Indigenous-style fire regime in all remnants of lowland native grassland could be a recipe for accelerated extinction.

In south-west Tasmania, rather than segregation of different sets of species into areas with different post-European disturbance regimes, the pattern has been range reduction of those species unsuited to the new regimes, without notable expansion in the ranges of other species in areas subject to the new fire regimes. Thus, gymnosperms and Deciduous Beech have not survived in burned areas of rainforest and alpine vegetation (Kirkpatrick & Dickinson 1984a), and the range of the Orange-bellied Parrot has contracted to those small parts of the area where patch burning has continued through the long periods of general fire exclusion (Brown & Wilson 1984).

There is no practical way to reinstate an Indigenous-style fire regime

Where Indigenous people still inhabit the landscape, and wish to do so using their traditional fire-management techniques, practicality is assured (e.g. see Langton 1999). Where Indigenous people no longer inhabit the landscape, or have no desire to reinstate traditional fire regimes, there may be a substantial cost associated with the reinstatement of the regime.

Due to the size and remoteness of south-west Tasmania, the only economically practical means for reimposing widespread patch burning of buttongrass moorlands is aerial ignition without ground crews or constructed firelines. Prior to the 1990s, aerial ignition of buttongrass moorland frequently resulted in more extensive fires than were planned. These escapes were primarily due to the flawed nature of the burning prescriptions which were current at the time and partly due to a failure to observe the prescriptions themselves. In the absence of research on buttongrass moorland, these original prescriptions were largely developed using fire behaviour data from dry sclerophyll forests and with only limited data from buttongrass moorlands (e.g. see Forestry Commission 1977; Gellie 1980). Once appropriate research was undertaken, it became apparent that buttongrass moorland will burn at moisture levels well in excess of those at which any other documented vegetation type will burn (Marsden-Smedley & Catchpole 1995b, in press; Marsden-Smedley *et al.* 1998).

The majority of the operational fire research required in order to securely conduct prescribed burning in buttongrass moorlands has now been completed. This research has provided systems for predicting fuel characteristics, fuel moisture, rate of fire spread, fire intensity, fire extinction, prescriptions for prescribed burning (for both ecological management and hazard-reduction) and the options available for wildfire control (Table 2). As a result, the aerial ignition of buttongrass moorland now has relatively predictable consequences in terms of rate of spread and intensity for a given set of climatic conditions and fuel ages (i.e. time since the past fire).

From this work, a methodology has been developed for conducting unbounded patch burning. Unbounded patch burning is where fires are lit under conditions which allow them to burn well during the day but self-extinguish overnight as a result of increases in fuel moisture, decreases in wind speed and dewfall (Marsden-Smedley *et al.* 2000, in press). This strategy for conducting burning is considered by the authors to be the one that most closely approximates the burning performed by Indigenous people.

Conflict with other management goals

An Indigenous-style fire regime could result in risks to adjoining property, result in unacceptable air quality in adjoining areas, and/or have impacts on perceived aesthetic or recreational quality.

The aesthetic values of the World Heritage Area were one of the main reasons for its listing (Parks and Wildlife Service 1999). If the restoration of an Indigenous-style fire regime succeeded in reducing the loss of fire-sensitive vegetation to fire then these values should be improved, as burned rainforest and alpine vegetation is regarded by most people as aesthetically unattractive. On the other hand, if burned buttongrass moorland is regarded as aesthetically unpleasant there will be much more of it under this regime. Some people may consider that this type of burning regime is inconsistent with the maintenance of wilderness qualities. However, the current Australian conception of wilderness recognizes Indigenous landscapes and management.

The main users of most of the study area are bushwalkers. Aerial ignition could potentially present a hazard to walkers, a hazard easily avoided by seasonal closure of areas in which it is to take place. Such closures would be highly unlikely to affect significant numbers of bushwalkers since bushwalking in south-west Tasmania is a highly seasonal activity with very few walkers being in the region during the prescribed burning season (April to October). For example, between April and October in south-west Tasmania, on average there is only one off-track remote area multi-day bushwalking trip every 8 years and about 40 on-track multi-day bushwalking trips per year. During this season most of these on-track bushwalking trips are on the South Coast and Huon Plains tracks with a small number of parties also using the Port Davey track (Parks and Wildlife Service, unpubl. data). There is probably more reason to be worried by the likely effects of the burning program on the behaviour of walkers and their impacts on the environment. Old buttongrass moorland is much more difficult to traverse than young. For this reason some early bushwalkers used fire to improve access. There is a possibility that Cinnamon Fungus and trampling damage will become more widespread in the region with the increased accessibility resulting from a more frequent burning regime. However, even in summer, the number of off-track bushwalking parties is currently extremely low (on average only about six bushwalking parties per year: Parks and Wildlife Service unpubl. data). Again, this problem is far from insurmountable, requiring only that measures be taken if increased usage becomes a problem.

