

**Wheatbelt Orchid Rescue Project**  
**Final Report 1**  
**Objectives, Outcomes and Overall Conclusions**

**Mark Brundrett**



Our environment, our future  
Environment and Conservation  
Department of



THE UNIVERSITY OF  
WESTERN AUSTRALIA



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## Wheatbelt Orchid Rescue Project Final Reports

Brundrett M. 2011a. Wheatbelt Orchid Rescue Project Final Report 1. Objectives, Outcomes and Overall Conclusions. Wheatbelt Orchid Rescue Project, University of Western Australia. **This Report**

Brundrett M. 2011b. Wheatbelt Orchid Rescue Project Final Report 2. Population Size and Vital Statistics Data for the Granite Spider Orchid (*Caladenia graniticola*). Wheatbelt Orchid Rescue Project, University of Western Australia. [Link 2](#)

Brundrett M. 2011c. Wheatbelt Orchid Rescue Project Final Report 3. Population Size and Vital Statistics Data for the Ballerina Orchid (*Caladenia melanema*). Wheatbelt Orchid Rescue Project, University of Western Australia. [Link 3](#)

Brundrett M. 2011d. Wheatbelt Orchid Rescue Project Final Report 4. Population Size and Vital Statistics Data for the William's Spider Orchid (*Caladenia williamsiae*). Wheatbelt Orchid Rescue Project, University of Western Australia. [Link 4](#)

Brundrett M. 2011e. Wheatbelt Orchid Rescue Project Final Report 5. Population Size and Vital Statistics Data for the Lonely Hammer Orchid (*Drakaea isolata*). Wheatbelt Orchid Rescue Project, University of Western Australia. [Link 5](#)

Brundrett M. 2011f. Wheatbelt Orchid Rescue Project Final Report 6. Population Survey Data for Southern Populations of the Western Underground Orchid (*Rhizanthella gardneri*). Wheatbelt Orchid Rescue Project, University of Western Australia. [Link 6](#)

Brundrett M and Ager E. 2011. Wheatbelt Orchid Rescue Project Final Report 7. Seed Collecting, Soil Baiting and Propagation of Orchids. Wheatbelt Orchid Rescue Project, University of Western Australia. [Link 7](#)

Brundrett M. 2011g. Wheatbelt Orchid Rescue Project Final Report 8. Translocation of Orchids in Wheatbelt Nature Reserves. Wheatbelt Orchid Rescue Project, University of Western Australia. [Link 8](#)

### Citation of 2 or more Project Reports

Brundrett M. 2011. *Wheatbelt Orchid Rescue Project: Case Studies of Collaborative Orchid Conservation in Western Australia*. University of Western Australia, Crawley, Western Australia.

# 1. Introduction

The Wheatbelt Orchid Rescue (WOR) Project is a Lotterywest funded collaboration between the Western Australian Native Orchid Study and Conservation Group (WANOSCG), the School of Plant Biology at the University of Western Australia (UWA), the Friends of Kings Park and the Department of Environment and Conservation (DEC). This project aims to help conserve Critically Endangered orchids in the Western Australian wheatbelt by obtaining knowledge required for sustainable management and directly contributing to recovery actions.

## 1.1. Rare Wheatbelt Orchids

Wheatbelt orchids Declared rare flora in Western Australia, which are listed as *Critically Endangered* and restricted to one or a few known habitats, have been selected as highest priorities for actions (see Table 1). The main threats to these orchids result from the scarcity and fragmentation of suitable new habitats and the impacts of factors such as weeds, herbivory, infrequent pollination, salinity, drought, and fire on existing habitats. Remedial actions are urgently required, but cannot proceed without research to understand the most important threats for each orchid and develop solutions to them.

Most WA orchids occur in the southwest which has a mediterranean type climate with cool, wet winters, followed by 5-8 months of summer drought when most orchids aestivate as dormant tubers. This region is a terrestrial orchid biodiversity hotspot of worldwide significance with an estimated 400 orchid species, most of which are endemic (<http://florabase.calm.wa.gov.au>). At present 37 taxa of WA orchids are Declared Rare Flora (DRF), but even common species are declining in urban and rural areas due to habitat loss, weed invasion and land degradation. Nine wheatbelt orchids are listed as Critically Endangered (the most threatened category of Declared Rare Flora in WA) because they are likely to become extinct without intervention (Table 1).

Prioritisation process with Andrew Brown (DEC) identified the five of the rarest wheatbelt orchid species as priorities for conservation actions (Table 1). These are the granite spider orchid (*Caladenia graniticola*), ballerina orchid (*C. melanema*), William's spider orchid (*C. williamsiae*), lonely hammer orchid (*Drakaea isolata*) and underground orchid (*Rhizanthella gardneri*). Vital statistics data were gathered by establishing permanent transects to monitor plant abundance and reproduction for three of these orchids as explained below. In addition there is ongoing research on the ecology of the underground orchid (*Rhizanthella gardneri*), which aims to provide information required for sustainable habitat management culminating in a thesis by Jeremy Bougoure a PhD student in 2009.

**Table 1.** Status of Critically Endangered West Australian wheatbelt orchids at the start of this project (data from DEC Interim Recovery Plans). Orchids considered the highest priorities for conservation work are highlighted.

Name	Common Name	Number of populations and status
<i>Caladenia bryceana</i> subsp. <i>bryceana</i>	Dwarf spider orchid	>12 mostly small populations known
<i>Caladenia graniticola</i>	Granite spider orchid	5 populations
<i>Caladenia drakeoides</i>	Hinged dragon orchid	< 18 small highly threatened populations known (some have been lost due to salinity)
<i>Caladenia elegans</i>	Elegant spider orchid	Several populations
<i>Caladenia melanema</i>	Ballerina orchid	1 small population
<i>Caladenia williamsiae</i>	Williams' Spider orchid	1 small population
<i>Drakaea isolata</i>	Lonely hammer orchid	1 small population
<i>Pterostylis</i> sp.	Northampton greenhood	3 populations
<i>Rhizanthella gardneri</i>	Underground orchid	6 (only 5 in recent years)

## 2. Objectives

The main purpose of WOR project is to conserve threatened wheatbelt orchids by obtaining knowledge required for their sustainable management. A list of objectives and outcomes is provided in Table 2 below. All the proposed recovery actions coordinated by the WOR project involve collaboration with community groups and government agencies.

