Mason's Darwinia (*Darwinia masonii*)

Recovery Plan

Revision 0

MGX and EHPL

June 2014

Mason's Darwinia (*Darwinia masonii*)

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Foreword

Recovery plans are developed within the framework laid down in Department of Environment and Conservation Policy Statements Nos. 44 and 50 (CALM 1992, 1994), and the Australian Government Department of Environment (DEWHA 2008a). Recovery plans outline the recovery actions that are required to address threatening processes most affecting the ongoing survival of threatened taxa or ecological communities, so enhancing the recovery process for the species.

The objectives of the plan have been planned for attainment. The nomination and provision of funds necessary to implement actions are subject to budgetary and other constraints affecting parties involved, as well as the need to address other business priorities.

Information in this recovery plan was accurate at June 2014.

Cover photograph: Mason's Darwinia (*Darwinia masonii*) on Extension Hill South in 2014.

Mount Gibson Mining 2014.

Abbreviations

BGPA	Botanic Gardens and Parks Authority
BIF	Banded Ironstone Formation
CALM	Department of Conservation and Land Management, Western Australia (changed to Department of Environment and Conservation in July 2006)
DoE	Commonwealth Department of the Environment (formerly DSEWPaC)
DEC	Department of Environment and Conservation, Western Australia (changed to Department of Parks and Wildlife in July 2013)
DEWHA	Commonwealth Department of Environment, Water, Heritage and the Arts (changed to DSEWPaC on 14 September 2010)
DSEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities (changed to DoE on 18 September 2013, formerly DEWHA)
Parks and Wildlife	Department of Parks and Wildlife, Western Australia (formerly DEC)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EHPL	Extension Hill Pty Ltd
DFES	Department of Fire and Emergency Services
GDTFRT	Geraldton District Threatened Flora Recovery Team
GNHwy	Great Northern Highway
IBRA	Interim Biogeographical Regionalisation for Australia
IUCN	International Union for Conservation of Nature
MGIOIP	Mount Gibson Iron Ore Mine and Infrastructure Project
MGM	Mount Gibson Mining Limited
NAN	Nuts About Natives
SCB	Species and Communities Branch, Parks and Wildlife
TPFL	Threatened and Priority Flora Database
UWA	The University of Western Australia
WA	Western Australia

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FIGURES

Photograph: Kiera Foster (Parks and Wildlife, Geraldton)

Summary

Species:	*Darwinia masonii*	**Common name:**	Mason's Darwinia
Family:	Myrtaceae	**Flowering period:**	April – November
IBRA Regions:	Avon Wheatbelt, Yalgoo	**IBRA Subregions:**	Avon Wheatbelt P1, Tallering
Shire:	Yalgoo	**NRM region:**	Rangelands NRM – Murchison subregion
Parks and Wildlife Region:	Midwest	**District:**	Geraldton
		Recovery team:	Geraldton District Threatened Flora Recovery Team (GDTFRT)

Status of Taxon as at June 2014:

- E*nvironment Protection and Biodiversity Conservation Act 1999:* Vulnerable
- Western Australia *Wildlife Conservation Act 1950*: Schedule 1, Extant and considered likely to become extinct or rare: ranked as Vulnerable D2 (using IUCN criteria)

1. Introduction

1.1. Purpose and Background

Ministerial Statement 753 (**MS753**) authorises the implementation of the Mount Gibson Iron Ore Mine and Infrastructure Project (**MGIOIP**), being the proposal to mine and price iron ore from Extension Hill and Extension Hill North, within the Mount Gibson Ranges, construct a pipeline to transport the magnetite slurry to Geraldton Port, and construct infrastructure at the port to strip the ore from the slurry for export.

Mount Gibson Mining Ltd (**MGM**) and Extension Hill Pty Ltd (**EHPL**) are both proponents for the purposes of MS753.

This *Darwinia masonii* full recovery plan has been prepared to meet condition 6-3 of MS753 and be consistent with the "Recovery Plan Guidelines for Nationally Listed Threatened Species and Ecological Communities under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*" (published on the Commonwealth Department of Environment website).

