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OBSERVATIONS FROM A POST-FIRE NATIVE ORCHID SURVEY AT FOUL BAY, S.A., 2008

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SUMMARY

In December 2007, an intense bush fire burnt 4.65 km^2 of native coastal mallee vegetation in Foul Bay, on the southern Yorke Peninsula, South Australia. A survey was conducted for native orchids the following winter and spring. Prior to the survey, 12 species of native orchid, from eight genera were known from the area. Thirty-two species of native orchid, from 12 genera are now recorded. This includes four listed threatened species: *Caladenia brumalis* (vulnerable in SA and nationally); *Prasophyllum calcicola* (vulnerable in SA); *Caladenia fuliginosa*$^{\alpha}$ (rare in SA) and *Caladenia bicalliata* (rare in SA). Due to a lack of pre-fire data, it is unknown whether the observed diversity and density of orchids was related to the fire event. The increase in the number of species recorded was most likely attributed to the targeted survey effort rather than a response to fire. A lack of evidence of autumn flowering orchids in the burn area may suggest they were negatively impacted by the fire. Permanent monitoring plots have been established at key sites identified during the post-fire surveys, to assist ongoing monitoring.

INTRODUCTION

Fire is a natural event that has influenced the composition and density of plant communities across Australia throughout time (Gill and Bradstock 1995; Jones et al. 2006). The impact of fire depends on four inter-related components:

- Timing (eg season);
- Frequency (i.e. fire intervals);
- Intensity and;
- Scale/spatial characteristics (Gill 1974, 2001).

The combination of these components will result in different responses of plant biota (Tozer and Bradstock 2002). The variation in response is related to species' life history attributes (Benson 1985; Gill 1996) and factors such as rainfall and weather patterns pre and post-fire, interspecific competition, herbivory and local environmental and climatic variations (Burgman and Lamont 1992; Bradstock et al. 1997; Clarke et al. 1996; Siddiqi et al. 1975; Tozer and Bradstock 2002).

$^{\alpha}$ Refers to a combination name. Currently accepted name does not appear in Barker et al. 2005

In southern Australia, wildfire events typically occur in the hot, dry summer months. Coastal mallee and heath communities are particularly 'fire-prone' because the vegetation is highly flammable and because of the drying effect of direct exposure to wind and solar radiation (Clarke et al. 1996; Keith et al. 2002; Tozer and Bradstock 2002). Many native plants display adaptive response to cope with fire, and some require periodic fire to stimulate flowering or germination (Bradstock and Auld 1995; Siddiqi et al. 1975).

There is little known regarding the population ecology of native orchids, including their response to fire (Weston et al. 2005). There is a popularly held generalisation that fire benefits native orchids (Barnett 1984). There are many accounts of prolific flowering and increase in seed set of orchids following fire (eg Adams and Lawson 1993; Backhouse and Jeanes 1995; Barnett 1984; Bates 1981, 1984; Calder et al. 1989; Coates et al. 2006; Coleman 1992; CSIRO no date; Janeckova et al. 2006; Jones 2006; Jones et al. 2006; Norton and De Lange 2003). Some orchids (eg certain species of *Caladenia*, *Diuris*, *Eriochilus*, *Microtis* and *Prasophyllum*) are reported to depend on fire for flowering (Adams and Lawson 1993; Jones et al. 2006). Fire could have short term or lasting adverse effects on some orchid species (Barnett 1984); the impact depending (among other factors) on fire intensity, timing and frequency.

Native orchids die back to a dormant underground tuber over summer, avoiding the stresses of heat and dryness. This trait may assist them to tolerate summer fires. In the absence of fire, the shrub layer becomes progressively denser, increasing the fuel load and likelihood of an intense fire. The shading and competitive effects of increase in shrub density can promote increased periods of dormancy and cause a significant reduction in the number of terrestrial orchids that flower (Coates and Duncan 2009; Coates et al. 2006; Grant and Koch 2003; Janeckova et al. 2006; Wake 2007). Fire may assist orchid species by opening up the ground cover and reducing competition for light (Bates 1984, 1996; Carstairs and Coates 1994; Coleman 1992; Grant and Loneragan 1999; Grove et al. 1986; Janeckova et al. 2006; Jones et al. 2006; Wake 2007). The ash produced from fire is thought to increase nutrient levels in the soil which may assist orchid growth and recruitment (Barnett 1984; Bates 1984; Humphreys and Craig 1981).

Fire could negatively impact on orchid species if the heat kills the orchid tubers and if the ground cover and mycorrhizal fungi important to their survival are destroyed (Barnett 1984). Fire may have a greater impact if it occurs whilst a species is in leaf, flowering or in fruit. This could be detrimental to the plant, or destroy the reproductive effort for that year and weaken the tubers by reducing the photosynthetic period of the growing season, possibly also resulting in reduced flowering the following season (Carstairs and Coates 1994; NSW NPWS 2002; Quarmby et al. 2008; Weston et al. 2005).

The limited information that exists on the response of orchid species to fire is based on observational accounts from years immediately following fire. At the time of writing this report there were no published long term or scientifically designed studies relating to Australian orchids and fire known to the authors. Burning and fire stimulation trials have been undertaken in South Australia and Western Australia to assess the impact on orchid growth but the results have not been published (DEC 2008; Quarmby et al. 2008). In May 2009, a three year research project was announced at the Royal Melbourne Institute of Technology (Helen Macpherson Smith Trust 2009) to investigate the impact of fire on orchids in Victoria, and to find out how fire affects the mycorrhizal fungi on which the orchids depend for survival.

Following the fire at Foul Bay in December 2007 a post-fire search for native orchids was undertaken with key aims being to improve knowledge of: the species/genera occurring in the area; their distribution and conservation status; and their response to fire.

BACKGROUND

Site Description

The survey was undertaken on two properties (Allotment 101; 0.4 km^2 & Sections 88, 89, 90, 91, 166; 8.5 km^2 total), located in the Hundred of Coonarie, Foul Bay, on southern Yorke Peninsula, South Australia (35°12'S, 137°12'E, ca 280 km from Adelaide) (Figure 1). The survey area forms part of a larger area of native vegetation protected under Heritage Agreement (# 1040). The Heritage Agreement covers 13.5 km^2, representing one of the largest contiguous blocks of native vegetation under private ownership on Southern Yorke Peninsula. It is situated less than a kilometre from the coast and is adjoined by, and in close proximity to other large patches of native vegetation.

The broad structural formation of the native vegetation is open low mallee. The dominant overstorey is *Eucalyptus diversifolia* ssp. *diversifolia* over a predominant understorey of *Acacia* sp., *Melaleuca* sp., *Acrotriche* sp., *Hibbertia* sp., *Lomandra* sp., *Beyeria lechenaultii* and *Lasiopetalum schulzenii* (DEH 1984). The soils are shallow calcareous sands overlaying aeolianite limestone (DEH 2003).

Based on information from the nearest weather stations (Stenhouse Bay, 25 km SW of Foul Bay; Warooka, 29 km N of Foul Bay; see Appendix), the area experiences a mean annual rainfall of 445 mm, with the highest rainfall occurring between May and August. Rainfall can vary considerably from year to year. The annual rainfall for the years 2006 to 2008 was less than the mean. Daily maximum temperatures range from 42.9ºC in January to 9.2ºC in July, and daily minimum temperatures range from 25.9ºC in December to 3.8ºC in July (Commonwealth of Australia 2009).

Site History

The survey area was first under pastoral lease in 1851 and the virgin scrub was cleared in 1950 for agricultural pursuits. A fire went through in 1958, resulting in a cool burn which assisted regeneration (May, K. pers. comm.; DEH fire burn year mapping layer). The land was placed under a Heritage Agreement (# 1040) in 1994 and was mostly under single ownership until 2006, when the comprising allotments were sold to individual parties.

Pre-fire data

Table 1 lists the native orchid species recorded for the Heritage Agreement area prior to the 2007 fire. Information on the orchid flora was limited to five 30 m by 30 m sites surveyed in October 2004 by the Department for Environment and Heritage (DEH 2008), as part of the Biological Survey of the Mid North and Yorke Peninsula of South Australia (Neagle 2008). Eleven species from eight genera were recorded during this survey (three of the eight genera were not identified to species level). An additional species, *Caladenia fuliginosa*[α], was opportunistically sighted on one property in 2007, but the exact location was not recorded.

The five survey sites established by DEH are referred to in this report as sites 1 through to 5 (locations shown in Figure 1). All of these sites fell within the survey area and were burnt by the fire.

