# TASMANIAN THREATENED ORCHID BASELINE DATA AND MONITORING: WHERE WE ARE AT AND WHERE WE NEED TO BE

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**SUMMARY**

As part of the implementation of the *Flora Recovery Plan: Tasmanian Threatened Orchids 2006 -2010* this study aimed to improve baseline data for priority Tasmanian threatened orchid populations. Ninety one populations of 36 species were surveyed across the State. Population data was collected from 62 populations, while 29 previously recorded populations could not be located. The data collected adds to our understanding of threatened orchid distributions and will inform management of those populations. However, the failure to locate several high priority species and lower than previously estimated populations sizes recorded for several species, is a concern. There is a need for continued long-term monitoring of priority species. These studies should be designed to capture demographic data with a view to improving our understanding of threatened orchid population dynamics. Such studies on mainland Australia have assisted in population recovery by identifying factors controlling population growth and decline, and tailoring management strategies accordingly. Developing working collaborations between community groups and government agencies to ensure the longevity of these monitoring programs is discussed.

## INTRODUCTION

A basic knowledge of population location and size is of principal importance to effective threatened plant conservation (Schemske *et al.* 1994; Slade *et al.* 2003). Although these might seem relatively simple parameters to obtain given the sessile nature of plants, when dealing with plants that show cryptic life-history stages they can prove challenging (Kéry *et al.* 2005). Knowledge of more detailed demographic information such as reproductive output and lifespan are important for identifying factors limiting population growth, but are also difficult to obtain from species with unidentifiable life history stages (Schemske *et al.* 1994; Kéry *et al.* 2005).

Terrestrial orchids typically show extended periods of dormancy without above ground structures (Jones *et al.* 1999). While most species show annual dormancy patterns, some species and/or populations can remain dormant for several consecutive years and dormancy of up to twelve years has been reported (Tamm 1972). The mechanisms controlling dormancy and emergence in orchids are not well understood, though it is assumed that environmental conditions and individual life-histories (previous emergence, flowering and reproductive efforts) are important contributors (Pfeifer *et al*. 2006). Some species are thought to only emerge after disturbance events. For example *Prasophyllum secutum* is almost exclusively found in coastal habitats the season following a fire (Wapstra *et al.* 2008). The initial challenge for conservation managers dealing with threatened terrestrial orchids is to identify the location and extent of populations so that they can be adequately protected (TSS 2006). Once populations are known and secure, then further research into population dynamics may allow insights into the factors controlling dormancy, emergence, flowering and ultimately population growth and decline (Schemske *et al*. 1994).

Tasmania has a rich orchid flora, although of its 207 terrestrial orchid taxa, 68 (31 endemic) are listed as threatened under the Tasmanian *Threatened Species Protection Act 1995* (TSPA) and 32 are listed nationally on the *Environment Protection and Biodiversity Conservation Act 1999* (EPBCA). Prior to 2006 orchid conservation in Tasmania was undertaken on an *ad hoc* basis as funding became available (TSS 2006). This approach had limited success and a need for a long-term commitment to orchid conservation was identified (TSS 2006). To address this need the Threatened Species Section (TSS), Department of Primary Industries and Water (DPIW), developed the *Flora Recovery Plan: Tasmanian Threatened Orchids 2006 -2010* (hereafter referred to as TORP for Threatened Orchid Recovery Plan). This multi-species plan presents a framework for threatened orchid recovery in Tasmania. Its primary aim is not only to prevent further decline and extinction of species, but to promote conditions and management practices that result in species becoming self-sustaining in the long-term.

In 2006, TSS received two year's funding under the cross-regional Natural Resource Management (NRM) initiative to *Implement Threatened Species Recovery Plans*. The implementation of the plan involves a wide range of recovery actions. One of the key priorities of the plan is to improve the quality of baseline data for priority species and populations. Although TSS holds a large number of threatened orchid records, many have poor positional accuracy and few have associated population and habitat information.

This paper presents and discusses a summary of baseline survey data collected over the 2006/2007 and 2007/2008 orchid flowering seasons as part of the implementation of the TORP. It then discusses the adequacy of current knowledge and the potential directions orchid conservation and research might take based on our knowledge and the resources available.

