INTERIM RECOVERY PLAN NO. 207

STIRLING RANGE DRYANDRA (*DRYANDRA MONTANA*)

INTERIM RECOVERY PLAN

2005-2010

Sandra Gilfillan[1], Sarah Barrett[2], Renée Hartley[3] and Colin Yates[4]
[1] Conservation Officer, CALM Albany Work Centre, 120 Albany Hwy, Albany 6330
[2] Flora Conservation Officer, CALM Albany Work Centre, 120 Albany Hwy, Albany 6330
[3] Technical Officer, CALM Albany Work Centre, 120 Albany Hwy, Albany 6330
[4] Senior Research Scientist, CALM Science Division, Locked Bag 104, Bentley Delivery Centre 6983

Photo: Ellen Hickman

April 2005

Department of Conservation and Land Management
Albany Work Centre,
South Coast Region,
120 Albany Hwy, Albany WA 6331

Natural Heritage Trust
Helping Communities Helping Australia

Government of Western Australia

DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

FOREWORD

Interim Recovery Plans (IRPs) are developed within the framework laid down in Department of Conservation and Land Management (CALM) Policy Statements Nos. 44 and 50.

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.

CALM 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 is a revision of the previous IRP for this species (1996-1999). *Dryandra montana* also forms part of the Threatened Ecological Community – Eastern Stirling Range Montane Heath and Thicket Community which is covered by an existing IRP (1999-2002).

This IRP will operate from March 2005 to February 2010 but will remain in force until withdrawn or replaced. It is intended that, if the taxon is still ranked Endangered, 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 CALM, as well as the need to address other priorities.

Information in this IRP was accurate at April 2005.

ACKNOWLEDGMENTS

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

Anne Cochrane	Manager, CALM's Threatened Flora Seed Centre
Greg Freebury	CALM's Albany Work Centre
Andrew Brown	Threatened Flora Coordinator, CALM Species and Communities Branch

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

SUMMARY

Scientific Name:	*Dryandra montana*	**Common Name:**	Stirling Range Dryandra
Family:	Proteaceae	**Flowering Period:**	November
CALM Regions:	South Coast	**CALM District:**	Albany Work Centre
Shires:	Gnowangerup	**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.naturebase.net/florabase/.

History and current status: *Dryandra montana* was declared as Rare Flora under the Western Australian *Wildlife Conservation Act 1950* in September 1987 and in 1995 was ranked as World Conservation Union Red List Category Critically Endangered (CR) under Criteria A1ce; B1+2c; C1 (IUCN, 2000). It is also listed under the *Environment Protection and Biodiversity Act* 1999 as Endangered. Its critical status is due to the loss of habitat as a result of *Phytophthora cinnamomi* infestation, combined with two intense fires in close succession and limited post-fire recruitment. Four populations consisting of 45 plants are currently known.

Habitat requirements: *Dryandra montana* occurs on mountain summit areas above 900 m above sea level (a.s.l.) on sandstone, metamorphosed sandstone and metamorphosed siltstone, in dense heath and thicket dominated by *Kunzea montana* and *Banksia oreophila* and including *Andersonia axilliflora* (DRF), *Darwinia collina* (DRF), *Banksia brownii* (DRF), *Leucopogon gnaphalioides* (DRF), *Aotus genistoides, Adenanthos filifolius* (P3), *Dryandra concinna* (P4), *Beaufortia anisandra, Calothamnus crassus* (P4) and *Sphenotoma* sp. Stirling (P3).

Habitat critical to the survival of the species, and important populations: The habitat critical to the survival of *Dryandra montana* comprises the area of occupancy of the known population; similar habitat within 200 metres of the known population; remnant vegetation that may link future populations; and additional nearby occurrences of similar habitat that do not currently contain the species but may have done so in the past and may be suitable for translocations. Given that this taxon is listed as Endangered it is considered that all populations are important populations.

Benefits to other species/ecological communities: *Dryandra montana* occurs exclusively within the Eastern Stirling Range Montane Heath and Thicket Threatened Ecological Community (Montane Heath and Thicket of the South West Botanical Province, above approximately 900m a.s.l.) which is listed as Endangered under the Commonwealth *Environmental Protection and Biodiversity Act 1999*. The Montane Threatened Ecological Community (TEC) contains an assemblage of plants that are susceptible to *Phytophthora cinnamomi* and many of which are threatened species. Recovery actions put in place for *D. montana* will benefit the Montane TEC and reciprocally, an integrated approach to the Montane TEC recovery will benefit *D. montana.*

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 and therefore this IRP does not affect Australia's obligations under any other international agreements.

Role and interests of indigenous people: According to the Department of Indigenous Affairs Aboriginal Heritage Sites Register, no sites exist near the *Dryandra montana* populations. Input and involvement will be sought from Noongar groups that have an active interest in the areas that are habitat for *D. montana* and this is discussed in the recovery actions.

Affected Interest: All natural populations are on Crown land. Population 7T is on private land.

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

Evaluation of the Plans Performance: The Department of Conservation and Land Management (CALM), in conjunction with the Albany District Threatened Flora Recovery Team (ADTFRT) will evaluate the performance of this IRP.

Existing Recovery Actions: The following recovery actions have been or are currently being implemented:

1. Appropriate staff at the CALM (Albany Work Centre) and the Senior Ranger (Stirling Range NP) are aware of the location and threatened status of the species.

2. Seed collections have been made by staff from CALM's Threatened Flora Seed Centre (TFSC) and Albany Work Centre.
3. Phosphite has been applied to all populations to control *Phytophthora cinnamomi*.
4. A seed orchard to preserve germplasm has been initiated.
5. Populations are monitored regularly.
6. Surveys for new populations were carried out between 1996 and 2004.
7. A Draft Fire Management Plan has been produced for the Stirling Range NP.
8. A study of the fire ecology of the Montane Heath and Thicket TEC is near completion.
9. Juvenile plants have been caged to protect them from herbivory.
10. An information sheet for *Dryandra montana* has been produced.
11. The ADTFRT are overseeing the implementation of this IRP.

IRP Objectives

1. Abate identified threats and improve the conservation status of *Dryandra montana* in the wild.
2. Establish an *ex situ* population in order to maintain genetic diversity, provide seed for future translocations and opportunities for research.

Criteria for success:

1. Abatement of a specific threat or group of threats resulting in a stabilization of the population over the period of the plan's adoption.
2. Establishment of an *ex situ* seed orchard and a canopy-stored seed bank over the period of the plan's adoption.

Criteria for failure:

1. A continuation of threats that result in a decline in population size over the period of the plan's adoption.
2. A significant decline in the size of the *ex situ* population over the period of the plan's adoption.

Recovery actions

1. Coordinate recovery actions
2. Continue aerial phosphite spraying of all populations
3. Monitor populations and seed orchard
4. Continue *Phytophthora cinnamomi* hygiene
5. Continue to collect seed from *in situ* populations
6. Continue to develop tissue culture techniques
7. Investigate the methodology for future translocation(s)
8. Implement fire exclusion for all populations
9. Obtain biological and ecological information
10. Continue caging of plants where necessary
11. Investigate and implement the best methods of rabbit control
12. Implement actions to reduce recreational impacts
13. Map habitat critical to the survival of the species
14. Survey for new populations and possible translocation sites
15. Promote awareness and encourage involvement
16. Review the IRP and assess the need for further recovery actions

1. BACKGROUND

History

Dryandra montana was first collected from Bluff Knoll (Population 1) in the Stirling Range by F. Lullfitz in 1964. The species was collected again from Bluff Knoll in 1966 by K. R. Newbey and in 1986 by G. J. Keighery. In 1995 there were thirteen *D. montana* plants known on Bluff Knoll. In 1996 A. Cochrane from CALM's Threatened Flora Seed Centre (TFSC) found an additional eight adult plants on Bluff Knoll, increasing the total known population size to twenty-one adult plants.