	Survey sites					
	1	**2**	**3**	**4**	**5**	**Opportune**
Burnt (B) or Unburnt (U) after Dec 2007	B	B	B	B	B	B
Caladenia cardiochila			✓			
Caladenia fuliginosa[α]						✓
Caladenia latifolia					✓	
Corybas sp.					✓	
Cyrtostylis robusta					✓	
Diuris orientis					✓	
Microtis sp.	✓		✓	✓		
Pheladenia deformis					✓	
Pterostylis longifolia				✓		
Pterostylis robusta					✓	
Pterostylis sanguinea					✓	
Thelymitra sp.	✓	✓			✓	

[α] previously known as *Caladenia fragrantissima* ssp. *fragrantissima*

Table 1. Orchid species known to occur within Heritage Agreement 1040 prior to the fire of 2007

2007 Bushfire

An intense bush fire (believed to be triggered by lightning hitting a power pole) went through the Foul Bay area in December 2007. The fire burnt a total area of 5.9 km^2. Approximately one third (4.65 km^2) of the vegetation forming Heritage Agreement 1040 was burnt. The fire scar is shown in Figure 1. An aerial view of the vegetation before and after the fire is shown in Figure 2.

METHODOLOGY

In winter (16-17 August) and spring (6-7 September) of 2008, targeted search for native orchids was undertaken by 12 members of the Native Orchid Society of SA (N.O.S.S.A.), along with property owners and other volunteers. An informal, ramble survey method was adopted, with a determination to cover as much of the burn zone within the specified survey area as possible (with a particular focus on Allotment 101). As is usually the case with hot fires, small pockets of vegetation were missed in the burn. These areas received considerable attention (due to the observed diversity of orchids present) and served as useful comparison with the burnt areas. A large portion of sections 91 and 166 were unburnt, and received some survey effort. Two members made a follow-up visit on the 15th of October 2008 to check a few specific records. A three hour search was also undertaken (by one person) on Allotment 101 for autumn flowering orchids in April 2009.

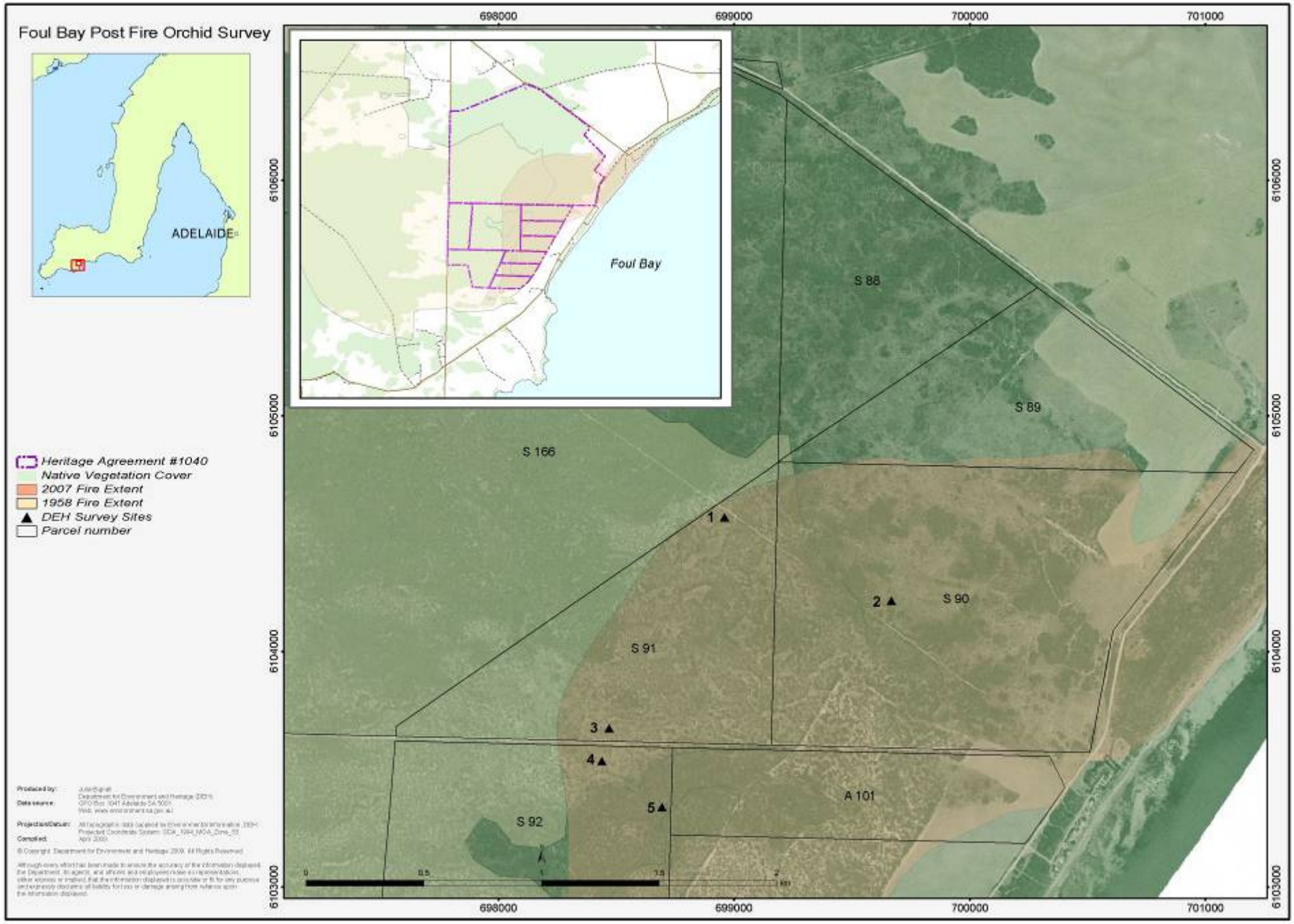

Figure 1. Location of Foul Bay Orchid Survey. Source: Department for Environment and Heritage.

(a)

(b)

Figure 2. Aerial view (looking west) of Heritage Agreement # 1040, in 2002 (a) and in 2008 (b), after the December 2007 fire. Source: Coast Protection Board.

RESULTS AND DISCUSSION

Thirty-two species of orchids were identified, with two others possible but not fully confirmed, and one hybrid. The diversity of orchids recorded from the survey area is considered high, and compares to that recorded at nearby Innes National Park (Houston, C. pers. obs.). A summary of the results is provided in Table 2.

Of the species found, twelve were of conservation significance, including *Caladenia brumalis*, listed nationally under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and *Caladenia bicalliata, Caladenia fuliginosa*$^{\alpha}$ and *Prasophyllum calcicola* listed in South Australia under the *National Parks and Wildlife Act 1972* (2008 update). A number of species are also considered threatened on a regional and sub-regional level (Gillam and Urban 2008).

Orchid response to fire

None of the known fire dependent orchid species (as identified in existing literature) were located in the survey area (N.B. *Prasophyllum elatum* may have been present but was not confirmed). The lack of pre-fire data meant it was impossible to know whether the pattern, abundance and diversity of recorded orchids was related to the fire event.

It would appear that autumn flowering species were adversely affected by the fire. Although the survey was conducted in winter and spring, flowering of *Genoplesium* could be ascertained by the occurrence of dried seed pods, most flowering resulting in a very reasonable pollination rate (Houston, C. pers. obs.). Three species were present, viz. *Genoplesium* (*Corunastylis*) *tepperi*$^{\alpha}$ (previously *Genoplesium nigricans*), *Genoplesium* aff. *rufum* and *Eriochilus cucullatus.* The latter puts up a flower in about April before the leaf appears. Dehisced pods were noted in the survey, so pollination had occurred and seed had already been released. *Genoplesium* produce the flower spike from within the sheathing leaf which is not apparent as a leaf once the plant is in flower. Only one report of *G*. aff. *rufum* was made, this being in sandy mallee heath. It is by far the least observed of the *Genoplesium* on Yorke Peninsula, *G. tepperi*$^{\alpha}$ being widespread and common. All records of these three species were from unburnt areas. This raises conjecture about what happened to the plants. Perhaps the tubers were damaged by the hot fire, the conditions unsuitable for growth or the timing following the heat insufficient for flowering. A brief search in autumn 2009 found three flowering plants in an unburnt patch within the burn area, but none were found in the burnt area. It remains to be seen if flowering plants will appear in the burnt areas in the following years. [N.B. There are a number of *Eriochilus cucullatus* records near Survey site 1 (see Foul Bay_Orchid_Map_Eriochilus) [Not provided with Supplement] which appear to be within the fire area, however, this is a patch of unburnt mallee/heath.]

Thelymitra species are one of the earliest emerging plants in a new season. *Thelymitra* aff. *nuda* was observed in numbers in the unburnt areas, under and near the base of mallee trees, especially in bark litter. No observations were made in burnt areas.

