Chapter 7

Eras and explanations for spatial and temporal patterns

7.1 Introduction

Patterns of fire frequency derived from fire scar chronologies have variously been explained and interpreted by reference to the activities of people and/or climate. For example, Banks (1982, 1990b) found that distinctly different periods of fire frequency were related to documented changes in land use. Similarly, Burrows et al. (1995) observed breaks in fire frequency which were closely correlated to changes in cultural land practices (between the early 1840s and the mid 1990s). An increase in the frequency of injurious fire scars around 1850 was reported in all three studies and was interpreted to respectively represent: arrival of settlers and gold seekers deliberately setting fires for improved access and substrate examination; settler occupation and burning of surrounding land to provide feed for cattle; and, an increase in fire intensity resulting from a preceding period of fire exclusion.

Many examples of fire frequency patterns which are correlated with human activity are found in a wide range of fire histories from North America (e.g. Stokes & Dietrich 1980; Swetnam & Baisan 1996) and Europe (e.g. Conderra & Tinner 2000; Groven & Niklasson 2005). In particular, Weisberg & Swanson (2002) used the occurrence of fire scars derived from ring counts (compiled from ten separate studies) and found that there was a highly significant relationship between widespread fires and spatial patterns of fire frequency which were related to human activity.
There is still debate and conflict regarding the influence of Aboriginal fire (Horton 1982; Bowman & Brown 1986; Ryan et al. 1995; Benson & Redpath 1997; Bowman 1998, Abbott 2003). The absence of fire scars has been taken by some to infer low intensity fires. However, caution is needed in making this inference (Horton 1982; Gill & Catling 2002).

Data for vegetation fires ignited by lightning show that 222 incidents were attended for the entire State between 1998 and 2007 (Tasmania Fire Service unpublished data). Of these 44% were in eastern Tasmania and 25%, or an average of 6 incidents per year, were confined to an area between the northeast coast and the Derwent River. This could reflect bias in the data related to the locations of fire stations. There are no data for lightning ignitions prior to 1998.

The temporal and spatial patterns observed in the previous chapter warrant some explanation. The main aim of this chapter is to interpret the distinctly different changes in fire frequency identified in the 274 year composite chronology. The overarching question to which the entire thesis has devoted itself, Have fire regimes changed in the Eastern Tiers of Tasmania? is thus addressed. This chapter also investigates differences in land use between public (Forestry) and private sites as an attempt to account for spatial patterns.

The term: fire scar data, used throughout this chapter, refers to the adjusted, mean decadal fire scar data presented in Table 6.2 in the previous chapter.
7.2 Data analysis

7.2.1 Land tenure

Land use can have a significant impact on fire occurrence (Banks 1982, 1988, 1990a). The fire scar data were highly skewed towards more fire scars in the later part of the chronology but were not transformed. Instead, simple parametric (Student's t) and non-parametric (Mann-Whitney rank sum) analyses were applied to test for differences in between-site fire scar distribution (Zar 1999).

Analyses were done in three stages. First, an overall test using fire scar data from each decade 1740 - 2004 between the public land sites and private land sites was calculated. Second, the same data were tested in the same way but were clustered into distinctly different periods. Thirdly, the 27 decades of fire scar data were divided into four groups and visually checked for similarities and differences in temporal fire scar distribution. These groups were:

- Class 1 - public land;
- Class 2 - private land;
- Class 3 - forested (those sites at higher elevation in the north of the study area); and
- Class 4 - southern Midlands.
7.2.1.1 Variability in fire scar distribution

The ecological effects of variability in the fire regime are related to the capacity of organisms with vastly different life history traits to co-exist in dry forest systems (e.g. Burrows & Friend 1998; Walshe & Williams 2003). This is an important point. Theoretical approaches to modelling the concept of fire regime variability were evaluated by McCarthy (2003). He concluded that a major limitation to the application of available models in Australia was the relatively short time period of available data and long fire intervals. He advocated the continued use of averages, and variance about the mean to explore spatial and temporal fire regime variability. Because one of the striking features of the fire scar data is the distinctly different periods, characterisation of the within-period variability could be useful as a between-period comparison. There are two periods each of 80 years, one of 60 years, one of 30 years and one of 14 years. The standard deviation was used to illustrate variability in distribution of decadal fire scar years within and between each period.

7.2.2 A cross-disciplinary approach

A wide literature search was made to discover the reasons for the patterns of distinctly different periods in the mean decadal fire scar data. Sources from a range of disciplines were exploited.
7.3 **Results**

7.3.1 **Differences in land tenure**

The fire scar data covering 27 decades were grouped into classes 1 and 2 (Table 7.1). The publicly owned forested sites were never cleared, had been selectively logged and intermittently grazed prior to the 1970s. This group includes SW59C which is located in the eastern section of the southern Midlands, even though the grazing lease was not revoked until the 1990s. The privately owned southern Midlands sites, and two in the northern parts of the study area (Q and W) were cleared, partially cleared, intensively grazed and/or had been extensively logged. This arrangement constituted the division between public and private sites (Table 7.1).

The forested and southern Midlands sites, classes 3 and 4, are slightly different in composition and are representative of a geographic (northern/southern) split in the data.
Only two sites, with two trees each, in the southern Midlands (class 4) were recording fires from the 1740s: SHU and LSP. The spike in fire scars from this class in the early part of the chronology is evident in Fig 7.1. However, this is an artefact of the sample size conversion procedure. The adjusted data are positively influenced by the low sample numbers during these decades. Tenure otherwise affected the number of fire scars mainly during the 3rd European period between 1910 and 1950 by a notable departure between private land, mainly in the southern midlands, and public, mainly forested land at higher elevations in the north of the study area.
There was no statistically significant difference (MW – P, Table 7.2) between the public land and private land when tested over the entire 27 decades (Table 7.2). However, as depicted in Fig 7.1, there was a marked departure in the pattern of fire scar distribution between forested and southern Midlands sites in the 3rd European period. This was significantly different (t test p = 0.003). However, the distribution between private and public land classes was not significantly different (t test p = 0.414) (Table 7.2) despite Fig 7.1 showing analogous patterns for both groups of similar classes. From the statistics, this indicates a spatial difference in the study area that is not related to land tenure. However, Fig 7.1 shows that it is for part of this period, between about 1910 – 1950 where the main difference lies. Location and tenure both contributed to this divergence. Later in the 3rd European period, about 1945 – 1985, the number of fire scars between public and private sites varies widely.
Chapter 7 - Explanations for fire frequency changes

