

ORCHIDS ON THE EDGE: THREATENED ORCHID RECOVERY IN THE NORTH CENTRAL REGION, 2003-2009

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This paper presents an overview of activities to conserve a suite of threatened orchid taxa within the North Central region between 2003 and 2009. Historical and current threats to orchid populations are outlined and management responses detailed, together with results of key management actions. Knowledge gaps are identified, with past and current actions to address some of these included. Future directions for the conservation of threatened orchids in the region are briefly discussed.

Key words: Orchids, *Caladenia*, threatened, reintroduction, pollination, Victoria.

VICTORIA'S terrestrial orchids are extremely varied in form and habitat, and comprise nearly one third of the orchid species found in Australia. These orchids are well adapted to a temperate but variable climate, growing each year from underground tubers, flowering during autumn, winter and spring, and surviving the harsh summer months in dormancy. Although some are capable of self-pollination, Victoria's terrestrial orchids are mainly insect pollinated, attracting native bees with scents and bright colours, fungus flies with sour odours, and wasps with chemicals resembling pheromones.

In many spider orchids (*Caladenia* spp.) the relationship between the orchids and the pollinating thynnine wasps appears to be highly specific, with each orchid species attracting only one species of wasp (Bower 2007). Symbiotic associations with mycorrhizal fungi are required for germination and growth of most Victorian terrestrial orchid species, the fungi assisting with the uptake of nutrients and the host orchid providing the fungi with carbon compounds. There appears to be a wide range of specificity and dependence, with some orchids requiring a specific mycorrhizal fungus, while others can host and utilise a wide range of fungi (Backhouse & Jeanes 1995).

With such complex ecological interactions necessary for growth and reproduction, these orchids are extremely vulnerable to ecosystem disturbance (Hopper and Dixon 2009). It is no surprise then, that Victoria's terrestrial orchids are in serious decline. At

least 10 native orchid species have become extinct in Victoria since European settlement, and nearly half of the approximately 400 Victorian orchid species, of which 40% are endemic, are considered threatened (Jeanes & Backhouse 2006).

In response to this significant decline, the Victorian Threatened Orchid Recovery Project was established in 1996. This represents a partnership between the Department of Sustainability and Environment (DSE), Royal Botanic Gardens, Melbourne (RBGM), the Australasian Native Orchid Society-Victorian Group (ANOS-Vic), Parks Victoria, Melbourne Zoo, University of Melbourne, Victoria University and RMIT University, and is assisted by a network of agencies, community groups and individuals from both within Victoria and interstate. The Threatened Orchid Recovery Project in the North Central region forms part of this state-wide project.

THE NORTH CENTRAL THREATENED ORCHID RECOVERY PROJECT

Prior to 2003, although some orchid conservation activities were conducted in the north central region, there was no coordinated program with specifically allocated staff or funding. The North Central region Threatened Orchid Recovery Project, led by DSE and funded through the North Central Catchment Management Authority (NCCMA) commenced in

2003, with funding to conserve two endangered spider orchid taxa, *Caladenia audasii* R.S.Rogers. 1927 (McIvor Spider Orchid) and *Caladenia xanthochila* D&C Beardsell. 1992 (Yellow-lip Spider Orchid).

By 2009, recovery plans for 12 threatened orchid taxa (Coates et al. 2002; Duncan 2005; Duncan et al. 2003) listed under the Victorian *Flora and Fauna Guarantee (FFG) Act (1988)*, or the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act (1999)* were being implemented in the north central region (Table 1).

Project objectives

The objective of the North Central region Threatened Orchid Recovery Project is to restore the endangered orchids of the North Central region to viable, self-sustaining populations via a number of strategies including:

- securing and protecting currently known populations from threats,
- improving the conservation status of threatened orchids by actively searching for new populations which can then be managed for conservation,
- increasing the numbers in existing populations using a variety of management strategies,
- establishing new populations where necessary,
- collecting data and assisting with research into the ecological requirements of native orchids,
- raising public awareness and fostering community involvement.

