WITTWER'S MOUNTAIN BELL

(*Darwinia wittwerorum*)

RECOVERY PLAN

Renée Hartley, Sandra Gilfillan and Sarah Barrett

Australian Government

Government of Western Australia

Department of Environment and Conservation

FOREWORD

Interim Recovery Plans (IRPs) are developed within the framework laid down in WA Department of Conservation and Land Management (CALM) Policy Statements Nos. 44 and 50. Note: the Department of CALM formally became the Department of Environment and Conservation (DEC) in July 2006. DEC will continue to adhere to these Policy Statements until they are revised and reissued.

IRPs outline the recovery actions that are required to urgently address those threatening processes most affecting the ongoing survival of threatened taxa or ecological communities, and begin the recovery process.

DEC is committed to ensuring that Threatened taxa are conserved through the preparation and implementation of Recovery Plans (RPs) or IRPs and by ensuring that conservation action commences as soon as possible.

This IRP will operate from October 2005 to September 2010 but will remain in force until withdrawn or replaced. It is intended that, if the taxon is still ranked Endangered (WA), this IRP will be reviewed after five years and the need further recovery actions assessed.

This IRP was given regional approval on 26 October, 2005 and was approved by the Director of Nature Conservation on 26 October, 2005. The provision of funds identified in this Interim Recovery Plan is dependent on budgetary and other constraints affecting DEC, as well as the need to address other priorities.

This IRP has been updated with information contained herein and is accurate as at January 2008.

This IRP was prepared with financial support from the Australian Government and has been adopted as a National Recovery Plan under the provisions of the Commonwealth *Environment Protection and Biodiversity Conservation Act* (EPBC Act).

ACKNOWLEDGMENTS

The following people have provided assistance and advice in the preparation of this Interim Recovery Plan:

Anne Cochrane Manager, DEC Threatened Flora Seed Centre
Andrew Brown Threatened Flora Coordinator, DEC Species and Communities Branch

Thanks also to staff of the W.A. Herbarium for providing access to Herbarium databases and specimen information, and DEC's Wildlife Branch for their assistance.

SUMMARY

Scientific Name:	*Darwinia wittwerorum*	**Common Name:**	Wittwer's Mountain Bell
Family:	Myrtaceae	**Flowering Period:**	August to November
DEC Region:	South Coast	**DEC District:**	Albany Work Centre
Shires:	Gnowangerup, Plantagenet	**Recovery Team:**	Albany District Threatened Flora Recovery Team

Illustrations and/or further information: Brown, A., Thomson-Dans, C. and Marchant, N. (Eds). (1998) *Western Australia's Threatened Flora*, Department of Conservation and Land Management, Western Australia; Western Australian Herbarium (1998) FloraBase - Information on the Western Australian Flora. Department of Conservation and Land Management, Western Australia. http://www.calm.wa.gov.au/science/.

Current status: *Darwinia wittwerorum* was declared as Rare Flora under the Western Australian *Wildlife Conservation Act 1950* in 1982 and is currently ranked Endangered (EN) under World Conservation Union (IUCN 1994) Red List criterion B1+2de, due to fragmentation and limited geographic range. The species is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Description: *Darwinia wittwerorum* is an erect spindly shrub to one metre high. The fine, linear leaves are triangular in cross-section and 5 to 10mm long. The bell comprises a cluster of five to nine flowers that hang down and are enclosed by colourful petal-like leaf bracts. The narrow outer bracts are cream and elliptic and the floral bracts are 18 to 21mm long, rose pink and obovate.

Habitat requirements: *Darwinia wittwerorum* is restricted to eight populations in low elevations in the central Stirling Range National Park. The habitat consists of open mallee over scrub in sandy clays over schist. It occurs in drainage lines from approximately 320 to 480 metres altitude.

Habitat critical to the survival of the species, and important populations: Habitat critical to the survival of *Darwinia wittwerorum* comprises the area of occupancy of the known populations; areas of similar habitat surrounding the known populations (these areas provide potential habitat for natural range extension and/or for allowing pollinators or biota essential to the continued existence of the species to move between populations) and additional occurrences of similar habitat that may contain important populations of the species or be suitable for future translocations or other recovery actions intended to create important populations. All population are considered important for the long-term recovery and survival of the species.

Benefits to other species/ecological communities: *Darwinia wittwerorum* occurs partly within the Montane Mallee Thicket Threatened Ecological Community (Mallee-heath and mallee-thicket community on mid to upper slopes of Stirling Range mountains and hills). The Montane Mallee Thicket TEC contains an assemblage of plants that are susceptible to *Phytophthora cinnamomi* and many of which are threatened species. Stirling Range National Park is also habitat for seven threatened fauna species. Recovery actions put in place for *D. wittwerorum* will benefit the Montane Mallee Thicket TEC and the adjacent threatened fauna species and reciprocally, actions put in place for the recovery of the Montane Mallee Thicket TEC and the adjacent threatened fauna species will benefit *D. wittwerorum.*

International obligations: This plan is fully consistent with the aims and recommendations of the Convention on Biological Diversity and will assist in implementing Australia's responsibilities under that convention. The taxon is not listed under any specific international treaty however, and therefore this IRP does not affect Australia's obligations under any other international agreements.

Role and interests of Indigenous people: Involvement of the Indigenous community is being sought through the advice of the Department of Indigenous Affairs to determine whether there are any issues or interests identified in the plan. A search of the Department of Indigenous Affairs Aboriginal Heritage Sites Register has determined that there are no registered sites of Aboriginal significance at or near *Darwinia wittwerorum* populations. Where no role is identified for the Indigenous community in the development of the recovery plan, opportunities may exist through cultural interpretation and awareness of the species. Indigenous involvement in the implementation of recovery actions will be encouraged.

