ORANGE FIELD NATURALIST AND CONSERVATION SOCIETY

Post-Fire Survey of Terrestrial Orchids in the Mount Canobolas State Conservation Area.

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Report to

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INTRODUCTION

A major wildfire in February 2018 burnt through approximately 70 percent of the 1672 hectare Mount Canobolas State Conservation Area (SCA). It had been over 30 years since the last wildfires in the reserve, in 1982 and 1985. Over that period, the vegetation had recovered completely and returned to a climax condition. The tall heaths had become tangled and largely impenetrable, and the ground cover was dominated by large tussocks of Snow Grass, *Poa sieberiana*. Immediately after the previous fires, there had been a prolific flowering of some species of native orchids, which diminished over the following seasons, and in one case ceased altogether after about 10 years (personal observations).

The February 2018 wildfire provided opportunities both to see whether the orchids would once again respond with enhanced flowering, and to monitor flowering over the following years. This report describes surveys of the distribution and abundance of native terrestrial orchids undertaken within the SCA in the first spring after the fire. These surveys are part of a broad-based program managed by the NSW National Parks and Wildlife Service to monitor the recovery of the SCA from the wildfire.

Responses of orchids to fire

There are many anecdotal accounts of the responses of orchids to fire in the popular literature, but rather few scientific studies. The impact of fire on Australian terrestrial orchids is influenced by many variables including principally the adaptations of each orchid species, seasonal timing of fires and fire frequency (Jones 1988). Natural wildfires occur mainly in summer to early autumn and the evolved responses of many orchids to fire appear to be adapted to this timing. Mass flowerings of terrestrial orchids in the spring following a summer wildfire are often reported and it is common for orchid enthusiasts to flock to severely burnt areas in the season following such fires (Jones 1988). Summer wildfires occur when most orchid species are dormant, i.e. the plants aestivate underground as tubers to avoid the hottest and driest months of the year. In general, wildfires do not harm tubers since soil is a good insulator against heat (Gill 1981).

By contrast, so-called controlled burns, which are lower intensity fires designed to reduce the volume of flammable material on the forest floor, do not appear to enhance orchid flowering (Jones 1988). Rather, controlled burns tend to be undertaken in the milder weather conditions of autumn or spring and may be harmful to orchids by destroying above ground parts that are actively growing or flowering at these times. Jasinge *et al*. (2018) found that autumn and winter burns reduced populations of *Glossodia major* and *Thelymitra pauciflora*, whereas spring and summer burns did not reduce emergence in the following season.

Jones (1988) identified three categories of fire response in Australian terrestrial orchids based on his own personal observations and anecdotal reports in the literature:

- Fire dependent species
- Fire stimulated species
- Fire inhibited species

Duncan (2012) recognised five fire response categories in southern Victorian orchids following systematic but mainly qualitative observations after the ‘Black Saturday’ bushfires in 2009:

- Fire killed species
- Fire sensitive species
- Fire neutral species
- Fire stimulated species
- Fire dependent species

Fire killed species identified by Duncan (2012) include those with tubers in the leaf litter, such as *Arthrochilus huntianus*, and those whose tubers extend only a few centimetres into the soil, including some *Chiloglottis* species. *A. huntianus* was severely impacted by the 'Black Saturday' fires, while the effects on *Chiloglottis valida* were variable, with some populations severely affected and others less so.

The fire sensitive category of Duncan (2012) is equivalent to Jones's (1988) fire inhibited class. Fire sensitive species undergo reduced flowering for one to several seasons following a wildfire and tend to be dominated by autumn and winter flowering taxa including many *Pterostylis*, *Corybas, Corunastylis* and *Acianthus* species. It is thought these species are adapted to shaded environments and do not thrive until the surrounding vegetation has recovered (Jones *et al*. 1999). Duncan (2012) found that responses to the 'Black Saturday' fires varied among these genera. *Acianthus* and *Corybas* species generally flowered normally and appeared little affected by the fires. By contrast, some autumn-flowering *Pterostylis* species were inhibited, but others flowered normally. However, some species that suffer reduced flowering in the first spring after autumn burns may exhibit increased flowering in the following year, e.g. *Diuris punctata* (Lunt 1994).

As the name implies, fire neutral species tend to flower at the same rates after wildfires as before (Duncan 2012). This group includes winter and spring flowering *Pterostylis* species, although occasionally very intense fires may show inhibitory effects on local populations. The 'Black Saturday' fires also had no impact on several *Calochilus* species, or on members of *Caleana, Lyperanthus, Spiranthes* and *Orthoceras*.

Fire-stimulated species undergo greatly enhanced flowering in the season or two following a wildfire, in which a much higher proportion of the plants in the population flower than in a normal year. These species are also referred to as facultative fire responders (Dixon and Barrett 2003, Lamont and Downes 2011). This phenomenon occurs in many *Caladenia*, *Diuris*, *Prasophyllum* and *Thelymitra* species, as well as some *Microtis* species and *Glossodia* (Jones 1988, Duncan 2012). Increased nutrient availability from fire ash and strong light penetration to the ground may increase plant vigour (Duncan 2012). The 'Black Saturday' fires stimulated increased flowering in a large number of orchid species including nine Finger Orchids (small *Caladenia* species), ten Spider Orchids (large *Caladenia* species), six species of *Prasophyllum* including one that had not been seen for 20 years, three species of *Diuris* and twelve species of *Thelymitra*, among others. The increase in flowering lasted for two seasons in many species, but only for the first season in others (Duncan 2012).

Fire-dependent species, also known as obligate fire responders (Dixon and Barrett 2003, Lamont and Downes 2011), only flower in the season after a summer wildfire. Most fire-dependent species occur in the south-west of Western Australia where summer fires are relatively more frequent than in south-eastern Australia (Jones 1988). In the interval between fires these species produce only annual leaves or no leaves at all. Only two fire dependent species are known for New South Wales, *Burnettia cuneata* and *Prasophyllum australe*, neither of which occurs west of the Great Dividing Range.

The stimulus for fire-induced flower initiation is thought to be ethylene gas in smoke generated by fire (Dixon and Barrett 2003, Lamont and Downes 2011, Miller and Dixon 2014). It is interesting that smoke alone can induce enhanced flowering in plants that remain unburnt near the fire front (Lamont and Downes 2011).

There are very few scientific studies that have attempted to correlate the flowering of orchids with time since a wildfire. Cropper (1993) presents long term monitoring data from Tonkinson and Parsons on *Diuris fragrantissima* showing enhancement of flowering in the first two seasons after a summer fire after which it returned to pre-fire levels. A detailed study over nine seasons in coastal heathland on the Critically Endangered *Caladenia orientalis* showed that one population responded with increased flowering after fire, but the number of flowering plants in a second population varied between seasons with no correlation to time since fire (Coates and Duncan 2009). The suppression of flowering

between fires on the first site was related to the rapid recovery of competing vegetation which also reduced leaf size. The second site was more open with less competition which allowed more flowering to occur. However, this site also experienced a decline in leaf size over time and an increase in the population of non-reproductive plants.

Lamont and Downes (2011) reviewed 386 fire-stimulated species, of which 173 were orchids, and concluded they take advantage of optimal resources and minimal competition in order to grow and reproduce in the one to two years following a fire. Research in grasslands and grassy woodlands has shown that removal of grass biomass promotes flowering in forbs and helps to maintain plant species diversity (Collins *et al*. 1999, Julita and Grace 2002, Lunt and Morgan 2002). For example, Lunt (1994) showed that grass competition suppressed flowering in some ground cover forbs in the absence of disturbance. By contrast, mass flowerings of many forbs occurred in the first year after a fire, but largely ceased in the second year for most species as the recovering grass sward closed over. Other forbs may tolerate the dense grasses for longer periods, although eventually declining (Lunt 1994).

The 2018 Mount Canobolas wildfire

The 2018 wildfire appears to have been initiated by a lightning strike near Mitchells Way in the SCA (S, Woodhall, per. comm.). The fire consumed approximately 70 percent of the SCA, being stopped by back burning within the SCA from the Gum Ridge Firetrail in the south west, the Towac Road south of the Gum Ridge Firetrail junction, the southern boundary trail, the Indigo Firetrail and the private property inholding, 'The Crater' (Figure 1). Two separate blocks comprise the thirty percent of the SCA that remained unburnt; areas south of the Gum Ridge Firetrail, and east of 'The Crater' and the Indigo Firetrail. Fire intensity varied from mild to severe such that effects on the tree canopy ranged from nil to complete loss, with tree death occurring in some cases. Fire intensity was most severe on the upper slopes and ridges and milder in the valleys and lower slopes. However, throughout the burnt area, with very few exceptions, the fire completely removed the shrub layer, leaf litter, fallen logs and ground cover forbs and grasses.

Background to orchids on Mt Canobolas

Some 34 species of native orchids are known to occur in the SCA. Appendix 1 gives the names of species attributed to the SCA in Giles (1961), Hunter (2002), Medd and Bower (2018), and the Australasian Virtual Herbarium (AVH) (2019) and BioNet (2019) databases. The Giles (1961) list is difficult to use as many of the species names have been superseded and the list applies to a much larger area than the SCA.

Mt Canobolas SCA is a mountainous remnant of a central shield volcano. Altitudes range from approximately 900 m at the lowest point on Towac Creek to 1397 m at the summit. The volcanic soils are fertile moisture-retentive clays and the climate is montane with higher rainfall and cooler temperatures than surrounding areas. Accordingly, Mt Canobolas supports cool montane and sub-alpine plant communities and a set of orchids typical of the higher altitude forests on volcanic and granitic soils along the higher parts of the Great Dividing Range to the east. Orchid species recorded on Mt Canobolas, but not in nearby lower altitude areas include:

Arthrochilus huntianus	Elbow Orchid
Caladenia sp. aff. *patersonii*	Canobolas Spider Orchid
Caladenia fitzgeraldii	Fitzgerald's Spider Orchid
Chiloglottis valida	Bird Orchid
Corybas hispidus	Bristly Helmet Orchid
Diuris sulphurea	Tiger Orchid
Gastrodia sesamoides	Potato Orchid

Prasophyllum sp. aff. *odoratum*	Canobolas Leek Orchid
Pterostylis aestiva	Long-tongued Summer Greenhood
Pterostylis decurva	Summer Greenhood

The last widespread wildfire in the SCA was in 1982. This fire stimulated enhanced flowering of *Prasophyllum* sp. aff. *odoratum* and *Caladenia fitzgeraldii* (personal observations) and probably other species as well. However, over the following ten years or so, flowering of both these species declined. Flowers of *Prasophyllum* sp. aff. *odoratum* were last recorded in 1994 and *Caladenia fitzgeraldii* has flowered sporadically and in very low numbers at only one known site since that time. It has also been noticeable that flowering of most other orchid species has declined on the mountain over the last 30 years. Notable exceptions are *Diuris sulphurea*, *Chiloglottis valida, Dipodium punctatum, Corybas hispidus* and members of the *Thelymitra pauciflora* group, which appear to flower relatively consistently.

It seems likely that flowering of *Prasophyllum* sp. aff. *odoratum* and *Caladenia fitzgeraldii* in particular is strongly enhanced by fire and declines to low levels or zero in its absence. The group of orchid species that flowered consistently between years is likely to be fire neutral. However, there appears to be another group that has declined dramatically over the last 30 years, the autumn flowering Greenhoods. *Pterostylis aestiva* was formerly common on sheltered lower slopes and in gullies, but is now very hard to find. Other autumn Greenhoods, including *P. decurva*, *P. coccina* and *P.* sp. B were previously uncommon, but have not been seen for many years. The decline of these species may be related to competition from grasses, which have not been thinned out by fire over much of the reserve for three decades. While Greenhood flowering may not be fire-stimulated, regular fire may be necessary to open up the habitat by reducing grass biomass in grassy woodlands and forests. This may also apply to other groups of orchids.

