Department of Sustainability and Environment

Response of Orchids to Bushfire

Black Saturday Victoria 2009 – Natural values fire recovery program

Mike Duncan

Parks VICTORIA

Victoria We will rebuild

Response of Orchids to Bushfire

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Front Cover photograph: Close up of *Caladenia orientalis* flowers at Wilsons Promontory National Park (Mike Duncan).

All photographs in this report are by the author unless otherwise credited.

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Summary

This project addresses general community concerns about the response of orchids to the 2009 'Black Saturday' bushfires, by documenting the range of orchid responses encountered across all fire affected areas. The information presented in the report is the result of data synthesis and direct field observations from a variety of sources, collected during the two years since the fires.

The response of orchids to the February 2009 bushfires was diverse, spanning the spectrum from being killed by fire, to being totally dependent upon the fire to flower. In this report, the spectrum of responses that were encountered have been divided into five broad categories.

1. Fire Killed Species
Populations of epiphytes (e.g. *Sarcochilus australis*) and terrestrials with shallow tubers (e.g. *Thynninorchis huntianus*) were killed by the intense fire front. In some cases, these species are likely to recolonise by seed from nearby unburnt areas, but in other cases, these species may require conservation intervention to assist in their recovery.

2. Fire Sensitive Species
Species such as *Pterostylis alveata* and *Corunastylis despectans* appear to have been sensitive to the bushfire, showing a large reduction in emergence over the following two years. Populations of these species are likely to recover naturally over a number of years.

3. Fire Neutral Species
The response of the winter and spring flowering *Pterostylis* species were generally fire neutral, with their flowering rates neither increasing nor decreasing in the two years since the bushfire.

4. Fire Stimulated Species
The flowering of many *Caladenia, Diuris*, *Prasophyllum* and *Thelymitra* species was strongly stimulated by the 2009 bushfire, creating spectacular patches of massed flowering in the fire-blackened landscape. Similarly, many smaller genera (e.g. *Pheladenia* and *Glossodia*) also showed a strong increase in flowering in response to the bushfire, sometimes producing clumps of more than 20 flowering plants.

5. Fire Dependent Species
There are four species (*Burnettia cuneata*, *Pyrorchis nigricans*, *Leptoceras menziesii* and *Prasophyllum australe*) that are dependent upon fire to flower. These species are able to survive for extended periods without flowering. Stimulated by the occurrence of the 2009 bushfire, these four species flowered *en masse* during spring 2009 (and to a lesser extent in spring 2010); the first time most of these plants have flowered since each site was last burnt.

Four nationally threatened orchid species (*Caladenia concolor*, *C. orientalis*, *C. tessellata*, and *Pterostylis chlorogramma*) occur within the area affected by the 2009 bushfire. These species are part of an ongoing monitoring program, and the collected data offers an opportunity to quantify the post-fire flowering response of these species. The data showed that grazing had negatively impacted seed production in each species since the 2009 bushfire. It would also seem reasonable to assume that similarly high levels of grazing have occurred to other orchid species during this period. A reduction in seed production is an important concern to any orchid species, but it is of particular concern to fire sensitive species, as it will lengthen the recovery time for these populations. A reduction in seed production represents a lost opportunity for species that are fire stimulated or fire dependent, in terms of achieving recruitment to a population. Fire-affected populations of these species will require careful management to ensure that seed production is not compromised into the future.

1 Background

1.1 The 'Black Saturday' 2009 bushfires

Fire is an integral part of the ecology of the Victorian landscape (Gill 1993), and bushfires occur regularly. The 2009 bushfires, occurring at the end of a 10 year drought during an extremely hot, windy period of weather, burnt with great intensity. They consumed areas that are regularly burnt (e.g. Wilsons Promontory National Park (NP)), and in areas that had not seen a bushfire since the Ash Wednesday (1983) or Black Friday (1939) bushfires (e.g. Kinglake). As in all large fires the 2009 bushfire produced a mosaic of intensities, damage and responses. At one end of the scale the fire was incredibly intense, even killing trees, while at the other end of the scale the fire trickled through the landscape, removing only the litter layer. Other small areas escaped the fire altogether and remained as small 'islands of green'. Large fires such as Black Friday (1939), Ash Wednesday (1983) and Black Saturday (2009) can have a devastating and long-lasting effects on human communities, but this is not necessarily the case for plant communities as many species are able to resist, recover and proliferate following a fire (Gill 1993).

1.2 Victoria's Orchid Flora

It is estimated that there are about 25,000 species of orchids worldwide, which is about 10% of all plant species (Pridgeon 2005). Approximately 70% of these species are epiphytes (growing in trees), and they mainly occur in tropical or sub-tropical regions of the planet. The other 30% are terrestrial species (growing in the ground), and they tend to be most common in temperate regions such as Europe, North America, southern Africa, Argentina, and southern Australia. In fact, with more than 1000 species of terrestrial orchids (Jones 2006), southern Australia has the greatest diversity of terrestrial orchids in the world.

Victoria's terrestrial orchid flora is remarkably rich, with more than 360 recognised species (Jeanes and Backhouse 2006). While Victoria comprises only 3% of Australia's land area (ABS 2009), it is home to about 28% of Australia's orchid species. This is largely due to our huge diversity of habitats. From Mallee scrubland to alpine herbfields, and coastal heathlands to tall eucalypt forests, Victoria packs a large number of orchid species into a small area. However, many species are easily overlooked due to their generally small stature, and as a result many Victorians are unaware of the amazing wealth of orchids in their own backyard.

Victoria is a special place for orchids, with approximately 110 species being endemic to the state, and therefore do not occur anywhere else (Jeanes and Backhouse 2006). Unfortunately, many Victorian orchid species are also threatened with extinction. Seventy-five species are formally recognised as threatened in Victoria under the *Flora and Fauna Guarantee Act* (1988) (Backhouse 2007), while more than 250 species are considered to be of conservation concern (DSE 2005). Forty-seven Victorian orchid species are formally recognised as Nationally threatened under the *Environmental Protection and Biodiversity Conservation Act* (1999).

2 Project Rationale

Orchids are popular with the community and this report aims to address community concerns about the response of orchids to the 2009 bushfires, by documenting the range of responses encountered across all fire affected areas. A specific focus was given to the response of four Nationally threatened species (used as case studies) – *Caladenia concolor*, *C. orientalis*, *C. tessellata*, and *Pterostylis chlorogramma*. Management recommendations, in response to bushfire, are also made for these species.

The only absolute rule about orchids is that there's an exception to every rule. This is largely due to the huge diversity in orchid morphology, biology, and ecology. Victorian orchids are dormant over summer and flower during spring – no, not always. Terrestrial orchids sprout from a small underground tuber – no, not always. Victorian orchids are stimulated to flower following a fire – no, not always. In fact, the response of orchids to bushfire covers the spectrum from totally dependent upon fire to flower, to being killed by fire (Brown *et al.* 2008, Jones 2006, Backhouse and Jeanes 1995, Bates and Weber 1990, Jones 2006). However, the response of the majority of Victorian orchid species to fire falls somewhere in between.

In this report, the spectrum of responses to bushfire, displayed by Victorian orchid species, have been divided into five broad categories:

1. Fire Killed Species
2. Fire Sensitive Species
3. Fire Neutral Species
4. Fire Stimulated Species
5. Fire Dependent Species.

3 Discussion

In the following sections, the response of orchids in each of the above five categories will be discussed, using specific examples from the 2009 bushfire areas.

Nomenclature follows that of Walsh and Stajsic (2007).

3.1 Fire Killed Species

Relatively few of Victoria's orchid species are killed when exposed to a bushfire and these species tend to fall into two groups. Firstly, there are the evergreen epiphytic and lithophytic species that grow in trees or on exposed rock surfaces. All plant parts are aerial and therefore at risk of being burnt during an intense bushfire. The second group consists of (generally) small terrestrial orchids whose tubers occur in the leaf and bark litter or in the first few centimetres of soil. As a result, their tubers are highly susceptible to being burnt and killed in a bushfire. In general, only a portion of the population are killed in any one fire, and it tends to be individuals that occur near large quantities of fuel (Jones 1988).