The primary objective of this plan is to maintain, and ultimately improve, the conservation status of *D. masonii*.

The development and preparation of this plan and the management actions within has been guided by the outcomes to date of the implementation of the *Darwinia masonii* Research Plan and the *Darwinia masonii* Interim Recovery Plan. The *Darwinia masonii* Research Plan and the *Darwinia masonii* Interim Recovery Plan were developed and implemented pursuant to conditions 6-1, 6-2, 6-4 and 6-5 of MS753. A summary of the outcomes of the Research and Interim Recovery Plan (**IRP**) is provided by way of background in sections 2 and 5.1 of this plan.

When this plan was prepared, some information continuing from the implementation of the *Darwinia masonii* IRP was not available to MGM and EHPL and therefore could not be incorporated to inform this recovery plan. This includes:

- recent research initiatives and specific methodologies of previous research conducted by BGPA; and
- the results of a population census that is currently being undertaken with a formal report, due later in 2014.

MGM and EHPL will review this full recovery plan in light of this outstanding information once it becomes available in accordance with the tasks assigned in Parks and Wildlife (2014).

MS753 includes several conditions which regulate the implementation of the MGIOIP in a manner that will manage the effects of the MGIOIP on *D. masonii*. For example, condition 8 (conservation of significant flora and communities), condition 9 (weeds) and condition 10 (bushfires). This plan does not repeat those obligations, but is intended to work alongside those obligations (and particularly the management plans that operate under those conditions) to meet the objectives of this plan and maintain an efficient process.

The Table below identifies the specific sections of this plan that address the matters stipulated by Condition 6-3 of MS753:

MS753 Condition	Matters	Section
6-3(1)	*Habitats which are critical to the survival of the species* *Actions needed to protect those habitats*	Section 2; Table 1; Figure 1 Section 5.2
6-3(2)	*Threats to the species and areas and populations under threat*	Section 3
6-3(3)	*Objectives to be achieved*	Section 4.1
6-3(4)	*Criteria against which achievement of the objectives is to be measured*	Section 4.2
6-3(5)	*Management actions based on the outcomes of the implementation of the Research Plan and Interim Recovery Plan that will remediate the impacts of the project and provide for a net improvement on the pre-mining status of the species*	Section 5.2
6-3(6)	*Further research required into the management or recovery of the species*	Section 5.3

The Recovery Plan has also been developed using the structure and matters outlined in the Recovery Plan Guidelines for Nationally Listed Threatened Species and Ecological Communities under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Attachment 4).

1.2. The Taxon

Darwinia masonii is an erect shrub 1.5 to 3 metres (m) tall, with narrow leaves approximately 1 centimetre (cm) long, which are almost triangular in cross-section. The leaves are closely crowded towards the ends of the branchlets. The flowering inflorescences are approximately 3 cm in diameter and are surrounded by numerous spreading pinkish bracts that are pendulous on the ends of small branchlets. The bracts are broad at the base but narrow to a pointed apex with a distinct midrib. Each bract is approximately 2 cm in length and 5 millimetres (mm) wide at the base. Each tubular flower is about 5 mm long with a style approximately 1.5 cm in length with hairs below the stigma (Brown et al., 1998).

Darwinia masonii has a known flowering period from April to November (Brown et al., 1998). As the rainfall in the region is unreliable, *D. masonii* is likely to respond opportunistically to rainfall events (i.e. tropical cyclonic summer rainfall events and southern winter cold fronts). Strong vegetative growth (but not reproductive stages) has been observed following summer rainfall events.

The species is known from one location with nine numbered groups from the IRP identified as one genetic population.

1.2.1. Conservation Status

Darwinia masonii is specially protected under the Western Australian (WA) *Wildlife Conservation Act* 1950 and was listed on 14th of November, 1980. It is currently ranked as Vulnerable in WA under the International Union for Conservation of Nature (IUCN, 2001) criteria D2 due to it being known at the time of ranking from one location (nine groups, one genetic population). It is listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) in July 2000.