Acianthus (*Nemacianthus*) *caudatus* is discussed in "Orchids of Conservation Significance" (see below). In view of the specific habitat requirements of this species (and preference for very heavy leaf litter) it is likely plants did not survive in the burnt areas.

Pterostylis (*Plumatichilos*) *plumosa* is another species which was not seen in burnt areas (see "Orchids of Conservation Significance" below).

Many *Caladenia* species are reported to respond favourably to hot summer fires (Barnett 1984; Bates 1996, 2009; Jones 2006; Quarmby 2006). *Caladenia* (*Arachnorchis* group) were recorded in the burnt areas and the areas that the burn missed at Foul Bay, but were not in high abundance.

Caladenia (*Petalochilus*) *carnea* was recorded in exceedingly low numbers. This may well be due to the fact that it is not readily noticed when in leaf stage, and even if it was the similarity to that of *Caladenia capillata* makes it hard to distinguish. Also, flowering time was after the timing of the surveys and in bud it is still not very conspicuous, when at that time, surveyors were concentrating mainly on flowering plants. Therefore, it is impossible to say whether this species was well represented in the area or not and if it responded to the fire. Clayson (1979) observed three times more plants in flower in a burnt area following a hot summer fire in the South-East of the state.

Pterostylis (*Oligochaetochilus*) sp.

The rufa group of greenhoods is found across a wide range of habitats and rainfall areas. They have a rosette on the ground and flowering often occurs late in the year after the leaves have dried. Three plants were recorded during the winter survey in an unburnt area. There was no confirmation of species since they were not seen in bud or in flower. During a follow-up trip in October the plants were unlocated, possibly due to the dry spring season. Greenhood orchids have previously been reported to decline immediately after fire (Barnett 1984; Quarmby, J. pers. comm.) with flowering increasing with time since fire (Bates, R. pers comm.; Quarmby 2006). The shallow depth of *Pterostylis* tubers in the soil could make them vulnerable to fire (Barnett 1984).

In general, the diversity and abundance of orchids in the immediate burn area at Foul Bay were much less than in the small patches of adjacent vegetation that the fire missed. These small unburnt patches would have still been heat affected and may have benefited from an increase in soil nutrients resulting from the fire.

Barnett (1984) reported several orchid species flowering in greater numbers for a few metres either side of the burnt area in the year following a burn.

Species List		Conservation rating				Survey timing						
Scientific name	**Common name**	**National**	**State**	**Regional**	**Sub-region**	**Winter**	**Stage**	**Spring**	**Stage**	**Notes**	**Burnt**	**Unburnt**
						16,17Aug		6,7Sept				
Acianthus (*Nemacianthus*) *caudatus* †	Mayfly orchid			CR	CR		b		f	Second record of this species for Yorke Peninsula.		
Acianthus pusillus	Mosquito orchid											
Caladenia (*Arachnorchis*) *brumalis*	Winter spider orchid	V	V	E	V		f		fo			
Caladenia (*Arachnorchis*) *cardiochila*	Thick lip spider orchid			CR	V				f			
Caladenia (*Arachnorchis*) *fuliginosa*[a] †	Coastal spider orchid		R	E	E				f	Previously *Caladenia fragrantissima* ssp. *fragrantissima.*		
Caladenia (*Arachnorchis*) sp.	Spider orchid/s						l, b		l			
Caladenia (*Jonesiopsis*) *bicalliata* ssp. *bicalliata* †	Limestone spider orchid		R	CR	CR		l, b		f, p			
Caladenia (*Jonesiopsis*) *capillata*	Pale whispy spider orchid			V	LC		b, f		f			
Caladenia (*Petalochilus*) *carnea*	Pink fingers								b	Flowering late September		
Caladenia latifolia	Pink fairies			V	LC		l, b		f			
Caladenia latifolia x Pheladenia deformis									f			
Corybas (*Corysanthes*) *despectans*	Shy helmet orchid						l, f			Found mostly on rises which was Mallee, with or without Melaleuca shrub layer.		
Corybas (*Corysanthes*) sp.	Helmet orchid						l, p		l, p			
Cyrtostylis robusta	Winter Gnat orchid			R	LC		l, f		l, f	On burnt limestone/Mallee ridges.		
Diuris orientis	Wallflower Donkey orchid			V	LC		b		f			
Diuris palustris †	Little Donkey orchid			V	LC		f		f			
Eriochilus cucullatus	Parsons bands			V	LC		l, p		l			
Genoplesium (*Corunastylis*) aff. *rufum*	Common midge orchid								p			
Genoplesium (*Corunastylis*) sp.	Midge orchid/s						p					
Genoplesium (*Corunastylis*) *tepperi*[a]	Mallee midge orchid						p					
Microtis arenaria	Sand hill onion orchid									Flowering in mid October.		
Microtis sp. unnamed										Flowering in mid October.		
Microtis sp.	Onion orchid						l			One of the most common species in all areas, especially conspicuous in burnt areas.		
Pheladenia deformis	Blue fairies			R	LC		f		f, p	One of the most common species throughout the burn.		
Prasophyllum calcicola †	Limestone leek orchid	V		E	E		b		f	Rated species reasonably well represented in the survey area.		
Prasophyllum elatum ?	Tall leek orchid			CR	E				b	Not confirmed this survey, due to drying conditions and flowers withering/aborting. rare on lower areas of Y.P.		
Prasophyllum fecundum †	Fertile leek orchid	R		CR	CR				f			
Prasophyllum occidentale †	Plains leek orchid			V	E				b			
Prasophyllum sp. 'late coastal dunes' †	Late leek orchid						l		l	Common in very localised areas. Buds within the leaf in spring. Flowers November/December.		
Prasophyllum sp.	Leek orchid						l		l			
Pterostylis (*Bunochilus*) *flavovirens*[a]	Little coastal banded greenhood			R	LC		b, f, p		p	A common species throughout the burn. Previously *P. longifolia.*		
Pterostylis (*Diplodium*) *dolichochila*	Common mallee shell orchid			R	LC		f			One very late flower seen but not photographed.		
Pterostylis (*Diplodium*) *erythroconcha*	Red shell orchid			R	NT		f, p		f, p	The most common *Diplodium* for the area.		
Pterostylis (*Diplodium*) *robusta*	Common green shell orchid			R	CR		l		l	Confirmed with flower.		
Pterostylis (*Linguella*) aff. *nana*	Little greenhood			R	R		b, f		f, p	Most, if not all, were 'coastal' form which is recognised at species level, but not yet named.		
Pterostylis (*Oligochaetochilus*) sp.	Rufous hood						l			Leaves found during survey, but not confirmed with bud or flower, probably due to dry Spring.		
Pterostylis (*Plumatichilos*) *plumosa*	Mallee beard orchid			R	R		l		l, b	A few records in vegetated areas. Only one seen with aborted flower.		
Pterostylis (*Urochilus*) *sanguinea*	Maroon banded greenhood			R	LC		l, f		fo, p			
Thelymitra aff. *nuda* †	Fragrant sun orchid						l		b	Common under mallee in unburnt areas.		

[a] indicates a combination name. Currently accepted name does not appear in Barker et al. 2005 l = leaf, b = bud, f = flower, p = pod, fo = flower over Conservation code abbreviations: CR = Critically Endangered; E = Endangered; V = Vulnerable; R = Rare; NT = Near Threatened; LC = Least Concern.

† indicates a collection made for Adelaide Herbarium (AD) Name in brackets represents unofficial new genus name Taxonomic abbreviations: sp. = identification possible only to genus level, ssp. = subspecies.

National ratings as per EPBC Act; State ratings as per the SA NPW Act Threatened Species Schedules, gazetted February 2008; Regional and sub-regional ratings as per Gillam and Urban (2008). The study areas falls within the Northern and Yorke region and the Southern Yorke sub-region.

Table 2. Orchid species recorded during the 2008 Foul Bay survey

It is possible that the intensity of the fire may have killed some of the seed or damaged tubers (Adam and Lawson 1993) in the burnt areas. Bates (1984) describes the Ash Wednesday fire as "sterilising the soil up to 5 cm deep in some areas, and the tremendous heat destroying all orchid tubers in some areas." The conditions in the burnt area in the first season post burn may have been unsuitable for orchid growth, eg due to an absence of mycorrhizal fungi, and lack of a litter layer which the fungi may require (Grant and Koch 2003).

