



## Western Australia

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The first part of this chapter provides **contextual information** on Western Australia, including basic information about its climate, geography, land use and population. It also provides an outline of the bushfire regimes, historically important bushfire events, and an overview of fire services in Western Australia. The second part represents an **analysis of data** provided by the Western Australian Fire and Emergency Services Authority (FESA) and the Western Australian Department of Conservation. Although FESA attends many types of fire incidents, and those data were supplied, this analysis exclusively refers to vegetation fires, unless otherwise indicated.

For an explanation of the key terms, limitations and methodology refer to the introduction, glossary and methodology chapters.

## Introduction

Western Australia covers an area of 2,529,880 square kilometres, occupying the western third of the Australian mainland; it is bordered by South Australia and the Northern Territory in the east, the Southern Ocean to the south, the Indian Ocean to the West and the Timor Sea to the north.

## Geography

Western Australia includes some the most ancient rocks and landscapes preserved on Earth, a factor that together with the climatic conditions shapes the distribution of fauna and flora and ultimately its people. Most of the state lies on a low plateau (400 m above sea level) that has exceptionally low relief, and no surface runoff. This plateau descends rapidly, sometimes via an escarpment, to the narrow coastal plain.

The far north is dominated by the Kimberley Plateau, bordered to the south by the King Leopold Ranges, and dissected by the Fitzroy and Ord rivers (Figure 1). Southeast of the plateau lies the rugged and arid landscape of the Pilbara, including the red ridges and gorges of the Hamersley Ranges. The latter contain vast reserves of iron ore, being the principal reason for establishment of small towns and settlements throughout the region, with a most notable settlement at Port Hedland. The highest point in Western Australia, Mount Meharry (1,251 m) is located nearby. Many of the coastal rivers in the northwest may be dry for much of the year but become raging torrents during cyclones. Nearer the coast, rivers ebb and flow with the large tidal variations. 'Rivers' further inland drain away from the sea into saline lakes within the Great Sandy and Gibson Deserts.

To the south of the Hamersley Ranges lies the Gascoyne River, beyond which lie the ancient rocks and landscapes of the Yilgarn Block. The west the Yilgarn Block is bounded by the Darling Fault separating the plateau of the shield from the coastal plain. The capital of Western Australia, Perth, and numerous other settlements lie on this plain, in the southwest corner of the state.

The southwest contains the state's only permanently flowing streams and true forests. It is also the most populated region in Western Australian outside of the metropolitan city of Perth. The Great Victorian Desert dominates the southeast of the state, south of which is the waterless, treeless Nullarbor Plain. The southern coast is bounded by unbroken, sheer cliffs beyond which lies the Southern Ocean.

Figure 1: Map of Western Australia



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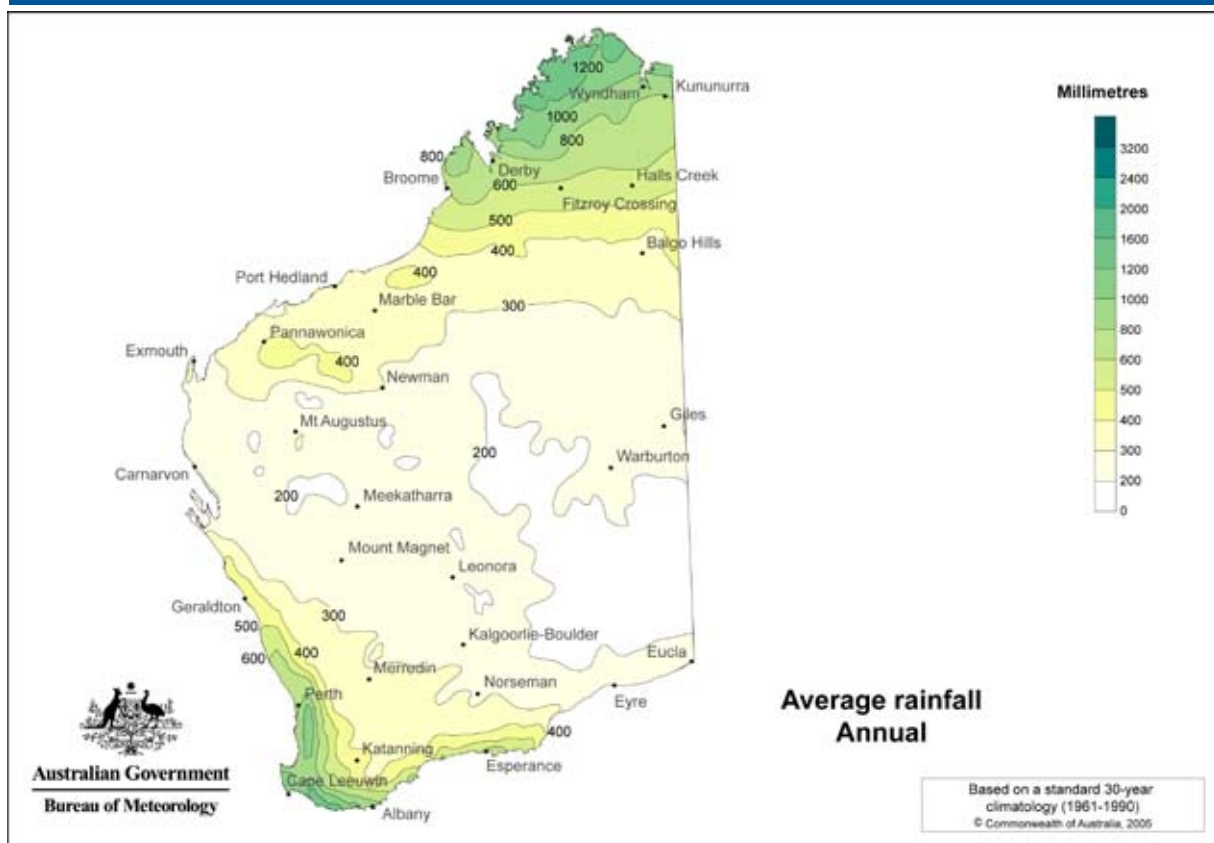
## Climate

Climate varies markedly both north–south and east–west across the state. The Kimberley region in the north has a tropical, hot monsoonal climate, receiving 500 to 1,500 mm annually. Almost 85 percent of the State’s runoff occurs in this area. However, this heavily rainfall is restricted to the wet season, and there is almost an absence of rainfall in the dry season, which spans from April through to November. Tropical savannas dominate the north of the state and owing to the extreme weather conditions and typically infertile soils this area is sparsely populated.

The southwest corner, covering an area of 140,000 square kilometres, is characterised by a temperate Mediterranean climate; summers are warm to hot and dry, winters are cool and wet. Owing to the concentration of rainfall by mountains near the coast, the far southwest corner receives as much as 1,400 mm per year (Figure 2).

Rainfall sharply decreases inland, with the central four-fifths of the state being semi-arid or desert; receiving only 200 to 250 mm per year. As well, rainfall in these parts is erratic, as it is commonly related to cyclone activity across the northern half of the state during the summer months (Australian Bureau of Meteorology 2007a).

**Figure 2: Average annual rainfall for Western Australia**



Source: Australian Bureau of Meteorology 2007a  
 © Australian Bureau of Meteorology

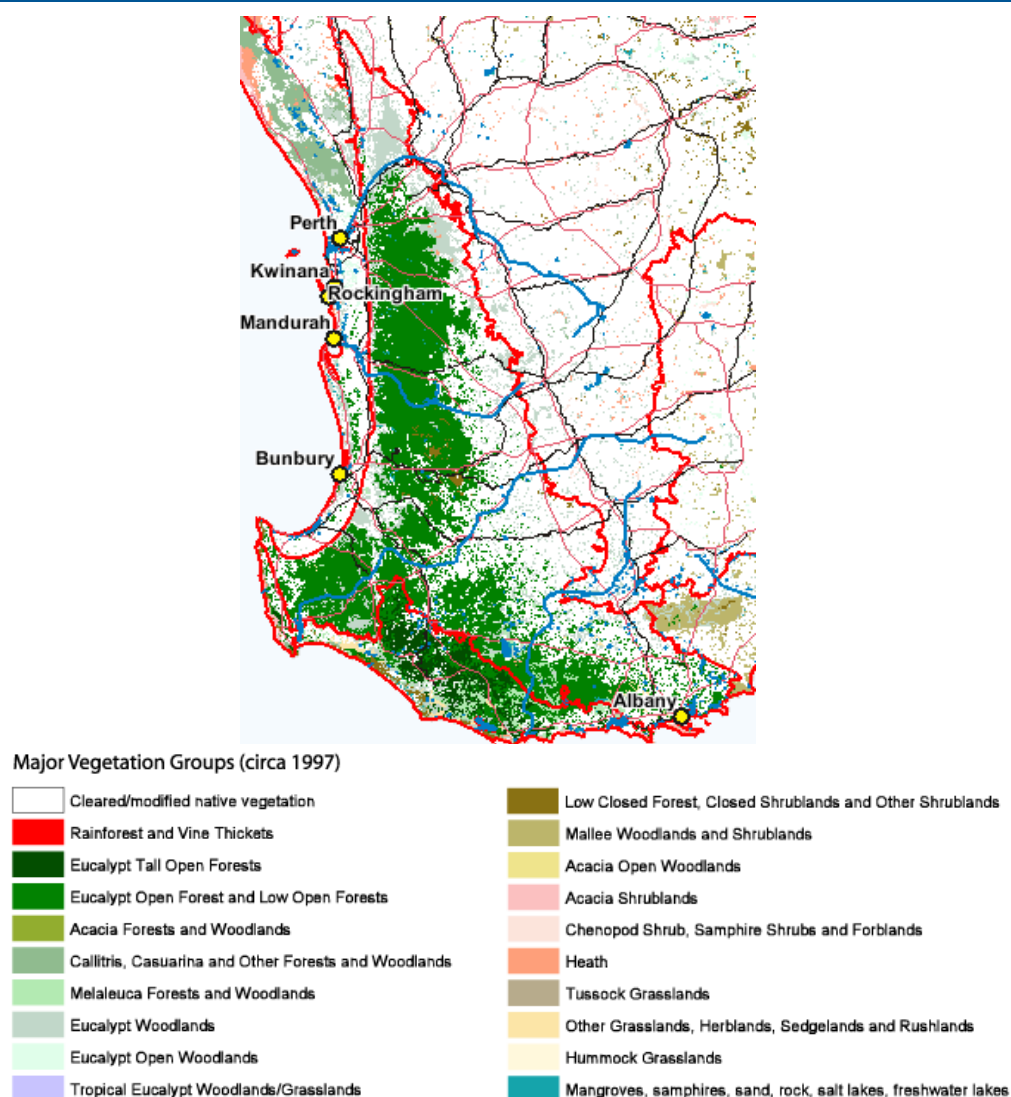
## Native vegetation

Vegetation types vary markedly across Western Australia. The Kimberley region is sparsely wooded savanna. Distinctive features include ubiquitous spinifex and moisture-storing baobab (bottle) trees. The Great Sandy Desert to the south is sparsely vegetated by spinifex, with some acacia scrubland (mulga) in the swales. The remainder of the arid interior is dominated by large expanses of hummock grassland, tussock grassland, chenopod (saltbush, bluebush), and samphire shrublands.

The southwest of Western Australia represents one of the top nine habitats for terrestrial biodiversity in world. There are more than 7,000 species of indigenous vascular plants, more than 2,400 of which are endemic to the area. Originally much of the southwest was heavily forested, including large stands of karri (eucalypt), one of the tallest trees in the world. Although some forests remain, much of the southwest

plateau has been cleared or modified for agricultural purposes. This has placed enormous strain on biodiversity; more than 800 species of vascular plants are rare or threatened, with 50 species already having become extinct. Of the remaining vegetation, there are abundant eucalypt forests and woodlands (including jarrah, marri and wandoo), often with a rich understorey (Figure 3). Other vegetation includes species-rich shrublands, heath, Agonis shrublands, Banksia low woodlands, swamps dominated by paperbark and swamp yate (Australia. Department of Environment and Heritage 2001b).

**Figure 3: Native vegetation groups – southwest Western Australia (c. 1997)**



Source: Australia. Department of Environment and Heritage 2001b  
 © Department of Environment and Heritage

## Land use

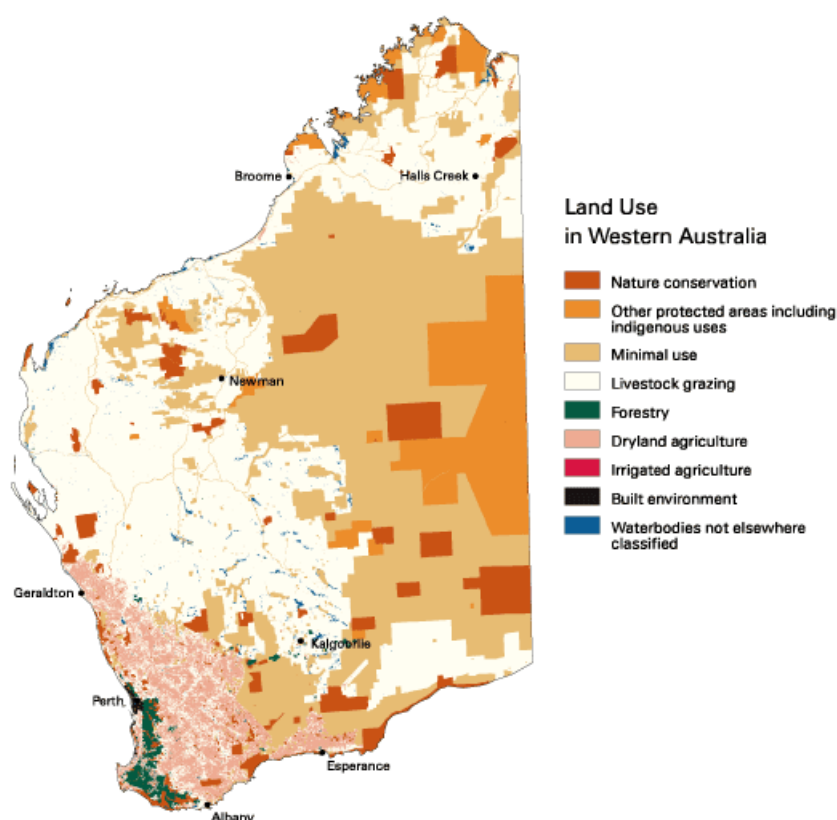
As at 1996–97, agriculture accounted for a little less than half the total area of Western Australia. Dryland agriculture occurred in five percent of the state, but was principally located in the moister southwest corner (Figure 4). Approximately 89 percent of agricultural land (42 percent of the state) was used for grazing of native pastures. This was concentrated in the north and in a broad swathe that extended from the northwest to the southeast of the state. Principal agricultural products included wheat, wool, beef and



lamb, but there was a diverse range of products generated, including other broadacre crops, horticulture, orchard and vineyards.

Approximately 92 million hectares (36% of the state) are minimal use areas that are largely vacant Crown land concentrated in the arid interior of the state. Traditional indigenous uses cover 23 million hectares (9%) of the state. Nearly 17 million hectares (7% of the state) is used for nature conservation, covering a range of environment types. Most of the area falls strictly within nature reserves. Forestry, including softwood timbers and woodchips from natural forests and plantations, principally occurs in southwest Western Australia (Australia. Department of Environment and Heritage 2001a).

**Figure 4: Land use (c. 1996–97)**



Source: Australia. Department of Environment and Heritage 2001a  
 © Department of Environment and Heritage

## Population

As at June 2006, Western Australia had a resident population of 2,050,900, accounting for 10 percent of Australia’s population (ABS 2006). The overwhelming majority of people live in the temperate southwest corner of the state, with almost three-quarters (73.5%) of the state population residing in the Perth statistical subdivision (SSD). Major regional centres in Western Australia include Mandurah, Bunbury, Geraldton, Kalgoorlie, Albany, Broome, Port Hedland, Karratha and Carnarvon. Western Australia is exceptionally rich in natural resources, and the location of townships in areas outside of the southwest is strongly correlated with the distribution of natural resources; these include mineral deposits of gold, nickel, iron and diamond, as well as oil reserves, fishing and pearling, and agriculture/forestry.



The median age of Western Australia's population in 2005 was 36.2, marginally lower than the national average of 36.6 at that time (ABS 2005a). Children aged 0 to 14 years accounted for 19.9 percent of the population. The largest proportion of children within the age group occurred in the Kimberly (26.2%) and the Pilbara (25.9%) regions. Approximately 14.4 percent of the state's population is Indigenous, although in central and northern Western Australia, Indigenous people account for 35 to 60 percent of the population (ABS 2005a).

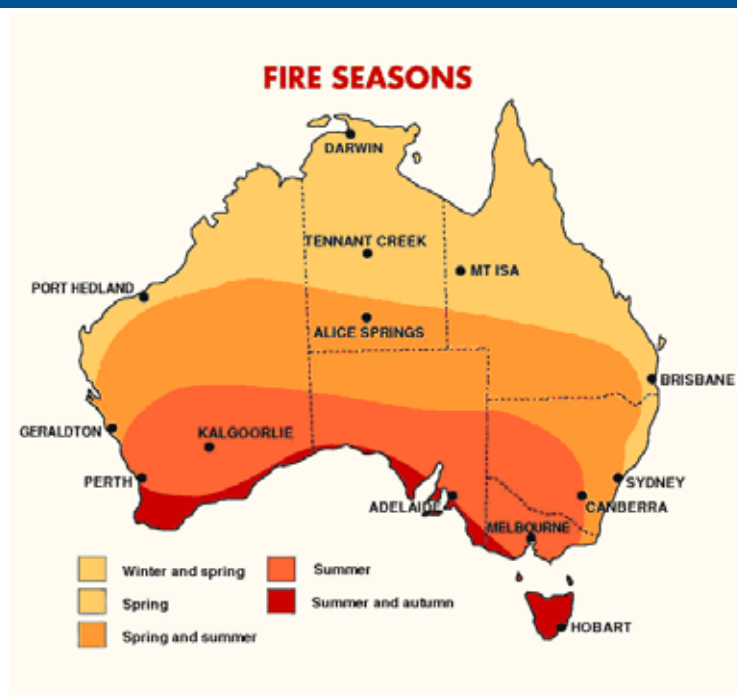
## Bushfire regimes

Fire regimes – that is, the intensity and the frequency of fires, the season in which they occur, their spatial pattern or extent, and their type – vary markedly across Western Australia as result of the inherently large diversity in climate, and hence ecology, population distributions, and land use patterns.

Due to significant latitudinal variations in climate Western Australia can potentially experience bushfires in any month of year. In the southern half of the state fires are most common in summer months but may extend into spring or autumn depending on the latitude, whereas the northern savannas experience widespread burning during winter and spring, with the predominance of spring burning increasing away from the equator (Figure 5).

In the Kimberley, vast tracts of the savannas are burned every year through natural fires, land management practices and to some extent, as a result of arson. The nature, timing, significance, and areas burned by savanna fires are discussed in detail in the Northern Territory chapter; such factors are also pertinent to the savanna fires of northern Western Australia. Many savanna fires occur in remote areas where firefighting, if it should be required, comes under the jurisdiction of landholders or local government and volunteer agencies. It is difficult to accurately assess the role of deliberate fire setting in these areas owing to the remoteness of the locations, the routine nature of burning practices and natural fires, and the fact that firefighting agencies do not actively attend many fires in these areas.

**Figure 5: Timing of bushfire seasons in Australia**



Source: Australian Bureau of Meteorology 2007c  
© Australian Bureau of Meteorology

## Bushfire history

Major bushfire events and bushfire seasons in Western Australia are summarised in Table 1, with the 1960–61 and 2002–03 being discussed in more detail below:

**1960–1961:** represents one of the most disastrous bushfire seasons in Western Australia's modern history. A series of large devastating wildfires occurred over much of the southwest, including at Mayanup, Pemberton, Shannon River and Kudardup (near Margaret River), but the most notable occurred at Dwellingup. Although this region had experienced drier than average conditions, the fires in southwest Western Australia were ostensibly associated with movement of a tropical cyclone across the northern part of the state. Development of a stationary strong high pressure system east of the cyclone resulted in temperatures above 40°C over five days and strong northeasterly winds in the southwest part of the state. On 19 January Dwellingup experienced dry thunderstorms as the cyclone moved slowly along the coast. Lightning started a series of fires. These rapidly spread due to the hot, windy conditions. Rains on 24 January eased the fire situation, but not all the fires were fully extinguished. Even stronger winds associated with the passage of another cyclone across the north, reignited fires in the southwest, and Dwellingup in particular, a month later (24 February). These fires subsequently consumed a number of towns in the southwest, including Pinjarra, Holyoake, Nanga Brook, Marrinup and Banksiadale, with the loss of 132 houses, but no loss of life. A total of 134,000 ha were burned in the Dwellingup fires, but approximately 1.5 million hectares were burned during that season. Investigations into the Dwellingup fires ultimately shaped subsequent fire management in Western Australia.

Cyclones played an intimate role both in ignition and reignition of the Dwellingup fires. This is not a unique situation in Western Australia, with cyclones also playing an intrinsic role in the cause and spread of the 1937 and 1978 bushfires in the southwest (Australian Bureau of Meteorology 2007b).

**2002–2003:** Exceptionally dry conditions associated with drought conditions over four to five consecutive years led to the most severe fire season since 1960–61. There was a six-fold increase in lightning-caused fires across the state, and many regions experienced extended periods of very high and extreme bushfire weather conditions. The Department of Conservation and Land Management (now Department of Environment and Conservation) reported an eight-fold increase in the average area burned over the last 20 years, with 140,000 ha being burned in the southwest and 2.1 million ha burned in total. Major fires occurred near Esperance (Cape Arid National Park), Ravensthorpe, Jurien Bay and Cervantes, on the south coast, and in the Mount Cooke area, southeast of Perth (Ellis, Kanowski & Whelan 2004).

**Table 1: Fire history of Western Australia**

| Date      | No. of deaths | Area of fire (ha) | Losses                                  | Location(s)   |
|-----------|---------------|-------------------|---|---|
| 1925      | 1             |                   |   | Katanning   |
| 1930      | 1             |                   |   | Northam   |
| 1940      | 1             |                   |   | Katanning   |
| 1948      |               | 278 fires         |   | Not known   |
| 1949      |               | 527 fires         |   | Many fires caused by locomotives of the Railways Department and private timber mills  |
| 1951      |               | 23,000            | Forest trees                            | Dwellingup, Manjimup district, various parts of southwest corner  |
| 1960–1961 |               | >1,500,000        | 132 houses, 2 service stations, 3 shops | Dwellingup (134,000 ha), Mayanup, Pemberton, Shannon River and Kudardup   |
| 1974–1975 |               | 29,000,000        |   | East and northeast of Kalgoorlie  |
| 2003      |               | 15,545,000        |   | Cape Arid National Park, Ravensthorpe, Jurien Bay, Cervantes, Walpole Wilderness Area, Mount Cooke, Kimberley and Desert Region |

Source: Ellis, Kanowski & Whelan 2004

## Fire services

The structure of fire fighting agencies in Western Australia has changed markedly since June 1997 when the Western Australian Government established a taskforce to look at ways of improving planning and coordination across Western Australia's emergency services. Broadly, fire services fall under two arms, the Fire and Emergency Services Authority of Western Australia, and the Western Australian Department of Environment and Conservation, although a number of internal divisions exist under the FESA umbrella.

The **Fire and Emergency Services Authority (FESA)** of Western Australia was formally established as a statutory government authority on 1 January 1999, replacing both the Fire Brigades Board and the Bush Fires Board, bringing together the Fire and Rescue Service, and the Bush Fire Service, the State Emergency Service, Volunteer Marine Rescue Services, Emergency Management Services and Community Safety Services.

The Operations Services division within FESA incorporates two components – the Fire and Rescue Service of Western Australia (career and volunteer) and bush fire brigades (volunteer). Career firefighters within the Fire and Rescue Service operate from 20 fire stations in metropolitan Perth and five regional centres – Bunbury, Geraldton, Albany, Kalgoorlie and Mandurah – providing coverage for the most densely populated regions in Western Australia, although coverage excludes some outer Perth suburbs (such as Ellenbrook and Baldivis). The Volunteer Fire and Rescue Service (FRS) operates in many major country towns, and the volunteer Emergency Service Units (ESU) that are an amalgamation of the FRS, Bush Fire Service (BFS) and State Emergency Service (SES), undertake combined emergency management roles. Most of the outer metropolitan and country local government areas establish, subsidise and manage local bush fire brigades.

FESA provides fire appliances through a statewide fleet resourcing program on a replacement basis. FESA has developed a training program for local government to implement while FESA officers deliver specialised training and provide local government annual operating grants to provide essential operational equipment, including personal protective equipment. These brigades operate in regional areas of the state; their responsibilities include fire suppression (but not prevention) works on unallocated Crown land outside town sites. FESA has prevention and response responsibility for town sites, and increasingly there is coordinated delivery of fire services, with other fire services through ESU. If asked, FESA Operational Services staff may take responsibility for bushfires that exceed the capability of the local bush fire brigades, with a formal handing over procedure occurring when a predetermined trigger is reached.

As at 2002, there were more than 2,500 volunteer firefighters in more than 100 volunteer FRS brigades, and 25,000 volunteer firefighters in other volunteer brigades across Western Australia. As in other jurisdictions, volunteer fire fighting services, supported by career FESA managers, provide coverage for the greatest total but least populated areas of the state. Further information about FESA can be found at <http://www.fesa.wa.gov.au>.