Affected interests: All known populations are on Crown land.

Social and economic impacts: The implementation of this Interim Recovery Plan (IRP) has minimal social and economic impact as all populations are on DEC managed land.

Evaluation of the Plan's Performance: The Department of Environment and Conservation (DEC), in conjunction with the Albany District Threatened Flora Recovery Team (ADTFRT), will evaluate the performance of this IRP.

Completed Recovery Actions: The following recovery actions have been implemented:

1. All land managers have been notified of the location and threatened status of the species.
2. Seed collections have been made by staff from DEC's Threatened Flora Seed Centre (TFSC).
3. Staff from the DEC Albany Work Centre have regularly monitored populations.
4. Rare flora markers have been installed at Population 1.
5. An information sheet on mountain bells has been provided to the land manager to promote awareness.

IRP Objective:
The objective of this Interim Recovery Plan is to abate identified threats and maintain or enhance *in situ* populations to ensure the long-term preservation of the species in the wild.

Recovery criteria
Criteria for success: The number of populations and individuals within populations remains stable or increases over the five years of the plan.
Criteria for failure: The number of populations or the number of individuals within populations decreases over the five years of the plan.

Recovery actions

1. Coordinate recovery actions.
2. Monitor populations.
3. Collect Seed.
4. Conduct further surveys.
5. Obtain biological and ecological information.
6. Assess susceptibility to *Phytophthora cinnamomi*.
7. Management of *Phytophthora cinnamomi*.
8. Develop and implement a fire management strategy.
9. Promote awareness and encourage involvement.
10. Map habitat critical to the survival of the species.
11. Review the IRP and assess the need for further recovery actions.

1. BACKGROUND

History

Darwinia wittwerorum was named in 1981 by Neville Marchant and Greg Keighery in honour of the horticulturalists Ernst and Magda Wittwer (Keighery and Marchant 1993). The first Herbarium specimen on record was collected by P.G. Wilson in September 1966 while collections were first made by E.J. Croxford from Population 1 (Talyuberlup) in 1986 and by G.J. Keighery from Population 2 (Hostellers Hills) in 1977. N. Hoyle located Population 3 (Stirling Range Drive) in 1985, E. Hickman discovered Population 5 (Central Lookout) in 1996 and L. Sandiford found Population 6 (Mt Gog) in 2003. S. Barrett and R. Hartley found Populations 7, 8A and 8B (Hostellers Hills) in 2004.

Description

Darwinia wittwerorum belongs to a sub-group in the genus *Darwinia* that contains the mountain bells and the rare Mogumber bell (*Darwinia carnea*). *D. wittwerorum* is an erect spindly shrub to one metre high. The fine, linear leaves are triangular in cross-section and 5 to 10mm long. The bell of the *Darwinia* consists of a cluster of five to nine hanging flowers enclosed by colourful leaf bracts. The narrow outer bracts are cream and elliptic and the floral bracts are 18 to 21mm long, rose pink and obovate.

Distribution and habitat

All nine mountain bells occur within the Stirling Range National Park and adjacent Hamilla Hills. *Darwinia* species in the Stirling Range have distinct, well-defined distributions and it is thought that landscape dissection, combined with climatic and microclimatic factors, has facilitated taxonomic divergence (Hopkins *et al.* 1983). The onset of drier conditions in the Holocene may have caused the contraction of *Darwinia* species to wetter upland and gully habitats which acted as refugia (Hopkins, *et al.* 1983).

Darwinia wittwerorum is restricted to eight locations at mid elevations in the central Stirling Range. Habitat consists of open mallee over heath and thicket on sand clay loam over sandstone and metamorphosed sandstone primarily in south-facing drainage lines on mountain slopes from approximately 320 to 480 metres altitude. The total extent of occurrence of *D. wittwerorum* is less than 16 km^2 with an area of occupancy of approximately 12 hectares.

Populations 3 and 6 occur within the Endangered Montane Mallee Thicket TEC (Mallee-heath and mallee-thicket community on mid to upper slopes of Stirling Range mountains and hills) (Western Australian Threatened Ecological Communities Scientific Committee listing). The community occurs on the mid to upper slopes of mountains and hills, mainly east of Red Gum Pass and above 400 m above sea level. The community generally extends further down-slope on the southern aspects of these hills, which may be due to the moister cooler conditions experienced on these southern aspects.

Biology and ecology

Many *Darwinia* species are killed by fire and regenerate from soil-stored seed, at this time forming dense local stands (Keighery 1985). Seedlings may flower from two to five years after germination but full maturity is not reached until seven to ten years. *Darwinia* seeds have no specialised means of dispersal and remain stored in the soil below adult plants until the next fire (Keighery & Marchant 1993). Population health is thought to decline after a period of around twenty years as the surrounding vegetation becomes too dense for *Darwinia* individuals to survive (Keighery and Marchant 1993). A fire is necessary at that time to restart the cycle.

Darwinia wittwerorum plants in Population 1 (Talyuberlup) and Population 5 (Central Lookout) were observed to commence flowering approximately five years after fire (S. Barrett and L. Sandiford, personal observation).

Darwinia wittwerorum populations are known to regenerate successfully after thirteen to fourteen-year fire intervals (S. Barrett, personal observation). Population 5, which consisted of around 200 mature plants in 1996, was burnt in January 1997 after a fire interval of fourteen years and recruited approximately 25,000 individuals. Similarly, Population 1 had a pre-fire population of around 10,000 and, since the 1997 fire, some 350,000 individuals were recruited.

