

**Fire history of the tall wet eucalypt forests of the Warra ecological research site,
Tasmania.**

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Summary

Fire history since 1850 was reconstructed by analysing tall wet eucalypt forest stands in the Warra long-term ecological research (LTER) site in southern Tasmania. Major fires occurred in 1898, 1906, 1914 and 1934. Fifty-seven percent of the forest has remained unburnt since 1850. Sixty percent of the forest burnt since 1850 occurs as mixed age stands, while 40 percent is pure regrowth. Ring counts of stumps of three veteran eucalypt trees indicated that the mature and oldgrowth forests of the Warra site represent a number of pre-1850 fires. One extant oldgrowth eucalypt stand was estimated to be over 450 years old. The common occurrence of multi-aged wet eucalypt stands has silvicultural implications where a management objective is to emulate pre-existing stand structures. While the fire history reported here is limited mainly to the period since 1850, it provides a good basis for understanding the current stand structures of the tall wet eucalypt forests of the Warra site. Such an understanding is essential to interpret results from current and planned ecological studies associated with the LTER program at Warra.

Introduction

The Warra long term ecological research (LTER) site was designated in 1995 to study the ecology of the cool temperate forest ecosystem in relation to forest management practices (Warra Policy Committee 1997). The site covers 15,900 ha and is located in southern Tasmania with its approximate centroid position (Mt Frederick) at 43°3'S, 146°39'E. The tall forests of the Warra site are dominated by wet *Eucalyptus obliqua* forest, the most widespread forest type in Tasmania (Public Land Use Commission 1996). The *E. obliqua* forest occurs in a full range of successional stages from young regrowth forests to oldgrowth mixed forests. Other eucalypt species found in tall forests at Warra include *E. delegatensis*, *E. regnans*, *E. johnstonii* and *E. nitida* (Corbett 1997). The site was inaccessible to motor vehicles until 1969 when a bridge was built across the Huon River (Packham 1995). About 840 ha of commercial forest was harvested and subsequently regenerated between 1972 and 1993 at an average rate of about 40 ha per year. Coupes were clearfelled, the slash was burnt at high intensity to create a receptive seedbed, and the area was regenerated by aerial sowing with eucalypt seed.

The fire history of the Southern Forests, a term which loosely defines the forests south of Hobart and east of the Tasmanian World Heritage Area, has been collated by Edgley (1960) from newspaper accounts from the period of 1854 to 1951. Marsden-Smedley (1998) has reconstructed the broad fire history of the moorlands and forests to the west of the Warra site for the period of 1830-1996 using historical accounts (1830s-1930s), aerial photographs (1940s to 1975) and fire history maps since 1975. The Warra site lies between the regions described by Edgley and Marsden-Smedley; the historical record of fires at the site is poor.

A history of disturbance to the site since 1947, the date of the first aerial photography for the area, is available from photo-interpreted forest type maps, and harvesting records. No major wildfires have occurred in the site since 1947. Fires prior to 1947 have been inferred, by Huon District staff, from ring counts on stems on permanent and temporary inventory plots in regrowth forests up to about 100 years old. No attempts have been made to estimate ages of mature or oldgrowth eucalypt forests in the area.

This paper documents the wildfire history, since 1850, of the tall forests of the Warra LTER site and compares the proportions of regrowth and mature forests in a natural landscape with the area of regeneration that has been established following regeneration burns since 1972. The Warra LTER site, and surrounding forests, have great potential for further study of natural and managed fire regimes at the landscape level. Studies of managed and pre-settlement landscape dynamics in forests elsewhere (eg. Morrison and Swanson 1990, Wallin *et al.* 1996) have allowed evaluation of alternative forest management strategies in terms of their capacity to emulate disturbance resulting from natural wildfires. Such studies generally assume that the forests, and their biodiversity complement, are adapted to natural levels of fire disturbance.

Method

The area of tall forests, with a potential height of more than 34m, was determined using 1:25,000 photo-interpreted forest-type maps (Weld, Picton, Scotts and Razorback) and overlaying it with the Warra LTER site boundary using an ARC-INFO GIS. The photo-interpreted (PI) maps classify the forest into various height and density classes. Eucalypts are assigned to seven height classes (Table 1) based on their actual or potential height (determined from mature stags or downers). The tall forests are defined as those greater than 30 m (Specht 1970) which is broadly equivalent to eucalypt height classes 1, 2 and 3+ used by Forestry Tasmania. Regrowth eucalypt forest is somewhat arbitrarily defined as eucalypt forest less than 110 years old. Forests of more than 110 years of age are called mature eucalypt forests.