The **Western Australian Department of Environment and Conservation (WADEC:** formerly the Department of Conservation and Land Management) is responsible for managing fires in or near national parks, nature reserves, state forests and other lands for which it has responsibility, including private lands managed by WADEC. Further information about WADEC can be found at <http://www.naturebase.net>.

This analysis incorporates both FESA and WADEC data although it is recognised that owing to the reporting arrangements, the FESA analysis does not incorporate all fires that occurred or were reported by FESA, as discussed below.

## Fire and Emergency Services Authority (Western Australia) analysis

### Background about the FESA dataset and its analysis

Although all fires attended by career FRS units, volunteer FRS units, ESU, etc., are reported to and recorded by FESA, the method of reporting and recording fire data varies somewhat between these services. All fires attended by career fire units operating from fire stations are recorded immediately within the AIRS database structure, and details of that fire are immediately available to FESA. This is not necessarily the case for ESU, volunteer FRS or bush fire brigade units. Typically the latter will notify FESA headquarters that a fire has occurred or been attended, but actual details of the fire may not be included within FESA's AIRS database until some later time. For some units this may be up to a year later, at the end of the financial year, with data being retrospectively entered into the database.

The data used in the following analysis incorporates only two components, namely:

- Total wildfire numbers for the period from 2000–01 to 2006–07 (sourced independently from FESA, and denoted as FESA for the 'source' in figures and in the text), to provide an overview of total vegetation fires numbers in Western Australia and thereby enable some consideration of the causal analysis undertaken below. This data also demonstrates the marked change in the number of fires that have occurred since introduction of a targeted arson reduction scheme in the 2000–01 to 2001–02 periods. It should be noted that this data would only include fires where suppression activities were undertaken and would not include fires that were merely monitored, even though the existence of such fires may have been reported to FESA at the time of their occurrence.
- Detailed data for causal analysis for the period 1997–98 to 2001–02. This data is in an AIRS database format and was submitted by FESA (denoted as AFAC–FESA in figures and text). This data is dominated by fires attended by career FRS fire units in major urban centres, but also appears to include some data submitted by volunteer FRS, volunteer bush fire brigades and ESU units in other parts of the state. It is emphasised that this data is incomplete, representing approximately one-half to two-thirds of all vegetation fires FESA recorded for the observation period. This data is probably most incomplete for more remote, sparsely populated regional areas. There can be discrepancies when using the FESA data, depending on the date of the data analysis, as local government only needs to report the number of fires FESA attended at the conclusion of the financial year. Most local governments are linked to the FESA-managed 000 call out system and the information is recorded immediately; however, it must be acknowledged that a number of calls are made to local FRS and not to the 000 network. Hence, it is possible that some local government data were not included within the data previously incorporated into the AFAC database. Although these AFAC–FESA data are incomplete, it does provide a broad guide to the trends for vegetation fires in Western Australia, trends that are overall consistent with those observed in other jurisdictions.

The AFAC–FESA vegetation fire data for 1997–98 to 2001–02 were not internally consistent over this period owing to changes in the coding and hence the classification of fires (Figure 6). This change in coding occurred shortly after FESA was established as a statutory government authority, and likely because of the transfer from a FESA database to the AIRS database structure. All statistics that used information about causal attributions in the following analysis used fire data from 2000–01 and 2001–02 fires only. In a limited number of cases, an alternative classification scheme was used to examine data for the five-year period from 1997–98 to 2001–02. This was principally undertaken to enable a more comprehensive guide to temporal variations. However, it should be noted that differences existed between the way in which the 2000–01 to 2001–02 and the 1997–98 to 2001–02 data are classified; the 2000–01 to 2001–02 incorporated all fires classified as wildfires (AIRS Type of Incident code = 160 to 179), whereas the 1997–98 to 2001–02 vegetation fires pertain to all fires where the vegetation variable was 0 to 99 (referred to as the alternative wildfire definition). The number of cases where there was a lack of correspondence between these two vegetation fire definitions was small (see methodology chapter).

Addition points about the FESA analysis for 2000–01 to 2001–02 are outlined below:

- The data were classified using Australian Incident Reporting System (AIRS) classification codes.
- The cause of fires was defined using the ignition factor variable.
- Deliberate fires include all fires classified as incendiary (AIRS ignition factor code = 110 or 120) or suspicious (AIRS ignition factor code = 210 or 220).
- Natural vegetation fires refer to all fires where the ignition factor codes were 800 to 890, incorporating any fire resulting from a natural condition or event. For FESA the breakdown of specific causes of natural fires was: high wind 9.7 percent, lightning 20.0 percent, high water (including flood) 0.9 percent, and any other natural condition (not classified [NC]/insufficient information to classify further [IO]) 69.3 percent.
- The dataset supplied included the form of heat of ignition variable.
- Smoking-related fires were classified based on: 'Form of heat of ignition' = 'Heat from smokers' materials' (AIRS codes 300 to 390). The cause of smoking-related fires was 40 percent accidental, three percent incendiary, 26 percent suspicious, and 29 percent unknown.
- All fires started by children were identified within the database as resulting from children playing and therefore were considered non-deliberate or accidental in origin. No information was available about the number of malicious fires started by children, as these fires were classified as incendiary or suspicious within the ignition factor variable, and cannot be delineated from other fires, included within these categories.
- The database included information about the 'type of incident'.
- Regions used in the FESA analysis were based on ABS (2005b) tourism regions. However, there was not an exact correspondence between tourism regions used in this analysis and ABS tourism regions. In this study, assignment was based on the highest levels of concordance between postcode (provided) and tourism region, but ABS tourism regions were constructed from smaller statistical areas that potentially crosscut suburb and postcode boundaries.
- Statistical subdivisions (SSDs) and statistical local areas (SLAs) were used to examine distribution of fires in specific areas of Western Australia. Although the general structure and terminology used for SSDs and SLAs follows ABS guidelines (ABS 2001a), again fundamental differences existed between the SSD and SLA used in this report and that defined by the ABS. SLAs were generated from the highest levels of concordance between postal areas and SLAs using ABS (2001b) guidelines. In contrast, SLAs the ABS used crosscut postal areas and postcodes. In this analysis SSDs were generated from the SLAs generated using the above method.
- The dataset supplied did not include information about the area burned.
- Information was available about the fire danger or fire restrictions at the time the fire occurred.

For more detail about these methodologies see the methodology chapter.

## Overview

Fires the FESA attended can be summarised as:

- FESA attended 61,446 vegetation fires from 2000–01 to 2006–07, with the number of fires annually decreasing from a high of roughly 12,000 in 2000–01 to a low of approximately 6,500 in 2005–06 (Figure 7). Fires FESA documented accounted for about 95 percent of all fires attended in Western Australia in a given year. The numbers of fires documented in the AFAC–FESA database were comparatively stable from 1997–98 to 2001–02 (based on alternative wildfire definition; Figure 6), although these data were incomplete. The AIRS data available for causal analysis (derived from AFAC for the 1997–98 to 2001–02 data above) included 6,962 vegetation fires for 2000–01 and 6,984 vegetation fires for 2001–02, representing 59 and 62 percent of all vegetation fires FESA documented.
- Based on the summarised data FESA provided for the 2000–01 to 2006–07 interval, 94 percent of all fires attended were classified as scrub or bush and grass mixture fires, with a further 3.5 percent being classified as small vegetation fires, and 1.3 percent were grassfires. Only 0.2 percent of fires attended were forest or wood fires greater than one hectare in size.
- Collectively, deliberate causes accounted for 68.5 percent of all fires (8.6% incendiary; 59.9% suspicious), representing 77 percent of known causes of vegetation fires (restricted to 2000–01 to 2001–02 data only).
- The greatest number of documented fires occurred within the Perth region, which accounted for 93 percent of fires where the causal data were examined, and a minimum of 54 percent of all fires attended by fires agencies in Western Australia.

## Cause

Detailed causal information was restricted to the 2000–01 to 2001–02 interval (Figure 6). Of these, 8.6 percent were classified incendiary with a further 59.9 percent being regarded suspicious in origin. Collectively, deliberate fires accounted for 76.7 percent of known causes of vegetation fires analysed (Figure 8). Accidental causes were responsible for 14.8 percent of fires. Natural causes accounted for just 1.6 percent. That high level of deliberate fires occurred in Western Australia during this interval is supported by the WADEC data for the same period; subtly lower rates of deliberate lightings for WADEC-attended fires likely reflects a greater proportion of natural and accidental fires in the nature parks and reserves and the greater distance of many of the WADEC lands from significantly populated areas.

Overall, the documented causes of fires remained comparatively stable across the two years (Figure 9). Subtle differences were, however, evident in the ratio of incendiary to suspicious fires.

## Specific ignition factors

Form of heat of ignition: Of the roughly 80 percent of cases where the heat of ignition contributing to vegetation fires were identified for 2000–01 and 2001–02, 60 percent were caused by open flames (Figure 10). This reflects the significant role that deliberate fire setting played in Western Australian bushfires, with open flames being responsible for three-quarters (76%) of all deliberate fires but just 34 percent of non-deliberate fires (Figure 11). Of those fires identified as having been started by open flames, the use of matches outweighed lighters by roughly 2.5 to one (Figure 12).

The numbers of fires started by mechanical (fuel powered), electrical, hot objects/friction or hostile fires were small (Figure 10). However, collectively, such fires comprised 20 percent of all non-deliberate fires (Figure 11). One-third of all non-deliberate fires were smoking-related.

**Fires started by children:** Children 16 years and younger were identified as being responsible for 370 non-deliberate fires or 2.7 percent of all documented fires for 2000–01 to 2001–02. The low number and percentage of non-deliberate child fires likely reflects the fact that many fires attributed to children were considered malicious and hence classified as either incendiary or suspicious.

Almost three percent of child fires were lit by children five years and under, 13 percent by 6 to 12 year olds and 18 percent by 13 to 16 year olds (Figure 13). In two-thirds of cases the age of the child was not indicated.

The majority of non-deliberate child fires involved use of an open flame (Figure 14), although other causes contributed to a greater proportion of fires for older age groups. Use of matches was documented more frequently than was lighters and other materials (Figure 15). Although absolute numbers were small, and therefore may have been unrepresentative, an increase in smoking-related fires was evident with age.

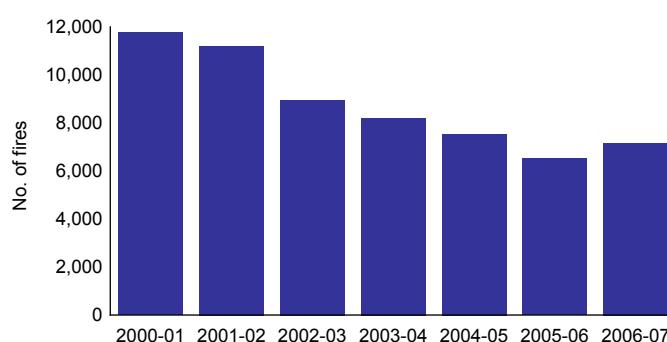
**Smoking-related fires:** A total of 1,631 fires in two years were documented as smoking-related, comprising 11.7 percent of fires documented in the AFAC–FESA database. Sixty percent of smoking-related fires were classified non-deliberate, 38 percent deliberate, and two percent unknown according to the criteria used in this study (Figure 16).

**Figure 6: Number and cause of vegetation fires annually (number), 2000–01 to 2001–02**



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

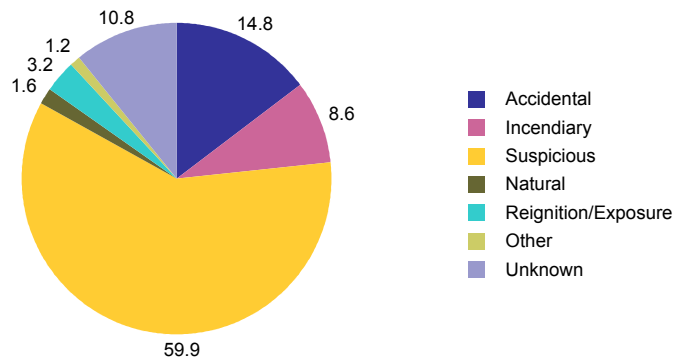
**Figure 7: Number of vegetation fires annually (number), 2000–01 to 2006–07**



Source: FESA 2000–01 to 2006–07 [computer file]

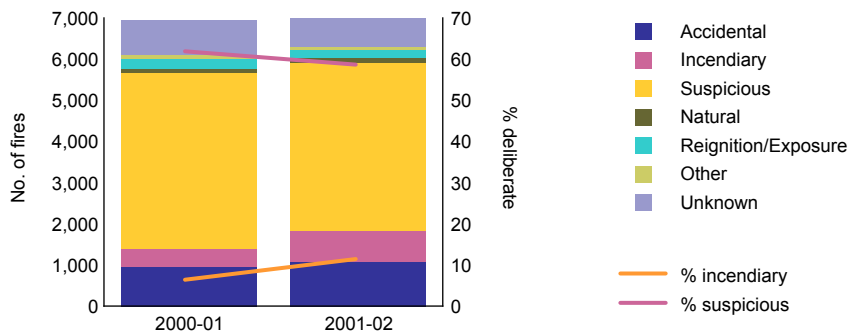


**Figure 8: Cause of vegetation fires (percent), 2000–01 to 2001–02**



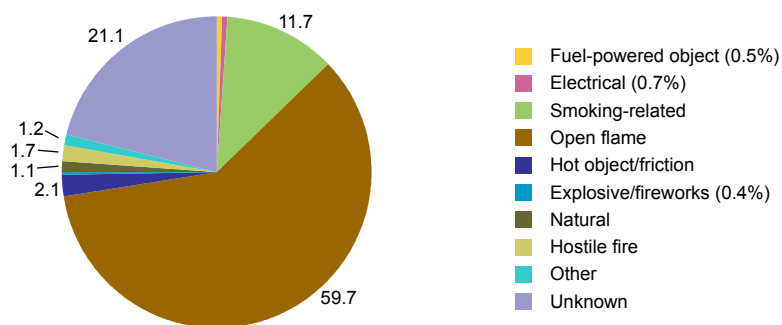
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 9: Cause of vegetation fires, each year, 2000–01 to 2001–02**



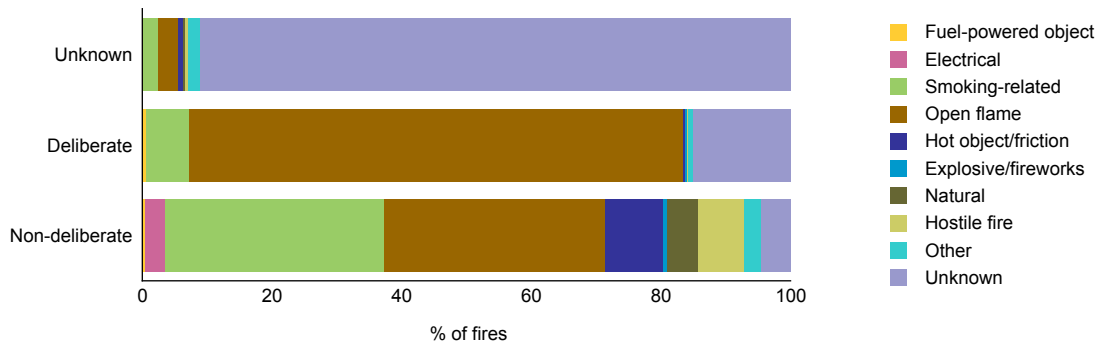
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 10: Form of heat of ignition (percent), 2000–01 to 2001–02**



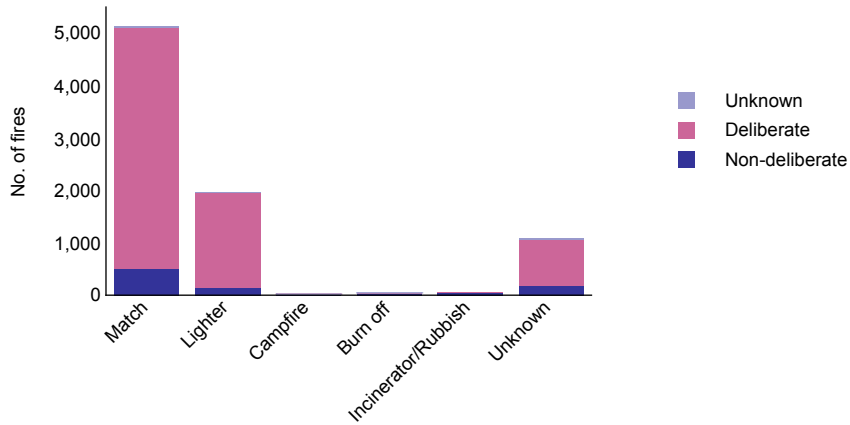
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 11: Form of heat ignition, by cause (percent), 2000–01 to 2001–02**



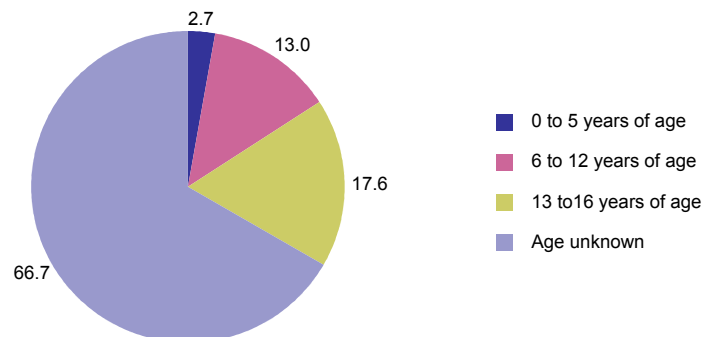
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 12: Form of heat of ignition, for fires started by an open flame (number), 2000–01 to 2001–02**



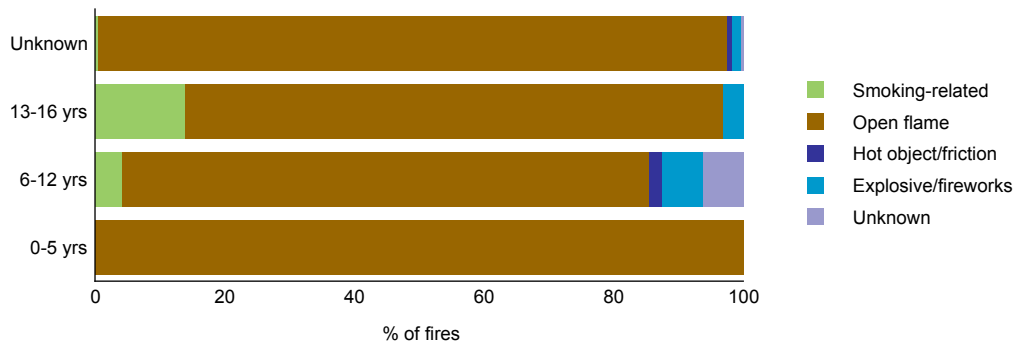
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 13: Non-deliberate child fires, by age (percent), 2000–01 to 2001–02**



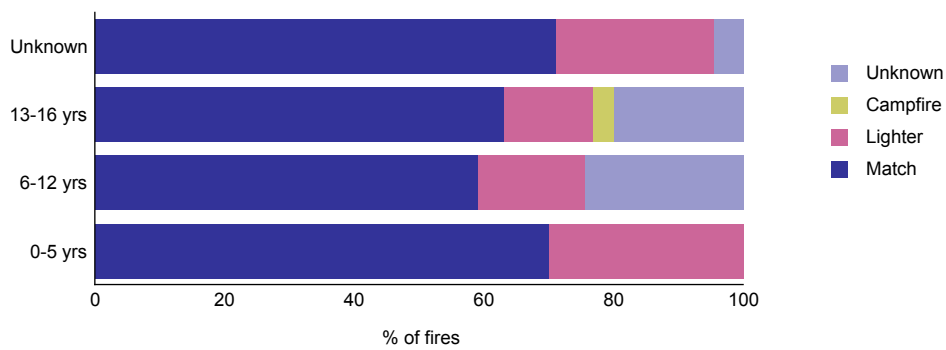
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 14: Form of heat of ignition for non-deliberate child fires, by age (percent), 2000-01 to 2001-02**



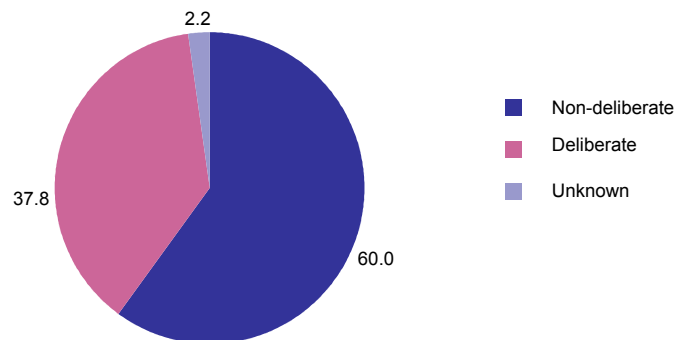
Source: FESA-AFAC 1997-98 to 2001-02 [computer file]

**Figure 15: Specific form of heat of ignition used in non-deliberate child fires started by an open flame, by age (percent), 2000-01 to 2001-02**



Source: FESA-AFAC 1997-98 to 2001-02 [computer file]

**Figure 16: Classification of smoking-related fires (percent), 2000-01 to 2001-02**



Source: FESA-AFAC 1997-98 to 2001-02 [computer file]

## Location

The location of AFAC–FESA vegetation fires was examined in terms of the region in which they occurred, and the concentration of fires, both absolute and relative to the population density in individual postcodes within the Perth region.

## Region

Of the 13,946 vegetation fires documented in the AFAC–FESA database, 90 percent were in the Perth region, with a further 2.4 percent and 2.1 percent being located in the Coral Coast and South West regions, respectively (Figure 17; Figure 18). This emphasises the strong bias of the AFAC–FESA database toward fires documented by fire services in the metropolitan areas. Similarly, fires that occurred in the largest regional centres dominate the data reported for other regions. For example, 98 percent of fires within the Coral Coast region occurred in the Geraldton postcode. In the North West, fires were more evenly distributed across the postcodes that encompassed the major urban centres of Broome, South Hedland, Karratha, Mount Newman and with lesser numbers in the Derby and Carnarvon postcodes. Fires in the South West principally occurred in the postcodes encompassing Bunbury, Albany and to a lesser extent Collie. Fires in the Outback region mainly occurred around Kalgoorlie and in other areas in the southwest of the state.

It is important to reiterate that the AFAC–FESA data are incomplete and the above distribution cannot be considered representative of the distribution of vegetation fires across the state as a whole. Given reporting arrangements, data in urban areas covered by career fire fighters was more likely complete or near complete. Based on the AFAC–FESA and FESA data, a minimum of 54 percent of all vegetation fires documented occurred in the Perth region. Hence, the incompleteness of the data does not undermine the observation that an overwhelming majority of vegetation fires in Western Australia were associated with the greatest density of people. The strong association between larger fire numbers and larger regional centres would also support this observation. Both are consistent with the trends observed in other jurisdictions; that the greatest numbers of vegetation fires are attended in the region that encompasses the capital, and that the greatest numbers of vegetation fires in regional areas occur near the largest regional centres. While fire service data for Western Australia are likely to provide a broad guide to the distribution of vegetation fires generally, it is recognised that many of the vast numbers of fires that occur each year in tropical savannas, be they deliberately lit or naturally occurring, may not be attended.

High rates of deliberate fires were evident across all regions, ranging between 63 (South Coast) and 77 percent (Coral Coast) in those regions for which more than 300 vegetation fires were documented in the AFAC–FESA database for the 2000–01 to 2001–02 interval (Figure 19). Lower rates were documented for the North West and Outback regions, but both areas were characterised by lower reported fire numbers and higher proportions of fires of unknown causes.

Of the fires reported in the AFAC–FESA database, approximately 94 percent of non-deliberate child fires occurred in the Perth region, with a further two and one percent in the Coral Coast and South West regions, respectively. This parallels the distribution of fires across the state generally. Non-deliberate child fires accounted for 2.8 percent of all fires documented in the AFAC–FESA database for the Perth region, and between zero (North West) and 2.4 (Coral Coast) percent of fires in regional areas. These statistics are unlikely to be representative of children's involvement in starting fires in these regions because the AFAC–FESA data was incomplete and child fires were often included within the incendiary and suspicious categories.

The greatest number of smoking-related fires occurred in the Perth (n=1,497) and Coral Coast (n=63) regions, contributing to 12 and 19 percent of fires in these regions, respectively. In other non-metropolitan regions, smoking-related materials contributed to 2.1 to 3.6 percent of fires, akin to the values observed throughout Australia for non-metropolitan areas. The high proportions of smoking-related fires for the Coral Coast region may reflect the fact that 98 percent of fires in this region were within the Geraldton postcode, and that the incidence of smoking-related fires is commonly higher in urban areas than in non-urban (see below).

## Perth region

This analysis examines the distribution and cause of fires included within the major metropolitan and Mandurah SSDs (Figure 20), excluding approximately 2.3 percent of fires that were listed as occurring in the Perth region but which were classified as belonging to other SSDs. It is reiterated that the SLAs and the SSDs used in this analysis are not identical to those the ABS used, and some discordance exists between SSDs and tourism regions.

SSD: The largest numbers of vegetation fires (all causes) were documented in the North region, followed by South East and South West Metropolitan SSDs, with these SSDs accounting for 29, 27 and 22 percent of the fires documented for the Perth region (Figure 21). A further 13 percent of vegetation fires in this region occurred in the East Metropolitan SSD. Substantially lower numbers occurred in the Central Metropolitan (4%) and Mandurah (3%) SSDs.

High rates of deliberate fires were evident across all SSDs except the Central Metropolitan SSD, with rates ranging from 60 percent in the Mandurah SSD to 77 percent in the North Metropolitan region (Figure 21). In contrast, only 29 percent of vegetation fires in the Central Metropolitan SSD were classified as deliberate in origin.

