ATTACHMENT D

Fire management in the Tasmanian Wilderness World Heritage Area: A report to the Tasmanian Parks and Wildlife Service

Report scope

This report provides fire related background information for the Update Report on the State of Conservation of the Tasmanian Wilderness being prepared in response to World Heritage Committee Decision **WHC 31 COM 7B.43**. The decision addresses concerns raised by Non Government Organisations relating to forestry operations in the vicinity of the Tasmanian Wilderness World Heritage Area (TWWHA) and in Tasmania generally, along with concerns about the integrity of the TWWHA.

Part 1: The role of fire in the Tasmanian Wilderness World Heritage Area

Fire has been an important aspect of the ecology of western and southwestern Tasmania (and hence the area that is now the TWWHA) for at least the last 10 000 years (Fletcher and Thomas 2007a) and for the last 70 000 years (Jackson 1999). In addition, recent palaeo-pollen work suggests that the region's vegetation type has been effectively stable in its distribution throughout the Holocene, probably as a result of continuous and active fire management by Indigenous people (eg see Fletcher and Thomas 2007a, 2007b).

However, in the approximately 200 years since European settlement there have been marked changes in the region's fire regime. These changes have resulted in the spread of fire into fire-sensitive temperate rainforest and alpine vegetation (Kirkpatrick and Dickinson 1984; Bowman and Brown 1986; Brown 1988; Cullen and Kirkpatrick 1988; Peterson 1990; Robertson and Duncan 1991). Conversely, a trend is also evident towards a reduction in the fire frequency in many of the region's buttongrass moorlands; which are dependent on shorter fire frequencies to maintain plant and animal diversity (see Brown and Wilson 1984; Marsden-Smedley 1993a, 1993b, 1998a, 1998b; Arkell 1995; Greenslade 1997; Driessen 1999; Driessen and Mallick 2007). Both changes have the potential to reduce the region's biological diversity, with the possibility of major alterations to ecological processes and biological patterning (Kirkpatrick 1994).

Fire history

Prior to human settlement, fires were infrequent in what is now the TWWHA (Fletcher 2007). The time period over which humans have occupied this region 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 review based on palaeoecological data, Jackson (1999) proposed that a occupation age of 70 000 years is possible.

Prior to European settlement in Tasmania there is strong evidence to support the concept that Indigenous people were actively living in and managing most of what is now the TWWHA and that they were using fire as their primary management tool. There are frequent references in the historical literature to Indigenous burning (eg see Kelly 1816; Goodwin 1828; Robinson 1829-1834; Calder 1847; Sharland 1861). In addition, descriptions of the country and the speed at which the early European explorers travelled suggest that many buttongrass moorlands were very open (eg Robinson 1829-1834; Burn 1842; Calder 1847, 1849, 1860a, 1860b, 1860c, Sharland 1861: reviewed in Marsden-Smedley 1998a; Johnson and Marsden-Smedley 2001).

From this information, the most likely fire regime utilised by Indigenous people in what is now the TWWHA was one of frequent (eg 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 utilised in parts of northern Australia's Top End by Indigenous people (Jones 1995; Andersen 1996). Under such a fire regime, the primary aim of the majority of burning would probably have been to create a large number of small recently burnt areas surrounded by thicker vegetation.

Following the removal of Indigenous people from what is now the TWWHA the fire regime changed to a regime of periods of few fires followed by a very large fire. Between the 1830s and early 1850s it is probable that few fires occurred in western and southwestern Tasmania. In the early 1850s at least a third of the region burned. Following on from the early 1850s fires it appears that although some fires occurred, most of the region would have remained unburnt until the summer of 1897/98. The fires in the summer of 1897/98 were the largest in Tasmania's recorded history and burnt about a third of the state. These fires also burnt over half of the area what is now the TWWHA. This pattern of few fires followed by a massive fire then repeated itself, with few fires occurring between 1897/98 and the summer of 1933/34 when about 414 915 ha or about a third of what is now the TWWHA burned. During the 1930s there were also very extensive fires elsewhere in western and southwestern Tasmania which burnt a greater area than the fires inside what is now the TWWHA (Marsden-Smedley 1998a; Johnson and Marsden-Smedley 2001).

These large fires burned very extensive areas of all vegetation types, taking several weeks to months to do so. These cycles of few fires followed by a very large fire were a reflection of periods where the region was more or less deserted followed by attempts to utilise it, followed by the next period when the region was abandoned again.

The primary cause of these very large fires was the deliberate and targeted activities of the early European explorers who used fire to open up the country, expose potential mineral deposits, improve access and/or to make the vegetation more economically productive. In their exploration reports, diaries and letters, they make very frequent reference to the fires they lit, for example:

> We burned the ground well filling the atmosphere with smoke ... Fired a vast tract of country. Never saw such a conflagration... JE Calder 1837.

> Whenever we could get a fine day we burned what we could, and the benefit to us was incalculable, rendering the travelling comparatively easy. D Jones 1881.

> ... sent James out on the previous day ... to put a match into the country, which is clothed with button grass and tea tree ... We found the fire had done excellent work and was still blazing ahead ... The fires burnt for a week, and cleared the hated button grass and bauera splendidly, in all directions for miles... TB Moore 1887.

> [moorland, scrub and forest can] ... be burned off in broad belts [and] … money spent in burning the country in this way is well spent… W Twelvetrees 1908.

As a result of these very large fires, there was massive structural and floristic change. These changes included the burning and transformation of the majority of the rainforest in the TWWHA into regrowth forms along with the destruction of extensive areas of King Billy pine rainforest, Huon pine rainforest, Deciduous beech, coniferous alpine heath and significant areas of other fire-sensitive vegetation types. For example, a minimum of 32% (Brown 1988) and probably greater than 50% (Marsden-Smedley unpublished data) of the area of King-billy pine, 8% of the area of Huon pine (Peterson 1990) and significant areas of Deciduous beech (Robertson and Duncan 1991) have been lost since Europeans arrived in Tasmania. Most of this loss has been within the TWWHA.

Since the 1930s, there has been no decade that has rivalled the area burnt in earlier periods. During this time, the fire management strategy changed to one of fire prevention and suppression in association with very limited area hazard-reduction and ecological-management burning.

Between 1940 and 2006/07 in what is now the TWWHA a total of about 424 375 ha was burnt. These fires included a total of 32 fires sized between 1 000 and 10 000 ha, six fires between 10 000 to 25 000 ha and five fires between 25 000 and 60 000 ha (Marsden-Smedley 1998a; Johnson and Marsden-Smedley 2001; PWS unpublished fire history records). With the exception of the 1960/61 Central Plateau fires all of these fires predominately burned buttongrass moorland, with much smaller areas of wet eucalypt forest, rainforest, alpine and subalpine vegetation being burnt. There is strong evidence from both anecdotal and government records (eg minutes of the Central Highlands Special Fire Area Committee) that the 1960/61 Central Plateau fires were deliberately lit by highland graziers in order to clean out thick vegetation and promote green-pick for sheep and cattle grazing.