All of the mountain bells are thought to be pollinated by nectar-feeding birds (Keighery and Marchant 1993). As birds locate food by sight, *Darwinia* species are brightly coloured and occur in dense populations in open areas to attract them. The bells are pendulous to keep rain from the nectar and are often quite large, although *Darwinia wittwerorum* has one of the smaller bells. They are positioned so that birds can probe the bell both from the ground and by perching on them (Keighery 1985).

Phytophthora cinnamomi is an introduced soil-borne plant pathogen. Infection results in plant death in susceptible species through the destruction of root systems. The impact of the disease on plant communities is variable between sites as it is dependent on temperature, soil type, nutrient and water status, and species susceptibility. The greatest impact usually occurs where soils are infertile and drainage is poor (Weste and Marks 1987; Shearer and Tippett 1989; Wilson *et al*. 1994).

Mountain bells planted in pots are susceptible to *Phytophthora cinnamomi* (Keighery and Marchant 1993). In 1993, after symptoms of *P. cinnamomi* infestation were observed in *Darwinia* populations, sampling of *Darwinia wittwerorum* individuals was carried out. Three out of five mature plants were found to be infected and the pathogen was isolated from twelve of twenty tissue pieces plated. All of the root systems were found to have completely rotted ([1]F. Podger, personal communication). Field observations of *D. wittwerorum* and monitoring data from 1999 to 2004 suggest it is moderately susceptible to the disease (S. Barrett, personal observation). However, the impact of *P. cinnamomi* on this species may vary according to site topography, soils and hydrology. Further inoculation studies are required to fully assess its susceptibility to the pathogen.

Phosphite has been shown to be effective in controlling *Phytophthora cinnamomi* in a number of native plant species (Shearer and Fairman 1991, 1997a, 1997b; Komorek *et al*. 1997). Phosphite may have a direct effect or act indirectly to enhance the host's defence response (Guest and Grant 1991). It cannot be used to eradicate the pathogen but can be used to control the disease.

Population 1 was treated with phosphite in June 1994 and July 1996 ([2]M. Grant, personal communication). The application focused on a small section of the large population where it appeared there was a slightly higher rate of *Darwinia* decline due to water discharge off the Scenic Drive and increasing *Phytophthora* activity.

Quadrats were established in March 1999, in both *Phytophthora cinnamomi* free habitat and *P. cinnamomi* infested habitat in Population 1 to compare survival rates and to provide an indication of natural rates of thinning. Quadrats in the *P. cinnamomi* free habitat were burnt in April 1996 and quadrats in the infested habitat were burnt in January 1997. The percentage survival of *D. wittwerorum* seedlings has been monitored in these quadrats from December 1999 to July 2004.

Figure 1 (below) shows that the rate of decline in the *Phytophthora cinnamomi* free habitat has been greater over time than that in the infested habitat. It should also be noted however, that the population density in the *P. cinnamomi* free habitat is significantly greater than that of the infested habitat. Such a steady decline in the number of individuals in *P. cinnamomi* free habitat could be due to natural thinning as growth of vegetation surrounding the *D. wittwerorum* leads to overcrowding (Keighery and Marchant 1993).

[1] Dr Frank Podger Consultant and Chairman WADRP
[2] Malcolm Grant Senior Operations Officer – Nature Conservation, DEC Ravensthorpe