The greatest number of smoking-related fires occurred in the South East, North and South West Metropolitan SSDs, accounting for 30, 21 and 21 percent of all smoking-related fires documented for the Perth region. Smoking-related materials were responsible for almost half of all fires in the Central Metropolitan area, but just 12 to 18 percent of fires in outlying SSDs (Figure 22).

SLA: The total number of vegetation fires varied markedly not only across the Perth region but also across individual SLAs within each SSD (Figure 23). The highest total numbers of fires within individual SLAs tended to occur in those SSDs that recorded the greatest numbers of fires overall, namely the North, South East and South West Metropolitan SSDs. In the South West Metropolitan SSD, the greatest number was documented for the Rockingham SLA, which experienced almost 1,400 vegetation fires in a two-year period. Similar levels were evident in the Canning SLA in the South East Metropolitan SSD. Although the North Metropolitan experienced the greatest number of vegetation fires overall, these tended to be more evenly distributed across SLA and postcodes in that region. Nevertheless, more than 900 vegetation fires were observed in two SLAs in the SSD in the two-year period (Joondalup–South and Stirling Central SLAs). All SLAs in the Central Metropolitan region were characterised by low numbers of vegetation fires.

In all outer metropolitan SSDs, the number and proportion of deliberate fires increased with increasing total numbers of fires (Figure 23), reflecting the fact that deliberate fires were the principal cause of increased fire numbers. The high percentage of deliberate fires documented for the North Metropolitan region as a whole was consistently observed at a local level, with rates of 70 to 80 percent being common across most SLAs in the SSD. In contrast to the outer metropolitan SSDs, the proportion of deliberate fires in the Central Metropolitan SSD tended to increase with decreasing numbers of fires per SLA. This reflected the higher numbers and proportions of accidental fires documented for the innermost areas of the city, namely within the Vincent and Perth–Remainder SLAs.

The greatest numbers of non-deliberate child fires were documented in the Rockingham, Canning, Melville, Armadale, Gosnells and Cockburn SLAs; areas that, overall, experienced high numbers of fires. Although statistically significant, there was only a moderate correlation between the number of non-deliberate child fires and the total number of fires in individual SLAs in the Perth region ( $r=.75$ ,  $p<.01$ ). The Rockingham, Canning and Melville SLAs accounted for 32, 18 and eight percent of all non-deliberate child fires in the Perth region. In these areas, non-deliberate child fires accounted for between five and eight percent of all fires in the SLA, higher than the average. The data were, however, incomplete and there were difficulties in ascertaining the distribution of child fires, owing to the incorporation of such fires in the incendiary and suspicious categories.

The number of smoking-related fires in a SLA was significantly positively correlated with the total number of fires in that SLA ( $r=.87$ ,  $p<.01$ ). That is, the greatest numbers of smoking-related fires tended to have been documented in those SLAs recording the greatest numbers of fires overall.

Postcode: The trends described at an SLA level were also demonstrated at a postcode level, albeit with greater variability at this more localised scale. When data were presented at a postcode level, it was clearly evident that a high proportion of all fires within a given SSD occurred within a comparatively small number of postcodes. For example, the eight postcodes each in the South East, seven postcodes in the North and four postcodes in the South West Metropolitan SSDs that recorded in excess of 200 vegetation fires (total) in two years were responsible for 66 to 83 percent of all fires in those SSDs (Table 2, Figure 24). In the South West the two suburbs recording in excess of 500 fires in two years were responsible for half the fires in the SSD. However, the concentration of fires varied between SSDs. For example, despite higher total numbers of fires than the South West Metropolitan SSD, only one postcode in the North Metropolitan SSD recorded in excess of 500 fires, accounting for just 14 percent of all vegetation fires in the SSD. This is consistent with the more dispersed nature of vegetation fires in this region, as outlined above. Nevertheless, even in areas that experienced low total fire numbers, like the Central Metropolitan region, fires tended to be concentrated in a small number of postcodes; 44 percent of fires in the Central Metropolitan region occurred in the two suburbs that recorded in excess of 100 fires in two years.

The trends described for vegetation fires overall were also evident within the deliberate fire data. In the North, South East and South West Metropolitan SSDs, the few suburbs recording in excess of 200 deliberate fires in two years, were responsible for between 53 and 70 percent of fires in those SSDs (Table 2, Figure 25). Postcodes with in excess of 100 deliberate fires were responsible for 83 to 86 percent of deliberate fires. In the South West one-fifth of all postcodes to record a fire of any cause were responsible for 86 percent of all deliberate fires (Figure 25). In the North and South East Metropolitan regions postcodes documenting in excess of 100 deliberate fires in two years, accounted for roughly 40 percent of suburbs to have experienced a fire. This concentration of fires within small areas enables targeted arson prevention strategies to be implemented within those areas.

**Table 2: Number of postcodes with deliberate and total fire numbers within the specified ranges, and the extent to which they contributed to total fires numbers within each SSD**

|                        | North Metropolitan |      | South East |      | South West |      | East Metropolitan |      | Central Metropolitan |       |
|------------------------|--------------------|------|------------|------|------------|------|-------------------|------|----------------------|-------|
|                        | n                  | %    | n          | %    | n          | %    | n                 | %    | n                    | %     |
| Total no of fires      | 3,586              |      | 3,359      |      | 2,693      |      | 1,645             |      | 515                  |       |
| Total no. of postcodes | 25                 |      | 21         |      | 23         |      | 20                |      | 14                   |       |
| TF>=500                | 1                  | 14.2 | 2          | 30.1 | 2          | 49.2 |                   |      |                      |       |
| 200-499                | 6                  | 51.6 | 6          | 53.1 | 2          | 25.6 | 2                 | 44.1 |                      |       |
| 100-199                | 5                  | 21.2 | 1          | 3.3  | 1          | 7.4  | 4                 | 35.2 | 2                    | 43.5  |
| 75-99                  | 2                  | 4.9  | 2          | 5.6  | 1          | 3.2  | 1                 | 5.9  |                      |       |
| 50-74                  | 3                  | 4.9  | 1          | 1.6  | 2          | 4.4  | 2                 | 7.5  | 1                    | 10.3  |
| 25-49                  | 2                  | 1.8  | 5          | 5.8  | 5          | 6.7  | 1                 | 2.4  | 5                    | 29.7  |
| <25                    | 6                  | 1.4  | 4          | 0.6  | 10         | 3.5  | 10                | 4.9  | 6                    | 16.5  |
| Incendiary fires       | 24                 |      | 20         |      | 21         |      | 16                |      | 14                   |       |
| Total Incendiary       | 2,761              |      | 2,275      |      | 1,917      |      | 1,078             |      | 147                  |       |
| >200                   | 6                  | 63.2 | 4          | 53.1 | 3          | 69.7 | 1                 | 30.1 |                      |       |
| 100-199                | 4                  | 20.1 | 4          | 32.2 | 2          | 16.1 | 3                 | 38.1 |                      |       |
| 75-99                  | 2                  | 7.0  |            |      |            |      | 1                 | 7.1  |                      |       |
| 50-74                  | 1                  | 2.6  | 3          | 8.2  | 1          | 2.8  | 2                 | 13.1 |                      |       |
| 25-49                  | 3                  | 3.8  | 1          | 1.1  | 4          | 7.0  | 2                 | 6.9  |                      |       |
| <25                    | 8                  | 3.3  | 9          | 5.4  | 11         | 4.3  | 7                 | 4.8  | 14                   | 100.0 |

Source: FESA-AFAC 1997-98 to 2001-02 [computer file]

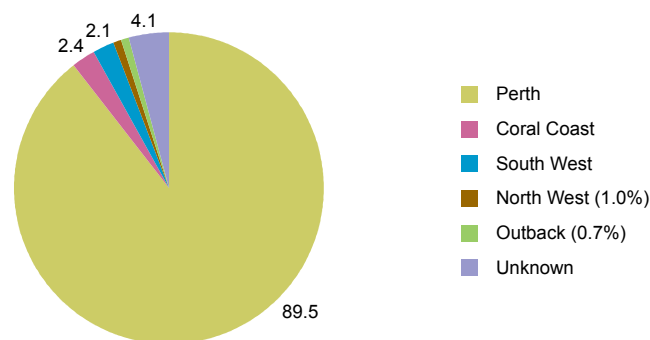


**Figure 17: Tourism regions of Western Australia**



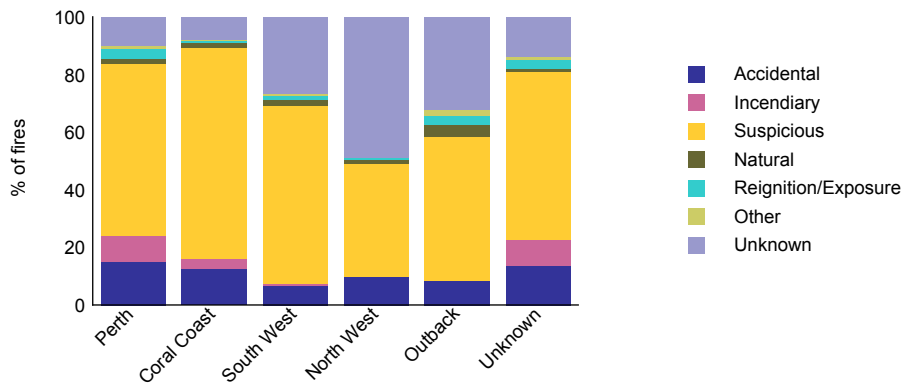
Source: ABS 2005b  
© Australian Bureau of Statistics

**Figure 18: Vegetation fires, by region, 2000–01 to 2001–02**



Source: FESA-AFAC 1997–98 to 2001–02 [computer file]

**Figure 19: Cause of vegetation fires, by region, 2000–01 to 2001–02**



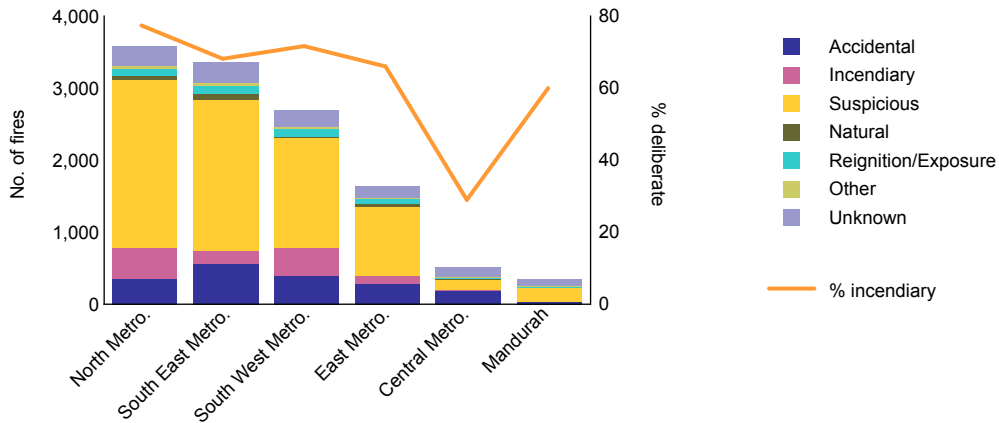
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 20: Map of SSDs in the Perth region**



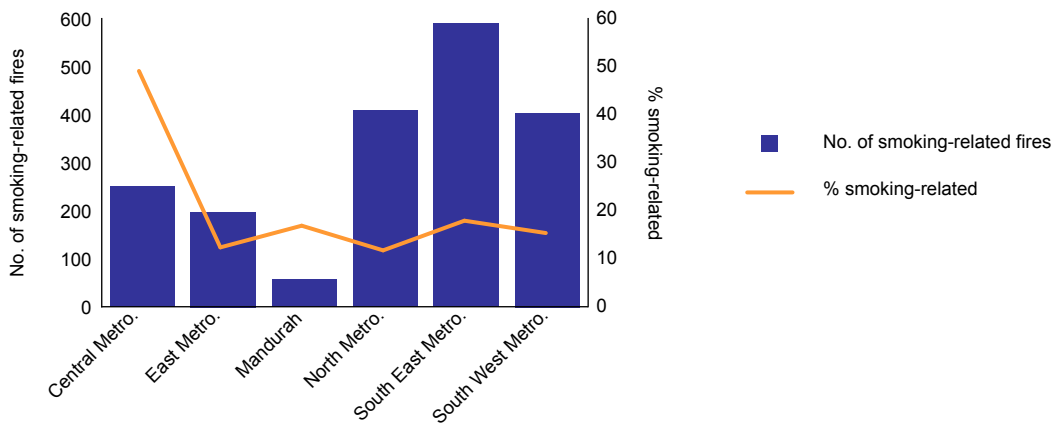
Source: ABS 2001a  
© Australian Bureau of Statistics

**Figure 21: Cause of vegetation fires in the Perth region, by SSD, 2000-01 to 2001-02**



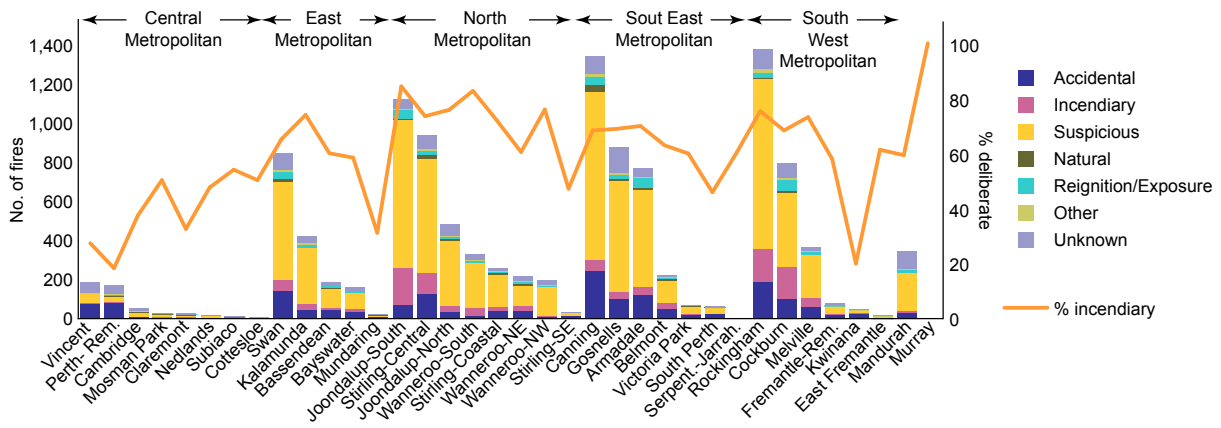
Source: FESA-AFAC 1997-98 to 2001-02 [computer file]

**Figure 22: Smoking-related fires in the Perth region, by SSD, 2000-01 to 2001-02**



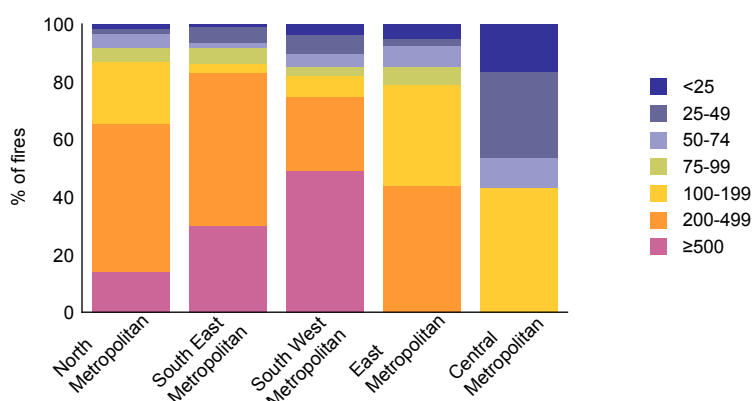
Source: FESA-AFAC 1997-98 to 2001-02 [computer file]

**Figure 23: Cause of vegetation fires in the Perth region, by SLA, 2000-01 to 2001-02**



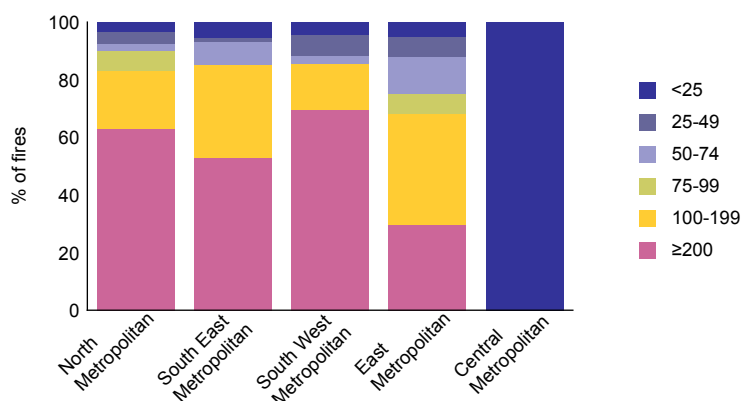
Source: FESA-AFAC 1997-98 to 2001-02 [computer file]

**Figure 24: Perth region – distribution of fires within postcodes in each SSD (percent), 2000–01 to 2001–02**



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 25: Perth region – distribution of deliberate fires within postcodes in each SSD (percent), 2000–01 to 2001–02**



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

## Population

This section examines the relationship between frequency and causes of vegetation fires in relation to populations within individual postcodes. It is restricted to postcodes in the Perth region, as inclusion of incomplete data for postcodes in regional areas would have a profound impact on the rates of fires documented for postcodes with small populations.

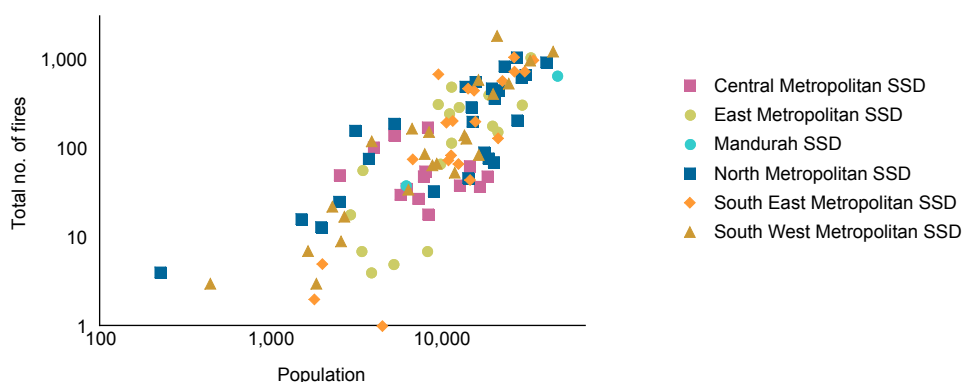
**All vegetation fires:** Overall, the total number of fires that occurred within individual postcodes increased as population of that postcode increased, consistent with the fact that people are the principle causes of vegetation fires (Figure 26). Individual postcodes in the Perth region commonly recorded between five and 200 fires per 10,000 people per year, although four postcodes – one each in the Kalamunda (East Metropolitan SSD), Stirling–Central (North Metropolitan SSD), Gosnells (South East Metropolitan SSD) and Rockingham (South West Metropolitan SSD) SLAs – recorded between 200 and 430 fires per 10,000 people per year (Figure 27). Consistent with the variability in absolute numbers of fires described above, a broad range of values was recorded in each SSD. Although postcodes with larger populations in the

Central Metropolitan SSD were characterised by low rates of fires on a per-person basis, postcodes with low populations were indistinguishable from other postcodes of the metropolitan area, having rates of fires of just over 100 fires per 10,000 people per year.

**Deliberate vegetation fires:** Individual postcodes in the Perth region were characterised by a broad range of deliberate fires on a per-person basis; typical values varied between one and 100 deliberate fires per 10,000 people per year, but two postcodes in the South East and South West Metropolitan SSDs recorded between 130 and 150 deliberate fire per 10,000 people per year (Figure 28). Overall, there was a tendency for the number of deliberate fires per person to increase with increasing population, although postcodes with similar populations tended to be characterised by high contrasting rates of fires, again highlighting that factors, other than population, affect the distribution of deliberate fires. Postcodes within the Central Metropolitan region were consistently characterised by low rates of deliberate fires on a per person basis, consistent with the low numbers of deliberate fires overall. Mandurah postcodes were also characterised by low rates of deliberately lit fires in comparison to similar-sized populations in other Perth postcodes.

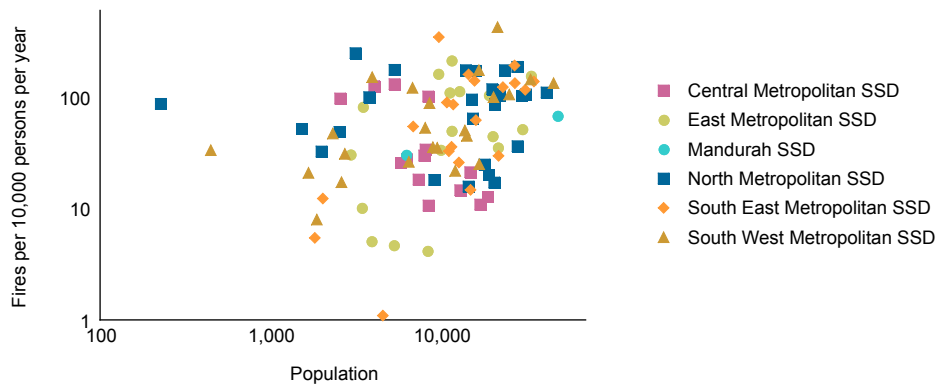
**Smoking-related fires:** Individual postcodes in the Perth region commonly experienced between one and 15 smoking-related fires per 10,000 people per year (Figure 29). Again, a broad range of values was observed in individual SSDs. This was most evident for the Central Metropolitan SSD, where between 20 and 70 smoking-related fires occurred in four postcodes that are overall characterised by low resident populations. It is highly probable that an increased incidence of smoking-related fires per person in this area was a result of higher migratory populations; large numbers of people visit inner city areas for work and social activities. On average, high rates of smoking-related fires were evident across the South East Metropolitan region. Although variable, comparatively lower rates were experienced in other metropolitan areas.

**Figure 26: Vegetation fires and population, by postcode and SSD for the Perth region (number), 2000–01 to 2001–02**



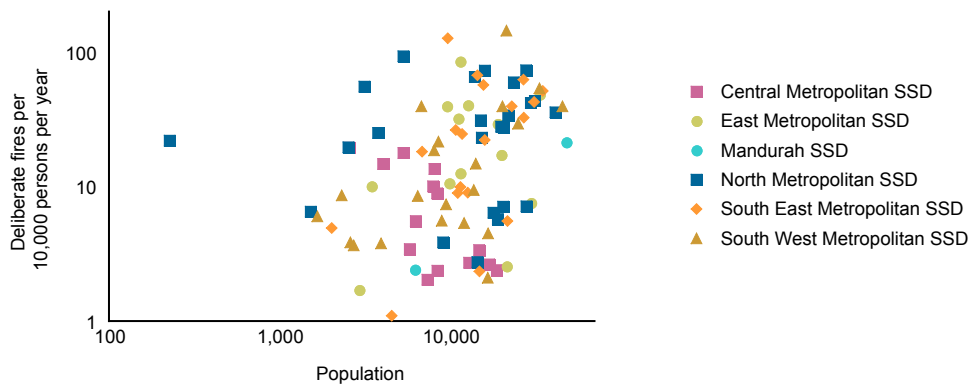
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

**Figure 27: Total number of fires per 10,000 people per year and population, by postcode and SSD for the Perth region (number), 2000–01 to 2001–02**



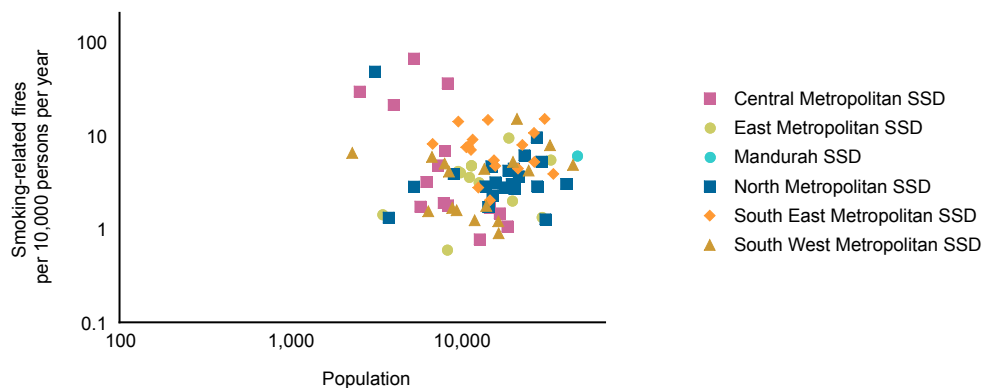
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

**Figure 28: Deliberate fires per 10,000 people per year and population, by postcode and SSD for the Perth region (number), 2000–01 to 2001–02**



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

**Figure 29: Smoking-related fires per 10,000 people per year and population, by postcode and SSD for the Perth region (number), 2000–01 to 2001–02**



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]; ABS 2004. Population by post office area, 2001 [computer file]

## Complex

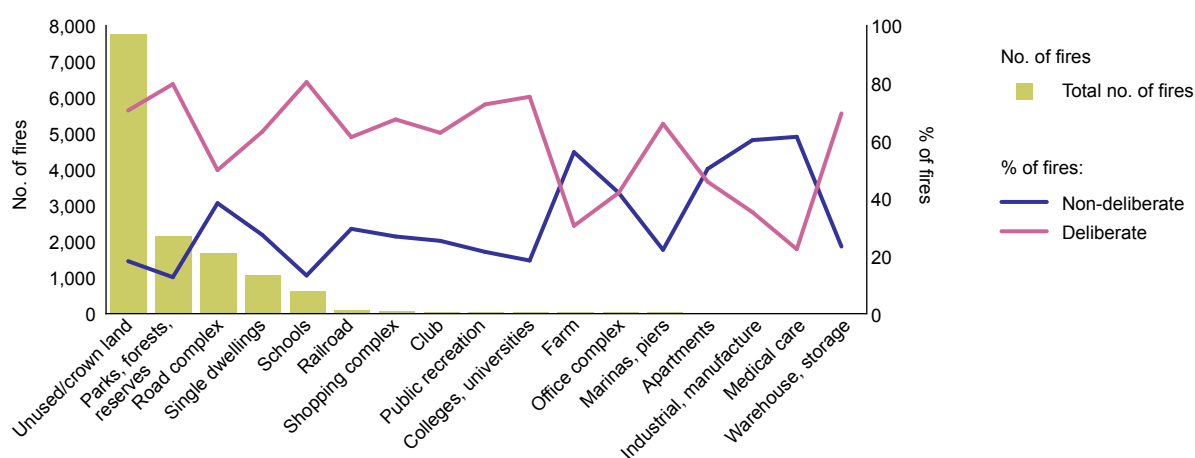
Fifty-six percent of all vegetation fires recorded in the AFAC–FESA database occurred on unused property or Crown land, with a further 40 percent occurring in parks and reserves, on roads, and around dwellings and schools (Figure 30).