Since 1995, habitats that are most likely to support *Dryandra montana*, including the Eastern Stirling Range Montane Heath and Thicket Community and the Montane Mallee Thicket communities, have been intensively surveyed for the species by CALM Albany District staff. These surveys discovered new plants on Bluff Knoll (Population 1) and three new populations on the peaks East Bluff (Population 6), Pyungoorup (Population 4) and Isongerup (Population 5), all within the Stirling Range NP. No plants were located on Coyanerup (Population 2) and this population is presumed extinct as a result of the significant impact of *Phytophthora cinnamomi* at this location. No plants were located on Kyanorup Eminence (Population 3) in October 2000 and the lower altitude and different plant community of this site suggests that this record may be inaccurate as there is no voucher specimen for this population (S. Barrett, personal observation).

The East Bluff Population (Population 6), found by S. Barrett in September 1996, consisted of sixty-one adults and eight juveniles. The Pyungoorup (Population 4), found by E. Hickman in October 1996, consisted of fifteen adult plants. In 1996 the first IRP was written for *Dryandra montana* and at that time the species was known from the above populations and consisted of ninety-seven adults and eight juveniles.

In February 1997, another population of *Dryandra montana* was discovered by E. Hickman on Isongerup (Population 5), consisting of six adults and one seedling.

Since 1997, the population dynamics of *Dryandra montana* have been intensively monitored. In 2000 there were 137 adult plants and 39 juveniles distributed across four populations. In October 2000, a fire burnt a large part of the East Stirling Range Montane Heath and Thicket Community including all four *D. montana* populations. The fire killed 63% of adult plants and 77% of juvenile plants resulting in a net loss of 116 plants with just 13 seedlings emerging in the post-fire environment.

In August 2003 and June 2004, 89 juvenile plants grown from seeds were planted *ex situ* in an effort to establish a seed orchard. Currently, the species is known from four extant populations - Bluff Knoll, East Bluff, Pyungoorup and Isongerup but has declined to 45 adults and 16 juveniles.

Description and taxonomy

A member of the family Proteaceae, *Dryandra montana* is an erect woody shrub to 2.5m in height. The leaves are up to 18cm long, with elongated, triangular, close fitting 5 to 8mm lobes, cut to the mid-rib and pointing towards the apex. The yellow flowers, borne on the old wood inside the foliage, are produced in January. The upper stems and fruits are covered by short red hairs. The oval follicles are about 9mm tall and 7 to 8mm broad with a hairy base at the point of attachment. The species is named from the Latin *montanus* (of mountains) in reference to the habitat (George 1996).

Distribution and habitat

The Stirling Range area has been identified as a centre of species richness and endemism in the Southwest Australian Floristic Region (Hopper and Gioia 2004). *Dryandra montana* is restricted to mountain summit areas between 900m and 1080m a.s.l. in the Eastern Stirling Range. The species grows on sandstone,

metamorphosed sandstone and metamorphosed siltstone in the Eastern Stirling Range Montane Heath and Thicket Community (Barrett 2000). This plant community is informally listed as Critically Endangered in Western Australia and as Endangered under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*. Other plant species endemic to the Eastern Stirling Range Montane Heath and Thicket Community are: *Andersonia axilliflora, Persoonia micranthera, Darwinia collina, Darwinia squarrosa, Darwinia* sp. Stirling Range, *Hypocalymma myrtifolium*, and *Stylidium keigheryi.* A key species indicative of the Montane Heath and Thicket Community's distribution is *Andersonia axilliflora*, which is or was abundant and dominant in the community (Barrett 2000).

Other species that characterise the community but are more geographically widespread include *Kunzea montana, Beaufortia anisandra, Sphenotoma* sp. Stirling Range, *Andersonia echinocephala* and *Darwinia* spp. A range of proteaceous species were or are structurally significant and include *Banksia oreophila, Banksia solandri, Banksia brownii* and *Dryandra concinna*. *Eucalyptus* species are notable for their absence from the community but occur at immediately lower altitudes (Barrett, 2000).

The Eastern Stirling Range Montane Heath and Thicket Community contains, in addition to *Dryandra montana*, ten other Declared Rare (Threatened) Flora species - *Darwinia collina, Darwinia squarrosa, Banksia brownii, Andersonia axilliflora, Sphenotoma drummondii, Darwinia* sp. Stirling Range, *Deyeuxia drummondii, Persoonia micranthera, Leucopogon gnaphalioides* and *Daviesia obovata*. Of these, *L. gnaphalioides, P. micranthera, B. brownii* and *A. axilliflora*, together with *D. montana,* are ranked as Critically Endangered under IUCN (World Conservation Union 2000) criteria..

Biology and ecology

Dryandra montana flowers annually between January and March with rates of flowering and seed production varying considerably between plants and within years. In 2004, the mean number of flowers per plant in the East Bluff population was 2.6 and the mean number of infructescences was 7.06 (n=16). In contrast, on Bluff Knoll in 2004, the mean number of flowers was 13.09 and the mean number of infructescences was 39.5 (n=11) (Yates and Barrett, unpubl. data). Fruits persist in the canopy for up to four years after which they begin to disintegrate. Several plants in all populations assessed from 2001 to 2004 produced very little seed (Yates and Barrett, unpubl. data). When last assessed in 2004, a high percentage of plants had a total canopy bank of less than 50 infructescences, in contrast to one individual on Bluff Knoll with 308 infructescences (Figure 1).

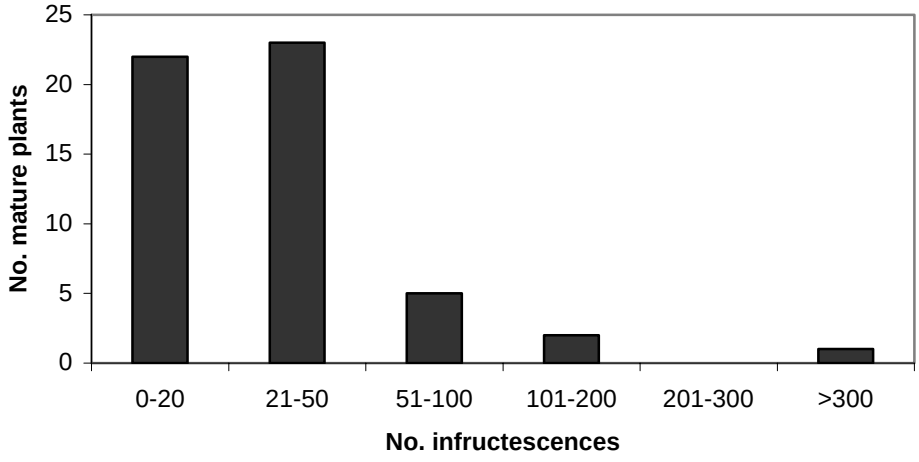

Figure 1: Frequency distribution of the number of infructescences per mature plants.

The numbers of follicles per infructescence ranges from 0 to 6 but is generally low. The mean number of follicles per infructescence is shown in Table 1, below. The reasons for variable flower, fruit and seed production in *Dryandra montana* populations are not clear and may be related to plant age, health and vigour and the effectiveness of pollination.

Table 1: Mean number of follicles per infructescence and mean number of seeds per follicle recorded in the four *Dryandra montana* populations.