<table>
<thead>
<tr>
<th></th>
<th>MW - P</th>
<th>MW - W</th>
<th>Median</th>
<th>T statistic</th>
<th>P</th>
<th>DF</th>
</tr>
</thead>
<tbody>
<tr>
<td>All periods (27)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>0.8085</td>
<td>725</td>
<td>0.84</td>
<td>-0.33</td>
<td>0.739</td>
<td>51</td>
</tr>
<tr>
<td>Public</td>
<td></td>
<td></td>
<td>0.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forested</td>
<td>0.7752</td>
<td>725.5</td>
<td>0.87</td>
<td>-0.36</td>
<td>0.722</td>
<td>46</td>
</tr>
<tr>
<td>Southern Midlands</td>
<td></td>
<td></td>
<td>0.85</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Aboriginal Period (8)     |        |        |        |             |     |    |
| Private                   | 0.7905 | 65.0   | 0.50   | -0.05       | 0.962 | 13 |
| Public                    |        |        | 0.65   |             |     |    |
| Forested                  | 0.6731 | 72.5   | 0.06   | 0.25        | 0.811 | 10 |
| Southern Midlands         |        |        | 0.55   |             |     |    |

| Transitional (1st European) Period (3) |        |        |        |             |     |    |
| Private                        | 0.3687 | 8      | 0.2    | -0.134      | 0.274 | 3  |
| Public                         |        |        | 0.4    |             |     |    |
| Forested                       | 1.000  | 10.5   | 0.35   | 0.35        | 0.746 | 3  |
| Southern Midlands              |        |        | 0.37   |             |     |    |

| 2nd European Period (6)       |        |        |        |             |     |    |
| Private                       | 0.9333 | 38     | 0.85   | -0.49       | 0.639 | 6  |
| Public                        |        |        | 0.85   |             |     |    |
| Forested                      | 0.8102 | 41     | 0.92   | 0.41        | 0.693 | 9  |
| Southern Midlands             |        |        | 0.92   |             |     |    |

| 3rd European Period (8)       |        |        |        |             |     |    |
| Private                       | 0.4566 | 60.5   | 1.20   | -0.84       | 0.414 | 13 |
| Public                        |        |        | 1.55   |             |     |    |
| Forested                      | 0.0101 | 43     | 1.17   | -3.60       | 0.003 | 13 |
| Southern Midlands             |        |        | 1.65   |             |     |    |

| 4th European Period (1.5)     |        |        |        |             |     |    |
| Private                       | 0.6985 | 6      | 0.66   | 0.94        | 0.511 | 1  |
| Public                        |        |        | 0.15   |             |     |    |
| Forested                      | 1.000  | 5      | 0.76   | 0.060       | 0.654 | 1  |
| Southern Midlands             |        |        | 0.30   |             |     |    |

Table 7.2. Combined Mann-Whitney (Zar 1999) and student’s t showing no significant difference between public and private sites when the fire scar data were tested over the entire length of the chronology. When grouped into periods, the 3rd European period showed a distinctly different trend between forested and southern Midlands sites. ( ) = n decades. MW-P = Mann-Whitney p statistic, MW-W = Mann-Whitney w statistic.
7.3.2 Periods and their characteristics

Five distinctly different periods were defined from the adjusted fire scar data (chapter 6). Here they have been labelled for reference and ease of identification. This labelling provides a foundation for exploration later in this chapter. The dates which determine each period are necessarily loose and reflect the effects of decadal delineation, rounding to a ‘10’ at the beginning and end of each period.

Aboriginal Period 1740 – 1820. This earliest period of 8 decades is characterised by an injurious fire in the study area about once every 14 years. There are a minimum of two sites each with a minimum of two trees recording fires in the earliest decade. This period is characterised by a greater between-decade fire frequency variability than other periods (Table 7.4) despite lower sample numbers.

Transitional Period (1st European) 1820 – 1850. The second period of 3 decades is characterised by an injurious fire in the study area about once every 25 years. There was a very significant drop in fire scars at ~1820. Two sites did not record a fire scar throughout the entire period.

2nd European Period 1850 – 1910. Fire scar occurrence increased to about one injurious fire every 10 years in the third period of 6 decades. All sites except one (SH12D) recorded a large increase in fire scars in the early 1850s.

3rd European Period 1910 – 1990. There was a moderate hiatus in fire scar frequency for a few years between the previous period and this one. This period is characterised by about one fire every seven years and has the full complement of 104 trees recording for the first 5 decades. One site (SW59C) recorded two fires each decade between 1910 – 1990 and another (SHU) recorded two fires each decade between 1920 - 1960. Both of these sites had a long history of intensive sheep grazing until 1999 and 1984 respectively. SW59C is still unofficially grazed.
4th European Period (Current) 1990 – 2004. Covering 14 years, this period is characterised by a return to a fire frequency the same as that recorded for the Aboriginal period with a fire about every 14 years in the study area. There was a low number of decades (1.4) for this period.