Only one of Victoria's five epiphytic/lithophytic species occurs within the area affected by the 2009 bushfire. *Sarcochilus australis* is a small epiphytic orchid that uses its roots to attach itself to a host tree. It produces a tuft of up to a dozen leathery or fleshy leaves, and a pendulous stem with up to eight green, white and brownish flowers (Figure 1). Prior to the 2009 bushfire, *S. australis* grew on the branches of *Coprosma quadrifida*, *Pomaderris aspera* and other host species in small pockets of cool temperate rainforest gullies and adjoining wet sclerophyll forest, on the southern slopes of Kinglake National Park (NP). Rainforest gullies such as these often escape summer bushfire due to their location in the landscape and the higher moisture levels in the vegetation and soil. However, the severity of the 2009 bushfire meant that these rainforest gullies were intensely burnt.

Examination of a *S. australis* population in Kinglake NP occurred in October 2009 and 2010 and found no surviving plants. Adams and Lawson (1984) state that this species has little fire resistance due to its small water reserve. At Kinglake, in most cases both the plant and host branch had been consumed by the fire, but in a few cases there was evidence of dead, burnt plants on some *C. quadrifida* shrubs (Figure 1). A large number of deaths of *S. australis* plants were also reported in East Gippsland following the 1983 Ash Wednesday fires (Adams and Lawson 1984), and in Ferntree Gully following the 1962 Mt. Dandenong fire (Beardsall and Beardsall 1983). The Mt. Dandenong fire destroyed the large and long-established Ferntree Gully *S. australis* population, which had been visited as early as 1876 by the famous botanists Robert Fitzgerald and Baron Ferdinand von Mueller (Beardsell and Beardsell 1983).

Hopefully, some of the *S. australis* plants have survived in unburnt pockets of rainforest somewhere in the Kinglake NP area, and will be able to act as a seed source for the recovery of this population.

Figure 1. *Sarcochilus australis* plant with two flowering spikes (left), and a dead plant following the Kilmore East-Murrindindi Complex South fire (right). Both pictures were taken in Kinglake National Park.

Figure 2. *Sarcochilus australis* habitat in Kinglake National Park nine months (top) and 21 months (bottom) after the Kilmore East-Murrindindi Complex South fire.

Fire can be particularly damaging to epiphytic species. If a bushfire is sufficiently intense to reach the canopy, it can not only kill orchid plants (Brown *et al.* 2008, Jones *et al.* 1999, Backhouse and Jeanes 1995, Jones 1988, 2006), but potentially kill their host trees as well. This is what occurred in Kinglake NP following the 2009 bushfire. where a large proportion of the preferred host trees of *S. australis* were killed by the fire front (Figure 2). These host trees will regenerate over time, and it is therefore likely that the natural recovery of *S. australis* in Kinglake NP will be slow. This species may benefit from conservation intervention to assist it to return to pre-fire levels. For example, the planting of host trees should be considered, as well as the possible reintroduction of *S. australis* plants with a local provenance, which could act as a seed source.

A number of small terrestrial orchids have been reported as killed by fire (Backhouse and Jeanes 1995, Jones 2006, 2008, Brown *et al.* 2008). However, in the majority of cases, these are populations of fire sensitive species that have been killed as a result of the intensity of the fire, rather than a predisposition of the species to be killed by fire.

One species that tends to be regularly killed by bushfire is *Thynninorchis huntianus*. It is a tiny orchid with insect-like flowers which achieves pollination by deceiving native wasps into trying to mate with its hinged labellum. The shape of its labellum gives the orchid its common name, 'Elbow Orchid' (Figure 3). It has a tiny tuber and a superficial root system that is shallowly covered by soil and leaf litter (Jones 2006). Along with its summer flowering period, it appears that the orchid's tubers are too shallow for the soil to insulate them from the heat associated with a bushfire, and these characteristics make the orchid highly susceptible to fire (Jones 2006).

Figure 3. *Thynninorchis huntianus* flowers (prior to the Kilmore East-Murrindindi Complex South fire) at a site in Kinglake National Park. No plants of this species have been at this site since the fire.

Backhouse and Jeanes (1995) considered *T. huntianus* to be widespread and locally abundant, particularly in sub-alpine parts of the Eastern Highlands. However, large scale bushfires throughout this region in 2003 and 2006 have greatly impacted the abundance of this species in the Australian Capital Territory (ACT) (Jones 2008) and Victoria, with many populations being wiped out or severely reduced in size. A similar result was reported following the 1983 Ash Wednesday fires, with no *T. huntianus* plants seen in the Anglesea area for more than 20 years (E. Foster pers. comm.). *T. huntianus* has also shown a highly sensitive response to the 2009 bushfire, with no plants being seen at known sites in the Kinglake NP, Bunyip State Park (SP) and Yarra Ranges NP in the two years following the fire. As an example, *T. huntianus* occurs in the leaf litter and hard, rocky mudstone soils on the edge of certain tracks in Kinglake NP (Figure 4). Two years after the fire, the recovery of groundcover vegetation has been slow, and there has been no evidence of *T. huntianus* reappearing in this exposed habitat niche. It is hoped that small pockets of plants escaped the fire in Kinglake NP, as has been observed for the species in Bunyip SP. In Bunyip SP, surviving plants that have been observed in unburnt forest will hopefully provide seed that will eventually lead to the recovery of nearby fire-killed populations.

Similarly, a number of *Chiloglottis* species can be killed by fire if the fire front is particularly intense. These species are active during the fire season, and a bushfire can be responsible for a decline in the fecundity of such species. *C. valida* and *C. cornuta* both occur throughout the area affected by the 2009 bushfire. Both species flower in late spring and summer, and produce a pair of ground-hugging leaves, with a small, single flower produced on a short stem in the centre of the leaves (Figure 5). During previous large-scale bushfires (2003 Great Alpine Fire), *C. valida* populations were reported to be completely destroyed or reduced to just a few individuals in the ACT (Jones 2008), and also in the hills above Omeo. In the 2009 bushfire, *C. valida* appears to have suffered a similar fate in Kinglake NP, with no signs of any flowering plants in some pre-existing populations in the two years following the fire. At Wilsons Promontory NP and Lake Mountain the results are more promising. While some populations in the Lilly Pilly Gully area appear to have been adversely affected by the bushfire (reduced number of emergent individuals), the majority of *C. valida* and *C. cornuta* populations surveyed during this project appear to have survived in both locations.

Figure 4. *Thynninorchis huntianus* habitat in Kinglake National Park (December 2010) following the Kilmore East-Murrindindi Complex South fire.

Figure 5. *Chiloglottis valida* plant that has survived the 2009 bushfire in Wilsons Promontory National Park (November 2010).

3.2 Fire Sensitive Species

Some orchid species are inhibited by bushfire, rather than killed. In particular, many autumn and winter flowering orchid species are inhibited by fires, while spring flowering species are not (Jones 1988). Many of these species suffer a reduction in flowering for one or a few seasons following a fire (Jones 1988). Historically, *Acianthus*, *Corybas*, *Corunastylis*, *Microtis* and *Pterostylis* species have been reported to be inhibited by fire, recovering after the surrounding bush recovers (Jones *et al.* 1999; Backhouse and Jeanes 1995). However, while the response of these orchids has been quite variable, this was not strictly observed in the first two years following the 2009 bushfire. The following examples illustrate the generally positive response from these genera observed in the aftermath of this bushfire. Those species and populations that have shown a negative response to the 2009 bushfire can be expected to naturally recover over the next few years.

Flowering of *Acianthus* and *Cyrtostylis* species has been previously reported to be inhibited by fires that occurred during the previous summer (Backhouse and Jeanes 1995). However, following the 2009 bushfire, *A. pusillus* flowered in good numbers in Bunyip SP and Wilsons Promontory NP, as did *A. caudatus* at Bunyip SP, Wilsons Promontory NP and Won Wron State Forest (SF) (Figure 6). Numerous seed pods were also observed. Similarly, *Cyrtostylis reniformis* and several *Corybas* species (*C. aconitiflorus*, *C. diemenicus*, *C. fimbriatus* and *C. unguiculatus*) flowered well following the bushfire in Wilsons Promontory NP (Figures 6 and 7), and *C. reniformis* also flowered well at Mt. Jack SF and Bunyip SP. In all cases, flowering appeared to be unaffected by the bushfire.

Figure 6. *Acianthus caudatus* plant (left), and a seed pod (centre), and an albino *Cyrtostylis reniformis* plant (right), following the 2009 bushfire in Wilsons Promontory National Park.

On the other hand, *Corunastylis despectans* has not been seen at a number of sites in Kinglake NP since the bushfire, suggesting that flowering has either been inhibited, or that some individuals were killed by the often very intense fire (Figure 8). The recovery of this species is likely to take a number of years. *C. despectans* has been observed flowering at pre-fire levels in Bunyip SP and therefore the effect of the 2009 bushfires on this species appears to have varied from site to site.