Ensuring that existing populations are protected from active or potential threats is the highest priority of the project, but an integrated approach that addresses all aspects of orchid conservation is likely to be more effective in achieving the long-term objective. To some extent, strategies such as survey, monitoring, research and population enhancement can be seen as contributing to overall threat reduction as they address less tangible but nevertheless important impacts on population viability.

Threats to orchid populations – historical and current

Historically the most significant threat to native orchids in the North Central region, as for many other flora and fauna species, has been loss of habitat. The broad-scale land clearing for agriculture that removed up to 87% of the region's native vegetation

cover (NCCMA 2003) continued until relatively recently, and must have resulted in the loss of countless native orchid populations, and possibly some undescribed taxa.

Less extensive, but still significant, have been the impacts of timber harvesting, mining and urban development, which taken with the broad-scale clearing have left a legacy of fragmented and degraded remnants of native vegetation to support the remaining native orchid populations. Some of these small remnants continue to come under pressure from housing developments and infrastructure projects.

The impact of the rabbit plagues of the late 19th and early 20th century, and the invasion of much of the remaining remnant native vegetation by pest plants, have resulted in many of the native orchids of this region being reduced to small, scattered, vulnerable populations. These populations are at significant risk from a number of current threats:

Grazing. Grazing by herbivores such as rabbits, hares, goats, wallabies and kangaroos can have serious adverse effects on the long-term viability of orchid populations, by reducing plant vigour and removing reproductive plant parts (Vallius 2001; Shefferson et al. 2005; Pellegrino & Musacchio 2006).

Disturbance. The impact of disturbance on threatened orchid sites can range from minor degradation of orchid habitat to, in extreme cases, the total loss of a population. The most common causes of site disturbance are human and vehicular traffic that can result in plants being crushed, trampled or buried, and soil compacted, removed, gouged or eroded.

Weeds. Invasive weeds can directly compete with orchids for resources such as water and sunlight (Duncan et al. 2005), reduce habitat for beneficial flora and fauna such as pollinating insects and their forage plants, and effect changes to litter decomposition and nutrient release, (Kochoy and Wilson 1997) all of which can impact on the vigour and reproductive success of orchids, and ultimately lead to a decline and loss of populations.

Fire. The long-term impacts of fire are poorly known for many native orchids, although it appears that, like many geophytes, Victoria's terrestrial orchids are adapted to cope with occasional destruction of aerial plant parts by fire, by virtue of their underground storage organs (Parsons 2000). Most Victorian terrestrial

Table 1. Orchid species and conservation status. V = Vulnerable, E = Endangered, CR = Critically Endangered, IUCN = International Union for the Conservation of Nature.

Species		FFG Act	EPBC Act	IUCN criteria
<i>Caladenia cruciformis</i> D.L. Jones, 1999	Red Cross Spider Orchid	Yes	–	E
<i>Caladenia cretacea</i> D.L. Jones & G.N.Backhouse, 2007	Stuart Mill Spider Orchid	Yes	–	CR
<i>Caladenia clavescens</i> D.L. Jones, 2006	Castlemaine Spider Orchid	Yes	V	CR
<i>Caladenia xanthochila</i> D. & C.Beardsall, 1992	Yellow Lip Spider Orchid	Yes	E	CR
<i>Caladenia audasii</i> R.S.Rogers, 1927	McIvor Spider Orchid	Yes	E	CR
<i>Caladenia</i> sp. aff. <i>fragrantissima</i>	Bendigo Spider Orchid	Yes	–	CR
<i>Pterostylis despectans</i> M.A.Clem. & D.L. Jones 1989	Lowly Greenhood	Yes	E	E
<i>Pterostylis</i> sp. aff. <i>bicolor</i>	Sutton Grange Greenhood	Yes	–	CR
<i>Prasophyllum hygrophilum</i> D.L.Jones & D.T.Rouse, 2003	Swamp Leek Orchid	Yes	–	CR
<i>Prasophyllum validum</i> R.S. Rogers, 1927	Sturdy Leek Orchid	–	V	V
<i>Thelymitra mackibbinii</i> F. Mueller 1881	Brilliant Sun Orchid	Yes	V	CR
<i>Diuris protena</i> D.L. Jones, 2006	Northern Golden Moths	Yes	–	–

orchids are adapted to fires occurring in summer, when most orchids are dormant. (Duncan et al. 2005)

Regular and untimely fires, however, such as prescribed fuel reduction burns, when leaves or flowers are present, pose an unacceptable risk to small threatened orchid populations.