The survey provided a snapshot of the orchid flora in the first season following an intense fire. There may be a lag period before the effects of fire are evident. Lunt (1994) and Norton and Delange (2003) recorded peak flowering of some orchid species two years after fire. Orchid response can depend on local conditions, and irrespective of a fire event, orchid emergence and flowering can be variable and unpredictable (Barnett 1984; Quarmby et al. 2008). For example, Barnett (1984) recorded divergent orchid response to fire at different burn sites. It should be noted that any apparent change in the first post-fire season may not be indicative of the real long term effects on orchid populations. An increase in flowering simply indicates a greater proportion of tubers grown in previous years have been stimulated into flowering (Barnett 1984). It is unknown if such a response is followed by high rates of pollination and seed set (i.e. an adaptive advantage).

Orchids of Conservation Significance

Of the 32 species found during the survey one has a nationally listed rating, viz. *Caladenia brumalis.* A further four species have state listed ratings and a further eight have regional and/or sub-regional listings.

Threatened species found in the survey area at Foul Bay are discussed individually below.

Caladenia (*Arachnorchis*) *brumalis*

C. brumalis is a medium sized off-white to yellowish spider orchid of the *C. patersonii* complex, found mainly on the "leg" of Yorke Peninsula. *C. brumalis* is nationally rated as vulnerable under the EPBC Act. It is a South Australian endemic. The occurrence at Foul Bay is well south of other known populations and is only the second population on the foot of Yorke Peninsula that is known to the authors. Less than 20 plants were found and virtually all of these were in advanced bud or flower during the winter visit. They occurred as scattered individuals in burnt areas of mallee and around some of the small unburnt remnants. No flowers were observed later to have been pollinated, but constraints of time and areas covered precluded follow-up of individual plants.

Prasophyllum calcicola

This attractive, bright green and red leek orchid is South Australia's smallest. It is found around exposed limestone areas and in calcareous sands near the coast on Eyre Peninsula, Yorke Peninsula and Kangaroo Island, as well as Western Australia. *P. calcicola* has a state rating of vulnerable, and regional and sub-regional rating of endangered. It was well represented in the area surveyed and the record constitutes a significant addition to the species' known range. Large groups of plants were observed in both burnt and unburnt areas. Barnett (1984) reports fire to benefit some *Prasophyllum* species.

Caladenia fuliginosa$^{\alpha}$ (*Caladenia fragrantissima* ssp. *fragrantissima*)

A large creamy yellow spider with a sweet perfume, this species has more recently been named as *Arachnorchis fuliginosa* (Jones 2006). It is endemic to South Australia, viz. Yorke Peninsula, and has a limited range always near the coast. Most populations are found on the foot of Yorke Peninsula. It is not considered fire dependent but following fire it is often more readily seen in flower mainly because of the open environment (Houston, C. pers. obs.). Gillam and Urban (2008) list it as regionally endangered and as *C. fragrantissima* ssp. *fragrantissima* it has a state rating of rare. This survey recorded it as scattered but in three main areas. About 150 plants were recorded with a flowering rate of about 50%. A visit in mid October to two of the three main areas found only one plant with a capsule, that being in a small area of unburnt mallee/heath. The population in the fully burnt area did not have any flowers pollinated. It is thus presumed that the pollinator was not present in the burnt area.

A fairly intensive search was made of the general area where the opportune sighting had been made previously. Members failed to find any plants, let alone any flowering plants. Bates (2009) suggests *Caladenia fuliginosa*$^{\alpha}$ may intergrade with *C. brumalis* as in wetter years the latter flowers into spring. We found no suggestion of this as both species were mutually exclusive in their flowering time in 2008. *C. brumalis* was found in late bud and flower during the winter visit, whereas *C. fuliginosa*$^{\alpha}$ was in bud or flower during the springtime visit.

Caladenia (*Jonesiopsis*) *bicalliata* ssp. *bicalliata*

This attractive spidery-looking orchid is found predominantly growing in limestone areas which makes the Foul Bay area very suitable for the orchid. The grey upright hairy leaves are very distinctive and often grow in small clumps, of which only one or up to several may be flowering plants. The flowers are self-pollinating so only last a couple of days. Capsules were recorded during the survey. Plants were found predominantly in unburnt areas, very few being seen in burnt locations. Some of the pockets of retained vegetation were quite small but they still seemed to afford protection to these plants.

C. bicalliata is listed as rare in SA. Regionally and sub-regionally it is critically endangered. The results of the survey were consistent with the regional rating, with low numbers of plants found over a large area. On only one occasion were more than a handful of plants recorded at any site.

Prasophyllum fecundum

P. fecundum is a smallish and inconspicuous leek orchid endemic to South Australia. It has a state listing of rare and a regional and sub-regional rating of critically endangered. It was found during the spring survey in extremely low numbers, the largest group (16 plants) being at the edge of a small opening in thick unburnt mallee/heath. Of the plants identified, about one third flowered. There may have been more leaves, but without buds or flowers it was almost impossible to distinguish these from other *Prasophyllum* species. Confusion also existed with non-flowering *Microtis* sp. The numbers observed validated its southern Yorke rating.

Acianthus (Nemacianthus) caudatus

On Kangaroo Island this species generally occurs under tall mallee with heavy leaf litter on the ground. In 2002 the species was discovered in similar habitat in Innes National Park, the first record for Yorke Peninsula. A small colony of *A. caudatus* was discovered on Allotment 101 during this survey; the second record of the species for Yorke Peninsula. It was in very heavy litter in an unburnt remnant of mallee/heath. Seven buds were seen in the winter survey, but due to lack of moisture only about half of these managed to flower. Regionally and sub-regionally the species is critically endangered.

Caladenia (*Arachnorchis*) *cardiochila*

This species was known to be present before the fire. Rated as vulnerable in the southern Yorke sub-region, it was found in low numbers during the spring survey, most of which were to flower or flowering. A handful of plants were located in the vicinity of DEH survey site 3, where they had previously been recorded.

Prasophyllum elatum

P. elatum is known to flower prolifically after fire, however, on Yorke Peninsula where plants are found in limestone soils, a fair percentage of any population flowers without the stimulus of fire (Bates 2009). *P. elatum* is considered endangered in the southern Yorke sub-region, being encountered mainly on the leg of Yorke Peninsula. It would be significant if either of the two possible records were confirmed as *P. elatum* (see discussion of under "Follow-up visit"). A group of 13 plants seen in an unburnt area of Section 166 bore a very strong resemblance to this species in leaf. If they were not *P. elatum* the most likely alternative due to size and timing of flowering would be *P.* sp. 'coast sandhills' which was not found during this survey. If this

latter species was present there would more likely be observable buds or even flowers during the spring survey.

Prasophyllum occidentale

The Plains Leek orchid in its truest form is found only in South Australia (Jones 2006). It is a smallish to medium sized leek orchid with a sweet perfume, found in grassy habitats on more fertile soils. Much of this habitat has been cleared and used for agricultural pursuits in South Australia (Bates 2009). On Yorke Peninsula the species has a vulnerable rating, but within this sub-region it is rated as endangered. At Foul Bay it was found in one reasonably sized, loosely spread colony. However, its flowering time was after the spring survey so it is possible there may be other colonies in the area surveyed. Flower colours ranged from pale yellowish green to green to red. Flowers were noticeably "dirty" with ash. Perhaps this was in some part due to attention of insects visiting them. *Prasophyllum* are recognised as using nectar and perfume to attract pollinators (Backhouse and Jeanes 1995; Bates 2009) and are often observed with many insects in attendance.

Pterostylis robusta (*Diplodium robustum*)

P. robusta has a very widespread range across South Australia, New South Wales and Victoria. In the Northern and Yorke region it is rated as rare, however, sub-regionally it is listed as critically endangered. *Diplodium* species produce different flowering and non-flowering plants. They form large clonal colonies of rosettes which are the non-flowering plants. Flowers stand on shortish scapes which have stem leaves. Flowering plants are usually produced quite sparingly. Although *P. robusta* is a winter flowering species, only one "tired" flower was encountered during the survey. Some very large masses of rosettes were seen. Difficulty with identification of rosettes from the three *Diplodium* species present can be encountered; however, N.O.S.S.A.'s most experienced observers are able to distinguish between most colonies.

Pterostylis (*Linguella*) aff. *nana*

Jones (2006) is of the opinion that true *P. nana* does not occur in South Australia. Within SA at least six separate taxa are recognised. The one recognised at Foul Bay was confirmed as *P.* sp. 'coastal' variety which occurs from the west coast through to the south east of the state, always close to the coast. On Yorke Peninsula it is found only on the tip of the foot. Regionally *P. nana* is rare and this rating is the same for the sub-region. More than one taxa would be recognised in this rating while no clear naming of separate species has occurred as yet. In the Foul Bay survey *P.* aff. *nana* was well represented with some reasonable sized groups of plants in flower. Colonies are clonal in nature. Bates (2009) mentions that seed capsules are rare. We observed several examples of seed set with at least one colony of about 50 flowers having three capsules within the group.