The PI typed patches within each tall eucalypt height class were tallied into the following categories to broadly determine the frequency of mixed age forest:

1. patches that contain mature eucalypts only,
2. patches that contain a mixture of mature and regrowth eucalypts, and
3. patches that contain regrowth eucalypts only.

The age of particular regrowth stands within the Warra LTER site was determined by ring counts on stems from understorey species (*Pomaderris apetala*, *Phebalium squameum*, *Melaleuca squarrosa*) on 20 permanent Continuous Forest Inventory (CFI) plots. These plots have been established, on a stratified random basis, in regrowth and mixed regrowth/ mature eucalypt stands at a rate of one 0.2 ha plot per 250 ha (Forestry Commission 1985). Fire years estimated from plots were considered along with the collation of newspaper and anecdotal reports of fires in southern

Tasmania compiled by Edgley (1960). Major fire years were defined as those which were recorded on at least two CFI plots and coincided with newspaper records at the time.

A generalised map of fire years which initiated significant areas of regrowth was prepared by attributing the recorded stand age from both CFI and temporary inventory plots to areas of adjoining regrowth and mixed regrowth/ mature forest with similar PI types. In cases where two, or more, fires were known to have occurred, the fire which had established the majority of regrowth was mapped as the regrowth fire age. For example, areas of regrowth which were established by a fire in 1898 and reburnt in 1934 were mapped as 1898 regrowth where the present forest contains more 1898 regrowth than 1934 regrowth. Alternatively, where most of the regrowth arose after the 1934 fire, the patches have been mapped as originating from the 1934 fire. A broad map showing major fires in tall eucalypt forest was compiled for all areas containing a component of regrowth forest.

Seven 0.1 ha additional inventory plots were located in 1997 in an area of approximately 200 ha of regrowth and mixed regrowth/ mature eucalypt forest which is being developed for a silvicultural systems trial. Stem ages from these plots were used to test, at a coupe scale, the broad stand ages inferred at the landscape scale (e.g. 10,000 ha) from the low intensity sampling of the CFI plots. A detailed map showing multiple regrowth fire ages was prepared for the silvicultural systems trial area.

No pre-existing stem or stand age data were available for patches containing only mature eucalypts. It is likely that the extensive tracts of such forest contain a number

of stand ages between the limits of 110 years and 400 years - which is the age often attributed to the oldest tall eucalypts in Tasmania (eg. Gilbert 1959). Three sections were sampled from large eucalypt stumps from two logging coupes separated by about 9 kms. The sections were sanded and the rings were counted. In addition, two celery-top pines (*Phyllocladus aspleniifolius*) were felled from the understorey of a tall oldgrowth mixed forest stand (Grid Reference 8211 Huon DN709365) and discs taken at 1.3 m and 8 m for ring counts at a dendrochronology laboratory at the University of Tasmania. Celery-top pines are well suited to dendrochronological studies (Ogden 1978) as they are long-lived, have distinct annual growth rings and their wood is highly durable. They are more easily killed by fires than eucalypts, hence it is reasonable to assume that the celery-top pine age is equal to, or less than, the age of the eucalypt overstorey. The structure of the stand was described by recording the diameter of all species with woody stems greater than 5 cm dbh on a 20 m by 20 m plot.

Results

Figure 1 shows the distribution of the tall eucalypt forests in the Warra LTER site. Table 2 shows the area and proportion of each tall eucalypt height class mapped as mature, mixed regrowth/ mature or regrowth stands from PI typing. Fifty-seven percent of the tall eucalypt forest is shown to be mature forest and has appeared to have been unburnt in the last century. Seventeen percent of the forest has been subjected to fires in the last century which have been sufficiently intense to result in pure regrowth stands. Twenty-six percent of the forest has been burnt by at least one fire in the past century, resulting in mixed stands of regrowth and mature trees. The

analysis shows that sixty percent of the forest burnt in the last century now occurs as mixed age stands, while 40 percent is pure regrowth.

Table 3 shows fire years estimated from regrowth stem ages from CFI plots in the Warra LTER site. Table 4 is a summary of the number of plots which have been burnt by one or two fires in the last century. Although the sample size is small, the analysis shows that 74 per cent of the plots have been subjected to fires which had not resulted in stand replacement but did initiate some regrowth. Eight of the nineteen plots still contained veteran mature trees which had survived at least two fires. Only two plots contained pure regrowth after a single fire.