## MATERIALS AND METHODS

*Aim of surveys*

The TORP identifies a paucity of accurate data for many priority threatened orchid species and/or populations. These surveys aimed to collect accurate data on population location, habitat, population extent, and basic demographic data (number of individuals flowering, fruiting or vegetative) in accordance with recommendations in the TORP. Given the large number of species involved and time and resource limitations it was necessary to prioritise species, with the aim of surveying as many priority populations as possible.

*Setting priorities*

A small team of botanists and leading orchid experts were assembled to rate the currently listed threatened Tasmanian orchids as being of low, medium, or high priority for action. Given the complex issues and large number of taxa involved, the team used a matrix-model based on 14 criteria to determine which priority species should be given, and to minimise subjectivity (modelling data held by TSS).

*Surveys*

Location data was obtained from the *Natural Values Atlas* (NVA), and more accurate personal accounts were sought from landowners, orchid enthusiasts and experts where possible. Flowering information was collated from relevant sources using expert knowledge where possible. Survey areas were split into NRM regions (Cradle Coast, North and South; Figure 1), and trips planned to locate as many flowering species as possible in each region.

*Data collection*

The following data was collected from every population that was located: an accurate GPS location in GDA94 datum; an estimation or GPSed polygon of the population extent (this was not practical for some species); a detailed habitat and site description including soil type, geology, slope, aspect, percent bare ground and rock cover, and a vegetation description; a population count, including the number of plants flowering, the number in bud, the number in fruit, and the number in a vegetative state (accurate counts were not always possible, in these cases estimates were taken usually based on a subset). Threats to the population were also identified and described.

*Threats*

Although detailed threat information was collected from relevant populations, for simplicity populations were divided according to the nature of the threat and its potential impact on management needs for the population. This resulted in four broad categories: (1) those requiring habitat management (HM); (2) those threatened by land use practices (LU); (3) those threatened by grazing (G); and (4) those threatened by weeds (W).

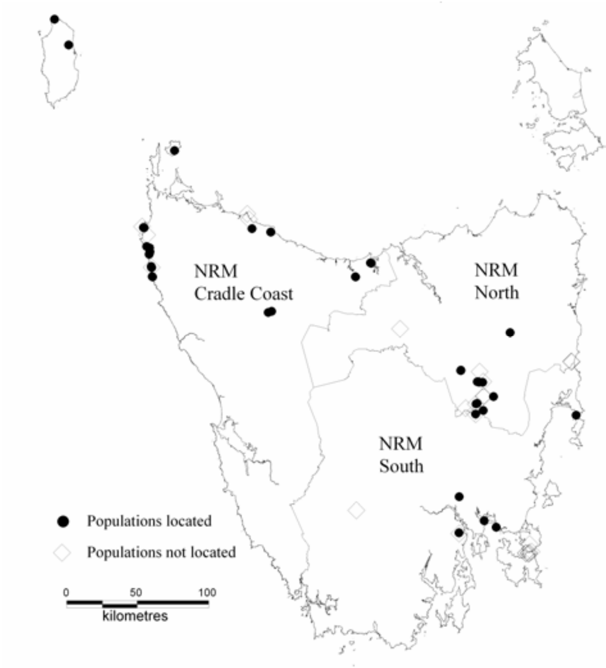


**Figure 1.** Distribution of threatened orchid populations surveyed for in this study: successful (n=62) and unsuccessful sites (n=29), showing the NRM regions (Cradle Coast, North and South).

## RESULTS

*Surveys*

A total of 91 populations of 36 species were surveyed across the State. Forty-four of the populations were high priority species, 27 were medium priority, and 20 were low priority (Table 1, Appendix). Of the 91 populations, data was collected from 62, leaving 29 sites where no plants could be located (Table 1, Figure 1, Appendix). Several species proved difficult to locate. The high priority species *Pterostylis commutata* and *Thelymitra jonesii* were surveyed at four and six separate locations, respectively, without success (Table 1, Appendix). Other species were relatively easily located. *Caladenia anthracina* was found at six of the seven populations surveyed, and *Caladenia dienema* was found at all six sites surveyed. Eight of the species surveyed are known only from a single location

(Table 1), and population data was collected from six of these. The remaining two species *Prasophyllum taphanyx* and *Thynninorchis nothofagicola* were surveyed on several occasions during their respective flowering windows to no avail.