1.2.2. Biology and Ecology

Darwinia masonii is one of 65 Western Australian species of Darwinia. The genus is unusual because it has a high proportion of species that are considered rare and endangered as a result of intrinsic rarity i.e. a species with a naturally small range as a result of limiting natural factors such as edaphic requirements and/or breeding biology. Its limited known geographic range appears to signify a species limited in distribution which is unlikely to have originally resulted because of human influence.

Darwinia masonii has a slow, irregular and modular growth form (Botanic Gardens and Parks Authority: **BGPA**, 2010). Seedling growth forms are more regular with increases in height and stem diameter correlated with age. Older plants may experience dying back of branchlets at their extremities during drought years, and branchlet growth within the canopy during good seasons. Their stems are often irregularly shaped, having cracks, swellings, or a presence or absence of spongy bark. Individuals may be prostrate or reclining, and the canopy is not uniform in shape.

Further details on the biology and ecology of the species are given in Attachment 1.

1.2.3. Habitat and Distribution

Darwinia masonii is found within the Mt Gibson Ranges, 350km north-east of Perth. *Darwinia masonii* appears to predominantly occur on the slopes, crests and ridges of eleven major hills that comprise the six kilometre (km) range. In the same district, it has also been found on a granite breakaway area to the east of Extension Hill. The current known distribution of *D. masonii* is mapped in **Figure 1.**

Research (Muir, 1995, Bennett, 2000, Paul Armstrong and Associates, 2004 and ATA Environmental, 2005) suggests that the species is restricted in distribution to the Mt Gibson Ranges. Areas with similar geology (banded ironstone formation or chert) and vegetation to that of the Mt Gibson Ranges were surveyed by Paul Armstrong and Associates (2004), ATA Environmental (2004), and BGPA (2008), however no additional groups or populations were located during those surveys.

Furthermore, *D. masonii* specimens were also found on a granitic breakaway to the East of Extension Hill (DEC, 2008) and at the base of a valley on granitic substrate. This finding may imply a broader definition of suitable habitat and the potential for a wider occurrence/ distribution of the species. Additional regional surveys based on a desktop analysis of suitable habitat are scheduled by the mining proponents for winter 2014.

There is anecdotal evidence (Muir, 1995) that *D. masonii* may have been previously recorded from Mt Singleton, although no voucher specimens have been found to date at the Western Australian Herbarium and brief later examinations of the site by Paul Armstrong and Associates (2004) and ATA Environmental (2004) did not identify the species from this location.

The habitat where *D. masonii* grows was described by Brown et al. (1998) as tall shrublands on yellow-brown clay loams on the Banded Ironstone Formations or granite breakaway. ATA Environmental (2004) targeted surveys recorded *D. masonii* from eight vegetation communities. These were previously identified and mapped by Bennett Environmental Consulting (2000) and included one mallee, six thicket and one heath community:

T1 Dense Thicket of mixed species dominated by Acacia species, *Allocasuarina acutivalvis* subsp. *prinsepiana*, *Calycopeplus paucifolius* and *Melaleuca nematophylla* over Low Shrubland in jaspilite rocks and pockets of loam.

T2 Dense Thicket dominated by *Acacia assimilis*, *A. stereophylla* var. *stereophylla*, *A. ramulosa* and *Allocasuarina acutivalvis* subsp. *prinsepiana* over Low Shrubland of *Acacia acuaria*, *Hemigenia* sp. Paynes Find and *Baeckea* aff. *cryptandroides* in loam with scattered rocks on the surface.

T3 Dense Thicket dominated by *Acacia assimilis*, *Allocasuarina acutivalvis* subsp. *prinsepiana* and *Melaleuca nematophylla* over Low Shrubland of *Hemigenia* sp. Paynes Find and *Hibbertia crassifolia* in loam pockets in jaspilite rocks.

T4 Dense Thicket of *Allocasuarina acutivalvis* subsp. *prinsepiana* with occasional *Eucalyptus oldfieldii* over an Open Scrub of Acacia species over Open Shrubland of *Hemigenia* sp. Paynes Find or Open Herbs of *Xanthosia bungei*.