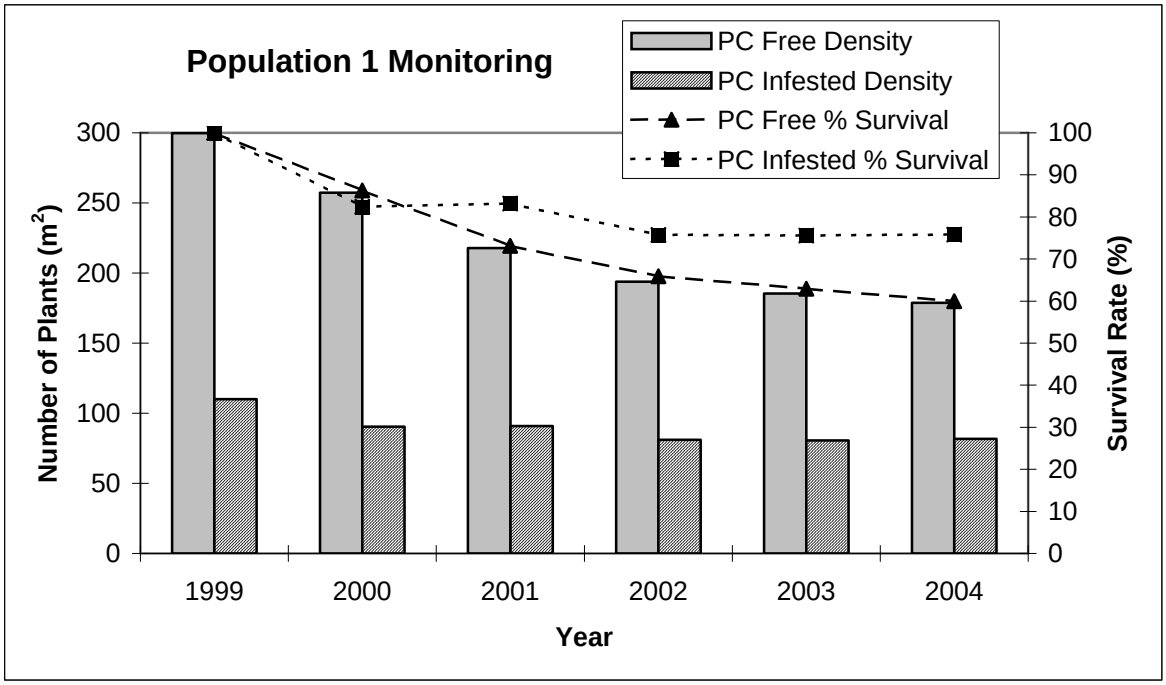

Figure 1: Percentage survival and number of individuals of *Darwinia wittwerorum* (Population 1) in *Phytophthora cinnamomi* free habitat compared with *P. cinnamomi* infected habitat, from 1999 to 2004. Values are mean percentage survival in four 1m x 1m quadrats.

Observed changes in vegetation structure and floristics caused by *Phytophthora cinnamomi* will also have an effect on the abundance of vertebrate pollinators in communities (Wills 1993). Possible effects on pollinators include loss of foods sources, loss of habitat and increased predation risk (Wilson *et al.* 1994; Nichols 1998). As *Darwinia wittwerorum* is thought to be bird pollinated, *P. cinnamomi* is likely to have an indirect effect on this species through a reduction in the abundance of its pollinators.

Threats

Darwinia wittwerorum was declared as Rare Flora under the Western Australian *Wildlife Conservation Act 1950* in 1982 and is currently ranked Endangered (EN) under World Conservation Union (IUCN 1994) Red List criterion B1+2de, due to fragmentation and limited geographic range. The species is listed as Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

All areas occupied by *Darwinia wittwerorum* are affected or potentially affected by one or more threats identified in this IRP. Threats include:

- ***Phytophthora cinnamomi*:** *Darwinia wittwerorum* was found to be susceptible to *Phytophthora cinnamomi* (F. Podger, personal communication) and it poses an ongoing threat. The disease is present in three *D. wittwerorum* populations and all others are at risk. Population 1 (Talyuberlup) contains significant *P. cinnamomi* infested areas with only small healthy pockets left. Population 2A has evidence of the disease along the drainage line. There are spot infestations of *P. cinnamomi* within Population 7 on the southern aspect of Hosteller Hills. Populations 5 (Lookout) and 6 (southwest of Mt Gog) are as close as fifty metres to an infestation. Population 8 (Hosteller Hills) appears to be healthy at present (S. Barrett, personal observation).

  Densities of *Darwinia wittwerorum* are considerably lower in infested habitat (Fig. 1). While recruitment after fires in 1996 and 1997 has been significant, even within infested habitat, it is unclear how viable these populations are in the long-term. The relationship between *Phytophthora cinnamomi* and fire regimes and their impact on population densities requires further clarification. The rate of spread of *P. cinnamomi* from infested to healthy habitat has not been determined to date for any

populations. However, on sites with significant gradients in the Stirling Range this rate of spread can range from several metres to more than a hundred metres per annum (Grant and Barrett 2003).

- **Inappropriate fire regime:** A minimum desirable fire interval may be estimated by a doubling of the primary juvenile period (time to first flower) (Gill and Nichols 1989). A juvenile period of approximately five years has been observed for *Darwinia wittwerorum* and successful post fire regeneration has been observed to take at least fourteen years post fire. A fire interval of ten years or longer is recommended for *D. wittwerorum*. However, a longer fire-free interval may be required for other members of the plant community, particularly within the Montane Mallee Thicket TEC (S. Barrett, unpublished data).

- **Recreation:** The Stirling Range National Park averages approximately 80,000 visitors per annum and all populations are at risk to some extent as a result of the recreational activity.

  Populations 1 and 5 occur along Stirling Range Drive, which is a popular scenic drive and a main road within the park. Roadworks and maintenance can be considered a threat to these populations. Rare flora markers are in place at Population 1. Population 5 is at considerable risk of *Phytophthora cinnamomi* introduction from infected gravel on the Drive or Lookout area. Management of the carpark area to prevent ponding of water is important as this provides ideal conditions for soil and disease transfer (Watson and Passmore 1993). The disease-free status of Population 5 is unexpected given the opportunity for vectoring of the pathogen by vehicle or foot traffic in the past and may be related to unknown site characteristics.

  Populations 5, 6 and the northern section of Population 1 are in a Natural Environment Zone of the Stirling Range National Park. This is defined as 'areas which can sustain, with minimum impairment, a selected range of low density activities with a minimum of related facilities' (CALM 1999). Population 1 has been subject to trampling in the past, however there is little evidence of such impacts currently. No evidence of disturbance due to recreation has been observed in or around Population 6. Paths have been created from Stirling Range Drive through to Population 5, which is located directly opposite the Central Lookout carpark. The lookout receives high levels of visitation though the reason for this path formation is unknown. At present, there is no evidence of direct trampling impacts on Population 5.