Illegal collection. Collecting native orchids from the wild by orchid enthusiasts is no longer the common and widespread practice it once was, due mainly to changes in legislation, and the shift in focus by orchid enthusiast groups towards conservation rather than acquisition. Nevertheless, illegal collection is still regarded as a serious potential threat to some endangered orchids, particularly those with critically small populations (Coates et al. 2002).

Small population size. It is well recognised that very small populations of any species are at risk of extinction from chance events. The influence of stochastic variation in reproductive and mortality rates is also likely to be higher for small populations, with a greater probability that fluctuations will lead to extinction. Small populations have restricted potential for long-term sustainability due to inbreeding and genetic depression. It has also been suggested that small populations of orchids are less likely to attract pollinators and therefore suffer from decreased seed set and recruitment (Jaquemyen et al. 2007).

Insufficient knowledge of ecology and distribution. There are significant knowledge gaps in many areas

of native orchid distribution, ecology and biology. These include:

- pollinators for many species, and their habitat requirements
- recruitment processes at a population level, including pollination rates, germination triggers, and seedling survival
- spatial distribution of mycorrhizal fungi and influencing factors
- life history transition rates, including dormancy
- population genetics, including genetic diversity within populations and between closely related species.

To adequately conserve threatened orchids, it is necessary to know exactly where they occur, so that all populations can be managed for the best conservation outcomes (Pimm 2005). An integrated approach to orchid conservation is required for best results, and will necessitate a combination of plant genetics, population biology, and restoration ecology in order to both implement urgent actions to prevent species loss, and to acquire the essential information and understanding of orchids and their ecosystems needed for positive long-term conservation outcomes (Swarts & Dixon 2008).

Climate Change. Very little is known about the effects of a changing climate on the threatened orchids of Australia, let alone those of the North Central region of Victoria. Currently, less than 1% of published research on the impact of climate change on biodiversity comes from the southern hemisphere

(WA Conservation Council 2009). Climate models suggest that if greenhouse gases continue to increase, the likely effects will be higher temperatures, more frequent and intense droughts, changes in rainfall patterns, reduced soil moisture and increased likelihood of sub-tropical pests and diseases spreading southwards.

The physiological and life-history attributes of threatened orchids, e.g. narrow geographic ranges, low genetic variability, poor dispersal and specialist requirements such as pollinators and mycorrhizal fungi, make them highly vulnerable to the impacts of climate change induced disturbance (DCC 2009).

Potential impacts of climate change on orchid populations may include:

- reduced seed set due to withering effects of hot dry weather earlier in the flowering season
- prolonged dormancy due to drought, resulting in reduced opportunity for seed set and recruitment
- breakdown of evolved synchronicities that are vital to long-term population survival, e.g. the decoupling of flowering and pollinator emergence, or seed availability and mycorrhizal activity
- increased weed invasion.

Threat management

Management of threats is the key to sustaining and rehabilitating orchid populations and reducing the risk of extinction, and is therefore the main objective of the North Central Threatened Orchid Recovery Program. Management activities for each major threat are outlined below:

Grazing. Control programs for herbivores such as rabbits and hares can be effective at threatened orchid sites in the short-term, but require regular follow-up, particularly if not part of a broader landscape scale pest animal program.

Nomadic herd animals like feral goats are extremely difficult to locate and control using lethal methods, and the notion of using such methods to reduce the impact of grazing by kangaroos and wallabies are consistently rejected by the broader community.

Protective fencing is, therefore, the most effective and reliable method of minimising grazing impacts on threatened orchids in the long-term. A systematic program of fencing key sites is part of the recovery project in the North Central region, and has proven successful in significantly reducing herbivory and

increasing the number of plants that flower and set seed. For example, in one monitored population of *Caladenia cretacea* D.L. Jones 2006 (Stuart Mill Spider Orchid) the number of plants flowering, and hence available for pollination and seed set, increased from an average of four over the previous three years, to 19 flowers the season following fencing (G. Nevill pers. obs. 2007). This represents a typical result for other orchid populations fenced as part of the project.