This project involves work with plant species and plant communities designated as threatened by the state and nationally. Collection permits and permission to access and implement this project in these sites were obtained from the relevant agencies and private landowners. The second stage of the project also required permits for propagation and translocation of rare flora. All work was planned in consultation with DEC to minimise adverse impacts on plants and animals in these habitats.

**Table 2.** Objectives and expected outcomes of the WOR project.

Objective	Outcomes
1. Conserve endangered wheatbelt orchids by obtaining knowledge required for their sustainable management.	1. Identify the most critical threats to orchids in their remaining habitats by continuing to help monitor rare flora.
2. Determine the most important biotic and abiotic factors defining the habitats of these species.	2. Assist in risk assessment for the production of Threatened Flora Recovery plans.
3. Provide essential resources to orchid conservation workers in community groups and directly contribute to the implement recovery actions.	3. Investigate the role of habitat fragmentation, weeds, disturbance and other threats to orchids.
4. Enhance community group involvement by providing training and resources.	4. Use orchid seed baiting techniques to locate suitable new habitats in remnant vegetation.
5. Assist in providing recognition of the role of community groups such as WANOSCG, FoKP and Landcare Groups in orchid conservation.	5. Continue key role in Recovery Teams by working with community groups to implement on-the-ground work.
6. Promote outcomes of Western Australian conservation efforts in the national and international arena and heighten the environmental profile of the Lotteries Foundation.	6. Collect seeds and fungi for propagating of orchids.
7. Develop closer ties between rural and urban conservation volunteers and workers.	7. Provide propagated orchids for establishment in suitable natural habitats.
8. Use orchids as icon species to help promote biodiversity conservation in Perth's urban bushland and our southwestern Australian biodiversity hotspots.	8. Continue to provide strong input through presentations, collaborative projects and other means.
	9. Provide expertise in plant propagation and habitat management to community groups.
	10. We anticipate a substantial media profile for recovery actions through a web page, posters, displays, media releases and published articles.
	11. Publish outcomes in articles in popular and widespread magazines.
	12. Communication activities listed for 5 above.
	13. Key events include revealing the nature of the nutrition and genome of the underground orchid - one of the World's most amazing plants.
	14. Collaborate for rare orchid surveys.
	15. Extend existing collaborations with wheatbelt and Perth based groups and foster relationships with groups in other areas.
	16. Presentations on orchid diversity.
	17. Perth's bushland orchids posters.
	18. Posters and presentations.
	19. Orchid conservation website.
	20. Displays at public events.

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| <p>9. Expand the existing collaborative framework between government organisations and community groups for conservation projects.</p> <p>10. Help support conservation initiatives with other rare flora and fauna.</p> | <p>21. Continue existing strong working relationships.</p> <p>22. Help to manage shared resources required by plant conservation programs.</p> <p>23. Use knowledge and skills gained to help investigate the role of fungi in the ecology of other critically endangered species.</p> |
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**Table 3.** Orchid Recovery Actions undertaken as part of the WOR project, as explained in WOR Reports 2-8.

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| <ol style="list-style-type: none"> <li>1. Contribute to meetings of recovery teams and community groups</li> <li>2. Obtain relevant permits and permissions</li> <li>3. Continue annual surveys which estimate population sizes</li> <li>4. Measure orchid mortality, seed set and recruitment in permanent monitoring plots</li> <li>5. Assess habitat condition and orchid habitat preferences</li> <li>6. Select 4 wheatbelt orchids which are in the greatest danger of extinction</li> <li>7. Obtain required biological and ecological knowledge for each species to identify the most important threats</li> <li>8. Undertake feasible actions to ameliorate threats and promote population growth (fencing, pollination, weed control, etc.)</li> <li>9. Provide expertise in plant propagation and habitat management to community groups and conservation workers.</li> <li>10. Investigate the benefits or costs of supplementary pollination</li> <li>11. Collect seeds &amp; isolate fungi required to propagate orchids</li> <li>12. Use orchid seed baiting of soil samples to identify suitable new sites and locations within sites</li> <li>13. Propagate sufficient material for out-planting to field sites</li> <li>14. Introduce orchid seedlings or seed to permanent plots within chosen sites</li> <li>15. Monitor survival of planted or seeded orchids within plots</li> <li>16. Use knowledge gained to recommend future conservation activities and habitat management by updating recovery plans</li> <li>17. Summarise results and communicate project outcomes to community groups and government agencies</li> <li>18. Undertake other communication activities to promote awareness of rare flora and threats to biodiversity in the wheatbelt</li> </ol> |
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### Part 3. WOR Project Outcomes Relative to Objectives

#### Objective 1: Obtaining knowledge required for sustainable management of rare orchids

During the first two years of the WOR project a principal objective has been to gather knowledge required for sustainable management by surveys of orchid habitats, as listed in Table 4. The WOR project (Mark Brundrett) has met this objective by undertaking individual trips and by leading major group surveys along with DEC staff. Andrew Brown of DEC Species and Communities Branch has also made major contributions to project planning and survey work, along with regional staff from Esperance and Narrogin, as acknowledged in WOR Reports 2 to 6. One key example is the three-day survey of populations of the granite spider orchid with WANOSCG at Dragon Rocks Nature Reserve in September 2008 (WOR Report 2). This survey resulted in the first accurate count of individuals for this species and increased estimates of population sizes in this nature reserve by an order of magnitude over estimates in the Interim Recovery Plan for this species (>300 were found). Accurate GPS information obtained for all orchids sighted was used to produce habitat maps to guide future conservation activities, as explained below. Field trips for orchid surveys and translocation for the WOR project have required substantial time and resources due to the remoteness of locations, a trips take 3-6 days and often cover distances well over 1000 km. In addition to the key role played by WANOSCG volunteers in surveys members of wheatbelt community groups have been of great assistance by attending surveys and providing accommodation. These collaborations are fully explained and acknowledged in reports for each species (WOR Reports 2-9)

**Table 4.** WOR fieldwork for surveys, vital statistics, seed collections and translocations. Major surveys with community group support are highlighted in green.