As a result, although the majority of the TWWHA has been burnt in the past about 150 years, most of it has not been burnt since the fires of the 1930s or 1890s (Marsden-Smedley 1998a; Johnson and Marsden-Smedley 2001). This change is probably the result of a reduction in human initiated fires, as a result of declining social and legal acceptability of unplanned ignition of bush. The fire history data also indicates that since the 1930s within what is now the TWWHA 58% of fire seasons account for only 1% of the area burnt while 1% of fire seasons are responsible for over 40% of the area burnt. However, it is important to note that there has been a major increase in the incidence of lightning fires in the past seven to ten years indicating that ignition sources are now common in the TWWHA and therefore there is a high wildfire risk.

The area of the TWWHA burnt since the 1930s is summarised in Table 1. Nearly half of the area of the TWWHA that has been subjected to fire since the 1930s was burnt in two fire seasons: 1933/34 and 1938/39 (Marsden-Smedley 1998a; Johnson and Marsden-Smedley 2001) with that decade accounting for 3.7 times the average for subsequent time periods (Table 1).

Table 1 Area of the Tasmanian Wilderness World Heritage Area burnt since the 1930s

Decade	Area burnt	%	Average per year	ratio
1930s	414 913.4	47.8	41 491.3	3.7
1940s	2 664.4	0.3	266.4	0.0
1950s	112 774.9	13.0	11 277.5	1.0
1960s	113 415.0	13.1	11 341.5	1.0
1970s	84 042.6	9.7	8 404.3	0.8
1980s	68 250.1	7.9	6 825.0	0.6
1990s	5 068.5	0.6	506.9	0.0
2006/07	66 188.0	7.6	9 455.4	0.8
total	867 317.0		11 196.0	

Vegetation adaptations to fire

The major fire-attributes vegetation groups in the TWWHA are alpine heath and grassland, buttongrass moorland, wet eucalypt forest, rainforest and wet scrub (see below). 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 and Jackson 1981). A common lowland sequence from less productive and/or more flammable to more productive and/or less flammable sites is: buttongrass moorland – wet scrub – wet eucalypt forest – rainforest (Jackson 1968).

Below the alpine zone there are few places that could not support any of rainforest, wet 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. Wet 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 with increasing time since fire, in the prolonged absence of fire, or other major exogenous disturbance, almost all of the non-alpine parts of the TWWHA 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.

Most rainforest and alpine shrub and tree species will regenerate after fire, with several fires with less than about 80 to 120 years between them being necessary for their local elimination. In contrast, the reestablishment 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 and Dickinson 1984). Conversely, under prolonged absence of fire in lowland sites, *Eucalyptus* can be eliminated from an area if the interval between fires exceeds their lifespans of about 350 to 500 years. 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 southwest 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 (eg see Brown and Podger 1982; Jarman et al. 1988a, 1988b; Marsden-Smedley 1990) but are transformed, at least structurally, into a tall closed wet scrub community by the time they are about 150 years old (Marsden-Smedley unpublished data). More frequent fires are therefore needed to maintain buttongrass moorland and its suite of animal species (see below).

The most critical ignitions are those that occur when any or all of tea-tree scrub (particularly its fibrous duff and peat layer), wet 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 southwest 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 wet scrub increases with increasing buttongrass moorland fuel loads. 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 and Catchpole 1995a, 1995b, 2001; Marsden-Smedley *et al.* 1998, 1999, 2001). 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 wet scrub to develop should also result in a lowering of the probability of fire in forest and alpine vegetation. The literature (eg Brown and Podger 1982; Jarman *et al.* 1988a, 1988b; Marsden-Smedley 1990, 1998b; Brown et al. 2002) 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. However, the fire history and weather data (see below) very strongly indicates that the probability of extensive areas of buttongrass moorland remaining unburnt for longer than about 75 to 100 years is extremely low.

Fire regimes appropriate to flora and fauna and the effect of variation in fire interval

<u>Flora</u>

The floristic values of the TWWHA have been reviewed by Balmer et al. (2004).

The vegetation of the TWWHA has been mapped by the TasVeg mapping program (Harris and Kitchener 2005) at a nominal scale of 1:25 000. A total of 158 mapping units have been identified by the TasVeg mapping program, 127 of which occur in the TWWHA. However, a major issue with the TasVeg mapping program relates to its complex classification of vegetation type along with its low accuracy in the identification of vegetation type and location. As an example, significant areas (~30 000 ha) of dry eucalypt forest have been mapped in the TWWHA despite the entire region having too high rainfall levels for this vegetation assemblage. In addition, damp eucalypt forest, wet sclerophyll forest and mixed forest have not been reliably differentiated, nor have implicate, thamnic or callidendrous rainforest resulting in these assemblages needing to be combined respectively into wet forest and rainforest.

In order to reduce some of the problems associated with the TasVeg data was simplified and summarised into 22 fire-attributes vegetation types by Pyrke and Marsden-Smedley (2005), 20 of which occur in the TWWHA (Table 2; Appendix 1). The fire characteristics of the fire-attributes vegetation types in the TWWHA are summarised in Table 3. This table and the following descriptions on the fire requirements and sensitivities of the fire-attributes vegetation types have been summarised from the TWWHA Tactical Fire Management Plan (PWS 2004).

Table 2 Fire-attributes vegetation types in the Tasmanian Wilderness World Heritage Area

Group	Fire-attributes vegetation assemblages	
Alpine and subalpine heath and grass	Ac	Alpine/subalpine coniferous and/or fagus heath
	As	Alpine/subalpine heath (without native pines and/or fagus)
	Ag	Alpine/subalpine grassland
	Sp	Sphagnum
Wet forest, damp forest and woodland	Mf	Mixed forest
	Wf	Wet eucalypt forest
	Wd	Wet eucalypt woodland
	Dp	Damp eucalypt forest
	Df	Dry eucalypt forest
Rainforest	Rc	Coniferous rainforest
	Rf	Rainforest
Buttongrass moorland	Bs	Buttongrass moorland
	Wl	Swamp/wetland
Wet scrub and heath	Ws	Wet scrub
	Ds	Dry scrub
	Hh	Heathland
Miscellaneous vegetation types	Gr	Lowland native grassland
	Sr	Silvicultural regeneration, plantation
	We	Weeds (mostly gorse and blackberry)
	Zz	Non-vegetated

Table 3 Fire requirements and sensitivities of vegetation in the Tasmanian Wilderness World Heritage Area

		Fire	Fire-sensitivity		Flammability	
Fire-attributes vegetation formations		dependant	rating	freq (yrs)	rating	SDI
Ac	alpine/subalpine coniferous heath	no	E	>500	L-M	>15
As	alpine/subalpine heath	no	M-VH	>250	L-M	>15
Ag	alpine/subalpine grassland	var	M	>25	H	>15
Sp	sphagnum	no	H	>250	L	>15
Rc	coniferous rainforest	no	E	>1000	L	>50
Rf	rainforest	no	VH	>80	L	>50
Mf	mixed forest	yes	VH	80-350	L-M	>25
Wf	wet eucalypt forest	yes	H	25-350	L-H	>25
Wd	wet eucalypt woodland	yes	H	25-350	M	>20
Bs	buttongrass moorland	yes	L	5-100	VH	N/A
Ws	wet scrub	yes	L-H	15-150	M-H	>15
Wl	swamp, wetland	yes	L	5-100	L	N/A
Gr	lowland native grassland	yes	L	1-25	H	>10
Dp	damp eucalypt forest	yes	M	25-100	M-H	>15
Df	dry eucalypt forest	yes	L-E	10-20	M-H	>15
Ds	dry scrub	yes	L-M	10-50	H-VH	>5
Hh	heathland	yes	L-VH	10-30	H-VH	>5
Zz	non-vegetated	N/A	N	N/A	N	N/A

Note: fire dependence indicates whether fire is required for regeneration; fire sensitivity frequency indicates the formation's normal frequency between fires; flammability indicates the approximate soil dryness index above which the formation will burn.