Planned burning does not address the problem

The major rationale for restoring patterns of Indigenous-style burning by people is that this action is likely to maintain native biological diversity more effectively than alternatives. However, illegal and accidental burns are not precluded by these planned burns. Thus, planned burning may end up being additive to other burns, possibly producing a fire regime of excessive frequency for the conservation of the biota of an area. This is particularly a problem where levels of incendiarism are high and the vegetation has a restricted low-fuel period.

In south-west Tasmania, a fire lit on one of the few days in which the fuels in all or most vegetation types are dry enough to burn could only be stopped by immediate suppression, which is usually impossible. With dry fuels and a strong wind buttongrass moorland will burn within a couple of years after the last fire (Marsden-Smedley 1998b). Patch burning of buttongrass moorland on a cycle of decades would be almost totally ineffective in fire control in these extreme conditions, providing only safe bases for back-burning

Table 2. Technical reports and papers relating to buttongrass moorland fire behaviour research

Topic	Technical reports	Refereed scientific papers
Fuel characteristics	Marsden-Smedley (1993a)	Marsden-Smedley & Catchpole (1995a)
Fuel moisture	Marsden-Smedley *et al.* (1998)	Marsden-Smedley & Catchpole (in press)
Fire behaviour	Marsden-Smedley (1993a)	Marsden-Smedley & Catchpole (1995b)
Fire extinguishment	Marsden-Smedley *et al.* (1998)	Marsden-Smedley *et al.* (in press)
Operational management	Tasmanian Fire Research Fund (2000)	Marsden-Smedley *et al.* (2000)

where the planned burns had been undertaken in the last few years. The only feasible tactic for avoiding such fires is prevention of ignition. This tactic has been largely effective in 1999–2000, which had very low precipitation, yet no landscape-scale fires. The adoption of this tactic is probably the reason that few large fires occurred in the south-west of Tasmania in the 1990s as a whole, a period in which there were many periods of weather suitable for such a conflagration.

Loss of fire-susceptible ecosystems is but one of the fire management problems in south-west Tasmania. The other is the loss of fire-requiring ecosystems. Planned burning is not appropriate for most tea-tree scrub and eucalypt forest, because the days on which it is possible to burn these ecosystems are days on which it would be too risky for rainforest and alpine vegetation to do so. No matter what strategies are adopted in the future for fire management in south-west Tasmania, it seems likely that sufficient unplanned fires will occur in eucalypt forest and tea-tree scrub to ensure their perpetuation as major elements in the landscape, as they require only one fire every 100–350 years. There is, however, a possibility that a large proportion of buttongrass moorland will be lost if fire exclusion remains the prevailing policy for the area. The ecological data suggest that a fire frequency of decades rather than centuries is necessary to maintain the biological diversity of this system. Widespread aerial patch burning seems a possible solution to this potential problem of buttongrass moorland loss.

The fact that all these elements survived several millennia of landscape management by Indigenous people does not inexorably lead to the conclusion that a restoration of their regimes will be a total solution to the problems of decline. In the year 2000 there is much less vegetation with gymnosperms and Deciduous Beech than there was in 1800, and much more vegetation of relatively high flammability. The protection of the surviving areas of fire-susceptible vegetation seems to require more intensive protection than that which would be provided by patch burning of buttongrass moorland at a frequency of decades. In the year 2000 the potential for fires lit at particularly dangerous times in particularly dangerous situations is likely to be much higher than it was in 1800. Action to prevent accidental or malicious ignition in these circumstances seems an essential element of fire management. We also have the handicap of lack of knowledge of the exact nature of the Indigenous fire regimes. Yet, given these provisos a strong case can be made for changing fire management in south-west Tasmania in the direction of the putative regime that prevailed before 1800.