The proportion of deliberate fires did not vary substantially between complex types where there was a high incidence of vegetation fires; 60 to 80 percent of fires were typically deliberately lit in these complex types. Nevertheless, subtle variations were evident. For example, the percentage of deliberate fires was lower for road complexes as a result of higher numbers of smoking-related fires. Conversely, a higher proportion of fires at schools, and parks, forests and reserves tended to be deliberate. The proportion of deliberate fires was more variable for more obscure locations (such as medical facilities) for which there were low fire frequencies.

Non-deliberate child fires also most commonly occurred on unused property or Crown land, followed by parks, forests and reserves, and single dwellings (Figure 31). The tendency for non-deliberate child fires to occur around dwellings decreased with increasing age. In contrast, there was a greater tendency for older children to light fires in parks, forests, and reserves. There was also clear evidence that the diversity of location where non-deliberate child fires occurred increased with age.

The majority of smoking-related fires also occurred on unused property or Crown land, but this cause comprised a small proportion of all fires that occurred at that complex type (Figure 32). Road complexes were the other principal location where smoking-related fires occurred, with smoking-related materials; 35 percent of all fires that occurred at road complexes were classified as smoking-related. There appears to be a very strong correlation between mulch used in streetscape beautification and bush fires caused by discarded material (such as cigarettes). The cause of these fires can be determined with some certainty, as the cigarette butt will remain after igniting the mulch. This residue characteristic is not present with either grass or native bush fire ignition. Not surprising, smoking-related causes also accounted for a comparatively high proportion of vegetation fires for locations like office complexes (33.3%; n=12), medical and care facilities, motels, apartments and restaurants, locations where large numbers of people, most routinely concentrate to smoke. However, overall such locations contributed a comparatively small number of smoking-related vegetation fires, possibly because these locations also tended to be equipped with adequate cigarette disposal facilities.

**Figure 30: Number and cause of vegetation fires, by complex, 2000–01 to 2001–02**

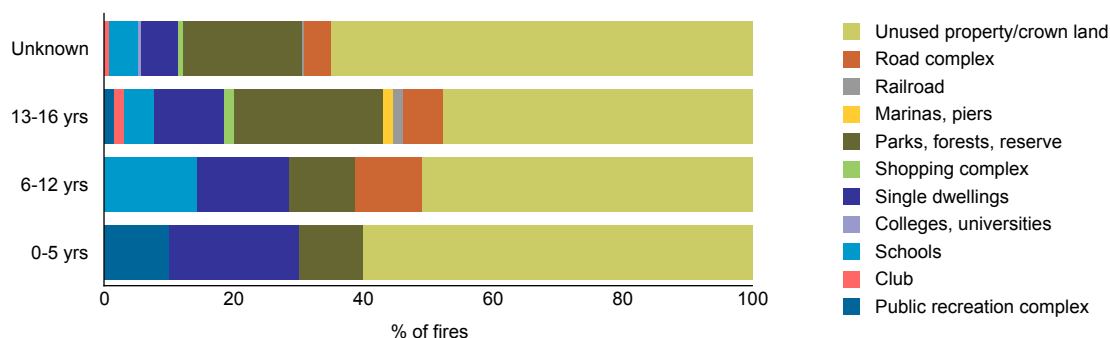


Note: Only includes locations where 10 or more incidents were recorded in two years

Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

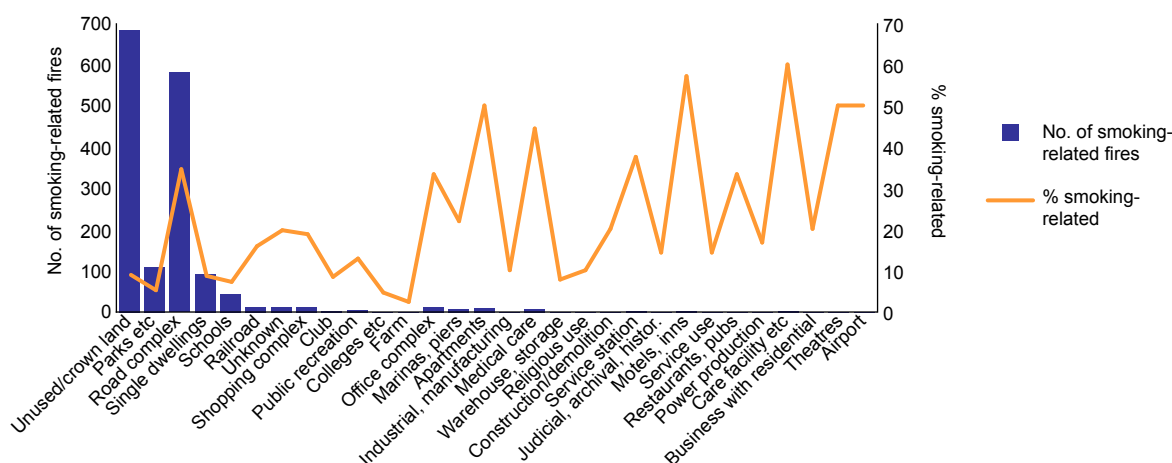


**Figure 31: Non-deliberate child fires, by complex (percent), 2000–01 to 2001–02**



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 32: Smoking-related fires, by complex, 2000–01 to 2001–02**



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

## Timing

The timing of fires was examined by week of the year, day of the week, and by time of the day. The analysis for fires by week of the year is based on the AFAC–FESA database for the period spanning 1997–98 to 2001–02, unless otherwise noted. Hence, this analysis uses vegetation fires defined using the alternative definition of wildfires. In contrast, the analysis of fires by day of the week and time of day only used data from the 2000–01 to 2001–02 interval, where vegetation fires were defined using the AIRS wildfire definition.

### Week of the year

As noted in the introduction, due to significant latitudinal variations in climate Western Australia can potentially experience bushfires in any month of year. Consistent with fire regimes, most vegetation fires in the South West and Perth regions occurred during spring and summer, whereas peak numbers in the North West region occurred between June and November (Figure 33). As most fires within the AFAC–FESA database were located in southern Western Australia, there was overall dominance toward spring–summer fires in the analysed data. Nevertheless, subtle differences were evident between regions in the southern half of the state. Fire frequencies on the Coral Coast in the Outback peaked largely within a

narrow interval from mid October to mid January and mid December respectively. A similar peak in activity was evident for the Perth region, although high numbers in that region remained until late April (Figure 34).

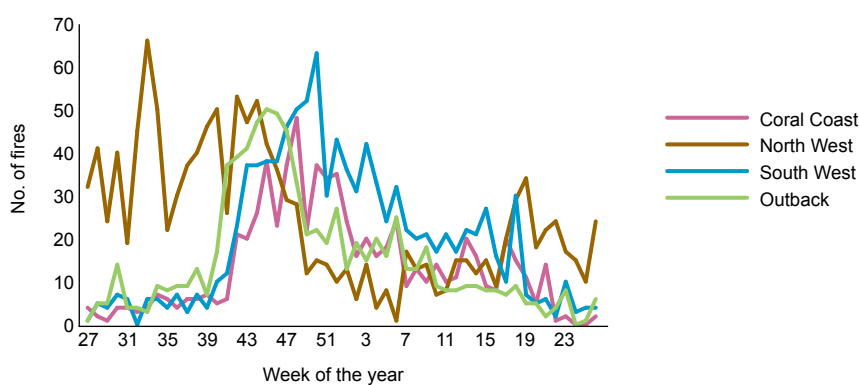
Systematically higher weekly average fire numbers were observed in the latter portion of the calendar year relative to the beginning of the following calendar year in virtually all SLAs in the Perth region (Figure 35). This trend was also observed for the Coral Coast and South West regions. There is no obvious evidence to suggest that the fire danger is any different during the November–December period as compared to January–February.

Overall, the timing of the bushfire season was remarkably uniform across years (Figure 36), with the greatest variability occurring between week 6 (mid February) and week 15 (mid April). This is consistent with climatic variations observed for southern Western Australia. The rapid increase in fire frequency in the Perth region during October accompanied the equally rapid decline in rainfall in that month, which occurs consistently each year. In contrast, rainfall in January–March is more variable, contributing to the more variable fire frequencies during that time (Figure 37).

There was strong correspondence between the timing of deliberate and non-deliberate fires in a given year. Peak numbers of natural fires occurred from the beginning of December through to the end of February.

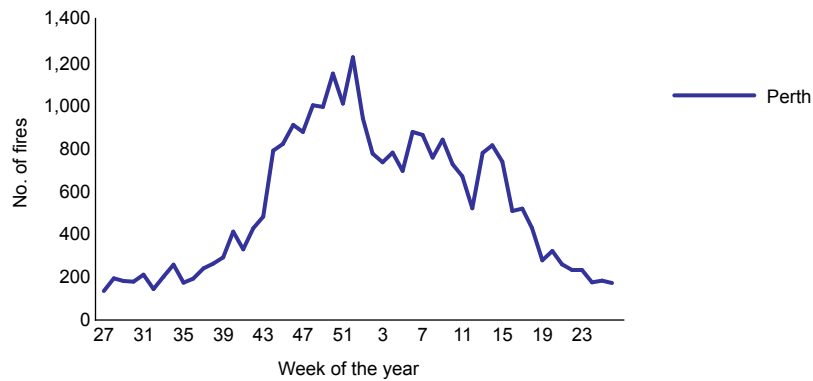
Fires lit by 6 to 12 year olds and 13 to 16 year olds principally, but not exclusively, coincided with the bushfire season (Figure 38). Whether this reflected an increased awareness of the susceptibility of the environment to fire, or increased mobility in the environment during the summer months is unclear. A large spike in non-deliberate fires lit by 13 to 16 year olds occurred in week 10 and week 45, in the middle of the first and last school terms respectively (based on 2000–01 to 2001–02 data only).

**Figure 33: All vegetation fires, by region and week of the year (number), 1997–98 to 2001–02**



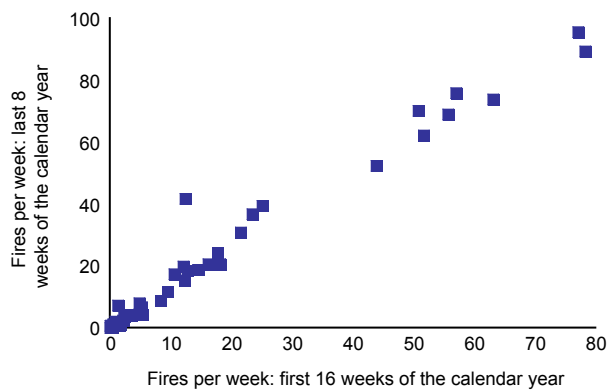
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 34: All vegetation fires in the Perth region by week of the year (number), 1997–98 to 2001–02**



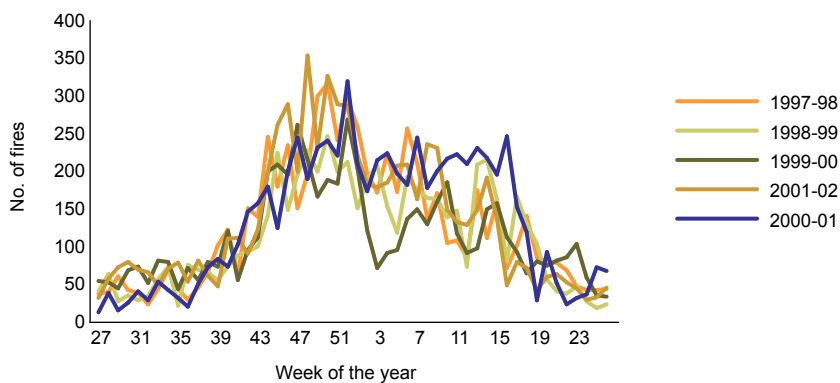
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 35: Fire frequencies at the end and beginning of the calendar year (number), by Perth SLA, 1997–98 to 2001–02**



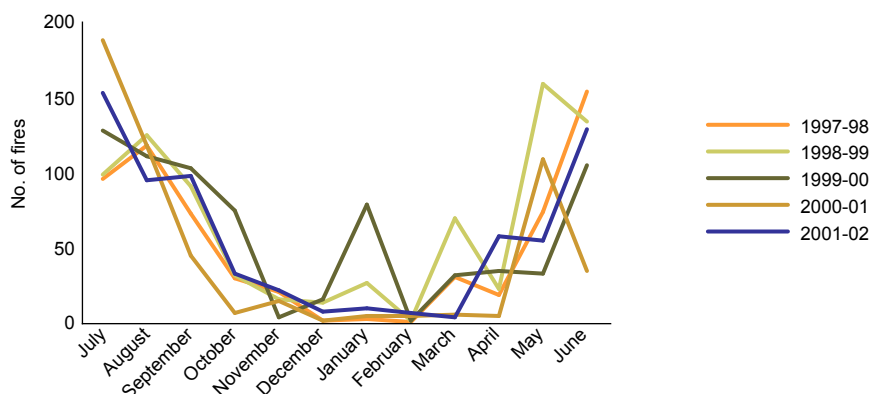
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 36: All vegetation fires, by week of the year and year (number), 1997–98 to 2001–02**



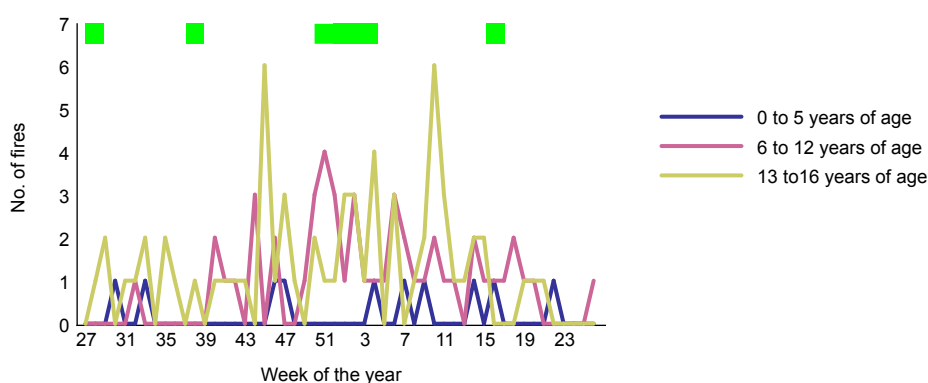
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 37: Central Coast region, district average rainfall (number), 1997–98 to 2001–02**



Source: Australian Bureau of Meteorology [computer file]

**Figure 38: Non-deliberate child fires, by week of the year (number), 2000–01 to 2001–02**



Note: green blocks indicate the typical timing of school holidays

Source: FESA-AFAC 1997–98 to 2001–02 [computer file]

### Day of the week

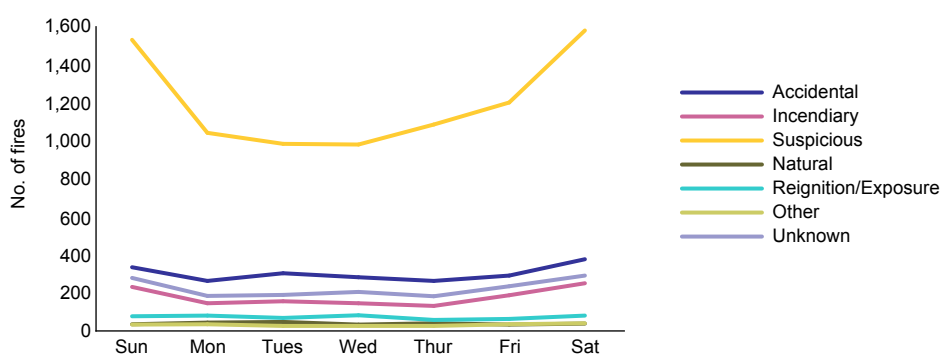
A considerably higher proportion of vegetation fires occurred on Saturdays and Sundays relative to weekdays. Notably, 47 percent more fires occurred on Saturday and 39 percent more fires occurred on Sunday than the weekday average for 2000–01 and 2001–02. This trend was evident for both accidental and deliberate fires (Figure 39). Forty-six percent more deliberate fires occurred on Sunday, and 52 percent more deliberate fires occurred on Saturday relative to the weekday average. In contrast, 21 percent more accidental fires occurred on Sunday and 36 percent more accidental fires occurred on Saturday relative to the weekday average.

Based on the available data, it appears that the increase in the number of vegetation fires on weekend days was not uniformly manifest across the state. The proportion of fires on weekends was greatest for the Perth region, with a slightly greater incidence occurring on Saturday (46%) relative to Sunday (41%; Figure 40). Increased fire frequencies occurred on both Saturdays and Sundays in the Southwest, but only on Saturdays for the North West and Outback regions (Figure 41).

Not surprising, given that a higher proportion of deliberate fires were lit on weekends and that a higher proportion of deliberate fires related to use of an open flame than to non-deliberate fires, there was an increase in the number of fires resulting from open flames on Saturdays and Sundays (50 to 55% increase). In contrast, the incidence of smoking-related fires was 26 percent higher on Saturday, but no more likely on Sunday compared to the weekday average.

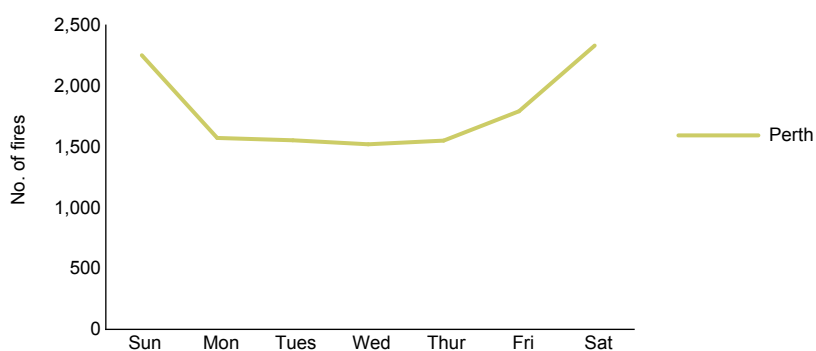
Non-deliberate child fires were 58 percent higher on both Saturday and Sunday relative to the weekday average (based on 2000–01 to 2001–02 data only). This increase was most pronounced for the 13 to 16 year old age group (Figure 42).

**Figure 39: Cause of fires, by day of the week (number), 2000–01 to 2001–02**

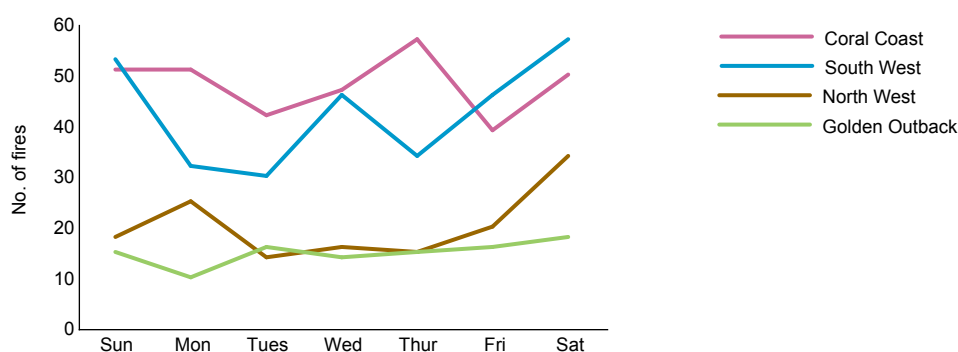


Source: FESA-AFAC 1997–98 to 2001–02 [computer file]

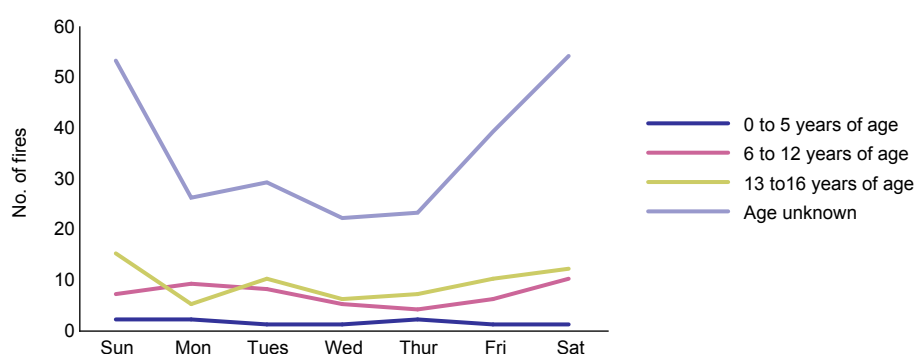
**Figure 40: All vegetation fires, by day of the week for the Perth region (number), 2000–01 to 2001–02**



Source: FESA-AFAC 1997–98 to 2001–02 [computer file]

**Figure 41: All vegetation fires, by day of the week for selected regions (number), 2000–01 to 2001–02**


Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 42: Non-deliberate child fires, by day of the week and child age (number), 2000–01 to 2001–02**


Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

### Time of day

The time of day was based on the time the alarm was raised. Although it does not provide an exact time the fire started, it does serve as a useful guide, particularly given that delay between ignition and detection, and subsequent alerting of authorities is likely to be comparatively short in urban areas. Detection times were only available for 61 percent of fires in the AFAC–FESA database, for 2000–01 and 2001–02.

Clearly divergent trends were evident for non-deliberate and deliberate fires (Figure 43). The number of non-deliberate fires increased from 8 am onwards, peaked at between 2 and 3 pm and then declined through the remainder of the day and into the early hours of the following morning. In contrast deliberate fires defined a bimodal distribution. One peak coincided with non-deliberate fires. Nevertheless, in contrast to non-deliberate fires the daytime peak for deliberate fires has an asymmetrical distribution, with peak numbers of fires occurring between 3 and 4 pm, coincident with the end of the school day. After 7 pm the number of deliberate lightings increased markedly, thereby defining a second peak with a maximum around midnight. Deliberate fire frequencies subsequently declined to a minimum at 5 to 7 am the following morning.

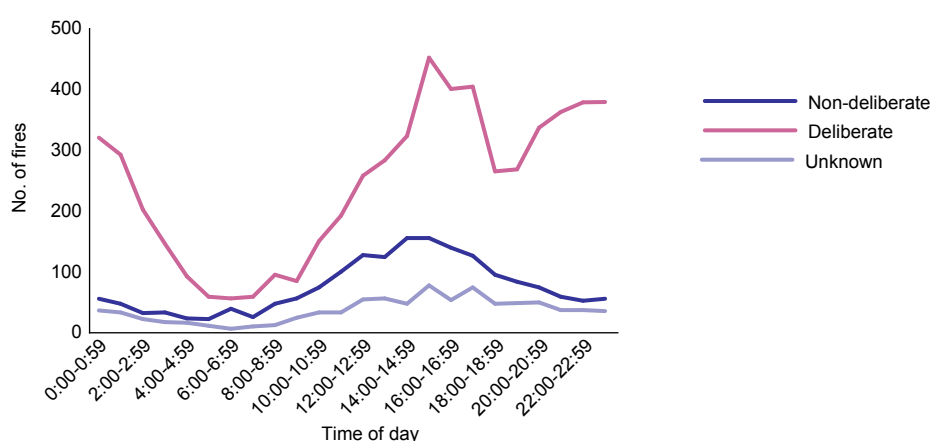
Deliberate fires at night were observed across all regions, but most strongly manifested (based on available data) in the Perth (Figure 44) and South West (Figure 45) regions. One-half of all deliberate fires

in these areas occurred between 7 pm and 6 am with 19 percent occurring between midnight and 6 am. In comparison, 35 to 37 percent of deliberate fires the North West and Golden Outback regions occurred between 7 pm and 6 am, with 13 and 20 percent being between midnight and 6 am in these regions respectively. The available data for the Coral region indicates one-quarter of deliberate fires occurred between 7 pm and 6 am with just six percent occurring between midnight and 6 am. Similarly, deliberate fires at night were a feature of all SLAs within the Perth region where total numbers of deliberate fires exceeded 20 in two years (Figure 46). A high proportion of deliberate fires occurred at night in the Joondalup–South, Kalamunda and Stirling–Coastal SLAs. In contrast, a smaller proportion of deliberate fires occurred at night in the Rockingham, Joondalup–North and Mandurah SLAs.