Alpine and subalpine heath normally consists of a diverse range of species between 0.5 to 2 m in height with the dominant species including *Richea scoparia, Orites acicularis, Orites revoluta,* tea-trees *(Leptospermum* spp.), paper-bark (*Melaleuca* spp.), *Epacris* spp., *Cyathodes* spp. and *Nothofagus cunninghamii* (dwarf form). This assemblage is not fire-dependent and many of its species are highly fire-sensitive. Where this formation includes coniferous species and/or fagus it becomes extremely fire-sensitive and may take 500 to 1000 years to recover from the effects of a single fire. The dominant highly fire-sensitive species include King-billy pine (*Athrotaxis selaginoides*), Pencil pine (*Athrotaxis cupressoides*), dwarf conifers (*M. tetragona, M. niphophilus, P. lawrencei, D. archeri*) and fagus (*Nothofagus gunnii*). Alpine and subalpine grassland consists of grass dominated vegetation mostly on medium to high fertility substrates. It often forms extensive plains below inverted tree-lines in frost prone areas, and in areas with high levels of climatic exposure which have been subjected in the past to moderate fire frequencies. Many of these native grasslands have a sparse to moderate cover of eucalypts and in some sites, especially at higher altitudes and/or in more climatically exposed areas may contain fire-sensitive species such as Pencil pines. In the TWWHA significant areas of Sphagnum only occur in moderate to high altitude areas which also have high fertility substrates (especially dolerite) and poor drainage. Although the Sphagnum is fire-sensitive, the fire dynamics in these formations is highly dependent on how dry the soil is when the fire occurs. If fires occur when soils are wet (eg when the Soil Dryness Index (SDI, Mount 1970) is below 10) only the most elevated fuels may burn resulting in minor impacts. In contrast, if fires occur when soils are dry (eg when the SDI is greater than 25) extensive peat fires may occur resulting in long term deleterious impacts.

In the TWWHA, rainforest assemblages are normally dominated by myrtle (*N. cunninghamii*), sassafras (*Atherosperma moschatum*), leatherwood (*Eucryphia lucida*) and/or horizontal (*Anodopetalum biglandulosum*). While rainforests are fire sensitive and do not require fire for the maintenance of species diversity, if they are burnt either by single fire or at low frequency (eg greater than 120 years between fires) there are normally minimal impacts to their species diversity. In contrast, where rainforests contain highly fire senstive species such as King-billy pine (*Athrotaxis selaginoides*), Huon pine (*Lagarostrobos franklinii*), Pencil pine (*Athrotaxis cupressoides*) or fagus (*Nothofagus gunnii*) even a single fire will cause long term (ie greater than 500 to 1000 years) adverse impacts to species diversity.

Extensive areas of wet forest occur in the TWWHA. These forests range from damp eucalypt forests dominated by *Eucalyptus viminalis – E. ovata, E. pauciflora*, *E. dalrympleana*, *E. rodwayi, E. ovata, Notelaea ligustrina* (native olive) and/or *Pomaderris apetala* (dogwood) and a highly variable understorey through to wet sclerophyll and mixed forests dominated by *Eucalyptus regnans, Eucalyptus nitida*, *Eucalyptus obliqua, Eucalyptus delegatensis, Eucalyptus dalrympleana, Eucalyptus johnstonii, Eucalyptus coccifera* and/or *Eucalyptus subcrenulata*. The understorey in highland wet sclerophyll forests is typically dominated by *Hakea* spp., tea-trees, banksia (*Banksia marginata*), bauera (*Bauera rubioides*) and cutting grass (*Gahnia grandis*) while in lowland areas it is typically dense and dominated by blanket bush (*Bedfordia salicina*), *Phebalium squameum*, stinkwood (*Zieria arborescens*), tea-tree, paper-bark, banksia, bauera and cutting grass. Extensive areas of mixed forest occur in the TWWHA and normally consist of a rainforest assemblage (as above) with a overstorey of eucalypts. As noted above, significant areas of dry eucalypt forest have been mapped by the TasVeg program in the TWWHA (see Appendix 1), but these types are considered to be a miss-typing and have been included in the wet forest category. Wet forests are fire dependent and their normal fire frequency are normally about 25 to 80 years for wet sclerophyll and damp eucalypt forests and between 80 and 350 years for mixed forests.

Buttongrass moorlands are the most extensive vegetation type in the TWWHA (Appendix 1). These moorlands are highly flammable, fire dependent and typically consist of a lower sedge dominated stratum up to about half a metre tall overtopped by a heath dominated stratum up to about one to two metres tall. The dominant species in this assemblage include buttongrass (*Gymnoschenous sphaerocephalus*), tea-tree, paper-bark, sprengelia (*Sprengelia incarnata*), banksia and mallee form western pepermint (*Eucalyptus nitida*). Swamp and wetland assemblages in the TWWHA have a relatively restricted distribution and are normally dominated by sedges, paper-bark and tea-tree. Swamp and wetland assemblages may be highly flammable when dry.

In the TWWHA, wet scrub, heathland and dry scrub associations normally consist of a closed, dense vegetation typically two to ten metres tall typically dominated by western peppermint, tea-tree, paper-bark, banksia, *Acacia* spp., bauera and cutting grass. This assemblage is fire dependent and typically carries fires at 15 to 500 year intervals.

<u>Fauna</u>
To date, in the TWWHA and its associated areas there has only been very limited research into fire - fauna interactions with the majority of the research performed being in buttongrass moorlands. Driessen and Mallick (2007) reviewed the research performed to date and their review has been summarised below with additional information from the 2007 Buttongrass Moorland Management Workshop (see below).

Observational evidence suggests that the optimal feeding habitat for Orange-bellied parrots are buttongrass moorlands between three to 12 years of age and that habitat greater than 20 years of age is unsuitable (Brown and Wilson 1984) although quantitative evidence to support these age ranges is not available. In order to manage for Orange-bellied parrots in the Melaleuca area the Melaleuca-South West Cape Fire Management Plan (PWS 1997a) recommends small scale patch burning on a ten to 12 year rotation.

Bryant (1991) investigated the relationship between Ground Parrot density and fire. Peak densities occur at four to seven years following fire with moderate to high bird densities persisting in buttongrass moorlands up to at least 75 years post-fire (Marsden-Smedley unpublished data).

Gellie (1980) noted that Southern Emu Wrens and Striated Field Wrens require dense vegetation for cover and nest materials, and both species may take from five to seven years to recolonise an area after a fire, unless suitable pockets of unburnt vegetation are left. This is supported by the work of Chaudry et al. (2007) who found these species utilised riparian habitats to a much higher extent than open buttongrass moorlands possibly due to a higher abundance of arthropod prey along with other resources such as cover, perches and nesting sites. Site productivity in buttongrass moorlands also appears to be important. In medium productivity buttongrass moorlands the availability of prey resources was higher in medium aged sites (five to 16 years post-fire), while prey resources appear to be severely limited in recently burnt sites (one year post-fire) and may also be less available in old sites (greater than 30 years post-fire). These patterns were largely driven by Hemiptera, Diptera, and Araneae which together comprised the majority of total energy content of potential arthropod prey. In contrast, in low productivity buttongrass moorlands site age appeared to not have significant influences on bird numbers (Chaudry et al. 2007).