The wildfire of February 2018 provides an opportunity to document the fire responses of Mt Canobolas orchids quantitatively and to determine whether the observations made after the 1982 fire are repeated. Accordingly, a longitudinal study has been designed to answer the following questions over the next five or more years:

- Based on observations of flowering plants, what is the distribution and abundance of orchids on Mt Canobolas immediately after the February 2018 fire?
- How do flowering orchid numbers change in subsequent years?
- Is *Caladenia* sp. aff. *patersonii* still present on the mountain?
- What is the current status of *Caladenia fitzgeraldii*, and how does flowering change over time?
- Is *Prasophyllum* sp. aff. *odoratum* still present, and if so, how do the numbers of flowering, vegetative and dormant plants change over time?
- What is the current status of *Pterostylis aestiva* and other autumn flowering greenhoods, and how do their numbers change over time?

METHODS

This report gives the results of the spring 2018 survey, which was run as a 'Citizen Science' initiative using community volunteers who were mainly members of the Orange Field Naturalist and Conservation Society. The survey was led by the author.

Participants

The following 13 volunteers took part:

Andrew Rawson
Bruce Hansen
Cath Stapleton
Colin Bower
Helmut Berndt
Jane Paul
Jenny Medd
Jo McPhee
Kerrie McGann
Melinda Trudgen
Richard Medd
Rosemary Stapleton
Tachir Orme-Smith

Study area

Mount Canobolas SCA is the study area for this report. Most of the survey effort was concentrated in areas known to be orchid hotspots historically, which are concentrated around the Orange View Lookout Area in the north east of the SCA (Figure 1). The environs of the Walls Lookout were also known to support a variety of orchids (Figure 1). The survey also visited other parts of the SCA including the surrounds of the Federal Falls Camping area, and sites along the Gum Ridge, Indigo and Pine Ridge Firetrails (Figure 1). Surveys near the Gum Ridge and Pine Ridge Firetrails included areas of unburnt grassy woodland and heath.

Timing

The survey was undertaken over the main orchid flowering period on Mt Canobolas between 28 October and 2 December 2018. Excursions were conducted twice weekly; 2-5 pm on Sundays and 10-1 pm on Wednesdays. Over this time ten group excursions took place. Additional excursions were undertaken by individuals or pairs from the above group on 12 further days, some of which extended beyond 2 December into January 2019, particularly aimed at the later flowering Hyacinth Orchids, *Dipodium* spp.

Resources

Survey participants were provided with a detailed identification guide to the orchids of Mt Canobolas (Selwood 2018) and a guide to the leaves of terrestrial orchids (Bower and Medd 2018). These materials are available from the author. One or both of C. Bower and R. Medd attended all surveys to provide confirmation of identifications where needed. Each participant was also provided with a survey data sheet (Appendix 2) and wire pins with pink flagging tape to mark the locations of individual plants of species that will be subject to more detailed long-term monitoring.

Data recorded

The data sheet (Appendix 2) has provision for recording the orchid name and GPS location of each individual orchid or orchid group sighted. Flowers were identified to species and leaves without flowers were identified to genus, if it was not possible to determine the species. Participants were asked to count the number of plants of each orchid species at each recorded location. Separate locations referred to single orchids or groups of orchids more than approximately five metres apart.

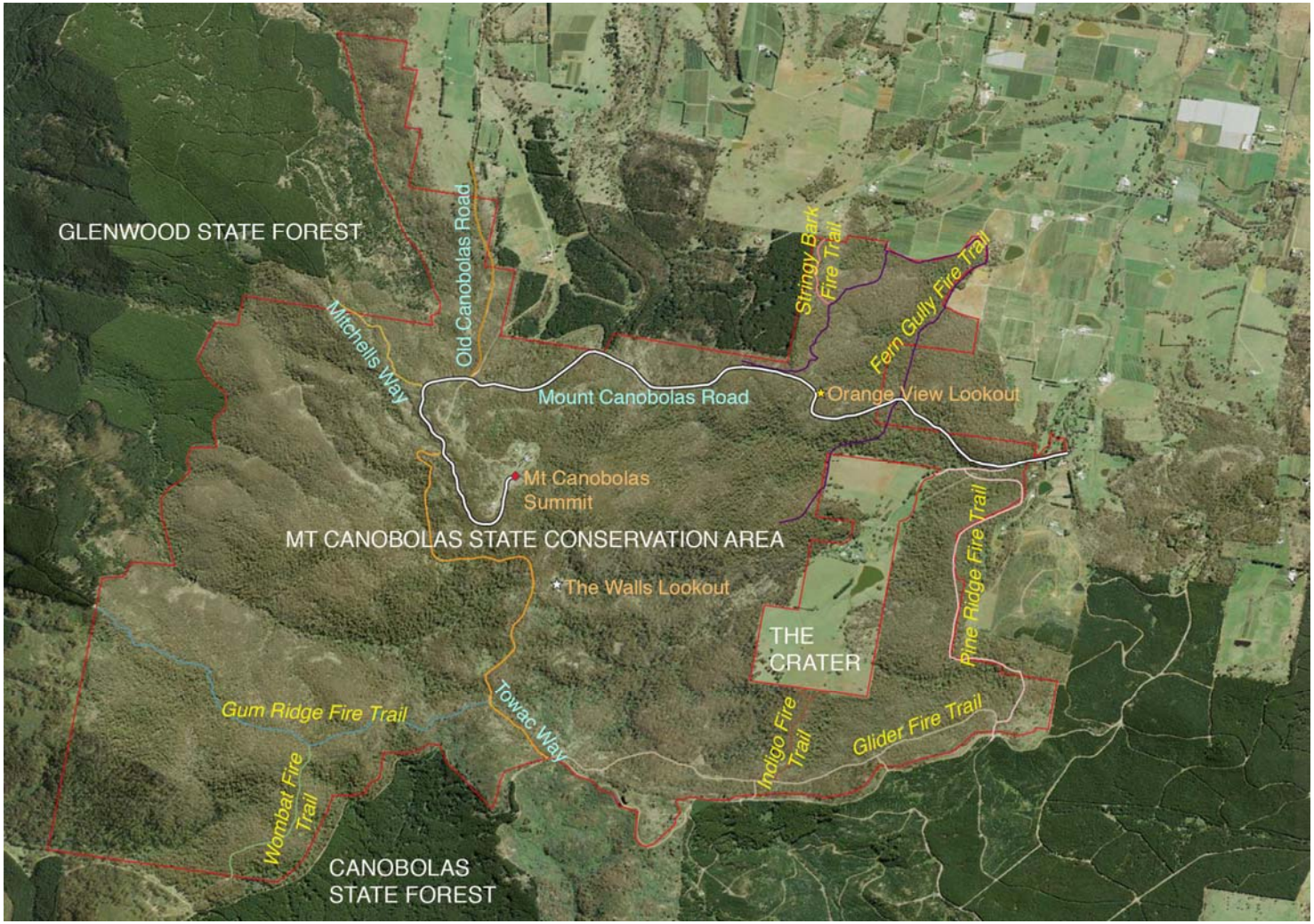

Figure 1. Mount Canobolas State Conservation Area (red border) showing main roads, trails and features.

Survey method

Areas known to be orchid hotspots within the SCA were prioritised to ensure they were thoroughly covered. These areas were walked by participants along lines approximately 10 m apart along the length of the area surveyed.

Areas of unknown orchid status were also surveyed in order to detect new hotspots and to gain a wider coverage of the SCA. These areas were surveyed by a random meander approach in which surveyors fanned out in different directions to broadly cover as much new ground as possible.

GPS protocol

Hand-held GPS units such as the Garmin GPSmap64s were used to determine and record orchid locations. These devices are reportedly accurate to 10 m (Garmin 2018). Occasionally, the same plant was recorded separately by two different participants in the survey. To avoid duplication of counts, any GPS readings by different observers that were within 10 m of each other were databased as the same plant and one of the observations was removed.

Targeted species

The survey recorded all orchid species encountered except for the Onion Orchids, *Microtis* spp. Onion Orchids were bypassed because of their extremely high abundance which would have required too much time to document, thereby diluting the survey effort for less common species. It was clear that *Microtis* on Mt Canobolas are fire enhanced and almost ubiquitous. All plants examined were the Common Onion Orchid, *Microtis unifolia*.

Three species, *Caladenia* sp. aff. *patersonii*, *Caladenia fitzgeraldii* and *Prasophyllum* sp. aff. *odoratum* were the principal targets of the survey owing to the rarity of all three and the taxonomic uniqueness of the first and last. All observed plants of these species were marked with flagging tape on a wire pin. In addition, plants of a third potential new species discovered by the survey in an orchid group not previously recorded on Mt Canobolas, *Diuris* sp. aff. *chryseopsis*, were individually marked by flagging tape. Unless they were very close together (< 1 m) a GPS location was recorded for every plant of the targeted species.

Taxonomy

The scientific nomenclature in this report is based on the current generic and species names on the PlantNet website of the Royal Botanic Gardens and Domain Trust, Sydney. Several species in this report are referred to *Genus* sp. aff. *species*. 'Sp. aff.' is 'species with an affinity to' meaning 'species related to'. Taxa listed in this way are entities that may be new undescribed species. For most of these entities specimens have been collected and forwarded to the Dr MA Clements at the Australian National Herbarium, Canberra. Collections were made under NSW Scientific Licence No. SL100744 in the name of the author.

Permanent marking

Three orchid taxa have been selected for detailed demographic monitoring over the next five or more years; *Caladenia fitzgeraldii*, *Prasophyllum* sp. aff. *odoratum* and *Diuris* sp. aff. *chryseopsis*.

Individual plants marked with pink flagging tape during the survey were permanently tagged with stainless steel discs stamped with a unique letter and number code (Plate 1) in early January 2019. The discs were placed 10 cm due north of the plant remnant (if any remained) and held in place with a two-pronged wire pin (Plate 1). If no plant remnant remained, the tag was placed where the flagging tape pin had been inserted.

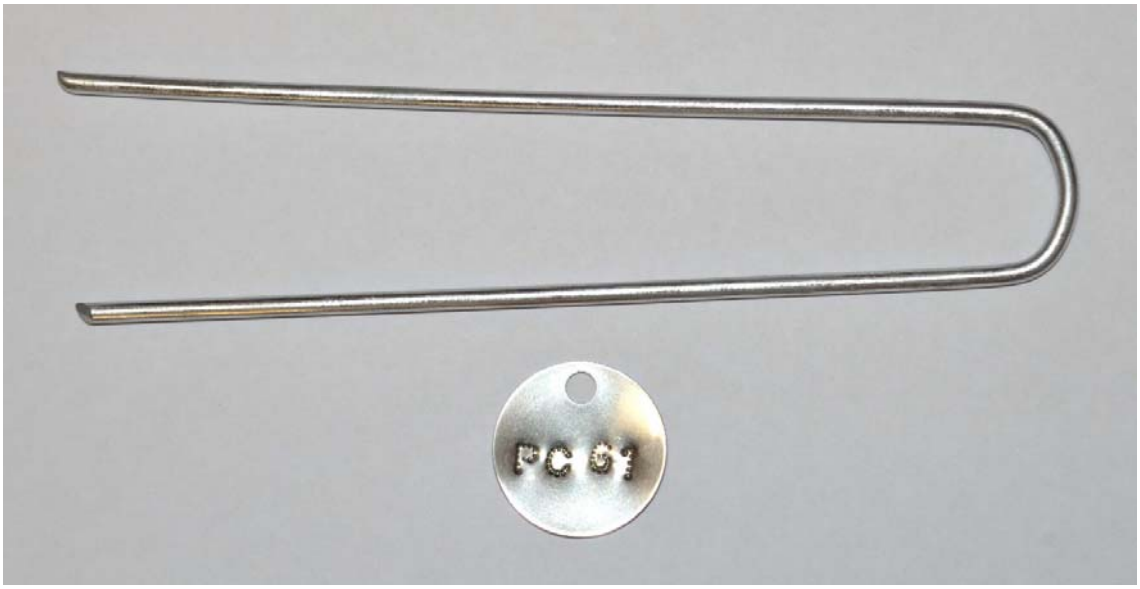

Plate 1. Tag and pin for permanently marking individual orchid locations.