Similarly, *Microtis* species have exhibited a hugely variable response to bushfire. While they are commonly reported to be sensitive to fire, Jones (1988) has seen flowering of species (*M. unifolia*, *M. parviflora* and *M. rara*) in this genus stimulated by fire in some cases, and inhibited in others. Similarly, the author has seen *M. oblonga* show a strong flowering response in the Wonnangatta valley following the 2003 Great Alpine Fire, while *M. oblonga* and *M. unifolia* show increased flowering following a bushfire in the Grampians NP in 1999. In the two years since the 2009 bushfire, *M. unifolia* at Wilsons Promontory NP and Bunyip SP, and *M parviflora* at Bunyip SP, have both been observed flowering at pre-fire rates. The bushfire appears to have had no negative impacts on either of these potentially fire sensitive species.

Figure 7. *Corybas diemenicus* (left) and *C. fimbriatus* (right) both flowered in good numbers following the 2009 bushfire in Wilsons Promontory National Park.

Figure 8. *Corunastylis despectans* habitat in Kinglake National Park (October 2009), severely burnt during the Kilmore East-Murrindindi Complex South fire.

Jones and Clements (2002) have reported that no *Pterostylis* species are stimulated to flower by fire. It is generally accepted that flowering by *Pterostylis* species is suppressed by hot summer fires, until a suitable microhabitat returns (Jones and Clements 2002). In particular, it is believed that the autumn flowering *Pterostylis* species are often negatively impacted in the first few years after a fire (Jones and Clements 2002).

Numerous autumn flowering *Pterostylis species* occur in the areas affected by the 2009 bushfires. *P. alveata* at Wilsons Promontory NP showed a lower flowering rate than had been observed prior to the bushfire (Figure 9). Similarly, the flowering of *P. grandiflora* in Won Wron SF appeared to be negatively impacted at some sites by the 2009 bushfire. On the other hand, the flowering of *P. striata* and *P. sanguinea* at Wilsons Promontory NP, *P. parviflora* at Bunyip SP, Kinglake NP and Wilsons Promontory NP appeared to be as normal. *P. parviflora* has been previously reported to be occasionally inhibited by bushfire (Jones 1988).

Figure 9. Flowering in a *Pterostylis alveata* population prior to the 2009 bushfire in Wilsons Promontory National Park.

3.3 Fire Neutral Species

Pterostylis is a large and diverse genus. While many autumn flowering *Pterostylis* species are inhibited by summer bushfire, the many winter and early spring flowering *Pterostylis* species are generally considered to be fire neutral. That is, they survive the fire and their flowering neither increases nor decreases in the years following the fire. The flowering of species such as *P. tasmanica* (Figure 10), *P. cucullata* subsp. *cucullata* and *P. foliata* at Wilsons Promontory NP, *P. nana* at Won Wron SF, *P. nutans* and *P. pedunculata* at Mt. Jack SF, Wilsons Promontory NP and Won Wron SF, *P. monticola* (Figure 11) at Lake Mountain, and *P. alpina* at Mt. Jack SF was unaffected by fire. However, there was an exception. The flowering of *P. alpina* populations was inhibited by the 2009 bushfire in the northern section of Mt. Disappointment SF. This area was severely burnt and appears to have negatively affected *P. alpina* populations, with only a few scattered individuals flowering in the first two years following the bushfire. This may be due to the direct impact of the intense fire on the *P. alpina* tubers, but it may also be due to the indirect impact of the fire removing much of the pre-existing overstorey and understorey (Figure 12). This may inhibit flowering of the species, as *P. alpina* usually grows in protected, damp sites (Backhouse and Jeanes 1995). If this is the case, it can be expected that the *P. alpina* population will recover over time as vegetation regenerates.

Figure 10. Close up of a *Pterostylis tasmanica* flower in Wilsons Promontory National Park following the 2009 bushfire.

Figure 11. *Pterostylis monticola* plants (circled) flowering on the roadside at Lake Mountain (January 2011), following the Kilmore East-Murrindindi Complex North fire.

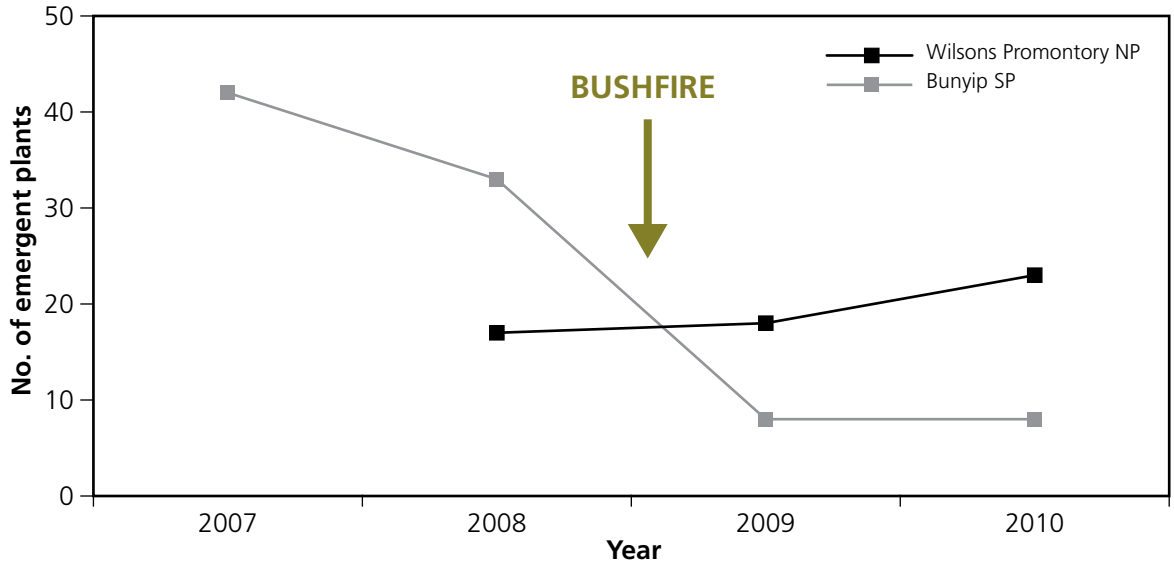
Figure 12. Severely burnt *Pterostylis alpina* habitat in Mt. Disappointment State Forest (October 2010) following the Kilmore East-Murrindindi Complex North fire.

Three members of the Tall Greenhood (*P. longifolia*) complex occurred within the area affected by the 2009 bushfire: *P. chlorogramma* at Bunyip SP and Wilsons Promontory NP (Figure 13); *P. melagramma* at Bunyip SP, Mt. Jack SF and Won Wron SF; and *P. tunstallii* at Wilsons Promontory NP. All of these species generally showed a neutral response to the bushfire and flowered as if the fire had not occurred. *P. chlorogramma* is Nationally listed as a Vulnerable species, and as such populations of this species at both Bunyip SP and Wilsons Promontory NP have been monitored prior to and following the 2009 bushfire. As a result, it is possible to quantify the post-fire flowering response of this species (Figure 14).

At Wilsons Promontory NP, the number of emergent *P. chlorogramma* plants did not vary greatly before (2008) or after (2009 and 2010) the bushfire. Variation in the number of emergent plants was within the range of variation that occurs naturally from year to year. Conversely, at Bunyip SP, the number of emergent *P. chlorogramma* plants did show a large change following the bushfire. At this site, the number of emergent plants was greater than 30 for the two years prior to the bushfire, while the number of emergent plants was less than 10 for the two years since the fire. Thus, the bushfire appears to have inhibited the emergence of *P. chlorogramma* plants at this site. Many of the *P. chlorogramma* plants at this site occur in the shallow soil around the edge of flat granite outcrops, and as a result they may have been more greatly impacted by the high intensity of the bushfire as it passed through this area, leading to an inhibition of flowering. Ongoing monitoring of this population will be necessary to determine if these plants are dormant or were killed by the intensity of the 2009 bushfire.

Figure 13. Close up of a *Pterostylis chlorogramma* flower in Bunyip State Park following the 2009 bushfire.

Figure 14. The number of emergent *Pterostylis chlorogramma* plants prior to and following the 2009 bushfires at Wilsons Promontory National Park and Bunyip State Park.