  Populations 2, 7, 8A, 8B and the southern portion of 1 are in a Special Conservation Zone. This is defined as 'areas which are the most intact examples of ecosystems in the Parks and which would be threatened by uncontrolled access. Introduction and spread of dieback and other diseases poses a major threat, though minor infections do occur within the zone. A permit is required for access (CALM 1999). There is no evidence of recreational impacts in these populations. Strict management of foot access to Populations 2, 7 and 8 is critical to prevent the spread or introduction of *Phytophthora cinnamomi.*

- **Climate Change:** The Stirling Range lies between the moist, mild areas of the south-west, where rainfall can exceed 1400mm a year, and the drier north, where average annual rainfall is around 400mm. Rainfall on the eastern peaks may be up to double that on the surrounding plains, however rainfall varies significantly on all the peaks (Keighery and Marchant 1993). Temperatures are highly variable and the peaks can endure temperatures of roughly five degrees less than the surrounding plain (Keighery and Marchant 1993). Clouds occur on some of the peaks approximately two out of every three days and snow and hail are not uncommon (Keighery and Marchant 1993). These unique climatic conditions caused the mid to upper slopes of the Stirling Range to become a refugia for several specialised flora and fauna species, including *Darwinia*. It is thought that the onset of drier conditions in the Holocene has caused the contraction of *Darwinia* to uplands slopes and gullies (Hopkins, *et al.* 1983). Therefore, it must be considered that climate change could accelerate this process, significantly reducing the area of habitat suitable for *Darwinia wittwerorum.*

Summary of population land vesting, purpose and tenure

Population		Vesting	Purpose	Tenure
1.	Talyuberlup	WA Conservation Commission	National Park	National Park
2A.	Hostellers Hills (NW)	WA Conservation Commission	National Park	National Park
2B.	Hostellers Hills (NE)	WA Conservation Commission	National Park	National Park
3	9km along Stirling Range Dr	WA Conservation Commission	National Park	National Park
4.	Sth Henton Tk Intersection	WA Conservation Commission	National Park	National Park
5.	Central Lookout	WA Conservation Commission	National Park	National Park
6.	SW of Mt Gog	WA Conservation Commission	National Park	National Park
7.	Hostellers Hills (SW)	WA Conservation Commission	National Park	National Park
8A.	Hostellers Hills (SE summit)	WA Conservation Commission	National Park	National Park
8B.	Hostellers Hills (SE gully)	WA Conservation Commission	National Park	National Park

Summary of population information and threats

Pop. No. & Location		Year/No. of plants adults (juveniles)		Habitat Condition	Known Fire History	Threats
1.	Talyuberlup	1989 1992 1993 1994 1998 1999 2000 2001 2002 2003 2004	100 1,500 100 10,000 20 (100,000) (500,000) 20 (450,000) 20 (450,000) 400,000 300,000 (100,000) 350,000	Healthy Trampled Healthy Healthy Healthy Moderate Moderate Moderate Healthy Moderate Moderate	1983 1996 (south) 1997 (north)	Inappropriate fire regime, *Phytophthora cinnamomi*
2A.	Hostellers Hills (NW)	1998 2004	20 (5-10,00) 375,000	Healthy Moderate	1996	Inappropriate fire regime, *P. cinnamomi*
2B.	Hostellers Hills (NE)	2004	120,000	Healthy		
3.	9km along Stirling Range Dr	2004	0	Unable to Locate		
4.	Sth Henton Tk Intersection	2004	0	Unable to Locate		
5.	Central Lookout	1996 1998 2001 2003 2004	200 (80) (700) 850 25,000	Healthy Healthy Healthy Healthy Moderate	1983 1997	Inappropriate fire regime, *P. cinnamomi* Recreation
6.	SW of Mt Gog	2002 2003	50 1,000	Healthy Healthy	1997	Inappropriate fire regime, *P. cinnamomi*
7.	Hostellers Hills (SW)	2004	500,000	Moderate	1997	Inappropriate fire regime, *P. cinnamomi*
8A.	Hostellers Hills (SE summit)	2004	25,000	Healthy	1996	Inappropriate fire regime, *P. cinnamomi*
8B.	Hostellers Hills (SE gully)	2004	125,000	Healthy		

Habitat critical to the survival of the species, and important populations

Habitat critical to the survival of the species includes the area of occupancy of important populations; areas of similar habitat surrounding important populations – these areas provide potential habitat for natural range extension and/or for allowing pollinators or biota essential to the continued existence of the species to move between populations; and additional occurrences of similar habitat that may contain important populations of the species or be suitable for future translocation or other recovery actions intended to create important populations. All population are considered important for the long-term recovery and survival of the species.

Benefits to other species/ecological communities

Darwinia wittwerorum occurs partly within the Montane Mallee Thicket Threatened Ecological Community (Mallee-heath and mallee-thicket community on mid to upper slopes of Stirling Range mountains and hills). The Montane Mallee Thicket TEC contains an assemblage of plants that are susceptible to *P. cinnamomi* and many of which are threatened species.

Seven threatened fauna species occur within Stirling Range National Park. They include three endangered species; Carnaby's Cockatoo (*Calyptorhynchus latirostris*), the Dibbler (*Parantechinus apicalis*) and the Stirling Range Moggridgea spider (*Moggridgea* sp. (B.Y. Main 1990/24, 25) WA listed only) and four vulnerable fauna species; Quokka (*Setonix brachyurus*), Numbat (*Myrmecobius fasciatus*), Malleefowl (*Leipoa ocellata*) and Baudin's Cockatoo (*Calyptorhynchus baudinii*).

Recovery actions put in place for *Darwinia wittwerorum* will benefit the Montane Mallee Thicket TEC and the seven threatened fauna species through threat abatement and close management. Reciprocally, actions put in place for the recovery of the Montane Mallee Thicket TEC and the seven threatened fauna species will benefit *D. wittwerorum.*

International obligations

This plan is fully consistent with the aims and recommendations of the Convention on Biological Diversity, ratified by Australia in June 1993, and will assist in implementing Australia's responsibilities under that convention. The taxon is not listed under any specific international treaty however, and therefore this IRP does not affect Australia's obligations under any other international agreements.