Plant survival

At the time of permanent plant tagging in early January, plants of *Caladenia fitzgeraldii*, *Prasophyllum* sp. aff. *odoratum* and *Diuris* sp. aff. *chryseopsis* were examined to determine whether they had been subject to florivory (flower removal by florivores) or herbivory (removal of all or most of the flower, stem and leaf). In some cases only the inflorescence and part of the stem was eaten, in others the whole plant was removed.

Measurement of reproductive success

Reproductive success is defined as the proportion of flowers that develop seed pods and was determined for *Caladenia fitzgeraldii*, *Prasophyllum* sp. aff. *odoratum* and *Diuris* sp. aff. *chryseopsis* in early January when the permanent markers were emplaced.

Sub-populations

Individual plants of some species in the survey were noticeably clustered together (Figures 2 to 13). Clusters of plants that are separated by distances of more than 100 m are considered much less likely to exchange genetic material between clusters than within them via insect pollen vectors. Accordingly, clusters are considered likely to function as sub-populations within the larger metapopulation of each species in the SCA. The number of sub-populations detected by the survey is given for each species in Table 1.

Survey Constraints

The survey is based primarily on the detection of flowering plants and to a lesser extent the presence of leaves. However, the leaves of some species, particularly some Thelymitras, may be difficult to distinguish. In addition, self-pollinating Thelymitras, such as *T. pauciflora* and *T*. sp. aff. *ixioides*, only open their flowers briefly on a few warm days and are mostly encountered with closed or finished flowers. *T. brevifolia* and *T. peniculata* have distinctive leaves and were reliably identified.

Table 1. Mt Canobolas Orchid Survey - orchid species, plant numbers, number of locations and number of sub-populations.

Scientific Name	Common Name	No. of Inflorescences	No. of Sterile Leaves	Total Plants	No. of Locations	No. of Sub-populations
Caladenia carnea	Pink Fingers	2	0	2	2	1
Caladenia congesta	Black Tongue Caladenia	2	0	2	1	1
Caladenia fitzgeraldii	Fitzgerald's Spider Orchid	11	8	19	9	5
Caladenia gracilis	Musky Caladenia	125	0	125	24	3
Caladenia phaeoclavia	Brown-clubbed Spider Orchid	132	1	133	21	4
Calochilus campestris	Copper Beard Orchid	1	0	1	1	1
Calochilus robertsonii	Purple Beard Orchid	3	6	8	2	2
Chiloglottis valida	Large Bird Orchid	24	~6000	~6000	60	widespread
Corybas hispidus	Bristly Helmet Orchid	0	38	38	3	3
Dipodium sp.	A Hyacinth Orchid	84	NA	84	25	6
Diuris pardina	Leopard Orchid	141	0	141	28	2
Diuris sulphurea	Tiger Orchid	588	0	588	297	widespread
Diuris sp. aff. *chryseopsis*	Small Snake Orchid	5	0	5	3	1
Gastrodia procera	Tall Potato Orchid	1	NA	1	1	1
Gastrodia sesamoides	Potato Orchid	20	NA	20	9	4
Prasophyllum brevilabre	Short-lipped Leek Orchid	11	0	11	5	3
Prasophyllum sp. aff. *odoratum*	Sweet Leek Orchid	86	0	86	61	5
Pterostylis nutans	Nodding Greenhood	2	0	2	2	1
Microtis unifolia	Common Onion Orchid	not counted	not counted	not counted	not counted	widespread
Thelymitra brevifolia	Short-leaf Sun Orchid	9	0	9	4	3
Thelymitra pauciflora	Slender Sun Orchid	66	(139)[1]	205	48	widespread
Thelymitra peniculata		4	0	4	1	1
Thelymitra sp. aff. *ixioides*	Dotted Sun Orchid	342	0	342	29	5

[1] A proportion of the leaves attributed to *T. pauciflora* are likely to have been *T.* sp. aff. *ixioides*.

However, it is likely that *T. pauciflora* and *T*. sp. aff. *ixioides* were sometimes confused owing to closed flowers and similar leaves. The two generally occupy different habitats, rock plate heath and grassy woodland, respectively, but this was not noted during the survey.

RESULTS AND DISCUSSION

Orchid species recorded

The survey recorded 23 species of orchids in the SCA in spring to early summer 2018 (Table 1, Figures 2 to 13). Nine species were uncommon to rare with less than 10 individuals recorded (Table 1). Another six species were occasionally to commonly encountered with up to 100 plants identified. Eight species with more than 100 plants observed are regarded as frequent.

Two species were recorded for Mt Canobolas for the first time: Pink Fingers, *Caladenia carnea* and the Small Snake Orchid, *Diuris* sp. aff. *chryseopsis*. The survey confirmed the presence of the Tall Potato Orchid, *Gastrodia procera*, and Purple Beard Orchid, *Calochilus robertsonii*, which had been reported by Hunter (2002), but needed confirmation (Appendix 1). These records bring the number of confirmed orchid species in the SCA to 38.

Detection of orchids was made easier by the removal of shrub and grass cover by the wildfire. Most plants were detected by the presence of flowers; the exceptions being the Large Bird Orchid, *Chiloglottis valida*, and the Bristly Helmet Orchid, *Corybas hispidus*, for which mainly leaves were present (Table 1). The Large Bird Orchid is a clonal species that forms very extensive colonies by tuber multiplication. Its conspicuous paired leaves may form dense mats between grass tussocks on the forest floor, usually on shaded slopes. The Large Bird Orchid is the most common orchid in the SCA (Table 1, Figure 5). The Bristly Helmet Orchid flowers in May and only leaves are visible in spring. It was found in only 3 locations; two in roadside cuttings on Mount Canobolas Road and one in a small cutting on the Federal Falls Walking Track. It appears to take advantage of physical disturbance to soils.

Responses to the wildfire

Seven common or frequently encountered flowering species are likely to have been strongly fire-stimulated. These include the Musky Caladenia, *Caladenia gracilis*, the Brown-clubbed Spider Orchid, *Caladenia phaeoclavia*, the Leopard Orchid, *Diuris pardina*, the Tiger Orchid, *Diuris sulphurea*, the Canobolas Leek Orchid, *Prasophyllum* sp. aff. *odoratum*, the Slender Sun Orchid, *Thelymitra pauciflora* and the Dotted Sun Orchid, *Thelymitra* sp. aff. *ixioides*. In all these species, except the Slender Sun Orchid, almost all plants seen were flowering, suggesting a strong response to summer wildfire.

The Tiger Orchid flowered prolifically in the SCA in 2018, in both burnt and unburnt areas of the reserve (Table 1, Figure 8). It also flowers quite consistently, although less abundantly, in years without fire. Accordingly, it is difficult to know the extent to which it is fire-stimulated. It is possible that intense smoke from the fire that drifted over the unburnt areas of the reserve was sufficient to stimulate plants in nearby unburnt areas. It will be of interest to track the flowering of this species in years to come.

It is not possible to infer a role for fire stimulation to the uncommon species owing to their very low numbers, although some may well have been stimulated to flower. This is likely to be the case for the Short-lipped Leek Orchid, *Prasophyllum brevilabre*, which is well-known to be a fire-dependent species (Jones (2008). Observations in the SCA following the 1982 wildfire suggested flowering of Fitzgerald's Spider Orchid was fire enhanced and gradually declined subsequently.

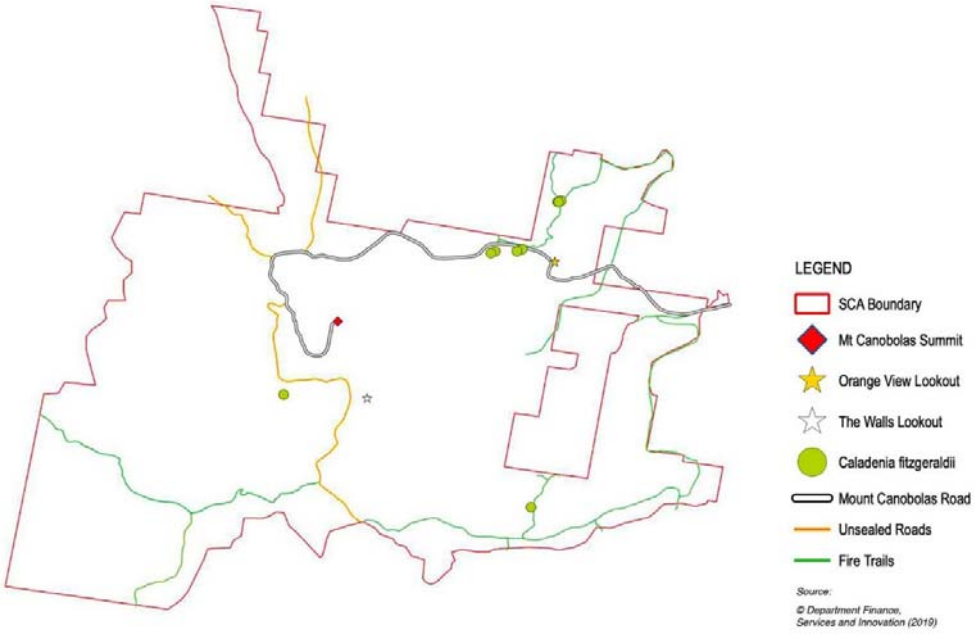

Figure 2. Distribution of *Caladenia fitzgeraldii*.

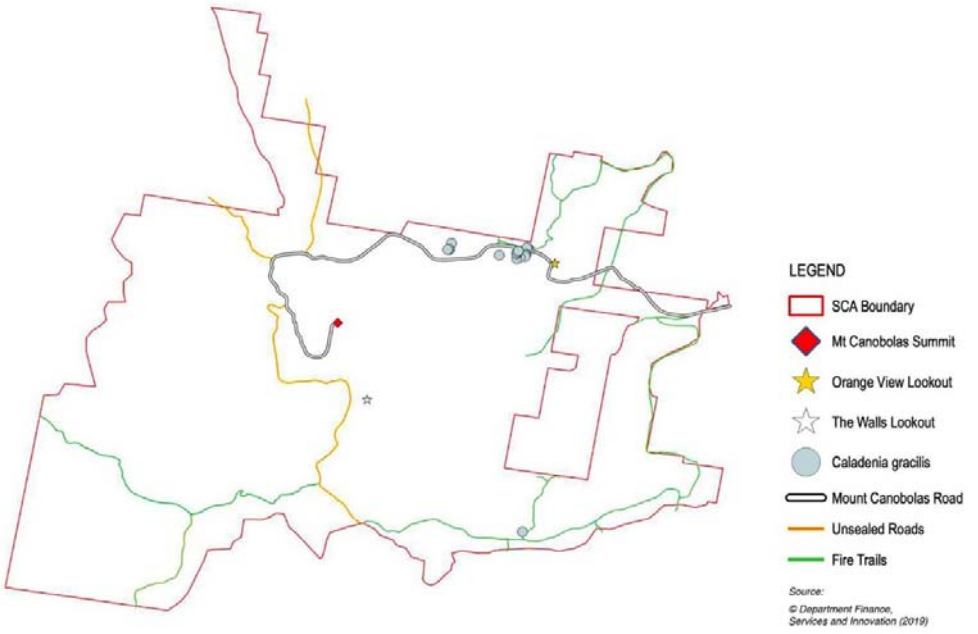

Figure 3. Distribution of *Caladenia gracilis*.