	Mean no. follicles / infructescence	Mean no. seeds / follicle
1. Bluff Knoll	1.4	0.96
4. Pyungoorup	1.1	0.99
5. Isongerup	1.5	1.25
6. East Bluff	1.4	0.97

Ladd *et al*. (1996) investigated pollen presenter and style characteristics in the genera *Dryandra* and *Banksia*. In *Dryandra montana*, the pollen presenter is 1mm in length and 0.3mm in diameter, is of equal width to the style and is cylindrical with little differentiation from the style. The style is constricted below the pollen presenter and is bowed in shape and the stigmatic groove is oblique terminal. The approximate distance from the pollen presenter to the receptacle is 26mm. Ladd *et al.* (1996) suggest that these characteristics are consistent with mammal or insect pollination. However, no pollinators of *D. montana* have been observed to date and it is not known for sure what animal pollinates the species.

Dryandra montana is a serotinous non-sprouting shrub. Plants are killed by fire and persistence of the species is contingent on seeds stored in the canopy being released, germinating, seedlings establishing and plants growing to reproductive maturity before the next fire. Keith (1996) identified a number of fire-driven mechanisms of plant population decline and extinction for non-sprouting shrubs. These mechanisms included death of standing plants and seeds, failure of seed release and or germination, failure of seedling establishment, interruption of maturation or developmental growth and failure of seed production. Keith identified fire regimes associated with multiple mechanisms of plant population decline and extinction. These included both high frequency and low frequency fires. Bradstock *et al.* (1998) used a spatially explicit model to simulate plant extinction in relation to fire frequency and scale and found that extinction probabilities in non-sprouting perennial shrubs increased with fire frequency and scale.

Non-sprouters like *Dryandra montana* are more sensitive to frequent fire regimes than sprouters because they are entirely dependent on seeds for persistence and therefore require a minimum fire free period to reach reproductive maturity and produce enough seeds to replace themselves. Local extinction will occur if the fire interval is shorter than the time taken for the plants to reach reproductive maturity (the primary juvenile period). Alternatively, in the long absence of fire, it is hypothesized that non-sprouting fire recruiting plants may senesce and die before there is an opportunity for regeneration (Whelan, 1995; Bond & van Wilgen, 1996). In species that store their seed in the canopy, the seed bank does not persist for long following the death of the parent. Local extinction could result if there is complete senescence of the stand.

Clearly, age specific fecundity is of central importance for the demography of species like *Dryandra montana* that are killed by fire. The core question being how much seed must be held on parent plants to enable the replacement of the population after fire? Gill and Nicholls (1989) proposed that "Until further data becomes available it is suggested that a doubling of the general juvenile period of the species observed at the monitoring site be used as the guide to when the species is likely to be able to replace itself to pre-fire abundance levels." For *D. montana* the minimum time recorded for first flowering is nine years after seedling emergence. Using Gill and Nicholls' formula the minimum fire interval for *D. montana* to persist may be 18 years.

In the last 33 years there have been three major fires in the eastern Stirling Range. These occurred in February 1972, April 1991 and most recently in October 2000. Analyses of aerial photography and recent field surveys indicate that these fires burnt extensive areas of the Montane Heath and Thicket Community with some areas including *Dryandra montana* populations being burnt by one, two or all three of the fires. As a consequence, some areas of the Montane Heath and Thicket Community and *D. montana* populations have had three fires in the last 28 years with fire return times of 28 and 9 years (Yates and Barrett, unpubl. data).

The impact of the 1972 and 1991 fires on *Dryandra montana* populations is unknown. However, the impact of the 2000 fire on *D. montana* has been closely monitored. The 2000 fire killed 79% of plants in the Bluff Knoll (Population 1), 79% of plants in the Isongerup (Population 5), 73% of plants in the East Bluff (Population 6) and 8% of plants in the Pyungoorup (Population 4)(Yates and Barrett unpubl. data).

Moreover, seedling recruitment following the 2000 fire was very low and considerably less than the number of plants killed by the fire 1 (Figure 2). On Bluff Knoll, 12 seedlings were recruited but 41 plants were killed. For the East Bluff Population, 1 seedling was recruited but 61 plants were killed. In the Isongerup Population, 0 seedlings were recruited but 11 plants were killed. For the Pyungoorup Population, 0 seedlings were recruited but 2 plants were killed (Yates and Barrett, unpubl. data). In addition, 40% of seedlings that emerged following the 2001 fire were heavily grazed by either rabbits or quokkas and all seedlings were subsequently protected from further grazing with cages (Yates and Barrett, unpubl. data).

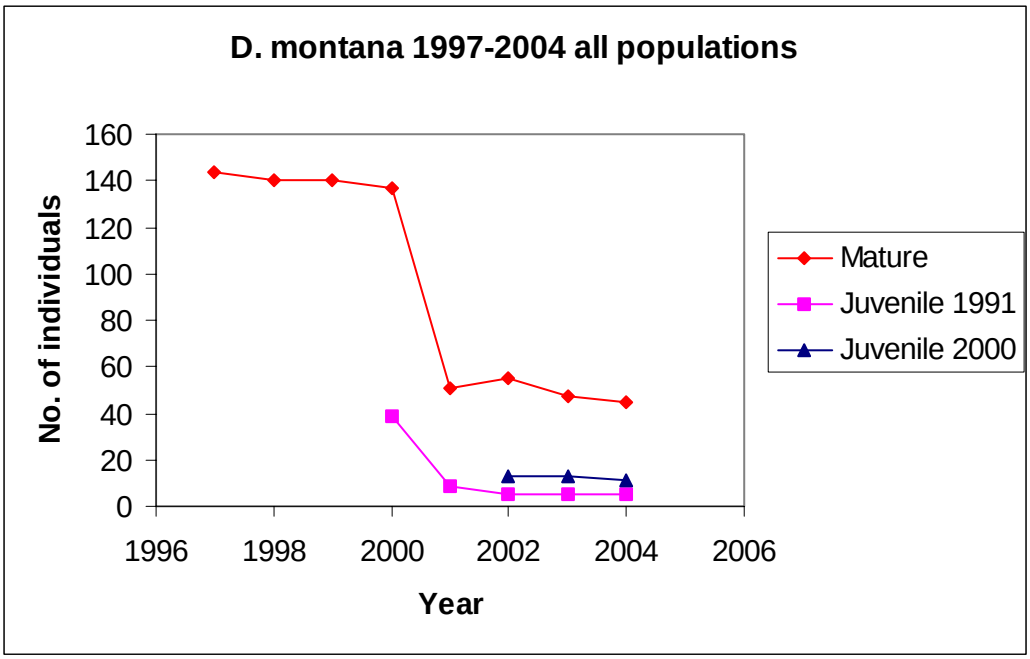

Figure 2: Number of *Dryandra montana* individuals recorded, from 1997 to 2004.

A small number of inter-fire recruits (two plants) have established under long unburnt canopy on Bluff Knoll. In addition, recruits were observed on Bluff Knoll in 1999 and 2002 that would appear to have germinated much later than the general post-1991 fire recruitment, indicating that the seed may remain viable in the soil or can be dispersed considerable distances (Barrett, personal observation).

While there has been no formal study to date of the interactions between fire and *Phytophthora*, field observations indicate that the impact of the pathogen may be exacerbated post fire due to altered hydrology and increased surface run-off (Barrett, 1996; [5]M. Grant, personal communication). Also the non-suberised root tissue of seedlings may be more vulnerable to the pathogen while phosphite may also be less effective in the seedling stage ([6]B. Shearer, personal communication)

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).