7.3.2.1 Variability in the distribution of fire scars

The mean decadal fire frequency data from Table 6.2 are summarised in Table 7.3. Standard deviation and variance (Anderson-Darling normality test) showed that the variability of mean decadal fire frequency within each era was higher for the Aboriginal period (Table 7.4). The 4th European period was not tested due to paucity of data length (1.4 decades).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.8</td>
<td>0.2</td>
<td>0.8</td>
<td>1.7</td>
<td>0.1</td>
</tr>
<tr>
<td>2</td>
<td>0.6</td>
<td>0.5</td>
<td>1.2</td>
<td>1.4</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0.4</td>
<td>1</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.6</td>
<td></td>
<td>0.9</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.9</td>
<td></td>
<td>1</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.3</td>
<td></td>
<td>0.9</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.7</td>
<td></td>
<td></td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0.7</td>
<td></td>
<td></td>
<td>1.5</td>
<td>0.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean period frequency</th>
<th>0.7</th>
<th>0.4</th>
<th>1</th>
<th>1.5</th>
<th>0.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average years between fires</td>
<td>14</td>
<td>25</td>
<td>10</td>
<td>7</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 7.3. Mean decadal fire frequency summarised from Table 6.2.
Table 7.4 Descriptive results showing more decadal fire scar variance in the Aboriginal era than in the other three eras. * = insufficient data.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>St.dev</td>
<td>0.17525</td>
<td>0.15275</td>
<td>0.13292</td>
<td>0.0991</td>
<td>*</td>
</tr>
<tr>
<td>Variance</td>
<td>0.03071</td>
<td>0.02333</td>
<td>0.01761</td>
<td>0.0098</td>
<td>*</td>
</tr>
</tbody>
</table>
7.4 Discussion

Fire years through most sites followed a very similar distribution from the earliest year of the chronology (1740) until about the 1910s. A divergence between public and private land in the pattern of distribution was evident between the 1910s and ~1950 and continued, albeit less markedly, until around 1990. This contrasts with other fire history reconstructions where great between-site variability in temporal fire scar distribution has been recorded (e.g. Banks 1982).

7.4.1 Explanations for distinctly different periods

7.4.1.1 1740 - 1820

Aboriginal period 1740-1820

Tasmania was officially settled by Europeans in 1803, although coastal areas of the island had intermittently been visited (and documented) by sea-based explorers since 1642 (Robson 1983; Thomas 1994). Aborigines, comprising family groups and larger tribal associations, occupied the island.

Strong cases have been made for the use of fire in forests by Aborigines. Based on differences in sediment cores covering the same time frame between Tasmania and New Zealand, one researcher suggested that Aborigines have been burning the vegetation in Tasmania for > 70,000 years (Jackson 1999b) and that the eastern forests as had been “…severely modified by extensive and constant firing” (Jackson 1999a:13). Gammage (2002, 2005, 2006) contends that the Tasmanian Aborigines deliberately and predictably burned landscapes to provide a continuous supply of food and other resources, effectively cycling the vegetation.
to produce edges which were preferentially used by prey animals. Others have found no explanation other than fire for the boundaries between rainforest and grassland which are evident in many places in Tasmania. In northeastern Tasmania, Ellis (1984, 1985), Thomas (1991, 1993) and Ellis & Thomas (1998) worked extensively with soil properties and pollen respectively to explain such boundaries, naming Aboriginal fire as the causal agent. Similarly, in the southwest, Marsden-Smedley (1998) argued that the vast plains of buttongrass which abut eucalypt and rain forest were an artefact of Aboriginal burning. A case was made for a return to Aboriginal-style burning for the maintenance and ecological health of buttongrass (Gymnoschoenus sphaerocephalus) plains and protection of adjoining non-buttongrass communities (Marsden-Smedley & Kirkpatrick 2000).

In southeastern Australia generally, there is an abundance of evidence that Aborigines used forests as “...an important foci for Aboriginal resource exploitation and ritual” (Cosgrove 1982:2). Boutland (1988) and Feary (1988) compiled extensive review documents detailing the use of forests and woodlands by Aborigines in southeastern Australia. Excerpts from explorers journals were blended with evidence from archaeological, paleoecological, palynological and contemporary ecological research to irrefutably place Aborigines using fire in forests and woodlands. After exploring the available evidence for Australia-wide Aboriginal burning in an epic treatise, Bowman (1998) concluded “It is wrongheaded to ignore the ecological impact of a long history of Aboriginal burning” (Bowman 1998:405).

More specifically, Cosgrove (1982) and Lourandos (1970) found archaeological evidence for extensive Aboriginal forest use in the study area. Quarries, stone tools and artefact scatters were found beside creeks, river flats, drainage depressions and benched areas at a range of altitudes in the topographically diverse landscapes of the Eastern Tiers. After 1970, forestry burns made visible this type of evidence but roading and harvesting had obliterated many other sites, because flat areas were preferentially used by both Aborigines and loggers.

A history and interpretation of fire frequency in dry eucalypt forests of Eastern Tasmania
Others (e.g. Clark 1983a; Benson & Redpath 1997; Kershaw et al. 2002) prefer climate as the driving force behind the evolution and distribution of Australian vegetation and believe that > 30,000 years of Aboriginal occupation had little or no impact. One writer succinctly encapsulates these views: “Aboriginal use of fire had little impact on the environment and … the patterns of distribution of plants and animals which obtained 200 years ago would have been essentially the same whether or not Aborigines had previously been living here” (Horton 1982: 237).

There is likely to be a perennial debate regarding the use of forests by Aborigines and their impacts (e.g. Bowman 1998; Feary 2005). Because the frequency of fire in the forests and woodlands of eastern Tasmania, before European influence (i.e. before the mid 1600s when disease may first have been introduced), may never be known, it is important to establish the integrity of the fire scar record of the Aboriginal period, because European use of the forests and woodlands has since altered the distribution, structure and composition of vegetation (Kirkpatrick 1994; Duncan & Brown 1995) making comparison between subsequent eras complex.

**Was the Aboriginal fire regime intact until the first break in the fire scar data?**

There are many historic references to Aboriginal fires intended for deterrence (e.g. Meredith 1979: 77-88; Roth 1899; King 1963; Robson 1983; Kee 1990; Brown 1991; Pyne 1995:34). Moreover, after > 30,000 years of occupation (Jones 1969; Singh et al. 1991; Cosgrove 1989; Cosgrove et al. 1990; Thomas 1991; Ellis & Thomas 1998; Jackson 1999b) one would expect a sound predictive knowledge of fire use by Tasmanian Aborigines (e.g. Gammage 2006). Thomas (1994) distilled the ethnographical record and made a strong case for the tactical use of fire by Aboriginal people confronted by Europeans in coastal areas. However, Europeans were not used to seeing fires in their country-of-origin landscapes and, through ignorance, their interpretation could have grossly exaggerated the nature, extent and size of fires they saw (Watson 1969; Thomas 1994). The important point is that fires lit for defensive, offensive or tactical purposes could have influenced the fire scar evidence for a ‘natural’ regime by increasing the number and distribution...
of fire scars, thus introducing an artifice into the dataset prior to 1803. However, reports of Aborigines lighting strategic fires before the 1820s are from coastal areas and from inland areas in the late 1810s (Thomas 1994). Evidence for tactical fires used by Aborigines in other areas includes northern Australia (Preece 2002) and the American southwest when archival documents dating to the seventeenth century were analysed (Kaib 1998 cited in Swetnam & Basian 1995).