As regards small mammals in low productivity buttongrass moorlands, Gellie (1980), Arkell (1995) and Driessen (2007) suggest Swamp Rats, Broad-toothed Mice and Swamp Antechinus prefer buttongrass moorlands with moderate to dense covers, and that all three species may require ten to 15 years for the vegetation to recover sufficiently for species to regain their pre-fire species diversity and numbers. In contrast, in medium productivity sites Broad-toothed mice, Swamp rats and Swamp Antechinus recovered their pre-fire species diversity and numbers within four to six years following fire (Driessen 2007).

Greenslade and Driessen (1999) investigated the relationship between the age of buttongrass moorland and the abundance and diversity of invertebrates and found that both abundance and morphospecies richness was highest in intermediate aged sites (11 to 19 years post-fire) compared to younger sites (one to five years post-fire). They found that mites, spiders, springtails, beetles, flies and moths were the taxa most influenced by site age. Furthermore, there was some evidence to suggest that abundance and morphospecies richness declined in sites older than 20 years. In contrast, Green (2007) suggests that mite diversity and abundance increased significantly in buttongrass moorlands that had been left unburnt for about 30 years.

No research has been published to date on the effects of fire on reptiles, amphibians or fish in the TWWHA.

A major finding of the fauna and flora research reported on above relates to the importance of having a diversity of fire regimes within an area. This diversity includes having a range in fire sizes, frequencies, intensities and burning seasons.

Current age classes of buttongrass moorland, wet forest and wet scrub

Due to issues with the resolution of the available vegetation mapping (see above), the area in different fire ages classes were only assessed for the three main fire-dependent vegetation groups: buttongrass moorland, wet forest (combination of damp eucalypt forest, wet eucalypt forest and mixed forest) and wet scrub. These age class areas were then compared against the area that would be ecologically desirable.

Currently, within the Tasmanian scientific community discussions as to what the target proportion in different ages classes should be have only been made for buttongrass moorlands and even in this case, broad consensus is not available or been subject to peer review. As a result, when comparing the age distributions of buttongrass moorland, wet forest and wet scrub against what would be desirable the age ranges outlined in Table 4 were used.

Table 4 Time period last burnt for fire dependent vegetation group age classes in the Tasmanian Wilderness World Heritage Area

	Age class		
Vegetation group	regrowth	mature	old-growth
buttongrass moorland, low productivity	1990s and 2000s	1970s and 1980s	pre-1970s
buttongrass moorland, medium productivity	1990s, 2000s	1980s	pre-1980s
wet forest	1980s to 2000s	1930s to 1970s	pre-1930s
wet scrub	1990s and 2000s	1930s to 1980s	pre-1930s

Due to there also being a lack of consensus in the scientific community as to what are the optimal age classes for ecological management, this assessment was done assuming that equal proportions in each age class was the desired target. This age class assessment is summarised in Table 5 which shows the area, percentage of the total and ratio of target of regrowth, mature and old-growth buttongrass moorland, wet scrub and wet eucalypt forest by tenure type, and for the entire TWWHA. The majority of the area of these vegetation types are in Cradle mountain - Lake St Clair, Franklin - Gordon and Southwest National Parks.

Assuming that the desired age range target is as described above, the area of regrowth buttongrass moorland, wet scrub and wet eucalypt forest is about a third of the target while the area of mature and old-growth is over represented (Table 5). This over representation of mature and old-growth is a reflection of the very extensive fires in the 1930s and 1890s followed by a marked reduction in burning since the 1930s.

Table 5 Area of buttongrass moorland, wet forest and wet scrub in different age classes and their corresponding proportions of the target in the Tasmanian Wilderness World Heritage Area

Cradle Mountain - Lake St Clair National Park

Age class	Buttongrass moorland	%	ratio of target	Wet eucalypt forest	%	ratio of target	Wet scrub	%	ratio of target
regrowth	50.3	0.4	0.0	444.4	0.6	0.0	20.9	0.2	0.0
mature	22.9	0.2	0.0	27944.9	35.0	1.1	7522.0	57.5	1.7
old-growth	12808.6	99.4	3.0	51379.3	64.4	1.9	5547.0	42.4	1.3
total	12881.8			79768.6			13089.9		

Walls of Jerusalem National Park

Age class	Buttongrass moorland	%	ratio of target	Wet eucalypt forest	%	ratio of target	Wet scrub	%	ratio of target
regrowth	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
mature	0.0	0.0	0.0	13853.6	61.3	1.8	36.8	28.9	0.9
old-growth	134.5	100.0	3.0	8728.8	38.7	1.2	90.6	71.1	2.1
total	134.5			22582.4			127.4		

Central Plateau Protected Area

Age class	Buttongrass moorland	%	ratio of target	Wet eucalypt forest	%	ratio of target	Wet scrub	%	ratio of target
regrowth	0.9	2.1	0.1	1177.4	4.0	0.1	1.6	0.6	0.0
mature	0.0	0.0	0.0	21907.1	74.3	2.2	202.6	80.1	2.4
old-growth	42.2	97.9	2.9	6396.4	21.7	0.7	48.8	19.3	0.6
total	43.1			29480.9			253.0		

Franklin - Gordon National Park

Age class	Buttongrass moorland	%	ratio of target	Wet eucalypt forest	%	ratio of target	Wet scrub	%	ratio of target
regrowth	9154.3	8.3	0.2	11072.0	8.4	0.3	1707.5	3.4	0.1
mature	31384.7	28.3	0.9	53838.6	40.6	1.2	31636.1	62.6	1.9
old-growth	70165.7	63.4	1.9	67688.2	51.0	1.5	17191.6	34.0	1.0
total	110704.7			132598.8			50535.2		

Table 5 Area of buttongrass moorland, wet forest and wet scrub in different age classes and their corresponding proportions of the target in the Tasmanian Wilderness World Heritage Area, continued

Macquarie Harbour Historic Site / Farm Cove Game Reserve

Age class	Buttongrass moorland	%	ratio of target	Wet eucalypt forest	%	ratio of target	Wet scrub	%	ratio of target
regrowth	434.0	13.6	0.4	111.2	4.5	0.1	38.3	6.8	0.2
mature	1874.0	58.7	1.8	709.7	28.9	0.9	228.0	40.6	1.2
old-growth	885.2	27.7	0.8	1635.0	66.6	2.0	295.4	52.6	1.6
total	3193.2			2455.9			561.7		

Southwest National Park

Age class	Buttongrass moorland	%	ratio of target	Wet eucalypt forest	%	ratio of target	Wet scrub	%	ratio of target
regrowth	30289.8	14.1	0.4	9306.2	7.8	0.2	6498.5	7.0	0.2
mature	46425.1	21.5	0.6	38138.6	32.1	1.0	47806.1	51.4	1.5
old-growth	138795.7	64.4	1.9	71241.6	60.0	1.8	38696.4	41.6	1.2
total	215510.6			118686.4			93001.0		