Tasks and locations	Rare Orchids	Dates
Corragin area survey with WANOSCG	Underground orchid	June 7-9, 2007
Survey Munglinup area	Underground orchid	July 17-20, 2007
Surveys near Brookton and Pingrup	Ballerina orchid, William's spider orchid	Aug. 29-31, 2007
Surveys near Pingrup with WANOSCG	Lonely hammer orchid, ballerina orchid	Sept. 13-18, 2007
Surveys near Hyden and Pingaring	Granite spider orchid	Sept. 25-27, 2007
Seed collecting	Many species	Nov. 9-12, 2007
Seed collecting at wheatbelt sites	Rare and common species	Nov. 23-24, 2007
DEC Yilgarn District	Recovery team meeting	Dec. 5-6, 2007
Survey of populations near Corrigin and Babakin	Underground Orchid	June 4, 2008
Munglinup area survey with WANOSCG	Underground orchid	July 24-26, 2008
DEC Esperance District	Recovery team meeting	July 28, 2008
Surveys near Pingaring and Dragon Rocks Nature Reserve with WANOSCG	Granite spider orchid, ballerina orchid	Sept. 16-21, 2008
Fieldwork Jarrahdale and Perth	Orchid samples for isotopic analysis	Oct. 2008
Seed collecting	Rare and common species	Dec. 2-3, 2008
Survey of populations near Corrigin	Underground orchid	June 3-4, 2009
Survey of populations near Munglinup	Underground orchid	July 20-24, 2009
Translocation trials established near Brookton, Pingrup and Hyden.	William's spider, granite spider and ballerina orchids	Aug. 6-7, 2009
Survey of populations near near Pingrup	Ballerina orchid	Aug. 31- Sept 2, 2009
Survey of populations in Dragon Rocks	Granite spider orchid	Sept. 21-24, 2009

Nature Reserve		
Seed collection near Brookton and Pingrup	William's spider and ballerina orchids	Oct. 26 2009
Lake Magenta Reserve flora survey for Newdegate Rare Flora Group	Vegetation surveys	Oct. 26-27, 2009
Survey of populations in Dragon Rocks Nature Reserve	Granite spider orchid	Oct. 29, 2009
Orchid habitats near Denmark	Seed collection	April 20-24, 2010
Seed and soil collection near Brookton	William's spider orchid	Mar. 17, 2010
Survey of populations and habitats near Munglinup	Underground orchid	July 14-17, 2010
Translocation trials established near Hyden	Granite spider orchid	July 19-20, 2010
Soil collection near Brookton and Pingrup	William's spider, and ballerina orchids	July 21, 2010
Survey of populations and habitats near Brookton	William's spider orchid	Aug. 26, 2010
Survey of populations and habitats between Pingrup and Lake Grace	Ballerina orchid	Sept. 7-9, 2010
Survey of populations near Hyden	Granite spider orchid	Oct. 12, 2010
Seed collecting near Pingrup	Ballerina orchid	Oct. 13, 2010
Seed collecting near Brookton	William's spider	Dec. 13, 2010



**Figure 1.** A large group of volunteers from WANOSCG conducted surveys at Dragon Rocks Nature Reserve. This photo was taken at the location of new sub-population they discovered approx. 1 km from previously known plants (right photo).

### 1.1. Examples of important rare flora survey outcomes

1. Four large surveys had major contributions by WANOSCG members who attended for several weekdays and in greater numbers on weekends. Outcomes of these surveys are summarised in separate reports for each species (WOR Reports 2-6). The WOR project was able to fund accommodation at Munglinup, but other accommodation and transportation costs were borne by WANOSCG members.
2. Data was supplied to DEC in Appendices provided with WOR Reports 2 to 6 and Rare Flora Report Forms. These data include accurate GPS coordinates and the number of flowering and nonflowering individuals of each population. This information will allow future surveys to be much more efficient and effective.

3. Habitat maps have also been produced for the granite spider, ballerina and William's spider orchid to facilitate effective management, especially by defining areas for fire management (WOR Reports 2-4).
4. Mapping critical habitat and providing an accurate population data for >300 individuals of the granite spider orchid in the eastern wheatbelt near Hyden (WOR Report 2). The size and diversity of habitat types was found to be greater than expected. Several potential habitat areas remain unexplored, due to the remoteness of granite areas within Dragon Rocks.
5. Production of a comprehensive habitat map and population census of the lonely hammer orchid was completed after a WOR/DEC/WANOSCG survey (WOR Report 5).
6. Nature reserve planning for southern populations of the western underground orchid is underway in collaboration with DEC Esperance. The WOR project mapped boundaries for a new nature reserve to protect the largest populations of this orchid following surveys near Munglinup in 2008-2010 (WOR Report 6).
7. Seed and soil collection provided resources for translocation trials and soil bioassays which identify suitable habitats for translocation trials (Table 5).
8. Observations of the pollinator of the underground orchid and other orchids were obtained. The underground orchid pollinator was phorid fly (*Megastelia* sp.), as reported by George & Cooke (1981), and a thynnid wasp was collected from the ballerina orchid.
9. Another key outcome of increased community involvement has been discovery of 3 new populations and 5 subpopulations of the ballerina orchid (WOR Report 3).

## **Objective 2: Determine the most important biotic and abiotic factors defining habitats of species**

Permanent transects were established in 2007 to determine flowering, seed-set and survival rates to for the same plants each year. Data has allowed the major threats to orchids in their habitats to be identified and is summarised in comprehensive reports, Rare Flora Report Forms and Translocation Proposals.

### *2.1. Vital Statistics data*

1. Vital statistics data for the ballerina, granite spider and William's spider orchids for 2 years are summarised in separate reports (WOR Reports 2-4).
2. Pollination and seed set data obtained from permanent transects confirmed that pollination is not a major issue in most habitats, but seed set is low at one site.
3. These accurate measurements of orchid populations have shown that grazing of flowering plants is the most important impact on rare orchids in most habitats.
4. As a result of data in WOR reports, fences have been erected by DEC to protect the densest subpopulation of the ballerina orchid. Five fenced enclosures were constructed to minimise grazing impacts (WOR Report 3).
5. Seed baiting trials have confirmed that seed collected is viable and some habitats have compatible fungi so may be suitable for translocation of endangered orchid species (WOR Report 7).

### *2.2. Detailed reports and translocations proposals*

Six preliminary reports were submitted to DEC in April 2009 to provide detailed information about the habitats and ecology of threatened orchids required to support translocation proposals (Brundrett 2009a-g). These were similar to the final reports are listed in the inside cover of this document, but only contained 2 years of data. Additional reports include a Nature Reserve Proposal for the western underground orchid habitats on the Oldfield River. Three translocation proposals were written in collaboration with DEC and approved in 2009, as listed below.

