

INTERIM RECOVERY PLAN NO. 208

KAMBALLUP DRYANDRA

(*DRYANDRA IONTHOCARPA* SUBSP. *IONTHOCARPA* MS)

INTERIM RECOVERY PLAN

2005-2010

Renée Hartley¹ and Sarah Barrett²

¹ Technical Officer, CALM Albany Work Centre, 120 Albany Hwy, Albany 6330.

² Flora Conservation Officer, CALM Albany Work Centre, 120 Albany Hwy, Albany 6330



Photo: J.A. Cochrane

April 2005

Department of Conservation and Land Management
Albany Work Centre,
South Coast Region,
120 Albany Hwy, Albany WA 6330

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This IRP will operate from May 2005 to April 2010 but will remain in force until withdrawn or replaced.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 for 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.

ACKNOWLEDGEMENTS

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

Anne Cochrane	Manager, CALM Threatened Flora Seed Centre, Science Division
Leonie Monks	Research Scientist, CALM, Science Division
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:	<i>Dryandra ionthocarpa</i> subsp. <i>ionthocarpa</i>	Common Name:	Kamballup Dryandra
Family:	Proteaceae	Flowering Period:	September to October
CALM Regions:	South Coast	CALM District:	Albany Work Centre
Shires:	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; Monks, L. (2000) Conservation biology of the rare and threatened *Dryandra ionthocarpa*, *D. mimica* and *D. serra*. Curtin University of Technology, 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: *Dryandra ionthocarpa* was declared as Rare Flora in July 1989 under the *Western Australian Wildlife Conservation Act* 1950 and was listed as Critically Endangered in September 1995. In 1999 a purported new population of this species was located near Narrogin some hundreds of kilometres north of previously known populations. In 2004, the species was divided into two subspecies - *D. ionthocarpa* subsp. *ionthocarpa* ms and *D. ionthocarpa* subsp. *chrysophoenix* ms. *D. ionthocarpa* subsp. *ionthocarpa* ms is currently ranked as Endangered under World Conservation Union Red List Criteria B1ab(v) and B2ab(v) (IUCN 2000) due to a decline in the number of mature individuals, a single known population and the limited area of occupancy and extent of occurrence. One natural population consisting of two subpopulations totalling 917 plants over less than five hectares is currently known. A translocated population supports another 46 individuals. The subspecies is also listed under the Commonwealth *Environment and Biodiversity Protection Act* 1999 as Endangered.

Description: *Dryandra ionthocarpa* subsp. *ionthocarpa* ms is a caespitose, tufted prostrate shrub with a very short stem and leaves up to 30 cm long. The leaf lobes are broadly triangular, up to 8 mm and cut within 1.5 mm of the midrib. It is a *non-sprouter* with pale yellow flowers borne close to the ground within the leaves. The subspecies has characteristic follicles, which are not woody, contain one seed, are about 5 mm in size and covered in 7 to 8 mm long erect hairs. It is unusual in having floral bracts that do not elongate as the fruit develop. The robust pistils are prominently bowed before anthesis, then recurved very strongly afterwards.

Dryandra ionthocarpa subsp. *ionthocarpa* ms (Kamballup) differs from *D. ionthocarpa* subsp. *chrysophoenix* ms (Narrogin) as plants in the Narrogin population resprout from a lignotuber, in contrast to Kamballup plants that are non-lignotuberous and therefore killed by fire.

Habitat requirements: *Dryandra ionthocarpa* subsp. *ionthocarpa* ms is known from 917 mature plants in a single natural population, comprising two subpopulations, in the Kamballup area. Subpopulation 1A is on a Class C recreation reserve vested in the Shire of Plantagenet and Subpopulation 1B in an adjacent unvested Class C reserve for the purpose of public utility. The species occurs on gravely clay-loam over spongolite in open shrub mallee habitat dominated by scattered *Eucalyptus falcata* and *E. pleurocarpa* over scrub and dwarf scrub of *Melaleuca* spp., *Allocasuarina thuyoides*, *Beaufortia micrantha*, *Isopogon buxifolius*, *Verticordia* spp. and *Xanthorrhoea platyphylla*.

Habitat critical to the survival of the species, and important populations: The habitat critical to the survival of *Dryandra ionthocarpa* subsp. *ionthocarpa* ms 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: The reserves in which the species occur have high conservation value. They provide habitat for a number of other rare flora species and several flora species at the limits of their range. Recovery actions put in place for *D. ionthocarpa* subsp. *ionthocarpa* ms will benefit these species and reciprocally, recovery actions put in place for these species will benefit *D. ionthocarpa* subsp. *ionthocarpa* ms.

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. *Dryandra ionthocarpa* subsp. *ionthocarpa* ms is not specifically listed under any international treaty and therefore this plan 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, *Dryandra ionthocarpa* subsp. *ionthocarpa* ms Population 1A occurs at Kamballup Pool which is a registered site. Populations 1A, 1B and the translocated Population 7T all occur within two kilometres of at least one other registered site. The Department has welcomed any future consultation that will seek input and involvement from Noongar groups that have an active interest in the areas that are habitat for *D. ionthocarpa* subsp. *ionthocarpa* ms.