Options for fire management in south-west Tasmania

Possible fire management strategies include combinations of hazard-reduction burning, ecosystem-management burning, fire suppression and/or fire exclusion. The main aim of hazard-reduction burning is to broaden the weather conditions within which effective fire suppression can be performed and within which fires will not sustain. Implicit within hazard-reduction burning is the assumption that wildfire control is the most important management aim and that ecological considerations are of secondary importance. In buttongrass moorlands hazard-reduction burning is normally performed on a 5–8 year rotation (Marsden-Smedley *et al.* 2000) and, as a result, a major shift in community dynamics occurs due to the reduction in the dominance and cover of the heath component of the vegetation (Marsden-Smedley, unpubl. data). In contrast, ecosystem-management burning aims to advantage particular species and/or community types. An ecosystem-management burn which results in a patchy burn will probably be superior to a fire which burns all of the site (e.g. see Bradstock 1993; Cary & Morrison 1995; Bradstock *et al.* 1996). On the basis of presently available ecological data, a variable regime of burns with an average frequency of one fire every 20 years (frequency range from about 8–50 years) appears generally suitable for ecosystem-management burning in buttongrass moorlands, although much lower frequencies would be appropriate for subalpine moorlands and higher frequencies might be necessary to provide suitable habitat for particular species. Hazard-reduction and ecosystem-management burning can be performed at either a broad scale or a tactical scale. Broad-scale burning is where the aim is to burn the majority of the site subjected to burning while tactical-scale burning is where specific areas are targeted and only part of the area is burned.

Fire management options

Seven potential fire management strategies for south-west Tasmania are discussed below: (1) do nothing; (2) broad-scale ecosystem-management burning; (3) tactical ecosystem-management burning; (4) broad-scale hazard-reduction burning; (5) tactical hazard-reduction burning; (6) tactical ecosystem-management and hazard-reduction burning along with wildfire suppression; and (7) broad-scale ecosystem-management burning, tactical hazard-reduction burning and wildfire suppression.

Within these different fire regimes, if natural (i.e. lightning) fires occurred within conditions that were unlikely to result in large-scale wildfires, then consideration could be given to letting the fires burn.

1. Do nothing

The option of doing nothing will be cheap in economic terms but will also be highly unlikely to provide adequate protection for fire-sensitive assets (Blanks 1991) or suitable conditions for the maintenance of fire-dependent buttongrass moorlands. The probability of excluding fires from the region for long enough for the vegetation to undergo succession to less flammable community types (e.g. buttongrass moorland to rainforest) is extremely low (Jackson 1968). Under this option when the inevitable fires occur, they will tend to have high rates of spread and intensities and have a high potential to burn rainforest, subalpine and/or alpine vegetation types. In addition, if extensive areas of buttongrass moorland occur with fire ages in excess of 65–150 years, then this regime will almost certainly result in decreased species richness (Marsden-Smedley, unpubl. obs.). As a result, such a policy of 'benign neglect' (see Brown 1996) will only provide for a low level of protection for fire-sensitive rainforests, subalpine and alpine vegetation types while also failing to adequately maintain the ecological values of buttongrass moorlands.

It needs to be borne in mind, however, that there is no certainty that an absence of planned fire will necessarily result in the almost total disappearance of the buttongrass moorland ecosystem. The careless incendiarists and lightning might maintain the ecosystem, if not all its elements.

2. Broad-scale ecosystem-management burning

Current ecological research indicates that broad-scale ecosystem-management burning on about a 20-years rotation has a high probability of maintaining ecological values of buttongrass moorlands. This option should also provide for moderate fire protection to fire-sensitive assets by breaking up the area of buttongrass moorlands into a range of fire ages. Such a regime would involve the application of a large number of variable frequency, variable size and intensity fires and is analogous to the fire regime most likely to have been practised by Indigenous people prior to European settlement.

3. Tactical ecosystem-management burning

This regime is currently employed in two small parts of the World Heritage Area, Birch Inlet and Melaleuca, in order to promote Orange-bellied Parrot habitat (Marsden-Smedley 1993b). Although the burning of small selected areas for ecosystem management has the potential to maintain selected fire-dependent species and/or community types, it is unlikely to be effective at either protecting fire-sensitive assets or maintaining buttongrass moorland species richness across extensive areas.