T5 Thicket of Allocasuarina acutivalvis subsp. *prinsepiana* and *Grevillea obliquistigma* with emergent *Callitris glaucophylla* over Low Shrubland dominated by *D. masonii*, *Hibbertia crassifolia*, *Melaleuca radula*, and *Philotheca brucei* over Herbs of *Xanthosia brucei* in loam pockets in dense jaspilite rocks.

T6 Thicket of *Acacia acuaria* and *Acacia stowardii* over Low Shrubland of mixed species with large numbers of *D. masonii* in loam with abundant rocks on the surface.

M4 Very Low Open Shrub Mallee of *Eucalyptus leptopoda* with emergent *Eucalyptus loxophleba* subsp. *supralaevis* over Thicket of *Acacia ramulosa* over herbland of Asteraceae in loam.

HS1 Low Heath of *Ptilotus obovatus* with emergent shrubs of *Acacia stowardii* and *Calycopeplus paucifolius* over Herbs in loamy clay large amongst large boulders.

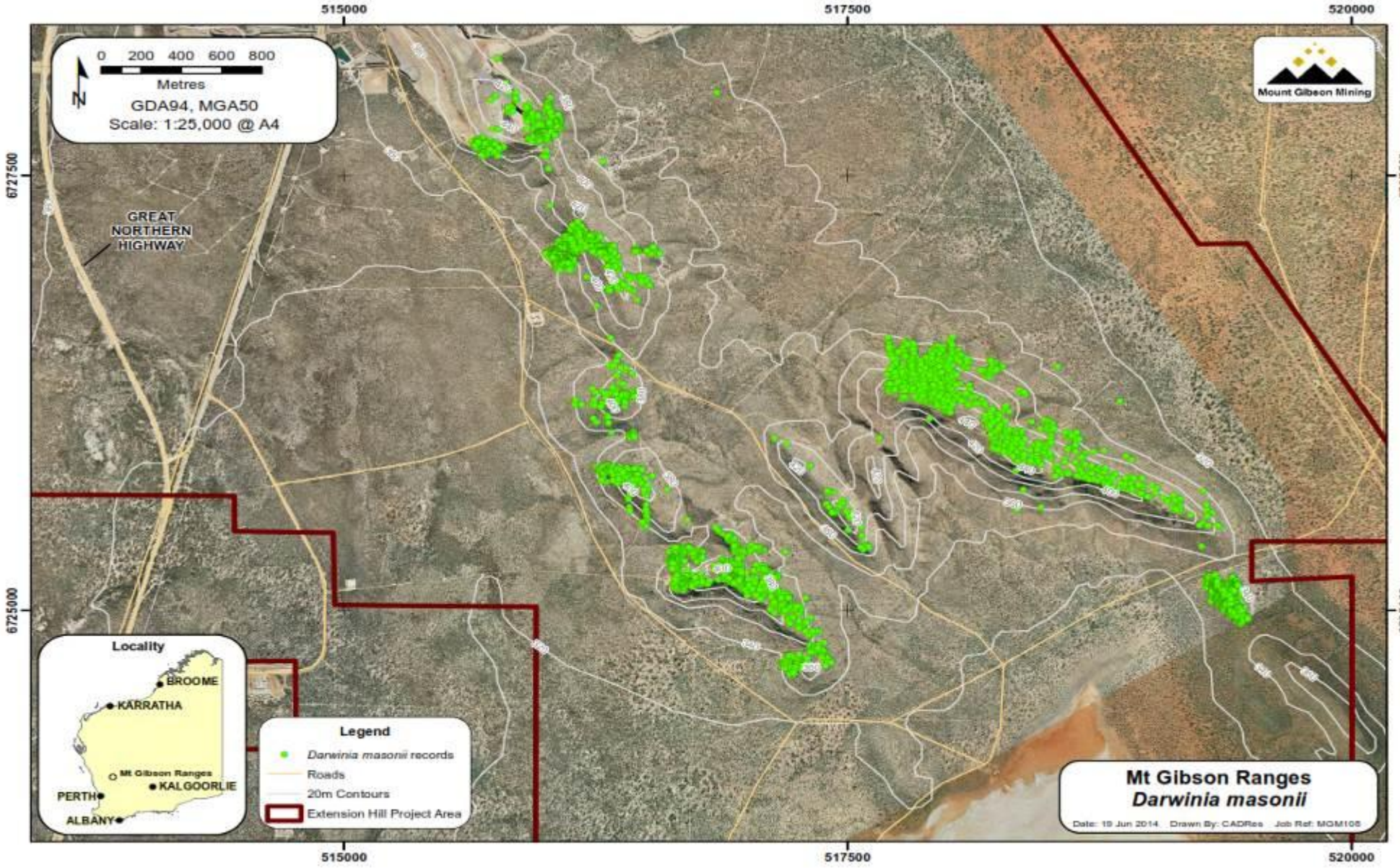

Figure 1: Occurrence of Darwinia masonii at Mt Gibson Range

1.3. Population Recent History

The Western Australian Department of Parks and Wildlife (**Parks and Wildlife**) have recently collated the data from numerous surveys into one database and identified ten groups of the *D. masonii* population, current records of which occur on Mt Gibson Range (Figure 1; Table 1).

To date, the most comprehensive survey of the population that has been fully reported was undertaken by ATA Environmental (2004). Discrete groups (also known as sub-populations) were based on the use of the Parks and Wildlife definition to delineate them (i.e. 500 m separation). Using this criterion, nine groups were recorded from the Mt Gibson study area during the ATA Environmental June and July 2004 field surveys. One more group has since brought the total number of groups of *D. masonii* to ten (Table 1). That tenth group was mentioned in the IRP (DEC, 2008) and first recorded in February 2008 on a granitic breakaway to the East of Extension Hill and at the base of a valley on granitic substrate, but was not listed at that time. The combination of the ten groups or sub-populations comprises the one known population of the species.

An old record indicated that *D. masonii* may have occurred on Mt Singleton, however this area is reported to have been searched with no occurrences of this particular *Darwinia* recorded.

1.3.1. Population Size

The size of the population when the IRP was prepared in 2008 comprised 14,315 mature plants (DEC, 2008). Using the most current data from established records for each Threatened and Priority Flora Database (**TPFL**) population (Table 1), the size of the *D. masonii* population is estimated as 13,169 mature plants. The available data indicated that the population had decreased which largely related to the approved MGIOIP and development of the mine pit to date.