The fate of each *P. chlorogramma* flower produced at both these sites was monitored (Figure 15). In the monitored population at Bunyip SP, between 7% and 8% of all flowers produced a seed pod in the years prior to the bushfire. However, in the two years since the bushfire, not only has there been a reduction in the number of emergent plants (and therefore the total number of flowers), there has only been one *P. chlorogramma* seed pod produced. A major factor that is limiting seed pod production is the alarming rise in grazing that is occurring at this site, with 85% of flowers grazed in 2010. Thus, it is a high priority management action for *P. chlorogramma* plants to be protected from grazing by erecting cages, which has already been done at some sites (Figure 16). It is also important that these cages are sealed, as grazing of some flowering *P. chlorogramma* plants in open-topped cages was observed in spring 2010. This grazing was most likely caused by macropods (kangaroos and/or wallabies) and/or Samba Deer, all of which would be able to push their mouths into open-topped cages.

The level of grazing of *P. chlorogramma* flowers was also high following the bushfire in a population in Wilsons Promontory NP, with 26% of flowers being grazed in 2010 (Figure 15). Therefore, grazing appears to be a significant issue for *P. chlorogramma* in the years following a bushfire, and could be expected to be a problem for other fire neutral species.

A range of other orchid species have a neutral or very slight flowering response following a bushfire. For example, *Calochilus* species have been previously reported to be inhibited by summer fire (Backhouse and Jeanes 1995, Jones 1988), while others have noted that some species are fire stimulated (Jones *et al.* 1999). The author has seen *C. paludosus* and *C. robertsonii* flower strongly following the 2006 Grampians bushfire, *C. paludosus* following the 2006 Moondarra bushfire, and *C. paludosus* and *C. herbaceus* following the 2008/09 Cann River-Genoa bushfire. However, there were no reports of a similar post-fire flowering response by any *Calochilus* species following the 2009 bushfire. For example, *C. paludosus* and *C. robertsonii* in Bunyip SP and *C. campestris* and *C. robertsonii* in Wilsons Promontory NP all flowered following the 2009 bushfire, but at about the same rates as they flowered in the years prior to the fire.

Caleana major is one of Victoria's most unique looking orchids, and its appearance has led to it being commonly known as the 'flying duck orchid' (Figure 17). It mainly forms colonies in bare areas of well-drained gravely or sandy soils, where it receives little competition from other plants, and no impediment to flowering. Because of the low amount of vegetation in the area immediately surrounding this species, bushfires often jump these areas, leaving *C. major* populations unburnt or only lightly burnt. The usual changes in the local environmental conditions caused by a bushfire tend to have little impact on the micro-climate associated with *C. major* populations. For example, a bushfire usually removes the understorey vegetation, and opens up the canopy, allowing more light to reach the ground. However, because the ground is naturally bare and open in the vicinity of *C. major* populations, the occurrence of a bushfire tends to have no effect. *C. major*, a free-flowering species, continues to flower at the same level following a fire, and this is what was observed in numerous *C. major* populations in Bunyip SP and Won Wron SF following the 2009 bushfire.

Figure 15. The fate of individual *Pterostylis chlorogramma* flowers prior to and following the 2009 bushfire at Bunyip State Park, and (to the right of the dashed line) in 2010 at Wilsons Promontory National Park.

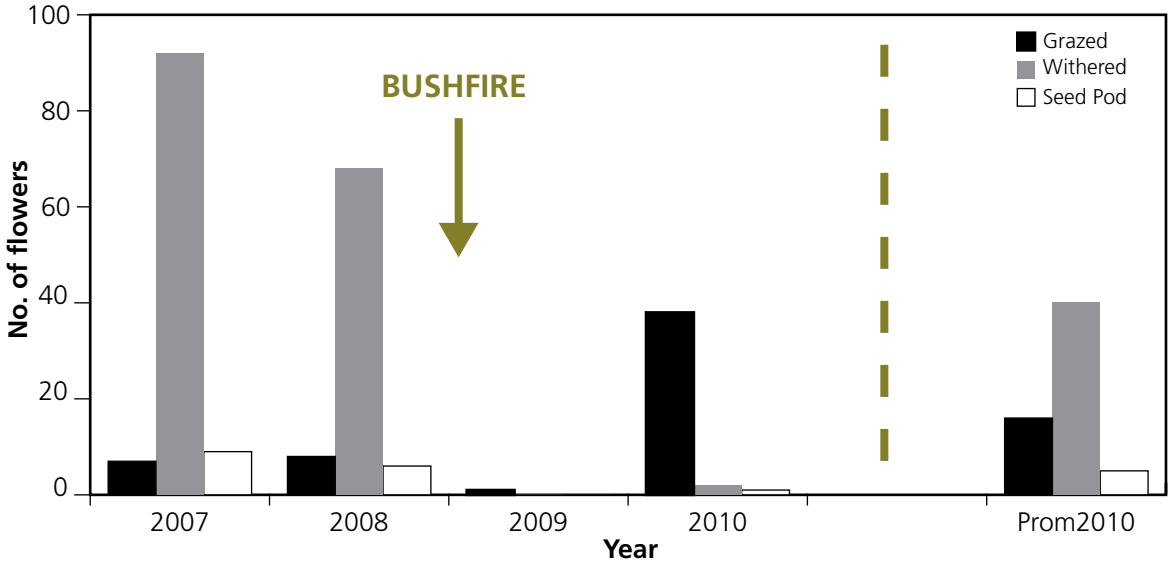


Figure 16. Monitoring a *Pterostylis chlorogramma* population in Bunyip State Park (August 2010) following the 2009 bushfire. Some plants are caged.

Figure 17. Close up of a *Caleana major* flower in Won Wron State Forest (left) and a *Spiranthes australis* flower (right) following the 2009 bushfire.

Lyperanthus suaveolens is the eastern Australian representative of a genus of only two species (the other – *L. serratus* – occurring in southwest Western Australia). This species has sometimes been reported as being sensitive to summer bushfire (Jones 1988), but more commonly as being neutral to summer bushfire (Backhouse and Jeanes 1995, Jones *et al.* 1999, Jones and Clements 1994). The author has seen *L. suaveolens* show a mild flowering response following a 2004/05 bushfire near Genoa. A neutral flowering response by this species to the 2009 bushfire was observed at sites in Wilsons Promontory NP and Won Wron SF.

Spiranthes australis produces an attractive, spiralling, multi-flowered spike of pink and white flowers (Figure 17). This species has been previously reported to be inhibited by summer fire (Backhouse and Jeanes 1995, Jones 1988), but there was no observed change in the post-fire flowering response of this species in Wilsons Promontory NP following the 2009 bushfire. *S. australis* generally occurs in permanently damp areas in swamps and along streamsides that often don't burn as intensely as the surrounding vegetation (if at all). Inhibition of *S. australis* flowering is most likely to result from hot fires that burn these areas intensely. However, as the intensity of the 2009 bushfire in the northern section of Wilsons Promontory NP was relatively low, *S. australis* flowering was not inhibited, and post-fire flowering response was neutral.

The flowering of *Orthoceras strictum* has been previously reported to be stimulated by summer fire (Backhouse and Jeanes 1995); however no flowering response was observed in Wilsons Promontory NP following the 2009 bushfire. This species occurs in the same northern section of the park as *S. australis*, where *O. strictum* flowers freely in the low heathy vegetation that occurs on the slight rises above the swamp margins where *S. australis* grows. Following the relatively low intensity of the 2009 bushfire in this area, *O. strictum* has continued to flower freely, and has shown no evidence of an increased flowering rate during the subsequent two years.

3.4 Fire Stimulated Species

Fire is important for many Victorian orchids and most significant Victorian habitats for orchids are regularly burnt (Jones 1988). Many orchid species in these habitats not only survive a fire, they have adopted fire as a major component of their life cycle, flowering more profusely following a summer bushfire (Jones 1988, 2006, Jones and Jones 2000, Gill 1981, 1993, Wark *et al.* 1987, Coates and Duncan 2009, Calder *et al.* 1989, Roe 2004). In particular, a number of large Victorian orchid genera including *Caladenia, Diuris*, *Prasophyllum* and *Thelymitra* respond dramatically to bushfire, and these post-fire floral displays can be an impressive sight. Orchids are often more robust in the burnt ground (due to increased light reaching the ground, and increased nutrient availability in the mineral-rich ash bed), and are often more visible once the surrounding vegetation has been removed (Jones 1988).

Long unburnt areas often have high levels of litter on the ground, leading to reduced flowering, smaller leaves, and a high rate of dormancy. Bushfires in these areas tend to be very intense due to the high fuel loads, and often lead to a dramatic orchid flowering response, as was observed in the ACT following the Great Alpine Fires in 2003 or in Victoria following the Ash Wednesday fires in 1983 (Jones 1988, 2006, 2008). For example, Jones (2008) reported that both *Prasophyllum brevilabre* and *Caladenia montana* showed a strong post-fire flowering response in the ACT following the 2003 bushfire. A similar strong post-fire flowering response has been observed in many areas following the 2009 bushfire.