**Table 1.** Summary of orchid species surveyed between 2006 and 2008.

| Species | Priority | No. popns surveyed | No. plants located | Threats identified | Previous population estimate (year)# |
|---|---|---|---|---|---|
| *Caladenia anthracina* | High | 7 | 52 | HM,W | 52 (2002) |
| *Caladenia campbellii* | High | 2 | 118 | HM,LU | 50 (1997) |
| *Caladenia dienema* | High | 6 | 32 | HM | 65 (1998) |
| *Caladenia tonellii* | High | 3 | 270 | HM,W | - |
| *Corunastylis nudiscapa** | High | 1 | 49 | LU,W | - |
| *Prasophyllum crebriflorum* | High | 2 | 3 | HM | 125 (2000) |
| *Prasophyllum favonium* | High | 1 | 0 | - | 8 (1999) |
| *Prasophyllum incorrectum* | High | 1 | 2000 | LU | 1500 (1999) |
| *Prasophyllum pulchellum* | High | 2 | 20 | HM | 61 (2005) |
| *Prasophyllum stellatum* | High | 2 | 33 | HM ,LU | 40 (1993) |
| *Prasophyllum taphanyx** | High | 1 | 0 | HM | 3 (2001) |
| *Prasophyllum tunbridgense* | High | 4 | 23 | HM,LU, W | 135 (1999) |
| *Pterostylis commutata* | High | 4 | 0 | HM,LU | 30 (1999) |
| *Pterostylis wapstrarum* | High | 2 | 642 | HM,LU,G | 120 (1998) |
| *Thelymitra jonesii* | High | 6 | 0 | HM | 20 (2002) |
| *Caladenia congesta* | Medium | 1 | 0 | - | 5 (1998) |
| *Caladenia sylvicola** | Medium | 1 | 0 | - | 12 (1997) |
| *Chiloglottis trapeziformis** | Medium | 1 | 60 | W | 30 (2003) |
| *Diuris lanceolata* | Medium | 2 | 253 | HM | 150 (2002) |
| *Prasophyllum apoxychilum* | Medium | 4 | 0 | - | 93 (1996) |
| *Prasophyllum limnetes** | Medium | 1 | 6 | HM | 12 (2003) |
| *Pterostylis cucullata* | Medium | 4 | 4860 | HM,LU,G | 770 (2005) |
| *Pterostylis rubenachii* | Medium | 5 | 294 | HM,LU,G | 753 (1999) |
| *Thelymitra malvina* | Medium | 2 | 0 | HM | 14 (1998) |
| *Thynninorchis nothofagicola** | Medium | 1 | 0 | G | 5 (2003) |
| *Caladenia caudata* | Low | 3 | 169 | HM,W | 1003 (1998) |
| *Caladenia patersonii* | Low | 3 | 5 | HM | 2 (1998) |
| *Caladenia pusilla* | Low | 4 | 14 | HM | - |
| *Caladenia saggicola* | Low | 2 | 202 | HM,G,W | 200 (2000) |
| *Diuris palustris* | Low | 1 | 21 | HM,G | 55 (2002) |

| Species | Priority | No. popns surveyed | No. plants located | Threats identified | Previous population estimate (year)# |
|---|---|---|---|---|---|
| *Prasophyllum atratum** | Low | 1 | 43 | HM,LU | 70 (1999) |
| *Prasophyllum milfordense** | Low | 1 | 20 | HM,G,W | 200 (2000) |
| *Pterostylis grandiflora* | Low | 5 | 20 | LU | 305 (2005) |
| *Pterostylis ziegeleri* | Low | 4 | 1500 | HM,G | 740 (1999) |
| *Thelymitra holmesii* | Low | 1 | 1 | HM | - |

* Species known from a single population

+ HM = habitat management; LU = land use practice; G = grazing; W = weeds

# Previous population estimates were only considered from populations visited in this study. Data source TSS (2006) or TSS unpublished.

The difference in the number of individuals recorded in these recent surveys compared to previous population estimates varied considerably between species (Table 1). The number of individuals located was similar to previous estimates for some species e.g. *Caladenia anthracina* and *C. saggicola* (Table 1). Significantly fewer individuals were located than previously estimated for *Prasophyllum crebriflorum*, *P. pulchellum*, *P. tunbridgense*, *P. milfordense*, *Pterostylis rubenachii*, *P. grandiflora* and *Caladenia caudata* (Table 1). Significantly higher numbers of individuals were located than previously estimated for *Caladenia. campbellii*, *Prasophyllum incorrectum*, *Pterostylis wapstrarum*, *P. ziegeleri*, *P. cucullata* subsp. *cucullata* and *Diuris lanceolata* (Table 1).