Hartz Mountains National Park

Age class	Buttongrass moorland	%	ratio of target	Wet eucalypt forest	%	ratio of target	Wet scrub	%	ratio of target
regrowth	0.0	0.0	0.0	148.6	3.9	0.1	0.0	0.0	0.0
mature	0.0	0.0	0.0	793.3	20.6	0.6	363.4	58.1	1.7
old-growth	45.4	100.0	3.0	2903.1	75.5	2.3	262.3	41.9	1.3
total	45.4			3845.0			625.7		

Total Tasmanian Wilderness World Heritage Area

Age class	Buttongrass moorland	%	ratio of target	Wet eucalypt forest	%	ratio of target	Wet scrub	%	ratio of target
regrowth	39929.3	11.7	0.3	22259.8	5.7	0.2	8266.8	5.2	0.2
mature	80087.7	23.4	0.7	157185.8	40.4	1.2	87795.0	55.5	1.7
old-growth	222496.3	65.0	1.9	209972.4	53.9	1.6	62132.1	39.3	1.2
total	342513.3			389418.0			158193.9		

Impact of fire on geoheritage values

Over the past 20 years the impact of fire on geoheritage values and specifically, buttongrass moorland organosols, has been subject to considerable debate. The majority of this debate however, has not been published in either papers or reports.

Probably the most important research question regarding geoheritage values relates to the impacts of fire on buttongrass moorland organosols. Pemberton (1998, 1989) speculated that extensive areas of buttongrass moorland organosol has been eroded by fire in the TWWHA and its adjacent areas but provided no information as to whether these sites ever had more extensive organosols, the time frame over which these soils had been lost, nor a mechanism by which they had been destroyed. However, there is considerable evidence that many of these areas were very open prior to European arrival in western Tasmania in the early 1830s (eg Robinson 1829-1834; Burn 1842; Calder 1847, 1849, 1860a, 1860b, 1860c, Sharland 1861; see also Marsden-Smedley 1998a; Johnson and Marsden-Smedley 2001). Marsden-Smedley (1993a) performed some preliminary research into the ignition thresholds of buttongrass moorland soils. This research found that the buttongrass moorland soils would not sustain combustion unless they were extremely dry (ie at moisture contents that would only be expected to occur during major droughts) and had a high percentage of organic matter (ie above about 75%). This threshold in organic content is higher than occurs in the vast majority of buttongrass moorland soils (di-Folco 2007) and probably is the major explanation as to why peat fires in buttongrass moorlands are extremely rare. For example, Marsden-Smedley (unpublished data) has recorded a total of two peat fires in buttongrass moorlands in the last 20 years despite making detailed observations on the effects of over 1000 fires with both of these peat fires occurring when the Soil Dryness Index exceeded 50. In contrast, in all other vegetation types than buttongrass moorland, if the vegetation is dry enough to burn it is normal to get duff and peat fires (Marsden-Smedley et al. 1991).

Bridle et al. (2003) examined the effect of fire in buttongrass moorland soils which were too low in their organic content to be classified as peat (di-Folco 2007). Some of these issues are being researched at Gelignite Creek (Jerie and Household 2007), abet again in a site with low organic content soils (di-Folco 2007). As a result, neither the Bridle et al. (2003) or Jerie and Household (2007) studies will be able to address the major organosol research requirement, that being the impact of fire on buttongrass moorland peat soils.

2. Current fire ecology research

Between 4 and 6 July 2007 a workshop was held at the University of Tasmania investigating management issues in buttongrass moorlands. This workshop was jointly sponsored by the PWS, Department of Primary Industries and Water, Department of Environment and Water Resources, and Ecological Society of Australia. At the workshop a series of papers relating to fire were presented, as summarised below.

Examination of pollen cores from western Tasmania indicates that these cores have the potential to provide a good indication of the vegetation type in the surrounding area when the core was deposited (Fletcher 2007). This information can then be used to examine past fire regimes which suggest that during the last inter-glacial fires in this region were relatively uncommon and switched to a much higher frequency in the current inter-glacial, probably as a result of occupation of the region by Indigenous people. Following the end of the last glacial period this change in fire regime probably allowed for the expansion of buttongrass moorland whilst preventing the widespread expansion of rainforest (Fletcher 2007).

The effects of a range of factors, including low intensity prescribed fire, are being examined in two small catchments located near the Scotts Peak Road (Jerie and Household 2007). The buttongrass moorland in the catchment is underlain by a organosol with a low organic content (di-Folco 2007). This study aims to examine how the morphological and hydrological characteristics of the catchment affect water flow and stream sediment before and after burning but as discussed above, this study will be unable to address the major fire management issue of the effects of fire on organosols due to the site’s low organic content soils.

Although organosols contain a large proportion of the stored carbon in the TWWHA, little research has been conducted on their characteristics. Di-Folco and Russell (2007) and di-Folco (2007) examined how variation in vegetation type, slope, temperature and distance from coast influenced soil organic carbon content and developed a model for predicting soil organic carbon for Tasmania in terms of the dominant soil forming factors.

A review of fire weather and area burnt between 1892/93 and 2006/07 was presented by Marsden-Smedley (2007). This review found that the risk of large scale fires in the

TWWHA was very high, both in terms of suitable weather conditions and ignition sources. The review is discussed further in the section below on the climatic potential for wildfires.

Storey and Balmer (2007) presented data pre and post-burn comparisons of vegetation structure and floristics in two buttongrass moorlands. These sites were a moderately fertile highland site and a low fertility lowland site. At the high fertility site there was a increase in herb and graminoid diversity following fire but little change occurred in the low fertility site. Seed regenerating woody species at both sites were slow in their recovery, suggesting that frequent fires have the potential to adversely affect these species. These results suggest that buttongrass moorland vegetation will respond to fire in markedly different ways depending of the characteristics of the site and of the pre-burn vegetation.

Balmer and Storey (2007) presented data from a series of long term monitoring sites located at Forest Lag (20 years of data, see Brown et al. 2002) and Birches Inlet (10 years of data) in order to examine the effects of fire interval and frequency. The overall conclusion from these studies is that moorland floristics and structure are most strongly determined by environmental factors such as site fertility, climate, soil depth and drainage with fire having a significant but smaller effects. Frequent and recent fire promotes a number of herbaceous species which become less observable in the vegetation as time since fire increases. In the immediate post-fire recovery phase shrubs are significantly diminished in importance and in low fertility areas are slow to recover their former cover and height. In the short to medium term it appears that *Phytophthora cinnamomi* (root dieback fungus) has a greater effect on species dynamics than does variation in fire regime (see also Rudman 2007). In low fertility sites, the fire regime which has the lowest risk to moorland floristics is relatively long fire free intervals (greater than 20 and probably greater than 30 years). In higher fertility sites higher fire frequencies pose significantly lower risks to species diversity and may reduce the risk of some species being excluded from older aged moorlands.

3. Fire management of the TWWHA and neighbouring areas

A major issue with fire management is that fires do not recognise tenure boundaries. This means that fire management has to be performed in a multi-tenure integrated manner in order to be effective. This fire management needs to include comprehensive fire planning covering the assets at risk and the values being managed for, information on wildfire suppression potential, prescribed burning, well resourced wildfire suppression operations and adaptive research to ensure that the strategies utilised meet management goals.