The flowering rate of a large number of orchid species has dramatically increased in the two years since the 2009 bushfire (Figure 18). Small flowered *Caladenia* species such as *C. catenata* (Figure 18a) at Bunyip SP and Won Wron SF, *C. praecox* (Figure 19) at Bunyip SP and Kinglake NP, *C. carnea* at Bunyip SP, Mt. Jack SF, Wilsons Promontory NP and Won Wron SF, *C. gracilis* at Kinglake NP and Won Wron SF, *C. alata* at Won Wron SF, and *C. latifolia* (Figure 18d), *C. transitoria*, *C. aurantiaca* (Figure 20) and *C. pusilla* at Wilsons Promontory NP were all strongly stimulated to flower by the 2009 bushfire. These species have small to tiny flowers that occur as scattered individuals in the absence of fire. However, following the 2009 bushfire these species appeared in loose groups, adding colourful white or pink spots to an otherwise blackened landscape.

Figure 18. Various orchids that were stimulated to flower following the 2009 bushfire. a) *Caladenia catenata* (Won Wron State Forest); b) *Diuris pardina* (Mt. Jack State Forest); c) *Prasophyllum lindleyanum* (Wilsons Promontory National Park); d) *Caladenia latifolia* (Wilsons Promontory National Park; e) *Thelymitra ixioides* (Kinglake National Park); f) *Prasophyllum elatum* (Wilsons Promontory National Park); g) *Caladenia clavigera* (Wilsons Promontory National Park); h) *Diuris orientis* (Bunyip State Park); i) *Thelymitra rubra* (Kinglake National Park); and j) *Glossodia major* (Won Wron State Park).

Figure 19. A close up of a *Caladenia praecox* plant at Bunyip State Park following the 2009 bushfire.

Figure 20. A close up of a *Caladenia aurantiaca* flower at Wilsons Promontory National Park following the 2009 bushfire.

Much more obvious are the large flowered *Caladenia* species, commonly referred to as spider orchids (Figures 18g and 21). The common name refers to the long, thin, tapering, and often drooping floral segments (Figure 21). Species such as *C. phaeoclavia* at Bunyip SP, Mt. Jack SF, and Wilsons Promontory NP, *C. concolor* (Figure 21) at Mt. Jack SF, *C. tentaculata* at Wilsons Promontory NP and Won Wron SF, and *C. clavigera* (Figure 18g), *C. orientalis*, *C. dilatata*, *C. tessellata*, *C. australis*, and *C.* (x) *variabilis* at Wilsons Promontory NP were all strongly stimulated to flower by the 2009 bushfire. At Wilsons Promontory NP in particular, there were fields of spider orchids in the heathlands of the northern section of the park in spring 2009 and 2010.

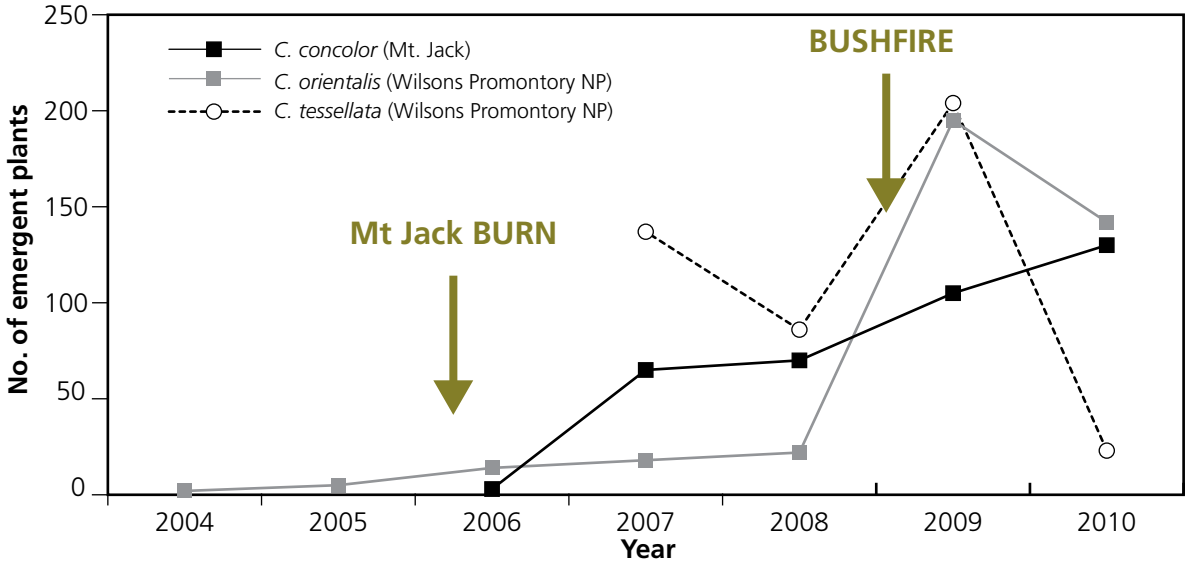
Figure 21. A close up of *a Caladenia concolor* flower at Mt. Jack State Forest following the Library Road (Beechworth) fire.

Three of these *Caladenia* species (*C. concolor*, *C. orientalis* and *C. tessellata*) are Nationally listed as Vulnerable, Endangered and Vulnerable respectively (DSE 2005), and as a result selected populations are the subject of ongoing monitoring programs (Figure 22). The data collected prior to and following the 2009 bushfire clearly illustrates an increased level of emergence in populations of each species stimulated by the bushfire in January 2009 (Figure 23). However, the data also highlights that while *Caladenia* species are stimulated by bushfire, the post-fire flowering response can vary between species and/or sites. The *C. orientalis* population in Wilsons Promontory NP showed a 10-fold increase in emergence from spring 2008 to spring 2009, with this response being slightly diminished in spring 2010. In the same park, a *C. tessellata* population also showed a strong increase in emergence from spring 2008 to spring 2009. However, the post-fire flowering response lasted only one year, with only a very small proportion of plants emerging again in spring 2010. This drop possibly reflects that there is a cost of reproduction for this species, in that the extra energy required by a plant to produce a flower and possibly a seed pod depletes the resources of the tuber, thus reducing the probability of the plant re-emerging during the next year. This cost of reproduction has been observed in other *Caladenia* species (Coates and Duncan 2009).

Finally, the *C. concolor* population at Mt. Jack SF showed a considerable increase in emergence from spring 2008 to spring 2009, but this increase continued in spring 2010, rather than waning as it did in the other two species. In addition, more than 20 seedlings were recorded in 2010. This continued response may reflect the favourable environmental conditions that occurred in northeast Victoria in 2009 and particularly in 2010, but this cannot be proven. The data also shows that almost no plants emerged in spring 2006 due either to the lateness of a fuel reduction burn (May 2006) or the prevailing drought conditions at that time. As a result, the full extent of this population was not established until the following spring (2007) when detailed site survey was carried out.

Figure22. Department of Sustainability and Environment, and Southern Cross University staff monitoring the flowering response of a *Caladenia concolor* population at Mt. Jack State Forest following the Library Road (Beechworth) fire.

Figure 23. The number of emergent plants of three *Caladenia* species prior to and following the 2009 bushfire at Mt. Jack State Forest and Wilsons Promontory National Park.



During the 2010 flowering season, the fate of the flowers in a population of each of these three Nationally threatened *Caladenia* species were measured (Figure 24). In both species that occur at Wilsons Promontory NP, the most common fate of a flower was to be grazed. Fifty-five percent of the *C. orientalis* flowers and 50% of the *C. tessellata* flowers were grazed, clearly demonstrating that the potential benefits of the post-fire flowering response, such as increased seed production and therefore increased recruitment of new individuals, was severely limited by grazing. In the *C. orientalis* population, 30% of flowers successfully produced seed pods, which is a relatively good rate for a species employing sexual deception as its pollination strategy (Tremblay *et al.* 2005). On the other hand, only 10% of *C. tessellata* flowers successfully produced seed pods in 2010. This low rate of seed production is a concern for the recovery of *C. tessellata*, and this species is likely to benefit from caging of individuals, fencing of populations, and hand pollination of flowers to increase seed production.