*Threats*

Habitat management and land use practice were identified as the most common threats to species surveyed, being identified as issues for 25 and 11 species, respectively (Table 1). Grazing and weeds were identified as threats to eight species (Table 1).

Some examples of the types of threats acting on different habitats and sites supporting threatened orchid species are provided in Plates 1-4.

## DISCUSSION

*Baseline data*

The data collected for the 62 threatened orchid populations located adds to our understanding of orchid distributions and will be used to assit in identifying appropriate management practices at those sites. For example, as part of the implementation of the TORP and as a direct result of this study, threat mitigation and habitat management has been undertaken in collaboration with landowners/managers for several species including *Corunastylis nudiscapa*, *Prasophyllum limnetes*, *P. atratum*, *P. pulchellum*, *P. tunbridgense*, *Caladenia saggicola* and *P. milfordense* (AVK 2008; TSS unpublished). Baseline data is essential for assessing the effectiveness of management actions (TSS 2006; AVK 2008). Therefore the survey results will be important in ensuring these management actions are producing the desired conservation outcomes.

**Plate 1.** Habitat of several species of threatened orchids in a private reserve showing the ecological burn undertaken to promote flowering of orchids. Habitat management (e.g. appropriate fire regime) is the key factor in maintaining populations of species such as *Prasophyllum limnetes* (inset photo: Peter Tonelli).

The survey results also highlight the difficulties associated with terrestrial orchid conservation. There were no plants located at almost a third of the populations surveyed, and the status of these populations remains uncertain. Furthermore, the surveys recorded lower than previously estimated population sizes for several species, raising questions about population decline that cannot be answered with existing data because of the cryptic nature of orchids. These represent significant gaps in the existing baseline data.

The failure to locate several high priority species is of particular concern. *Prasophyllum favonium*, *Pterostylis commutata*, *Thelymitra jonesii* and *Thynninorchis nothofagicola* are all EPBCA-listed as Critically Endangered, occur in small disjunct populations and have total estimated population sizes of less than 50 individuals (TSS 2006). Locating these species to determine their status is now considered a priority. Accurate population locations exist for these species, so it is likely that either survey timing was wrong, or the populations failed to emerge this season (which would not be surprising given the drought conditions). Survey timing is essential because flowering material is necessary to identify almost all Tasmanian orchids to species level, and many only flower for a few weeks a year (Wapstra *et al*. 2008). The failure of orchid populations to emerge and extreme fluctuations in population size is thought to be a response to the timing and amount of rainfall in the preceding year, or a disturbance requirement as in *P. secutum* (Wapstra *et al*. 2008). These two aspects of orchid ecology not only make surveying for baseline information and long-term monitoring problematic (Gregg & Kéry 2006), but they make assessing the impact of development proposals in potential orchid habitat difficult (Wapstra *et al*. 2008). It is essential that potential orchid habitat is surveyed at the appropriate time of year to maximise the likelihood of finding threatened orchids, if they are present (Wapstra *et al.* 2008). Identifying the best time to undertake a survey has been made easier through the recent publication of a comprehensive Tasmanian orchid flowering guide, which also identifies species that require disturbance events to flower readily (Wapstra *et al.* 2008). This guide will be useful in directing future baseline and monitoring surveys. The difficulties associated with identifying orchid populations in the wild highlights the need for accurate baseline data collection and long-term monitoring of populations.

**Plate 2.** Habitat of several species of threatened orchids in a private reserve showing the fencing established to minimise grazing pressure. Habitat management, weed incursions and grazing pressure are identified as factors affecting populations of species such as *Caladenia saggicola* (inset photo: Matthew Larcombe).