Although deliberate fires occurred after 7 pm and before 6 am on all nights of the week (timing may vary at a local scale) by far the greatest number occurred on Friday night–Saturday morning and Saturday night–Sunday morning (Figure 47). Notably, 48 percent of all deliberate fires in the Perth region that occurred between 7 pm and 6 am occurred on Friday night–Saturday morning and Saturday night–Sunday morning. These fires accounted for almost one-quarter of all deliberate fires in the Perth region, where the time of fire was documented. Fifty-nine percent of all deliberate fires documented in the AFAC–FESA database to have occurred between 12 am and 6 am also occurred on Friday night–Saturday morning and Saturday night–Sunday morning. Deliberate fires at this time accounted for 11 percent of all deliberate fires in the Perth region, where the time of the fire was documented. These trends indicate a strong relationship between social activities and deliberate fire ignitions, with many possibly being associated with drug and/or alcohol use.

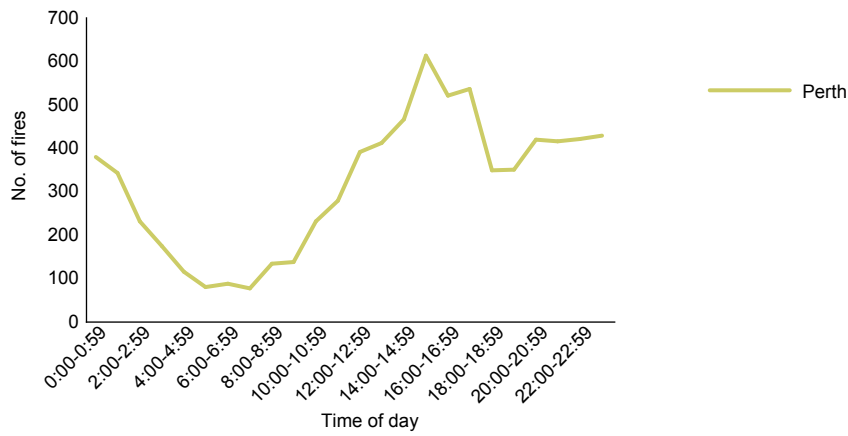
The time of day was available for 65 percent of non-deliberate child fires. The majority (70%) occurred between 8 am and 8 pm (Figure 48). Slight differences were evident between age groups. Fires attributed to children less than five years of age occurred within the interval between midday and 7 pm whereas older groups were observed throughout the day. Although based on a small sample, it was evident that the greater proportion of fires that occurred outside the 8 am and 8 pm interval increased with age from zero for less than 5 year olds to 13 percent for 6 to 12 year olds and 24 percent for 13 to 16 year olds. However, peak times for both the 6 to 12 and 13 to 16 year age groups were between 3 and 4 pm, coincident with the end of the school day.

**Figure 43: Time of day, by cause (number), 2000–01 to 2001–02**



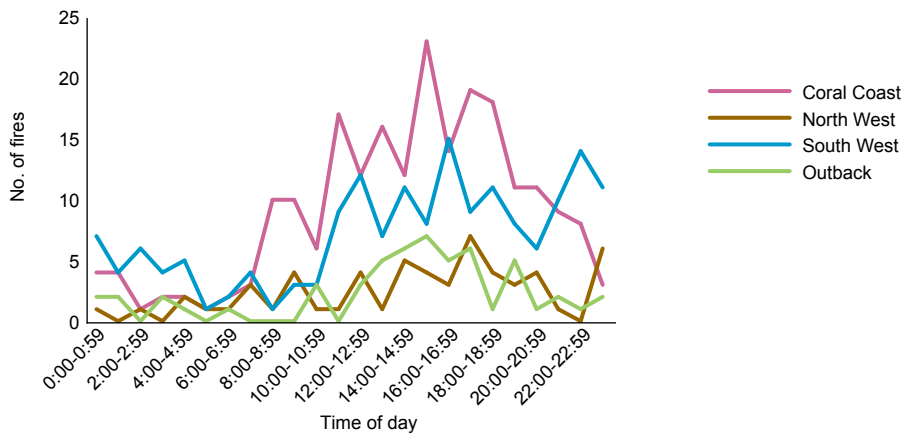
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 44: Time of day for all vegetation fires in the Perth region (number), 2000–01 to 2001–02**



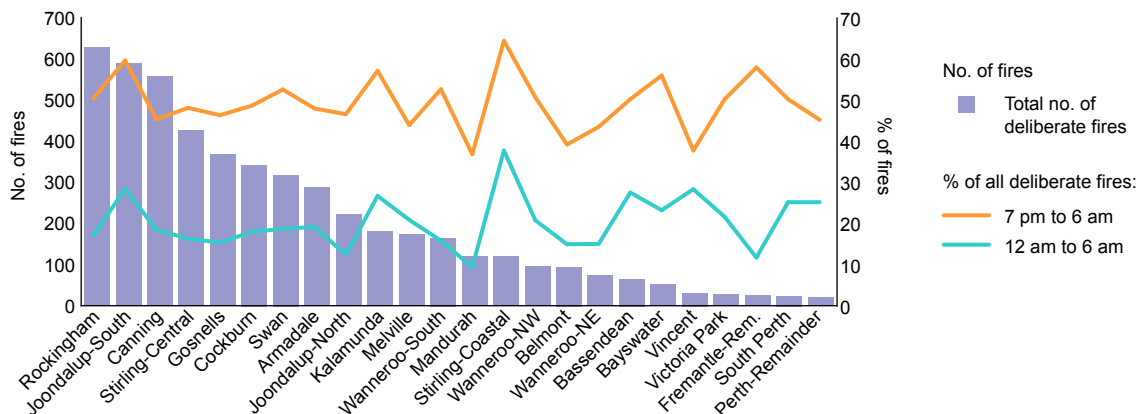
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 45: Time of day for all vegetation fires in other regions (number), 2000–01 to 2001–02**



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 46: Deliberate fires at night<sup>a</sup>, by Perth SLA, 2000–01 to 2001–02**

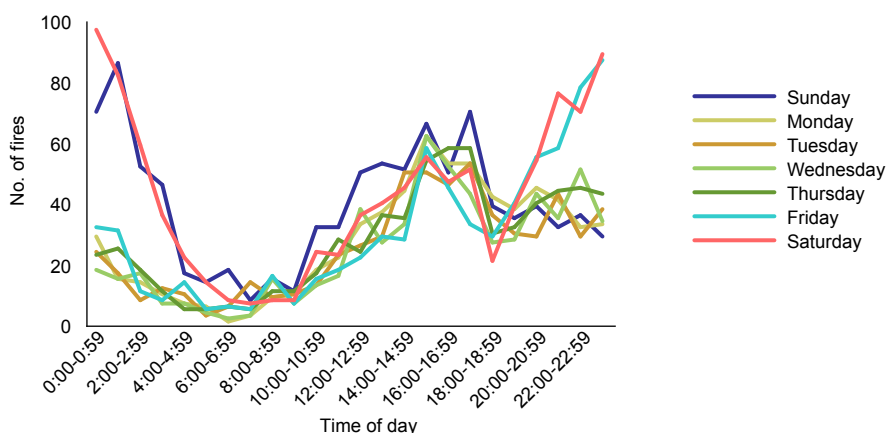


a: the number of deliberate fires only refers to the number of deliberate fires for which the detection time was known; only includes SLAs where there were more than 20 deliberate fires in two years where the time was known

Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

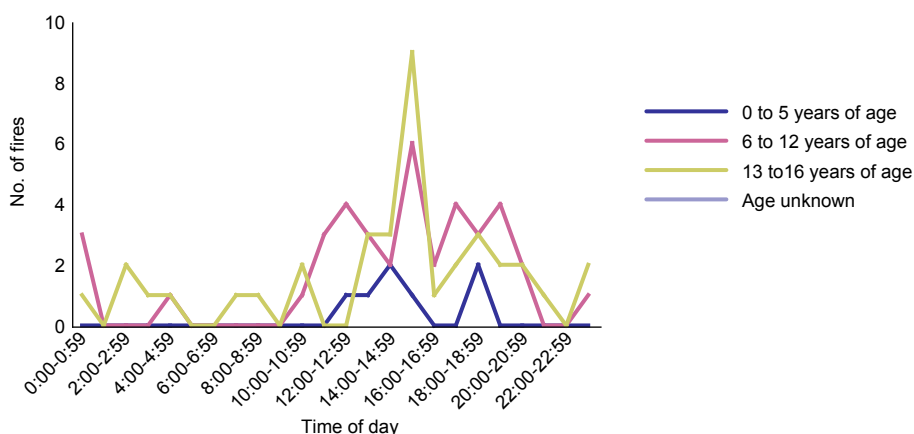


**Figure 47: Time of day for deliberate fires in the Perth region, by day of the week (number), 2000–01 to 2001–02**



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 48: Non-deliberate child fires, by time of day and child’s age (number), 2000–01 to 2001–02**



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

### Fire danger

Information about fire danger rating was only available for 22 percent of cases for 2000–01 and 2001–02, with ‘not applicable’ attributions having been made in 76 percent of cases in the AFAC–FESA database. The distribution of data covers the entire year. As both deliberate and non-deliberate fires primarily occurred during the bushfire danger season, a high proportion of fires fell within periods of high fire danger (Figure 49). Overall, fires occurring under high fire danger conditions (62% of known) outweighed those occurring during moderate (17% of known) and very high danger (11% of known). Only nine percent of instances where the fire danger rating was assigned occurred under low fire danger conditions. Only one percent occurred under extreme fire conditions.

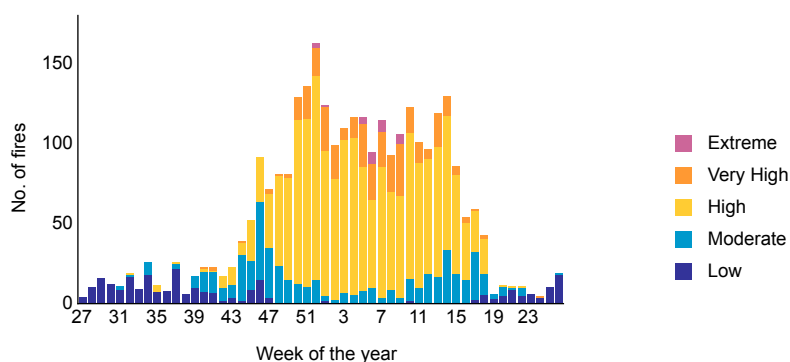
This general distribution was evident irrespective of whether the cause of the fire was deliberate or non-deliberate (Figure 50), indicating that the distribution is largely governed by distribution of fire danger rating over the bushfire season. However, the proportion of deliberate fires decreased with increasing fire danger, commensurate with an increased proportion of accidental and natural fires (Figure 51); there was

a 2.5 and five times increase in the proportion of accidental and natural fires under extreme, as opposed to moderate, fire danger rating conditions.

Of interest, is whether there is a tendency for deliberate fires to occur during periods of fire restrictions or total fire bans (TFBs). A far greater body of information was available about the status of fire restrictions and TFBs than for fire danger, but there was not a one-to-one relationship between the two within the available data. A broad range of restriction/TFB status was reported for each fire danger category. As would be expected the proportion of TFB fires increased with increasing bushfire danger (Figure 52). Three-quarters of the fires in Western Australia took place when no fire restrictions or bans were in place (Figure 53).

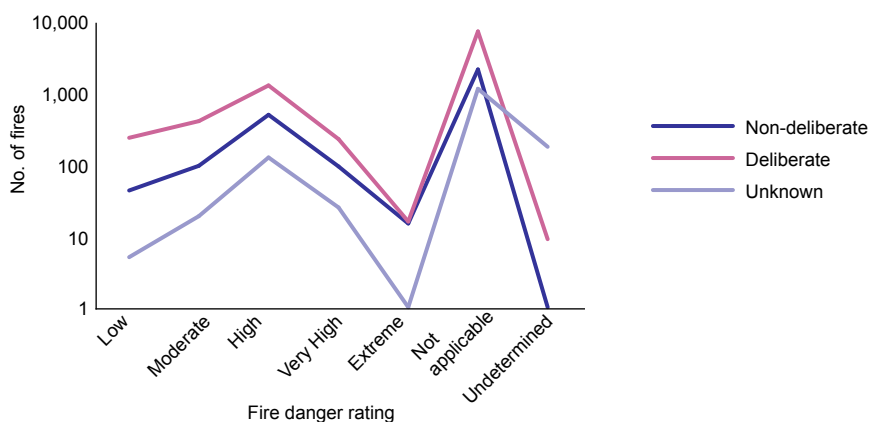
There was a broad relationship between general fire frequency and incidences of vegetation fires under a TFB. Overall, the number of fires lit during a TFB within a particular postcode increased with total fire frequency (Figure 54), such that one-quarter of all fires that occurred during a TFB were in the five postcodes that recorded more than 500 fires in a two-year interval (Figure 55). Almost 80 percent of fires lit during a TFB occurred in the 24 postcodes that recorded 100 or more fires per year. Between 40 and 50 percent of postcodes recording in excess of 200 fires in two years also recorded more than 10 percent of fires lit during a TFB (Figure 56).

**Figure 49: All vegetation fires, by bushfire danger rating (number), 2000–01 to 2001–02**



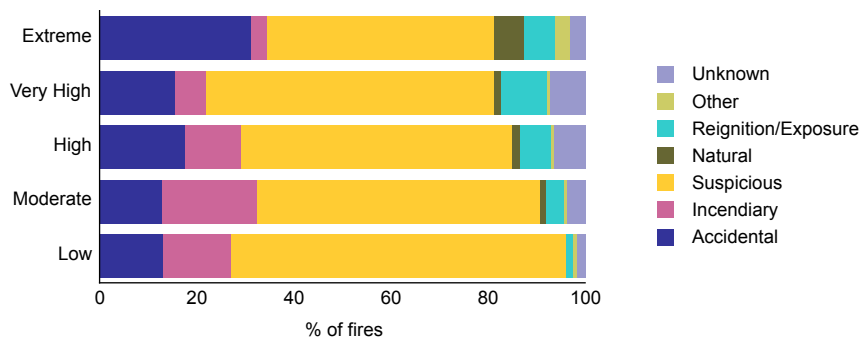
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 50: Fire danger index, by cause (number), 2000–01 to 2001–02**



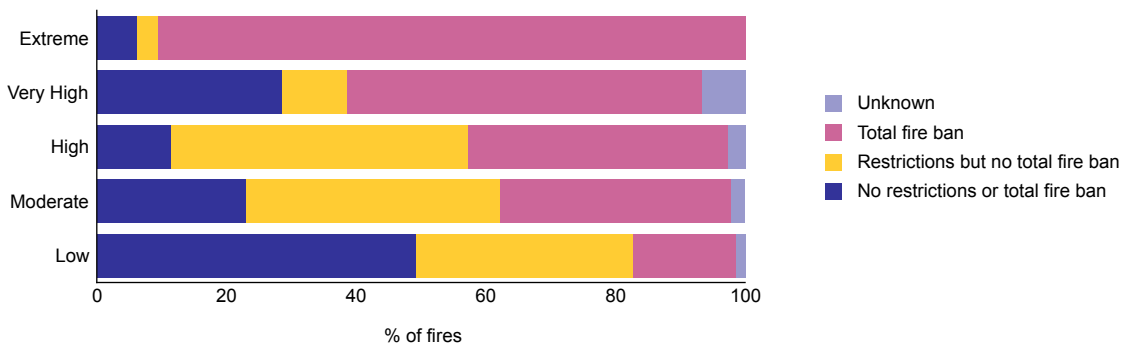
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 51: Fire danger index, by cause (percent), 2000–01 to 2001–02**



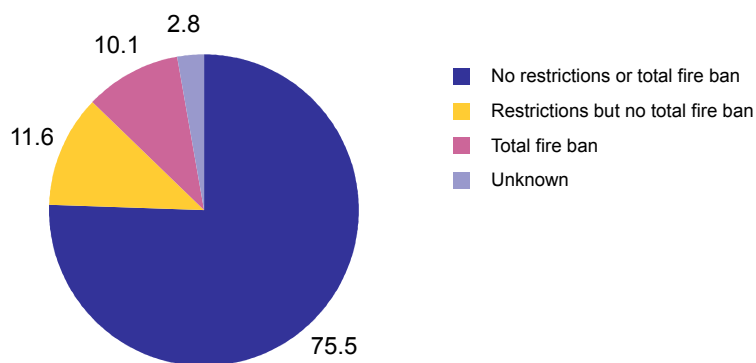
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 52: Fire restrictions and bans, by fire danger (percent), 2000–01 to 2001–02**



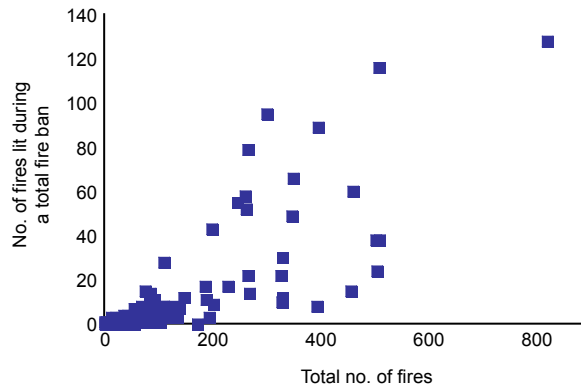
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 53: Fire restrictions and bans (percent), 2000–01 to 2001–02**



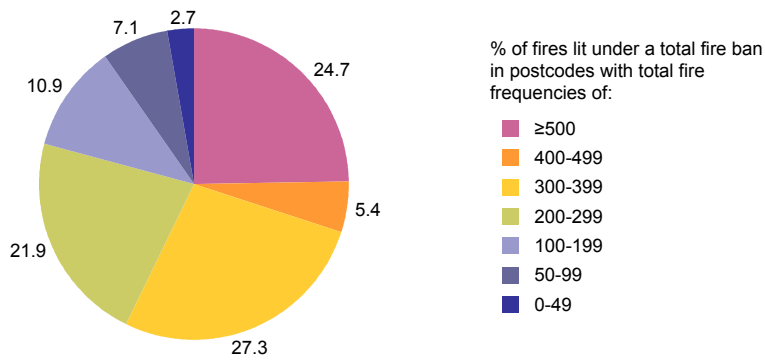
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 54: Fires lit during a TFB and total fires, by postcode (number), 2000–01 to 2001–02**



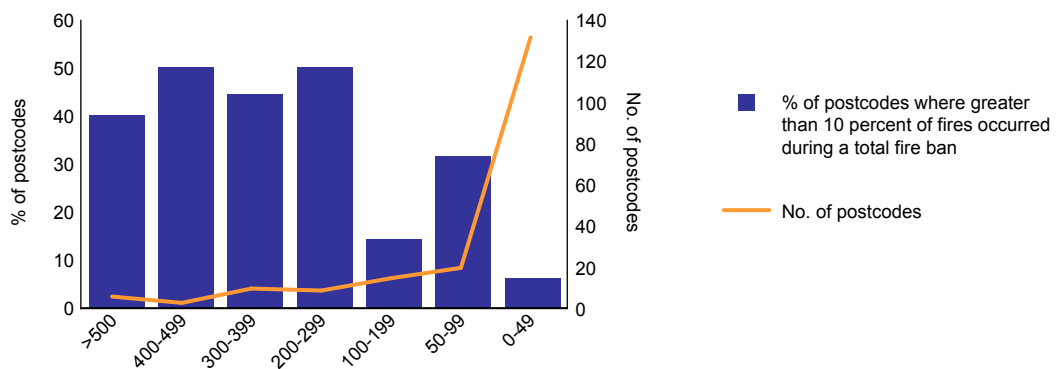
Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 55: Fires lit during a TFB, by total number of fires recorded in a postcode in two years (percent), 2000–01 to 2001–02**



Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

**Figure 56: Percentage of postcodes recording in excess of 10 percent of fires during a TFB, arranged by decreasing total fire frequency, 2000–01 to 2001–02**

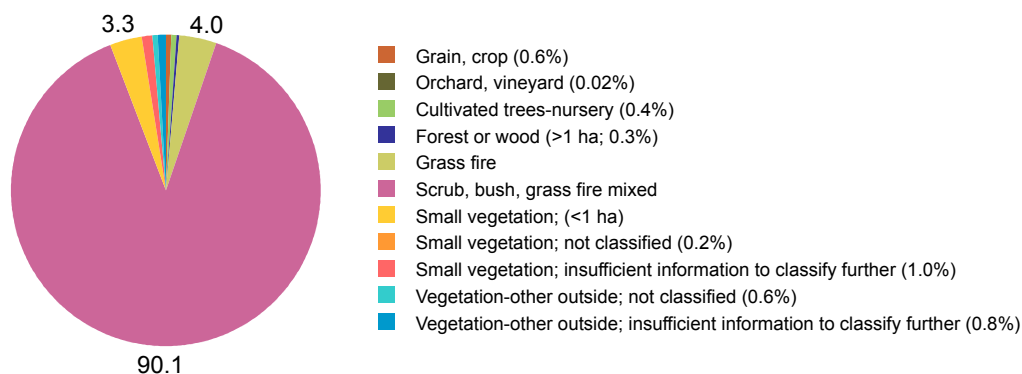


Source: FESA–AFAC 1997–98 to 2001–02 [computer file]

## Type of incident

The type of incident attended was ‘all vegetation fires documented by FESA for the interval 2000–01 to 2006–07 (supplementary data supplied by FESA). Of these, 94 percent were documented as scrub or bush and grass mixtures, 3.5 percent were small vegetation fires (principally less than one hectare), and 1.3 percent were grassfires (Figure 57). Only 0.2 percent of fires were forest or wood fires (greater than one hectare).

**Figure 57: Type of incident (percent), 2000–01 to 2006–07**

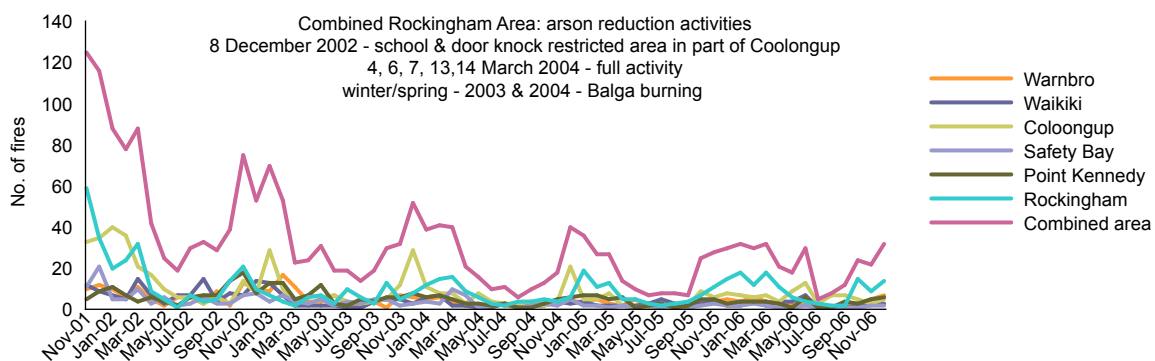


Source: FESA 2000–01 to 2006–07 [computer file]

## Factors impacting on FESA fire frequencies

Concurrent with, and subsequent to, this analysis FESA introduced a number of initiatives that virtually halved the total number of vegetation fires occurring in Western Australia each year, with numbers dropping from almost 11780 fires in 2000–01 to 6529 fires in 2005–06. These initiatives included targeted arson reduction measures, such as school visits, door knocks and shopping centre displays. Other measures were taken to manage fuel loads in key areas during critical periods and implement strategies to reduce the likelihood of smoking-related fires in urban streetscapes. The impact of such programs at a local level is demonstrated in Figure 58.

**Figure 58: Number of fires monthly in selected areas, individually and combined, before and after introduction of targeted arson reduction measures**



Source: FESA [computer file]

## Western Australian Department of the Environment and Conservation

### Background about the WADEC dataset and its analysis

Important details about the Western Australian Department of the Environment and Conservation (WADEC) data analysis are summarised below:

- The data were sourced from WADEC.
- The dataset provided included only vegetation fires for the period 1999–2000 to 2002–03.
- The database does not use AIRS codes.
- The cause of fires was defined based on the 'Fire cause description' variable.
- Within the 'Fire cause description' variable, WADEC defined a causal category titled deliberate. In order to maintain consistency across agencies, these fires are titled incendiary within the seven-fold causal classification scheme (that is, accidental, incendiary, suspicious, natural, etc.) and as deliberate in the non-deliberate versus deliberate classification schemes adopted in this analysis. In addition, fires where the cause was listed as 'unknown' or 'cause not listed' but for which an offence was suspected, in the 'Offence suspected' variable, were classified as suspicious within the seven-fold causal category variable and as deliberate within the non-deliberate versus deliberate classification scheme.
- Natural vegetation fires were exclusively the result of lightning.
- Information about form of heat of ignition was supplied.
- The regions used in the WADEC analysis were provided by WADEC and differ from the regions used in the FESA analysis. WADEC further subdivides regions into divisions.
- The database included area burned.
- Information was available about fire restrictions or fire danger index but was in a numerical format, and was not used.
- Detailed information was available about the type of vegetation burned, and the tenure of lands on which fires occurred.

For more detail about these methodologies see the methodology chapter.

### Overview

Fires WADEC attended can be summarised as:

- WADEC recorded 2,511 vegetation fires in the years 1999–2000 to 2002–03. Overall, the number of fires attended in any one year was comparatively uniform, ranging from 545 in 1999–2000 to 706 in 2000–01 (Figure 59).
- Of these, 25 percent were in national parks, nature reserves and other WADEC reserves, 44 percent were in state forests, 17 percent were on private property and 13 percent were on other Crown lands.
- Just over half (54%) the fires were deliberately lit (42% incendiary; 12% suspicious), with deliberate causes accounting for 60 percent of assigned causes.
- Three-quarters of vegetation fires occurred in the Swan (Perth) or South West regions of Western Australia.
- Collectively 4,876,416 ha were burned in WADEC fires, with incendiary and suspicious fires being responsible for 6.7 percent of the total area burned.