Pterostylis (*Plumatichilos*) *plumosa*

Pterostylis plumosa was located in very few places during the survey and in each instance there were only a handful of plants at each site. It is a species which is not often encountered on Yorke Peninsula and as such is rated as rare in both the region and sub-region. Flowering, if it occurred would have been after the spring survey. Hence some of the plants were targeted in the informal "follow-up" visit. One plant had flowered and appeared to be pollinated. The taxonomy of this species is unsure in South Australia. Jones (2006) says that true *P. plumosa* does not occur in South Australia and that a number of undescribed cryptic species may be present. *P. tasmanica* is a species recognised as occurring in South Australia, however, it is found only in the South-East of the state and around swamp margins. The plant seen at Foul Bay bore a resemblance to this species in a pollinated state, but since it was not seen in flower and the habitat is incorrect the identification of this plant must remain with *P. plumosa* until more is known about the South Australian *Plumatichilos.*

Pterostylis (*Diplodium*) *erythroconcha*

Another South Australian endemic, the red shell orchid is an attractive greenhood with red appointments and widely divergent sepal extensions giving it a distinctive appearance. Like other *Diplodium* species it produces ground hugging rosettes in small to large colonies. It is a species which usually flowers in low numbers within each colony. Numbers of plants can run into the hundreds due to vegetative increase but flowering numbers may be only a handful. In fact, with the drier conditions currently being experienced it has been noted that many colonies do not produce any flowers at all. This appeared to be the case in the survey area. This was one of the commonest species seen during the survey, in terms of actual numbers encountered, which confirms why Gillam and Urban (2008) assessed it as not threatened within the sub-region. Regionally it is rated as rare. A small number of flowers were seen in August in both burnt and unburnt environments; in a few cases capsules were also present.

Most common species in the survey area

A number of species were widespread throughout the survey area and in prolific numbers. In order of the number of records, the most common were *Microtis* spp., *Pheladenia deformis*, *Caladenia* (*Jonesiopsis*) *capillata, Pterostylis* (*Bunochilus*) *flavovirens*$^{\alpha}$*, Pterostylis* (*Diplodium*) sp. including *P. erythroconcha, Corybas* (*Corysanthes*) sp. including *C. despectans, Cyrtostylis robusta, Thelymitra* aff. *nuda, Caladenia latifolia* and *P.* (*Linguella*) aff. *nana*.

Microtis spp.

Microtis spp. were found throughout the burn and unburnt areas in high numbers. As they had not flowered by the time the spring survey occurred, very little is known about them. However, during a brief follow-up in

October two species were seen in flower, viz. *M. arenaria* and *M.* sp. unnamed. At this time it was noted that very few *Microtis* were flowering; virtually the only flowering plants were found where vegetation remained. This was probably attributable to a couple of factors; very low spring rainfall and excessive exposure in burnt areas which caused many plants to senesce early. Quarmby et al. (2008) reported a positive effect of burning trials on *M. unifolia* emergence.

Pheladenia deformis

This species flowered prolifically and was seen in most habitats. In burnt areas the flowers were often small on extremely short stems (some almost having the flower on the ground). They did appear as single plants, but were found more commonly in loose scattered groups. The blue flowers were a stark contrast to the white burnt sand. Bates (1984) observed *Caladenia* (*Pheladenia*) *deformis* flowering in the hundreds in Cleland Conservation Park following the Ash Wednesday fires in the Adelaide Hills in 1983. He had not recorded the species in the park prior to this. However, he did acknowledge one effect of the fire was to open up the area so making orchids more visible. Disturbance trials undertaken by Quarmby et al. (2008) found burning had no significant effect on *Pheladenia deformis,* although as acknowledged by Quarmby et al. (2008), the fire trials may not have been of high enough intensity to trigger an effect. Since we have no pre-fire data about *P. deformis* at Foul Bay, we are not able to say if the prolific flowering was in any part due to the effects of fire. Our own observations of *P. deformis* on Yorke Peninsula are that it is a freely flowering species. Capsules were reported during the spring survey, both in burnt and unburnt areas.

Caladenia (*Jonesiopsis*) *capillata*

The pale whispy spider orchid was located in a variety of habitats, but flowering was definitely more often noted in areas which were protected with some remaining vegetation. During the survey no pollination was noted, but, during September more buds were observed than flowers indicating it was still fairly early in their flowering time. However, during the visit in October a significant number of plants were seen with healthy capsules. One bud was noted during the survey, which did not have the normal pigmentation so it would have opened in albino form.

Pterostylis (*Bunochilus*) *flavovirens*$^{\alpha}$

P. flavovirens$^{\alpha}$ is considered part of the *P. longifolia* group which is recognised by Jones and Clements (2002) as *Bunochilus*. This genus produces non-flowering plants which are rosettes produced on short stalks. The flowering plant has leaves up the stem, with the flower/s produced at the top. In the Foul Bay environment following the fire, flowers were generally few, at the top of the stem. They are readily pollinated, being self pollinating (Bates 2009) so lots of capsules were observed in both surveys. The

flowering plants occurred in both burnt and unburnt areas, but it was of interest to note that not many non-flowering plants were seen in burnt areas. Barnett (1984) reported seeing only occasional scattered *P. longifolia* rosettes after fire in areas where it had previously flowered regularly.

Pterostylis (*Diplodium*) spp.

Diplodium species form colonies, sometimes quite large, with hundreds of ground-hugging rosettes in one area. Several authors mention the tubers being close to the surface and even sometimes in the leaf litter (Bates 2009; Backhouse and Jeanes 1995; Hornsby 1981), thus making them vulnerable to hot summer fires. The observations of the Foul Bay survey do not suggest that many, if any, tubers were killed due to heat of the fire. Colonies were numbered in hundreds and even thousands.

It is well known that the flowering rate in this genus is often relatively low (Bates 2009). In the area surveyed at Foul Bay in 2008 the flowering rate was even lower than could normally be expected. From observations around the State this is in part due to several years of below average rainfall where these species have experienced lower than anticipated flowering rates. In many cases there were colonies without any flowers. This was the case at Foul Bay where many of the species occurred on open, exposed and burnt sites. Identification of the various species was difficult. The three species involved are *P. dolichochila, P. robusta* and *P. erythroconcha*. Flowering is mostly across winter with *P. dolichochila* being the first and *P. erythroconcha* being the last to flower. Of the thousands of rosettes recorded during the survey, it seems reasonable to assume most of those present were *P. erythroconcha* which is ideally suited to the exposed limestone areas of Foul Bay.

Corybas (*Corysanthes*) spp.

Corybas species are readily identifiable in leaf form; flat round leaves hug the ground in colonies which are sometimes large. Flowering time can be quite short since flowers are soft and short lived. Flowering time for the two species at Foul Bay is similar, towards the end of July into early August. In 2008 the season proved to be no more than two weeks with flowering not commenced on 28th July, but most flowers over by the time the first survey was conducted on 16, 17th August. Hence identification of both species was difficult. *Corybas despectans* is common around coastal areas of the state so the majority of colonies at Foul Bay could be expected to be this. *Corybas expansus* is also a coastal species with a far more selective and disjunct range. The former is considered to be self pollinating and several observations were made of plants with formed capsules. Some large colonies were reported in both burnt and unburnt areas.

Cyrtostylis robusta

South Australia has two *Cyrtostylis* of which *C. robusta* is the winter flowered species. It is the only one found on Yorke Peninsula. Colonies and leaves are superficially like *Corybas*, but closer identification shows them to be thicker and more textured. Once again, some authors (see *Pterostylis* (*Diplodium*) spp. above) note the tubers are shallow and small therefore prone to destruction by hot fires. It is significant to note that the Foul Bay survey showed they survived the fire. Colonies of leaves were sometimes reported to be in the thousands but noted flowering rates were exceedingly low.

Thelymitra aff. *nuda*

This is a dainty species of sun orchid when encountered in this habitat. Flowers are perfumed and remain open for some time on mildly warm days in an attempt to attract a pollinator. The *T. nuda* complex covers a range of species and the one found at Foul Bay is readily identifiable by its lax leaf. The leaves and even the flowering stems were very reddish in colour. It favours coastal mallee areas, but not exclusively (see discussion under "Orchid Response to Fire").

Caladenia latifolia

Pink fairies is a common species of coastal areas and this was the case at Foul Bay. Large colonies of leaves, formed by vegetative reproduction, were encountered in both burnt and unburnt areas. This is a species which can have a variable rate of flowering. In the exposed burnt areas of Foul Bay the flowering rate was low. Pollination occurred within the burnt areas.