Preliminary results from a census currently being completed indicates that the total number of plants has increased (R. Browne-Cooper, 2014; pers. comm. 20 June 2014). That latest regional survey and census, based on a desktop analysis of suitable habitat, is scheduled for completion before the end of winter 2014.

Table 1: Summary of plant records

TPFL Pop No.	IRP Pop No.	Date of first database record (database)	Broad location description	Take status	WA Herbarium Sheet (PERTH No.)	Quadrat monitoring site	Date of most accurate monitoring record (method)	Number of plants	Comment
1	6	01/01/1994 (TPFL)	Iron Hill South	Not taken	06874460	D4, D5, D6, D7, D8, D24	19/07/2004 (estimate)	1,601 (970) []	Majority of area was burnt in Jan 2003 wildfire and last census in 2004.
8	4	11/05/1995 (TPFL)	Iron Hill North	Not taken		D19	19/07/2004 (estimate)	586 (33) []	Majority of area was burnt in Jan 2003 wildfire and last census in 2004.
9	5	11/05/1995 (TPFL)	Iron Hill Middle	Not taken	06874509		19/07/2004 (estimate)	370 (597) []	Majority of area was burnt in Jan 2003 wildfire and last census in 2004.
2	2	11/05/1995 (TPFL)	Extension Hill	Partially taken - pit	07356595	D1	19/07/2004 (estimate)	1,924* (12) []	Last census in 2004
10	Not listed	12/2/2008 (TPFL)	E of Extension Hill South (~450m SE of TPFL pop 2)	Not taken			24/09/2013 (Partial survey, low quality) 12/02/2008 (estimate)	43 (0) [0] Several hundred	Partial survey, low quality in 2013
3	1	11/05/1995 (TPFL)	Extension Hill North	Taken	05313368; 06874495		Present	0 (0) [0]	This population has been taken
4	3	01/10/2003 (TPFL)	Extension Hill South	Not taken		D2, D3, D16, D17, D18	19/07/2004 (estimate)	1,874 (26) []	Last census in 2004.
5A, 5B	7	10/1950 (WA Herb)	Iron Hill East	Not taken	01005820; 01005382; 01005790; 01005367; 01005812; 01005359; 01005804; 01005855; 01005375; 01005839; 01005340; 01005847; 00137626; 00719536; 02521741; 02521733; 06796680; 01000691		19/07/2004 (estimate)	70 (11) []	Did not survey areas (majority) burnt by Jan 2003 wildfire during last census in 2004.
6A, 6B, 6C	8	28/07/1986 (WA Herb)	Mt Gibson	Not taken	07290810 04977025 (no det)	D9, D10, D11, D12, D21, D22, D23	19/07/2004 (estimate)	7,021 (61) []	Did not survey area burnt in Jan 2003 wildfire during last census in 2004
7	9	01/01/1994 (TPFL)	Mt Gibson South	Not taken		D13, D14, D15	04/12/2013 (actual)	837 (36) [1]	ATA (2004) recorded 325 in total