[5] Malcolm Grant Senior Operations Officer – Nature Conservation, CALM Albany Work Centre, Ravensthorpe Office
[6] Bryan Shearer Principal Research Scientist, CALM Science Division

The Eastern Stirling Range Montane Heath and Thicket Community has been significantly affected by *Phytophthora cinnamomi*. The mountain range results in considerable orographic rainfall including summer precipitation. This, combined with topography, shallow nutrient-deficient peaty soils and a plant community once dominated by highly susceptible members of the Proteaceae, Epacridaceae and Papilionaceae, provides ideal conditions for sporulation, survival, dispersal and infection by the pathogen (Grant and Barrett 2003).

Native fauna, introduced fauna and humans can act as vectors of *Phytophthora cinnamomi* aiding the wide and rapid spread of the disease, enabling it to establish new centres of infection in previously uninfected areas (CALM 2000). Humans are thought to have spread the pathogen to the peaks where the Montane Heath and Thicket Community occurs through the transport of infected soil, mostly by foot access, as a result of recreational walking (Gillen and Watson, 1993; Wills, 1993). Areas where water pools on tracks or where soils are muddy loams provide ideal conditions for soil and disease transfer (Watson and Passmore 1993).

Evidence for the possible role of native animal vectors in the spread of *Phytophthora cinnamomi* comes from observations of spot infestations of *P. cinnamomi* on Yungemere in the Stirling Range NP. Yungemere occurs within a "Special Conservation" zone, which has access by permit only. Recent observations of spotting were associated with large numbers of quokka (*Setonix brachyurus*) and/or bandicoot (*Isoodon obesulus fusciventer*) diggings. (S. Barrett and [7]G. Freebury, personal communication).

Phytophthora cinnamomi has infected the Bluff Knoll, East Bluff and Pyungoorup populations of *Dryandra montana*. The Isongerup population remains unaffected due to its location on a knoll disjunct from the main ridge. Recovery of the pathogen from dead *D. montana* plants and field observations (S. Barrett, personal observation) indicate that *D. montana* is highly susceptible to *P. cinnamomi*. However, disease susceptibility may vary between plants with some individuals continuing to survive in a healthy state within infected vegetation. This contrasts to other species in the Eastern Stirling Range Montane Heath and Thicket Community such as *Banksia brow*nii that are uniformly highly susceptible (McCredie *et al*, 1985).

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). It is unknown what group of animals pollinates *Dryandra montana,* but possible effects on pollinators include loss of foods sources, loss of habitat in the form of thick ground cover and increased predation risk (Wilson, *et al.* 1994; Nichols 1998).

Threats

Dryandra montana was declared as Rare (Threatened) Flora under the Western Australian *Wildlife Conservation Act 1950* in September 1987 and is currently ranked as Critically Endangered (CR) under World Conservation Union (IUCN 2000) Red List Criteria A1ce; B1+2c; C1. It is listed under the Commonwealth *Environment Protection and Biodiversity Act* 1999 as Endangered.

Dryandra montana is a naturally rare, geographically restricted narrow endemic. *Phytophthora cinnamomi* infection and fire have resulted in decline of the species reducing it to four isolated small populations. The Bluff Knoll population (Population 1) consists of 7 adults and 15 juveniles, the Pyungoorup (Population 4) consists of 19 adults, Isongerup (Population 5) 3 adults and East Bluff (Population 6) 16 adults and 1 juvenile. All populations continue to be threatened by *P. cinnamomi* and future fires. Juvenile plants are particularly susceptible to vertebrate grazing. Moreover, as population size decreases and isolation increases, populations may become more vulnerable to extinction for three main reasons (Hobbs and Yates, 2003). Firstly, loss of genetic variation and increased inbreeding are considered to be associated with a reduction in the ability of a population to adapt to short-term environmental change (Young *et al.*, 1996; Keller and Waller, 2002). Secondly, small populations are more susceptible to chance events

[7] Greg Freebury Operations Officer – Nature Conservation, CALM Albany Work Centre

associated with demographic and environmental stochasticity (Groom, 1998). Finally, Allee effects may occur, whereby at some density or population size, reproductive capacity drops below a threshold and the organism can no longer replace itself (Groom, 1998; Menges, 2000; Dennis, 2002).

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

***Phytophthora cinnamomi* infestation**

- Three of four extant populations of *Dryandra montana* are infested with *Phytophthora cinnamomi*. The disease has killed plants in these three populations. At least one population has become locally extinct presumably from *P. cinnamomi* infestation (and possibly fire). It is not known whether *P. cinnamomi* may also reduce plant vigour and in turn, reproductive success in surviving plants.

- Indirect effects of *Phytophthora cinnamomi* have not been quantified for *Dryandra montana* but are likely to impact on the species through changes in the structural and floristic composition of the vegetation, affecting abundance of pollinators.

Inappropriate fire frequency

- The obligate seeding, together with the long juvenile period of *Dryandra montana* makes it vulnerable to short fire intervals and a fire interval greater than 18 years is recommended for adequate seed storage to accumulate. The extensive, intense wildfire that occurred in 1991 affected a small part of East Bluff (Population 6) and a significant part of Bluff Knoll (Population 1). The fire in 2000 affected all populations. Low seedling recruitment has been observed for populations that were affected by both wildfires, with a fire interval of only 9 years.

Grazing

- Vertebrate grazing has affected a significant proportion of *Dryandra montana* juvenile plants that regenerated after the 2000 fire, as well as juveniles from the 1991 fire. These juveniles have been partially to completely defoliated. Both quokkas (*Setonix brachyurus*) and rabbits occur on the Bluff Knoll plateau and are both grazers but it is not known which species graze on *D. montana* seedlings.

- In 1992, Botanic Gardens and Parks Authority (BGPA) staff commented on the high level of invertebrate predation on collected seed. Invertebrate grazing has also been observed on the foliage of *in situ* plants and of plants in the seed orchard (S. Barrett, personal observation). Considering the low number of individuals of *Dryandra montana*, this predation pressure may impact on populations if it reduces the vigour of plants.

Recreation

- Recreational activities on Bluff Knoll and the Eastern Peaks Route (from Ellen Peak to Bluff Knoll) have been implicated in the spread of *Phytophthora cinnamomi* to all of the *Dryandra montana* populations (excluding Isongerup). The higher peaks of the eastern Stirling Range attract visitors interested in bushwalking, nature observation and rock-climbing (Barrett 2000). Bluff Knoll receives the highest level of visitation as it is the highest mountain in the southwest. It also provides opportunities for rock climbing and abseiling. The Eastern Peaks Route from Ellen Peak to Bluff Knoll is a popular walk which takes between two and three days to complete.

  Human activity is thought to have spread the pathogen through the transport of infected soil, mostly by foot access, as a result of recreational and other activities (Gillen and Watson 1993; Wills 1993). Areas where water pools on tracks or where soils are muddy loams provide ideal conditions for soil and disease transfer (Watson and Passmore 1993). Although *Phytophthora cinnamomi* is present in these areas, control of access and hygiene procedures are still a priority due to the risk of introducing new strains of the pathogen (B. Shearer, personal communication).

- Other potential impacts on *Dryandra montana* populations through recreation include direct trampling and damage (particularly at Bluff Knoll), side path formation, path erosion, bare-ground occurrences, camp fire remains, litter and nutrient enrichment from human excreta (Barrett 2000).

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 have temperatures about 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 refugia for several specialised flora and fauna species. It is thought that the onset of drier conditions in the Holocene has caused the contraction of some species to upland 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 *Dryandra montana*.