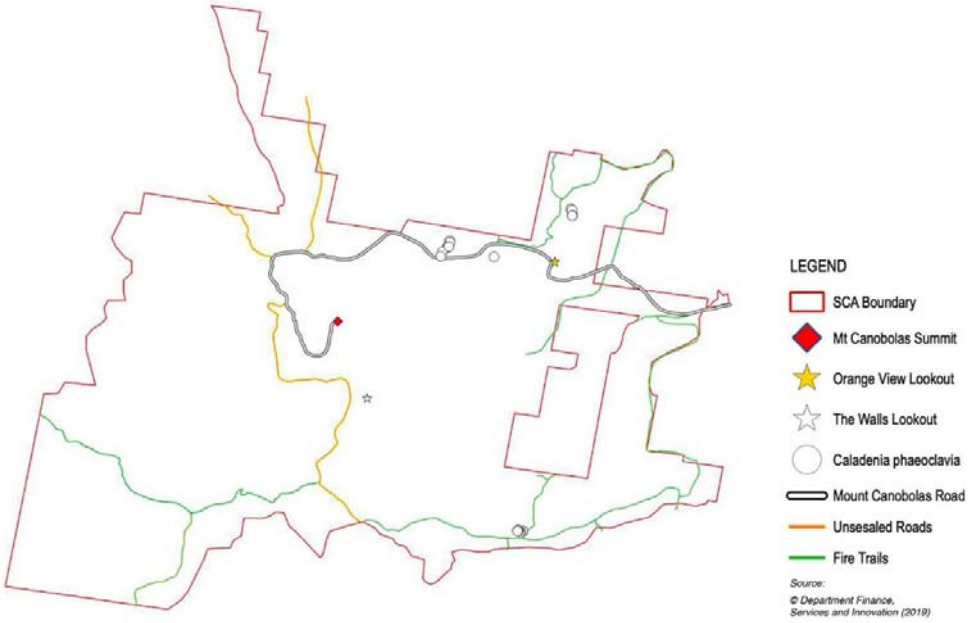

Figure 4. Distribution of *Caladenia phaeoclavia*.

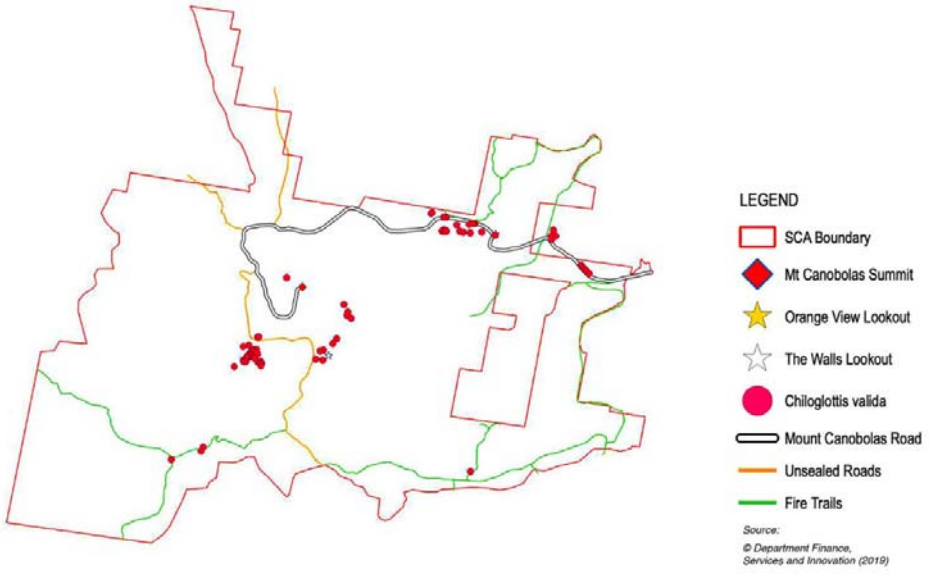

Figure 5. Distribution of *Chiloglottis valida*.

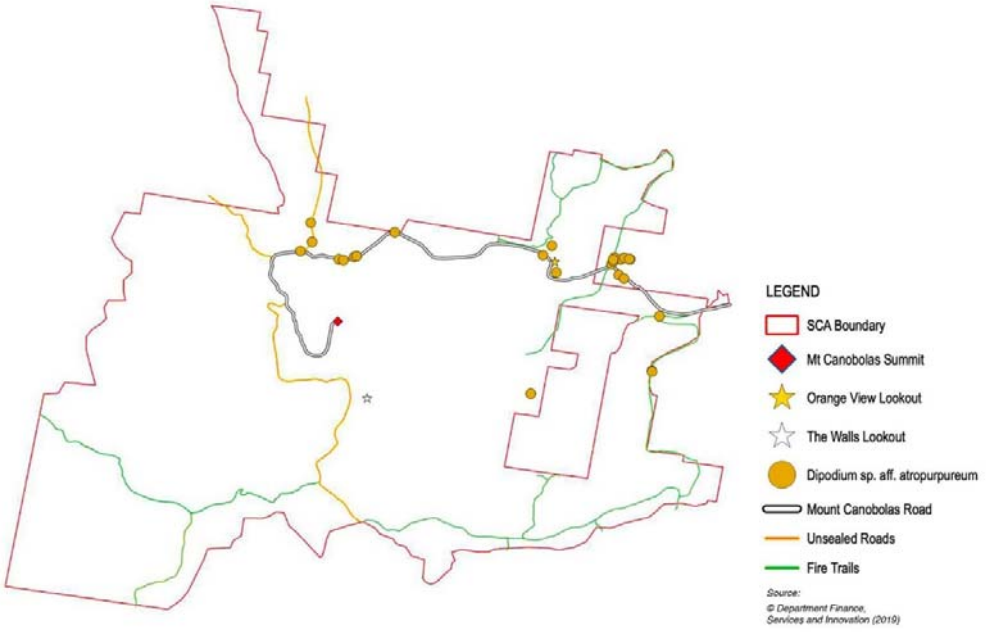

Figure 6. Distribution of *Dipodium* sp. aff. *atropurpureum*.

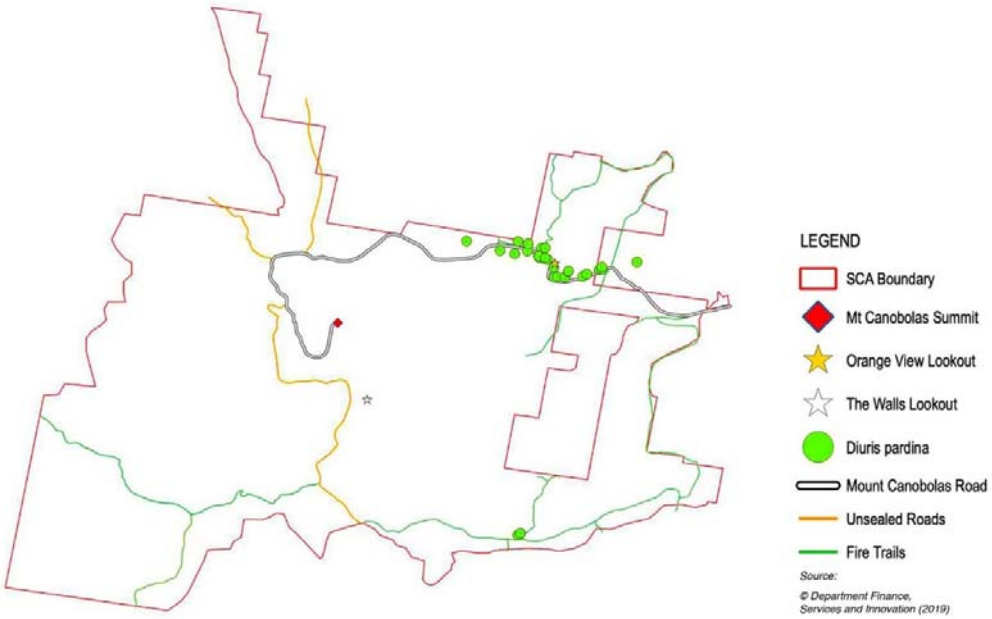

Figure 7. Distribution of *Diuris pardina*.

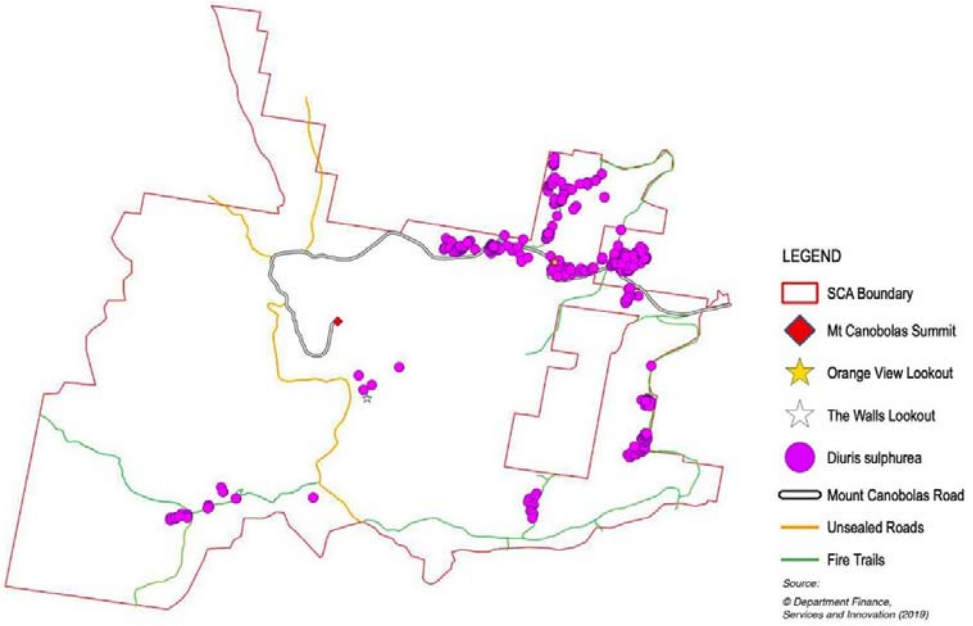

Figure 8. Distribution of *Diuris sulphurea*.