Table 5 is a list of major fire years reported for Southern Tasmania by Edgley (1960), Marsden-Smedley (1998) or recorded from CFI plots in the Warra LTER site. The three sources indicate very large fires in 1898, 1914 and 1934. Marsden-Smedley (1998) estimates that the 1898 and 1934 fires each burnt more than a third of Tasmania's land area (or more than 2 000 000 ha) and that the 1898 fire was the largest in Tasmania's recorded history. An extensive fire in 1906 burnt some of the Warra site. Local fires may have occurred at the Warra site in 1939, 1940, 1941 and 1944. Extensive fires in 1939 are reported for Southwest Tasmania by Marsden-Smedley (1998) but did not extend to the Warra site.

Figure 2 shows the extent of major fires in the tall eucalypt forest of the Warra site which initiated significant areas of regrowth since 1850. Some areas attributed to regrowth fires prior to 1934 were reburnt in 1934 but the majority of regrowth is considered to have arisen from the earlier fire. The map does not indicate the extent of

the fires in vegetation other than tall eucalypt forest and some, particularly the 1934 fire, are known to have burnt large areas of alpine, subalpine and moorland vegetation at the Warra site (Marsden-Smedley 1998).

Figure 3 shows the areas of tall eucalypt forest burnt by major wildfires or silvicultural fires (1972-1993) at the Warra LTER site since 1850. The 1934 fire burnt more forest than the three other wildfires combined. Silvicultural fires, while individually small, amount to the second largest cause of forest regeneration where considered together over a 22 year period.

Table 6 gives fire ages from plots in the 200 ha Warra Silvicultural Systems Trial and Figure 4 shows more detailed fire mapping, including multiple-regrowth fires, than shown in Figure 2. Ring counts for two plots (1A, 1B) suggest that the main regrowth fire may be older than 1914 as mapped in Figure 2. It is probable that there was some overlap in areas burnt by the 1898, 1906 and 1914 fires. Hence, the older regrowth is shown on Figure 4 as 1898/1914 in origin. Table 6 shows that all but one (plot 1A) of the nine stands surveyed were reburnt by a moderate fire in 1934 - although all stands consist predominantly of older regrowth. All plots contain remnant veteran trees resulting from a fire prior to 1850. Hence most of the 200 ha area appears to have been subject to at least three fires which relate to the current stand structure (Figure 5): at least one pre-1850 fire (which established the mature trees); an early regrowth fire (1898/ 1914) which established most of the regrowth; and a 1934 fire which replaced much of the understorey species and probably established some additional regrowth.

Attempts to directly age the oldest eucalypt trees were largely unsuccessful. Eucalypt stumps in a clearfelled oldgrowth mixed forest site were almost invariably hollow, or at least heavily decayed, at their centre. Rings in sections taken from some of the largest stumps could not be counted with confidence. Rings were often very indistinct and incomplete, even within sound sections of wood. However, three oldgrowth trees were counted (Table 7) and provide some indication that the mature and oldgrowth forests of the Warra site represent a number of age classes.

Good ring counts were able to be made (K. Allen *pers comm.* 1997) of the celery-top pine discs and are shown in Table 8. It would take the oldest tree (tree 2) 12 years to reach a height of 1.3 m at its mean height increment of 10.8 cm y^{-1} . Hence it appears that the stand is at least 459 years old. If the celery top pine tree regenerated at the same time as the adjacent eucalypts then the originating fire would have been in the early 1500s.

Discussion

The results show that just over half the tall eucalypt forests of the Warra LTER site, an unroaded wilderness area until 1969, occur as mature and oldgrowth stands that established following fires between the early 1500s and 1850. The number and extent of fires pre-1850 has not been considered in this study. While almost half the tall eucalypt forest area has been burnt by at least one fire since 1850 less than half of the post-1850 burns resulted in pure regrowth stands. It appears that complete stand replacement following wildfires in tall wet eucalypt forests is less common, at least at the Warra site, than would be inferred from Jackson (1968) and Mount (1979) for Tasmania. However the findings here do concur with descriptions of multi-aged tall

forest stands by Gilbert (1959) and Ashton (1981). Ough and Ross (1992) reported that 38 percent of *E. regnans* forest in two large unlogged catchments in Victoria was dual or multi-aged.