Role and interests of Indigenous people

Involvement of the Indigenous community is being sought through the advice of the Department of Indigenous Affairs to determine whether there are any issues or interests identified in the plan. A search of the Department of Indigenous Affairs Aboriginal Heritage Sites Register has determined that there are no registered sites of Aboriginal significance at or near *Darwinia wittwerorum* populations. Where no role is identified for the Indigenous community in the development of the recovery plan, opportunities may exist through cultural interpretation and awareness of the species. Indigenous involvement in the implementation of recovery actions will be encouraged.

Affected interests

All known populations are on Crown land.

Social and economic impacts

The implementation of this recovery plan has minimal social and economic impact as all populations are on DEC managed land.

Guide for decision-makers

Section 1 provides details of current and possible future threats. Developments in the immediate vicinity of the population or within the defined habitat critical to the survival of *Darwinia wittwerorum* require assessment for the potential for a significant level of impact.

Evaluation of the Plan's Performance

DEC, in conjunction with the Albany District Threatened Flora Recovery Team, will evaluate the performance of this recovery plan.

2. RECOVERY OBJECTIVE AND CRITERIA

Objective

The objective of this Interim Recovery Plan is to abate identified threats and maintain or enhance *in situ* populations to ensure the long-term preservation of the species in the wild.

Criteria for success: The number of populations and individuals within populations remains stable or increases over the five years of the plan.
Criteria for failure: The number of populations or the number of individuals within populations decreases over the five years of the plan.

3. RECOVERY ACTIONS

Completed recovery actions

Staff at DEC (Albany Work Centre) and the Ranger in Charge (Stirling Range NP) have been made aware of the Declared Rare status of *Darwinia wittwerorum* and the legal responsibility to protect it.

In 1999, two monitoring sites were established within Population 1 on the east slopes of Talyuberlup. One of these sites is infested with *Phytophthora cinnamomi* and the other is not. The continual monitoring of these sites has provided ongoing data on the species survival in *P. cinnamomi* infested vegetation, compared to survival rates and natural thinning in non-infested pockets. All other populations are also being monitored.

Declared Rare Flora (DRF) markers have been installed at Population 1. Although the plants are inside the National Park, the population borders the Scenic Drive. The markers alert road workers of the presence of threatened flora and help prevent accidental damage during maintenance operations.

Samples of dead plants were collected to verify *Phytophthora cinnamomi* infection in Population 1. This population was treated with phosphite in June 1994 and July 1996. Spray to runoff application (using a backpack sprayer) was used to treat approximately 125 plants, at a rate of 0.3% active solution, adjacent to and directly down slope from the road drain. The application focused on a small section of the large population, as it appeared there was a slightly higher rate of *Darwinia* decline due to water discharge off the Scenic Drive and increasing *Phytophthora* activity.

Staff at DEC's Threatened Flora Seed Centre (TFSC) have made two seed collections of *Darwinia wittwerorum*. Both samples were taken from Population 1, five months after phosphite application (1994 and 1996). *Darwinia wittwerorum* seed is contained within a fruit and that is how the seed is stored. In the lab, the seed is excised from the fruit and germinated on agar containing 25mg/l Gibberellic acid ([3]A. Crawford, personal communication).

[3] Andrew Crawford Senior Technical Officer, DEC Threatened Flora Seed Centre

Initial germination yielded 18% and 0% for the 1994 and 1996 samples respectively and retest germination resulted in 3% and 5%, respectively. Fungal contamination has been a problem in germinating this species and for future work the seed will be soaked in a 50% solution of Plant Preservative Material for fifteen minutes after the seed has been excised to prevent the problem repeating (A. Crawford, personal communication). Smoke has been used for the *Darwinia wittwerorum* but a non-smoke treatment has not been tested so it is unclear if this has had any effect on germination (A. Crawford, personal communication). Further tests on germination are currently underway.

Darwinia wittwerorum was included in an article in the Sunday Times (27/10/2001) on threats to flora in the Stirling Range NP. The Ranger in Charge has been provided with an information sheet on Mountain Bells for visitors to the Stirling Range.

Ongoing and future recovery actions

The following recovery actions are roughly in order of descending priority; however this should not constrain addressing any of the priorities if funding is available for 'lower' priorities and other opportunities arise.

1. Coordinate recovery actions

The Albany District Threatened Flora Recovery Team (ADTFRT) is coordinating recovery actions for *Darwinia wittwerorum* and will include information on progress in their annual report to DEC's Corporate Executive and funding bodies.

Action: Coordinate recovery actions
Responsibility: DEC (Albany Work Centre) through the ADTFRT
Cost: $3,000 per year.

2. Monitor populations

Continue regular (annual) monitoring of all *Darwinia wittwerorum* populations. Monitoring of factors such as spread and impact of *Phytophthora cinnamomi*, habitat degradation and population stability is required for appropriate management.

Action: Monitor populations
Responsibility: DEC (Albany Work Centre)
Cost: $3,060 per year.

3. Collect Seed

Preservation of germplasm is essential to guard against the possible extinction of wild populations. Seed can also be used to propagate plants for future translocations. Seed is required from all populations to maximise the genetic diversity of *ex situ* material. Seed collection will be ongoing to obtain seed from as wide a range of individuals as possible. Five seed collections are currently held at DEC's Threatened Flora Seed Centre.

Action: Collect seed
Responsibility: DEC (Albany Work Centre and Threatened Flora Seed Centre)
Cost: $3,060 per year.