1. Brundrett M and Edgley M. 2009a. Translocation proposal Granite Spider Orchid *Caladenia graniticola* Hopper & A.P.Br. (Orchidaceae). Wheatbelt Orchid Rescue Project, University of Western Australia (13 pages).
2. Brundrett M and Edgley M. 2009b. Translocation proposal Granite Spider Orchid *Caladenia williamsiae* Hopper & A.P.Br. (Orchidaceae). Wheatbelt Orchid Rescue Project, University of Western Australia (11 pages).
3. Brundrett M and Edgley M. 2009c. Translocation proposal Granite Spider Orchid *Caladenia melanema* Hopper & A.P.Br. (Orchidaceae). Wheatbelt Orchid Rescue Project, University of Western Australia (13 pages).

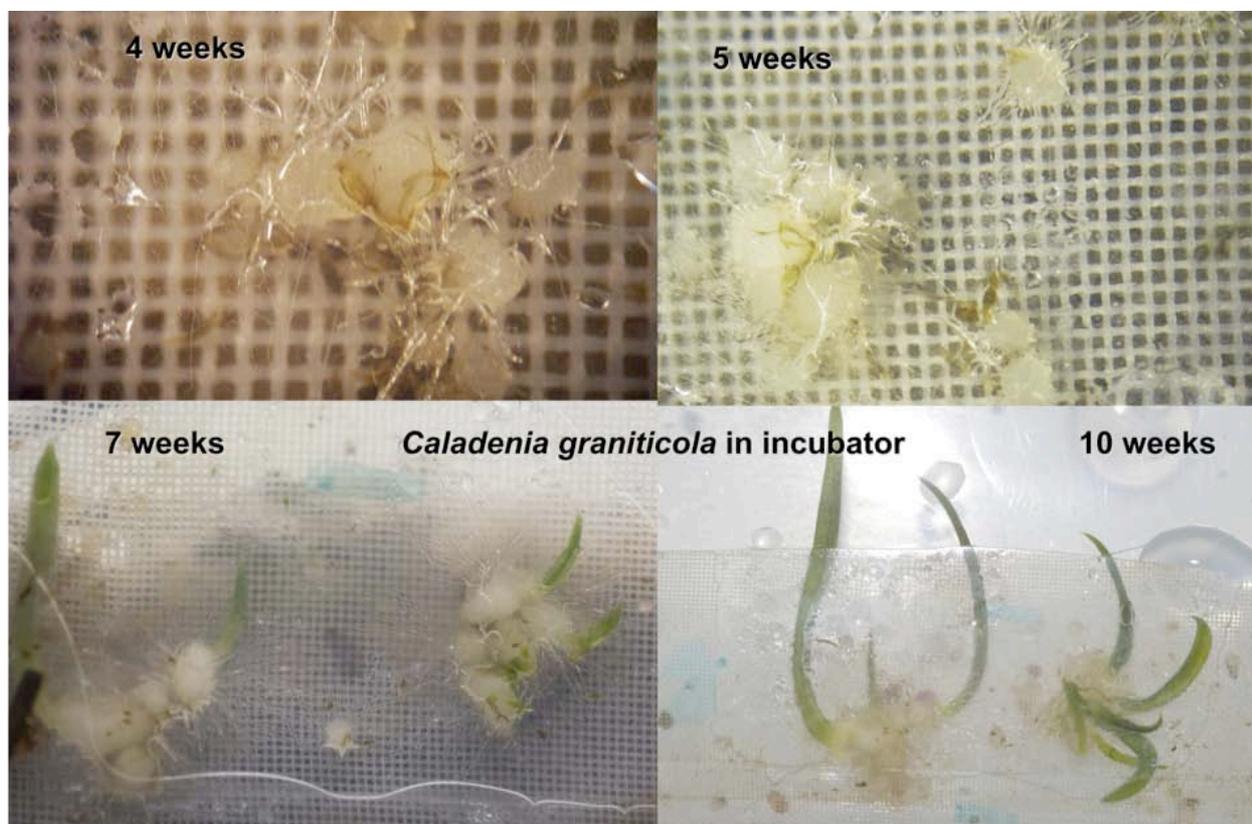
**Objective 3: Provide essential resources to orchid conservation workers in community groups and directly contribute to the implement recovery actions (2008-2010)**

*3.1. Seed collecting*

There were over 250 collections of seed of rare and common orchids by the WOR project (WOR Report 7). Seed of rare orchids is required for seed baiting and orchid propagation. Common orchids that occur in the same habitats as rare orchids were also included trials for comparison. Seed of common orchids was also required for student research projects.

*3.2. Orchid propagation*

Seed baiting trials confirmed that seed collected from these orchids is viable and that compatible mycorrhizal fungi are present in potential translocation sites (WOR Report 7). These soil samples were then used to provide compatible fungi for orchid propagation. Propagation trials for rare and common orchids were conducted in 2009 and 2010 to compare methods and provide seedlings for translocation.



**Figure 2.** Seedling germination in permeable pouches designed for the WOR project.

Several methods are routinely used to propagate orchids for horticulture or conservation, but sterile asymbiotic or symbiotic germination are the most commonly used. An alternative method, where symbiotic fungi germinate orchid seeds in a non-sterile environment was first suggested by Brundrett et al. (2003), but had not been trialled on a large scale.

Emily Ager, a 4<sup>th</sup> year student at UWA conducted experiments and compiled comparative growth data. All experiments included one or more co-occurring common *Caladenia* species along with the rare species required for translocation and determined their relative growth capacity was similar in most cases (WOR Report 8).

The WOR project (MB) developed an innovative germination pouch system to protect and track growth of very small orchid seedlings (Fig. 2). This method germinated orchid seeds in semi-permeable packets in contact with organic matter containing highly active mycorrhizal fungi (symbiotic fungi required by orchids for germination and growth). After germination, protocorms are transplanted into larger permeable pouches placed in potting mix inoculated with the same mycorrhizal fungi (Fig. 3).

Once they had grown to sufficient size for transfer to the field of glasshouse, seedlings were placed in larger pouches in a growth cabinet until they reach sufficient size for establishment in soil (Fig. 4). Results of these experiments are described in WOR Reports 7 and 8.



**Figure 3.** Seedling of the Granite Spider Orchid after transfer into growing pouches placed in potting mix inoculated with compatible fungi.



**Figure 4.** Spider orchid seedlings in pouches growing in an incubator.

The new orchid propagation methods described in WOR Report 7 are collectively referred to as FORGE [Fungal induced - Orchid seed - Realistic environment (non-sterile soil) - Germination - in Enclosures (pouches)]. In comparative studies, the FORGE method was the most successful and

efficient method for propagation of rare or common *Caladenia* species and represents a substantial breakthrough in our capacity to propagate rare Australian orchids.