Supporting evidence for the persistence of a ‘natural’ Aboriginal fire regime until ~1820 comes from the Sydney area (Cumberland Plain) where, in the 1820s, the Aborigines were observed to be still burning eucalypt woodland understorey in the traditional manner despite the area having been explored and eventually settled around this time (Kohen 1986). Pre-settlement burning practices by Aborigines in inland (Swan coastal plain) south-west Western Australia was also thought to have persisted for some time after settlement (Hassell & Dodson 2003: 81).

The decrease in fire scars in the 1820s which delineates this period from the next, is co-incident with the build-up to, and onset of, the Black war 1824 – 1830. By the 1830s few Aborigines survived in the wild in Tasmania (Meredith 1979: 77-88; Robson 1983; Plomley 1992). Indeed, during the 1820s Aborigines were hunted and their fires would have betrayed their locations. Tasmania, without an external source of warmth, is a cold environment for human beings (pers. obs.). Plomley (1992) analysed accounts of items stolen by Aborigines during this period. Blankets and food were the most common items taken, the assumption being that warmth from them was a survival essential as the Aborigines most likely ceased, or at least severely curtailed, their use of fire (Pyne 1991:129). By 1835 most of those who remained of the Aboriginal population had been moved to Flinders Island. Thus, the Aboriginal fire regime is unlikely to have survived beyond ~1820.
7.4.1.2 1820 - 1850

Transition Period (1st European) ~1820 - 1850

A transitional period is likely to have been experienced by the forests in the period between the cessation of Aboriginal burning in the early 1820s and the active management of grazing land by European settlers.

Hunting for food and skins with packs of dogs appears to have impaired the development of agriculture throughout the 1820s and 1830s (Boyce 2006). This activity was not entirely in keeping with official plans for agriculture development and such independence was not encouraged. A dog tax in 1830 was subsequently introduced as a means of control, whereupon dogs were abandoned. With growing numbers of sheep, dogs were shot and poisoned throughout the 1840s and 1850s. It is unknown whether the labourers employed by the colonists preferred to hunt in burnt or unburnt forest.

There are accounts of settlers burning the bush “...as the aborigines used to...” (Meredith 1979: 45, who was writing in 1852). An understanding of fire use between Aboriginal and European could have been transferred but is likely to have occurred in the first decades of settlement. Boyce (2006) has documented very early settlers (1800s) sharing land, hunting and dogs with the Aborigines in the Hobart area. Their relatively isolated outposts provided early shepherds with opportunity for interaction with Aborigines (Cubit 1996) and it is thought that such opportunity for exchange may have resulted in the transfer and adaptation of fire technology from remote areas to lands becoming settled and increasingly stocked with sheep. If the shepherds had learned about fire from the Aborigines then this information would have eventually been passed on to the landholders, thus setting the scene for a practice which continued in some parts of the Midlands until the 2000s (Gilfedder et al. 2003).
The southern Midlands sites, except SW59C were alienated prior to 1820 and the two northerly sites (Q and W) were alienated in the 1820s. The remainder of the northern study sites were never alienated and there was little movement through the interior of the northern Eastern Tiers until around the 1830s. The southern Midlands sites recorded marginally more fires than those in the north during this period and may have been related to earlier settlement with concomitant clearing and grazing.

The demise of Aborigines and their burning practices would have impacted on the vegetation. Indeed, an early Government Servant, decrying the loss of Tasmanian Aborigines, stated: “...the consequent absence of extensive periodical fires (has allowed the bush to grow up) to a most important degree, spoiling the sheep runs and open pasture and affording harbourage to snakes and other reptiles which are becoming yearly more numerous” (Lieutenant Henry Bunbury cited in Pyne 1991: 129). Heathy and shrubby understorey vegetation would have gained volume during this period and, without fire, litter accumulation would have increased. In the early part of this period, fires were probably infrequently lit by landholders or their employees. When they did eventually start to use fire it was probably with varying degrees of predictive knowledge of fire behaviour due to inexperience (Pyne 1991: 129). When the forests did burn, it is possible that they did so with higher intensity due to increased fuel (King 1963; Duncan 1981). Sheep numbers were steadily increasing (Kirkpatrick 2007a).

Sheep runs (hilly, often steep bush country) would have been becoming established during this period, radiating east and west from the Midlands valley. These areas would have been periodically burnt by shepherds for the provision of fresh feed. Conditions, such as property improvements achieved by clearing and burning, were placed on the holders of some land grants (Robson 1983). It is doubtful that such conditions were widely met immediately upon receipt of a land grant because many landholders elected to remain in the relative safety of Hobart leaving shepherds or leaseholders in charge of their properties (Scott 1965) as bands of escaped convicts roamed at large.
Chapter 7 - Explanations for fire frequency changes

An alternate view of the events during this period is one of more burning, more regularly and more thoroughly thereby eventually ensuring fires of low intensity, due to a scarcity of fuel, which were less likely to cause scarring about the stems of eucalypts. As Kirkpatrick (2007a) pointed out, landholders had access to convict labour and were many more in number than the entire Aboriginal nation in earlier times. The flaw with this view is that the Eastern Tiers were in their infancy of settler influence, limiting opportunity to maintain annual fire regimes. Only two sites (W and AR) recorded fire scars in two successive decades during this period. Site AR was part of the Font Hill (1805) grant and a grazing regime would have been well established. W is favourably situated on a gently undulating plain on the western slopes of the Eastern Tiers and was granted in the 1820s.