The results at Warra can be used to calculate a simple natural fire rotation length (Heinselman 1973 cited in Wallin *et al.* 1996) based on the occurrence and extent of wildfires since 1850. The natural fire rotation length is calculated as the time period divided by the proportion of the study area burned during the period. A total of 3 025 ha, or 33 per cent of tall eucalypt forest was burnt by wildfires in the period from 1850 to 1998 at the Warra site. This implies a natural rotation length at Warra of 448 years which is significantly longer than the 80-100 year silvicultural rotation length applied to wet eucalypt forests in Tasmania. The analysis assumes that the non-silvicultural fires in the 1850 to 1998 period were indeed natural in their cause, extent and severity. While it is clear that the fires burnt in a natural landscape at Warra, it is uncertain if they were caused by human intervention or if their extent, outside the Warra site, was increased by a considerable level of post-settlement disturbance.

A comprehensive study of the effects of natural versus silvicultural fragmentation, as carried out by Wallin *et al.* (1996) for Pacific Northwest forests, would require a detailed knowledge of the extent and frequency of fires pre-1850. Old eucalypt forests appear to be much more difficult to age than coniferous forests of the Pacific Northwest and it is uncertain if this information could be reliably gathered at the Warra site.

The estimated minimum stand age of about 460 years for an oldgrowth mixed forest stand at Warra is notable. The stand may be considerably older because celery-top pine can have a protracted regeneration period. Barker and Kirkpatrick (1994) noted that celery-top pine seedlings in mixed forest stands may have extended recruitment phases spanning at least 100 years. However, Hickey (1993) recorded an average period of only six years between eucalypt and celery-top pine regeneration in 20-30 year old mixed forest stands. Even at 460 years, the estimate is the oldest data-based record for a eucalypt species in Tasmania.

The recognition of the common occurrence of multi-aged stands has silvicultural implications if the management objectives include a desire to emulate pre-existing stand structures, and presumably habitat, in silviculturally regenerated forests. This approach is advocated by Lindenmayer and Franklin (1996) for *E. regnans* forest and may be achieved by using Retained Overwood systems (eg. Campbell 1997) where a proportion of regrowth and mature trees are retained at the time of logging. This system is being investigated at the Warra Silvicultural Systems Trial.

While the fire history reported here is preliminary and limited mainly to the period since 1850 it does provide a good basis for understanding the current stand structures of the tall eucalypt forests of the Warra site. Such an understanding is essential in interpreting results from current and planned ecological studies associated with the LTER program at Warra.

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Fire ages from CFI plots have been diligently collected by staff of the Huon District for many decades and their efforts are greatly acknowledged. Rodney Evans provided valuable technical assistance with recent plot establishment and gathering of stem ages. Kathy Allen provided accurate ring counts of *Phyllocladus aspleniifolius* from the oldgrowth site. Tony Rainbird prepared Figures 1, 2 and 4. Funding for GIS manipulation of PI data and analysis was provided by the Forests and Wood Products Research and Development Corporation.

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Table 5. Major fire years, for the period preceding aerial photography, reported from (a) newspaper reports for the Southern forests (from Edgley 1960) or (b) fire histories of southwest Tasmania (from Marsden-Smedley (1998) or (c) at least 2 CFI plots in the Warra LTER site.

Table 6. Fire years estimated from stem ages on inventory plots in the 200 ha Silvicultural Systems Trial at the Warra LTER site. (R = regrowth eucalypts; M = mature eucalypts. Severity refers to an estimate of the fire intensity of the last fire on the plot. Ps = *Phebelium squameum*, Pa = *Pomaderris apetala*, Ms = *Melaleuca squarrosa*, Eo = *Eucalyptus obliqua*. Plots 1106 and 1108 are routine CFI plots established in 1969).

Table 7. Ring counts of oldgrowth eucalypt stumps.

Table 8. Ring counts of celery-top pine trees from an oldgrowth mixed forest stand.

Table 1. Mature eucalypt height classes for photo-interpreted forest-type maps.

E1*	average height more than 76 m
E1	average height from 55-76 m
E2	average height from 41-55 m
E3+	average height from 34-41 m
E3-	average height from 27-34
E4	average height from 15-27 m
E5	average height less 15 m

Table 2. Areas and proportion of tall eucalypt forest classes mapped as mature, regrowth/ mature or regrowth stands in the Warra LTER site.

Potential ht	E1	E2	E3+	Total	
	ha	ha	ha	ha	%
Mature	1,935	2,608	719	5,262	57%
Regrowth/ Mature	440	1,622	307	2,369	26%
Regrowth	275	920	425	1,620	17%
Total	2,650	5,150	1,451	9,251	100%

Table 3. Fire years estimated from stem ages from CFI permanent plots in the Warra LTER site. (R = regrowth eucalypts; M = mature eucalypts as determined from PI types). Dates shown in bold indicate a disparity between the mapped fire age (Figure 2) and the ages recorded on the plot.