* This population has been partially taken. Approximately 1,702 plants have been removed for the hematite mine, which infers that the number of plants remaining may be 767.

() = number of seedlings/juveniles; [] = number of dead. All population data will be updated following a comprehensive population census to be conducted in winter 2014.

Plants related to past translocation trials are not recorded in the above table. These may account for approximately 100 to 200 plants.

1.3.2. Initial Information on Population Genetics

Certain genetic studies have been undertaken to examine population structure. Current findings and some of the potential implications including for future management are described below. BGPA (2010) reported on genetic research carried out on *D. masonii*. Two genetic surveys took place beforehand, with the initial survey based on 75 samples from individuals in four groups. The subsequent survey captured a larger sample size of 179 samples from individuals in six groups of *D. masonii* on the Mt Gibson Range. Deoxyribonucleic Acid (**DNA**) was extracted from the young leaf tips of the samples for genetic analysis.

Genotyping was also carried out on 401 samples from individuals in thirteen populations of *D. purpurea* and *D*. sp. Chiddarcooping (S.D. Hopper 6944). These are two species with which *D. masonii* is most closely related but their relationship remains unresolved. BGPA (2010) concluded that "they are closely related and possibly speciated allopatrically, through isolation and subsequent adaptation of a previously widespread species."

There was low genetic differentiation demonstrating weak population structure between the seven *D. masonii* groups. Analysis of Molecular Variance (**AMOVA**) partitioned 94% of the variation within the groups, and 6% between groups. However, pairwise permutation tests between each of the tested groups showed that there is genetic distinction (a departure from random mating) between some of the groups (Table 2). Two groups (TPFL no. 4 and 7) were statistically different and were therefore interpreted as being genetically isolated from each other and all but one or two of the other tested groups. These TPFL's are located on Extension Hill South and Mount Gibson South. The testing also showed genetic isolation between certain other groups. Various theories were put forward as potential reasons for this genetic isolation including: groups being disjunct; age of the population since fire causing the DNA analysis from that population skewed by older samples; and differential selection at loci linked to some microsatellite markers. As a result of this finding, BGPA (2010) recommended that genotypes of respective groups should not be mixed in restoration activities.

Darwinia masonii shows no indication of inbreeding depression due to past bottlenecks in the population (BGPA, 2010).

Table 2: Statistical significance* of sub-population differentiation in *Darwinia masonii*

Groups							
A	**B**	**D**	**E**	**F**	**G**	**MW**	
	S	S	**S**	S	NS	NS	**A**
		NS	**S**	**S**	NS	NS	**B**
			S	**S**	S	NS	**D**
				S	**S**	**S**	**E**
					S	**S**	**F**
						NS	**G**
							MW

*(**S** – significant at p< 0.001, S – significant at P < 0.005, NS – not significant)

Group codes – A: Mt Gibson, B: Iron Hill, D: Extension Hill, E: Extension Hill South, F: Mt Gibson South, G: Iron Hill East, MW: between Mt Gibson and Iron Hill East

Results of a more recent assessment of the genetic survey of *D. masonii* indicate a weak genetic structure in the nuclear microsatellite data, with some of the groups listed in the IRP exhibiting isolation-by-distance (M.