Affected interests: Subpopulation 1A is on a Class C recreation reserve vested in the Shire of Plantagenet and Subpopulation 1B in an adjacent unvested Class C reserve for the purpose of public utility.

Social and economic impacts: The implementation of this IRP has the potential to have some minimal social and economic impact, as a population is located on Class C Reserves for the purposes of recreation and utility. The Shire of Plantagenet and the Department of Conservation and Land Management (CALM) are currently considering the combination of the two reserves into one Nature Reserve. Recovery actions refer to continued negotiations between stakeholders with regard to these areas.

Evaluation of the Plans Performance: 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. All land managers have been notified of the location and threatened status of the species.
2. Volunteers and staff from the CALM's Albany Work Centre regularly monitor populations.
3. Seed collections have been made by staff from CALM's Threatened Flora Seed Centre (TFSC).
4. Seedlings are housed in the KPBG nursery.
5. A Masters study has been conducted on the species biology and ecology.
6. CALM staff have investigated seedling recruitment and survival.
7. Soil and tissue samples have been tested for the presence of *Phytophthora cinnamomi*.
8. Access barriers have been installed to discourage entry under unfavourable soil conditions.
9. Fire management is implemented through the maintenance of firebreaks.
10. Weed management has been implemented through spraying the firebreak and the establishment of shelter bed.
11. A small population has been established by translocation.
12. A survey for new populations in similar habitat in the surrounding area has been conducted.
13. An information poster on the species has been developed and distributed.

Objectives

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.

Recovery actions

- | | |
|--|--|
| 1. Coordinate recovery actions. | 7. Conduct further surveys. |
| 2. Monitor populations. | 8. Promote awareness and encourage involvement. |
| 3. Additional seed collection. | 9. Liaise with land managers. |
| 4. Implement fire management. | 10. Map habitat critical to the survival of the species. |
| 5. Disease management. | 11. Review the IRP and assess the need for further recovery actions. |
| 6. Obtain biological and ecological information. | |

1. BACKGROUND

History

A member of the Proteaceae family *Dryandra* is endemic to southwestern Australia, with the highest species richness occurring around Eneabba and the Stirling Range. These areas of richness lie in the 400 to 600 mm annual rainfall zone where they are closely correlated with extensive areas of Kwongan or sclerophyllous shrublands (Kershaw *et al.* 1997). *Dryandra*s are sclerophyllous, perennial shrubs, restricted to well-drained sandy or lateritic soils (Monks 1999).

Dryandra ionthocarpa subsp. *ionthocarpa* ms was discovered near Kamballup by P. Luscombe who made the first collection of it in 1987. Considerable survey effort throughout the surrounding district has failed to find another population despite extensive searches of what appears to be suitable habitat.

Due to the low number of plants and the threats associated with a single population in a highly specific habitat, *Dryandra ionthocarpa* subsp. *ionthocarpa* ms was declared as Rare Flora in July 1989 (as *D. ionthocarpa*) and ranked as Critically Endangered in September 1995 (Kershaw *et al.* 1997). In 1999 a purported new population of this species was located near Narrogin. In 2004, the species was divided into two subspecies - *D. ionthocarpa* subsp. *ionthocarpa* ms (Kamballup) and *D. ionthocarpa* subsp. *chrysophoenix* ms (Narrogin). Plants in the Narrogin population resprout from a lignotuber, in contrast to the Kamballup plants that are non-lignotuberous and therefore killed by fire (Barrett and Cochrane 2004).

In 1999 and 2000, 283 seedlings were translocated to Kalgan Plains Nature Reserve, near Kamballup in an area of similar habitat to the natural population. However, survival was in poor and, by 2004, the population consisted of just 46 individuals. Six of these individuals flowered for the first time in the 2003 flowering season.

Description

Dryandra ionthocarpa subsp. *ionthocarpa* ms is a caespitose, tufted shrub with a very short stem and leaves up to 30 cm long. The leaf lobes are broadly triangular, up to 8 mm and cut within 1.5 mm of the midrib. It is a *non-sprouter* with pale yellow flowers borne close to the ground within the leaves. The subspecies has characteristic follicles, that are not woody, differing from those found in most *Dryandra* species. Each follicle contains one seed, is about 5 mm in size and covered in 7 to 8 mm long erect hairs. The subspecies is also unusual in having floral bracts that do not elongate as the fruit develop. The robust pistils are prominently bowed before anthesis, then recurved very strongly afterwards. The species epithet is taken from the Greek *ionthas* (shaggy) and *carpos* (a fruit), in reference to the prominent tuft of hairs on the follicle (George 1996).

Distribution and habitat

Dryandra ionthocarpa subsp. *ionthocarpa* ms is known from a single natural population comprising two subpopulations, in the Kamballup area. Its extent of occurrence is less than one kilometre and total area of occupancy is less than five hectares. The population supports 917 mature plants in total. Subpopulation 1A is on a Class C recreation reserve vested in the Shire of Plantagenet and Subpopulation 1B in an adjacent unvested Class C reserve for the purpose of public utility. The unvested reserve has in the past been subject to mining for spongolite stone and the mine is in close proximity to the plants. However, mining is not currently being undertaken and there are no current mining tenements approved or pending approval on this land (¹D. Coffey, personal communication).