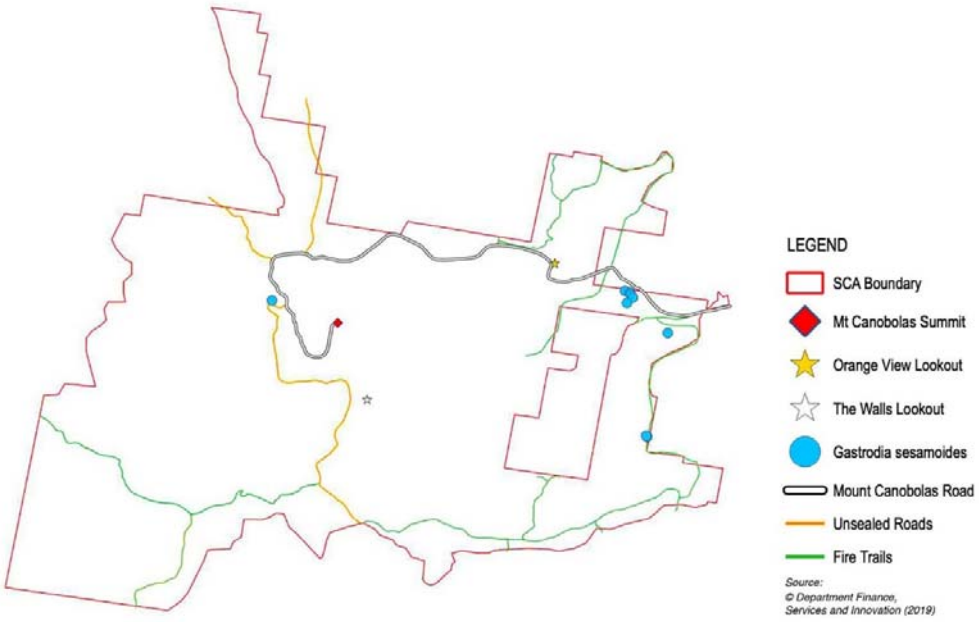

Figure 9. Distribution of *Gastrodia sesamoides*.

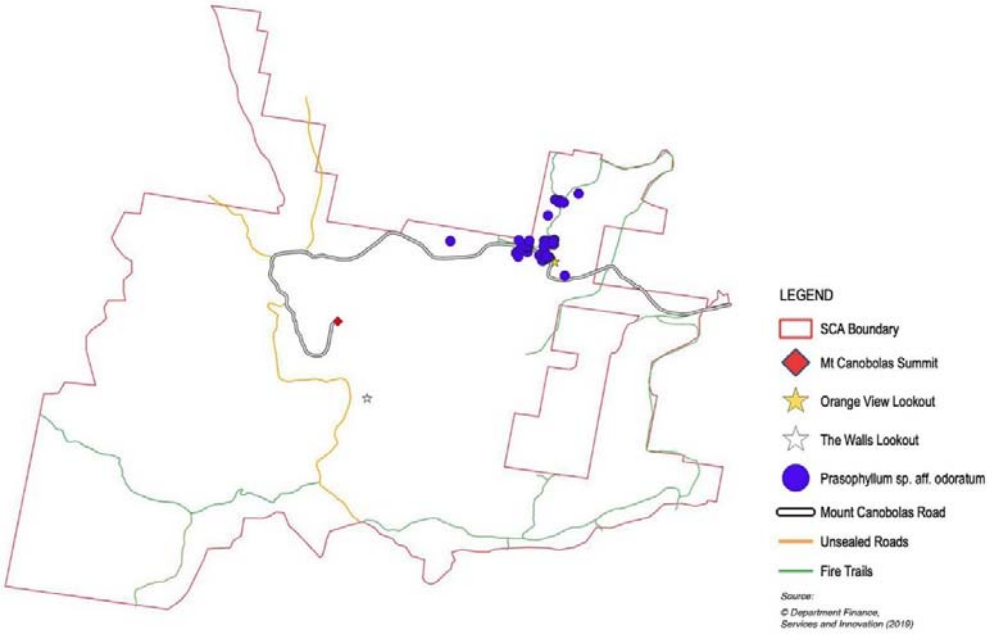

Figure 10. Distribution of *Prasophyllum* sp. aff. *odoratum*.

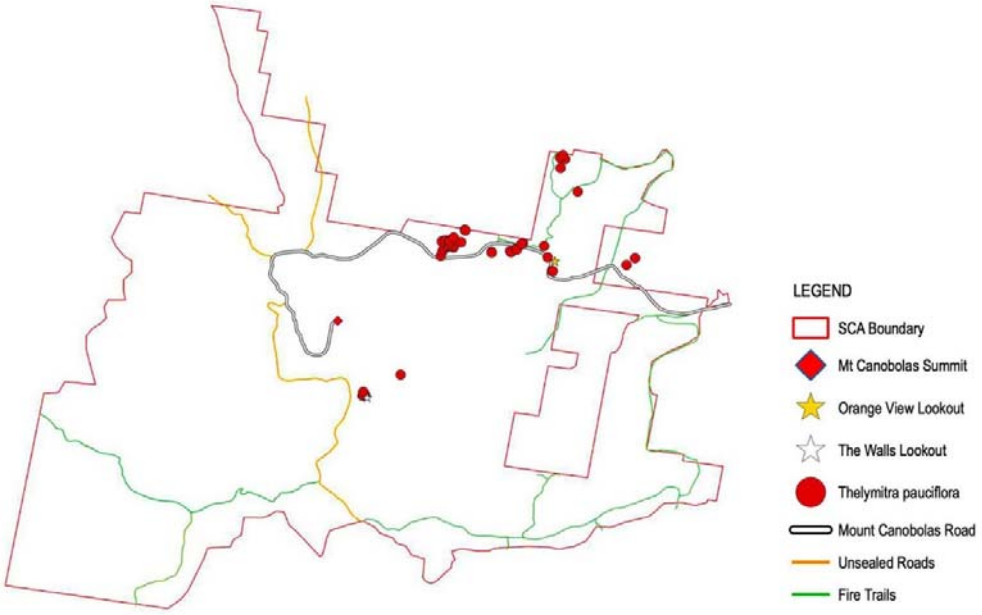

Figure 11. Distribution of *Thelymitra pauciflora*.

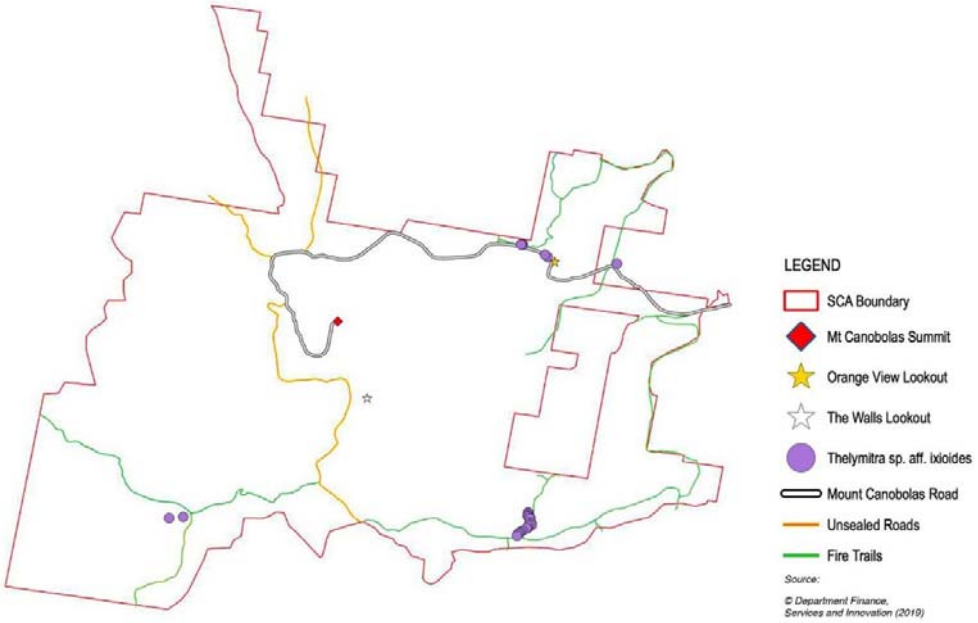

Figure 12. Distribution of *Thelymitra* sp. aff. *ixioides*.

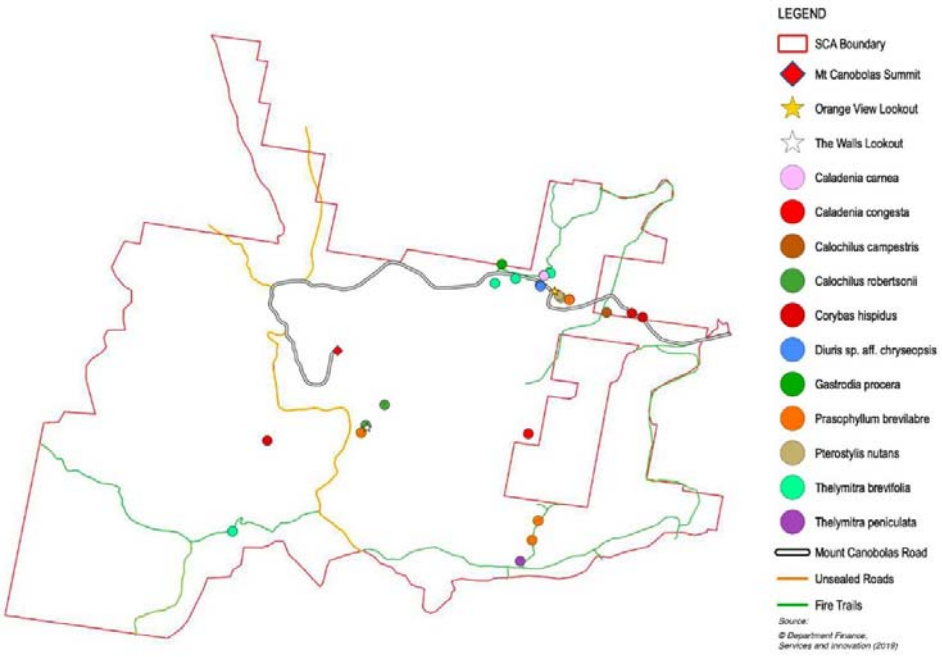

Figure 13. Distributions of 11 uncommon orchid species.

The Large Bird Orchid is notable in that it appears not to have been stimulated by the fire. Only a very small proportion of plants flowered (Table 1), which is normally the case with this species, whose flowering appears to be related to seasonal conditions. However, it is interesting that *C. valida* a high proportion of the flowers were pollinated indicating that sufficient numbers of the Thynnid wasp pollinator, *Neozeleboria monticola*, survived the fire to effect high levels of pollination. Plants of the Large Bird Orchid may be killed in severe fires owing to shallow tuber depths (Duncan 2012). Some populations in the SCA known to the author certainly produced far fewer leaves in 2018 than in a normal year, suggesting inhibition of the species by fire. Nonetheless, very large populations survived, presumably in areas of lower fire intensity, including the steep slopes of cuttings on Mount Canobolas Road.

Orchid hotspots

The orchid distributions shown in Figures 2 to 13 indicate that certain areas of the SCA are orchid 'hotspots'. Orchid hotspots are characterised by high orchid diversity measured as both high numbers of species present and high populations of each species. The main known orchid hotspot in the SCA straddles the Mt Canobolas Road between the Orange View Lookout and the Spring Glade parking area. This important area of high orchid diversity has been known since the 1980s and was confirmed by this survey. The hotspot also extends north of Orange View Lookout along the Fern Gully Firetrail to the junction of the Stringybark Firetrail.

A second known hotspot is the rock outcrop area in the Devils Hole on the western side of the private property inholding (Figure 1). The Devils Hole was not explored by this survey owing to difficult access.

The 2018 survey discovered a third very important hotspot in the south of the SCA extending along the full length of the Indigo Firetrail. This hotspot features many of the same orchids as in the Orange View Lookout area (Figures 2 to 13). A minor hotspot occurs on rock plate heaths in The Walls Lookout area, but has fewer species and lower populations than the main hotspots.

Other undiscovered hotspots may occur in less explored parts of the SCA. Attempts will be made to extend coverage to other areas in the future. Some parts of the SCA appear to have low orchid diversity represented only by the more common species such as *Chiloglottis valida*, *Diuris sulphurea* and *Microtis unifolia*. However, the absence of records in Figures 2 to 13, does not mean these areas do not support significant orchid diversity. The survey was designed to demonstrate orchid presence, not absence. Areas of low or no orchid diversity were not specifically documented.