### 3.3. Orchid translocations

Seedlings were transplanted to field sites in the wheatbelt in August 2009 after final approval of translocation proposals first submitted to DEC in March (WOR Report 8). Orchid seedlings were produced by Mark Brundrett, Emily Ager, Nur Koshkuson and volunteers from the Friends of Kings Park Orchid Carers Group (WOR Report 7). Unfortunately, sites in the eastern wheatbelt were exceptionally dry in 2009 and despite some supplemental watering, the majority of seedlings perished in 2009. However, seedling survival in the same soils was better in the glasshouse where supplemental water was applied every few days. An additional translocation trail was initiated in 2010 by Mark Brundrett and Phylis Robertson (FoKP Orchid carers) with an earlier start and some supplemental watering. Unfortunately 2009 was even drier (lowest rainfall on record) and survival rates again were low. Additional monitoring is required to measure survival rates and establish if new populations have been established.



**Figure 5.** Translocation of *Caladenia williamsiae* near Brookton (Left - Nur Koshkuson -volunteer and Emily Ager - research project student).

#### **Objective 4: Enhance community group involvement by providing training and resources**

This objective has primarily been addressed by presentations and displays on orchid conservation to community groups and undergraduate students as listed below. In addition to the presentations listed a number of trip reports have been published in the WANOSCG Bulletin.

#### 4.1 Community group support

A key outcome from the community group perspective has been the opportunity to see and photograph some of the rarest WA orchids during field trips, while contributing to knowledge of their habitats. WANOSCG members were also provided with the opportunity to attend field trips with Andrew Brown, who showed them some very good examples of orchid habitats and also helped many WANOSCG members to identify orchids in their photographs. Dr Brundrett is a frequent speaker/contributor at WANOSCG meetings and has also provides support to other community groups as listed below. In 2009 and 2010 Dr Brundrett held numerous training and orchid propagation sessions with the Friends of Kings Park Orchid Carers Group.

#### 4.2 *Presentations to Recovery Teams and Community Groups*

1. Presentation for Yilgarn Recovery Team - DEC, Avon NRM Group (Dec 8, 2006).
2. Orchid conservation seminar for WANOSCG (March 21, 2007).
3. Seminar on conservation in WA biodiversity hotspots for DEC (May 15, 2007).
4. Presentation for Esperance Recovery Team on the underground orchid (July 20, 2007).
5. Seminar on orchid conservation for Plant Biology at UWA (Aug 27, 2007).
6. WANOSCG Trip Report (Oct 17, 2007).
7. Seminar on conservation or rare flora in biodiversity hotspots in Yilgarn ironstone ranges – seminar and lecture at UWA (Feb 25, 2008).
8. Talk for WANOSCG on orchid conservation (March 19, 2008).
9. Talk for WANOSCG on essential plant-fungus partnerships (May 21, 2008).
10. Discussion with WANOSCG on plans for 2008 surveys (July 16, 2008).
11. Conservation or rare flora in biodiversity hotspots in Yilgarn ironstone ranges for the Perth Branch of the Wildflower Society of WA (June 10, 2008).
12. Joint presentation on gardening with native plants for the Perth Branch of the Wildflower Society of WA (May 13, 2008).
13. Conservation Biology forum to lunch new mycorrhizas website (May 15, 2008).
14. Lecture for practitioners on ecosystem rehabilitation on guidelines for effective restoration of disturbed habitats (July 1, 2008).
15. Presentation to WANOSCG on project outcomes (15/10/08).
16. Kwongan Symposium presentation: Can we resolve conflict between mining and conservation in a newly recognised biodiversity hotspot (13/9/08).
17. Lecture on conservation of rare orchids in WA presented at the WA Orchid Spectacular 2 (27/9/08).
18. Perth Urban Fungus Project foray leader on weekends (June-Aug 2007-2010).
19. Presentation on winter orchids to Perth of Wildflower Society (9/6/09).
20. Presentations on WOR project to community groups and DEC at recovery team meetings at Northam (24/3/09).
21. Presentation on rare orchids to Armidale Branch of Wildflower Society (12/11/09).
22. Contributed to ANPC Translocation Workshop (24/2/10).
23. Presentation to Great Southern Recovery Team meeting at Narrogin (7/5/10).
24. Presentation to WNOSCG on WOR project (16/7/10).
25. Presentation to Naturalist Club of WA on orchid ecology (17/8/10).
26. WOR project outcomes presented at Australian National Plant Conservation Society Conference (29/9/10).
27. End of project (Jan. 21, 2011).
28. Handover of final reports to DEC, FoKP and WANOSCG (Jan 26, 2011).
29. Summary of project provided for Great Southern Recovery Team - DEC (Feb. 1, 2011).
30. Summary of project provided for WANOSCG members (planned for March 16, 2011).

#### 4.3 *Community group presentations in eastern Australia.*

31. Presentation to 2009 Annual Orchid Conservation Workshop in eastern Australia (Albury Dec 7-10) on the ecology and propagation of 3 Endangered *Caladenia* species from the Wheatbelt of WA.
32. The wheatbelt orchid rescue project the role of community groups and scientists for the Australasian Native Orchid Society Toorak Victoria (4/12/9).

#### 4.4 *Presentations to conservation biology students*

33. Lecture on plant surveys for biodiversity conservation for Australian vegetation (Oct 9, 2007).
34. Conservation of rare orchids in WA for introduction to ecology (May 23, 2008).

35. Lecture on rare flora in biodiversity hotspots in Yilgarn ironstone ranges for conservation biology course (June 2, 2008).
36. Lecture on biodiversity in WA for plant taxonomy course (July 31, 2008).
37. Brief introduction to rare WA orchids at Conservation Biology Forum for UWA students (Aug 28, 2008).
38. Lecture on role of botanical data in environmental impact assessment to Australian Vegetation (2007-2009).
39. Field trips for UWA students concerning plant adaptations in a biodiversity hotspot (2008, 2009).
40. Conservation Biology Forums for undergraduate students (2008-2010).
41. Two lectures on orchid conservation and orchid biology (16/9/10).