The species occurs on clay-loam over spongolite, overlaid by the Late Eocene Plantagenet group geological formation (spongolite with minor siltstone and sandstone), in open shrub mallee habitat with *Eucalyptus falcata*, *E. pleurocarpa* and scrub of *Melaleuca* spp., *Allocasuarina thuyoides*, *Beaufortia micrantha*, *Isopogon buxifolius*, *Verticordia* sp. and *Xanthorrhoea platyphylla*. Vegetation surrounding

¹ Daniel Coffey Environmental Officer, CALM Environmental Protection Section

Dryandra ionthocarpa subsp. *ionthocarpa* ms is predominantly less than one metre high and consists entirely of small shrubs and herbaceous species (Monks 1999).

Dryandra ionthocarpa subsp. *ionthocarpa* ms has been translocated to Kalgan Plains Nature Reserve, near Kamballup. The translocation is considered to be an 'introduction' as the species is not known to have occurred naturally at this site in the past, however it is within the known range of the subspecies and in similar habitat. The site has similar climatic conditions, geology and vegetation.

Biology and ecology

The seeds of *Dryandra ionthocarpa* subsp. *ionthocarpa* ms are quite different to those of other *Dryandra* species because they lack a wing; instead the follicles have a small tuft of hairs that appear to be designed to stick to fur (Kershaw *et al.* 1997). It is suggested that the species is mammal pollinated due to the dull appearance, low positioning and strong smell of the inflorescences, as well as the large number of viable seeds produced (Monks 1999; S. Barrett, personal observation).

A study by Leonie Monks, then of Curtin University, found that *Dryandra ionthocarpa* subsp. *ionthocarpa* ms did not regenerate from rootstock following fire, however seedlings did recruit after fire. A large amount of viable seed is produced annually, which is mostly dispersed as the seed crop ripens. Seed that does not disperse may remain viable within the cones, naturally deteriorate or be predated. Favourable post-fire conditions, in particular following adequate rainfall, may be imperative as the majority of seedlings die from drought over summer (Monks 1999; Barrett and Cochrane 2004). A very small number of seedlings underneath live plants were observed in the absence of fire, however none survived over summer (Barrett and Cochrane 2004). The species was concluded to have the attributes of a non-sprouter with seedling recruitment confined to the post fire period.

Dryandra ionthocarpa subsp. *ionthocarpa* ms is thought to be weakly serotinous with little significant seed bank stored in the canopy or soil (Monks 1999). Consequently, poorly timed fires, i.e. in spring or summer, could have a very detrimental effect on the population (Monks 1999). However, in a study by Barrett and Cochrane (2004), 76% of *D. ionthocarpa* subsp. *ionthocarpa* ms seed was found to remain intact in the soil for at least nine months. The ability for viable seed to persist in the soil was confirmed by seedling germination observed in spring 2004. Forty-nine seedlings germinated in the second spring post-fire; however survival has been poor to date, with only 10% surviving to mid-December after a dry spring. No seedlings germinated around control or smoke treated plants in 2004 (S. Barrett, unpublished data).

There is no reliable data on the longevity of *Dryandra ionthocarpa* subsp. *ionthocarpa* ms and the juvenile period for naturally occurring plants is unknown (Monks 1999). However, six translocated plants in 1999 were recorded to have flowered for the first time in 2003 (L. Monks, personal communication). Monks (1999) determined that there is a linear relationship between plant height, volume, diameter and number of cones. It is estimated that individuals begin to set fertile cones once a height of approximately 0.3 metres is reached (Monks 1999). Barrett and Cochrane (2004) found that *D. ionthocarpa* subsp. *ionthocarpa* ms cone load varied considerably between plants and was related to crown volume, while the magnitude of post-fire recruitment was related to the canopy seed bank.

Seed viability results indicated the potential longevity of the species seed under a range of storage conditions (Barrett and Cochrane 2004). Greatest viability was obtained from fresh seed, with 78% germination achieved without treatment. Soil-stored seed ranged from 50% to 65% germination. Under laboratory conditions, 64% of seed stored for one year at -20°C and 62% of seed stored at ambient temperature for ten years germinated with no treatment (Barrett and Cochrane 2004).

In the same study, fire was certainly the most significant stimulus for seedling emergence. Smoke treatment resulted in minimal germination of the soil-stored seed (five germinants). In laboratory studies germination of seed treated with smoke water was less successful than germination of seed with no treatment (63% compared to 78%). The few recruits observed around unburnt plants failed to survive through summer, supporting observations that inter-fire recruitment is unlikely to significantly augment population numbers (Barrett and Cochrane 2004).