## Cause

Incendiary and suspicious fires accounted for 41.9 and 11.6 percent of vegetation fires, respectively (Figure 60). Collectively, deliberate causes (incendiary and suspicious combined) accounted for 53.5 percent of all fires, being the single largest cause of vegetation fires. Deliberate causes accounted for 59.6 percent of all fires for which a cause was assigned. Natural fires comprised 21.7 percent of WADEC vegetation fires. An additional 13.4 percent of fires resulted from accidental causes.

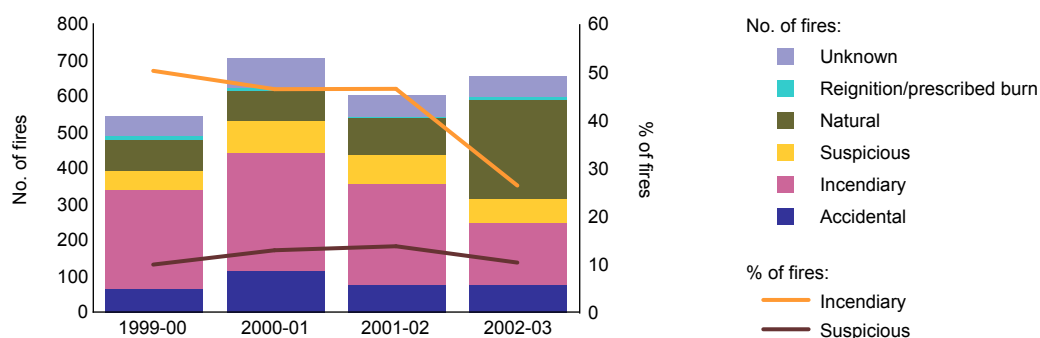
The greatest number of deliberate fires occurred in 2000–01 (n=417), and the lowest occurred in 2002–03 (n=239; Figure 59), despite the adverse fire conditions experienced in that year. Increased numbers of fires in 2002–03 principally resulted from the more than two-fold increase in the number of fires attributed to lightning; numbers of natural fires increased from 83 in 1999–2000 and 101 in 2001–02 to 275 in 2002–03.

The proportion of deliberate fires dropped from 59 to 60 percent for the first three years of the observation period, to 36 percent in 2002–03, reflecting both the increased proportion of natural fires and the genuine decrease in the number of deliberate fires (Figure 59). Whereas, natural fires, on average, comprised 15 percent of fires from 1999–2000 to 2001–02, and 42 percent of fires in 2002–03 were natural in origin. The decrease in the number of deliberately lit fires (principally in fires recorded as incendiary, as opposed to suspicious) is coincident with a marked reduction in deliberate fires FESA recorded in response to its targeted bushfire arson reduction programs (Ellis, Kanowski & Whelan 2004; Smith 2004; Figure 7).

## Specific ignition factors

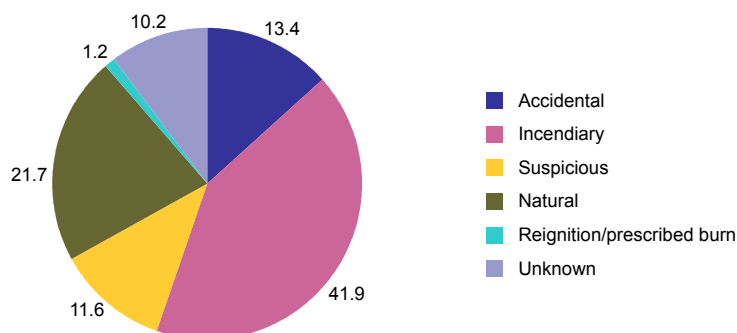
All fires classified as reignition/prescribed burn in Figure 59 and Figure 60 exclusively refer to escapes of prescribed burns being conducted by WADEC. Collectively, accidental fires comprised 13.4 percent of all vegetation fires WADEC attended (Figure 60). These derive from four distinct categories, namely: non-WADEC burn offs comprised 43 percent of all accidental fires, recreationists initiated a further 30 percent, the timber industry caused four percent and other industries accidentally caused the remainder. Subtle variations were evident in the number of fires resulting from these four causes each year. Collectively, the greatest number of accidental fires occurred in 2000–01, with increases evident across all four sub-categories (Figure 61).

**Figure 59: Cause of fires each year**



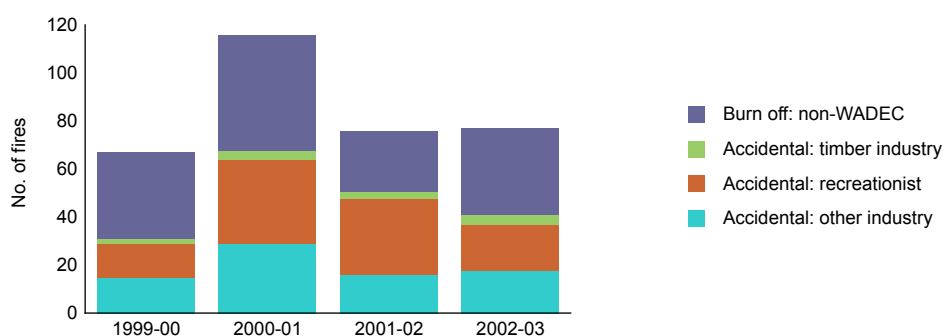
Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 60: Cause of fires (percent)**



Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 61: Specific causes of accidental fires, by year (number)**



Source: WADEC 1999–2000 to 2002–03 [computer file]

## Location

The location of fires was examined by the region in which fires occurred and by land tenure.

### Region

The distribution of WADEC regions is illustrated in Figures 62 and 63. The strong relationship between a high incidence of vegetation fires and higher population densities demonstrated in the FESA analysis is also clearly reflected in the WADEC data. Fifty-nine percent of vegetation fires WADEC attended occurred in the Swan region, which is centred on Perth (Figure 64). The majority of vegetation fires located outside the Swan region occurred in the South West (18%), Warren (10%) and South Coast (7%) regions (Figure 64).

The close relationship between fires and population is further demonstrated by the fact that of the 55 percent of fires WADEC attended in the Swan region were in the Perth division. A further 33 percent occurred in the Mundaring division and 12 percent were in the Dwellingup division (Figure 65).

Overall, the proportion of deliberate fires was greatest in those areas experiencing the greatest numbers of fires (Figure 66). This was evident both on a regional scale, but also within the Swan region itself (Figure 65). Notably, deliberate causes were responsible for 70 percent of fires in the Swan region – consistent with the rates observed by FESA in that region – 42 percent of fires in the South West region, 35 percent



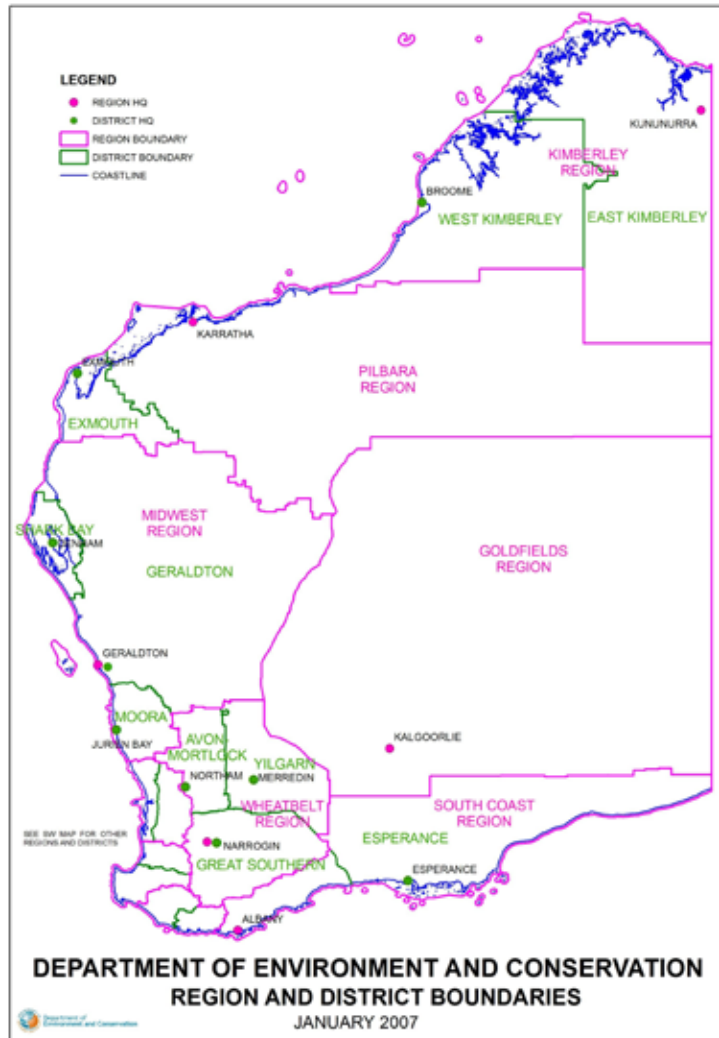
of fires in the Warren region, and 23 percent of fires in the South Coast region were deliberate. Within the Swan region, deliberate fires accounted for 84 percent of fires in the Perth divisions but just 56 and 40 percent of vegetation fires in the Mundaring and Dwellingup divisions, respectively (Figure 67).

Deliberate fires accounted for 44 percent of WADEC-attended vegetation fires in the Kimberley region, but on average less than two deliberate fires occurred each year. WADEC recorded no deliberate fires in the Pilbara region, but unknown attributions were markedly higher than in other regions (Figure 66). At a division level, Manjimup, South West Capes, Merredin and Kununurra–East Kimberley all record a comparatively high proportion of deliberate fires (Figure 67).

Despite these anomalies, there was an exceptionally strong correlation between the number of deliberate vegetation fires and the total number of vegetation fires in a region ( $r=.99$ ;  $p <.001$ ). This strong correlation is also evident at a division level ( $r=.98$ ;  $p <.001$ ).

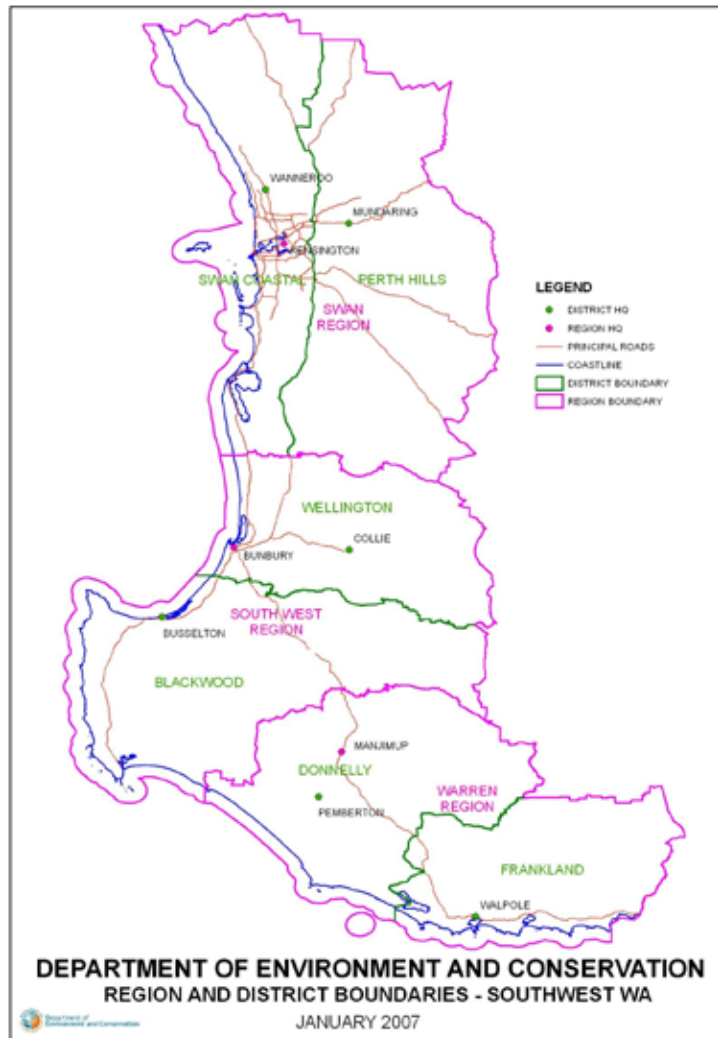
More remote locations in the state typically recorded higher proportions of natural ignitions, with a broad tendency for the proportion of natural fires to increase concomitant with decreasing proportions of deliberate lightings (Figure 66). Nevertheless, the actual numbers of natural fires documented tended to increase with increasing total fire frequency. Hence, the greatest numbers of natural fires were documented for the Swan region (Figure 68). This may reflect the fact that natural fires in more populated areas were more likely spotted and suppressed; many natural fires in remote areas are unlikely to be spotted, or may be allowed to burn because they fulfil ecological land management objectives.

Figure 62: WADEC regions for Western Australia



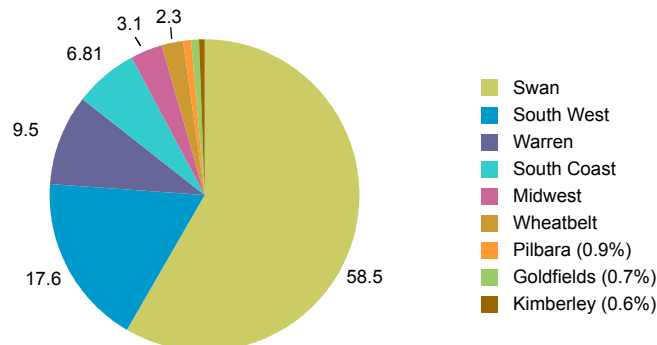
Source: © Western Australian Department Environment and Conservation 2007

**Figure 63: WADEC regions in southwest Western Australia**



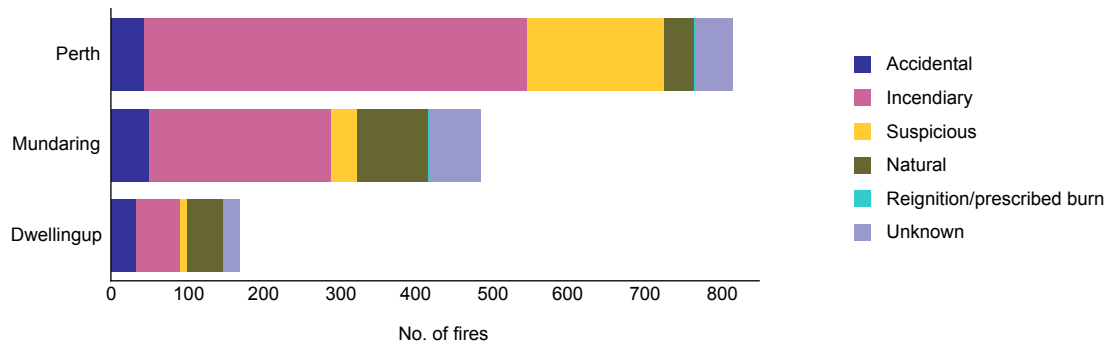
Source: © Western Australia. Department Environment and Conservation 2007

**Figure 64: Location of fires, by region (percent)**



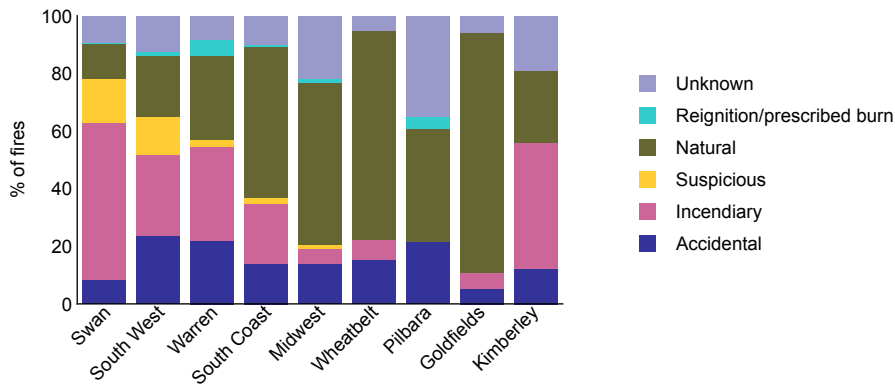
Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 65: Cause of fires in the Swan region, by division (number)**



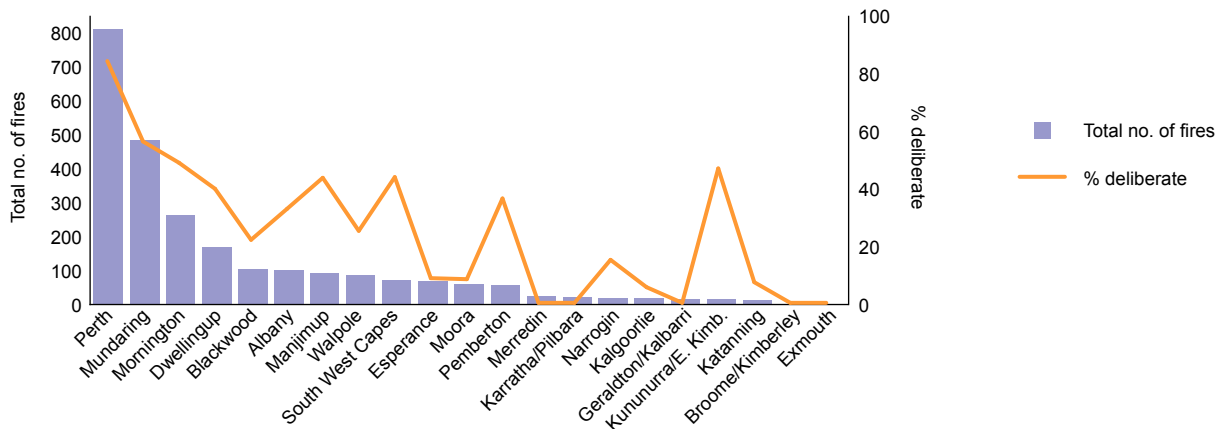
Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 66: Cause of fires (percent), and total number of fires, by region**



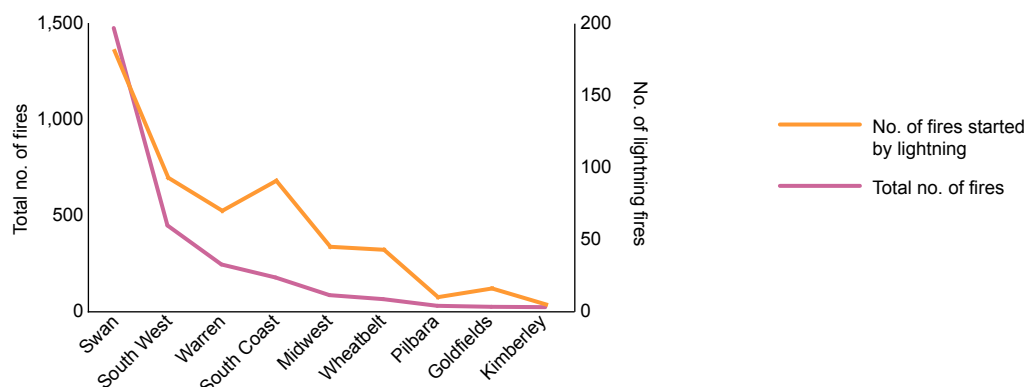
Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 67: Total number and proportion of deliberate fires, by division**



Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 68: Natural and total fires, by region (number)**



Source: WADEC 1999–2000 to 2002–03 [computer file]

### Tenure

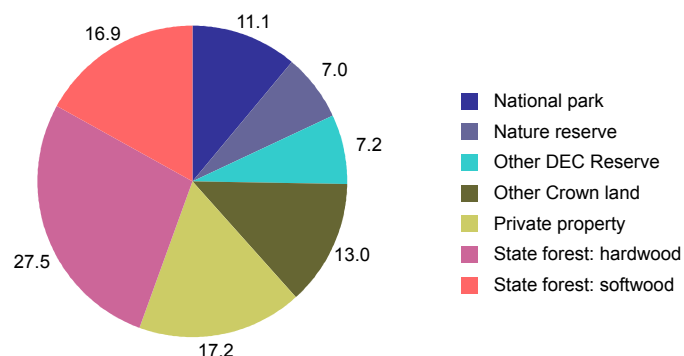
Collectively, 44 percent of vegetation fires WADEC attended occurred in state forests (hardwood 28%, softwood 17%; Figure 69). Eleven percent of vegetation fires occurred in national parks, seven percent each in nature reserves and in other WADEC reserves. Thirteen percent were on other Crown land and 17 percent were on private property.

The proportion of deliberate fires varied between tenures. Deliberate causes were responsible for 76 to 82 percent of fires in softwood state forests and on other WADEC reserves but only 53 to 54 percent of fires in hardwood state forests and other Crown land (Figure 70). In national parks and nature reserves deliberate causes were responsible for 38 to 41 percent of vegetation fires, respectively.

Natural causes comprised a much higher proportion of vegetation fires in national parks and nature reserves (38 to 43%), occurring at similar levels to deliberate fires in those tenures. Almost one-quarter of all fires in hardwood forests and other Crown land tenure also resulted from lightning. The greatest number and proportion of accidental fires occurred on private property.

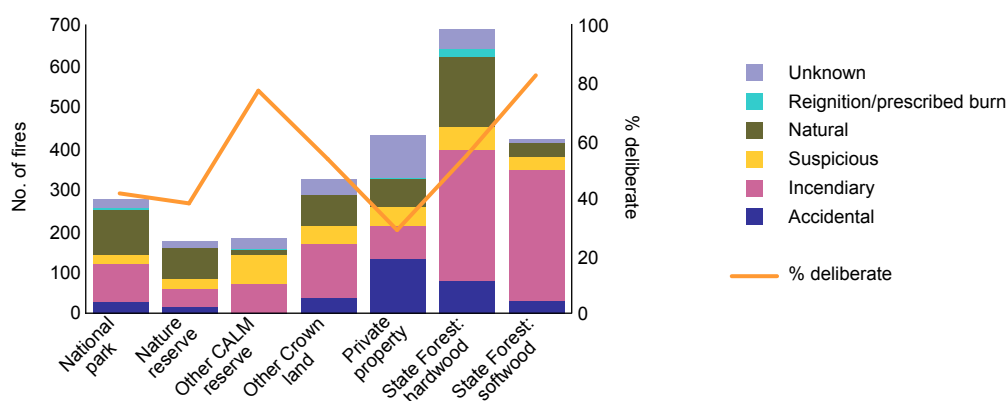
Collectively, 31 percent of all natural fires and 28 percent of all deliberate fires WADEC attended occurred in hardwood state forests. Twenty-six percent of all deliberate, but only six percent of natural fires, WADEC attended fires occurred in softwood state forests. In contrast, 19 percent of all natural fires, but only nine percent of all deliberate fires occurred in national parks. Similarly, 14 percent of all natural fires occurred in nature reserves, but just five percent of all deliberate fires occurred in that domain.

**Figure 69: Fires, by tenure (percent)**



Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 70: Cause of fires by tenure**



Source: WADEC 1999–2000 to 2002–03 [computer file]

## Timing

The timing of fires WADEC attended was examined by week of the year, by day of the week and by time of the day.

### Week of the year

The natural timing of the bushfire seasons varies substantially across the state (Figure 5). This natural tendency is reflected in the timing of all fires WADEC attended. For example, fires in the Kimberley region principally occurred from April to September and fires in the Pilbara principally occurred from July to January, during the dry season (Figure 71). In contrast, most fires in the southern part of the state occurred from late October to late April (Figure 71 and Figure 72). The most intense period was between late October and mid February, coincident the period of lowest rainfall.

Overall, the increase in the number of fires at the beginning of the bushfire season and the decrease at the end of the season occurred systematically each year (Figure 73). This reflects the regularity with which periods of greatest rainfall end and to a lesser extent begin each year in many Western Australian regions (Figure 37).

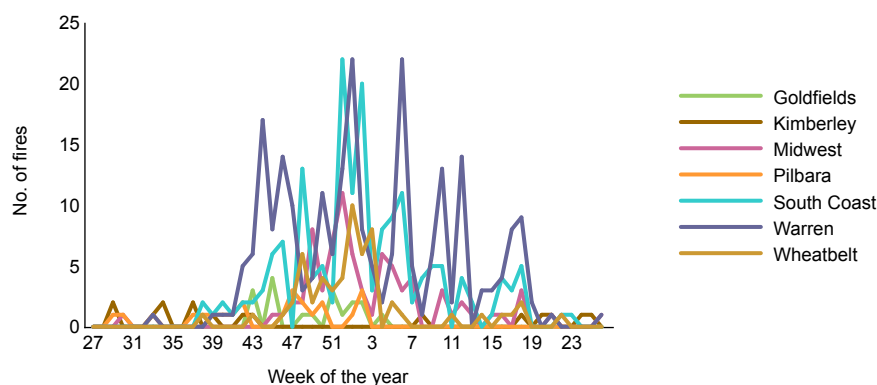
There was a tendency for WADEC to attend a greater number of vegetation fires before rather than after the New Year. This occurred for all years except 2001–02, when a large number of fires occurred during week 3 in January (Figure 73). Fifty-six of the 89 fires recorded during that week resulted from natural ignitions, but increased numbers of deliberate ignitions were also detected.