A study of plants in permanent plots at Wilsons Promontory NP shows that while some seed pods are being produced, the impact of grazing in the post-fire environment is also a serious concern for the recovery of *C. orientalis* (Figure 25). Prior to the 2009 bushfire, a *C. orientalis* population at Wilsons Promontory NP was fenced to protect it from grazing, trampling and accidental destruction. Following the bushfire, *C. orientalis* plants were found over a much wider area, both inside and outside the fenced area (Figure 26). In the two years following the bushfire, two thirds of the flowers outside the fence were grazed, while only one plant was grazed inside the fence. This flower was probably grazed by invertebrates (e.g. caterpillars), while the wider grazing problem in the park is related to large macropods (kangaroos, wallabies and deer). *C. orientalis* is likely to benefit from caging of individuals, fencing of populations, and hand pollination of flowers to increase seed production.

Figure 24. The fate of *Caladenia* flowers in three populations during spring 2010 (second year since the 2009 bushfire).

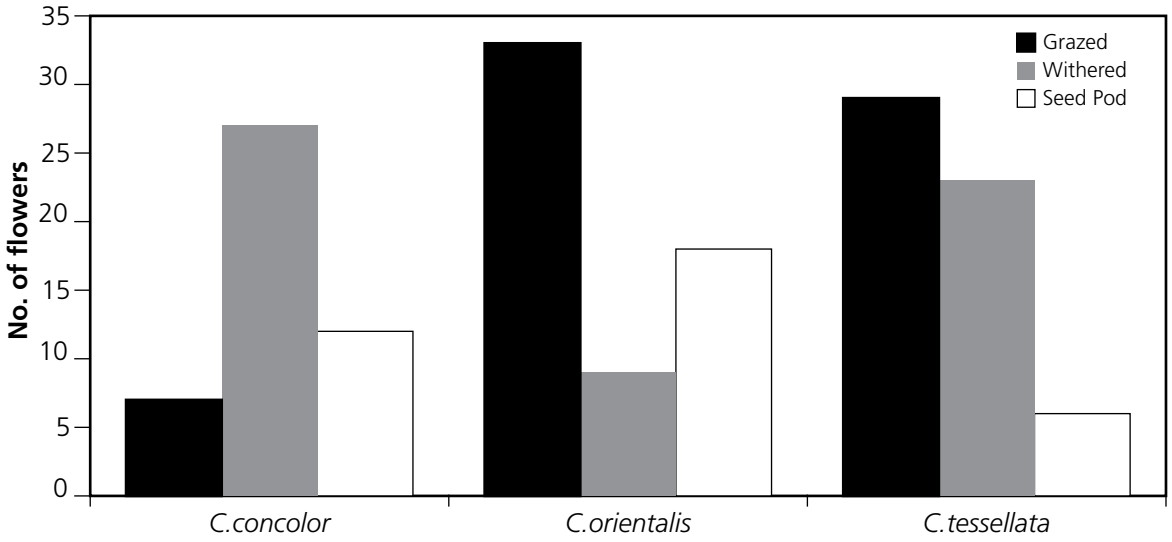
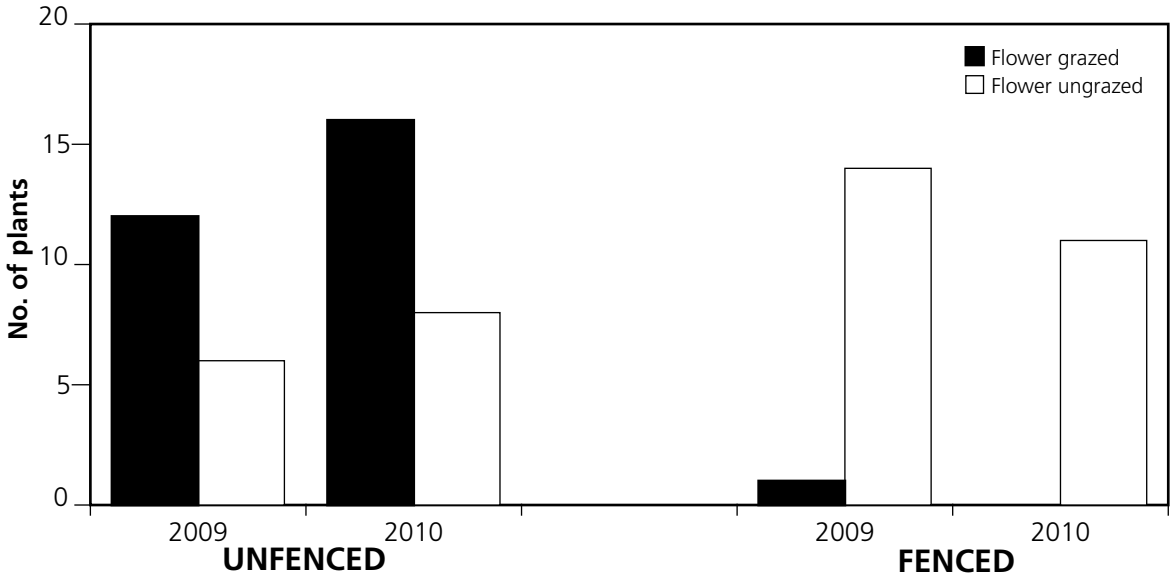


Figure 25. Uncaged and grazed *Caladenia orientalis* plants (left), and a caged and fertilised *Caladenia orientalis* flower, with a developing seed pod (right), in Wilsons Promontory National Park following the Cathedral fire.

Figure 26. Elevated view of a fenced *Caladenia orientalis* population in Wilsons Promontory National Park approximately 8 months (top) and 20 months (bottom) after the Cathedral fire.

Figure 27. Impact of grazing on *Caladenia orientalis* plants in fenced and unfenced permanent plots in Wilsons Promontory National Park during the first two years following the Cathedral fire.



The strong stimulation of flowering that occurs in many orchid species following a bushfire also offers a great opportunity to search for and discover new populations. Jones (2008) reported that new populations of *Calochilus therophilus*, *Microtis oblonga* and other species were discovered in the ACT following the 2003 Great Alpine Fire. To capitalise on this window of opportunity, a search weekend was organised at Wilsons Promontory NP to try and discover new populations of *C. orientalis* and *C. tessellata*. Members of the 'Promenades' (a Friends of Wilsons Promontory Group) and the Australasian Native Orchid Society (Victorian Group), a conservation volunteer group, joined DSE and PV staff for the search. They not only located 28 orchid species in flower but also located multiple new populations of both target species, some comprising more than 100 individuals. By the end of the weekend everyone was tired, blackened by the burnt landscape, and very happy (Figure 28).

Figure 28. A happy orchid enthusiast who was part of a group that found new populations of two Nationally Threatened species, during a search weekend in Wilsons Promontory National Park (photo: Emma Roe).

Figure 29. A close up of a *Prasophyllum odoratum* spike (left) and flower (right) in Bunyip State Park following the 2009 bushfire.

In addition to the *Caladenia* species, populations of *Prasophyllum lindleyanum* were also found during the search weekend (Figure 18c). This species was previously known from the northern section of Wilsons Promontory NP, but had not been seen for more than 20 years. Numerous flowering plants were discovered in other locations. A number of other *Prasophyllum* species flowered *en masse* following the 2009 bushfire. Species such as *P. pyriforme* at Steels Creek, *P. brevilabre* at Kinglake NP and Wilsons Promontory NP, *P. alpestre* at Lake Mountain, *P. elatum* (Figure 18f) at Wilsons Promontory NP and Bunyip SP, and *P. odoratum* (Figure 29) at Bunyip SP were all stimulated to flower by the 2009 bushfire. Many of these species flower at very low rates in the absence of a summer bushfire, and then flower prolifically in the year after a fire. Their flowering response often only lasts for a single year, with only a small fraction of the plants flowering again in the second year after a bushfire. It is often not possible to see these species in flower in the years between fire events.

Diuris species flower more freely, with scattered individuals flowering annually in the absence of fire. However, it is only in the first few years following a bushfire that it becomes obvious just how common these species can be. Following the 2009 bushfires, species such as *D. sulphurea* at Bunyip SP, *D. orientis* (Figure 18h) at Kinglake NP, Bunyip SP, Won Wron SF and Wilsons Promontory NP, and *D. pardina* (Figure 18b) at Kinglake NP, Mt. Jack SF, Won Wron SF and Wilsons Promontory NP all flowered at an increased rate. The colourful, relatively large, predominantly yellow and brown flowers of these species are a pleasant sight and easily spotted in the post-fire environment. The flowers of these species mimic the shape and colour of native peas. While the pea flowers offer their pollinator a nectar reward, the orchids trick the same pollinators into visiting their flowers while offering no reward (Backhouse and Jeanes 1995, Jones 1988, 2006).