4. Conduct further surveys

Surveys supervised by DEC staff and with assistance from local naturalists and wildflower society members are being conducted during the species' flowering period (August to November). Similar habitat has been identified but has not yet been surveyed.

Action: Conduct further surveys

Responsibility: DEC (Albany Work Centre)
Cost: $5,100 per year.

5. Obtain biological and ecological information

Improved knowledge of the biology and ecology of *Darwinia wittwerorum* will provide a better scientific basis for the species management. An understanding of the following is particularly necessary for effective management:

1. Investigate soil seed bank dynamics and the role of disturbance, competition and the interaction between fire and *P. cinnamomi* in germination and recruitment, plant longevity and population dynamics. Determine minimum and maximum tolerable fire intervals for the species.
2. The reproduction biology, pollination, phenology and seasonal growth of the species.

This action is currently underway.

Action: Obtain biological and ecological information
Responsibility: DEC (Science Division and Albany Work Centre)
Cost: $24,000 per year for the last three years.

6. Assess susceptibility to *Phytophthora cinnamomi*

Limited research has been done on the susceptibility of *Darwinia wittwerorum* to *Phytophthora cinnamomi*. Further information will facilitate accurate decision-making.

Action: Assess *Phytophthora cinnamomi* susceptibility
Responsibility: DEC (Science Division and Albany Work Centre)
Cost: $1,400 in the first year.

7. Management of *Phytophthora cinnamomi*

Populations will be reviewed annually with regard to the urgency of phosphite application and phosphite will be applied as appropriate. Access to all populations will be restricted to dry soil conditions and appropriate hygiene ensured, with permit access only to populations within the Special Conservation Zone. Suitable drainage in the recreational area adjacent to Population 5 needs to be ensured. The species has been included in an aerial phosphite program with application planned for 2008.

Action: Management of *Phytophthora cinnamomi*
Responsibility: DEC (Science Division and Albany Work Centre)
Cost: $400 per year with an additional $5,676 biannually or as required.

8. Develop and implement a fire management strategy

Darwinia wittwerorum re-establishes from seed after fire and the primary juvenile period (time to first flower) of the species is approximately five years. A minimum desirable fire interval can be estimated by a doubling of the primary juvenile period (Gill and Nicholls 1989). Therefore, a fire interval of at least ten years is recommended for *D. wittwerorum*.

A Draft Fire Management Strategy has been developed for the Stirling Range NP (Barrett, *et al.* 2004). The strategy recommends that demographic processes and life history attributes be used to identify fire sensitive species and ecological communities to determine the minimal tolerable fire frequency for these species and communities. Planned fire may be introduced to lowland areas to protect threatened species and communities. A fire management plan for this species will be included as part of a broader strategy for the National Park.

Fire management for the term of this Interim Recovery Plan (five years) will be in the form of fire exclusion to achieve the desired fourteen-year fire interval discussed in Section 1.

Action: Develop and implement a fire management strategy
Responsibility: DEC (Albany Work Centre)
Cost: $1,000 per year.

9. Promote awareness and encourage involvement

The importance of biodiversity conservation and the need for the long-term protection of wild populations of this species will be promoted to the community through poster displays and the local print and electronic media. Formal links with local naturalist groups and interested individuals will also be encouraged. Particularly, input and involvement will be sought from any Noongar groups that have an active interest in the areas that are habitat for *Darwinia wittwerorum*. A Bush-book on Stirling Range flora has been produced. The book contains a section on the Mountain Bells.

Action: Promote awareness and encourage involvement
Responsibility: DEC (Albany Work Centre) through the ADTFRT
Cost: $900 per year.

10. Map habitat critical to the survival of the species

Although habitat critical to the survival of the species is identified in Section 1, all the areas described have not yet been accurately mapped and are being addressed under this action. If additional populations are located, habitat critical to their survival will also be determined and mapped.

Action: Map habitat critical to the survival of the species
Responsibility: DEC (Albany Work Centre)
Cost: $600 in the first year.

11. Review the IRP and assess the need for further recovery actions

If the *Darwinia wittwerorum* is still ranked as Endangered at the end of the five-year term of this IRP, the plan will be reviewed and the need for further recovery actions assessed.

Action: Review the IRP and assess the need for further recovery actions
Responsibility: DEC (WATSCU and Albany Work Centre) through the ADTFRT
Cost: $4,000 in the fifth year (if required).

4. TERM OF PLAN

Western Australia

This Interim Recovery Plan will operate from October 2005 to September 2010 but will remain in force until withdrawn or replaced. If the taxon is still ranked Endangered (WA) after five years, this IRP will be reviewed and, if necessary, further recovery actions put in place.

Commonwealth

In accordance with the provisions of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) this adopted recovery plan will remain in force until revoked.

The recovery plan must be reviewed at intervals of not longer than 5 years.

5. REFERENCES

Atkins, K. (2008) *Declared Rare and Priority Flora List for Western Australia.* Department of Conservation and Land Management, Western Australia.

Barrett, S. (1999) Aerial application of phosphite in the south coast region of Western Australia. Unpublished Report.Department of Conservation and Land Management.

Barrett, S., Broomhall, G., Comer, S., Freebury, G., Grant, M., (2004) Fire Management Strategy for the Stirling Range National Park - Unpublished Draft, Department of Conservation and Land Management.

Brown, A., Thomson-Dans, C. and Marchant, N. (Eds) (1998) *Western Australia's Threatened Flora*. Department of Conservation and Land Management, Western Australia.

Department of Conservation and Land Management (1999) Stirling Range and Porongurup National Parks Management Plan 1999-2009.