Summary of population land vesting, purpose and tenure

Population	**Vesting**	**Purpose**	**Tenure**
1. Bluff Knoll	WA Conservation Commission	National Park	National Park
2. Coyanarup	WA Conservation Commission	National Park	National Park
3. Kyanorup Eminence	WA Conservation Commission	National Park	National Park
4. Pyungoorup	WA Conservation Commission	National Park	National Park
5. Isongerup	WA Conservation Commission	National Park	National Park
6. East Bluff	WA Conservation Commission	National Park	National Park
7T. Washpool Rd	-	-	Freehold Land

Summary of population information and threats

Pop. No. & Location	**Year/No. of plants adults** (juveniles)	**Condition**	**Threats**
1. Bluff Knoll	Mar 2004 7 (15)	Moderate (some caged plants recovering from grazing)	*Phytophthora cinnamomi*, inappropriate fire interval, grazing, recreation
2. Coyanarup	1999-2000 0 (0)	Presumed locally extinct	
3. Kyanorup Eminence	Oct 2000 0 (0)	Presumed locally extinct	
4. Pyungoorup	Feb 2004 19 (0)	Moderate (recent death due to *Phytophthora cinnamomi*)	*Phytophthora cinnamomi*, inappropriate fire interval
5. Isongerup	Mar 2004 3 (0)	Moderate (individuals healthy, no grazing apparent)	*Phytophthora cinnamomi*, inappropriate fire interval
6. East Bluff	Feb 2004 16 (1)	Moderate (deaths due to *P. cinnamomi*), grazing	*Phytophthora cinnamomi*, inappropriate fire interval, invertebrate and vertebrate grazing
7T. Washpool Rd	June 2004 0 (89)	Healthy	Introduction of *Phytophthora cinnamomi*, fire

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

Given that this species is listed as Endangered under the Commonwealth EPBC Act, it is considered that all known habitat is habitat critical to the survival of the species. In addition all populations, including any

translocated populations, are considered important to the survival of the species. Habitat is defined as the biophysical medium or media occupied (continuously, periodically or occasionally) by an organism or group of organisms, or once occupied (continuously, periodically or occasionally) by an organism or group of organisms, and into which organisms of that kind have the potential to be reintroduced (*Environment Protection and Biodiversity Conservation Act 1999*). The area of occupancy of the currently known *Dryandra montana* populations has been mapped. However, other parts of the habitat critical to the survival of *D. montana* have not been mapped and an action outlined in this Interim Recovery Plan is to map all habitat as defined above.

The habitat critical to the survival of *Dryandra montana* therefore comprises:

- the area of occupancy of known populations;
- areas of similar habitat within 200 metres of known populations that provide potential habitat for natural recruitment;
- remnant vegetation that surrounds and links populations (this is necessary to allow pollinators to move between populations) and
- additional occurrences of similar habitat that do not currently contain the species but may have done so in the past (these represent possible translocation sites).

Benefits to other species/ecological communities

Dryandra montana occurs exclusively within the Montane TEC (Montane Heath and Thicket of the South West Botanical Province, above approximately 900m above sea level which is listed as Critically Endangered in Western Australia and Endangered under the Commonwealth *Environmental Protection and Biodiversity Act* 1999. The Montane TEC contains an assemblage of plants that are susceptible to *Phytophthora cinnamomi* and many of which are threatened species.

Seven threatened fauna species occur within Stirling Range National Park. Three endangered fauna species; Carnaby's Cockatoo (*Calyptorhynchus latirostris*), the Dibbler (*Parantechinus apicalis*) and the Stirling Range Moggridgea spider (*Moggridgea* sp. (B.Y. Main 1990/24, 25)) 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 *Dryandra montana* will benefit the Montane TEC and the seven threatened fauna species through threat abatement and close management. Reciprocally, actions put in place for the recovery of the Montane TEC and the seven threatened fauna species will benefit *D. montana.*

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

According to the Department of Indigenous Affairs Aboriginal Heritage Sites Register, no sites have been discovered near the *Dryandra montana* populations. Input and involvement will be sought from Noongar groups that have an active interest in the areas that are habitat for *D. montana.* This is discussed in the recovery actions.

Affected Interest

All populations are on Crown land. Population 7T is on private land.

Social and economic impacts

The implementation of this recovery plan has minimal social and economic impact as all natural populations are on CALM 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 critical habitat of *Dryandra montana* require assessment for the potential for a significant level of impact. No developments should be approved unless the proponents can demonstrate that they will not have a detrimental impact on the species, or its habitat or potential habitat, or the local surface and ground water hydrology.

Evaluation of the Plan's Performance

The Department of CALM, in conjunction with the Albany District Threatened Flora Recovery Team will evaluate the performance of this recovery plan. In addition to annual reporting on progress against the criteria for success and failure, the plan is to be reviewed within five years of its implementation. Any changes to management or recovery actions made in response to monitoring results will be documented accordingly.

2. RECOVERY OBJECTIVE AND CRITERIA

IRP Objectives

1. Abate identified threats and improve the conservation status of *Dryandra montana* in the wild.
2. Establish an *ex situ* population in order to maintain genetic diversity, provide seed for future translocations and opportunities for research.

Criteria for success:
1. Abatement of a specific threat or group of threats resulting in a stabilization of the population over the period of the plan's adoption.
2. Establishment of an *ex situ* seed orchard and a canopy-stored seed bank over the period of the plan's adoption.

Criteria for failure:
1. A continuation of threats that result in a decline in population size over the period of the plan's adoption.
2. A significant decline in the size of the *ex situ* population over the period of the plan's adoption.

3. RECOVERY ACTIONS

Existing or completed recovery actions

Appropriate staff at CALM (Albany Work Centre) and the Senior Ranger (Stirling Range NP) are aware of the location, threatened status and legal responsibility to protect the species.

"Essential" Recovery Actions outlined in 1996-1999 IRP

1. Phosphite application

Phosphite has been shown to be effective in controlling *Phytophthora cinnamomi* in a number of native plant species (Shearer and Fairman 1991, 1997; Komorek *et al*. 1997; Ali and Guest 1998; Aberton *et al*. 1999; Wilkinson *et al*. 2001). Phosphite may have a direct fungicidal 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.

Aerial phosphite application techniques enable the spaying of whole plant communities as well as individual target species in an infested population or along *Phytophthora cinnamomi* fronts to protect *P. cinnamomi*-free vegetation (Komorek, *et al*. 1997). Aerial spraying trials in the Stirling Range NP (Bluff Knoll and East Stirling Range Montane Heath and Thicket Community) found that, in *Phytophthora* infested vegetation, the percentage of survival of members of the family Epacridaceae 18 months to 3 years after spraying was significantly higher in the sprayed compared with non-sprayed quadrats (Barrett, 2003).

In 1996, two plants on Bluff Knoll were hand-sprayed using an ultra-low volume mister containing 20% phosphite. Since 1997, aerial low-volume phosphite application has been used to control *Phytophthora cinnamomi* in all extant *Dryandra montana* populations. The phosphite spray history for *D. montana* populations is as follows:

	1997	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Bluff Knoll (Population 1)	24 kg/ha			18 kg/ha (single spray)		12 kg/ha	12 kg/ha	12 kg/ha
Pyungoorup (Population 4)		6 kg/ha (2nd spray missed due to weather)	12 kg/ha		24 kg/ha (southern unburnt half)	12 kg/ha	12 kg/ha	12 kg/ha (burnt) 18 kg /ha (unburnt)
Isongerup (Population 5)	24 kg/ha			18 kg/ha (single spray)		12 kg/ha	12 kg/ha	12 kg/ha
East Bluff (Population 6)	24 kg/ha			18 kg/ha (single spray)		12 kg/ha	12 kg/ha	12 kg/ha

Since 2002, a lower application rate of 12 kg/ha applied in two separate sprays has been used to minimise the potential for chemical leaf burn to juvenile plants.

There has been 94% survival of sprayed mature plants over all populations from 1997 to pre-fire in 2000. The total percentage survival from 2001 to 2004 was 83% for mature and juvenile plants combined and 85% for seedlings.