An overland route from Hobart to the East Coast was first explored in 1821 (Commonwealth Parliament 1921) and it wasn’t until the mid 1820s that small landholdings were granted on the central East Coast around Swansea just east of the southern part of the study area. All the best, most productive land close to Hobart in the Midlands valley had been alienated before 1825 (Roberts 1924), leaving the more distant hilly to mountainous Tiers country to the east ripe for alienation during this period. Indeed, much of the central Midlands and the central East Coast was alienated between 1823 and 1844 (Scott 1965). The forests of the northern part of the study area were never alienated but were subject to timber licenses from the 1830s. These were granted for eight week terms throughout this period. In the 1830s, records of timber licenses showed no reference to the lighting of fires but by 1845 clause 4, “…the party holding this license is requested not to fire the bush” was inserted (Archives Office of Tasmania LSD 1/64). In addition, seize and sell operations were apparently rife in parts of the Eastern Tiers. Landholder complaints to the crown of unauthorised fires and pailings theft throughout the 1840s (Archives Office of Tasmania 67/14789) indicating increasing human activity in the forests and reflecting the high value placed on timber protection. The activity of people in the forests was about to substantially increase.
7.4.1.3 1850 - 1910

Second European period 1850 - 1910

A complex of factors could have influenced fire activity during this period. However, the implications of one factor were immediate. The finding of gold in Victoria in 1851 saw a mass migration of settlers, farm workers, shepherds and even whalers from Tasmania to the goldfields (Robson 1983). Indeed, 23% of the male population emigrated from Tasmania between 1851 and 1853 (Barnard 1854). An abrupt labour shortage may have meant that the capacity to either deliberately initiate or control burns on run country was temporarily impaired. Meredith (1979: 45) describes deliberately lit fires in the vicinity of her property on the central east coast in the late 1840s which were not controlled and were not extinguished until it rained.

In other parts of the Eastern Tiers, any regular burning up until this time may have temporarily ceased causing the accumulation of both live and dead fuel, or may not have been widespread in the first place. The steady build-up of dead and scrubby fuels during the previous period would facilitate fires of high intensity in conducive conditions. The increased tree scarring during the 1850s could be the result of this type of fire producing tree injury rather than increased fire frequency.

Another contributing factor for the large increase in fire scars during the early 1850s could have been attributed to those who did not migrate but instead chose to remain in the forests engaged in legitimate, or otherwise, timber getting. There was a drastically drained male labour population with 6613 departures from Tasmania in 1851. This rose to 21,917 departures in 1853, but was partially offset by strong immigration and huge increases in the value of trade, especially
timber (Barnard 1854). While quantities of goods did not necessarily increase, the early 1850s appeared to be a boom time for Tasmania with the value of imports rising 354% to £2,273,397 and exports 263% to £1,756,316 between 1851 and 1853 (Barnard 1854). The demand for Tasmanian timber rose sharply during the early 1850s primarily to feed the goldfields infrastructure in Victoria. Some of the gold-rush wealth was fed back into Tasmania because the value and quantity of exported timber rose 1500% from 1851 to 1853, making this industry more profitable and reliable than the goldfields. In order to get the timber, fires were used to clear the understorey vegetation to enable access and reduce the risk of unplanned fire in the immediate vicinity. Despite this, or because of it, accidental fires from such a high increase in timber-getting activity, perhaps some of it undertaken by inexperienced bush people eager to capitalise on this valuable resource, could have occurred during this phase. Forest fires rapidly became problematic. The first Bush Fires Act in Tasmania was introduced in 1854 describing penalties for the lighting of summer fires but was apparently largely ignored (Wettenhall 1975).

The fires probably continued as an unprecedented amount of Crown Land was sold in 1852 and 1853 (Barnard 1854). Those returning rich from the goldfields bought land and their clearing and burning activities would have added to the timber getting fires.

The nature of vegetation and therefore fuels were also probably changing due to the vast herds of sheep. The impact of grazing by sheep reduces the grassy fuels. What remained of the native macropod (*Macropus* spp. and *M. giganteus*) population (West 1852) would have been preferentially browsing herbs and shrubs but with probable negligible effect due to excessive hunting in the transitional period, 1820 – 1850. With 1.9 million sheep in 1853, grass would have been at a premium (Barnard 1854). Co-incident with a gold-rush induced labour shortage, timber extraction becoming as lucrative as gold fossicking, grassy fuels were decreased by grazing while shrubby fuels accumulated due to low numbers of marsupial browsers. The abrupt increase in tree scarring in the
early 1850s could partly be the result of changed fuel structure which led to increased flammability and continuity and therefore higher intensity fires.

Perhaps attempts were made to confine and protect increasingly large numbers of sheep from theft and predation after the first wave of labour loss in 1852 (Morgan 1992; Kirkpatrick 2007a). Timber post and rail fencing was a major forest product by the 1850s and fencing most likely became a priority. As a result, protection from fire was a major consideration and was largely undertaken by the maintenance of reduced fuel about fence lines using fire (Meredith 1979: 45).

During the middle of this period, Tasmania was the leading producer of trams and tramways for the timber industry. Tramways were extensively used in Tasmanian forests - first in the southern forests and spreading to other areas of the state much later. Saw mill operators had complete control of forests - Tasmania was the last State to develop a Forest Act in the 1920s - throughout this entire period and preferentially took only the best trees (Evans 2005). The retention of timber on selected land was illegal and in those areas remote from roads or ports, entire stands were ring-barked and burnt (Stubbs 1998). It is not clear when ring-barking commenced in Tasmania (Evans 2005) although Pyne (1991) reported the activity from the 1840s in the Midlands. This method involves the killing of standing trees by removing a collar of bark around the stem. The dead trees were then repeatedly burnt in order to remove them, and accumulated debris, in preparation for pasture development or to improve rough grazing capacity. Each repeated fire in forested areas of sufficient intensity could have encouraged new growth and seedling germination requiring more fire for its control. Grassy fuels would have been generally low due to the ubiquitous sheep grazing. A cycle of burning in response to vegetation growth could also perhaps explain the increasing occurrence of fire scars throughout this period which, after a short hiatus, grew to almost double in frequency during the next period.