**Objective 5: Assist in providing recognition of the role of community groups in orchid conservation (2007-2010) and promote outcomes of Western Australian conservation efforts in the national and international arena and heighten the environmental profile of the Lotteries Foundation**

These promotional objectives are very similar and are addressed together. A banner has been produced for the WOR project and used in displays as listed below. A flier on orchid conservation has also been produced in conjunction with the UWA science communication staff. A web page on WA orchid conservation is under development ([orchids-wa.info](http://orchids-wa.info)). There also have been numerous presentations on orchid conservation to community groups as listed above.

*5.1 Posters and Displays*

1. A Poster on conservation in WA biodiversity hotspots was presented at the Mediterranean Ecosystems Conference (Sept. 2007) and at the Ecological Society of Australia (Dec. 2007).
2. Orchid conservation displays for prospective students and the public at University Open House days (2008, 2009, 2010).
3. A display and a talk on WA orchid conservation presented to orchid enthusiasts at the WA Orchid Spectacular (Sept 26-29, 2008).
4. Perth Orchids Poster produced and used for displays.
5. Perth Bushland Wildflowers Poster (display at Duncraig Public Library, Aug. 2008).
6. Display of orchid propagation methods for International Year of Biodiversity in the University of Western Australia library (April -May, 2010).

**Objective 6: Promote outcomes of Western Australian conservation efforts in the national and international arena and heighten the environmental profile of the Lotteries Foundation (see 8 also)**

*6.1 Comprehensive reports*

1. Six preliminary orchid status reports were submitted to DEC in 2009.
2. Three translocation proposals were approved by DEC in 2009 (Brundrett and Edgley 2009abc).
3. Eight detailed reports on ecology and management of endangered orchid species completed (see inside cover). These will be published online (UWA document repository).

*6.2. Webpages*

1. The [mycorrhizas.info](http://mycorrhizas.info) website on plants and symbiotic fungi includes comprehensive information on WA plants and fungi was published online on May 2, 2008. By 2010, the site had 90,000 visits a year from 150 countries.

2. Web site for orchids-wa.info was partially designed but could not be completed before funding ran out.

### *6.3. Popular articles and media contacts*

1. Newspaper article on plants in hotspots (Subiaco Post on June 7, 2008)
2. Newspaper article quotes on saving orchid habitats (West Australian on October 2 2007).
3. Contributions to Plant Biology online newsletters.
4. Trip reports WANOSCG bulletin.
5. Article on WOR project and WANOSCG in Greener Times (June 2009)
6. Article in "For People and Plants" the FoKP magazine about Orchid Carers and the WOR project (Spring 2010 issue).
7. Healthy Bushland E-news Avon NRM article on WOR project published (Dec. 2010).
8. Press release on Underground Orchid Chloroplast genome by Etienne Delannoy, Ian Small and Mark Brundrett (Feb. 7 2011) resulting in over 20 articles about this endangered WA orchid throughout the world.
9. A second press release summarising the WOR project is under development.

### **Objective 7. Develop closer ties between rural and urban conservation volunteers and workers**

The WOR project established collaborations with community groups for fieldwork to survey populations of rare flora. These collaborations involved WOR, WANOSCG and DEC (especially DEC regional staff). Wheatbelt community groups and the Friends of Kings Park Orchid Carers also have opportunities to work closely during fieldwork, orchid propagation and translocation trials. Contact with community groups outside of WANOSCG includes people who attend rare flora surveys. The WOR project also had a strong working relationship with landowners concerned with rare orchids, especially in Brookton, Lake Grace and Munglinup. One example is an orchid trip to Dragon Rocks with members of the Newdegate Conservation Group occurred in Sept. 2009 (organised by Ann Rick). The author (MB) has also been a major contributor to botanical surveys by the Wildflower Society of Western Australia and fungal diversity surveys by the Perth Urban Bushland Fungus Project.

Community group volunteers who have assisted in WOR surveys were from Brookton (Judy Williams), Nyabing (Jocelyn Ward), Pingrup (Lucy Skipsey), Munglinup (Ruth Rirchner), Albany Pam Goodman) and Perth (Margaret Petrides, Wayne Merritt, John Ewing, Etienne Delannoy and many others). Ann and Barry Rick of Newdegate have generously provided accommodation and support for rare orchid surveys and translocations.

### **Objective 8. Use orchids as icon species to promote biodiversity conservation in our biodiversity hotspots (see 6 also)**

UWA Science Communication students produced a flier on the WOR project under the supervision of Dr Nancy Longnecker. Popular articles on orchid conservation are listed below (see reference list). An interactive display about orchid diversity and conservation was produced for University of West Australia Open Day displays.

Two major review articles explaining the global significance of symbiotic plant-fungal associations and explaining how the flora of WA is uniquely different from plants growing elsewhere in the world was published as a Marschner Reviews in Plant and Soil Brundrett 2009, Lambers et al.

2010). The importance of plant-fungal associations in Australia and the world is also summarised in a website ([mycorrhizas.info](http://mycorrhizas.info)).

The location of this project at the University of Western Australia has resulted in the opportunity to sequence underground orchid chloroplast genome by Etienne Delannoy and Ian Small in the Plant Energy Biology Centre of Excellence. This has resulted in considerable new knowledge about the diversity and evolution of underground orchids published in the high profile journal *Molecular Biology and Evolution* in early 2011. Press release about the underground orchid chloroplast research was released on Feb 7 2011 and resulted in popular articles in Australia and international venues (e.g. *Cosmos Magazine* and many online publications).

In late 2009 Andrew Brown and I were approached by a publisher and have agreed to produce a field guide to orchids in WA. This book will be the first to contain comprehensive keys and illustrations for WA orchids and will be of great value to community group members, orchid enthusiasts and visitors to WA.

### **Objective 9: Expand the existing collaborative framework between government organisations and community groups for conservation projects**

A very strong DEC / WANOSCG / UWA collaboration has been a key aspect of the success of this project especially for rare flora surveys. The role of the FoKP Orchid Carers Group and the WOR project was described in a feature article in the Spring issue of "For People and Plants" the Friends of Kings Park Magazine. This collaboration resulted in seedlings of rare orchids used for translocation. The Botanic Gardens and Parks Authority was provided with seeds and fungi for the Kings Park collection. Collaboration with other scientists has resulted in a number of important outcomes that add value to the WOR project.