Gill, A.M and Nichols, A.O. (1989). Monitoring fire prone flora in reserves for nature conservation. In: "Fire Management on Nature Conservation Lands". Occasional Paper 1/89. Department of Conservation and Land Management, Perth.

Grant M and Barrett S (2003) The distribution and impact of *Phytophthora cinnamomi* Rands in the south coast region of Western Australia. In Proceedings of '*Phytophthora* in forests and natural ecosystems, (2nd International IUFRO Working party, Albany).

Guest, D.I and Grant, B.R. (1991) The complex actions of phosphites as antifungal agents. *Biological Review* 66; 169-187.

Hopkins, A.J.M., Keighery, G.J. and Marchant, N.G. (1983) Species-rich uplands of south-western Australia, *Proceedings of the Ecological Society of Australia* **12**: 15-26.

IUCN (2001) *IUCN Red List Categories and Criteria: Version 3.1.* Prepared by the IUCN Species Survival Commission. IUCN0, Gland, Switzerland and Cambridge, UK.

Keighery, G. (1985) Rediscovering Mountain Bells. *Landscope*. Vol. 1 (1) pp. 3-10 Department of Conservation and Land Management.

Keighery, G. and Marchant, N. (1993) Mountains of Mystery- a natural history of the Stirling Range. Eds. C. Thomson, G Hall and G. Friend. Department of Conservation and Land Management.

Komorek , B., Shearer, B. Smith, B. and Fairman, R. (1997) Application technologies and phosphanate movement in the host. Project 1, Part A in "Control of *Phytophthora* and *Diplodina* Canker in Western Australia. Final Report to the Threatened Species and Communities Unit, Biodiversity Group, Environment Austaralia".Department of Conservation and Land Management Unpublished Report.

Muhling PC and Brakel AT (1985) Mount Barker-Albany. Geological Survey of Western Australia: 1:250,000 Geological Series Explanatory Notes. Geological Survey of Western Australia.

Nichols, O.G (1998) Impacts of dieback-induced vegetation changes on native faunal communities in south-western Australia. Scope Item 7 In: Control of *Phytophthora cinnamomi* and Diplodina Canker in Western Australia.Final Report to the Threatened Species and Communities Unit, Biodiversity Group, Environment Australia. Department of Conservation and Land Management.

Shearer, B. L. and Fairman, R.G. (1991) Control of Phytopthora species in native communities with phosphorous acid. In " Proceedings of Conservation Biology in Australia and Oceania Conference" P. 72 . University of Queensland, Brisbane.

Shearer, B. L. and Fairman, R.G. (1997a) Phosphite inhibits lesion development of *Phytophthora cinnamomi* for at least four years following trunk injection of *Banksia* species and *Eucalyptus marginata*. In "Proceedings of the 11th Biennial Conference of the Australasian Plant Pathology Society" p. 181. Australian Plant Pathology Society: Perth.

Shearer, B. L. and Fairman, R.G. (1997b) Foliar application of phosphite delays and reduces the rate of mortality of three *Banksia* species in communities infested with *Phytophthora cinnamomi*. In "Proceedings of the 11th Biennial Conference of the Australasian Plant Pathology Society" p. 180. Australian Plant Pathology Society: Perth.

Shearer, B.L. and Tippett, J.T. (1989) Jarrah dieback, the dynamics and management of Phytophthora cinnamomi in the jarrah (*Eucalyptus marginata*) forest of south-western Australia. Research Bulletin No.3. Department of Conservation and Land Management: Perth.

Watson, J.R. and Passmore, T.P. (1993) A Western Australian approach to path restoration. *Australian Ranger*. **27**: 31-34.

Weste, G. and Marks, G.C. (1987) The biology of *Phytophthora cinnamomi* in Australasian forests. *Annual Review of Phytopathology* 24: 207-229.

Wills, R.T. (1993) The ecological impact of *Phytophthora cinnamomi* in the Stirling Range National Park, Western Australia. *Australian Journal of Ecology* 18; 145-159.
Wilson, B.A., Newell, G., Laidlaw, W.S. and Friend, G. (1994) Impact of plant diseases on faunal communities. *Journal of the Royal Society of Western Australia* 77: 139-144.

6. TAXONOMIC DESCRIPTION

Marchant, N.G. and Keighery, G.J. (1980) A new species and a new combination in *Darwinia* (Myrtaceae) from Western Australia. Nuytsia 3, 2: 179-182

Erect, single-stemmed *shrub* 30-80 cm tall. *Leaves* scattered, linear-triquetrous, 5-10 mm long, less than 0.5 mm wide, apex acute; leaf scars persistent. *Inflorescence* ovoid, pendulous; *outer bracts* elliptic in lower half, linear above, cream; *inner bracts* elliptic-obovate, 18-21 mm long, 6-9 mm wide, cream in lower half, pink or rose pink in upper part. *Flowers* 5-9. *Bracteoles* 4, linear in lower half, concave spathulate in upper half, 6-9 mm long, 1-2 mm wide. *Floral tube* narrow, circular in cross section, with faint ribbing, 4-6 mm long. *Calyx lobes* minute, triangular, less than 0.25 mm long. *Corolla lobes* cream coloured , ovate, entire, 3-4 mm long. *Stamens* 10; filaments less than 1 mm long. *Style* falcate, bent towards centre of inflorescence, terete, 8-10 mm long. *Stigma* globose, minute, subtended by a 1-2 mm wide band of rigid hairs forming a cone-shaped brush. *Ovules* 2.