Significant orchids

The Mt Canobolas SCA is home to a number of unique orchid species that are not known to occur anywhere else. Two of these have been recognised for many years, the Canobolas Leek Orchid, *Prasophyllum* sp. aff. *odoratum* (Plate 2) and the Canobolas Spider Orchid, *Caladenia* sp. aff. *patersonii* (Plate 3). Three other potentially endemic species have come to light as a result of the spring 2018 survey, *Diuris* sp. aff. *chryseopsis* (Plate 4), *Dipodium* sp. aff. *atropurpureum* (Plate 5) and *Thelymitra* sp. aff. *ixioides*. A further significant orchid is Fitzgerald's Spider Orchid, *Caladenia fitzgeraldii* (Plate 6), which is a regionally rare species that appears to be in decline. Each of these significant species is discussed below.

<u>*Prasophyllum* sp. aff. *odoratum*</u>

The Canobolas Leek Orchid, *Prasophyllum* sp. aff. *odoratum*, has been recognised as a new taxon restricted to Mt Canobolas by David Jones, Associate of the Australian National Herbarium, Canberra. The manuscript name of the new species is *Prasophyllum canobolasensis* (ms).

This orchid is a fire dependent species. It was locally common after the 1982 wildfire in the same areas where it was identified in this survey (Figure 10). It was described by Giles (1961) as being uncommon in the south-western parts of the Orange district. Following the 1982 wildfire, its flowering declined until it was no longer recorded by 13 years post-fire. It is of interest that every plant of the 86 detected by this survey flowered in the season following the 2018 fire, suggesting a remarkably strong and complete fire response. It appears that no plants produced leaves without flowering. The sudden post-fire reappearance of these plants also suggests they may have been dormant for 20 to 30 years waiting for another wildfire to occur. It is not known whether these plants produced any leaves without flowering in the intervening years. The status of this species as a narrow range endemic to Mt Canobolas with a known population of less than 100 plants indicates it would qualify for listing as Critically Endangered under the BC Act.

In order to gain some insight into the fire adaptations of the Canobolas Leek Orchid, 60 plants have been permanently tagged for monitoring of leafing, flowering, reproductive success and dormancy in future seasons.

Appendix 3 also presents data on plant survival, total numbers of flowers and the number of seed pods present at the time of permanent plant tagging. Of the 86 plants detected, four were sampled and submitted to the Australian National Herbarium in Canberra, leaving 82 plants in situ. Approximately half (53.7%) of these plants failed to produce seed owing to various misadventures including mainly predation by herbivores, but also being knocked over by passing animals or falling bark and branches (Appendix 3). The remaining 38 plants (46.3%) matured an average of 14.3 flowers of which an average of 6.8 developed seed pods. The mean percentage of seed pods per plant was 43.8 percent, varying from zero to 100 percent. This level of seed production is relatively high for orchids and indicates a high reproductive success for *Prasophyllum* sp. aff. *odoratum* following the fire. It also indicates survival of its pollinators. However, it was also evident that pollination levels varied considerably between sub-populations suggesting that pollinator populations varied across the landscape (Table 2).

Table 2. Mean Pollination Percentages across Sub-populations of *Prasophyllum* sp. aff. *odoratum*.

Sub-population	Location	No. of plants	Mean % pollination
1	Stringybark FT	6	84.6
2	N of Orange View Lookout (OVL)	8	44.8
3	OVL	10	19.3
4	Spring Glade	3	85.1
5	200 m NW OVL	4	48.5

Caladenia sp. aff. *patersonii*

David Jones, Associate of the Australian National Herbarium, Canberra has recognised the Canobolas Spider Orchid, *Caladenia* sp. aff. *patersonii* (Plate 3), as a new species with the manuscript name of *Caladenia boweri* (ms). This taxon has been observed only once, in 1988. The inflorescence of the plant was collected and is now preserved as a dissected specimen on a card at the Australian National Herbarium, Canberra. The collection site of this species was visited every spring for the next 10 years following its discovery and has not been seen again. It was not detected during the 2018 survey in which the original collection location was also revisited. This species is extremely rare in the SCA and may be extinct. It would certainly qualify for listing as Critically Endangered under the BC Act.

Plate 2. *Prasophyllum* sp. aff. *odoratum*

Plate 3. *Caladenia* sp. aff. *patersonii*

Plate 4. *Diuris* sp. aff. *chryseopsis*

Plate 5. *Dipodium* sp. aff. *atropurpureum*

Diuris sp. aff. *chryseopsis*

A small patch of *Diuris* in the *chryseopsis* group comprising five plants was identified during the survey near Orange View Lookout. This species had not been recorded specifically for Mount Canobolas, although Giles (1961) reported its presence in areas south west of Orange. The patch comprised only five plants that were late flowering for this species. Flower morphology also appeared to be distinctive, so photos (Plate 4) were sent to David Jones, who considered the population may represent a new undescribed taxon. A specimen will be forwarded to Dr MA Clements at the Australian National Herbarium, Canberra, next spring, if they reappear. This taxon, if eventually recognised as a new species, would also qualify as Critically Endangered under the BC Act.

Dipodium sp. aff. *atropurpureum*

Hyacinth Orchids, *Dipodium* spp. (Plate 5) flowered in December after the spring survey had finished. A small group of survey participants followed up with observations on *Dipodium*. Prior to this survey several *Dipodium* species had been recorded in the SCA (Appendix 1). These included *Dipodium punctatum*, which is widespread on volcanic soils elsewhere in the Orange district; *Dipodium roseum*, which also occurs in the Mullion Ranges north and east of Orange and *Dipodium variegatum*, which is normally found on the east coast and the escarpment of the Great Dividing Range.

During the 2018 survey it was noticed that few of the Dipodiums seemed to conform strictly to *D. punctatum*, none represented *D. variegatum* and some seemed closest to *D. roseum*. However, most appeared to be intermediate between *D. punctatum* and *D. roseum.* Specimens were sent to Dr MA Clements of the Australian National Herbarium, who considered they may represent either an isolated population of *Dipodium atropurpureum*, which is principally a NSW northern tablelands and escarpment species, or a new species related to it. The specimens have been retained for further study and DNA samples taken from them, which will be used in future phylogenetic work on the genus. In the meantime, the Mt Canobolas Dipodiums are referred to as *Dipodium* sp. aff. *atropurpureum* in this report.

Caladenia fitzgeraldii

Caladenia fitzgeraldii (Plate 6) is a regionally rare species for which Mount Canobolas is its main stronghold in Central Western NSW. It flowered vigorously after the 1982 wildfire and occupied a relatively large area within the hotspot around Orange View Lookout. Its flowering gradually declined over the following seasons and in the last 20 years has been seen at only one location where it flowered sporadically. It was not known whether the metapopulation had actually declined or most of the plants lay dormant waiting for another summer wildfire.

In spring 2018 flowering of *C. fitzgeraldii* within its previously known distribution increased but not to the levels seen after the 1982 fire. Ten plants were detected, half of which carried flowers while the other half produced only leaves (Appendix 4). The area of occupancy in 2018 was noticeably smaller than post 1982. It is possible that a larger flowering will occur in 2019, especially if soaking rains occur in autumn-winter.

The 2018 survey detected two previously unknown populations (Figure 2). One of these was only a single flowering plant, but the other on the Indigo Firetrail contained eight plants, five of which flowered.

An ominous sign for *C. fitzgeraldii* in the SCA is that no plants reproduced in 2018, the best opportunity to multiply that this species has had for several decades (Appendix 4). The reasons were a high level of florivory, eight plants lost flowers to herbivores, possibly macropods which were active after the fire, and the very large distances between flowers, which reduce the likelihood of pollen transfer by insects. The population of *C. fitzgeraldii* in the SCA has been nominated by the author to

the NSW Scientific Committee for listing as Endangered owing to the its decline over the last 30 years and ongoing threats to its survival.

Plate 6. *Caladenia fitzgeraldii*

Thelymitra sp. aff. *ixioides*

In late spring 2018, widespread flowering of a self-pollinating form of the Dotted Sun Orchid, *Thelymitra ixioides*, occurred. Earlier in spring the typical outcrossing form of the Dotted Sun Orchid flowered in the South Mullion Range SCA east of Orange. The outcrossing form opens its flowers freely on most days, but self-pollinating plants open shyly and only on very warm sunny days. Most plants of the latter only half-opened their flowers briefly around the middle of the day. Specimens of the self-pollinating form were sent to Dr MA Clements of the Australian National Herbarium. It is considered these plants may represent another undescribed taxon, which is called *Thelymitra* sp. aff. *ixioides* in this report. The strong flowering of this form following the February wildfire suggests it is fire-stimulated.

Value of the Mount Canobolas SCA for orchid conservation

The SCA is one of the most important areas for the conservation of native orchids in the NSW Central West owing to its high orchid diversity and unique geographical attributes. Mount Canobolas is an isolated volcanic inselberg supporting the most westerly island of sub-alpine vegetation in central NSW. It provides a refuge for an eclectic assemblage of high altitude orchid species, some of which are narrow-range endemics restricted to the mountain. The extent of orchid endemism on Mt Canobolas is only just beginning to be understood and much further research is required to reveal the evolutionary relationships of these orchids with those elsewhere.

A total of 38 orchid species is known to occur, a high diversity, of which 10 are high altitude species that do not occur in the surrounds (page 3). Two of these, *Caladenia* sp. aff. *patersonii* and

Prasophyllum sp. aff. *odoratum* are recognised as being narrow-range endemic species known only from Mt Canobolas and are soon to be formally named. A further three taxa, as outlined above, are morphologically distinct and may potentially be new species; *Diuris* sp. aff. *chryseopsis*, *Dipodium* sp. aff. *atropurpureum* and *Thelymitra* sp. aff. *ixioides*. When it is considered that several other narrow-range endemic species in other plant groups occur in the SCA it is clear that Mount Canobolas has been a centre of vicariant evolution and is a refuge for unique high altitude flora (Medd and Bower 2018).

Mount Canobolas SCA is a small reserve of only 1672 ha, yet supports an unusually high and scientifically important diversity of orchids and other plants. The SCA is a vitally important conservation reserve, undoubtedly the most important in the region, and is of state and national significance.

Management of orchids in the SCA

Fire

There is anecdotal evidence that populations of some orchids or groups of orchids have declined in the SCA over the last 30 or so years. The surge in orchid flowering in spring 2018 following the previous summer's wildfire suggests that lack of summer fires may be a major contributing factor. Lack of fire may impact orchids in two main ways:

- Fire stimulated species flower strongly after fire and the proportion of plants that flower declines markedly with time after the fire, reducing reproduction and resulting in falling population sizes.
- In the absence of fire, grasses and shrubs become dominant, shading out orchids and other herbs, so reducing their vigour and inhibiting flowering.

The fire regime adopted for the SCA since the 1982 wildfire has been one of fire exclusion over the core areas of the reserve. Controlled burns have taken place around the perimeter mainly aimed at reducing perceived risks to the surrounding State Forest plantations. Sub-alpine woodlands are currently considered to be areas of low natural fire frequency and a burning interval of 35 years has been recommended. This interval may not be appropriate for Mt Canobolas given the fire dependence shown by a significant number of the orchids and other ground cover forbs that appeared in abundance following the 2018 fire.

However, there is doubt as to the efficacy of current controlled burning practices for inducing fire responses in many fire-stimulated forb species, which are stimulated strongly by summer fires, but appear to respond poorly, or not at all, to the late autumn and early spring burns that are preferred by fire management agencies. Accordingly, there is a need to consider the merits of more frequent burning of the SCA, possibly a ten year rotation, and preferably on a mosaic pattern. Where possible, some burns in areas of high ground cover diversity should occur in the summer- early autumn period.