Plot Number	Forest Type	Regrowth Ages	Oldest Regrowth	Youngest Regrowth	Mapped Fire Age
1086	R/ M	2	1906	1934	1906
1087	R/ M	2	1906	1934	1906
1106	R/ M	2	1906	1934	1898
1108	R/ M	2	1898	1934	1906
1122	R/ M	2	1918	1934	1934
1125	R/ M	1	1936	-	1934
1126	R	1	1934	-	1934
1132	R	2	1914	1934	1934
1133	R	2	1914	1934	1914
1135	R/ M	2	1934	-	1934
1138	R/ M	1	1934	-	1934
1162	R/ M	1	1934	-	1934
1164	R/ M	2	1914	1934	1906
1168	R/ M	1	1898	-	1914
1177	R	1	1941	-	-
1200	R/ M	1	1934	-	1934
1201	(Rainforest)	0	-	-	-
5700	R/ M	1	1944	-	1934
5707	R	2	1944	1955	1934
5708	R/ M	2	1900	1939	1934

Table 4. Summary of number of fires recorded from CFI plots in the Warra LTER site.

	Regrowth		Regrowth/ Mature		Total	
	plots		plots		plots	
	No	%	No	%	No	%
One fire	2	10	6	32	8	42
Two fires	3	16	8	42	11	58
Total	5	26	14	74	19	100

Table 5. Major fire years, for the period preceding aerial photography, reported from (a) newspaper reports for the Southern forests (from Edgley 1960), (b) fire histories of southwest Tasmania (from Marsden-Smedley (1998), and (c) at least 2 CFI plots in the Warra LTER site.

(a)	(b)	(c)
	1851	
	1859	
	1862	
1854		
1875		
	1887/88	
1881		
1898*	1897/98	1898
1903		
1906		1906
1912		
1914*	1914	1914
1915		
1920*?		
1922		
1926		
1934	1933/34	1934
1939*#	1939	
1940*#		
1941*#		
		1944

*Edgley records fires in the Warra area for these years (he is unsure of the extent of fires in 1920).

#Edgley refers to relatively small fires near the Weld River, e.g. the ‘50 acre fire’ on Weld Plains, at the confluence of the Weld and Huon Rivers, on 29/12/1939.

Table 7. Ring counts of oldgrowth eucalypt stumps. (Location grid references from Huon sheet 8211; stumps 1 and 2 are in Warra Cpt 18 and stump 3 is in Warra Cpt 1B).

Stump	Date	Location	Species	DBH (cm)	Rings	Felled	Origin
1	Oct-96	717/368	<i>E. obliqua?</i>	161	207	1993	1786
2	Oct-96	712/ 367	<i>E. obliqua?</i>	355	368+ ¹	1993	c.1600
3	Mar-98	755/ 283	<i>E. obliqua</i>	213	261	1998	1737

¹poor estimate due to rotten core.

Table 8. Ring counts of celery-top pine trees from an oldgrowth mixed forest stand dominated by *Eucalyptus delegatensis* with a maximum DBH of 235 cm. (Location: 8211 Huon 709/365)

Tree	DBH (cm)	Disc height (m)	Rings	Mean DBH inc. (mm y ⁻¹)	Mean Ht inc. (cm y ⁻¹)
1	25.4	1.3	430	0.59	
		8.0	325		6.4
2	29.3	1.3	447	0.66	
		8.0	385		10.8

Captions for Figures.

Figure 1. Distribution of tall eucalypt forests in the Warra LTER site.

Figure 2. Fire years which initiated significant areas of regrowth since 1850 in the Warra LTER site. Note that some areas attributed to regrowth fires prior to 1934 were reburnt in 1934 but the majority of regrowth is considered to have arisen from the earlier fire.

Figure 3. Area of tall eucalypt forest burnt by major wildfires or silvicultural fires (1972-1993) at the Warra LTER site since 1850.

Figure 4. Fire years which initiated significant areas of regrowth since 1850 in the Warra Silvicultural Systems Trial.

Figure 5. Stand structure at the Warra Silvicultural Systems Trial. The largest *Eucalyptus obliqua* stem (middle left) regenerated from a wildfire pre-1850, the larger regrowth (right) regenerated from the 1898/1914 wildfire and the smaller regrowth regenerated in 1934. (Note: the understorey has been cleared prior to felling).