Monks (1999) found the number of seedlings recruited per parent plant after the first summer was considerably lower than would be expected for a non-sprouter in southwestern Australia (1.4 seedlings per parent plant in Population 1A and 0.2 seedlings per parent plant in Population 1B). Barrett and Cochrane (2004) concluded that initial recruitment may vary considerably within and between subpopulations and from year to year. This variation may be due to the canopy-stored seed bank of individual plants as well as seed predation pre- and post-dispersal. Post-dispersal predation may be intensified when small experimental plots are burnt and predator satiation does not occur. It is possible that recruitment under a more extensive burn may have been higher (Barrett and Cochrane 2004). However, poor seedling survival after the first summer was the critical factor limiting successful recruitment.

Threats

Dryandra ionthocarpa was declared as Rare Flora in July 1989 under the *Western Australian Wildlife Conservation Act 1950* and was listed as Critically Endangered in September 1995. In 1999 a purported new population of this species was located near Narrogin some hundreds of kilometres north of previously known populations. In 2004, the species was divided into two subspecies - *D. ionthocarpa* subsp. *ionthocarpa* ms (Kamballup) and *D. ionthocarpa* subsp. *chrysophoenix* ms (Narrogin). Plants in the Narrogin population resprout from a lignotuber, in contrast to the Kamballup plants that are non-lignotuberous. *D. ionthocarpa* subsp. *ionthocarpa* ms is currently ranked as Endangered under World Conservation Union Red List Criteria B1ab(v) and B2ab(v) (IUCN 2000) due to a decline in the number of mature individuals, a single known population and the limited area of occupancy and extent of occurrence. One natural population consisting of two subpopulations totalling 917 plants over less than five hectares is currently known. A translocated population supports another 46 individuals. The subspecies is also listed under the Commonwealth *Environment and Biodiversity Protection Act 1999* as Endangered.

All areas occupied by *D. ionthocarpa* subsp. *ionthocarpa* ms are affected or potentially affected by one or more threats identified in this IRP. Threats include:

- **Inappropriate fire regime:** Both natural subpopulations occur in long-unburnt habitat, estimated at around twenty-five years of age. While occasional fire is required for seedling recruitment, inappropriate timing, intensity and frequency of fire may be detrimental, as plants need to reach reproductive maturity to build up a seed bank. For species with a soil-stored seed bank, a conservative estimate for the minimum desirable fire interval may be determined by multiplying the primary juvenile period (time to first flower) by two and a half (Gill and Nichols 1989). The juvenile period for *Dryandra ionthocarpa* subsp. *ionthocarpa* ms is unknown but is thought to be a least 4 years to first flowering.

Dryandra ionthocarpa subsp. *ionthocarpa* ms seedling survival post-fire is poor and unpredictable. If conditions are not favourable for seedling recruitment and survival in the year mature plants are burnt, population decline is likely to be substantial.

It is considered that the rubbish dump to the south of the population is a fire hazard. In the past, neighbouring landholders have requested to have the two reserves burnt as they were considered a fire hazard to surrounding farmland. Subsequently, the Shire of Plantagenet constructed firebreaks around the reserve boundaries. A firebreak is also maintained between the two subpopulations as it is important to ensure that the two do not burn at the same time.

- **Small population size:** As population size decreases, the population may become more vulnerable to extinction for three main reasons. 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. Secondly, small populations are more susceptible to chance events associated with demographic and environmental stochasticity. 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 (Hobbs and Yates 2003).

- **Drought:** Drought is a threat to both subpopulations because of the skeletal soils and rocky substrate on which the subspecies grows. Drought may directly impact the subspecies by reducing flowering, seed set and population recruitment, and by increasing plant mortality (Barrett and Cochrane 2004).

Decline in the number and health of *Dryandra ionthocarpa* subsp. *ionthocarpa* ms was observed from 1991. A survey of Population 1 in 1994 suggested that the species was suffering from drought. *Phytophthora cinnamomi* was ruled out as a possible cause through laboratory tests and field observations.

In 1995 and 1996, a study by Leonie Monks used the monitoring of the plants' water potential (xylem tension) and changes in photosynthetic pigments to determine the level of water stress within the population. All plants were found to be under some level of water stress in the 1995/96 summer drought, although orange and intermediate coloured plants were under more stress than green coloured plants. The presence of orange foliage was considered a good indicator of water stress. Orange and intermediate coloured plants are thought to be more likely to recover over winter than die, however these plants became orange and intermediate again at the onset of the next period of summer drought. This indicated that either the plants had not fully recovered to pre-stress levels and would therefore succumb to the next summer drought, or plants with naturally lower chlorophyll levels are more prone to drought stress (Monks 1999).

Monks (1999) also monitored the recruitment and survival of seedlings post-fire. A significant loss of seedlings occurred following summer drought, with only 3.3% of the Subpopulation 1A seedlings and 8.3% of Subpopulation 2A seedlings surviving the first summer period (Monks 1999). Experimental watering of seedlings that recruited in 2003 was trialled (Barrett and Cochrane 2004), 52% of watered seedlings survived through to spring 2004 compared to the 5% survival of the seedlings that were not watered (S. Barrett, unpublished data). Hence, drought poses a considerable threat to the survival of recruited seedlings. Experimental watering of seedlings recruited in 2004 is currently underway.