A well documented drought in the early years of the 20th C (Marsden-Smedley 1998) may have been related to an increase in the number of fires in the late 1890s, especially in the southern Midlands sites. There was a sharp drop in the
number of fire scars in the few years prior to 1910 perhaps reflecting a public response to an unpleasant association with drought and fire, assuming human ignition. If so, this association did not remain strong in the collective mind because by the mid 1910s, the fire frequency had increased to significantly higher levels than at any time in the previous two periods.

After the rash of fires in the late 1890s there is a marginal drop in the numbers of fires for the first decade of the 20th century, more pronounced in the southern Midlands than in the forested parts of the study area. Possibly the area had been well cleared and burned by this time after a peak of fire activity through the 1890s, resulting in low intensity fires. A boom, resulting from Federation in 1901 which made 3rd class land, most of it in the Eastern Tiers, readily available via relaxed purchase terms, occurred in the period 1902 – 1911 (Scott 1965). The ‘closer settlement’ scheme became a reality through the Closer Settlement Act 1906. This act was designed to make more land available to more people for the sole purpose of farming. Title was not provided until such ‘improvements’ were carried out. (An Act of Parliament waived the clearing before title clause only in 1976).

The entire range of circumstances described here most likely contributed to the higher than previous levels of fire scar incidence. As the colony prospered into the 20th Century, lighting fires became an integral part of life for people in the bush.

7.4.1.4 1910 - 1990

Third European period 1910 - 1990

The effects of more people moving onto land previously unavailable resulted in fires lit for land clearance of which escapes were also probably commonplace.
Closer Settlement Act of 1906 enabled the breakup of some of the larger landholdings placing more people on to smaller lots (pers. comm. Tim Jetson). Property ‘improvement’ requirements (ringbarking, clearing, burning, fencing, buildings, pasture development) were still imposed. Indeed, there are surveyors records which comment: "only improvement is the burning" (National Archives of Australia #719) – this, for a Midlands property at an unknown date prior to 1929. A levelling off in fire scar evidence occurred across all sites, both public and private, from the mid 1910s until about the mid 1920s. This fits with the period during which much of the land granted under the closer settlement scheme of the first decade of the 1900s reverted to the Crown during and, for a while after, World War I (Scott 1965).

The mean frequency of fire scars increased from about one every ten years to one every seven years across the study area between these periods. It appears that a culture of burning had developed during the preceding 60 years, almost a single generation, and fires had become an entrenched tradition which was passed on. Fire was so prevalent that attitudes to it were quite relaxed, reflecting familiarity with its use (see Gilfedder et al. 2003; Kirkpatrick et al. 2007b). Increasingly, industrialisation of activities that were previously performed by horses or bullocks opened up a wider range of options for land exploitation and transport in particular. Pyne (1991, 2006) has concluded that Australians on the land developed a penchant for fire during this period and generally became very comfortable with its use. For example, the mail service from Swansea, on the East Coast to Campbell Town, in the northern Midlands in the 1920s and 1930s was operated by vehicles which ran gas producers. These devices were fed with organic material which made methane gas to power the vehicle. The ash was tipped out on the side of the road en route and restocked, often with cow dung collected from roadside paddocks. Many of these vehicles operated in Tasmania during this time and were directly responsible for fires (Gilfedder et al. 2003: 32).

‘Bad’ fire years occurred throughout Tasmania in 1913-1915, 1927, 1931/32, 1934, 1939, 1945/46 and 1961 (Wettenhall 1975; Luke & McArthur 1978; Pyne 1991). ‘Bad’ fire years would also have occurred in previous periods (such as in
1851 and 1898/99) but were either not recorded with the diligence of those record-keepers in the 20th Century or fire was less remarkable and therefore not recorded. Even after the horrendous widespread fires in Victoria, NSW and the ACT of 1939 (Collins 2006) the incidence of fire scars did not decrease on the private land in the study area. There was a marginal decrease for several years in the late 1930s in the forested public land sites but this appears to have occurred before the 1939 fires. The effect of the Victorian fires of 1939 was to initiate reform in the system of forest management in Victoria and New South Wales (Stretton 1939). It appears that no such effect occurred in Tasmania (Collins 2006).

The more open and grassy, southern Midlands sites, which, in all likelihood were more intensively grazed than the forested sites, recorded significantly more fire scars between 1910 – 1990 (Fig. 7.1). It seems most likely that landholders were regularly burning their runs for fresh pick.

Sheep numbers were still high until the 1960s when wool prices fell and, according to one source from the Midlands “Burning was conducted relative to grazing demand” (Gilfedder et al. 2003: 26). Fire was widely and, by this time, traditionally, used in run country in the southern Midlands and the Eastern Tiers up until the ~1970s. It wasn’t until the fires in the south-east of 1967, and the following parliamentary enquiry (Chambers and Brettingham-Moore 1967), that adequate resources were allocated to undertake broad scale fuel reduction burning and fire suppression was actively promoted. Commercial forestry operations commenced in the Eastern Tiers in 1971. The debris from logging (slash) was initially burned hot to stimulate regeneration from aerially sown seed (Dickinson & Kirkpatrick 1985) then later, cool, slash reducing burns were introduced. There were escapes but these were poorly recorded and very poorly mapped. Forestry operations became more widespread and efficient at timber extraction. Sheep were considered an anathema to regenerating eucalypt forests and grazing leases on public land were cancelled through the 1970s and 1980s. However, a grazing lease was maintained on one publicly-owned site (SW59C)
until 1999. This site recorded the most fire scars per tree and overall. The single fire in the 2000s was recorded from this site.

It would appear that, unlike the southwestern United States (e.g., Touchan et al. 1993; Grissino-Mayer 1995), the presence of large numbers of sheep in Tasmania was co-incident with increased fire scars. This indicates that humans were the source of ignition because native pasture and native runs were regularly burnt to promote fresh growth for sheep feed. If ignitions from lightning have remained constant throughout the past ~300 years, then climate cannot explain the fire frequency changes reported here.

**7.4.1.5 1990 - 2004**

**Fourth European period - current 1990 – 2004**

There are several factors which have influenced the lack of fire scar evidence during this period. Commercial eucalypt plantations were established throughout Tasmania in the 1960s and 1970s. Harvesting of the fast growing *E. nitens* and *E. globulus* plantations were underway in the early 1990s relieving some of the pressure on the native forest estate for a short period in the early 1990s. The enactment of the Tasmanian Regional Forest Agreement in 1998 (AFFA 1998) enabled a renewed assault on the forests but, with the advent of the Forest Practices Board and subsequent Forestry Code of Practice, new guidelines and constraints were placed upon the use of fire for regeneration of forests after logging (FPA 2003).