1. An undergraduate student assisted with orchid seed baiting trials as a volunteer in 2009 (Jesse Kalic).
2. A 4<sup>th</sup> year student has completed a research project on orchid propagation for the WOR project in 2009 (Emily Ager).
1. As described above, Dr. Etienne Delannoy and Professor Ian Small of the Plant Energy Biology Centre for Excellence have sequenced the chloroplast genome of the Underground Orchid as a result of Faculty of Natural Sciences and Agriculture funding provided to Mark Brundrett (Delannoy et al. 2011). While primarily concerned with the loss of photosynthetic genes in a very old achlorophyllous plant, this project is also providing very important data on the genetics of different populations.
2. A research collaboration with Prof. Gerhard Gebauer at Beyreuth University in Germany has been established to investigate nutrient sources and photosynthesis of WA orchids. Johanna Pausch recently completed a visit to WA to measure photosynthesis and stable isotope compositions in orchids and other plants (Pausch 2009).
3. A funding application was prepared for an ARC linkage project with DEC to help conserve Gilbert's Potoroo, which is Australia's rarest animal by determining which plants and fungi define its critical habitat was prepared (2007).
4. The WOR project has provided support and information to scientists trying to conserve the eastern underground orchid (Drs Chris Howard and Mark Clements).
5. A funding application to allow production of an interactive Lucid key to identify WA orchids is being developed (Collins, Brown, Brundrett).
6. A funding application is under development for a project to clarify orchid taxonomy for rare and common WA orchids in the *Caladenia filamentosa* species complex is under development (Brown, Moody, Brundrett).

7. A funding proposal on the co-evolution of Australian plants and fungi has been submitted (ARC discovery).

### **Objective 9. Help support conservation initiatives with other rare flora and fauna**

In addition to conservation biology training / lectures described above, three conservation forums for students at UWA were held in August and Oct 2008 to provide information on potential student projects were organised by Dr Brundrett. A major outcome resulting from communication with undergraduate students, is that several volunteers and a potential 4<sup>th</sup> year project student have come forward to assist in orchid propagation and translocation activities in 2009. By funding my position the WOR project has made major contributions conservation biology education by student supervision and publications as listed below. Note that several of the papers listed below have a high rate of citation (use by other scientists). The website on mycorrhizal fungi has become a very important resource for students, landcare and agricultural workers with over 90,000 visits a year including many from developing nations. Highlights arising from the WOR project include:

1. A substantial review article on terrestrial orchid conservation biology was published in the Australian Journal of Botany (Brundrett 2007).
2. Three major papers on the ecology, physiology and fungal associations of the western underground orchid (Bougoure et al. 2008, 2009, 2010 and 2 in preparation).
3. A major website which functions as an online textbook on mycorrhizal associations was launched in May 2008 (mycorrhizas.info).
4. Invited Marschner Review published in the scientific journal Plant and Soil on beneficial plant-fungus symbioses (Brundrett 2009).
5. Authoritative review on unique features of native plants growing in ancient WA soils (Lambers et al. 2010).
6. A paper on Jarrah forest orchids is published in the Australian Journal of Botany (Collins et al. 2007) and several others on orchid recovery after disturbance in preparation.

#### *9.1. Supervision of conservation biology students*

1. Orchid recovery after disturbance (Margaret Collins, PhD 2007).
2. The Underground Orchid (Jeremy Bougoure PhD 2008).
3. Survival of orchids in urban bushland (Belinda Newman PhD 2009).
4. Nutrition and photosynthesis of orchids (Johanna Pausch 2009)
5. Impact of jarrah forest dieback on beneficial fungi (Prue Anderson Honours Project 2007).
6. Comparison of methods for orchid propagation (Emily Ager 4<sup>th</sup> year project 2009).
7. Relationships between trees, soils and mycorrhizal fungi (Jemima Rogers Honours Project 2010).

#### *9.2. Scientific papers and book chapters*

1. Bougoure J, Brundrett M, Grierson PG. (in preparation). Carbon and nitrogen isotope natural abundance of obligately myco-heterotrophic *Rhizanthella gardneri* (Orchidaceae).
2. Pausch J, Brundrett MC, Bidartondo MI, Gebaeur G. (in preparation). Carbon and nitrogen gains by selected green orchids from Western Australia.
3. Collins M, Brundrett M. 2011. Recovery of terrestrial orchids in natural ecosystems after severe disturbance. In: *Mining in Ecological Sensitive Areas*. Edited by: M. Tibbett. CSIRO Canberra, Australia.
4. Brundrett MC. 2011. Commentary on de Vega et al. (2010) paper on hyphae in the parasite *Cytinus*: Mycorrhizal fungi growing within plants are not always mycorrhizal. American Journal of Botany **98**: (in press for April issue).

5. Delannoy E, Fuji S, des Francs CC, Brundrett M, Small I. 2011. Rampant gene loss in the underground orchid *Rhizanthella gardneri* highlights evolutionary constraints on plastid genomes. *Molecular Biology and Evolution* (online first Feb 2011).
6. Anderson P, Brundrett M, Grierson P, Robinson R. 2010. Impact of severe forest dieback caused by *Phytophthora cinnamomi* on macrofungal diversity in the northern jarrah forest of Western Australia. *Forest Ecology and Management* **259**: 1033.
7. Bougoure J, Brundrett M, Grierson PG. 2010. Carbon and nitrogen supply to the underground orchid. *New Phytologist* **186**: 947-956.
8. Lambers H, Brundrett MC, Raven JA, Hopper SD, 2010. Plant mineral nutrition in ancient landscapes: high plant species diversity on infertile soils is linked to functional diversity for nutritional strategies. *Plant and Soil* **334**: 11-31. (Invited Marschner Review).
9. Brundrett MC 2009. Mycorrhizal associations and other means of nutrition of vascular plants: Understanding the global diversity of host plants by resolving conflicting information and developing reliable means of diagnosis. *Plant and Soil* **320**: 37-77. (Invited Marschner Review).
10. Bougoure J, Ludwig M, Brundrett M, Grierson PG. 2009. Identity and specificity of the fungi forming mycorrhizas with the rare myco-heterotrophic orchid *Rhizanthella gardneri*. *Mycological Research* **113**: 1097-1106.
11. Bougoure J, Brundrett M, Brown A, Grierson PG. 2008. Habitat requirements of the rare Western Underground Orchid, *Rhizanthella gardneri* Roger. *Australian Journal of Botany* **56**: 501-511.
12. Brundrett MC. 2007. Scientific approaches to terrestrial orchid conservation with particular reference to Western Australia. *Australian Journal of Botany* **55**: 293-307. (Advances in Plant Conservation special issue).
13. Collins M, Koch J, Brundrett M, Sivasithamparam K. 2007. Colonisation of bauxite mine rehabilitation areas of south-west Western Australia by orchid mycorrhizal fungi. *Australian Journal of Botany* **55**: 653-664.
14. Bonnardeaux Y, Brundrett M, Batty A, Dixon K, Koch J, Sivasithamparam K. 2007. Diversity of mycorrhizal fungi of Western Australian terrestrial orchids: Compatibility webs, brief encounters, lasting relationships and alien invasions. *Mycological Research* **111**: 51-61.