The higher than previously estimated population sizes identified for several species in this study are likely to be a function of increased survey effort. *Pterostylis cucullata* subsp. *cucullata* was thought to be extinct on the Tasmanian mainland until 2001, when a small population was found at Arthur River, followed by a second of about 340 plants discovered south of Temma in 2002 (Dalgleish & Schahinger 2006). Surveys conducted in the present study have estimated about 2000 plants in this second population (Appendix), while the total population is likely to be higher still. However, the population's remoteness has limited survey effort (Dalgleish and Schahinger 2006). The increases in *Pterostylis wapstrarum* and *P. ziegeleri* populations are also likely to be a function of increased survey effort, largely by Norris (2007). This highlights the importance of extension surveys. In South Australia the single largest effect on the conservation status of several threatened orchids has been locating new populations through targeted extension surveys (Joe Quarmby pers. comm. 2007). Extension surveys should target areas of suitable habitat, when species are likely to be obvious and in large numbers i.e during flowering time and where possible after disturbance events such as fire (TSS 2006). Extension surveys will continue to improve our understanding of threatened orchid distributions in Tasmania.

**Plate 3.** Habitat of several species of threatened plants including orchids at Possum Banks in northwestern Tasmania (photo: Richard Schahinger). Habitat management, land use practices and grazing pressures are identified as factors affecting populations of species such as *Pterostylis cucullata* (inset photo: Matthew Larcombe).

*Threats*

Habitat management was identified as posing the most common threat to orchid populations in this study. Terrestrial orchids typically respond well to disturbance (Jones *et al.* 1999; Coates *et al.* 2006). The reduction of interspecific competition, increased nutrient availability (associated with disturbance by fire) and increased light are thought be important factors in orchid's response to disturbance (Coates & Duncan 2007). It is not surprising then that the most orchid-rich habitats in Tasmania are disturbance prone, including coastal heath, dry eucalypt forest and woodland and native grasslands, and these habitats harbour a majority of our threatened orchid flora (Jones *et al.* 1999; TSS 2006). Post-European landscape alteration in Tasmania has resulted in significant shifts in the way these habitats are disturbed (Fensham 1989; Jones *et al.* 1999; Kirkpatrick & Harris 1999). Principally, fire has been suppressed or used as a management tool to reduce fuel loads with cool temperature spring and autumn burns (Kirkpatrick & Harris 1999; AVK 2008). Historically intense wild fires would have occurred in summer, and indigenous land management would probably have involved regular burning of these habitats (Jackson 1999; Kirkpatrick & Harris 1999). There is anecdotal and some published evidence that the shift in intensity and regularity of fire is actually reducing orchid diversity and extent in these orchid rich habitats (Coates *et al.* 2006; Coates & Duncan 2007). Habitat management techniques that mimic or substitute natural disturbance regimes will be important in the future management of threatened orchids and are discussed in detail by Janes *et al.* (2008) in this issue of *The Tasmanian Naturalist.* Improving understanding of how orchids respond to different disturbance regimes will be an important part of future monitoring programs.

Land use was identified as the second most common threat to orchid populations in this study. Land use practices that result in habitat degradation and fragmentation pose the greatest risk (Jones *et al.* 1999). Landscape alteration is most apparent in the Tasmanian Midlands where conversion of native grasslands and grassy eucalypt woodlands to pasture has been extensive since European settlement (Fensham 1989). Several high priority species restricted to the Midlands are at risk from habitat fragmentation. For these species, conservation should focus on protecting existing populations, ensuring appropriate land use practices and identifying and conserving potential habitat. Identifying potential habitat is complicated because terrestrial orchids show highly specialised relationships with mycorrhizal fungi and often pollinators (Bonnardeaux *et al.* 2007; Brundrett 2007). On the mainland long-term monitoring of populations combined with targeted research has significantly improved understanding our of these complex relationships (VTORT 2006; Brundrett 2007). These types of studies may be important for priority Tasmanian species if management practices are to promote self sustaining populations.

*Future directions for threatened orchid monitoring*

Monitoring and accurate recording of populations is a difficult but essential first step in conserving our threatened orchids. In many ways Tasmanian orchid conservation is lagging behind other Australian States (Jones *et al.* 1999; Marshall 2005; TSS 2006; Janes *et al.* 2008). However, this places Tasmanian in an ideal position to learn from the experiences of the other States, and rapidly close this gap. Mainland States are taking a multi-disciplinary approach to orchid conservation, using the skills of government agencies, universities, botanic gardens and community groups to implement wide ranging *in situ*, *ex situ* and research based conservation programs (Marshall 2005; Brundrett 2007).