Feral Pigs

Orchids and many other forbs on Mount Canobolas are perennials with underground tubers. Roots and tubers are important food sources for feral pigs which have long resided in the SCA. During the survey, areas of deeper moist soils turned over by feral pigs were observed. These soils are favoured by many orchids including the Large Bird Orchid (*Chiloglottis valida*) and many Greenhoods (*Pterostylis* spp.). Indeed, colonies of the Large Bird Orchid affected by feral pigs were observed on several occasions. Grazing by feral pigs may be one of the reasons for the decline in Greenhoods in the SCA over the last few decades. It is also noticeable that the largest concentrations of orchids found during the survey tended to be in areas of shallower stony soils on ridgetops that are less likely

to be favoured by feral pigs. This suggests the extant orchid populations in the SCA may have survived mainly in habitats less favoured by feral pigs.

It is recommended that concerted efforts be made to reduce feral pig numbers with the aim of eventually eradicating them from the SCA.

Assessing the impacts of future developments in the SCA on orchids

The orchid surveys reported here were conducted because it was expected that the February 2018 wildfire would stimulate significant flowering events in the springs of 2018 and 2019, after which flowering in fire responders would decline to low levels. This survey provided the first opportunity to investigate the distribution and abundance of fire-stimulated orchids in the SCA in over 30 years. In the long periods between fires, these orchids are virtually undetectable, since they exist in vegetative states as dormant tubers, or tubers with only small cryptic leaves above the soil surface. Because it is impossible to detect dormant plants and very difficult to detect plants in leaf, surveys for these orchids as part of the normal environmental assessment process for developments would likely fail to detect most plants. Consequently, any developments within or near the known distributions of these orchids are considered likely to have unintended adverse impacts.

At least two, and up to five, orchid taxa are endemic to the SCA. All are likely to qualify for listing as Critically Endangered under the BC Act once they are formally recognised as being sufficiently distinct to warrant recognition as new species. Potential development impacts on these species would be deemed as Serious and Irreversible Impacts under the BC Act, since adverse impacts on these species may place them at risk of extinction. If a project is shown to have a Serious and Irreversible Impact approval can be refused or additional mitigation measures may be imposed.

It is recommended that no development should take place within the orchid hotspots identified in this report, or within 100 m of recorded locations of the Canobolas Leek Orchid, Fitzgerald's Spider Orchid, the Canobolas Spider Orchid or the Small Snake Orchid.

Future work

Methodology

The 2018 survey encountered a number of methodological issues including problems with GPS readings, the temporary plant tagging system and orchid identification in some groups. These are discussed below.

Hand held GPS units are accurate to only 10 m and this is insufficient for refinding individual plants in the field, especially if the plants have suffered herbivory, accidental displacement or had their temporary tags lost or displaced. Accordingly, it is recommended that:

- Permanent markers be applied to plants that are to be individually monitored at the time they are first located and not delayed until fruit set measurements are made.
- A more accurate GPS positioning system be acquired for readings of plant locations. The Trimble Catalyst system is one potential unit. It is accurate to within 1 m and can be used with an Android mobile phone. One metre accuracy would greatly facilitate the relocation of permanent markers in subsequent seasons.

Difficulties in identifying species were encountered in Diuris and Thelymitra. Survey participants sometimes confused *Diuris pardina* and *Diuris sulphurea* in the bud and post-flowering stages. This was mainly a problem late in the survey when post-anthesis plants of both species were present. Early in the survey, *Diuris pardina* was in flower and *D. sulphurea* was in bud so that a few *D. sulphurea* may have been recorded as *D. pardina*.

In the case of Thelymitra, the main confusion was between *T. pauciflora* and *T.* sp. aff. *ixioides*. The presence and prevalence of the latter was unknown in the SCA prior to the survey. The leaves of the two taxa are both slender, grooved and red at the base. Both species are also self-pollinating and open their flowers very shyly. Accordingly, it is likely that many plants of *T.* sp. aff. *ixioides* were identified as *T. pauciflora* before the existence of the former was identified. However, it was also observed that *T. pauciflora* is a more diminutive species that occurred almost exclusively in rock plate heaths, while *T.* sp. aff. *ixioides* was more robust and occurred predominantly in grassy woodland. Some adjustment of the results has been made on this basis.

Volunteers for future surveys will be trained to distinguish *D. pardina* and *D. sulphurea*, and *T. pauciflora* and *T.* sp. aff. *ixioides*.

Citizen Science Surveys

It is proposed to repeat the 2018 surveys annually for up to five years, depending on the enthusiasm of volunteer participants and the results obtained. The fire stimulation effects are expected to carry over into 2019 in some species, e.g. Fitzgerald's Spider Orchid, but to show a decline in others, e.g. the Canobolas Leek Orchid. Future surveys will revisit areas surveyed in 2018 to assess changes in flowering intensity. Searches will also be conducted for new orchid hotspots and populations of rare species in unsurveyed parts of the SCA.

Population Monitoring

Marked plants of the Canobolas Leek Orchid, Fitzgerald's Spider Orchid and the Small Snake Orchid will be monitored in spring 2019 to determine the proportions of plants that flower, flowers that set seed, plants that produce leaves only, and plants that do not produce leaves and may be dormant or dead. Any new plants of these species observed in the general orchid surveys will be permanently marked and monitored.

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

- Some native orchids are known to undergo enhanced flowering in the season or two following hot summer wildfires.
- A 'Citizen Science' survey of terrestrial orchids in the Mount Canobolas State Conservation Area (SCA) was conducted in late spring 2018 following a wildfire that burnt 70 percent of the reserve in February 2018.
- The survey was undertaken twice a week for five weeks by 13 community volunteers.
- Areas surveyed were known orchid 'hotspots' and a selection of areas considered likely to support orchids.
- The numbers of individuals and their locations were recorded for each orchid species.
- Prior to the survey some 34 orchid species were known with confidence from the SCA and another 11 records were considered to require verification.
- The survey recorded 23 spring-flowering species, two of which were new records for the SCA and two other sightings confirmed species that required verification, bringing the total number of confirmed orchid species for the SCA to 38.
- Flowering of eight orchid species clearly appeared to be fire-stimulated, including one, the Canobolas Leek Orchid, that had not been seen for over 20 years.
- A previously known orchid 'hotspot' identified after the 1982 wildfire in the north east of the SCA was again a main centre of orchid diversity. The survey also revealed a new 'hotspot' in the south of the SCA.

- Mt Canobolas SCA hosts two recognised but undescribed endemic orchid species, the Canobolas Spider Orchid, *Caladenia* sp. aff. *patersonii* and the Canobolas Leek Orchid, *Prasophyllum* sp. aff. *odoratum*, that are soon to be described as new. The survey revealed three other taxa that appear to be distinctive and may also be new species; *Diuris* sp. aff. *chryseopsis*, *Dipodium* sp. aff. *purpureum* and *Thelymitra* sp. aff. *ixioides*.
- Enhanced post-fire flowering occurred in an important population of Fitzgerald's Spider Orchid, *Caladenia fitzgeraldii*, for which the SCA is the main stronghold in Central Western NSW. However, flowering was much less than observed after the 1982 fire.
- Sixty plants of the Canobolas Leek Orchid, 14 plants of Fitzgerald's Spider Orchid and five plants of the Small Snake Orchid were permanently marked for future population monitoring.
- It is proposed to repeat the orchid survey for up to five years to monitor flowering trends over time.

Conclusions

- Mt Canobolas SCA is one of the most important areas for orchid conservation in NSW owing to its high orchid diversity, two recognised endemic orchid species and three other potential new species.
- The SCA is small, only 1672 ha, yet supports an unusually high and scientifically important diversity of orchids and other plants. It is the most important reserve in the region, and is of state and national significance.
- At least half of the spring-flowering orchids in the SCA are fire stimulated and consequently may be disadvantaged by the current policies of fire exclusion in the core of the SCA. The late autumn timing of most controlled burns in the Central West may also be ineffective in stimulating fire-induced flowering.
- Feral pigs are an important threat to orchids and other tuberous forbs in the SCA.
- At least two, and up to five, orchid species are endemic to the SCA, have very small population sizes and would qualify for listing as Critically Endangered under the BC Act.
- The cryptic nature of fire-stimulated terrestrial orchids in the intervals between fires makes them impossible to accurately survey for environmental assessments.

Recommendations

It is recommended that:

- No developments be approved within known orchid 'hotspot' areas.
- No developments occur within 100 m of recorded locations of endemic and important orchid species, including the Canobolas Leek Orchid, Fitzgerald's Spider Orchid, the Canobolas Spider Orchid and the Small Snake Orchid.
- A regime of mosaic summer – early autumn burning be applied to the core areas of the SCA to reduce grass cover and stimulate orchids and other fire-responsive forbs.
- Control programs for feral pig control be intensified with the objective of eradicating pigs from the SCA.

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APPENDIX 1

Annotated List of Orchids Recorded Historically in the Mt Canobolas SCA Prior to the 2018 Survey. [Currently accepted names are shaded in green]

Scientific Name	Common Name	Source			Name Accepted	Comment
		AVH	BioNet	Hunter		
Arthrochilus huntianus	Elbow Orchid		✓		✓	Specimen at Royal Botanic Gardens, Sydney.
Caladenia congesta	Black-tongue Caladenia			✓	✓	
Caladenia cucullata	Lemon Caps				X	No specimens in herbaria. Needs confirmation.
Caladenia dimorpha					X	No specimens in herbaria. Needs confirmation.
Caladenia fitzgeraldii	Fitzgerald's Spider Orchid		✓		✓	Specimen at Royal Botanic Gardens, Sydney
Caladenia fuscata	Dusky Fingers			✓	✓	Bower and Kenna (1998).
Caladenia gracilis	Musky Caps		✓	✓	✓	
Caladenia phaeoclavia	Brown-clubbed Spider Orchid		✓	✓	✓	
Caladenia sp. aff. *patersonii*	Canobolas Spider Orchid				✓	Specimen at the Australian National Herbarium, Canberra.
Caladenia tentaculata				✓	X	*C. tentaculata* has been observed by the author west of the SCA, but not within it. Possible confusion with *C. phaeoclavia*. Requires verification.
Calochilus campestris				✓	✓	Observed by author in SCA..
Calochilus robertsonii				✓	X	Possible. No specimens in herbaria. Requires verification.
Chiloglottis pluricallata					X	Specimen in NCW Beadle Herbarium, University of New England. Most likely a misidentification of *Chiloglottis valida.* Needs verification.
Chiloglottis reflexa					X	Recent studies of *Chiloglottis* recognise *C. reflexa* as a coastal and sandstone species in NSW. Former records for Mt Canobolas are *C. trilabra*.
Chiloglottis trilabra				✓	✓	Bower and Kenna (1998). Rare.
Chiloglottis valida		✓	✓	✓	✓	Specimens at the Australian National Herbarium, Canberra and the Royal Botanic Gardens, Sydney.