No unsprayed controls were available for comparison as all populations were required to be sprayed due to the urgency of the threat of *Phytophthora cinnamomi* infestation.

Alternative methods of phosphite application such as trunk injection may potentially be more effective than low volume aerial phosphite application (Shearer *et al*. 2004). However, the potential for phytotoxic side effects exists, particularly in shrub species with relatively small trunk diameter (Shearer, personal communication). New application techniques that require further research at this stage include bark application of phosphite (Shearer, personal communication). Supplementary low-volume hand-spraying of juveniles may also be appropriate where surrounding vegetation covers the canopy of young plants.

2. Preserve genetic diversity of species

a. Seed collection, storage and germination trials

Approximately 587 seeds have been collected from all *Dryandra montana* populations between 1994 to 2004 and are stored in CALM's Threatened Flora Seed Centre (TFSC). Only limited germination trials have been conducted; percentage germination of seed from Population 1 was 19% in 1994. More recent

trials have used cold stratifying and cycling of cold and warm and this treatment appears to be increasing germination rates (unpublished data, [8]A. Cochrane and [9]A. Crawford).

b. Establishment of a seed orchard

While the restocking of depleted *Dryandra montana* populations or an alternative translocation site may be considered by the Albany District Threatened Flora Recovery Team in the future, in the short term there is a need to ensure that there is sufficient material for such a project, for seed storage in general and for other *ex situ* possibilities.

This need led to the establishment of a seed orchard under an approved translocation proposal in August 2003, to preserve the germplasm of *Dryandra montana* and to obtain seed for *in situ* restocking. The orchard was established at Peter Luscombe and Susanna Woytaszek's property at Woogenillup, north of the Porongurup Range. To ensure correct management of these plants, a Memorandum of Understanding between CALM and the property owners was created and the plantings were carried out under the guidelines of the translocation proposal. The plants within the seed orchard are regarded as Declared Rare Flora and have the same protection under the Western Australia *Wildlife Conservation Act 1950* as *in situ* plants.

Fourteen plants were propagated by BGPA from seed supplied by the TFSC in November 2002 and February 2003, from East Bluff, Bluff Knoll and Pyungoorup. These were planted in the seed orchard in August 2003. In October 2003, a water tank was installed for irrigation and the plants were monitored in December 2003 and April 2004. All plants appeared healthy with all showing signs of new growth.

Eighty-five additional plants were planted out into the seed orchard in June 2004 from the seed collected in 2003 from Pyungoorup and East Bluff, germinated by the TFSC and grown on by BGPA.

Ex situ cultivation of *Dryandra montana* in a seed orchard will provide opportunities for the necessary research into its reproductive biology, including possible identification of pollinators, hand pollination trials and factors limiting seed production and recruitment.

c. Tissue culture

Tissue culture is seen as an important alternative way to restock for future translocations. Staff at BGPA commenced tissue culture trials in 2002 on *Dryandra montana* plants propagated at BGPA. Tissue culture has been unsuccessful to date due to contamination of material ([10]E. Bunn, personal communication).

d. Propagation of cuttings

Cuttings from *in situ* populations of *Dryandra montana* have been sent to BGPA for propagation, however as material is limited, this has been tried only three times. In December 1999, four cuttings were propagated, all of which had died by January 2000. Sixteen more cuttings were tried in January 2002 and they had all died by May of that year. In February 2004, another lot of 53 cuttings were propagated, of which 22 are still alive but are not healthy. There has been no obvious reason for the cuttings failing in terms of pests, diseases or insufficient watering. The species is very difficult to propagate from cuttings and given the rarity of the material, it is undesirable to take too much off plants in order to perform trials ([11]A. Shade, personal communication).

3. Population monitoring

[8] Anne Cochrane — Manager, CALM's Threatened Flora Seed Centre
[9] Andrew Crawford — Technical Officer, CALM's Threatened Flora Seed Centre
[10] Eric Bunn — Research Scientist (Propagation Science), BGPA
[11] Amanda Shade — Assistant Curator, Nursery, BGPA

Staff from CALM's Albany Work Centre monitor populations of this species. All populations are monitored annually with plant numbers, recent deaths, threats, canopy measurements, flowering, fruiting and plant health recorded.

Translocated plants within the seed orchard are monitored every six months, commencing at planting out of the seedlings. Monitoring includes counting the number of surviving seedlings, height of the surviving seedlings, canopy measurements, reproductive state and general health of the plants.

4. Develop a fire management plan

Fire management objectives and strategies for the Stirling Range are outlined in the Stirling Range and Porongurup National Parks Management Plan 1999-2009 (CALM 1999). More recently, a refined 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 (vital attributes) be used to identify fire sensitive threatened species and ecological communities within each cell to determine the minimal tolerable fire frequency for these species and communities, and that the core mountain areas (corresponding to *Dryandra montana* distribution) are designated as "no planned burn" areas for the duration of the Master Burn Plan. The strategy also recommends the judicious use of prescribed fire within the lowland areas to protect the high conservation values of the montane community.

A new strategy for fire management implemented in 2004 is the placement of water bombers in Albany. This enables quick action to be taken to control fires in remote areas with high conservation values, including the Stirling Range Threatened Ecological Communities ([12]J. Watson, personal communication).

A study of the fire ecology of the Montane Heath and Thicket TEC is near completion.

"Desirable" Recovery Actions outlined in 1996-1999 IRP

1. Survey for other populations and suitable translocation sites

Surveys for new populations have been carried out between 1996 and 2004. No new populations have been found since 1997. The surveys indicate that there are no suitable sites within the known and historical distribution of the species due to the extent of infestation by *Phytophthora cinnamomi* and it is unlikely that other populations exist. However, given the topography, further survey could be productive. There are a limited number of *Phytophthora*-free mountaintops in the Stirling Range, outside the current and recent historical distribution of *Dryandra montana*, which could potentially be used as 'introduction' sites.

2. Conduct research

Fire ecology study

In February 2001, a three-year research program investigating the fire ecology and demography of the Montane Heath and Thicket community, which includes *Dryandra montana*, was initiated by CALM's Science Division (Dr. Colin Yates) and the Albany Work Centre (Dr. Sarah Barrett). The study is near completion. Preliminary data on the fire ecology of *D. montana* is presented in Section 1 of this Interim Recovery Plan.

3. Translocation

Translocation of *Dryandra montana* was listed as a desirable recovery action for the species in 1997 (Kershaw, *et al.* 1997). The current status of *D. montana* indicates that translocation is now crucial to its recovery. However, a number of factors dictate that a translocation will not be possible within the time frame of this plan (5 years). These include:

1. Limited availability of *ex situ* plants for translocation.

[12] John Watson Regional Manager, Albany Work Centre

2. No suitable *Phytophthora cinnamomi*-free sites within the known and historical distribution of the species.
3. The majority of the potential *Phytophthora cinnamomi*-free sites occur within the Montane Mallee TEC. Translocation to these sites would involve an 'introduction' of *Dryandra montana* which may have a negative impact on the functioning of the Montane Mallee community. It is CALM Policy only to consider introduction where there are exceptionally strong conservation reasons for so doing and is has been demonstrated that the impact of the introduced species is unlikely to be significant (CALM, 1995).
4. Access to suitable areas is restricted to avoid introduction of *Phytophthora cinnamomi*.

The establishment of a seed orchard for *ex situ* stocking of *Dryandra montana* is a first step towards a possible future translocation. This recovery action is outlined above, and below in "Future Recovery Actions"

4. Information dissemination

Information regarding *Dryandra montana* has been disseminated to the public and scientific community through the production of an information sheet produced by CALM, which includes a description of the plant, its habitat, threats, recovery actions and photos. Other media events include an article in the Sunday Times (27/10/2001); radio interviews (Regional ABC, 2003); and several presentations to scientific and general audiences, including an international mountain workshop at the 2003 World Parks Congress (Watson and Barrett 2004) and the international Science for Plant Conservation Conference 2002 (Barrett 2002).