An even more beautiful sight in the post-fire environment is the mass flowering of colourful *Thelymitra* species. This genus has the common name of sun orchids, because their flowers generally only open on warm, sunny days. Their blue, pink, yellow or mauve flowers can be a spectacular sight. Following the 2009 bushfires, *Thelymitra* species including *T. carnea*, *T. media* and *T. holmesii* at Bunyip SP, *T. aristata* at Bunyip SP and Wilsons Promontory

NP, *T. ixioides* (Figure 18e) at Bunyip SP, Kinglake NP and Wilsons Promontory NP, *T. pauciflora* and *T. rubra* (Figure 18i) at Kinglake NP and Wilsons Promontory NP, *T. cyanea* (Figure 30) at Lake Mountain, and *T. antennifera*, *T. flexuosa*, *T. benthamiana*, and *T. mucida* at Wilsons Promontory NP were all stimulated to flower.

In addition to these large genera, there are a range of smaller genera that also display a strong flowering response to summer bushfires. For example, the metre high candy pink flowering spikes of *Dipodium roseum* (Figure 31) were a common and striking sight at Bunyip SP, Kinglake NP, Yarra Ranges NP, Won Wron SF and Wilsons Promontory NP in the two years following the 2009 bushfires. These wholly pink and reddish spikes are leafless and therefore unable to produce their own energy (i.e. they lack chlorophyll). The plants are instead dependent upon a symbiotic relationship they have with mycorrhizal fungi in the soil, and a nearby host tree (Jones 2006). At the other end of the scale, a carpet of the tiny yellowish-green flower spikes of *Microtidium atratum* could be seen in damp, swampy areas in Bunyip SP (Figure 32). The whole spike of these plants is less than 100 mm high and individual flowers are only 1–2 mm wide. As a result, this species can be easily overlooked.

On the other hand, *Glossodia major* is a common and widespread species throughout Victoria, and its large, widely opening, purplish-blue flowers will be familiar to many (Figure 18j). It is a free-flowering species, but has an increased flowering rate in response to a bushfire. This was observed at Bunyip SP, Kinglake NP, Mt. Jack SF, Wilsons Promontory NP, and Won Wron SF following the 2009 bushfires.

Finally, *Pheladenia deformis* is another orchid species that is stimulated to flower by summer bushfire (Figure 33). This species flowers freely in the Wimmera region of western Victoria, but elsewhere, flowering individuals are rarely seen in the absence of fire. That is, this species is almost fire-dependent in southeast Victoria. At Wilsons Promontory NP, hundreds of *P. deformis* plants flowered in spring 2009 in spots where flowering individuals had been rarely observed in the past and therefore the post-fire flowering response of this species was very strong. Adding to the spectacle of hundreds of these purplish flowers appearing in the burnt heathland, *P. deformis* has a tendency towards a clumping habit, so dozens of groups containing up to 20 flowering plants created a beautiful post-fire sight.

Figure 30. A close up of a *Thelymitra cyanea* flower at Lake Mountain following the 2009 bushfire.

Figure 31. A close up of a *Dipodium roseum* flower spike near Marysville following the 2009 bushfire.

Figure 32. Mass flowering (left) and a close up of a *Microtidium atratum* flower (right) at Bunyip State Park following the 2009 bushfire.

Figure 33. Mass flowering (left) and developing seed pods (right) of *Pheladenia deformis* in Wilsons Promontory National Park following the 2009 bushfire.

3.5 Fire Dependent Species

While many Victorian orchid species are stimulated to flower by a bushfire, some are totally dependent upon fire to flower. These species have evolved their whole life cycle around only flowering in the year (or occasionally a couple of years) following a bushfire. While the removal of competing vegetation (such as tall growing grasses), and an increase in available nutrients may both play a role in breaking dormancy in these species (Dixon and Tremblay 2009), the main factor stimulating mass flowering is believed to be the ethylene gas released during the passing of a fire front (Brown *et al.* 2008, Jeanes and Backhouse 1995, Dixon and Tremblay 2009, Dixon and Barrett 2003). Ethylene is known to induce flowering and fruit ripening in other plants, and has been reported to stimulate flowering in numerous orchid species (Jones 1988, Dixon and Tremblay 2009). The horticultural practice of enclosing a ripened banana in a plastic bag with a pot of summer-dormant orchid tubers often elicits a flowering response similar to that of the post-fire environment (Dixon and Tremblay 2009).

Jones (1988) reported that only three orchid species in southeast Australia were dependent upon fire to flower – *Burnettia cuneata*, *Pyrorchis nigricans* and *Leptoceras menziesii*. However, *Prasophyllum australe* should be added to this group. All four fire dependent species occur within the area affected by the 2009 bushfire, and all showed a strong flowering response.

Figure 34. Close up of a *Burnettia cuneata* plant in Wilsons Promontory National Park following the Cathedral fire.

One species that is rarely seen is *B. cuneata*. It spends most of its life cycle underground as a small dormant tuber. During this period, which may last for many decades, it is probably dependent upon a mycorrhizal fungus for its nutrient supply (Backhouse and Jeanes 1995). However, this all changes following a bushfire, when the period of dormancy is broken and *B. cuneata* plants are stimulated to flower *en masse*.

This phenomenon occurred at Wilsons Promontory NP following the 2009 bushfire. Mass flowering of *B. cuneata* plants was observed in the moist, peaty soils associated with closed *Melaleuca squarrosa* swamps in the northern section of the park in late September and October 2009 (Figure 34). Hundreds of short, fleshy, dark reddish brown stems were seen emerging from the charred soil. Each plant has one to five whitish flowers that open fully for just a few days in warm weather. All plants then die after flowering, and as a result reproduction is entirely from seed (Backhouse and Jeanes 1995). These seeds will germinate and develop into a tuber, and then wait underground for the next fire to arrive.

This flowering response only lasts for the first year after a fire (Jones *et al.* 1999; Backhouse and Jeanes 1995, Jones and Jones 2000), and its brevity can be best illustrated by the observation that no flowering *B. cuneata* plants were reported in Wilsons Promontory NP during the second spring after the bushfire (i.e. Sept–Oct 2010). However, it should be noted that the odd *B. cuneata* flower has been previously reported during the second spring following a fire at other sites (Backhouse and Jeanes 1995, Jones *et al.* 1999), and has been observed by the author at Cape Liptrap.

Like *B. cuneata*, *P. nigricans* and *L. menziesii* are largely dependent upon bushfire to flower. However unlike *B. cuneata*, in the absence of fire both these species produce extensive colonies of ground-hugging leaves (Figures 35 and 36). *P. nigricans* produces large, thick, fleshy, dark green leaves that are commonly referred to as 'elephant's ears', while *L. menziesii* produces smaller,

Figure 35. *Pyrorchis nigricans* leaves in unburnt forest.

Figure 36. *Leptoceras menziesii* colony in unburnt forest. The colony consists entirely of vegetative plants with small false buds (no flowering individuals).

narrower, hairless, bright green leaves, with a ligule at its base (Backhouse and Jeanes 1995, Jones *et al.* 1999) which is often mistaken for a developing flower bud. In the interval between fires, both these species reproduce vegetatively by forming new tubers. As a result, large and dense colonies of both species can be a common sight during spring.

While it is relatively easy to find colonies of these species, it is much more difficult to see these colonies in flower. Odd flowers of each species are occasionally found in the absence of fire (Jones 1988). In Victoria, mass flowering of *P. nigricans* was observed in Bunyip SP and Wilsons Promontory NP (Figure 37), and of *L. menziesii* in the Yarram area and Wilsons Promontory NP (Figure 38) in September and October 2009. The post-fire flowering response was largely restricted to the first spring following the fire, with less than 5% of *P. nigricans* plants, and only the odd *L. menziesii* plant, flowering again in 2010.

Both species have attractive, unmistakeable, red and white coloured flowers. The flowers of *P. nigricans* are red and white striped, and have a strongly hooded dorsal sepal. Interestingly, their flowers possess the unusual feature of turning black as they age, leading to its common name of the 'undertaker orchid'. This species is also one of a minority of Australian orchid species that produce a nectar reward for its pollinator (Hoffman and Brown 1992). On the other hand, the red and white flowers of *L. menziesii* can be distinguished by the pair of dark red, erect, ear-like dorsal petals, which lead to its common name of the 'rabbit orchid' (Figure 38).

Figure 37. Mass flowering of a *Pyrorchis nigricans* colony in Wilsons Promontory National Park (September 2009) following the Cathedral fire.