**Plate 4.** Habitat of several species of threatened plants including orchids at the Pontville Army grounds in southeastern Tasmania. Habitat management, land use practices and grazing pressures are identified as factors affecting populations of species such as *Pterostylis wapstrarum* (inset photo: Matthew Larcombe), but note that unpredictable factors such as grazing by mites (Norris 2007) are also affecting plants at this site.

It is becoming increasingly clear that if orchid conservation is to succeed, it will be necessary to understand and be able to predict orchid population dynamics (Gregg & Kéry 2006; Coates & Duncan 2007). Understanding not only the distributions of populations and species but what factors are most important in controlling emergence, flowering, pollination, recruitment, lifespan and ultimately population growth and decline (Schemske *et al.* 1994; Gregg & Kéry 2006). In Victoria this detailed demographic information is considered fundamental to effective threatened orchid conservation, and is producing tangible conservation outcomes (Coates *et al.* 2006; Coates & Duncan 2007). Studies focusing on population demography have allowed the identification of habitat management regimes to promote population growth (Coates *et al.* 2006; Coates & Duncan 2007), and identified environmental factors controlling dormancy, which has lead to a better understanding of population size and growth-rates (Gregg & Kéry 2006; Coates & Duncan 2007). The results of these studies and others have lead to management actions that have actually resulted in population increases in four Critically Endangered (EPBCA) orchid species in Victoria (Marshall 2005; VTORT 2006). For example, germination and seedling establishment were identified as limiting factors in *Caladenia hastata*, and a program of assisted pollination and microhabitat manipulation (soil disturbance) has seen the wild population increased from ten plants in 1997 to over 800 today (VTORT 2006; Andrew Pritchard pers. comm. 2007).

The difficulty with population dynamic studies is that they require long-term annual monitoring, which is complicated by the species' cryptic biology and complex ecology (Schemske *et al.* 1994; Gregg & Kéry 2006). The short-term nature of government funding for conservation projects makes long-term (e.g. 5-10 year) monitoring programs difficult. For example, in 2002 demographic monitoring sites were established at two *Caladenia anthracina* populations that were to be monitored on an annual basis (Dalgleish 2003). However, because of a funding gap, 2007 was the first time the populations were re-monitored. If demographic monitoring is to be successful, systems must be established to ensure data is collected annually (Schemske *et al.* 1994). Government agencies should be involved to ensure data is collected and stored appropriately. However, community volunteer groups might be better placed to ensure annual monitoring is undertaken. The use of skilled volunteers has been highly successful on the mainland. For example, the Australasian Native Orchid Society (Victoria) is a "Principal Partner" in Victoria's award winning Threatened Orchid Recovery Team (VTORT 2006). In Tasmania, the newly formed Threatened Plant Action Group (TPAG, Wildcare Inc.) has made orchid conservation and monitoring their flagship project. The group is working closely with TSS and intend to establish and manage several long-term demographic monitoring sites across Tasmania. In collaboration with TSS, TPAG has arranged for Fiona Coates, one of Australia's leading orchid population demographic researchers, to run a two day training workshop on orchid monitoring techniques developed in Victoria to address the difficulties associated with orchid monitoring.

If successful, this project could help overcome some of the baseline data shortfalls identified in this study. A better understanding of dormancy rates will lead to improved estimates of population size and extent (Coates *et al.* 2006; Coates & Duncan 2007). Understanding environmental factors controlling emergence will allow managers to better predict population fluctuation (Coates & Duncan 2007). Additionally these studies will be important in demonstrating the effectiveness of various habitat management regimes and the influence of land use practices (Coates *et al*. 2006). Given these potential benefits, strong working relationships should be promoted between TPAG and other interested community groups and government agencies, as the future conservation of our orchid flora could depend on them.

## CONCLUSION

The results of this study have improved and/or updated our baseline knowledge of threatened orchid distributions in Tasmania, but have also highlighted areas that require further attention, particularly where high priority species could not be verified. Inappropriate habitat management and land use practices are the most common threats to threatened orchids and future monitoring programs should be designed to improve our understanding of the impacts of these threats. Future monitoring programs to assess these issues might focus on population dynamics for priority species and be implemented through community/government partnerships. Government agencies are needed to assist with technical and logistical support and supply data management facilities, while community groups could provide the extensive volunteer support and coordination needed for these programs to be successful in the long-term.

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## REFERENCES

AVK Environmental Management (2008). *Bushfire Management Plan* Eucalyptus viminalis *Woodland on "Milford"*. Department of Primary Industries and Water, Hobart.