Scientific Name	Common Name	Source			Name Accepted	Comment
		AVH	BioNet	Hunter		
Corybas hispidus				✓	✓	Bower and Kenna (1998).
Cryptostylis subulata			✓		X	Record in BioNet (2019) from Hunter survey, but not in Hunter (2002) species list.
Diuris pardina					✓	
Diuris punctata				✓	X	A distinctive species that is hard to mistake for anything else, but has not been recorded by anyone other than Hunter (2002). Needs verification.
Diuris semilunulata				✓	X	Plants thought to be *D. semilunulata* are *D. pardina.*
Diuris sulphurea			✓	✓	✓	A common species in the SCA.
Dipodium punctatum				✓	✓	Plants thought to be this species are commonly reported in the SCA.
Dipodium roseum				✓	X	No specimens in herbaria. Needs verification.
Dipodium variegatum			✓		X	Record in BioNet (2019) from Hunter survey, but not in Hunter (2002) species list. Well outside the normal range of this species.
Eriochilus cucullatus				✓	✓	A widespread common species.
Gastrodia procera				✓	X	No specimens in herbaria. Needs verification.
Gastrodia sesamoides					✓	Reported as common by Giles (1961)
Genoplesium sagittiferum				✓	✓	Observed by Medd and Bower (2010)
Microtis parviflora		✓			✓	Specimen labelled ‘Mt Canobolas’ in Australian Tropical Herbarium, Townsville.
Microtis unifolia		✓	✓	✓	✓	Specimens at the Australian National Herbarium, Canberra. Recorded in Hunter (2002) as *M. uniflora.*
Prasophyllum brevilabre				✓	✓	
Prasophyllum odoratum				✓	X	Plants on Mt. Canobolas are thought to be a new species as below.
Prasophyllum sp. aff. *odoratum*			✓		✓	Specimen at Royal Botanic Gardens, Sydney.

Scientific Name	Common Name	Source			Name Accepted	Comment
		AVH	BioNet	Hunter		
Pterostylis aestiva			✓		✓	Specimen at Royal Botanic Gardens, Sydney.
Pterostylis alata				✓	X	Now known as *Pt. striata*.
Pterostylis coccina				✓	X	Possibly mistaken for *Pterostylis aestiva*. One plant thought to have been seen in the 1980s by the author. Needs verification.
Pterostylis decurva				✓	✓	Seen in the 1980s by the author. Rare.
Pterostylis falcata					X	May once have occurred (Giles 1961), but not seen in last 50 years.
Pterostylis laxa					X	Reported to author by reliable observer. Needs verification.
Pterostylis longifolia				✓	X	Revisions of this group of Pterostylis have described the local species as *Pt. tenuis*. *Pt. longifolia* is confined to sandstone areas near the coast.
Pterostylis nutans				✓	✓	Bower and Kenna (1998).
Pterostylis parviflora				✓	X	Possible, but more likely to be *Pt. rubescens* which was described as new after Hunter's survey and photographed by Medd and Bower in the Devils Hole in 2010.
Pterostylis pedunculata			✓	✓	X	Nine records from Hunter survey in BioNet (2019), suggesting the species is common, but it has not been observed by anyone else. Appears to be a misidentification.
Pterostylis rubescens					✓	Photographed by Medd and Bower (2010) in the Devils Hole.
Pterostylis sp. B					✓	Seen in the 1980s by the author. Rare.
Pterostylis striata					X	Unlikely, would not have been flowering during Hunter's survey, when he called it *Pt. alata*. Occurs in dry forests at lower altitudes. Needs confirmation.
Pterostylis tenuis					✓	Identified in the Devils Hole by Bower and Kenna (1998).
Spiranthes lancea		✓			X	Specimen at the Australian Tropical Herbarium, Townsville. Now considered to be *S. australis*.
Spiranthes australis					✓	Likely to be in SCA. Reported for district by Giles (1961).

Scientific Name	Common Name	Source			Name Accepted	Comment
		AVH	BioNet	Hunter		
						Seen nearby by the author. Needs verification.
Thelymitra brevifolia					✓	Specimens from the SCA identified as *T. brevifolia* by J. Jeanes, Associate of Royal Botanic Gardens, Melbourne.
Thelymitra carnea					✓	Seen by the author in the Devils Hole in the 1980s and photographed there by Medd in 2005.
Thelymitra ixioides		✓	✓		✓	Specimen at Royal Botanic Gardens, Sydney.
Thelymitra megcalyptra				✓	X	Record in Hunter (2002), but not in BioNet (2019). Needs verification.
Thelymitra pauciflora					✓	Specimens from the SCA identified as *T. pauciflora* by J. Jeanes, Associate of Royal Botanic Gardens, Melbourne.
Thelymitra peniculata					✓	Specimens from the SCA identified as *T. peniculata* by J. Jeanes, Associate of Royal Botanic Gardens, Melbourne.
Thelymitra simulata					✓	Photos in Devils Hole by Bower and Medd in 2005.

APPENDIX 2

FIELD DATA SHEET

MOUNT CANOBOLAS ORCHID DATA SHEET

Site:				Date:		Observer:		
WP No.	Easting	Northing	Plant tagged?	Genus	Species	No. of plants	Approx. area (m^2)	Notes
Comments:								

APPENDIX 3.

***Prasophyllum* sp. aff. *odoratum* - Herbivory, Numbers of Flowers per Inflorescence, and Numbers and Percentages of Seed Pods.**

Site No[1].	Permanent Tag no.	Herbivory[2]	Number of flowers	Number of seed pods	Percent seed pods	Comment
240	PC1	✓	-	-	-	Plant missing - part of stem found
RM103	PC2	✓	-	-	-	Inflorescence gone from plant
RM98	PC3	-	15	15	100	
RM99	PC4	-	18	16	88.9	
RM99	PC5	-	7	0	0	All flowers shrivelled - probably died during anthesis
307	PC6	-	18	15	83.3	3 buds shrivelled at base of inflorescence
308	PC7	✓	2	0	0	Lost all but 2 basal flowers
55	PC8	-	19	14	73.7	Plant and tag displaced - 1m apart
54a	PC9	-	11	9	81.8	
53	PC10	✓	5	4	80	Half of inflorescence gone. 5 Flowers remaining
122	PC11	✓	-	-	-	Plant missing
324	PC12	-	20	10	50	Plant later flowering not completely dried out
63	PC13	-	12	5	41.7	
60	PC14	-	13	4	30.8	
59	PC15	-	16	4	25	
62	PC16	-	14	7	50	
61	PC17	-	15	11	73.3	
HB23	PC18	✓	-	-	-	All of inflorescence gone
CS72	PC19	-	19	15	78.9	Plant displaced by falling bark
CS71	PC20	✓	-	-	-	Could not locate - site covered in fallen bark
11a	PC21	✓	-	-	-	Top of plant gone - no flowers

Site No[1].	Permanent Tag no.	Herbivory[2]	Number of flowers	Number of seed pods	Percent seed pods	Comment
314	PC22	✓	-	-	-	Plant missing
315	PC23	✓	-	-	-	Inflorescence gone
313	PC24	-	12	1	8.3	
316	No Tag	✓	-	-	-	No plant or Tag found
5a	PC25	✓	-	-	-	No plant found
221	PC26	✓	-	-	-	Plant gone
AR1	No Tag	✓	-	-	-	Plant and tag gone
BH8	PC27	-	17	2	11.8	
325	PC28	-	8	0	-	
10a	PC29	✓	-	-	-	Plant gone
5	PC30	✓	-	-	-	Both plants missing
5	PC30	✓	-	-	-	
193	PC31	-	-	-	-	Plant to ANH (leaf and spike only)
194	PC32	-	12	2	16.7	
195	PC33	-	-	-	-	Remaining plant gone. 2 plants 8 cm apart, one to ANH
195	PC33	✓	-	-	-	
12	PC34	-	11	3	27.3	Six plants in 2 x1 m on either side and in drain.
12	PC35	-	14	14	100	
12	PC36	-	8	4	50	
12	No Tag	✓	-	-	-	Plant not found
12	No Tag	✓	-	-	-	Plant not found
12	No Tag	✓	-	-	-	Plant not found
196	PC37	✓	-	-	-	Plant gone
11	PC38	✓	-	-	-	Plant gone

Site No[1].	Permanent Tag no.	Herbivory[2]	Number of flowers	Number of seed pods	Percent seed pods	Comment
4	PC56	✓	-	-	-	No tag or plant seen
200	No Tag	✓	-	-	-	
199	PC39a	-	19	12	63.2	Two plants evident. Tight group sheltered by fallen branch.
199	PC39b	-	15	12	80	
199	PC39c	✓	-	-	-	Not found
3	PC40	✓	-	-	-	Plant gone
54	PC41	✓	-	-	-	No plant found
HB28	PC42	-	8+	0	-	Top of plant gone, maybe rotted off. Only bracts of flowers remaining.
188	No Tag	-	-	-	-	Plant to ANH (leaf and spike only)
14	PC43a	✓	-	-	-	Plant not found. 14 and 15 are probably same two plants as at 7.
15	PC43b	✓	-	-	-	
6	PC44	-	-	-	-	Plant to ANH (leaf and spike only)
8	PC45a	-	15	1	6.7	Marker gone, plants (3) present
8	PC45b	-	14	1	7.1	
8	PC46	-	9	0	0	
10	No Tag	✓	-	-	-	Marker absent
9	PC47a	-	16	1	6.3	
9	PC47b	-	20	0	0	
9	PC48	-	18	8	44.4	
9	No Tag	✓				
9	No Tag	✓				
9	No Tag	✓	-	-	-	
9	No Tag	✓	-	-	-	

Site No[1].	Permanent Tag no.	Herbivory[2]	Number of flowers	Number of seed pods	Percent seed pods	Comment
9	No Tag	✓	-	-	-	
9	No Tag	✓	-	-	-	
9	No Tag	✓	-	-	-	
13	PC49	-	33	17	51.5	
28	PC50	-	25	14	56	
27	PC51	-	18	0	0	
333	PC52	✓	-	-	-	
334	PC53	-	24	5	20.8	
24	PC54	✓	-	-	-	No plant found
RM1	PC55	✓	-	-	-	No plant found
CS7	PC57	-	14	13	92.9	
CS7	PC58	✓	-	-	-	
CS7	PC59	-	13	12	92.3	
CS7	PC60	-	10	7	70	
CS7	No Tag	✓	-	-	-	
CS7	No Tag	✓	-	-	-	
Total plants		**44**	**38**	**38**	**-**	
Mean			**14.3**	**6.8**	**43.8**	

[1] Original field survey site code.
[2] Herbivory includes plants that have lost all or part of inflorescences, part of stem, or plant has disappeared.

APPENDIX 4

Caladenia fitzgeraldii - Plants with Flowers, Plants with Leaves Only and Florivory.

Site No[1].	Tag no.	Flower	Leaf only	Seed pod	Florivory[2]	Comment
30a	CF1	✓	-	-	✓	Plant dry when first observed, flower missing
310	CF2	✓	-	-	-	Flower finished when first observed.
51	CF3	✓	-	-	?	No flower; leaf very shrivelled, brown and dry at plant marking
51	CF3	-	✓	-	-	Leaf not present at marking
1	CF4	✓	-	-	✓	Plant very dry, brown, shrivelled at marking
40	CF6	✓	-	-	✓	Stem still present at marking, dry straw-like
115	CF7	-	✓	-	-	Flag displaced at marking time
30	No Tag	✓	-	-	?	Not checked or marked at marking time, pink flag still in place
RM69	CF5	✓	-	-	✓	
RM69	CF5	✓	-	-	✓	
RM69	CF5	✓	-	-	✓	
RM69	CF5	✓	-	-	✓	
RM69	CF5	✓	-	-	-	
RM69	CF5	-	✓	-	-	
RM69	CF5	-	✓	-	-	
RM69	CF5	-	✓	-	-	
115	No Tag	-	✓	-	-	This plant not marked initially.
115	No Tag	-	✓	-	-	This plant not marked initially.
309	No Tag	-	✓	-	-	This plant not marked initially.

[1] Original field survey site code.

[2] Florivory comprises plants that have lost the flower to herbivores.