Disturbance. This disturbance is usually inadvertent, and is often caused during infrastructure maintenance activities such as road grading, construction of fire-breaks or walking tracks, clearing of apiary sites, and formation of run-off gutters. Recreational activities such as trail/mountain bike riding, and four-wheel driving, can also cause serious damage to orchid sites if riders/drivers venture off-track.

To minimise the risk of such impacts, regular liaison with the managers of land where threatened orchid sites occur, e.g. Parks Victoria, is vital, and is a key component in the recovery program. Many threatened orchid sites within State Forest or reserves are declared as Special Protection Zones or Special Management Zones, limiting the range of activities that can occur within them. In addition physical barriers such as fences, bollards, or logs are used to prevent vehicle access. Occasionally tracks are closed or re-aligned, or camping areas re-located to avoid damaging sensitive sites. The improved and coordinated liaison with land management agencies that has led to the identification and protection of sites has significantly reduced the potential for this type of disturbance related damage.

Weeds. Competition for resources by invasive weeds is a threat at a number of orchid sites within the North Central region. The most common weeds are introduced annual grasses such as Quaking Grass *Briza maxima* and Wild Oats *Avena fatua*. Onion Grass *Romulea rosea* also occurs at several sites. Broad scale control of these weeds with fire, grazing or herbicide is problematic given the generally synchronous growing season of weeds and orchids, and the most commonly used control strategy is hand-weeding around individual plants, to reduce competition and increase the chances of orchids flowering, setting seed and recruiting. Application of herbicide by hand-wiping has recently proven successful on Onion Grass at one site where this weed was competing with an endangered *Prasophyllum* species, and this

method has potential for use on other weed species (G. Nevill pers. obs. 2009).

Fire. As the impacts of fire are not well known, a precautionary approach has generally been taken, with fire excluded from all threatened orchid sites. This is accomplished by a regular review of DSE Fire Operations Plans (FOPS) and liaison with Parks Victoria and DSE Forest Management. Orchid sites are either protected with a non-destructive water barrier, or the area surrounding the site to the closest track or fire break is excluded from the prescribed burn.

Given the small size and number of threatened orchid populations, and therefore limited opportunity to experiment with fire impacts, it is likely that fire will continue to be excluded from threatened orchid sites until further research indicates otherwise.

Illegal Collection. Under Victoria's FFG Act, all native orchids are protected flora, and a permit is required to collect from the wild. Orchid enthusiast groups such as ANOS actively promote a conservation ethos amongst members, many of whom contribute significantly to threatened orchid recovery programs. To safeguard against illegal collection, and to keep site visitation to a minimum, the locations of threatened orchids are kept confidential as far as possible, and disclosed only to those actively engaged in conservation activities. Precise locations are not recorded on any publicly available databases, in published EPBC Recovery Plans or approved FFG Action Statements.

Small population size. Increasing the number and/or size of known populations is vital to the conservation of threatened orchids and one of the main objectives of the project.

This is achieved by:

- enhancement of existing populations using a range of strategies
- establishment of new populations.

Population enhancement can include strategies such as:

- hand pollination to improve recruitment
- seed sowing around adult plants or with supplementary mycorrhizal fungi
- introducing *ex situ* grown seedlings to an existing population.

Hand pollination to increase seed set has been conducted at a number of populations in the north central region, but recruitment due to this strategy is

difficult to quantify, particularly during the past several drought years when recruitment events may have been naturally rare, and recruitment low. Trials with seed sowing have also been conducted for several taxa, but without success to date, probably also due to ongoing dry conditions. It is likely that in this region, with the prevailing climate, that supplementary watering may be necessary to ensure success with this technique. While these methods can be costly, labour intensive and time consuming, they may be the most appropriate for some taxa, e.g. those where *ex-situ* propagation has not been successful.

A preliminary trial to introduce *ex-situ* grown seedlings of *Pterostylis maxima* M.A. Clem & D.L. Jones, 1989 (Tall Rustyhood) to a translocated population in 2006 was successful, and it is likely that this method of population enhancement will become more widely used as seedlings of more threatened orchids become available due to improvements in propagation techniques at RBG.