Pterostylis (*Linguella*) aff. *nana*

In the Foul Bay survey *P.* aff. *nana* was well represented with some reasonable sized groups of plants in flower. Colonies are clonal in nature. Bates (2009) mentions that seed capsules are rare. We observed several examples of seed set with at least one colony of about 50 flowers having three capsules within the group. It seems likely that most, if not all, of the *Pterostylis* (*Linguella*) sp. aff. *nana* are the recognised variety known as 'Coastal' (see "Orchids of Conservation Significance").

The other orchid species

Acianthus pusillus

Gillam and Urban (2008) found the Mosquito orchid to be of "least concern" in this sub-region. However, our records show it to be rare in this location. There were only three colonies located, two being in unburnt areas and one in the middle of a burnt area. The records were widely spaced. This is a colony forming

species with heart shaped leaves which are reddish purple underneath. Flowering occurs early in winter and can continue for a couple of months.

Diuris orientis

One colony of the Wallflower donkey orchid was located in the burn during the survey. Another small population was found in unburnt scrub well to the west of the burn. The area covered by this orchid in the burn area was relatively small, but the number of plants was considerable; leaves packed next to each other in a thick colony. Vegetative reproduction is a quality of this species. Bates (2009) remarks that flowering of this species can be quite spectacular after fires. We saw no evidence of this (see below notes on Herbivory).

Apart from the *Pterostylis* species, *Diuris* are one of the few orchids to have more than one leaf to a plant. They exhibit a variable number of grass-like leaves (anything up to seven or eight) making them somewhat inconspicuous in grassy habitats. However, in the survey areas only a few places had regenerated to reasonable grassy areas. Survey site 5 of 1994 recorded *D. orientis*, but none were located nearby in Allotment 101 (N.B. survey site 5 was outside the area surveyed in 2008, but close to the boundary with Allotment 101). Of "least concern" is the assessment for this sub-region, however, our observations do lend some concern to this species, which elsewhere on Yorke Peninsula, is vulnerable.

Diuris palustris

The Little donkey orchid was relatively common in the survey and located in a number of open flats, between the mallee rises. They were in loose collections, sometimes numbering in the hundreds and often spread over considerable areas of heavier soil. Flowering was prolific and capsules were observed so pollination had occurred within the burnt areas. The assessment of "least concern" in this sub-region is in keeping with our observations. On Yorke Peninsula it is a species with a rating of vulnerable.

Prasophyllum sp. 'late coastal dunes'

Bates (2009) recognises at least 17 species of *Prasophyllum* species in South Australia which are as yet unnamed. The Late leek orchid is one of these and is part of the *P. odoratum* complex. As such it was not assessed by Gillam and Urban (2008) and Bates (2009) does not suggest a status "due to lack of knowledge of its total distribution." It is a South Australian endemic orchid found only in southern coastal regions of Yorke Peninsula and Eyre Peninsula. Late flowering (November - December) and its sturdy nature set it apart from other *P. odoratum* species found on Yorke Peninsula. *Prasophyllum* sp. 'late coastal dunes' was locally common on Allotment 101 Foul Bay. Robust leaves with buds exerted from them were scattered over the burnt soils in October, when the vast majority of *Microtis* sp. leaves were withering or senesced.

Pterostylis (*Diplodium*) *dolichochila*

The Common mallee shell orchid was not recorded very often during the survey, all records being from the winter visit. It is the first to flower in this group (*Diplodium*) on Yorke Peninsula. One "tired" flower was noted, this being quite late in their flowering season. From what was recorded there could be some concern about the status of this species here. However, as mentioned previously, leaves alone can be difficult to identify, so there may be more than recorded. Many records were made only to *Diplodium* species level.

Pterostylis (*Urochilus*) *sanguinea*

The Maroon banded greenhood is a species widespread across South Australia and more. It has a long flowering time from about May to September. Flowers were recorded at Foul Bay on both visits. Plants with capsules were also recorded, so pollination had taken place. The large maroon and greenish flowers are readily identifiable, this being the only representative of *Urochilus* in South Australia. They were well represented in the survey, being found in both burnt and unburnt habitats. Plant numbers were usually quite low at each record point. Our observations concur with the assessment of "least concern" for the sub-region, although on Yorke Peninsula region it is rare.

Corybas (*Corysanthes*) *expansus*

Although *C. expansus* was not recorded specifically in the survey it is likely to be present here. As previously stated flowering time for *Corybas* was extremely short at Foul Bay in 2008. Three surveyors separately photographed or mentioned finding flowers well past being fresh, which exhibited some features found on *C. expansus*. It is a species of the coast and is often found under the shelter of *Eucalyptus diversifolia* (Bates 2009).

Caladenia latifolia x Pheladenia deformis

This natural hybrid has not been seen before (Bates, R. pers. comm.). One flower was located in an area of unburnt bush well to the west of the burn. It was growing with *C. latifolia* and *P. deformis* was nearby. It exhibited features from both parents, being a unique mauve colour. It was on a short scape with a small leaf similar to *C. latifolia*. The labellum was tri-lobed with marginal mauve and white calli on the mid lobe. Taller white calli were at the base of the labellum with shorter mauve and white calli scattered regularly on the remainder of the labellum. The side lobes were mauve patterned with darker horizontal stripes.

Notable Absences

Notable absences in orchid flora at Foul Bay were *Pterostylis pedunculata* (a species of the moist protected areas, not at all common on Yorke Peninsula) and *Caladenia* (*Arachnorchis*) sp. *dilatata*, i.e. either *C. stricta*

or *C.* aff. *tensa*. These latter two could flower later than when the survey was undertaken, however, no likely buds were found.

Herbivory

Some studies have shown that orchid flowers growing in recently burnt or exposed situations are at greater risk of being eaten than those growing under cover of vegetation (Coates et al. 2006; Petit and Dickson 2005; Quarmby et al. 2008; NSW NPWS 2002).

Herbivory was not observed at a notable level. A couple of observers remarked about *Prasophyllum* being nipped off and *Diuris orientis* which had been seen with a reasonable number of buds during winter only managed to raise one to flowering stage in spring. All buds had been in a very concentrated collection and were chewed off. A few *D. palustris* appeared to have some flowers nipped off but other than this there were no other remarks about herbivory.

Kangaroos were observed in the burnt areas, sometimes in considerable numbers. There appears to be only one record of a rabbit warren and little evidence other than this was encountered. Emus did not seem to have returned to the area at this time.

Rainfall

Rainfall in the seasons leading up to and after fire may have a significant impact on orchid populations, particularly in environments with calcareous soils over sheet limestone as present at Foul Bay (Jones et al. 2006). Autumn and winter rainfall is considered critical for recruitment, and leaf and flower production (Pfeifer et al. 2006; Quarmby et al. 2008; Weston et al. 2005). Above average spring rainfall may be necessary to ensure seedling survival through summer dormancy (Batty et al. 2006). Below average rainfall was recorded at Foul Bay in the three years prior to the fire (Commonwealth of Australia 2009) which could potentially contribute to prolonged dormancy. The emergence of orchids post-fire could also have an inverse relationship with rainfall if the rainfall promotes quick recovery of shading vegetation (Coates et al. 2006).

Pollinators

Most orchids have specialised relationships with pollinating invertebrates (see Adams and Lawson 1993; Weston et al. 2005). The impact of fire (including season and fire frequency) on orchid pollinators is completely unknown (Keith et al. 2002).

Previous survey sites visited

DEH survey sites 1 and 2 were located in burnt mallee with very few orchids around them. Survey site 1 had a number (less than 50) of *Microtis* sp. leaves, some (less than 20) of *Pheladenia deformis* flowering plants and two *Pterostylis flavovirens*$^{\alpha}$. This compares with two species when it was surveyed in 2004, viz. *Thelymitra* sp. and *Microtis* sp. As mentioned previously in this report, in 2008 no *Thelymitra* sp. was seen in burnt areas. No orchids were found at survey site 2. *Thelymitra* sp. was the only species recorded at the site in 2004.

Survey site 3 had three species. Eight plants of *Caladenia cardiochila* were recorded with five of them in bud; one bud of *C. bicalliata* was seen. There were many *Microtis* sp. leaves. The survey of 2004 found *C. cardiochila* and *Microtis* sp.

Follow-up visit in October 2008

Two members made a follow-up visit on the 15th October 2008 for the purpose of checking a few specific records. Of interest were any *Prasophyllum*, especially *P. elatum*, *Pterostylis plumosa*, *Pterostylis* (*Oligochaetochilus*) sp. and *Caladenia fuliginosa*$^{\alpha}$. Spring had been particularly low rainfall and everywhere was extremely dry. Of the two records for possible *Prasophyllum elatum* we found two plants in unburnt vegetation had attempted to flower. One of these had dried up and the other had aborted in bud. The other record was in the burnt area and was unfound, i.e. no plants could be located, presumably having dried off earlier. Two other species of *Prasophyllum* were confirmed, viz. *P occidentale* and *P.* sp. 'late coastal dunes'.