Bonnardeaux, Y., Brundrett, M., Batty, A., Dixon, K.W., Koch, J.M. & Sivasithamparan, K. (2007). Diversity of mycorrhizal fungi of terrestrial orchids: compatibility webs, brief encounters, lasting relationships and alien invasions. *Mycological Research* 111: 51-61.

Brundrett, M.C. (2007). Scientific approaches to Australian temperate terrestrial orchid conservation. *Australian Journal of Botany* 55: 293-307.

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

Coates, F. & Duncan, M. (2007). *Recovery of* Caladenia orientalis *(Eastern spider-orchid) at Wonthaggi Heathland Reserve 2000 – 2006*. Arthur Rylah Institute for Environmental Research. Department of Sustainability and Environment, Heidelberg, Victoria.

Dalgleish, A. (2003). Arachnorchis anthracina, *Black-tipped spider orchid, Baseline surveys October 2002*. Nature Conservation Branch, Department of Primary Industries, Water and Environment, Hobart.

Dalgleish, A. & Schahinger, R. (2006). Pterostylis cucullata *Tasmanian Baseline Surveys, November 2002, Revised August 2006*. Threatened Species Section, Department of Primary Industries and Water, Hobart.

Fensham, R.J. (1989). The pre-European vegetation of the Midlands, Tasmania: a floristic and historical analysis of vegetation patterns. *Journal of Biogeography* 16: 29-45.

Gregg, K. &, Kéry M. (2006). Comparison of size vs. life-state classification in demographic models for the terrestrial orchid *Cleistes bifaria*. *Biological Conservation* 129: 50-58.

Jackson, W. (1999). The Tasmanian Environment. In: *Vegetation of Tasmania.* (Eds. J. Reid, R.S. Hill, M.J. Brown & M.J. Hovenden). Australian Biological Resources Study, Hobart.

Janes, J.K., Steane, D.A. & Vaillancourt, R.E. (2008). The occurrence and conservation status of Tasmanian *Pterostylis* (Orchidaceae). *The Tasmanian Naturalist* 130: 86-99.

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

Kirkpatrick, J.B. & Harris, S. (1999). *The Disappearing Heath Revisited*. Tasmanian Environment Centre, Hobart

Kéry, M., Gregg, K.B. & Schaub, M. (2005). Demographic estimation methods for plants with unobservable life-states. *Oikos* 108: 307-320.

Marshall, D., Pritchard, A. & Duncan, M. (2005). The success of government-community partnerships in orchid conservation in Victoria, Australia. *Selbyana* 26: 293-298.

Norris, P. (2007). Observations of a new threat to one of Tasmania's threatened orchids: the story of the mite versus the greenhood. *The Tasmanian Naturalist* 129: 16-22.

Pfeifer, M., Heinrich, W. & Jetschke, G. (2006). Climate, size and flowering history determine flowering pattern of an orchid. *Botanical Journal of the Linnean Society* 151: 511-526.

Schemske, D.W., Husband., B.C., Ruckelshaus, M.H., Goodwillie, C., Parker, I.M. & Bishop, J.G. (1994). Evaluating approaches to the conservation of rare and endangered plants. *Ecology* 75: 584-606.

Slade, N.A., Alexander, H.M. & Kettle, D.W. (2003). Estimation of population size and probabilities of survival and detection in Mead's milkweed. *Ecology* 84: 791-797.

Tamm, C.O. (1972). Survival and flowering in some perennial herbs II. the behaviour of some orchids on permanent plots. *Oikos* 23: 23-28.

Threatened Species Section (TSS) (2006). *Flora Recovery Plan: Tasmanian Threatened Orchids 2006-2010*. Department of Primary Industries, Water and Environment, Hobart.

Victorian Threatened Orchid Recovery Team (VTORT) (2006). *Back from the Brink: Saving Victoria's Threatened Orchids.* An entry in the 'Land and Biodiversity Award' category for the Banksia Awards 2006. Available on line at www.dse.vic.gov.au.

Wapstra, M., Roberts, N., Wapstra, H. & Wapstra, A. (2008). *Flowering Times of Tasmanian Orchids: A Practical Guide for Field Botanists*. Self-published by the authors (April 2008 version).

Note: grey-scale embedded images in this article are shown in full colour and enlarged in the central pages of this volume.