Establishment of new populations using *ex situ* grown seedlings will possibly be the most effective strategy in conserving some of the most endangered orchid taxa in the north central region, and across the state.

In 2007 the reintroduction of approximately 160 *Caladenia cruciformis* (Red Cross Spider Orchid) plants, grown *ex situ* at RBGM, was carried out at two sites in the St Arnaud area. This was followed in 2008 by a second reintroduction to nearly double the original number of plants (Table 2). This was the first reintroduction of a threatened orchid into the wild in the North Central region and one of only a handful carried out in Victoria to date.

The successful establishment of these new populations is an encouraging development in threatened orchid conservation in the region, and reintroductions for other taxa are planned as soon as seedlings become available in sufficient numbers.

Insufficient knowledge of ecology and distribution. Surveys targeting potential habitat, identified via DSE vegetation mapping, are conducted either during the peak flowering season, or at a time when the plants are most easily observed, e.g. at rosette stage for *Pterostylis* species.

Volunteers from community groups such as ANOS and local field naturalist clubs regularly participate in these surveys, the success of which over the past six years in the North Central region has been largely due to their efforts. Parks Victoria rang-

Table 2. Reintroduction results for Red Cross Spider Orchid *Caladenia cruciformis*.

2007 Reintroduction			
Date	Re-emergence	Flowering	Natural Pollination
2008	90%	40.5%	28.3%
2009	83.6%	56%	38%
2008 Reintroduction			
Date	Re-emergence	Flowering	Natural Pollination
2009	91%	41.5%	50%

ers are also regular participants in these searches. For some species, the total known population has been significantly increased (Table 3) and the known range considerably extended. For instance, in 2003 *Pterostylis despectans* M.A.Clem. & D.L. Jones 1989 (Lowly Greenhood) was thought to be restricted to a few populations in the Maryborough area totaling approximately 1500 plants. Targeted surveys by community volunteers working with DSE and Parks Victoria staff between 2003 and 2009 found numerous new populations near Maryborough, St Arnaud and Moliagul, increasing the total known population to approximately 10 000 plants and considerably extending the known geographic range.

The result is that more populations are now under management for conservation, reducing the risk of population loss and extinction.

Activities to increase the understanding of orchid biology and ecology are an important component of the North Central Threatened Orchid Recovery Project. In the last three years the pollinators, two thynnid wasps and one native bee, have been identified for four of the six spider orchids under conservation (G.Nevill pers.obs. 2009). Future efforts will focus on establishing the distribution of these pollinators and gaining an understanding of their habitat requirements, which will assist in determining the best reintroduction sites, and enhancing existing sites for optimum natural pollination and recruitment.

Detailed demographic monitoring, conducted with assistance from community volunteers, has provided data for analysis to determine important life history stages for many taxa, including dormancy, flowering and natural pollination rates.

Research into the role of mycorrhizal fungi has met with mixed success. Field-based slide-baiting to establish the spatial distribution of mycorrhizal fungi was conducted for several years without success. This method employs a plastic slide with nylon cloth

enclosing seeds, which is buried for several months, and then examined to determine whether the seeds have germinated, indicating the presence of the appropriate mycorrhizal fungi (Rasmussen & Whigham 1993). However, it appears that this may not be a reliable technique for use in dry conditions such as those currently prevailing in the North Central region, as germination was detected in only two of approximately 2000 slides.

However, in 2004 and 2005, a PhD research project partly supported by the North Central region (Wright 2007) provided valuable findings regarding the role of mycorrhizal fungi in orchid germination which continue to inform current *ex situ* propagation efforts, in particular, the development of non-destructive methods of harvesting mycorrhizal fungi, improvements in selection of fungal isolates for propagation, and the use of site amendments to enhance the success of reintroductions.

The intensive monitoring of the reintroduced *Caladenia cruciformis* populations since 2007 has contributed to the knowledge of seedling growth rates, flowering, dormancy, natural pollination and recruitment.

Climate change. Although there is little or no published data on the specific effects of climate change on native orchids, there are precautionary strategies that can be employed until research more adequately informs this aspect of orchid conservation.