Follow-up visit in Autumn 2009

A brief (three hour) ramble survey was undertaken on 10th April 2009 on Allotment 101, traversing the burnt area. Three *Genoplesium tepperi*$^{\alpha}$ were found in flower, in an unburnt patch within the burn area.

Future Research

Permanent monitoring plots have been established at key sites identified during the post-fire surveys, to assist ongoing monitoring.

Long term research is needed to fill significant knowledge gaps regarding the impact of fire and inter-related factors on orchids, and on the mycorrhizal fungi and pollinators on which they depend.

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REFERENCES

Adams, P. B. and Lawson, S. D. (1993). Pollination in Australian Orchids: A critical assessment of the Literature 1882-1992. *Australian Journal of Botany* 41:553-75.

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

Barker, B., Barker, R., Jessop, J. and Vonow, H. (Eds.) (2005). *Census of South Australian Vascular Plants Edition 5.00.* State Herbarium of South Australia, Botanic Gardens of Adelaide and State Herbarium.

Barnett, J. M. (1984). The initial effects of fire on orchids in a stringybark-box forest. *Victorian Naturalist* 101(5): 188-189.

Bates, R. (1981). The ecology and biology of *Caladenia rigida* (Orchidaceae). *South Australian Naturalist* 58(4): 56-65.

Bates, R. (1984). Effects of Ash Wednesday bushfires on orchids in the Adelaide hills. *Native Orchid Society of South Australia Journal*. 8(1): 286.

Bates, R. (2009). *Orchids of South Australia* (CD), 3rd edition.

Bates, R. J. (1996). Recovery *Plan for Bayonet Spider-orchid Caladenia gladiolata R. Rogers.* Department of Environment and Natural Resources, South Australia.

Batty, A. L., Brundrett, M. C., Dixon, K. W. and Sivasithamparam, K. (2006). In situ symbiotic seed germination and propagation of terrestrial orchid seedlings for establishment at field sites. *Australian Journal of Botany* 54: 375-381.

Benson, D. H. (1985). Maturation periods for fire-sensitive shrub species in Hawkesbury sandstone vegetation. *Cunninghamia* 1(3): 339-349.

Bradstock, R. A. and Auld, T. D. (1995). Soil temperatures during experimental bushfires in relation to fire intensity: consequences for legume germination and fire management in south-eastern Australia. *Journal of Applied Ecology* 32: 76-84.

Bradstock, R. A., Tozer, M. G. and Keith, D. A. (1997). Effects of High Frequency Fire on Floristic Composition and Abundance in a Fire-prone Heathland near Sydney. *Australian Journal of Botany* 45: 641-655.

Burgman, M. A. and Lamont, B. B. (1992). A stochastic model for the viability of *Banksia cuneata* populations: environmental, demographic and genetic effects. *Journal of Applied Ecology* 29: 719-727.

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

Carstairs, S. and Coates, D. (1994). Conservation genetics and population ecology of five rare and threatened Western Australian orchids. *Department of Conservation and Land Management, Western Australia.*

Clarke, P. J., Myerscough, P. J. and Skelton, N. J. (1996). Plant coexistence in coastal heaths: Between- and within- habitat effects of competition, disturbance and predation in the post-fire environment. *Australian Journal of Ecology* 21: 55-63.

Clayson (1979). The Aftermath of the Caroline Fire. *Native Orchid Society of South Australia Journal*. 3(12).

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

Coates, F., Lunt, I. and Tremblay, R. (2006). Effects of disturbance on population dynamics of the threatened orchid *Prasophyllum correctum* and implication for grassland management in south-eastern Australia *Biological Conservation* 129: 59-69.

Coleman, R. (1992). Friendly Fire. *American Orchid Society Bulletin 61(2):* 130-135.

Commonwealth of Australia. (2009). *Climate Data Online*, Bureau of Meteorology www.bom.gov.au/climatic/averages accessed April 2009.

CSIRO (no date). Introduction to Australian Orchidaceae. www.publsih.csiro.au/samples/orchid%20key%20for%20web/html/intro-c_habitat.html accessed April 2009.

Department for Environment and Heritage (DEH) (1984). *Heritage Agreement 1040 Unique Vertebrate Fauna and Flora list.* Government of South Australia.

Department for Environment and Heritage (2003). *Innes National Park Management Plan.* Government of South Australia.

Department for Environment and Heritage (2008). *Biological Database of South Australia.* (accessed March 2008), Government of South Australia.

Department of Environment and Conservation (2008). *Conservation efforts protecting threatened WA orchids*, Media release 18 December 2008 www.dec.wa.gov.au/news/department-of-environment-and-conservation/conservation-efforts-protecting-threatened-wa-orchids.html, accessed April 2009.

Gill, A. M. (1974) *Fire and the Australian Flora: A Review in Australian Forestry.* CSIRO, Canberra.

Gill, A. M. (1996). How fires affect biodiversity in *Fire and biodiversity: The effects and effectiveness of fire management.* Commonwealth of Australia, Canberra.

Gill, A. M. (2001). Economically Destructive Fires and Biodiversity Conservation: an Australian Perspective. *Conservation Biology* 15(6): 1558-1560.

Gill, A. M. and Bradstock, R. (1995). Extinction of biota by fires in *Conserving Biodiversity: threats and solutions.* ed Bradstock R.A., Auld, T. D., Keith, D. A., Kingsford, R. T., Lunney, D. and Sivertsen, D. P., Surrey Beatty and Sons.

Gillam, S. and Urban, R. (2008). *Species Risk Assessment Pilot Project Phase 1 Report: Regional Species Conservation Assessments, Northern and Yorke Region.* Department for Environment and Heritage, South Australia.

Grant, C. D. and Koch, J. (2003). Orchid species succession in rehabilitated bauxite mines in Western Australia. *Australian Journal of Botany* 51: 453-457.

Grant, C. D. and Loneragan, W. A. (1999). The effects of burning on the understorey composition and vegetation succession of 11-13 year old rehabilitated bauxite mines in Western Australia: Vegetation characteristics. *Plant Ecology* 145: 291-305.

Grove, T. S., O'Connell, A. M., Dimmock, G. M. (1986). Nutrient changes in surface soils after an intense fire in jarrah (*Eucalyptus marginata* Donn ex Sm) forest. *Australian Journal of Ecology* 11: 303-317.

Helen Macpherson Smith Trust (2009). *Is fire a friend or foe of our native Victorian Orchids?* Media release 5 May 2009. www.hmstrust.org.au/news/post/is-fire-a-friend-or-foe-of-our-native-victorian-orchids, accessed May 2009.

Horsnby, P. (1981). Some thoughts occasioned by the visit to the Ash Wednesday Bushfire area. *Native Orchid Society of South Australia Journal* 5(1).

Humphreys, F. R. and Craig, F. G. (1981). Effects of fire on soil chemical, structural and hydrological properties. In Gill AM, Groves RH, Noble IR (Eds.) *Fire and the Australia Biota.* Australian Academy of Science, Canberra: 178-200.

Janeckova, P. Wotovova, K., Schodelbauerova, I., Jerokova, J. and Kindlmann, P. (2006). Relative effects of management and environmental conditions on performance and survival of populations of a terrestrial orchid, *Dactylorhiza majalis*. *Biological Conservation* 129: 40-49.

Jones, D. L. (2006). *A Complete Guide to Native Orchids of Australia and its Island Territories.* Reed New Holland Publishers, Australia.

Jones, D. L. and Clements, M. A. (2002). *Australian Orchid Research Volume 4*. Australian Orchid Foundation.

Jones, D. L., Hopley, T., Duffy, S. M., Richards, K. J., Clements, M. A. and Zhang, X. (2006). *Australian Orchid Genera, an information and identification system* (CD), CSIRO Publishing and Australian Biological Resources Study.

Keith, D. A., McCaw, W. L. and Whelan, R. J. (2002). Fire regimes in Australian heathlands and their effects on plants and animals in *Flammable Australia: the fire regimes and biodiversity of a continent.* (Eds.) R. A. Bradstock, J. E. Williams and A. M. Gill, Cambridge University Press, pp203-229.

Lunt, I. (1994). Variation in flower production of nine grassland species with time since fire, and implications for grassland management and restoration. *Pacific Conservation Biology* 1(4):359-366.

Neagle, N. (Ed.) (2008). A Biological Survey of the Mid North and Yorke Peninsula, South Australia, 2003-2004: Assessment of Biodiversity Assets at risk, Department for Environment and Heritage, South Australia.