Marked differences were evident between the timing of fires based on cause (Figure 74). Most natural fires occurred in a comparatively short interval from mid December to late February, although a small spike was also evident in late March. Accidental fires principally occurred from mid October to mid April, but with higher numbers of fires at the beginning (weeks 42 to 50; mid October to mid December) and at the end (weeks 16 to 18; mid March to early April) of the fire danger season. These were principally escapes of non-WADEC burn offs, with rural burns typically undertaken just before and just after bushfire season. In contrast, a small number of recreational fires occurred from November through to April.

High numbers of incendiary and suspicious fires occurred from mid October to mid May, although the highest numbers were typically recorded during the first half of the bushfire season in southern Western Australia. Two major spikes in deliberate fires also occurred during weeks 44 to 46 (early to mid November) and from weeks 51 to 5 (mid December to early February). The latter peak represented a confluence between inherently high bushfire danger (as reflected by natural fires) and the school holidays. The increase in the number of deliberate fires from weeks 44 to 46 was not coincident with school holidays, but was observed in two out of four years. The number of deliberate fires during this period clearly outweighed non-deliberate causes.

The 2002–03 season was interesting from a number of perspectives. Although there was an inherently high fire danger in 2002–03, as indicated by the large number of natural fires, comparatively fewer vegetation fires were deliberately lit during this year (Figure 75). This likely reflects the extensive arson reduction campaigns undertaken in Western Australia during 2001–02 and 2002–03. One factor that distinguishes 2002–03 from previous years is the low incidence of deliberate fires during the first part of the season, up until the middle of January. In previous years the number of deliberate fires during the first part of the bushfire season clearly outweighed the later part. The decrease in early-season deliberate fires occurred despite the inherently adverse bushfire conditions, as reflected in the large high numbers of natural fires during December and early January. The greatest number of deliberate fires in 2002–03 occurred during the period that bushfires devastated large areas of eastern Australia, when media coverage of bushfires was likely at its highest. The high numbers of deliberate fires at this time does not appear to reflect more adverse bushfire conditions in Western Australia as comparatively few natural fires occurred during this interval.

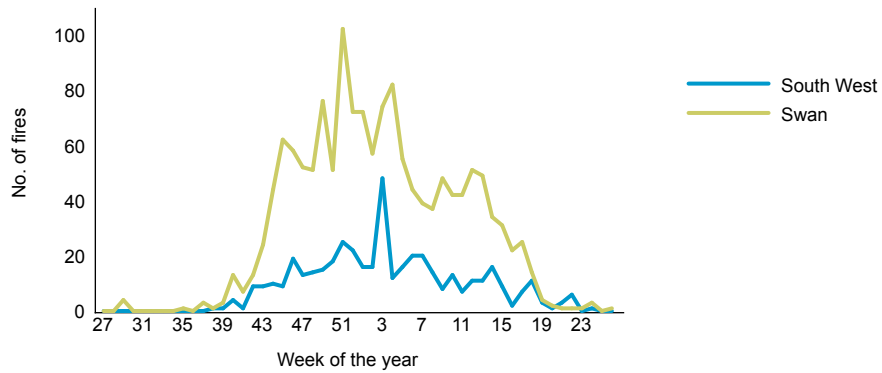
**Figure 71: All fires by week of the year, for fires in selected WADEC regions**



Note: week 1 pertains to the first week of January

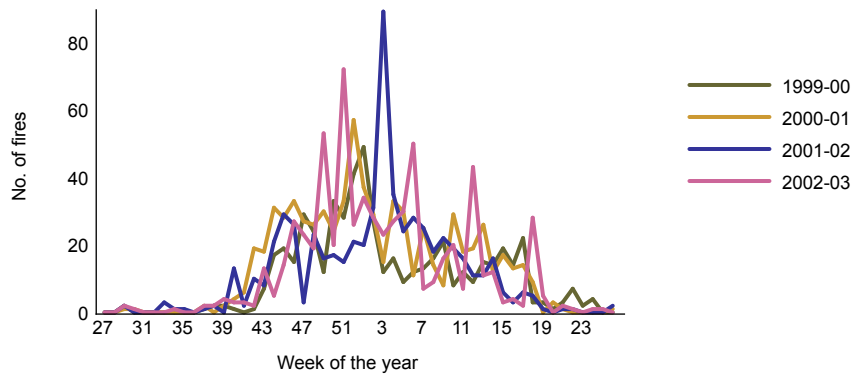
Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 72: All fires by week of the year for fires in the Swan and South West regions**



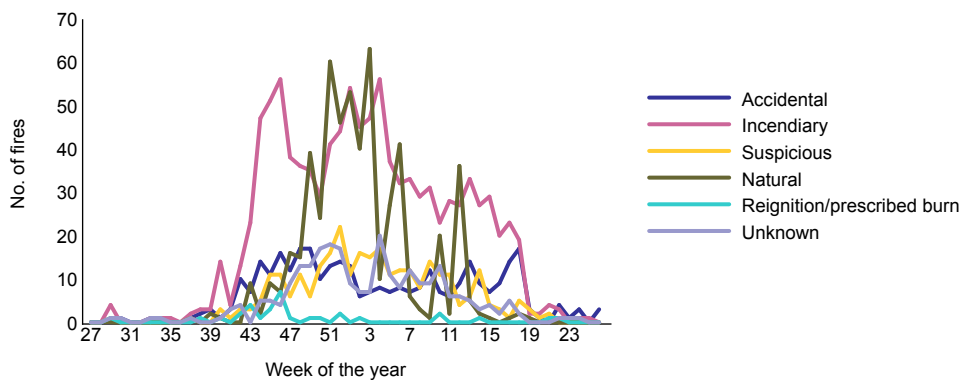
Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 73: All fires by week of the year, by year**



Source: WADEC 1999–2000 to 2002–03 [computer file]

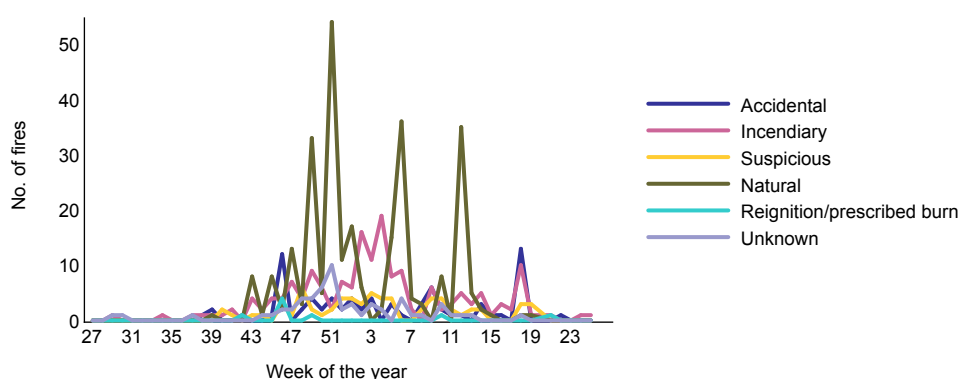
**Figure 74: Week of the year, by fire cause**



Source: WADEC 1999–2000 to 2002–03 [computer file]



**Figure 75: Week of the year, by cause, 2002–03**



Source: WADEC 1999–2000 to 2002–03 [computer file]

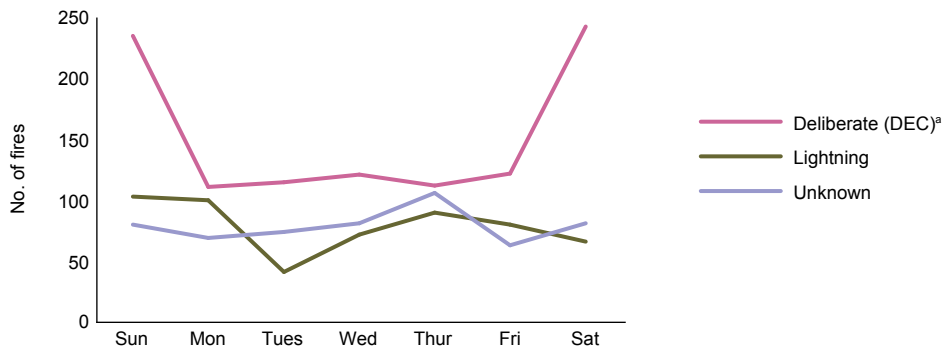
### Day of the week

The distribution of fires by day of the week was highly cause-dependent. Incendiary fires were twice as likely to occur on Saturdays or Sundays as during the week (Figure 76), whereas suspicious fires were only 15 percent higher on weekend days. The number of non-deliberate vegetation remained comparatively uniform throughout the week, for most causes. This reflects the predominance of natural fires, industry-related accidental fires, and escapes from burn offs. However, 2.5 times more recreational fires occurred on Saturday and Sunday relative to the weekday average (Figure 77).

The greater number of deliberate fires on weekends occurred in all years except 2002–03, where the number of deliberate fires lit on weekends was comparable to that during the week (Figure 78). The number of fires lit on weekdays was comparable across all years. This implies that arson prevention and reduction measures may have affected the type of behaviour and/or practices that had previously commonly manifested on weekends. The cause of this turn-about in deliberate fire setting for 2002–03, particularly given the severity of the bushfire season, and its potential relationship to concurrent arson reduction campaigns is obviously of great interest.

The propensity for higher numbers of deliberate fires on weekends varied between regions. Higher number of deliberate fires on weekends was most prevalent in those regions that experienced the highest numbers of fires overall. Hence, the weekend effect was most clearly observed in the Swan region (Figure 79). In the South West, higher deliberate lightings occurred on both Saturdays and Sundays, but also on Thursdays, whereas for the South Coast and Warren regions high deliberate fire frequencies only occurred on Saturday (Figure 80).

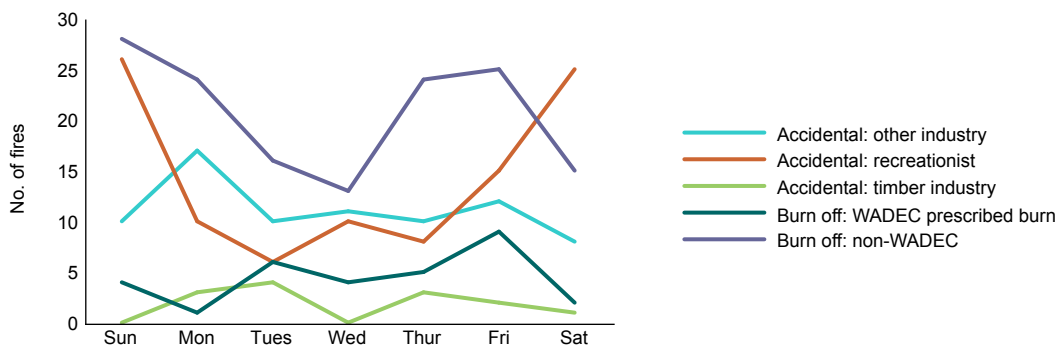
**Figure 76: Day of the week for selected fire causes (number)<sup>a</sup>**



a: deliberate fires according to the WADEC definition do not include suspicious fires; the above figure only includes fires classified as incendiary in this report

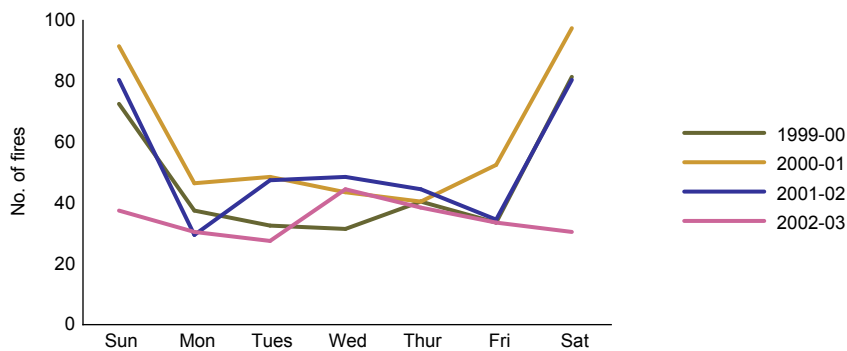
Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 77: Day of the week for non-deliberate, human-caused fires (number)**



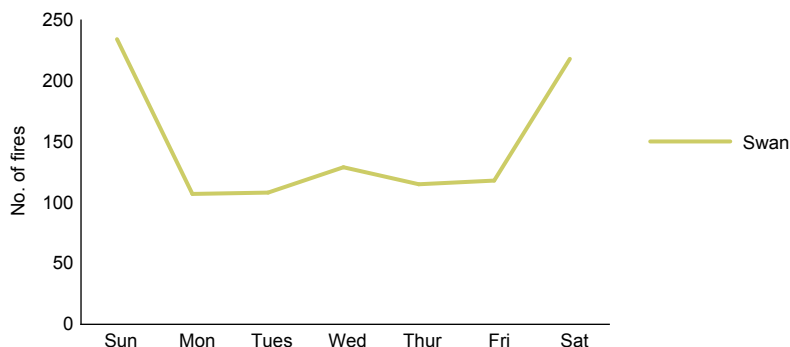
Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 78: Day of the week for deliberate fires, by year (number)**



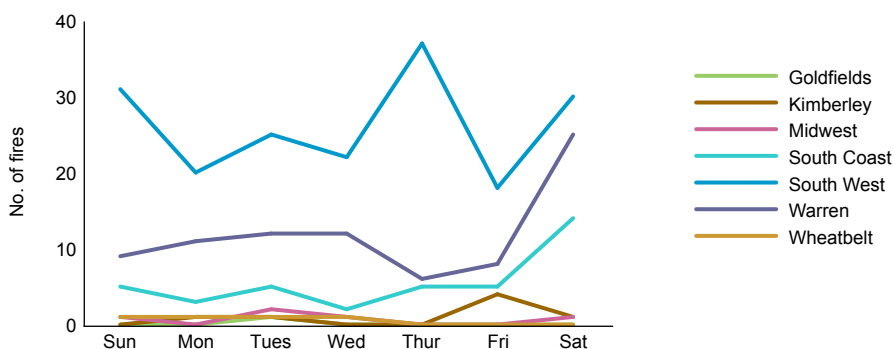
Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 79: Day of the week for deliberate vegetation for the Swan region (number)**



Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 80: Day of the week for deliberate vegetation for other regions (number)**



Source: WADEC 1999–2000 to 2002–03 [computer file]

### Time of day

Distinctly different trends were evident between the distribution of detection times for WADEC and FESA fires. The majority of WADEC fires occurred during daylight hours, irrespective of cause, with 86 percent occurring between 6 am and 8 pm. Nevertheless, there were notable differences between the timing of fires of different causes (Figure 81).

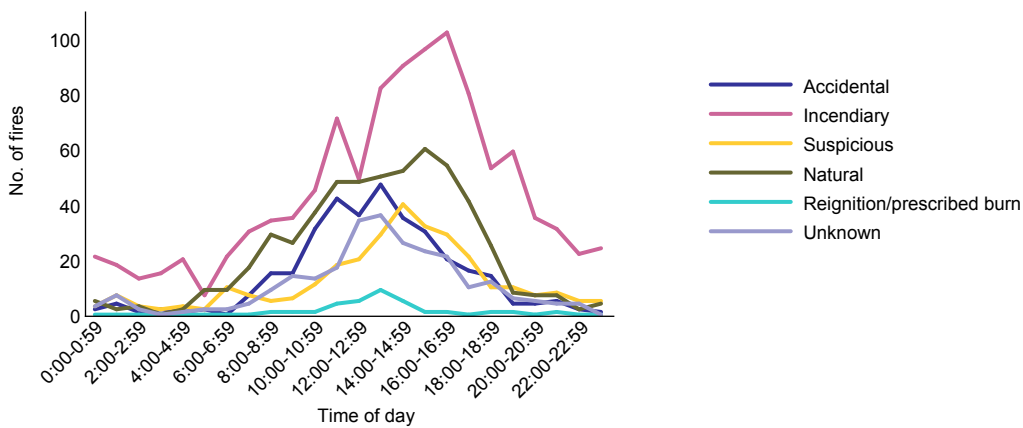
Peak numbers of deliberate fires occurred between 3 and 5 pm, somewhat later than that observed for non-deliberate fires. The peak number of accidental fires and prescribed burns (WADEC) occurred from 1 to 2 pm. Natural fires primarily occurred between 12 and 4 pm, with the peak being from 3 to 4 pm.

Twenty-two percent of WADEC-attended vegetation fires occurred between 6 pm and 6 am with only six percent occurring between midnight and 6 am. However, again variations in night fires were cause-specific. Fifty-two percent of deliberate fires occurred between 6 pm and 6 am, with 16 percent of deliberate fires occurring from midnight to 6 am. Deliberate causes accounted for 70 percent of all fires that occurred between 6 pm and 6 am and from midnight to 6 am. Although there were some differences, strong similarities were evident with the distributions of fires FESA attended.

The timing of fires was broadly consistent across regions (Figure 82). Nevertheless, the proportion of fires that occurred within specific intervals varied between and regions, reflecting differences in the proportion of deliberate fires but also differences in social patterns. For example, in the Swan region, the greatest number of deliberate fires between 10 and 6 am occurred in the Perth division, but fires within this timeframe accounted for a higher proportion of deliberate fires in the Mundaring and Dwellingup divisions.

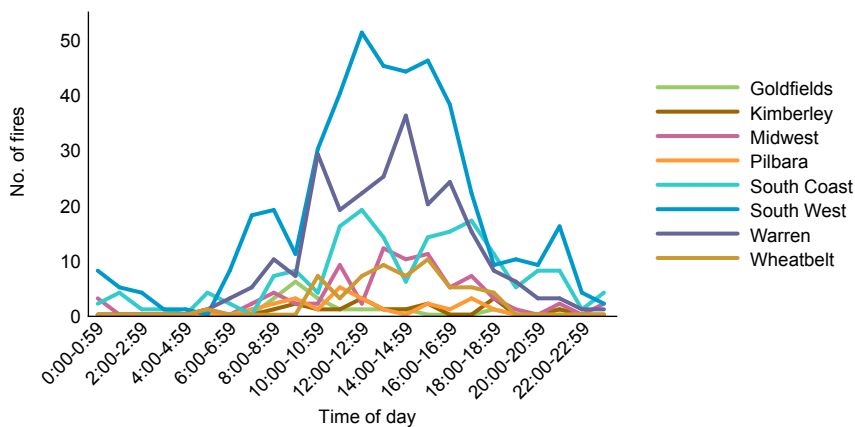
Greater numbers of deliberate fires on Saturday and Sunday principally occurred between 1 pm and 8 pm (Figure 83). This is in marked contrast to the trend observed in the FESA data where larger numbers of fires on the weekend reflected a high incidence of night-time fires on Friday night–Saturday morning and Saturday night–Sunday morning. No substantial difference was evident between the number of non-deliberate fires on the weekend and on other days of the week (Figure 84).

**Figure 81: Detection time, by cause (number)**



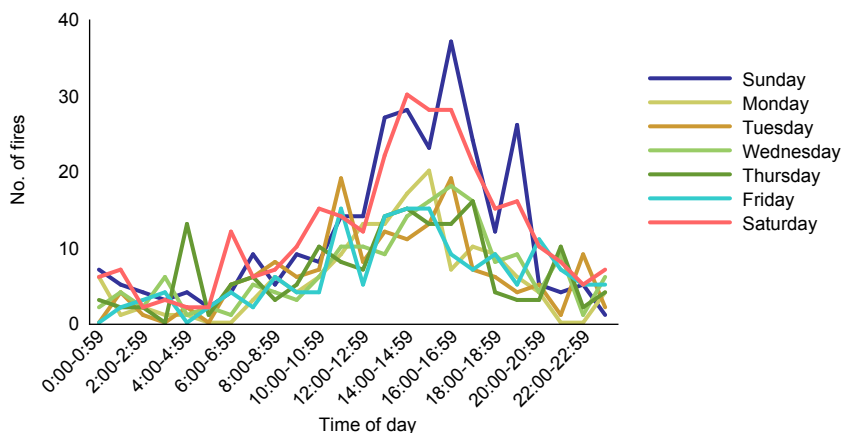
Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 82: Detection time, by region (number)**



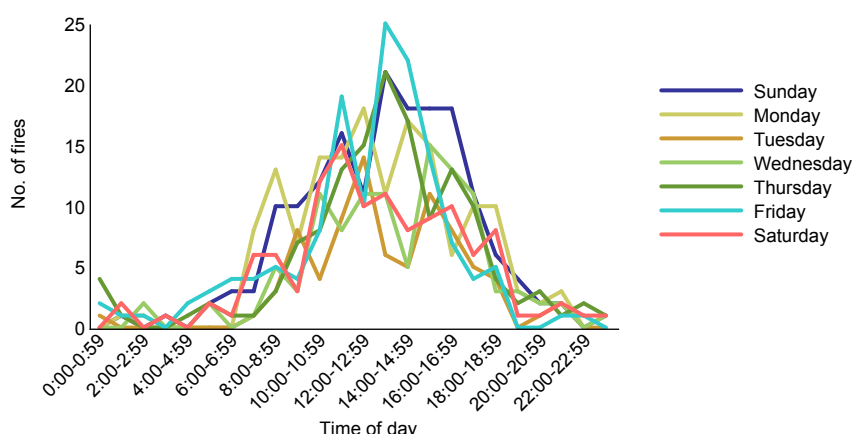
Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 83: Detection time of deliberate fires occurred, by day of the week**



Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 84: Detection time of non-deliberate fires, by day of the week**



Source: WADEC 1999–2000 to 2002–03 [computer file]

## Area burned

The majority of fires WADEC attended were small; 50 percent of fires were less than 1 ha and 75 percent were less than 10 ha. Although there was a strong tendency for the number of fires to increase with increasing fire size, irrespective of cause (Figure 85), some differences were evident between the size distribution of individual causes.

The vast majority of deliberate fires were small; 86 percent were less than 10 ha and deliberate causes accounted for a decreasing proportion of fires as the area burned category increased (Figure 86). Nevertheless, deliberate fires were responsible for six fires of greater than 5,000 ha each. Two of these burned greater than 100,000 ha in the Kimberleys during 2002–03.

Although the majority of lightning fires were also small, lightning was the principal cause of large fires (Figure 85). Approximately three-quarters of fires of greater than 1,500 ha resulted from lightning, with natural fires accounting for an increasing proportion of fires as the area burned increased (Figure 86).

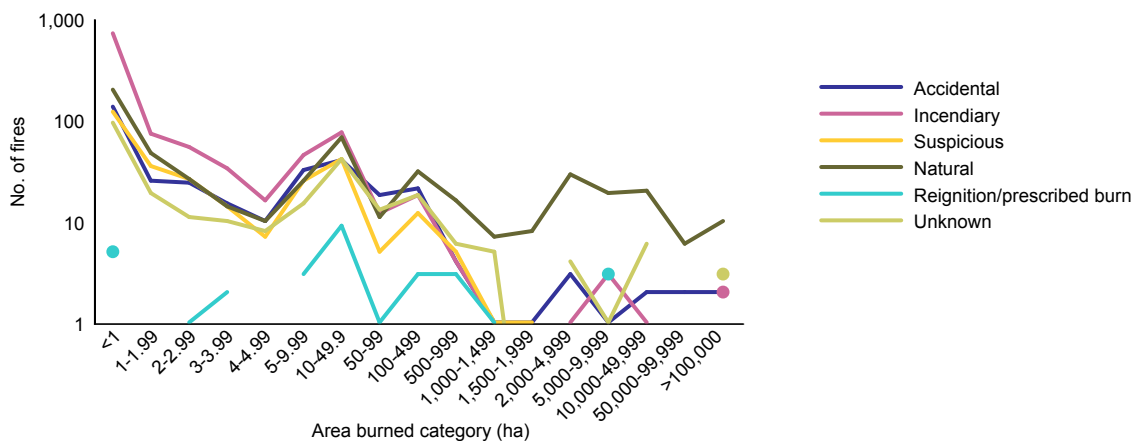
Statistics about the total area burned are naturally dominated by large fire events. Although deliberate fires were responsible for 54 percent of WADEC-attended fires, these contributed to less than seven percent of the total area burned between 1999–2000 and 2002–03, as overall the area burned in deliberate fires was typically small (Figure 87). The greatest total area was burned by natural (69%) and accidental (12%) fires.

The largest areas were burned during 2002–03 when 10 major fires individually burned in excess of 100,000 ha (Figure 88). Four of these fires were in the Kimberley, five on the South Coast and one was in the Wheatbelt region. Vast tracts of land were also burned on WADEC reserves in the Goldfields and Pilbara regions and fires greater than 10,000 ha occurred in all regions except the Swan and Warren. Deliberate fires were responsible for burning large areas in 2002–03; burning in excess of 100,000 ha in the Kimberley. Natural fires also burned extensive areas in 2000–01 and 2002–03 (Figure 88).

Given the location of the large fires in Western Australia, it is not surprising that the largest areas were burned in the South Coast, Pilbara, Kimberley and Goldfields regions. These were principally in sparsely populated areas dominated by savanna, desert or semi-desert. The overwhelming majority of land burned in the Goldfields, Wheatbelt and South Coast regions resulted from natural causes. Accidental fires featured most strongly in the Pilbara and Kimberley regions.