In the North Central region these include:

- seed collection for long-term storage in the Millennium Seed-bank or at Royal Botanic Gardens, Melbourne (RBGM)
- mycorrhizal fungi isolation and culture for propagation and long-term storage at RBGM
- strategic location of reintroduction sites regarding locality, aspect, slope and vegetation to best buffer against high temperatures and low soil moisture
- watering of selected sites to promote seed-set for collection, storage and propagation
- establishment of *ex situ* 'insurance' populations at RBGM.

Data collected during regular demographic monitoring will assist in detecting changes in patterns of flowering and pollination, and could provide valuable insights into the effects of climate change on native orchids.

Table 3. Increase in numbers of known populations of threatened orchids 2003-2009. * Source: Approved Recovery Plans, † Source: DSE Biodiversity Group – unpublished data.

Species		Total Known Population 2003	Total Known Population 2009†
<i>Caladenia cruciformis</i>	Red Cross Spider Orchid	150*	3450
<i>Caladenia cretacea</i>	Stuart Mill Spider Orchid	40*	190
<i>Caladenia clavescens</i>	Castlemaine Spider Orchid	300†	440
<i>Pterostylis despectans</i>	Lowly Greenhood	1500*	10 000+
<i>Pterostylis</i> sp. aff. <i>bicolor</i>	Sutton Grange Greenhood	10†	8300
<i>Diuris protena</i>	Northern Golden Moths	250†	5000
<i>Prasophyllum validum</i>	Sturdy Leek Orchid	500†	750

Community awareness and involvement

Increasing awareness and participation by community interest groups has been an extremely important aspect of the project. Presentations are made to several community groups each year, outlining the purpose of the project and associated activities. Fact Sheets have been produced for each of the threatened orchids and are made available at local field days, DSE and Parks Victoria offices, and on the DSE website. Regular reports in regional print media and interviews on local ABC radio highlight aspects of the orchid conservation program.

Participation in orchid conservation activities by volunteers from community groups is a vital component of the project, and responsible for much of its success. Volunteers regularly conduct surveys and monitoring, assist with hand pollination, seed collection, pollinator trapping and fencing, participate in translocations and reintroductions, and are represented on regional recovery teams. Expert volunteers from ANOS-Vic assist with threatened orchid propagation at RBGM. Community volunteers are also actively supported in attendance at workshops, conferences and training days, to maintain and enhance their skills and contribution.

CONCLUSION

The North Central Threatened Orchid Recovery Project has made significant progress in the conservation of the region's most endangered orchid taxa in a relatively short period, and the benefits of a specifically-funded, coordinated, integrated and prioritised approach are evident.

For some species, the known populations are now larger than previously realised, and the range more extensive. Most populations are now either actively

managed or have an increased level of protection from threats, which considerably reduces the risk of population decline or extinction. Volunteers from community interest groups actively participate in a range of orchid conservation activities and contribute considerably to the success of the project. Advances in orchid propagation at RBGM have provided the means to enhance existing orchid populations, and establish new ones, for some taxa. Seed and mycorrhizal fungi for most species are now in long-term storage at RBGM. Regional threatened orchid recovery teams meet regularly to assist with project coordination.

Yet despite this considerable progress in many areas, more than half of the threatened orchid taxa under conservation in the region are still considered Critically Endangered according to IUCN criteria (Backhouse and Cameron 2005). Several have populations of less than 20 plants, with no new populations having been located in recent years, and very low success rates so far for *ex situ* propagation. For these orchids, continued efforts to locate additional populations, propagate plants for population enhancement and establishment, and gain greater understanding of ecological requirements through research, are vital to their survival.

For the remainder of the region's threatened orchids, on-going survey effort, surveillance monitoring, threat abatement, population enhancement and activities to advance understanding of biology and ecology are important to restore and consolidate these taxa, to the point where they are no longer considered threatened.

With continued funding support, community participation and strategic direction from DSE in consultation with land managers and regional recovery teams, there is every reason to hope that the threatened orchids of the North Central region can be recovered from the edge of extinction, to become

secure, viable, self-sustaining populations that represent a precious part of our natural biodiversity heritage.

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