- **Weed invasion:** Weeds that suppress early plant growth by competing for soil moisture, nutrients and light are often blown in from adjoining pasture (Panetta and Hopkins 1991). Weed invasion is a particular threat to subpopulation 1A as it is relatively exposed and therefore subject to influences from adjacent cleared farmland. Influences include the introduction of exotic species, farm chemicals, modified hydrology and altered disturbance regimes (Panetta and Hopkins 1991).

Despite spraying the firebreak with Roundup® and planting a shelterbelt of *Eucalyptus* spp., weeds have persisted in subpopulation 1A, primarily at the edge. Weeds include paddy melon (*Cucumis myriocarpus*), capeweed (*Arctotheca calendula*) and veldt grass (*Ehrharta longifolia*) (S. Barrett, personal observation.). Rust was introduced to the bridal creeper (*Asparagus asparagoides*) in 2002 as the weed has the potential to spread rapidly through the area. The rust appears to be having some affect (S. Barrett, personal communication).

Weeds were more abundant in experimental plots after fire and were removed by hand (S. Barrett, personal communication). Post-fire conditions can be advantageous for weed invasion and reciprocally, the presence of weeds can encourage fire through altering the nature and spatial array of the fuel load (Panetta and Hopkins 1991).

- **Disease:** *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 status, water 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). *Dryandra ionthocarpa* subsp. *ionthocarpa* ms occurs in a winter-wet, poorly drained site, which is likely to favour *P. cinnamomi* infestation (M. Grant, personal communication).

In general, *Dryandra* species are highly susceptible to *Phytophthora* spp. and research has shown that *Dryandra ionthocarpa* subsp. *ionthocarpa* ms is susceptible (B. Shearer, unpublished data). However, *Phytophthora cinnamomi* has not been identified with any deaths of *D. ionthocarpa* subsp. *ionthocarpa* ms and the population currently appears to be *P. cinnamomi*-free. Soils and tissues samples were collected from Population 1 in 1994. Both samples tested negative for *P. cinnamomi* (M. Grant, personal communication). A sample was again taken in 2001, which also produced a negative result, indicating that *P. cinnamomi* had not infected the population at that time, however due to the access tracks passing through the habitat, the threat of pathogen spread is high (²P. Collins, personal observation).

R. Wills (formerly CALM, now WA Chamber of Commerce) has in the past observed aerial canker on *Dryandra ionthocarpa* subsp. *ionthocarpa* ms (Kershaw *et al.* 1997), however no further research has been done on the presence of this fungus. The effect of aerial canker on the population requires further investigation.

- **Altered hydrology:** It has been predicted that altered hydrology will cause the loss of habitat in many reserves if present trends continue. One quarter of southwest landscapes and up to half of some landscapes in low catchment areas may become salt affected over the next century (Monks 1999). While the reserve in which the *Dryandra ionthocarpa* subsp. *ionthocarpa* ms occurs is low in the catchment and adjacent to the salt-affected Kalgan River, the population occurs relatively high in the landscape and may be less vulnerable to the impacts of altered hydrology (S. Barrett, personal communication).

The presence of adjacent farmland can lead to increased run-on, often vectoring surplus chemicals and nutrients (Panetta and Hopkins 1991). This may not only have a detrimental effect on *Dryandra ionthocarpa* subsp. *ionthocarpa* ms, but also the remainder of the reserve plant community.

- **Herbivory:** Seed predation will reduce the number of viable seeds available for dispersal. In one year, insects destroyed 46% and 60% of follicles respectively in the two *Dryandra ionthocarpa* subsp. *ionthocarpa* ms subpopulations. The insect attack seemed to occur very early in the inflorescence development. While some follicles remain intact even after invasion, studies have shown that the application of insecticide just after pollination increases the number of intact cones. (Monks 1999).

There have been no obvious grazing effects on mature plants, however seedlings are subject to grazing by invertebrates and possibly vertebrates. Of the seedlings recruited in 2003, 37% showed effects of grazing and a further 11% died, most likely as a result of grazing. Grazing affects seedling vigour and survival. Only 65% of 2003 seedlings that were grazed survived to Dec 2004 (Barrett and Cochrane, unpublished data).

- **Land tenure:** Population 1 occurs in two Class C reserves, one for the purpose of public utility (spongolite mine) and the other for recreation (golf course). The Shire of Plantagenet and CALM are currently considering the combination of the two reserves into one Nature Reserve. Whilst there are no mining tenements currently approved or pending approval on this land (D. Coffey, personal communication), likely effects of mining or recreational use if approved in the future would include soil compaction, clearing and damage to vegetation, significant amounts of water and nutrients added to the soil and an increase in the likelihood of disease spread as a result of vehicle movement.
- **Climate change:** Long-term climate change is likely to adversely affect the single known *Dryandra ionthocarpa* subsp. *ionthocarpa* ms population given a predicted decrease in rainfall and an increase in temperature and evaporation. Current seedling survival is poor, primarily as a result of drought stress and any further adverse change in conditions due to climate change will be severely detrimental to recruitment. It is thought that groups likely to be most affected by climate change include geographically localised taxa such as *D. ionthocarpa* subsp. *ionthocarpa* ms, peripheral or disjunct

² Peter Collins CALM, Albany Work Centre

populations, specialised species, poor seed dispersers, genetically impoverished species, and coastal communities (Peters & Darling 1985).