Role of prescribed fire as a management tool in the TWWHA

Within the TWWHA prescribed burning is conducted for three purposes:

- hazard-reduction;
- ecosystem-management, and;
- research burning intended to provide information for improved fire management practices.

The primary objective of the hazard-reduction burning is to broaden the conditions within which effective fire management can be performed. Hazard-reduction burning does this, in order of decreasing importance, by reducing the:

- ratio of dead to live fuel;
- fuel continuity, and;
- total fuel load.

The low fuel loads that result from hazard-reduction burning could be used to physically stop fires under low to moderate levels of fire danger, anchor fire suppression operations and/or temporally slow wildfires during periods of high, very high or extreme fire danger. In addition, although these low fuel strips may fail to stop high intensity fires during the middle of the day, they may reduce the level of fire behaviour such that fires fail to sustain at night and/or their level of fire behaviour is such that fire suppression operations are feasible. This may then allow for effective fire suppression operations to be performed. In hazard-reduction burning is normally conducted at five to eight year intervals. The prescriptions for performing buttongrass moorland prescribed burning are in Marsden-Smedley et al. (1999). The prescriptions for performing dry eucalypt forest prescribed burning are in FT (2007b).

The primary objective of ecological-management burning is to create a small scale patchy mosaic with the aim of promoting species diversity (both flora and fauna) and is normally performed at eight to 30 year intervals. Ecological-management burning also has the secondary objective of breaking up the sites into a series of smaller areas which should in turn reduce the probability of large scale wildfires. Ecological-management burning prescriptions have been developed which are shown in Appendix 4.

The objective of the research burning is to provide information as to appropriate methodologies for performing prescribed burning by examining interactions between meteorological conditions, fire frequencies, fire intensities, seasons, lighting patterns, site parameters (eg slope or aspect), species diversity and community structure.

Fire management plans for the TWWHA

Over the past 20 years a series of fire management plans (FMP) have been produced for the TWWHA. The some of these plans are no longer current due to their planned replacement dates having been exceeded and/or due to changes in fire management priorities. These fire management plans are shown in Table 6.

Table 6 Fire management plans for the WHA and its adjacent areas

Superseded fire management plans	*Reference*
Cradle Mountain – Lake St Clair National Park FMP	LPW 1987
Franklin – Lower Gordon Wild Rivers National Park FMP	LPW 1988a
South – West National Park FMP	LPW 1988b
World Heritage Area Boundary FMP	FC 1989
World Heritage Area Tactical FMP versions 1 to 3	PWS 2000, 2001, 2003
Current fire management plans	*Reference*
Pencil Pine Development Zone Fire Protection Plan	PWH 1990
Orange-bellied parrot recovery plan: prescriptions for habitat management burns	Marsden-Smedley 1993b
Lyell Highway FMP	PWS 1996
Melaleuca – South West Cape FMP	PWS 1997a
Walls of Jerusalem National Park and Central Plateau Conservation Area FMP	PWS 1997b
World Heritage Area Tactical FMP version 4	PWS 2004

The Fire Management Section of the PWS is currently coordinating the development of a integrated Tasmanian fire risk plan which will include the TWWHA. This plan aims to identify the assets at risk of wildfire (eg fire sensitive vegetation, threatened species), the factors that contribute to that risk (eg ignition sources, fire history, vegetation fuels) and identify risk mitigation treatments (eg prescribed burning). The plan should be completed by the end of 2009.

The Inter-agency Fire Management Protocol is a Tasmania-wide protocol between the three main fire management agencies, the Tasmania Fire Service, Parks and Wildlife Service and Forestry Tasmania, which aims to ensure safe, efficient and effective fire management. The protocol is revised and updated annually and has as its underlying principle the concept that the most able and available resources will respond to wildfires regardless of land tenure or assets at risk. A critical aspect of the protocol is its inclusion of the multi-agency coordination group which aims to maintain a state-wide perspective on wildfire suppression priorities.

Fire risk management strategies in the TWWHA

The development of a integrated Tasmanian fire risk plan (see above) will form a critical aspect of managing fire risk in the TWWHA. Other important risk management strategies include integrated fire management planning detailing asset locations and prescribed burning, maintenance of annual fire action plans detailing the resources and suppliers available for wildfire suppression operations, along with wildfire detection strategies such as fire towers and fire spotter flights.

In addition, fire management strategies must be integrated with targeted, outcomes driven research which aims to provide management specific information on the values being managed for. The Buttongrass Management Workshop provides an example of how this integration of research into management could be performed.

Procedures for managing the risk of prescribed burn escapes

Prescribed burning is an inherently risky practice. It is not possible to totally eliminate the risk of adverse outcomes due to uncertainties in fuel conditions, weather, probability of equipment failure and human activities. However, with effective and comprehensive planning performed to high standards, adequate levels of resources during the burn and comprehensive post-burn follow-up these risks can be minimised. In addition, when prescribed burns are being planned and performed the prescribed burn risk must be explicitly balanced off against the risk of not doing the burn. In this area, this includes the risk of wildfires and/or the risk to values from ecological succession.

The training and accreditation system employed by the PWS in its low intensity burning training (see FT 2007b) along with the clear allocation of responsibility for performing all aspects of the burn has the potential to minimise adverse risks. This means that the District Manager will have overall responsibility for the burn and ensuring that the Fire Boss is appropriately trained, experienced and resourced. The Fire Boss is responsible for ensuring procedures are followed and that all fireground personnel have appropriate training, experience and equipment. Individual fireground personnel are personally responsible for their own actions and equipment.

Fire regime modelling in the TWWHA

A process-based fire regime and vegetation dynamics model, FIRESCAPE-SWTAS, has been developed over about the past five years for the southern two thirds of the TWWHA and its surrounding areas. This computer simulation model aims to examine the trade-offs between prescribed burning versus wildfires and their impacts on management values by investigating the effects of different prescribed burning strategies. The strategies examined included variation in the amount of prescribed burning, prescribed burn block size and the geographic location of burning blocks. Simulations identified that as prescribed burn treatment level increased and prescribed burn block size decreased the mean number and area burnt by wildfires decreased. The study also indicated that the strategic location of prescribed burn blocks had the potential to enhance the protection in the fire sensitive areas whilst minimising the area treated by prescribed burning (King et al. 2006, 2007a, 2007b).

5. Risks to assets within and neighbouring the TWWHA

Fire is a major risk to both economic and natural assets in the TWWHA. The risks to natural values have been summarised above. This risk is being managed through the development of a Integrated Tasmanian Fire Risk Management Plan (see below).

Area burnt and number of wildfires in the TWWHA

Major changes have occurred in the area of the TWWHA burnt by fires with different ignition causes since the 1980s (Table 7; Appendix 3). During this period there have been large changes in the number, size and area burnt by fires of different ignition cause, with arson fires decreasing and lightning fires greatly increasing. This increase in lightning fires probably occurred between about 1998 and 2000. The reason for this large increase in lightning is not known but it is consistent with the pattern that would be expected from climatic change (eg see below; Goldammer and Price 1998).