Figure 38. Close up of a *Leptoceras menziesii* plant in Wilsons Promontory National Park (September 2009) following the Cathedral fire.

In the absence of fire, the large, robust, tall flowering spikes of *P. australe* occur as occasional, widely scattered individuals (Backhouse and Jeanes 1995). However, following a summer bushfire, there can be up to a 500 fold increase in the number of flowering individuals. Thus, while *P. australe* is not completely dependent upon fire to stimulate flowering, the vast majority of individuals break dormancy and produce metre high flowering spikes in response to a summer bushfire (Figure 39). This phenomenon was observed in Wilsons Promontory NP following the 2009 bushfire, with hundreds of *P. australe* plants flowering in November and December 2009, in an area where this species had not been seen for more than 15 years. Similarly, a large population of *P. australe* plants flowered in the burnt area of Bunyip SP. The post-fire flowering response of *P. australe* is more long-lived than that of the other fire dependent orchid species (*B. cuneata*, *P. nigricans* and *L. menziesii*), with approximately one third of flowering plants reappearing in early summer 2010. The duration of the flowering response of *P. australe* appears to be primarily limited by the recovery of the surrounding swampy heathland vegetation, which usually becomes thick and covers any bare ground within about five years.

Figure 39. Close up of a *Prasophyllum australe* flowering spike in Wilsons Promontory National Park (December 2009) following the Cathedral fire.

4 Conclusions

The response of Victorian orchids to a summer bushfire is diverse, spanning the spectrum from fire killed to fire dependent. The response of orchids to the 2009 bushfire has reflected this spectrum, with populations of *Sarcochilus australis* and *Thynninorchis huntianus* being killed by the intense fire front. These species may require conservation intervention to assist in their recovery. Other species, such as *Pterostylis alveata* and *Corunastylis despectans* have been sensitive to the bushfire, showing a reduction in emergence for one or more years. Populations of these species are likely to recover slowly over a number of years. Winter and spring flowering *Pterostylis* species were generally fire neutral, with flowering rates neither increasing nor decreasing in the two years since the bushfire. One exception was the Nationally threatened *P. chlorogramma* at Bunyip SP, where the number of emergent plants since the bushfire has only been one third of that recorded prior to the fire. The recovery of this population should be monitored closely. The flowering of many *Caladenia*, *Diuris*, *Prasophyllum* and *Thelymitra* species was stimulated by the 2009 bushfires in many areas, creating spectacular patches of massed flowering in fire-blackened landscapes. Similarly, many smaller genera also showed a strong increase in flowering in response to the bushfires. And finally, a few species (*Burnettia cuneata*, *Pyrorchis nigricans*, *Leptoceras menziesii* and *Prasophyllum australe*) were fire dependent, having extended periods of dormancy broken by the 2009 bushfires, and flowered at sites for the first time since they were last burnt.

Some orchid species showed a response to the 2009 bushfires that varied from its published response to previous summer fires. For example, *Acianthus Corybas*, *Cyrtostylis* and *Microtis* species have been reported to be fire sensitive, but they appear to have suffered few if any negative effects from the 2009 bushfires. On the other hand, *Calochilus* species, *Caleana major* and *Orthoceras strictum* have previously been reported to have their flowering stimulated by a bushfire, while their response to the 2009 bushfires was neutral.

Monitoring of all four Nationally threatened species (*Caladenia concolor*, *C. orientalis*, *C. tessellata*, and *Pterostylis chlorogramma*) that occurred within the area affected by the 2009 bushfires has shown that grazing is an important factor that is limiting seed production in the years following a bushfire. It would also seem reasonable to assume that similarly high levels of grazing were occurring to other orchid species during this period. A reduction in seed production is an important concern to any orchid species, but it is of particular concern to fire sensitive species, as it will lengthen the recovery time for these populations. A reduction in seed production represents an opportunity lost for species that are fire simulated or fire dependent, in terms of achieving recruitment to a population.

References

ABS (2009). Land area and population for Australia states and territories: June 2007. Australian Bureau of Statistics. www/abs/gov/au

Adams, P.B. and Lawson S.D. (1984). The effects of bushfire on Victorian epiphytic and lithophytic orchids. *Orchadian* **7 (12)**, 282–286.

Backhouse, G.N. (2007). Are our orchids safe down under? A national assessment of threatened orchids in Australia. *Lankesteriana* **7 (1–2)**, 28–43.

Backhouse, G.N. and Jeanes, J.A. (1995). The Orchids of Victoria. Melbourne University Press, Melbourne.

Bates, R.J. and Weber, J.Z. (1990). Orchids of South Australia. Government Printer, South Australia.

Beardsall, C. and Beardsall, D. (1983). A Year of Orchids. Richard Griffin Publisher, Melbourne.

Brown, A.P., Dundas, P., Dixon, K.W. and Hopper, S.D. (2008). Orchids of Western Australia. University of Western Australia Press, Nedlands.

Calder, D.M., Cropper, S.C. and Tonkinson, D. (1989). The ecology of *Thelymitra epipactoides* in Victoria, Australia, and the implications for management of the species. *Australian Journal of Botany* **37**, 19–32.

Coates, F.C. and Duncan, M.J. (2009). Demographic variation between populations of *Caladenia orientalis* – a fire-managed threatened orchid. *Australian Journal of Botany* **57**, 326–339.

Dixon, K.W. and Barrett, R.L. (2003). Defining the role of fire in south-west Western Australian plants. In 'Fire in ecosystems of south-west Western Australia: impacts and management'. (Eds I Abbott, N Burrows) pp. 205–223. Backhuys Publishers, The Netherlands.

Dixon, K.W. and Tremblay, R.L. (2009). Biology and natural history of *Caladenia*. *Australian Journal of Botany* **57**, 247–258.

DSE (2005). Advisory list of rare or threatened plants in Victoria – 2005. Department of Sustainability and Environment, Melbourne.

Gill, A.M. (1981). Coping with Fire. *In*, The Biology of Australian Plants. Eds JS Pate and AJ McComb. University of Western Australia Press, Nedlands.

Gill, A.M. (1993). Interplay of Victoria's Flora with Fire. *In*, Flora of Victoria Volume 1 Introduction. Eds DB Foreman and NG Walsh. Inkata Press, Melbourne.

Hoffman, N. and Brown, A. (1992). Orchids of South-West Australia (2nd edition). University of Western Australia Press, Perth.

Jeanes, J.A. and Backhouse, G.N. (2006). Wild Orchids of Victoria Australia. Aquatic Photographics, Melbourne.

Jones, D.L. (1988). Native Orchids of Australia. Reed Books, Sydney.

Jones, D.L. (2006). A Complete Guide to Native Orchids of Australia including the Island Territories. Reed New Holland, Sydney.

Jones, D.L. (2008). Field Guide to the Orchids of the Australian Capital Territory. National Parks Association of the ACT, Canberra,

Jones, D.L. and Clements, M.A. (1994). *Pyrorchis*, a new genus of Orchidaceae from Australia. *Phytologia* **77 (6)**, 447–451.

Jones, D.L. and Clements, M.A. (2002). Australian Orchid Research Volume 4: A Review of *Pterostylis*. Australian Orchid Foundation, Melbourne.

Jones, D.L. and Jones, B. (2000). A Field Guide to the Native Orchids of Southern Australia. Blooming Books, Melbourne.

Jones, D., Wapstra, H., Tonelli, P. and Harris, S. (1999). The Orchids of Tasmania. Melbourne University Press, Melbourne.

Pridgeon, A. (2005). What Orchid is That? Lansdowne Press, Sydney.

Roe, E. (2004). Monitoring and management of the metallic sun-orchid *Thelymitra epipactoides* at Blond Bay Wildlife and State Game Reserve, East Gippsland 1995–2004. Department of Sustainability and Environment, Bairnsdale.

Tremblay, R.L., Ackerman, J.D., Zimmerman, J.K. and Calvo, R.N. (2005). Variation in sexual reproduction in orchids and its evolutionary consequences: a spasmodic journey to diversification. *Biological Journal of the Linnean Society* **84**, 1–54.

Walsh, N.G. and Stajsic, V. (2007). A Census of the Vascular Plants of Victoria. National Herbarium of Victoria, Royal Botanic Gardens, Melbourne.

Wark, M.C., White, M.D., Robertson, D.J. and Marriott, P.F. (1987). Regeneration of heath and heath woodland in the north-eastern Otway Ranges following the bushfire of February 1983. *Proceedings of the Royal Society of Victoria* **99**, 51–88.

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