Summary of population land vesting, purpose and tenure

Population	Vesting	Purpose	Tenure
1A. North of Kamballup	Shire of Plantagenet	Recreation Golf Course	Crown
1B. North of Kamballup	Unvested	Public Utility	Crown
7T. Kalgan Plains	WA Conservation Commission	Conservation of Flora and Fauna	Crown

Summary of population information and threats

Pop. No. & Location	Year/No. of plants adults (juveniles)	Condition	Threats
1A. North of Kamballup	1987 400+/-	Healthy	Weeds Fire Drought Disease
	1988 200+/-	Healthy	
	1990 200+/-	Healthy	
	1991 Approx. 15% death	Diseased	
	1992 476 (few)		
	1993 200+/-	Diseased	
	1994 475*	Moderate	
	1995 682*	Moderate	
	2000 700	Moderate	
	2001 600+	Moderate	
	2002 612*	Moderate	
	2003 612 (73)*	Moderate	
2004 589 (46)*	Healthy		
1B. North of Kamballup	1988 200+/-	Healthy	Fire Drought Disease Possible future mining
	1990 200+/-	Healthy	
	1991 Approx. 15% death		
	1992 250	Diseased	
	1993 200+/-	Diseased	
	1994 682*	Moderate	
	1995 500+	Moderate	
	1996 475*	Moderate	
	1999 400+		
	2000 400-	Moderate	
	2002 340*	Moderate	
2004 328*	Healthy		
7T. Kalgan Plains	1999 138 seedlings		Fire Drought Disease
	2000 145 seedlings		
	2002 58*	Moderate	
	2004 46*	Moderate	

NB: Early estimates were very approximate and as such are not counted.

*Precise count of individuals

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 ionthocarpa* subsp. *ionthocarpa* ms population has been mapped. However, other parts of the habitat critical to the survival of *D. ionthocarpa* subsp. *ionthocarpa* ms 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 ionthocarpa* subsp. *ionthocarpa* ms 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

The two reserves in which the subspecies occurs have high conservation value as they provide habitat for a number of other threatened and Priority flora taxa, including *Orthrosanthus muelleri* (DRF), *Stylidium diplectroglossum* (P1), *Verticordia huegelii* var. *tridens* (P1), *Chorizema carinatum* (P3), *Hakea lasiocarpa* (P3), *Trochocarpa parviflora* (P3), *Eucalyptus goniantha* subsp. *goniantha* (P4), *Pleurophascum occidentale* (P4), and several flora species at the limits of their range. Recovery actions put in place for *D. ionthocarpa* subsp. *ionthocarpa* ms will benefit these species and reciprocally, recovery actions put in place for these species will benefit *D. ionthocarpa* subsp. *ionthocarpa* ms.

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. However, as *Dryandra ionthocarpa* subsp. *ionthocarpa* ms is not listed under any international agreement, the implementation of other international environmental responsibilities is not affected by this plan.

Affected Interests

All populations are on Crown land. Subpopulation 1A is on a Class C recreation reserve vested in the Shire of Plantagenet and Subpopulation 1B in an adjacent unvested Class C reserve for the purpose of public utility. Population 7T is on a Nature Reserve vested in the WA Conservation Commission.

Role and interests of indigenous people

According to the Department of Indigenous Affairs Aboriginal Heritage Sites Register, *Dryandra ionthocarpa* subsp. *ionthocarpa* ms Subpopulation 1A occurs on the registered site Kamballup Pool and Populations 1 and 7T occur within two kilometres of at least one of the registered sites Kamballup Pool, Kamballup Bridge, Kalgan Downs and Arizona Pool. The Department has welcomed any future consultation that will seek input and involvement from Noongar groups that have an active interest in the areas that are habitat for *D. ionthocarpa* subsp. *ionthocarpa* ms. This is discussed in the recovery actions.

Social and economic impacts

As the subspecies is located on Class C Reserves for the purposes of recreation and utility, the implementation of this IRP has the potential to have some minimal social and economic impact. The Shire of Plantagenet and CALM are currently considering the combination of the two reserves into one Nature Reserve (D. Coffey, personal communication). Recovery actions refer to continued negotiations between stakeholders with regard to these areas.

Guide for decision-makers

Section 1 provides details of current and possible future threats. Developments in the immediate vicinity of the single known population or within the defined critical habitat of *Dryandra ionthocarpa* subsp. *ionthocarpa* ms require assessment to determine their 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 and/or recovery actions made in response to monitoring results will be documented accordingly.

2. RECOVERY OBJECTIVE AND CRITERIA

Objectives

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

Existing or completed recovery actions

All land managers have been notified of the location and threatened status of *Dryandra ionthocarpa* subsp. *ionthocarpa* ms. The notification details the Declared Rare status the subspecies and the legal responsibility to protect it.

Staff from CALM's Albany Work Centre regularly monitor the population.