Table 7 Mean number of fires of different ignition cause in the Tasmanian Wilderness World Heritage Area since the 1980/81 fire season

	1980s				1990s			
	count	%	area	%	count	%	area	%
Accident	0.4	7.0	1022.8	17.0	0.0	0.0	0.0	0.0
Arson	2.1	36.8	2773.5	46.1	1.3	46.4	99.3	47.2
Campfire	0.3	5.3	13.8	0.2	0.2	7.1	34.0	16.1
Escape management	0.5	8.8	1861.4	31.0	0.2	7.1	41.2	19.6
Lightning	1.0	17.5	169.9	2.8	0.7	25.0	19.9	9.4
Misc	0.1	1.8	5.7	0.1	0.3	10.7	16.2	7.7
Unknown	1.3	22.8	166.7	2.8	0.1	3.6	0.0	0.0
Total	5.7		6013.7		2.8		210.6	

	2000s				Entire TWWHA			
	count	%	area	%	count	%	area	%
Accident	0.4	7.3	341.6	3.9	0.3	5.6	485.0	10.5
Arson	0.9	14.6	3.2	0.0	1.5	31.7	1064.8	23.1
Campfire	0.0	0.0	0.0	0.0	0.2	4.0	17.7	0.4
Escape management	0.4	7.3	1129.3	12.8	0.4	7.9	997.4	21.7
Lightning	3.9	65.9	7323.6	83.2	1.6	34.9	1969.0	42.8
Misc	0.0	0.0	0.0	0.0	0.1	3.2	8.1	0.2
Unknown	0.3	4.9	3.3	0.0	0.6	12.7	62.6	1.4
Total	5.9		8801.0		4.7		4587.0	

In the fire history data since 1980/81 in addition to the increase in lightning caused fires and the decrease in arson fires there has been a decrease in fires of unknown cause. This decrease in the number of fires with unknown causes is a reflection of improved fire detection and investigation resulting in the cause of most fires now being determined. In addition, due to almost all of the 1980s fires with unknown causes starting on roads, 4wd tracks and the coast (PWS unpublished fire data) it is highly probable that most of these unknown cause fires would have been the result of arson and a very small proportion of the area burned would have been the result of lightning (Marsden-Smedley unpublished data). For example, between 1980/81 and 2006/07 only one fire larger than ten hectares of probable lightning cause was discovered when it was more than a few weeks after the date the fire happened. This fire was the 1987/88 Hardwood fire which was found in 1992/93 (D Heatley personnel communication).

Risk of fire escapes from silvicultural burning and forest harvesting activities
Forestry Tasmania has very stringent prescriptions for conducting silvicultural regeneration burning (FT 2007a) which, when followed, result in regeneration burning being a low risk to the TWWHA. These prescriptions rely on moisture differentials such that the coupe being burnt is highly flammable while the surrounding forest is too wet to burn.

In addition, in areas adjacent to the TWWHA regeneration burning is conducted at the end of the fire season between late February and early April. At this time of year the day length is rapidly decreasing and correspondingly, the potential for surrounding forest to dry sufficiently to carry a uncontrollable wildfire is also decreasing.

In the past ten years in Forestry Tasmania has conducted a total of 521 silvicultural regeneration burns covering a total of 10 748 ha on State Forest within five kilometres of the TWWHA boundary (Forestry Tasmania unpublished fire history data). None of these fires burnt into the TWWHA (PWS unpublished fire history data).

A good example of the robustness of the high intensity silvicultural regeneration burning prescriptions occurred in March 1998 when Forestry Tasmania used these prescriptions to light about 12 silvicultural regeneration burns. About a week later the worst March fire danger conditions in for 55 years occurred, and a total of about 62.5 ha was burnt outside the planned coupe boundaries, with all of these escapes being confined to State Forest (FT 1998; Forestry Tasmania unpublished fire history data).

The fire history records held by the Fire Management Section of PWS indicate that only one silvicultural regeneration fire has burnt into the area covered by the TWWHA (at the time this area had not been declared to be world heritage). This fire, the 1989 Clear Hill fire burnt across the Clear Hill Plain and spotted over to the northern bank of the Gordon Gorge in what is now the Franklin - Gordon National Park. However, since 1989 the prescriptions for conducting high intensity regeneration burning have been refined and the currently published high intensity burning prescriptions (FT 2007a) would not have allowed this fire to be lit.

No information on escapes from forest harvesting operations was provided by Forestry Tasmania. From the information that is available (PWS unpublished fire history data), only two forest harvesting caused wildfires are known, both of which occurred in the Picton River valley in summer within three kilometres of the TWWHA boundary.

The risk to the TWWHA from forest harvesting operations would have to be considered to be moderate due to their potential to cause wildfires at the height of the fire season. The procedures utilised by Forestry Tasmania have the potential to reduce but not eliminate this wildfire risk. These procedures specify the conditions for initiating suspension of hazardous activities due to severe weather along with the fire weather monitoring and fire fighting equipment required. These procedures include the weather and forest fire danger conditions at which harvesting operations will cease work, the methodology and schedule for monitoring the weather and the fire fighting resources that must be onsite at a harvesting operation.

Another important factor is the relative locations of the TWWHA and major logging areas with the majority of the State Forest logging areas being to the east and southeast of the TWWHA. This means that during high fire danger events that the majority of the TWWHA is upwind of State Forest. Where State Forest is located upwind during high fire danger events of the TWWHA (ie along the Great Western Tiers), the normal situation is that due to the rapid increase in elevation over the tiers, the relative humidity is also greatly increased resulting in decreased levels of fire danger. This is reflected in the fire history data since the 1930s where all of the large fires that have burnt between what is now TWWHA and State Forest have gone from the area covered by the TWWHA into State Forest and not vice-versa.

Climatic potential for wildfires

Variation in western and southwestern Tasmanian fire weather between 1892/93 and 2006/07 was examined by Marsden-Smedley (2007, unpublished data). This analysis used a modified Soil Dryness Index (SDI), whereby the temperature based evaporation function in the published version of the SDI (Mount 1970) was replaced with a function based on the day of the year and the Bureau of Meteorology predicted actual evaporation. This was done due to temperature data not being available for most sites prior to about 1970. The system was developed using the last 20 years of daily summer (December to March) rainfall and Bureau of Meteorology predicted SDI for Strahan, Zeehan, Mt Reid, Lake St Clair, Melaleuca and Maatsuyker Island. There was a high correlation ($r^2 = 0.78$) between the Bureau of Meteorology predicted SDI and the estimated SDI using the day of the year and predicted actual evaporation. The estimated SDI figures were then averaged across the region and compared to the flammabilities of the different vegetation types in the TWWHA using the system detailed in Marsden-Smedley et al. (1999). The fire season ratings, SDI categories, time periods, vegetation types at risk of burning and the corresponding number of fire seasons in each category are shown in Figure 1 and Table 8.

This analysis of estimated SDI indicated that over the past 114 years suitable conditions for landscape-scale fire seasons, and major fire seasons have occurred at about 10 to 15 year intervals and at about five year intervals respectively. A landscape-scale fire seasons and major fire season are defined to be where fires burn for at least a month, burn all vegetation types with landscape-scale fires consuming at least 500 000 ha and major fire seasons consuming between 50 000 and 500 000 ha.

The region's fire history data shows that landscape-scale fires have actually occurred twice during the time period 1892/93 to 2006/03 (ie in 1897/98 and 1933/34) and that major fire seasons have occurred four times (ie 1914/15, 1938/39, 1950/51 and 1960/61). In contrast, about two thirds of fire seasons are unlikely to burn anything other than buttongrass moorland and wet scrub (Figure 1, Table 8).