### 9.3. Promotional Articles

15. Pace. N. Underground orchid reveals major gene loss. *Cosmos Magazine* (Published online 10/2/2011).
16. Brundrett M, Robertson P. 2010. The Wheatbelt Orchid Rescue Project. *For People and Plants - Friends of Kings Park* **71**: 3-6.
17. Brundrett M. 2010. The Wheatbelt Orchid Rescue Project: Helping Endangered Orchids by Working With Community Groups. *Healthy Bushland E-news* December 2010.
18. Wild H, Brundrett M. 2010. Wheatbelt Orchid Rescue Program (Meeting - 4<sup>th</sup> December 2009). A. N. O. S. Victoria Group Bulletin Feb. 2010. pp. 5-6.
19. Brundrett M. 2009. The Wheatbelt Orchid Rescue Project. *Greener Times* June Issue. Conservation Council of Western Australia Inc.

### 9.4. Books & Webpages

20. Brundrett M. 2008. *Mycorrhizal Associations: The Web Resource* (online text book). url: mycorrhizas.info. (over 90,000 visits per year from 150 countries).

21. Brown A, Brundrett M. 2011. *A Field Guide to Orchids of Southwestern Australia*. Simon Nevill Publications (in ed. publisher commitment for mid 2011).

#### 9.5. Theses

22. Collins MT. 2007. *Factors affecting the recovery of orchids in a post-mining landscape*. PhD Thesis. University of Western Australia. (open access at <http://theses.library.uwa.edu.au>).
23. Bougoure JJ. 2008. *The role of mycorrhizal fungi in nutrient supply and habitat specificity of the rare mycoheterotrophic underground orchid, Rhizanthella gardneri*. PhD Thesis. University of Western Australia. (open access at <http://theses.library.uwa.edu.au>).
24. Pausch J, 2009. *Ecophysiological investigations on the carbon and nitrogen gain of a selection of Western Australian orchids*. Diploma Thesis. University of Bayreuth.
25. Newman B. 2009. *Orchids as Indicators of Ecosystem Health in Urban Bushland Fragments*. Murdoch University. PhD Thesis Murdoch University.
26. Ager E. 2009. *A Comparison of orchid propagation methods for Caladenia species (Orchidaceae): The ex vitro advantage*. 4<sup>th</sup> Year Project Thesis. University of Western Australia.
27. Rogers, J. 2010. *Links between soil properties and plant diversity in coastal woodland*. Honours Project Thesis. University of Western Australia.

**Table 6.** Brief summary of WOR project activities relative to major objectives in the Lotterywest project proposal.

<b>Conservation objective</b>	<b>Outcomes in brief</b>
1. Conserve Critically Endangered wheatbelt orchids by obtaining knowledge required for their sustainable management.	<ul style="list-style-type: none"> <li>• 4 years of vital statistics data collected on flowering, pollination, grazing, etc</li> <li>• Key spatial data on orchids and critical habitats provided to DEC</li> <li>• Supervision of PhD students working on orchid conservation</li> </ul>
2. Determine the most important biotic and abiotic factors defining the habitats of these species.	<ul style="list-style-type: none"> <li>• Key threats to orchids identified</li> <li>• Orchid seed baiting trials completed</li> <li>• Fencing for grazing protection by DEC</li> <li>• Provide advice to DEC in comprehensive reports</li> </ul>
3. Provide essential resources to orchid conservation workers in community groups and directly contribute to the implement recovery actions.	<ul style="list-style-type: none"> <li>• Communicate with Recovery Teams</li> <li>• Collect seeds and fungi</li> <li>• Propagate orchids with orchid carers</li> <li>• Provide propagated orchids for establishment in suitable natural habitats.</li> </ul>
4. Enhance community group involvement by providing training and resources.	<ul style="list-style-type: none"> <li>• Organise and lead surveys for rare flora</li> <li>• Presentations, displays and collaborative projects</li> </ul>
5. Assist in providing recognition of the role of community groups such as WANOSCG, FoKP and Landcare Groups in orchid conservation.	<ul style="list-style-type: none"> <li>• Posters, displays, media and scientific articles as listed in 8 below</li> <li>• Examples include UWA open house and the Orchid Spectacular displays</li> </ul>
6. Promote outcomes of Western Australian conservation efforts in the national and international arena and heighten the environmental profile of the Lotteries Foundation.	<ul style="list-style-type: none"> <li>• Communication activities listed for 5 above.</li> <li>• A major outcome has been presentations to WANOSCG, other community groups and students</li> <li>• Promote outcomes of project including future translocation work</li> <li>• Promotional articles</li> <li>• Website (in prep)</li> </ul>
7. Develop closer ties between rural and urban conservation volunteers and workers.	<ul style="list-style-type: none"> <li>• See 1 above</li> <li>• Present results at Recovery Team meetings</li> <li>• Primarily a responsibility of DEC via the Recovery Team process</li> </ul>
8. Use orchids as icon species to help promote biodiversity	<ul style="list-style-type: none"> <li>• WOR project display banner completed</li> </ul>

conservation in Perth's urban bushland and our southwestern Australian biodiversity hotspots.	<ul style="list-style-type: none"> <li>• Orchid conservation flier developed</li> <li>• Numerous presentations to community groups</li> <li>• WA biodiversity hotspots poster produced</li> <li>• Magazine articles and press release</li> </ul>
9. Expand the existing collaborative framework between government organisations and community groups for conservation projects.	<ul style="list-style-type: none"> <li>• Continue existing strong working relationships with DEC and WANOSCG</li> <li>• Help manage shared resources required by plant conservation programs</li> </ul>
10. Help support conservation initiatives with other rare flora and fauna.	<ul style="list-style-type: none"> <li>• Investigate the role of fungi in the ecology of other critically endangered species</li> <li>• Organisation of Conservation Biology Forums</li> <li>• Occasional conservation biology teaching</li> <li>• Supervision of graduate and undergraduate students</li> <li>• Mycorrhizas.info website</li> </ul>