Wildfire is detrimental to production forestry because the presence of charcoal is inconsistent with the needs of Japanese woodchip buyers who demand, and pay for, a clean product. Wildfire can kill regenerating eucalypts thereby severely affecting a future return. The public forests are in various states of regeneration. The forests are managed to produce trees which constitute high volumes of fuel in
solid stands of varying ages and heights. Both vertical and horizontal fuels, more notably in the older regeneration areas, could be described as continuous (pers. obs.). In addition, the vocal public and political perception of escaped forestry burns laying waste to the forests of the 1980s demanded changes (Watson 1990; Gee 2001). Slash burns after logging activities are today conducted with well trained crews of people and adhere to explicit guidelines governing conditions under which a fuel reduction fire may be started (FPA 2003). The vigorous, co-ordinated and better resourced suppression activity by land management agencies, Forestry Tasmania (FT) and Parks and Wildlife Service (PWS), and the emergency response agencies Tasmania Fire Service (TFS) and State Emergency Services (SES), has enabled a quicker and effective response to any escapes or other unplanned fires. In particular, it is the inter-agency agreement developed initially between FT and the TFS in 1992, which, a few years later, included the PWS that has enabled a unique approach to fire management in Tasmania. Whilst initially challenging, this system has been defined and strengthened by an actively cultivated environment of trust and respect developed from within the ranks, through inter-agency friendships over many years (A. Blanks pers. comm. 13 Jun 2008).

Therefore, during the current period, fires are generally efficiently extinguished. The contemporary source of ignition is via the arsonist or through an accidental escape. For example, TFS data show the strong relationship between settlement, demography and ignitions for Wellington Park, near Hobart (WPMT 2006). Ignitions are increasing in frequency as fire suppression agencies are increasing response capabilities.

A survey of many Midlands landholders (Gilfedder et al. 2005) revealed that few of them have purposefully burnt their run country since the 1970s, although Kirkpatrick et al. (2007a) reports the burning of sagg (Lomandra longifolia) and grasses in open situations on some properties up until the present day. Liability for escaped burns has been legislated into existence in the early 2000s creating an unacceptably high risk for landholders (e.g. Mokany et al. 2006:64). The
explanation for the lower incidence of fire scars during this brief period is related to the combined influence of these factors.

### 7.5 Conclusion and Application

This thesis documents changes in fire frequency between 1740 and 2004 and interprets the causes of these changes. The sampled eucalypts are not amenable to cross-dating. The fire scar data was demonstrated as reliable through the interrogation of ring counts and a range of potential sources of error were shown not to have any substantial influence on the accuracy of the fire year chronology. Distinct patterns of frequency in the fire scar data were subsequently explained by the assembly of a multidisciplinary cultural overlay.

It is difficult to interpret the observed changes in fire frequency as being caused by climate because the differences in the distribution of fire years (periods) were consistently different throughout the length of the chronology. These differences do not relate to rainfall patterns (1855 – 2004) which otherwise could have been suggestive of a strong relationship between drought and increased incidence of fire scars. Within each of the three most recent periods there are years of both high and low rainfall (Fig 6.7). There is no consistent correlation between years of high or low rainfall and an increase or decrease in the distribution of fire scars. Furthermore:

a) there are no empirical data for rainfall or temperature prior to the mid 1850s and none for lightning prior to 1998 with which to link trends in fire frequency from the early part of the chronology;
b) the correlation between years of low annual rainfall between 1855 – 2004 and fire years was 28% suggesting a weak relationship between drought and fire but not helping in identification of an ignition source;

c) changes in climate, if driving lightning, would need to be abrupt and severe to account for the large decreases and increases in fire scars detected at particular points in the record, across most sites;

d) the cultural record is a vast and compelling body of evidence for anthropogenic fire in the Eastern Tiers and southern Midlands.

7.5.1. Variability in the fire regime

Between-decade variability was tested within four of the five periods using the mean decadal frequency data (section 7.3.2.1). The highest variance was observed in the Aboriginal period which covered 80 years (range 0.3 – 1 fire years/decade).

Variability in fire occurrence (frequency and patchiness) and intensity (ground or crown) in dry eucalypt forests is vital for the maintenance of diversity of forest structure and species composition and habitat. Over time, too frequent fires can favour resprouters over seeders (e.g. Fox & Fox 1987; Knox & Clark 2006) although other factors such as drought are important. Intense fires can be lethal resulting in even-aged stands. If the biota has evolved with thousands of years of Aboriginal ignition, and there is a great diversity of life history attributes within communities, then variability in the components of the fire regime must have collectively contributed to the forcing of such attributes. Some researchers have even suggested that dry forests in Tasmania have developed on anthroposols, the result of many thousands of years of Aboriginal burning (McIntosh et al. 2005).

The evolution of our understanding of the implications of the fire cycle, fire frequency and fire intervals on the landscape have most recently been reviewed by Gill (2003). In an effort to achieve a diversity of outcomes such as conservation, ecological systems maintenance, fuel reduction, forest resource extraction and forest management, various methods have been proposed to
determine the likelihood of fire occurrence in a given landscape. In almost all cases the mean is used as a measure from which to interpret the historic or predicted future passage of fire. There has been focus on time-between-fires or the fire interval using data collected from fire scars (Burrows et al. 1995, Fulé et al. 2003, Reed & Johnson 2004) and from life history knowledge of component plant and animal species (e.g. Clark 1996; Tolhurst & Friend 2003). For example, the model developed by Bradstock et al. (2005) attempts to reconcile apparent contrasts in fire requirements for a mallee ecosystem, of which *Callitris verrucosa* is one component, and the mallee fowl (*Leipoa ocellata*), another. It includes parameters which relate to fire characteristics (including unplanned fires), landscape form, plant dynamics, habitat and life history attributes of mallee fowl and explores the consequences of particular prescribed fire frequency. Emphasis is placed on the need for the ‘invisible mosaic’ of the site fire history to be made visible because the spatial and temporal extent of each successive fire is critical for enabling quantification of the state of the prevailing fire regime which guides the decision making process (Bradstock et al. 2005). They concluded that a comprehensive landscape ecological approach was required.