Norton, D. A. and De Lange, P. J. (2003). Fire and Vegetation in a Temperate Peat Bog: Implications for the Management of Threatened Species. *Conservation Biology* 17(1):138-148.

NSW National Parks and Wildlife Service (2002). *Approved Recovery Plan for the Tallong Midge Orchid* (*Genoplesium plumosum*). NSW National Parks and Wildlife Service, Hurtsville NSW.

Petit, S. and Dickson, C. R. (2005). Grasstree (*Xanthorrhoea semiplana*, Liliaceae) facilitation of the endangered pink-lipped spider orchid (*Caladenia syn. Arachnorchis behrii*, Orchidaceae) varies in South Australia. *Australian Journal of Botany* 53(5): 455-464.

Pfeifer, M., Heinrich, W. and Jetschke, G. (2006). Long-term demographic fluctuations in an orchid species driven by weather: implications for conservation planning. *Journal of Applied Ecology* 43: 313-324.

Quarmby, J. P. (2006). *Recovery Plan for Twelve Threatened Orchids in the Lofty Block Region of South Australia 2007 - 2012.* Department for Environment and Heritage, South Australia.

Quarmby, J., Bickerton, D. and Faast, R. (2008). *Effects of disturbance on emergence and flowering of the endangered bayonet spider orchid Caladenia gladiolata R. Rogers (Orchidaceae)*, Unpublished paper.

Siddiqi, M. Y., Carolin, R. C. and Myerscough, P. J. (1975). Studies in the Ecology of Coastal Heath in New South Wales. III. Regrowth of Vegetation after Fire. *Proceedings of the Linnean Society of New South Wales* 101(1): 53-63.

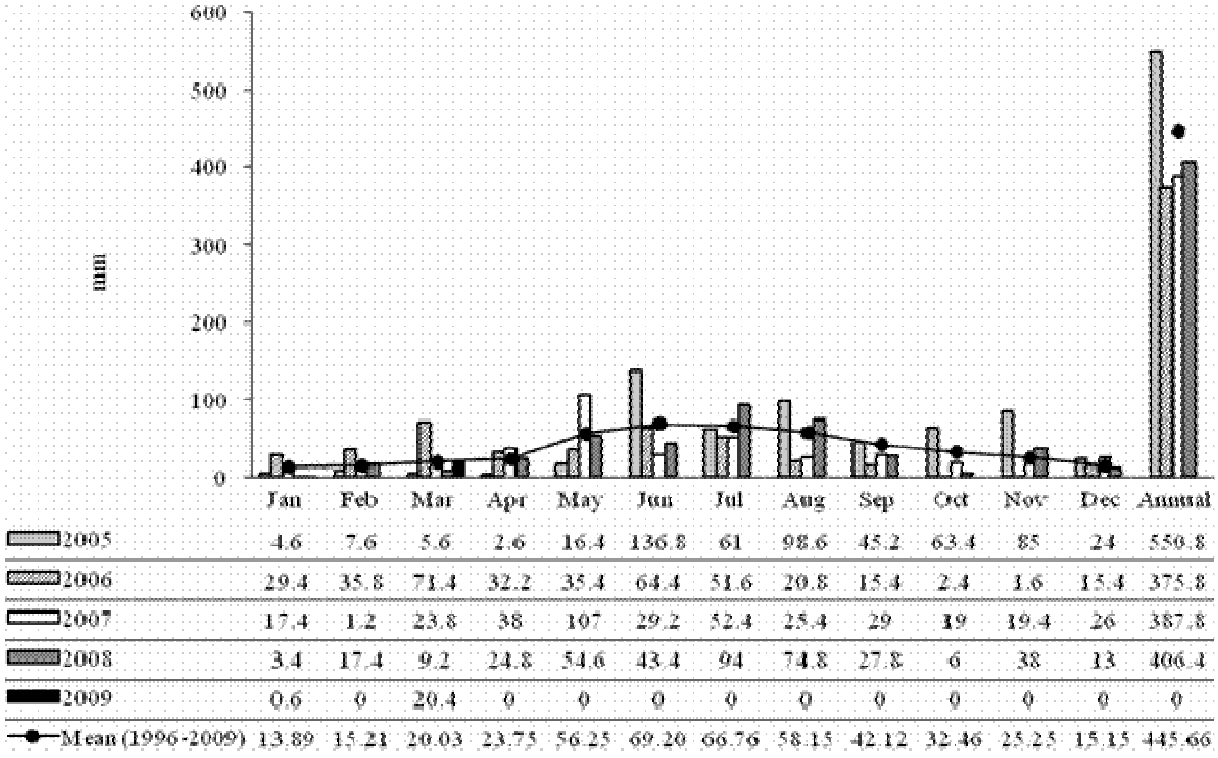
Tozer, M. G. and Bradstock, R. A. (2002) Fire-mediated effects of overstorey on plant species diversity and abundance in an eastern Australian heath. *Plant Ecology* 164: 213-223.

Wake, C. (2007) Micro-environment conditions, mycorrhizal symbiosis, and seed germination in *Cyperipedium candidum*: Strategies for conservation. *Lankesteriana* 7(1-2): 423-426.

Weston, P. H., Perkins, A. J. and Entwisle, T. J. (2005). More than symbioses: orchid ecology, with examples from the Sydney Region. *Cunninghamia* 9(1): 1-15.

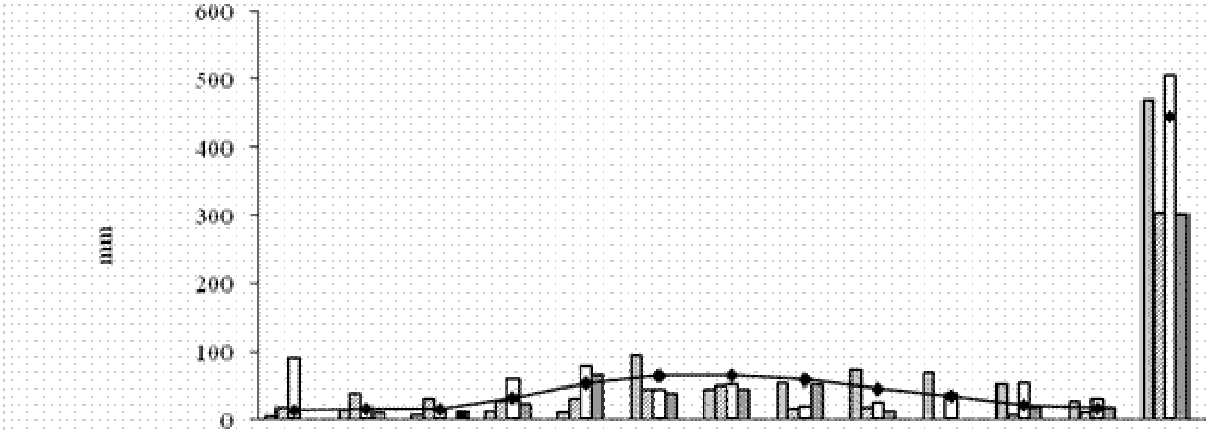
APPENDIX

RAINFALL RECORDS



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2005	4.6	7.6	5.6	2.6	16.4	136.8	61	98.6	45.2	63.4	85	24	550.8
2006	29.4	35.8	71.4	32.2	35.4	64.4	51.6	20.8	15.4	2.4	1.6	15.4	375.8
2007	17.4	1.2	23.8	38	107	29.2	52.4	25.4	29	19	19.4	26	387.8
2008	3.4	17.4	9.2	24.8	54.6	43.4	94	74.8	27.8	6	38	13	406.4
2009	0.6	0	20.4	0	0	0	0	0	0	0	0	0	0
Mean (1996-2009)	13.89	15.21	20.03	23.75	56.25	69.20	66.76	58.15	42.12	32.46	25.25	15.15	445.66

Monthly rainfall (mm) at Stenhouse Bay (25.1 km from Foul Bay) (Source: www.bom.gov.au)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2005	4.8	14.2	7.6	12.6	11.2	95.1	45.2	54.4	74	69	52.8	28.8	469.7
2006	19.2	40.4	33	28.4	31.2	45.2	51.6	16.2	19.8	0.8	8.4	11.4	305.6
2007	91.3	0.8	14	59.8	78.4	43.2	51	19.6	25.4	38.6	53.6	30.4	506.1
2008	4.4	11.8	3.6	25	66.2	39.6	44.6	53.4	13.5	4.6	18.6	18.2	303.5
2009	0.4	0.8	12.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mean (1861-2009)	14.5	16.6	16.1	33.1	54.5	64.6	65.4	59.4	45.6	35.8	22.6	17.4	445.8

Monthly rainfall (mm) at Warooka (29.4 km from Foul Bay) (Source: www.bom.gov.au)