Table 8 Fire season ratings, SDI categories, time periods, vegetation types at risk of burning and the number of fire seasons in each category in western and southwestern Tasmania between 1892/93 and 2006/07

Rating	Fire potential	SDI	Time period	Vegetation at risk of burning	Percentage of seasons
1 - very low		<15	entire fire season	buttongrass moorland	52.6
2 - low		<25	entire fire season	buttongrass moorland, wet scrub	11.4
3 - moderate	major	25-50	>1 month	buttongrass moorland, wet scrub, eucalypt forest	19.3
4 - high	landscape-scale	>50	1 to 2 months	all vegetation types	6.1
5 - very high	landscape-scale	>50	>2 months	all vegetation types	7.9
6 - extreme	landscape-scale	>75	>2 months	all vegetation types	2.6

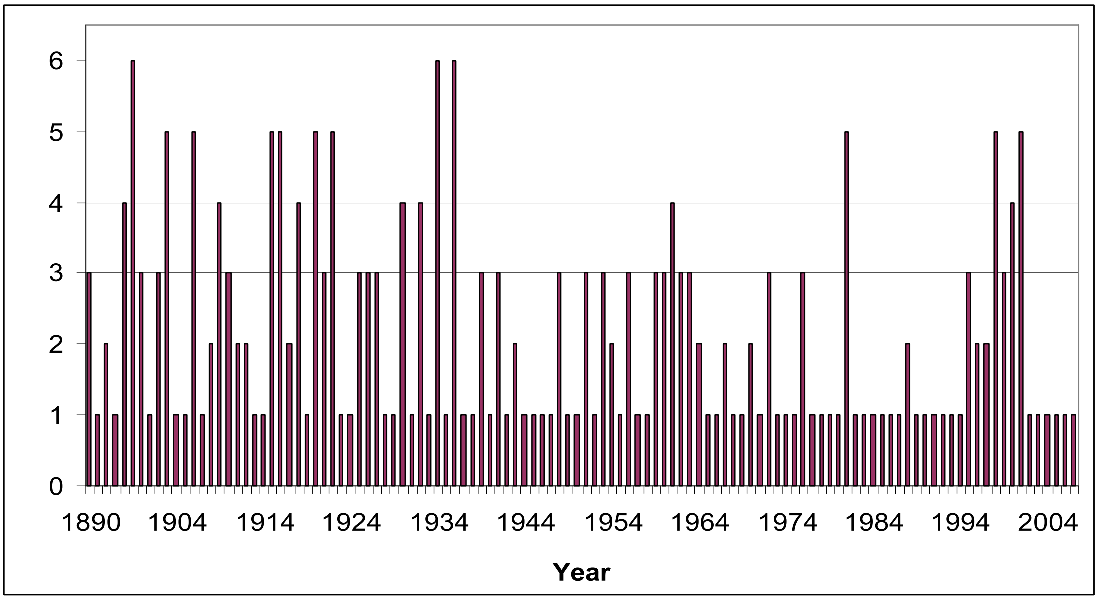

Figure 1 Fire season ratings in western and southwestern Tasmania between 1892/93 and 2006/07

A critical finding of this assessment of the climatic potential for wildfires is that in the TWWHA the risk of large scale fires that threaten human safety and ecological values is very high with the weather conditions and ignition sources for large scale fires occurring on a frequent basis.

The variation in Forest Fire Danger Rating (McArthur 1973) on a monthly basis in western and southwestern Tasmania has been calculated by the Severe Weather Section of the Bureau of Meteorology, Hobart, Tasmania (Figure 2; Appendix 5). This analysis indicates that over the past 20 years moderate to high fire danger weather occurs on a regular basis with very high and extreme fire danger being much less frequent. The highest levels of fire danger normally occur in January followed by February, December, March and November.

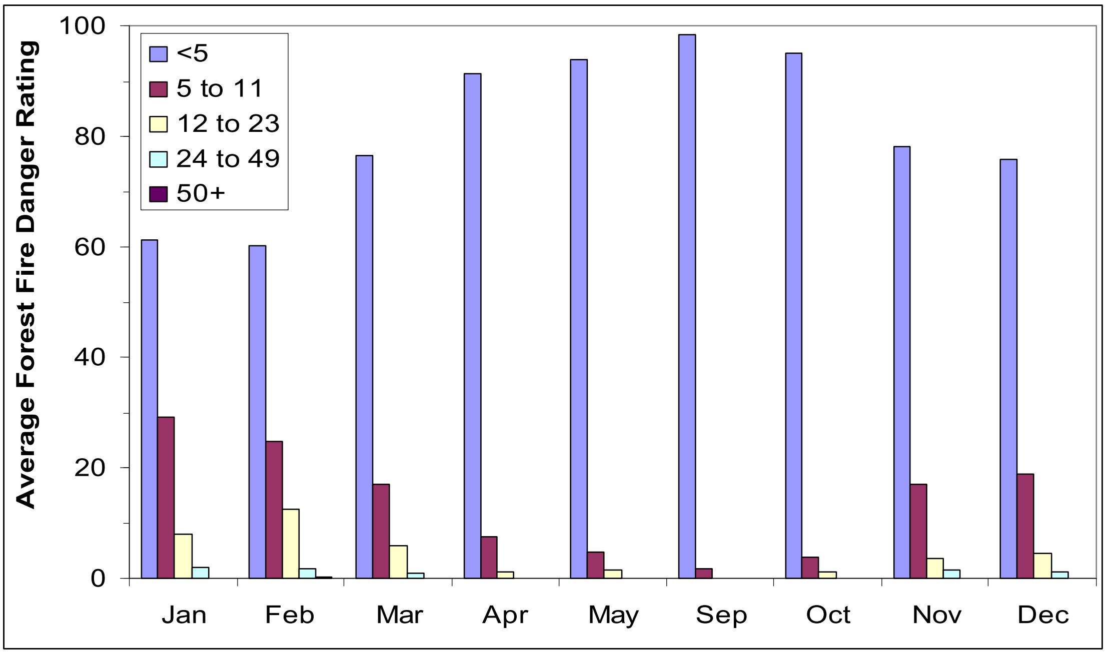

Figure 2 Percentage of days in different Forest Fire Danger Rating classes, averaged across western and southwestern Tasmania
Data source: Severe Weather Section, Bureau of Meteorology, Hobart, Tasmania; Appendix 5

In the TWWHA the issue of climate change versus the level of wildfire risk is highly uncertain. On the southeast Mainland of Australia and in the northeast of Tasmania large to very large increases in the incidence of severe fire danger weather are predicted to occur by 2050. In contrast, only small increases in the level of fire danger are predicted for western and southwestern Tasmania by this time (Lucas et al. 2007).

However, in the past seven to ten years in the TWWHA there appears to have been a major increase in dry lightning storms (PWS unpublished fire data). Whilst at the current time it is not possible to attribute this increase in dry lightning storms to climate change, it is consistent with the trend that would be expected under published climatic change scenarios (Goldammer and Price 1998; Lucas et al. 2007). This increase in dry lightning has been reflected in the large increase in the number and area burnt in lightning initiated fires (see above; PWS unpublished fire data).

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