Preservation of germplasm is essential to guard against the possible extinction of the wild population and may be used to propagate plants for translocations. Staff from CALM's Threatened Flora Seed Centre (TFSC) have made eleven *Dryandra ionthocarpa* subsp. *ionthocarpa* ms seed collections since 1990 with approximately five thousand seeds collected in total. The seed is stored at -18 degrees Celsius and requires no special treatment to achieve germination (³A. Crawford, personal communication).

Seeds have been successfully germinated and the resulting seedlings grown and maintained in the Botanic Gardens and Parks Authority (BGPA) nursery. There were 283 *Dryandra ionthocarpa* subsp. *ionthocarpa* ms seedlings translocated into the wild in 1999 and 2000 and 88 plants currently housed at the BGPA nursery are intended for translocation in winter 2005 (⁴A. Shade, personal communication)

As discussed in Section 1, Leonie Monks conducted a masters study on three *Dryandra* species including *Dryandra ionthocarpa* subsp. *ionthocarpa* ms. The study looked at the species demography, fire ecology, granivory and drought-stress and included a number of small translocations.

CALM staff have investigated factors affecting seedling recruitment and survival (Barrett and Cochrane 2004) (also discussed in Section 1). This included research into the soil seed bank, canopy seed bank, seed longevity, *ex situ* conservation, germination requirements and the role of disturbance (fire and smoke water application) in stimulating germination of the soil-stored seed reserve.

³ Andrew Crawford Senior Technical Officer, CALM Threatened Flora Seed Centre

⁴ Amanda Shade Botanic Gardens Parks Authority

Firebreaks are maintained around the reserve by CALM (⁵G. Broomhall, personal communication).

Samples of *Dryandra ionthocarpa* subsp. *ionthocarpa* ms were tested for *Phytophthora cinnamomi* in 1994 and 2001. All samples produced a negative result. However, to be safe, barriers on the entry track into Population 1 have been put in place to restrict access to times of dry soil conditions so as to reduce the risk of *Phytophthora* spread.

A shelter bed was planted around subpopulation 1A to inhibit weed invasion from the adjoining paddock. The area was initially sprayed with Roundup in preparation. Three rows were planted with *Eucalyptus recondata*, *E. uncinata* and *E. incrassata* seedlings. Survival of the outer two rows of eucalypts was poor and the rows were consequently replanted with *E. pleurocarpa* seedlings. The shelter bed has been slow to establish (S. Barrett, personal communication). Additional seed was collected from *Eucalyptus*, *Allocasuarina* and *Melaleuca* species in November 2004. The seed has been germinated and will be ready for planting along the shelter bed in autumn 2005 (⁶A. Cochrane, personal communication).

Information regarding *Dryandra ionthocarpa* subsp. *ionthocarpa* ms has been disseminated by CALM to the public and scientific community through the production of an information sheet that includes the plant's description, status and habitat, research projects in progress and photos.

In August 1996 Leonie Monks commenced the translocation of *Dryandra ionthocarpa* subsp. *ionthocarpa* ms to eight different study sites. The aim was to investigate whether the species would establish in different soil types or other areas with similar soil. Two of the translocation sites were within the known population (Population 1); two were in dark brown heavy clay soil, lower down the slope; two were on light coloured sandy loam soil, within the Kamballup Reserve; and the final two were on Spongolite soil in Kalgan Plains Nature Reserve.

The plants were germinated from seed obtained from both known subpopulations. Herbivores were excluded from the sites using shade cloth and monitoring focused on initial survival, survival over the first summer and growth (height). It was determined that suitable habitat and the correct soil type must be combined for good survival. Seedlings had better survival in spongolite soils, however where the habitat (i.e. vegetation surrounding the population) was not suitable, the survival rate was significantly lower. Monks (1999) considered ongoing monitoring (until flowering, fruiting and seedling recruitment) is imperative.

Monks (1999) found *Dryandra ionthocarpa* subsp. *ionthocarpa* ms to have the greatest percentage survival at one site in the Kalgan Plains Nature Reserve. The reserve is approximately 6.5 km from the natural population and has a similar vegetation structure and the same soil type. However, the population did not establish successfully long-term and by 2002 its condition was poor with only 58 of the 283 juveniles surviving. In 2004, 44 of the plants translocated in 1999 were surviving and only 2 of those planted in 2000 were surviving. Watering may have been inadequate over the first summer (1999). A further 88 plants are currently housed at Kings Park and Botanic Garden nursery for planting at Kalgan Plains in winter 2005. All plants will be watered and caged (L. Monks, personal communication).

In 2005, seed was collected from a single garden specimen of *Dryandra ionthocarpa* subsp. *ionthocarpa* ms. Tests resulted in 84% germination of this seed, demonstrating that the species is capable of self-pollination (A. Cochrane, personal communication). However, seedling fitness is yet to be determined.

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

⁵ Greg Broomhall Regional Leader Operations, CALM Albany Work Centre

⁶ Anne Cochrane Manager, CALM Threatened Flora Seed Centre

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

1. Coordinate recovery actions

The Albany District Threatened Flora Recovery Team (ADTFRT) is coordinating recovery actions for *Dryandra ionthocarpa* subsp. *ionthocarpa* ms 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. Monitor populations

Continue regular (annual) monitoring of all *Dryandra ionthocarpa* subsp. *ionthocarpa* ms populations (natural and translocated), with numbers and condition recorded. Continue regular monitoring of seedlings to determine the percentage survival to maturity and time to first flowering and seed set.