Another example, which uses surrogates to determine an appropriately variable fire frequency, is based on information derived from forest age, area and hollow occurrence data in Victoria (McCarthy et al. 1999). The data were collected from Mountain Ash (*Eucalyptus regnans*) forests subjected to European land management over the past 200 years. Their results showed that using hollow numbers and occupancy alone, a mean high intensity fire interval of ~250 years would support a maximum ‘...total abundance of mountain ash trees with hollows’ (McCarthy et al. 1999). This contrasted with age structure parameters where the mean fire interval was predicted at ~107 years. A constant mean fire interval in the model was needed to provide consistency between predictions based on the three parameters however their results were in accordance with previous work where a mean fire interval of ~100 years was postulated to describe the prevalence of multi-aged *E. regnans* forest. In reality, a constant fire interval is impossible and the authors suggested that biological factors contributing to vegetation and fuel changes may be more useful indicators to model.
The variability of fire frequency can be theoretically modelled according to the input parameters (life histories of component species, topography, weather conditions such as rainfall, fuel conditions, fire behaviour, time-since-last-fire etc.). However, contemporary human beings as a source of ignition cannot be adequately predicted because arson is prevalent among modern human beings. Dry forests are generally not managed sensitively because we do not rely on them for the most fundamental of survival requirements: food. Forests are widely managed as an economic commodity from which timber, wool and honey are produced or they are reactively burnt to reduce fuels for temporary population protection (viz. 10,000 ha fuel reduction burn near the East Coast town of Bicheno in September 2007, pers. com. B. Merritt October 2007). We are, today, simultaneously mindful of litigation should fires lit on land under one management regime escape on to land under another.

The fire scar data revealed very low between-decade variability in the 3rd European period between 1910 – 1990. It is not possible to determine variability of frequency in the 4th European period because 14 years is an inadequate timeframe. As lightning is an intermittent source of ignition in eastern Tasmania (Jackson & Bowman 1982; TFS unpubl. data p.186) the incidence of fire is most frequently determined by people. If relative climatic stability has been the norm throughout the Holocene (Dodson & Mooney 2002), indicating neither more nor less lightning, changes in fire frequency since European settlement cannot be adequately explained without accounting for people as a source of ignition (Carey & Banks 2000).

7.5.2. To the future

"…at the intimate level of local processes and human action, the effects of people on vegetation are more clearly evident." Thomas (1993:9).
Sediment records covering thousands of years are generally interpreted to infer that climate plays a stronger role in the distribution and composition of vegetation (pollen) than fire (Clark 1983b; MacPhail 1979, 1980) because of the time scale involved (Thomas 1993). Palaeo-disciplines have provided evidence that fire regimes generally have changed after the occupation of Australia, first by Aborigines and later by Europeans (e.g. Singh et al. 1981; Dodson & Mooney 2002). Scale is relevant here as a problem with charcoal sediments analysed in palynology, palaeoecology and archaeology is the general coarseness of data resolution (Clark 1983a), due in part to the long time-frames over which each discipline covers. Other problems include: charcoal may breakdown into smaller segments and be continuously washed into deposition sites for many years after a fire thereby hindering interpretation (Blong & Gillespie 1978) and, rainfall after a fire can affect the degree to which charcoal is represented (or missing) from a sediment sequence (e.g. Green et al. 1988). These problems seem to have been challenged by work in southeastern NSW. Fine-resolution evidence for the occurrence of frequent fires during the period 1950 – 1975 was found in the charcoal record of a peat bog in Bega Swamp yet fire scars in adjacent eucalypts (E. pauciflora) were few, indicating occasional more intense fires (Green et al. 1988). The evidence for frequent low intensity fires found in the charcoal record which was not recorded in the adjacent eucalypts could, like the grasstree research (Ward et al. 2001; Ward 2006), provide supporting evidence for making visible the 'invisible mosaic' (Bradstock et al. 2005) of past fires, at least on the local level.

Perhaps a warming climate will bring extended fire seasons where the conditions for fire are generated on more days during each year. However, unless there is a concurrent increase in dry thunderstorm activity, each fire still requires a source of human ignition.

Brookhouse (2006) has suggested that eucalypts have potential for further dendrochronological examination. The cross-dating attempts reported in this
thesis showed little value in this approach. Instead, with careful radius selection, this study has demonstrated that it is possible to date fire scars and age large, old eucalypts using ring counts. The potential for the development of fire histories in other areas, particularly those with forestry activity, is consequently greatly expanded using this method.

The fire scar data show that the temporal and spatial distribution of fire scars in Tasmania’s Eastern Tiers has increased consistently since ~1850, and decreased since the early 1990s. It is now possible to ask questions regarding the implications of such knowledge. As many researchers have observed (e.g. Burrows et al. 1989; Bradstock et al. 1995; Bradstock et al. 1996; Burrows & Friend 1998; Gill & McCarthy 1998; Burrows et al. 1999; Friend et al. 1999; Gill 1999; Gill et al. 1999; Gill & Catling 2002; Bradstock et al. 2005; Knox & Morrison 2005 to name but a few), perhaps future questions regarding fire frequency should continue to relate to the requirements of groups of species and the maintenance of habitat with a focus on private land. The fire history for the Eastern Tiers reported in this thesis forms a platform of knowledge from which future research can be crafted. Such endeavours would be enormously strengthened by the involvement of work from other disciplines such as anthropology and ethnohistory (Drew & Henne 2006).

Whilst not conclusively demonstrated, variability in the fire regime may nevertheless be the key to maintaining biodiversity in dry forest systems (e.g. Landres et al. 1999; Walshe & Williams 2003). However, with the current uncertain climate of change upon us, the capacity to implement such regimes may be beyond our control. As Jackson (1999 p.34) so succinctly pointed out “Whereas lightning is an important source of fire on mainland Australia (Gill 1981a), the vast majority of fires in Tasmania are man-made.”