4. Broad-scale hazard-reduction burning

This option probably has the highest potential for protecting fire-sensitive vegetation types by minimizing the area burned in wildfires. However, as was discussed above, such a regime will also cause high-level impacts to the ecological values of buttongrass moorlands and so will not meet the management goals outlined in the region's management plan (Parks and Wildlife Service 1999).

5. Tactical hazard-reduction burning

The application of tactical hazard-reduction burning, as occurs currently along the Lyell Highway, has the potential to reduce the area burned in wildfires by ensuring that arson fires have a lower probability of spreading and causing extensive area fires. In common with the tactical ecosystem-management regime, this regime will probably only provide for low level protection for fire-sensitive assets while also potentially failing to adequately maintain buttongrass moorland species richness.

6. Tactical ecosystem-management and hazard-reduction burning along with wildfire suppression

Maintaining the current regime of very limited tactical ecosystem-management and hazard-reduction burning in association with active fire suppression is unlikely to be effective in the long term at either protecting fire-sensitive assets or maintaining fire-dependent buttongrass moorlands. If fires occur in remote areas or burn away from access points prior to their being contained (a likely prospect due to the typically high rates of spread in old buttongrass moorlands), most of these fire-suppression operations will have a low to very low probability of success.

7. Broad-scale ecosystem-management burning, tactical hazard-reduction burning and wildfire suppression where appropriate

Over the majority of the region, a regime of broad-scale ecosystem-management burning in association with tactical hazard reduction and fire suppression would be very similar in its management aims to the second option; broad-scale ecosystem-management burning. However, this regime would also include tactical hazard-reduction burning in areas of demonstrated fire risk and where appropriate and feasible, fire suppression operations.

Since this option would manage the majority of the area of buttongrass moorland in south-west Tasmania using a ecosystem-management regime it should have the highest probability of meeting the ecological requirements of buttongrass moorlands. In addition, due to it also acting to break up the area of buttongrass moorland into a mosaic of patches with different ages, it should result in increased protection for fire-sensitive assets and enhanced wildfire suppression operations. This regime will be discussed in more detail below.

An integrated strategy for managing fire in south-west Tasmania

An integrated strategy of broad-scale ecosystem-management burning in association with tactical hazard-reduction burning and wildfire suppression where appropriate is considered to have the highest probability of achieving the goals of maintaining ecological values in buttongrass moorland while minimizing the area of fire-sensitive vegetation being burned. The implementation of such a program should greatly reduce the risk of large-scale wildfires by acting to break up the area of buttongrass moorland and reducing the potential for fires to burn into the region.

Across much of the region, the ecosystem-management fire regime would approximate (in its fire frequencies and intensities) the fire regime most probably utilized by Indigenous people prior to European settlement. As a result, where the aim is to replicate Indigenous-style burning there would be considerable scope for input from the Indigenous community in the planning and application of these burns.

The main aims of the ecosystem-management burning would be to develop a mosaic of fire ages, fire sizes and areas burned with different fire intensities with the region being divided up on the basis of its natural fire boundaries. Tactical hazard-reduction burning would aim to develop a series of fire control zones. These fire control zones would be located such that they crossed natural fire corridors, were adjacent to major areas of fire-sensitive vegetation, and/or were in areas of high ignition risk.

Conclusion

An analysis of fire management strategies in the context of biodiversity management goals suggests that the maintenance of the ecological values of south-west Tasmania is likely to be best served by an integrated program of broad-scale ecosystem-management burning (with strong similarities to what we understand to have been Indigenous fire regimes) in association with tactical hazard-reduction burning and fire suppression where appropriate. Thus, a return to Indigenous-style fire regimes seems both feasible and desirable. This return would be modified for the sake of insurance to increase fire protection for fire-sensitive assets, and involve ignition prevention and unplanned fire suppression to help restore the pre-European balance of landscape elements.

At least some of the constraints we have identified on the total adoption of Indigenous-style burning regimes in areas managed for nature conservation would apply to almost all of the reserve estate in Australia. However, in many large reserves, as with south-west Tasmania, a partial implementation of these regimes, in combination with other management measures, might lead to improved conservation outcomes.

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