Action: Monitor populations.
Responsibility: CALM (Albany Work Centre).
Cost: \$4,750 per year.

3. Additional seed collection

Further collection will be conducted to obtain as wide a range of genotypes as possible.

Action: Additional seed collection.
Responsibility: CALM (Threatened Flora Seed Centre and Albany Work Centre).
Cost: \$3,125 per year.

4. Implement fire management

For the life of this Plan (5 years) fire will, if possible, be prevented from occurring in the area of the *Dryandra ionthocarpa* subsp. *ionthocarpa* ms population.

Action: Conduct fire management through firebreaks and buffer burning.
Responsibility: CALM (Albany Work Centre).
Cost: \$400 per year.

5. Disease management

Prevent entrance into the reserve during unfavourable soil conditions through the maintenance of barriers and signs. All management access will be confined to dry soil conditions and all vehicles and boots must be clean on entry.

Action: Disease management.
Responsibility: CALM (Albany Work Centre).
Cost: \$200 per year.

6. Obtain biological and ecological information

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

1. Percentage of seedling survival to maturity and time to first flowering and seed set.
2. Pollination biology.
3. Factors limiting seed bank, including post-dispersal predation on soil-stored seed.
4. The population genetic structure, levels of genetic diversity and minimum viable population size.
5. Extent and effect of aerial cankers.
6. The effects of climate change.

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

7. Conduct further surveys

Remnant vegetation in and around the Kamballup area will be assessed for suitability and surveyed for *Dryandra ionthocarpa* subsp. *ionthocarpa* ms.

Action: Conduct further surveys.
Responsibility: CALM (Albany Work Centre).
Cost: \$4,750 per year.

8. Promote awareness and encourage involvement

The importance of biodiversity conservation and the need for the long-term protection of wild populations of this subspecies 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. An information sheet on *Dryandra ionthocarpa* subsp. *ionthocarpa* ms has been produced and will be distributed further.

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

9. Liaise with land managers

Staff from CALM's Albany Work Centre will continue to work with the Shire of Plantagenet to minimise impacts on the natural population and further investigate the possibility of combining the two Class C reserves into one Nature Reserve. Input and involvement will also be sought from any Indigenous groups that have an active interest in areas that are habitat for *Dryandra ionthocarpa* subsp. *ionthocarpa* ms.

Action: Liaise with land managers.
Responsibility: CALM (Albany Work Centre).
Cost: \$1,200 per year.

10. 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: \$400 in the first year.

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

If *Dryandra ionthocarpa* subsp. *ionthocarpa* ms is still ranked as 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 (WATSCU 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 [May 2005 to April 2010](#) but will remain in force until withdrawn or replaced. If the taxon is still ranked Endangered after five years, this IRP will be reviewed and, if necessary, further recovery actions put in place.

5. REFERENCES

- Barrett, S. and Cochrane, A. (2004) Seedling survival, soil seed bank status and disturbance response of the endangered *Dryandra ionthocarpa* A.S George ssp. *ionthocarpa* ms (Proteaceae): Final Report to Bankwest Landscape Visa Conservation Card Trust Fund, July 2004. Department of Conservation and Land Management, Western Australia.
- 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.
- 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.
- Kershaw, K., Holland, E. and Brown, A. (1997) Kamballup *Dryandra* (*Dryandra ionthocarpa*) Interim Recovery Plan 1996-1999. Department of Conservation and Land Management, Western Australia.
- Monks, L. (1999) Conservation biology of the rare and threatened *Dryandra ionthocarpa*, *D. mimica* and *D. serra*. Masters Thesis. Curtin University of Technology, Western Australia.
- Panetta, F.D. and Hopkins, A.J.M. (1991) Weeds in corridors: invasion and management. In *Nature Conservation. 2, the Role of Corridors* (eds D.A. Saunders & R.J. Hobbs). Surrey Beatty, Sydney. pp. 341-351

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 60 cm wide. *Stems* prostrate, short, ± underground, villous; prophylls many, linear, tomentose. *Leaves* pinnatifid, 8-25 cm long, 5-20 mm wide; margins flat; lobes 15-35 each side, triangular, obtuse, ± flat, rusty-villous when young, later glabrous except pits; petiole 4-6 cm long, ± glabrous. *Inflorescence* terminal, subtended by leaves, closely successive; involucre bracts linear-subulate, the inner ones narrowly lanceolate, to 2 cm long, dark rusty-tomentose; flowers 40-60. *Perianth* 39-43 mm long, curled-tomentose in lower third, pubescent above, pink-mauve with yellow limb; limb 7-8 mm long, keeled, appressed-puberulous. *Pistil* 43-44(57) mm long, curved, pilose in lower half, cream; pollen presenter 3.5-4.8 mm long, ribbed, green. *Follicles* ± obovate, 5-6 mm long, with an apical tuft of long rusty hairs, glabrous below.