An interpretive panel for the Montane Heath and Thicket TEC that will feature *Dryandra montana* is planned for the Bluff Knoll walk trail in 2004. A Bush Book of Stirling Range Flora (Barrett and Cochrane 2005) has been produced, with reference to *D. montana*, the Montane Heath and Thicket TEC and processes which threaten the species and the community.

Other existing recovery actions

1. Protection of plants from herbivory

In December 2002, twelve *Dryandra montana* seedlings were caged on Bluff Knoll (Population 1) and in 2003 and 2004, three juveniles and one young mature on Bluff Knoll and one juvenile on East Bluff (Population 6) were caged to protect them from grazing by rabbits and/or quokkas. This physical protection from grazers has been successful. Juveniles that had been grazed back to the stem at the time of caging have resprouted and no mortality of caged seedlings has been observed (S. Barrett, personal observation). It is still unclear as to which herbivorous species is responsible for the grazing.

2. Preliminary rabbit control

A proposal for the control of rabbits in the Stirling Range National Park has been written by CALM Albany Work Centre. This proposal outlined threats to non-target species and rabbit control options. Both quenda (*Isoodon obesulus fusciventer*) and quokka (*Setonix brachyurus*) occur within the area of occupancy of *Dryandra montana* and have LD50s of 20mg/kg and 40mg/kg respectively. The proposal recommended that the best method for control was to scatter 1080 one-shot oats from a ground-based operation in addition to an aerial application, with the target area confined to the threatened flora populations in the eastern section of the park. Each dropped packet would contain five poisoned oats containing less 1080 than acquired to achieve the LD50 of an adult bandicoot, the smaller of the two non-target species.

One trial of aerial baiting was conducted in 2002. However, rainfall during the night possibly caused the poison to leach out of the 1080 oats. It was unable to be determined if the rain had rendered the baits ineffective due to the difficulty of monitoring deaths of rabbits post-baiting. This indicates that methods of rabbit control need to be further investigated and refined.

Future recovery actions

Where populations occur on lands other than those managed by CALM, permission has been or will be sought from appropriate land managers prior to recovery actions being undertaken. 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 *Dryandra montana* and will include information on progress in their annual report to CALM's Corporate Executive and funding bodies.

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

2. Continue aerial phosphite spraying of all populations

Continue the current regime of aerial phosphite application to all populations. Consider and utilise other phosphite application techniques as appropriate.

Action: Continue aerial spraying of all populations with phosphite
Responsibility: CALM (Albany Work Centre)
Cost: $13,650 per year

3. Monitor populations and seed orchard

Staff from CALM's Albany Work Centre will continue to monitor populations of this species. Monitoring and maintenance of translocated plants within the seed orchard will also continue on a six monthly basis.

Action: Monitor populations
Responsibility: CALM (Albany Work Centre)
Cost: $3,360 in the first year, $3,060 each year thereafter.

4. Continue *Phytophthora cinnamomi* hygiene practices

Access by CALM personnel and volunteers to all *Dryandra montana* populations will be restricted to dry soil conditions in accordance with the guidelines outlined in "*Phytophthora cinnamomi* and disease caused by it." Volume 1. Management Guidelines (CALM 2000).

Action: Continue *Phytophthora cinnamomi* hygiene practices
Responsibility: CALM (Albany Work Centre)
Cost: $400 per year

5. Continue to collect seed from *in situ* populations.

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.

Action: Collect seed from *in situ* populations
Responsibility: CALM (Albany Work Centre and Science Division)
Cost: $4,500 per year

6. Continue to develop tissue culture techniques

While tissue culture has not been successful to date it is desirable that development of TC techniques is continued.

Action: Continue to develop tissue culture techniques
Responsibility: BGPA
Cost: $1,000 per year

7. Investigate the methodology for future translocation(s)

Within the 5-year time frame of the plan, the best methods for future translocations or re-stocking of *in situ* populations should be investigated and a decision made on the most appropriate translocation procedure.

Action: Investigate the methodology for future translocation(s)
Responsibility: CALM (Science Division and Albany Work Centre)
Cost: $1,000 for the first two years

8. Implement fire exclusion for all populations

For the life of this Plan (5 years) fire will, if possible, be prevented from occurring in the area of all *Dryandra montana* populations.

Action: Implement fire exclusion for all populations
Responsibility: CALM (Albany Work Centre)
Cost: $1,000 per year

9. Obtain biological and ecological information

Improved knowledge of the biology and ecology of *Dryandra montana* will provide a better scientific basis for management of the wild populations. An understanding of the following is particularly necessary for effective management:

1. Factors limiting seed production and recruitment;
2. The population genetic structure, levels of genetic diversity and minimum viable population size;
3. Pollination biology;
4. Test for *Phytophthora cinnamomi* resistant strains of *Dryandra montana* that may be utilized for future restocking of *in situ* populations.

Ex situ cultivation of *Dryandra montana* in a seed orchard will also provide opportunities for the necessary research into its reproductive biology when plants reach reproductive maturity.

Action: Obtain biological and ecological information
Responsibility: CALM (Science Division and Albany Work Centre)
Cost: $8,460 for the first year, $7,060 for the second year and $24,000 for the final three years

10. Continue caging of plants where necessary

Juvenile and young mature plants will continue to be caged where herbivory is evident and is having a detrimental impact on individuals.

Action: Continue caging of seedlings and juveniles where necessary
Responsibility: CALM (Albany Work Centre)
Cost: $510 per year

11. Investigate and implement the best methods of rabbit control

Implementation of rabbit control is necessary within the five-year time frame of the Plan. The initial rabbit baiting trial indicates that methods of rabbit control need to be investigated and refined further. Hand laying of baits may be a preferred option for Bluff Knoll and East Bluff populations.

Action: Implement and investigate the best methods of rabbit control
Responsibility: CALM (Albany Work Centre)
Cost: $4,480 per year

12. Implement actions to reduce recreational impacts on *Dryandra montana* populations

Recreation and conservation issues relating to the Eastern Peaks Route are currently being addressed by CALM. Currently a number of recommendations have been put forward, including:

1. installation of trailhead signs at Ellen Peak and Bluff Knoll describing the conservation values of these areas and code of conduct for the public;
2. code of conduct for wilderness camping along the walk;
3. trail management to minimise deviation from main route, formation of side-paths and trampling.

Decisions regarding which actions to take and the implementation of these actions are necessary within the time fame of this plan.

Track maintenance on the Bluff Knoll tourist footpath will aim to encourage all visitors to stay on the main path, minimise pooling of water and therefore reduce conditions conducive to the spread of *Phytophthora cinnamomi*.

Action: Implement actions to reduce the impact of recreation on *Dryandra montana* populations
Responsibility: CALM (Albany Work Centre)
Cost: $5,000 in the first year and $2,500 each year thereafter

13. Map habitat critical to the survival of the species

It is a requirement of the EPBC Act (Section 207A) that spatial data relating to critical habitat be determined. Although habitat critical to the survival of the species is alluded to in Section 1, all the areas described have not yet been accurately mapped and will be 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: CALM (Albany Work Centre)
Cost: $600 in the first year

14. Survey for new populations and possible translocation sites

Although surveys for additional populations or individuals of *Dryandra montana* and for suitable translocation sites have been carried out from 1998 to 2004 with little success, the rough terrain and inaccessibility of the Montane Heath and Thicket TEC hampers complete and comprehensive survey and therefore surveying as a recovery measure should not be discounted.