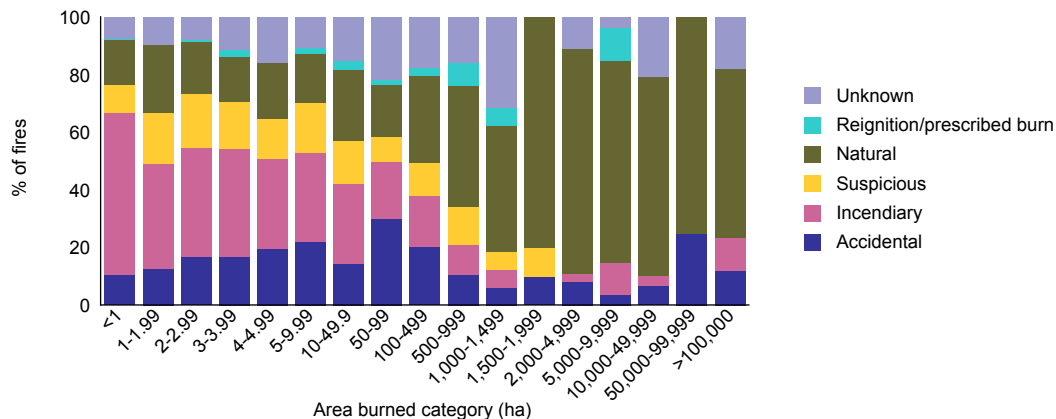
Although easy to overlook, in light of the large areas burned by natural fires, the role of deliberate fires was an important contributor to the areas burned in some areas. The greatest area burned (more than 100,000 ha) was burned by deliberate fires in the Kimberley region (Figure 89). Another 12,817 ha was deliberate burned on the South Coast, accounting for one percent of land burned in that region. Deliberate causes were a major contributor to the total area burned in the Swan region (18,824 ha), accounting for 27 percent of total area burned. The 2,742 ha of land burned by deliberate fires in the South West, represented 38 percent of total area burned in the region during the observation period. The Swan and South West regions were not only areas characterised by highest population densities and highest numbers of deliberate fires generally, but also have the greatest densities of forests, very high levels of biodiversity, and numerous vulnerable and endangered flora and fauna.

**Figure 85: Area burned category, by cause (number)**



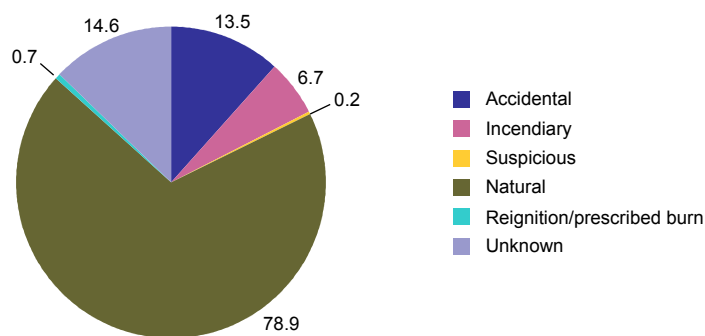
Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 86: Area burned category and total number of fires, by cause (percent)**



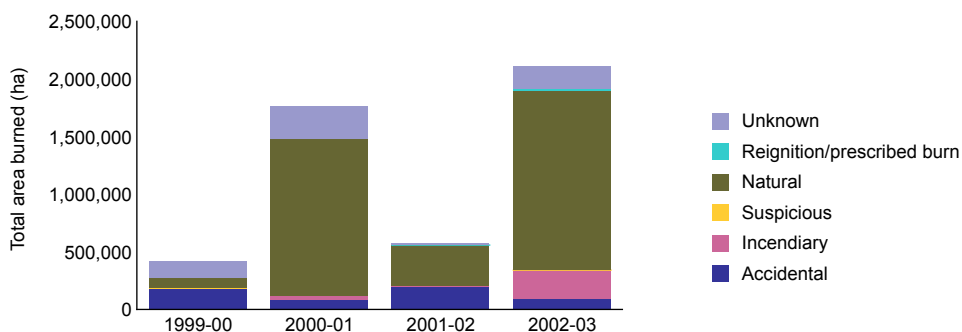
Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 87: Total area burned, by cause (percent)**

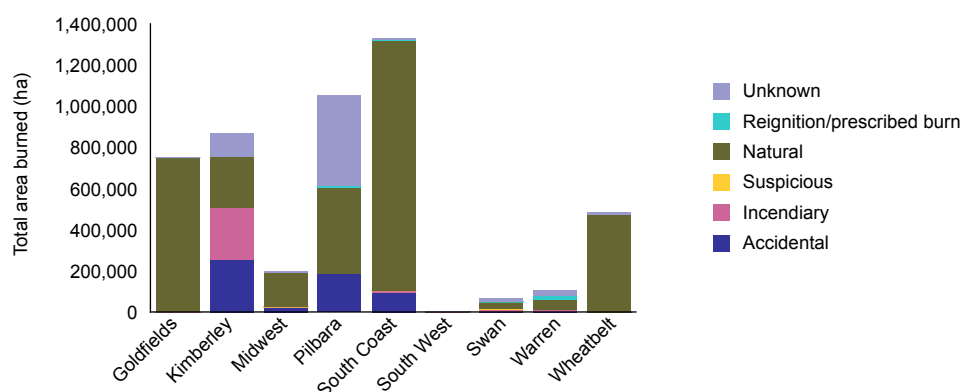


Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 88: Area burned, by each cause, each year (hectares)**



Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 89: Area burned, by cause, within each region (hectares)**

Source: WADEC 1999–2000 to 2002–03 [computer file]

## Vegetation

The WADEC database included detailed information about the vegetation burned in 83 percent of cases. Information about the damage to ecosystems was also recorded in 31 percent of fires.

The greatest number of fires occurred in northern jarrah and *Pinus pinaster* (Table 3). Sixty-eight percent of fires in northern jarrah occurred in state forest (hardwood), with just over half (54%) of fires in this vegetation type being deliberately lit. Ninety-five percent of fires in *Pinus pinaster* also occurred in state forests (softwood); 86 percent of fires in *Pinus pinaster* were deliberately lit.

High numbers of fires were also burned in banksia woodland (all tenure categories), grassland (commonly on private property), heathland (commonly national park or other Crown land) and low open woodlands (most tenure categories). The proportion of deliberate fires was variable between these vegetation categories, being highest in banksia woodland and to a lesser extent low open woodland, but comparatively low in grasslands, where fires were commonly the result of accidental fires on private property.

In production forests, fires most commonly resulted in crown scorch. However, in 12 percent of cases the regenerating vegetation was killed (Figure 90). Deliberate causes were responsible for 66 percent of instances of crown scorch in production forests, but only 43 percent of regeneration being killed.

Although fires in conservation forest most commonly resulted in crown scorch, defoliation of the crown or scorching of regenerating forests (Figure 90), deliberate fires potentially had substantial ecological impacts in WADEC reserves:

- in seven out of the 10 cases where fires killed regenerated areas in conservation reserves, deliberate causes were responsible
- all seven fires that occurred in fire sensitive ecosystems containing endangered and rare fauna resulted from deliberate lightings; the largest burned 100 ha
- deliberately lit fires accounted for 60 percent of the 134 fires in fire sensitive ecosystems
- 23 of the 34 fires in Tuart (endemic to South West Western Australia) reserves, 26 of the 54 fires in southern jarrah forests and approximately 30 percent of Karri forests resulted from deliberate lightings.

In the 31 percent of cases where ecosystem damage was assessed, 901,000 ha of conservation forest and 457,000 ha of fire sensitive ecosystems was affected, with the largest area having been burned in



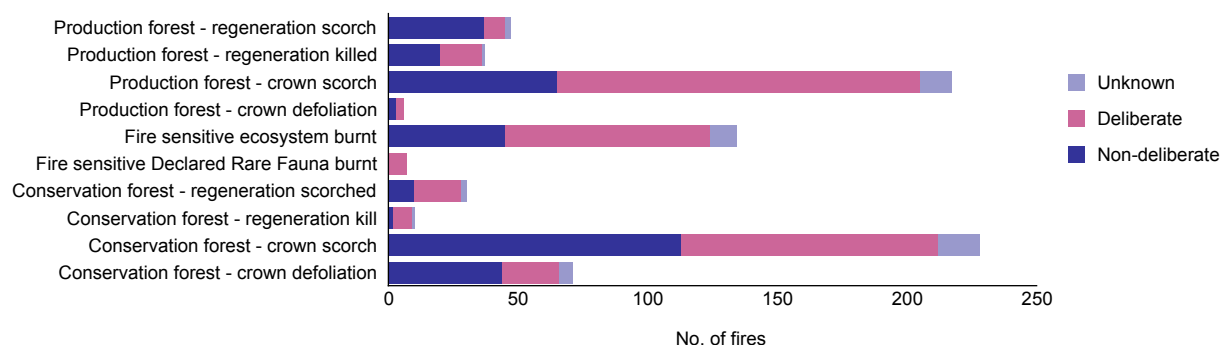
heathland, spinifex, savanna woodland, mallee, mulga and low open woodlands. The majority of this was not the result of deliberate lightings. Of the 35,000 ha of northern jarrah burned, 5,800 ha resulted from deliberately lit fires. Similarly, the majority of the 15,500 ha of karri forest burned did not result from deliberately lightings. Nevertheless the potential for ecosystem damage is again reflected in the fact that 80 percent of the 695 ha of Tuart forest burned, one-third of the 21,411 ha of southern jarrah burned, and all 166 ha burned in reserves containing endangered and rare fauna were deliberate lit.

**Table 3: Number, percentage of deliberate fires, and tenure of fires based on vegetation type**

| Vegetation type       | Total no. of fires | % deliberate | National park | Nature reserve | Other WADEC reserve | Other Crown land | Private property | State forest hardwood | State forest softwood |
|-----------------------|--------------------|--------------|---------------|----------------|---------------------|------------------|------------------|-----------------------|-----------------------|
| Northern jarrah       | 708                | 54.0         | 9.5           | 2.5            | 4.7                 | 6.9              | 7.3              | 67.9                  | 1.1                   |
| Missing               | 428                | 39.5         | 11.7          | 11.9           | 6.8                 | 17.3             | 20.6             | 18.5                  | 13.3                  |
| <i>Pinus pinaster</i> | 306                | 85.9         |               |                |                     | 1.3              | 1.3              | 2.6                   | 94.8                  |
| Banksia woodland      | 218                | 79.8         | 9.6           | 13.3           | 17.9                | 21.1             | 17.9             | 11.9                  | 8.3                   |
| Grasslands            | 185                | 36.2         | 3.2           | 3.8            | 9.2                 | 10.3             | 69.2             | 1.6                   | 2.7                   |
| Heathland             | 119                | 47.1         | 29.4          | 18.5           | 9.2                 | 31.1             | 11.8             | 0.0                   | 0.0                   |
| Low open woodlands    | 103                | 56.3         | 19.4          | 12.6           | 18.4                | 23.3             | 19.4             | 5.8                   | 1.0                   |
| Unforested flats      | 63                 | 60.3         | 12.7          | 19.0           | 23.8                | 17.5             | 15.9             | 6.3                   | 4.8                   |
| Other                 | 59                 | 45.8         | 8.5           | 5.1            | 6.8                 | 25.4             | 25.4             | 22.0                  | 6.8                   |
| Southern jarrah       | 54                 | 48.1         | 18.5          |                | 1.9                 | 3.7              | 13.0             | 61.1                  | 1.9                   |
| <i>Pinus radiata</i>  | 53                 | 32.1         | 1.9           |                |                     | 13.2             | 20.8             | 9.4                   | 54.7                  |
| Tuart                 | 34                 | 67.6         | 32.4          | 5.9            | 23.5                | 11.8             | 11.8             | 14.7                  | 0.0                   |
| Mallee                | 31                 | 3.2          | 19.4          | 22.6           |                     | 54.8             | 3.2              | 0.0                   | 0.0                   |
| Pure Karri            | 31                 | 32.3         | 38.7          |                |                     | 3.2              | 22.6             | 32.3                  | 3.2                   |
| Wandoo                | 31                 | 25.8         | 12.9          | 9.7            | 6.5                 | 6.5              | 22.6             | 41.9                  | 0.0                   |
| Other forest type     | 16                 | 43.8         | 6.3           | 6.3            | 12.5                | 25.0             | 37.5             | 12.5                  | 0.0                   |
| Crops                 | 15                 | 20.0         |               |                |                     | 0.0              | 80.0             | 6.7                   | 13.3                  |
| Spinifex              | 14                 | 7.1          | 42.9          | 7.1            | 7.1                 | 35.7             | 7.1              | 0.0                   | 0.0                   |
| Acacia scrub          | 11                 | 45.5         |               | 54.5           | 9.1                 | 18.2             | 18.2             | 0.0                   | 0.0                   |
| Tingle                | 8                  | 0.0          | 100.0         |                |                     | 0.0              | 0.0              | 0.0                   | 0.0                   |
| Savanna woodland      | 7                  | 42.9         | 71.4          |                |                     | 0.0              | 14.3             | 14.3                  | 0.0                   |
| Pinus (other species) | 5                  | 80.0         | 20.0          |                |                     | 0.0              | 0.0              | 0.0                   | 80.0                  |
| Karri mixed           | 4                  | 50.0         |               |                |                     | 50.0             | 25.0             | 0.0                   | 25.0                  |
| Mallet                | 3                  | 0.0          |               | 33.3           | 0.0                 | 33.3             | 33.3             | 0.0                   | 0.0                   |
| Saltbush or Bluebush  | 3                  | 0.0          | 33.3          |                |                     | 0.0              | 66.7             | 0.0                   | 0.0                   |
| Mulga scrub           | 2                  | 0.0          |               | 50.0           |                     | 50.0             | 0.0              | 0.0                   | 0.0                   |
| <b>Total</b>          | <b>2,511</b>       |              |               |                |                     |                  |                  |                       |                       |

Source: WADEC 1999–2000 to 2002–03 [computer file]

**Figure 90: Cause of fire, by ecosystem damage (number)**



Source: WADEC 1999–2000 to 2002–03 [computer file]

## Summary

Western Australia incorporates approximately one-third of the Australian continent. Important points about vegetation fires in this state are summarised as:

- Australian Productivity Commission reports indicated that FESA and WADEC attended 11,842 fires in 2000–01 and 11,309 in 2001–02. This is marginally lower than the figures derived from the combined FESA and WADEC data, which indicated attendance at 12,486 fires in 2000–01 and 11,823 in 2001–02. While both data sources provide a broad guide as to the number of vegetation fires Western Australian fire services attended, it is recognised that actual number of fires may be somewhat higher owing to large numbers of natural and human-caused ignitions that took place in the tropical savannas of northern Western Australia, that are not attended by fire agencies.
- Between 90 and 95 percent of fires are attended by the Fire and Rescue Service (career and volunteer) and Bush Fire Service, and combined fire services like the volunteer Emergency Service Units, and hence are reported under the umbrella of FESA fire services. Less than 5 to 10 percent of fires are attended by WADEC.
- FESA and WADEC recorded peak numbers of fires for 2000–01. By 2005–06, the introduction of a number of measures to reduce vegetation fires, including targeted arson reduction programs had almost halved the number of vegetation fires attended in any one year. Hence, some specific observations made within this analysis are no longer relevant to the situation in Western Australia. However, the overarching generalisations about the typical causes, timing and distributions of vegetation fires are likely the same, and therefore of relevance to Western Australian fire services as well as fire services in other jurisdictions.

**Cause of fires:** Although the data available for the FESA analysis were incomplete, some broad generalisations can be made about the principal causes of fires in Western Australia, namely:

- Most fires in Western Australia were deliberate in origin; of the approximately 60 percent of FESA fires for which causal information was available for 2000–01 to 2001–02 in the AFAC–FESA database, 69 percent were deliberate (9% incendiary, 60% suspicious). Fifty-four percent of WADEC-attended fires from 1999–2000 to 2002–03 were also classified as deliberate (42% incendiary, 12% suspicious).

- Natural fires accounted for 22 percent of WADEC-attended fires but only 1.6 percent of fires documented in the AFAC–FESA database.
- Approximately 15 percent of AFAC–FESA and 13 percent of WADEC fires were classified as accidental. However, accidental fires WADEC attended principally resulted from escapes of non-WADEC burns (43%), accidental fires causes by industries (26%), and escapes from recreational fires (30%), whereas 47 percent of accidental AFAC–FESA fires were smoking-related, with a further 18 percent being non-deliberate child fires.
- Non-deliberate child fires accounted for 2.7 percent of AFAC–FESA fires for 2000–01 to 2001–02, but this likely significantly underestimates the role of children in vegetation fire ignitions, as many fires started by children were likely classified as incendiary or suspicious or the person responsible for fires was not identified.
- Twelve percent of AFAC–FESA vegetation fires were smoking-related.

**Location:** The location of vegetation fires is summarised in terms of geographic distribution (region, SSD, SLA, postcode) and complex type.

*Region/SSD/SLA/postcode:* The distribution of vegetation fires was intimately linked with distribution of people although no one-to-one correlation existed between population and the number of fires occurring in a given area (for example, postcode or SLA):

- Between 50 and 90 percent of all vegetation fires attended in Western Australia occurred in the Perth region, with the greatest numbers occurring in outer metropolitan SSDs.
- Population densities also affected fires attended in neighbouring reserves, national parks and state forests; 59 percent of all fires WADEC attended occurred in the Swan region.
- High densities of fires in regional areas were also associated with regional population centres.
- A small number of locations accounted for a high proportion of fires within individual areas, be they those areas characterised by low, moderate or very high numbers of vegetation fires; in the Perth region, the eight postcodes in the South East, seven in the North and four in the South West Metropolitan SSDs that recorded in excess of 200 vegetation fires (total) in two years were responsible for 66 to 83 percent of all fires in those SSDs, and were collectively responsible for approximately two-thirds of all fires in the Perth region.
- However, the degree of concentration/dispersal of vegetation varied between areas; in some areas very high fire numbers may have been experienced in just a couple of postcodes, whereas in other areas, moderately high numbers of fires occurred in most postcodes within that area.
- The number of deliberate fires correlated with total number of fires; regions, SSDs, SLAs and postcodes characterised by the highest numbers of fires were characterised by highest numbers of deliberate fires; high proportions of deliberate causes were recorded across all SSDs, SLAs and postcodes that recorded high numbers of fires overall.
- Individual postcodes in the Perth region typically recorded between five and 200 fires in total and between one and 100 deliberate fires, per 10,000 people per year (based on 2000–01 to 2001–02 data), although higher values were recorded in several postcodes. Maximum recorded values in 2001–02 have markedly reduced following introduction of targeted arson reduction measures.
- The distribution of non-deliberate child fires paralleled the distribution of vegetation fires generally; most occurred in the Perth region, with high numbers being observed in postcodes recording high numbers of fires generally. However, not all postcodes recording high numbers of fires also documented high numbers of non-deliberate child fires.

- The number of smoking-related fires also broadly correlated with the distribution of vegetation fires generally. However, smoking-related fires accounted for 49 percent of vegetation fires in the central Perth region, as compared with 12 to 18 percent of fires in outer metropolitan areas, and commonly two to four percent of vegetation fires in regional Western Australia.

*Complex:* Most vegetation fires occurred on unused property or Crown land, followed by parks and reserves, on roads, and around dwellings and schools. High proportions of deliberate fires were evident across all complexes that experienced high numbers of fires, although slightly lower rates along road complexes reflected increased proportions of smoking-related fires.

**Timing:** Important aspects of the timing of vegetation fires in Western Australia are summarised in terms of the time of the year, day of the week and the time of day at which they occurred.

*Week of the year:* Most fires, irrespective of cause, occurred during the bushfire danger season, which varies substantially across the state. Subtle variations were also evident between causes. Hence:

- FESA recorded high numbers of fires in the North West region from July to January; WADEC recorded higher numbers in the Kimberley from April to September and in the Pilbara from July to January.
- High fire numbers in the southern half of the state coincided with the summer months, although variations were evident with latitude and, in the case of WADEC-attended fires, by fire cause. FESA recorded the highest numbers of fires on the Coral Coast from mid October to mid January; a similar peak existed for the Perth region although fire numbers in that region remained elevated until late April. Fires were highest in the South West from mid October to mid February.
- The timing of the increase in fire numbers for both FESA and WADEC occurred at a similar time every year, but the cessation of the bushfire season was less predictable in the FESA data. The regularity in fire frequencies reflects the comparative predictability of climatic cycles in this region.
- Systematically higher weekly average fire numbers occurred late in the calendar year in virtually all SLAs in the Perth region. A similar trend was evident in the WADEC data for southern Western Australia.
- Where FESA typically recorded strong correspondence between the timing of deliberate and non-deliberate fires in a given year, differences were evident between the timing of accidental and deliberate fires WADEC attended, a reflection of the increase in the number of fires resulting from escapes of burn offs just before and after the bushfire season. Peak numbers of natural fires occurred from the beginning of December to the end of February.
- Increases in non-deliberate child fires commonly coincided with school holidays but spikes in fire frequency also occurred in the middle of the first and last terms of the school year.

*Day of the week:* Higher numbers of fires occurred on weekends relative to weekdays, but the proportion of fires occurring on a weekend were cause and location dependent.

- **AFAC–FESA:** 52 more deliberate fires occurred on Saturday and 46 percent more occurred on Sunday than on the average weekday; this compared with an increase of 36 percent and 21 percent on Saturday and Sunday, respectively, for accidental fires. Increased numbers of deliberate fires on weekends principally reflected an increase in the number of deliberate fires on Friday night–Saturday morning and Saturday night–Sunday morning. In relation to specific accidental causes, smoking-related fires were higher on Saturday but not Sunday, whereas 58 percent higher numbers of non-deliberate child fires occurred on both Saturday and Sunday relative to the weekday average.

- **WADEC:** recorded between 80 and 85 percent more deliberate fires on Saturday and Sunday than during the week. In contrast, 43 percent more accidental fires occurred on Sunday and 10 percent more on Saturday, relative to the weekday average. However, cause-specific variations were evident within the accidental category; escapes of recreational fires were more than twice as high on a weekend, but fires resulting from many industries were less frequent on weekends. Reduced numbers of weekend fires were evident during 2002–03, being comparable to that observed on weekdays; the decrease in deliberate fires on weekends was the principal contributor to reduced numbers of deliberate fires in 2002–03. It is unclear if or how this reduction in weekend fires relates to the introduction of arson prevention measures introduced by FESA and/or WADEC.

*Time of day:* Differences were evident in the timing of fires, based on cause, location and, in some cases, day of the week.

- **AFAC-FESA:** most non-deliberate fires occurred during daylight hours with peak numbers occurring between 2 and 3 pm. In contrast, deliberate fires defined a bimodal distribution, characterised by an asymmetrical daytime peak that reached a maximum at 3 to 4 pm – coincident with the peak in non-deliberate child fires – and a distinct ‘night’ peak, that reached a maximum at midnight. Half of all deliberate fires in the Perth and South West regions occurred between 7 pm and 6 am with 19 percent occurring between midnight and 6 am. Although deliberate fires at night occurred on all days of the week, the greatest number occurred on Friday night–Saturday morning and Saturday night–Sunday morning. Differences were, however, observed between locations.
- **WADEC:** peak numbers of accidental fires and prescribed burns (WADEC) occurred between 1 and 2 pm, whereas the peak in deliberate fires occurred between 3 and 5 pm. While only 22 percent and six percent of all WADEC-attended fires occurred between 6 pm and 6 am and between midnight and 6 am, respectively, 52 percent of deliberate fires occurred between 6 pm and 6 am, with 16 percent of deliberate fires occurring from midnight to 6 am.

**Area burned (WADEC only):** overall fire frequency decreased with fire size, irrespective of cause, but deliberate fires typically accounted for a decreased proportion, and natural fires contributed an increased proportion of fires as fire size increased. Statistics about total area burned were dominated by large fire events; the greatest total area was burned by natural fires; the largest areas were burned in 2002–03; the greatest total area was burned in the least populated regions (South Coast, Pilbara, Kimberley and Goldfields). Deliberate causes accounted for less than seven percent of the total area burned, with the largest areas burned by deliberate fires occurring in the Kimberley region (dominated by a single fire event). However, deliberate causes accounted for a higher proportion of the total area burned in both the Perth and South West regions, areas where deliberate fires are most problematic and fire size is generally smaller.

**Type of incident (FESA only):** 94 percent of fires FESA documented from 2000–01 to 2006–07 were scrub or bush and grass mixtures; and only 0.2 percent were forest or wood fires greater than one hectare.

**Vegetation (WADEC only):** The greatest numbers of fires occurred in northern jarrah and *Pinus pinaster*, principally within state forest plantations. Deliberate causes accounted for 54 percent of fires in northern jarrah and 86 percent of all fires in *Pinus pinaster*. High numbers of fires also occurred in species-rich Banksia woodlands, and heathlands, with deliberate fires accounting for 80 and 47 percent of fires in these locations, respectively. While fires were typically small, deliberate ignitions led to significant ecological damage. Deliberate ignitions were the leading cause of vegetation death in regenerating vegetation in conservation reserves. In addition, there are the potential impacts placed on specific vulnerable, endangered and rare flora and fauna. Deliberate ignitions were the only listed cause of fires in fire-sensitive ecosystems containing declared and rare fauna. Similarly, 23 of the 34 fires in Tuart reserves

– a species endemic to South West Western Australia – were deliberate, with deliberate ignitions being responsible for 80 percent of the total 695 ha of Tuart forest burned in the four year period.

Fire danger, fire restrictions and total fire bans (FESA only): The majority of fires in Western Australia occurred under high fire danger conditions, but only one percent of fires in the AFAC–FESA database occurred under extreme fire conditions. The distribution of recorded fire danger indices was largely in accord with the distribution of fire danger conditions experienced during the Western Australian bushfire danger season. Deliberate ignitions accounted for a decreased proportion of fires as fire danger increased from high to extreme. Three-quarters of the fires in Western Australia took place when no fire restrictions or bans were in place. Fires occurring during a total fire ban were most likely to take place in those areas that experienced high numbers of fires overall; almost 80 percent of fires lit during TFB occurred in the 24 postcodes that recorded 100 or more fires per year.

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