The known historical range of *Dryandra montana* will continue to be surveyed for new populations and possible translocation sites when the opportunity exists.

Action: Survey for new populations and possible translocation sites
Responsibility: CALM (Albany Work Centre and Species and Communities Branch)
Cost: $1,550 per year

15. 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, the local print and electronic media. Formal links with local naturalist groups and interested individuals will also be encouraged. Input and involvement will be sought from any Noongar groups that have an active interest in the areas that are habitat for *Dryandra montana*.

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

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

If the taxon is still ranked as Critically Endangered at the end of the fourth year 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: CALM (Species and Communities Branch and Albany Work Centre) through the ADTFRT
Cost: $4,000 in the fifth year (if required)

4. TERM OF PLAN

This Interim Recovery Plan will operate from March 2005 to February 2010 but will remain in force until withdrawn or replaced. If *Dryandra montana* is still ranked Critically Endangered after five years, this IRP will be reviewed and if necessary, further recovery actions put in place.

5. REFERENCES

Barrett, S. (1996) Biological survey of mountains in southern Western Australia. Department of Conservation and Land Management, Perth, Western Australia.

Barrett, S. (2000) Montane Heath and Thicket of the South West Botanical Province, above approximately 900m above sea level. Interim Recovery Plan 1999-2000. Department of Conservation and Land Management, Perth , Western Australia.

Barrett, S. (2002) Use of the fungicide phosphite to protect flora threatened by the plant pathogen *Phytophthora cinnamomi* in southern Western Australia. In Proceedings of 'Science for Plant Conservation' (International Conference for Botanic Gardens, Dublin).

Barrett, S (2003) Monitoring of aerial phosphite applications for the control of *Phytophthora cinnamomi* in the Albany District. p. 132-137 In: *Phytophthora* in Forests and Natural Ecosystems. 2nd International IUFRO Working Party 7.02.09 Meeting Albany, W. Australia 30th Sep- 5th Oct 2001. Eds Jen McComb, Giles Hardy and Inez Tommerup.

Barrett, S. and Cochrane, J.A. (2005) Wildflowers of the Stirling Range. In Press. Department of Conservation and Land Management, Western Australia.

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

Bond, W.J. and van Wilgen, B.W. (1996) Fire and plants. Chapman and Hall, London.

Bradstock, R.A., Gill, A.M., Kenny, B.J., and Scott, J. (1998) Bushfire risk at the urban interface estimated from historical weather records: consequences for the use of prescribed fire in the Sydney region of south-eastern Australia. *Journal of Environmental Management*, **52**: 259-271.

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

CALM (1995) Policy Statement No. 29. Translocation of threatened Flora and Fauna. Department of Conservation and Land Management, Western Australia.

CALM (1999) Stirling Range and Porongurup National Parks Management Plan 1999-2009. Department of Conservation and Land Management for the National Parks and Nature Conservation Authority, Perth, Western Australia.

CALM (2000) *Phytophthora cinnamomi* and the diseases caused by it. Volume 1 - Management Guidelines. Department of Conservation and Land Management. Unpublished Report.

Dennis, B. (2002) Allee effects in stochastic populations. *Oikos* **96**: 389-401.

George, A.S. (1996) New taxa and a new infrageneric classification in *Dryandra* R. Br. (Proteaceae: Grevilleoideae). *Nuytsia* 10 (3): 313-408.

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, Western Australia.

Gillen, K and Watson, J.R. (1993) Controlling *Phytophthora cinnamomi* in the mountains of south Western Australia. *Australian Ranger*. **27**: 18-20.

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).

Groom, M.J. (1998) Allee effects limit population viability of an annual plant. *The American Naturalist* **151**: 487-496.

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

Hobbs, R.J. and Yates, C.J. (2003) Impacts of ecosystem fragmentation on plant populations: generalising the idiosyncratic. *Australian Journal of Botany*, **51**: 471-488.

Hopper, S.D. and Gioia, P. (2004) The Southwest Australian Floristic Region: Evolution and Conservation of a Global Hot Spot of Biodiversity. *Annual Review of Ecology, Evolution and Systematics* **35**: 623-50.

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

Keith, D. (1996) Fire-driven extinction of plant populations: a synthesis of theory and review of evidence from Australian vegetation *Proc. Linn. Soc. N.S.W* pp 37-78.

Keller, L.F. and Waller, D.M. (2002) Inbreeding effects in wild populations. *Trends in Ecology & Evolution*. **17**: 230-241.

Kershaw, K., Holland, E. and Brown, A. (1997) Stirling Range Dryandra (*Dryandra montana*), Interim Recovery Plan. Department of Conservation and Land Management, Perth, Western Australia.

Komorek, B., Shearer, B. Smith, B. and Fairman, R. (1997) The control of *Phytopthora* in native plant communities. Final Report to the Threatened Species and Communities Unit, Environment Australia. Department of Conservation and Land Management, Western Australia.

Ladd, P.G., Alkema, A.J. and Thomson G.J. (1996) Pollen presenter morphology and anatomy in *Banksia* and *Dryandra. Australian Journal of Botany* **44**: 447-471.

McCredie, T.A., Dixon, K.W. and Sivasithamparam, K. (1985) Variability in the resistance of *Banksia* L.f. species to *Phytophthora cinnamomi* Rands. *Australian Journal of Botany* **33**: 629-637.

Menges, E.S. (2000) Population viability and analyses in plants: challenges and opportunities. *Trends in Ecology & Evolution*. **15**: 51-56.

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 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).

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. p181. 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. p180. Australian Plant Pathology Society: Perth).

Shearer, B. L., Crane, C.E. and Fairman, R.G. (2004) Phosphite reduces disease extension of a *Phytophthora cinnamomi* front in *Banksia* woodland, even after fire. *Australasian Plant Pathology* **33**: 249-254.

Watson, J. and Barrett, S. (2004) Small is beautiful: conserving the nature of low-altitude mountain protected areas in South Western Australia. In 'Managing Mountain Areas: Challenges and Responses fort the 21st Century', Andromeda, Italy.

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.

Whelan, R.J. (1995) The ecology of fire. Cambridge University Press, Cambridge.

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.

Young, A., Boyle, T. and Brown, T. (1996) The population of genetic consequences of habitat fragmantation for plants. *Trends in Ecology & Evolution*. **11**: 413-418.

6. TAXONOMIC DESCRIPTION

George, A.S., (1996). New taxa and a new infrageneric classification in *Dryandra* R. Br. (Proteaceae: Grevilleoideae). *Nuytsia* 10 (3): 313-408.

Shrub to 2.5 m, without lignotuber. *Stems* rusty-villous. *Leaves* pinnatisect: lamina 8-25 cm long, 6-11 mm wide, hirsute, glabrescent above, closely tomentose below but reticulum evident and midrib prominent; lobes 35-60 each side, obliquely triangular, slightly overlapping at base, strongly curved adaxially and twisted so that underside faces apex of leaf; margins revolute; petiole 10-30 mm long. *Inflorescence* sessile on branchlet 1 or 2 years old; involucral bracts linear to lanceolate, obtuse to acute, villous outside, glabrous inside, the innermost c. 15 mm long: flowers 50-6- per head. *Perianth* 17-19 mm long, villous grading to hirsute on claws, yellow: limb 3 mm long, closely pubescent and with a few long hairs toward apex. *Pistil* 18021 mm long, gently bowed, glabrous except long hairs at apex of ovary, pale yellow: pollen presenter scarcely thickened, ribbed, 0.8-1 mm long. *Follicles* obliquely obovoid, 9-11 mm long, sculptured, sparsely hairy, dark red-brown.