Barrett 2013, pers. comm., 16 December). A determination of the discrete nature of groups for conservation, in the light of these findings, is yet to be determined for the known population.

1.3.3. Human Influenced Impacts on Population Occupancy and Extent of Occurrence

MGM and EHPL have Ministerial approval to take approximately 2,100 mature plants or 15% of the total number of plants recorded during the ATA Environmental (2004) survey of the Mt Gibson Ranges which is inclusive of all plants within the approved footprint (MS753). A total of 1,702 mature individuals have been removed to date. Plants in the immediate vicinity of mining activities are at greater risk of potential secondary impacts (addressed in Section 3.1.2).

Plants grown from clones of the genotypes from the mine footprint and established in two translocation trials may also persist at the locations of previous studies. The fenced plot established at Iron Hill East for the trial investigating the effects of irrigation and herbivores was re-visited in March 2014 and 168 plants (81% of the original number) within the fenced plot were still alive, despite having not been watered for 7 years (J. Sackmann 2014, pers comm., 6 May). There may also be plants present at the site of the other translocation trial.

A research program also involved translocation trials in areas of differing soil types (BGPA, 2010). There were mixed survival rates recorded in those trials. Also the effects of a controlled fire on *D. masonii* were also studied with an assessment of seedling recruitment occurring over the following winter. Unfortunately a period of drought conditions post trial planting resulted in low seedling survival rates (BGPA, 2010).

2. Habitat Critical to Survival of the Plant Species

This taxon is listed as Vulnerable under the World Conservation Union (IUCN 2001) Red List. As a result of its IUCN conservation status, emphasis is placed on the known habitat which is critical to the survival of the plant species, as well as, any successfully rehabilitated populations. The habitat where *D. masonii* grows was described by Brown et al. (1998) as tall shrublands on yellow-brown clay loams on the Banded Ironstone Formations or granite breakaways. ATA Environmental (2004) targeted surveys recorded *D. masonii* from eight vegetation communities. These were previously identified and mapped by Bennett Environmental Consulting (2000) and described in Section 1.1.4.

Research conducted by BGPA (2010) further refined and characterised suitable habitat. BGPA (2010) broadly defined the habitat requirements and found that suitable habitat that could be critical to the long term health and survival of *D. masonii* was more extensive than the currently known areas of occupancy. In addition, translocation trials supported the broad habitat characterisation by demonstrating significantly higher survival rates of translocated plants in suitable habitat versus those planted in unsuitable habitat and was demonstrated on the Mt Gibson Ranges as well as under nursery conditions.

The model considered geology from the Mt Gibson Iron Deposit Geological Plan, fire history using satellite and air photo imagery (1969 to 2007), and solar radiation receipt, aspect, slope, curvature and elevation using a 1 m interval contour map (BGPA 2010). Slope alone made up approximately 80% relative contribution to the models prediction, with geology (1.7%), elevation (15.4%) and summer midday solar radiation (1.4%) making up the rest of the relative contribution. The model showed that *D. masonii* has a habitat preference to slopes over 7-8 degrees, elevation over 380m and all geology types (except 14 and 99: white rock, footslopes, saddles; areas that were not slopes and ridges were not included in the mapping) (BGPA 2010).

Habitat that appears critical to the survival of *D. masonii* includes a range of land categories and types, which show:

- the current area of occupancy of the population (**Figure 1**),
- suitable habitat surrounding the known population (i.e. potential habitat for future population expansion) (as generally depicted in **Figure 2**), and
- suitable habitat that may contain undiscovered specimens.

Furthermore, there may be other potentially important land in the region with suitable habitat (such as slope and rugosity, regolithy, midday solar radiation) that, even though it may not contain a population of the species, may be suitable for occurrence and/or translocation programmes in the future.

It is not evident whether or not local catchment areas, which are known to influence the surface and/or groundwater, have any influence on the physical quality of habitat of the species.

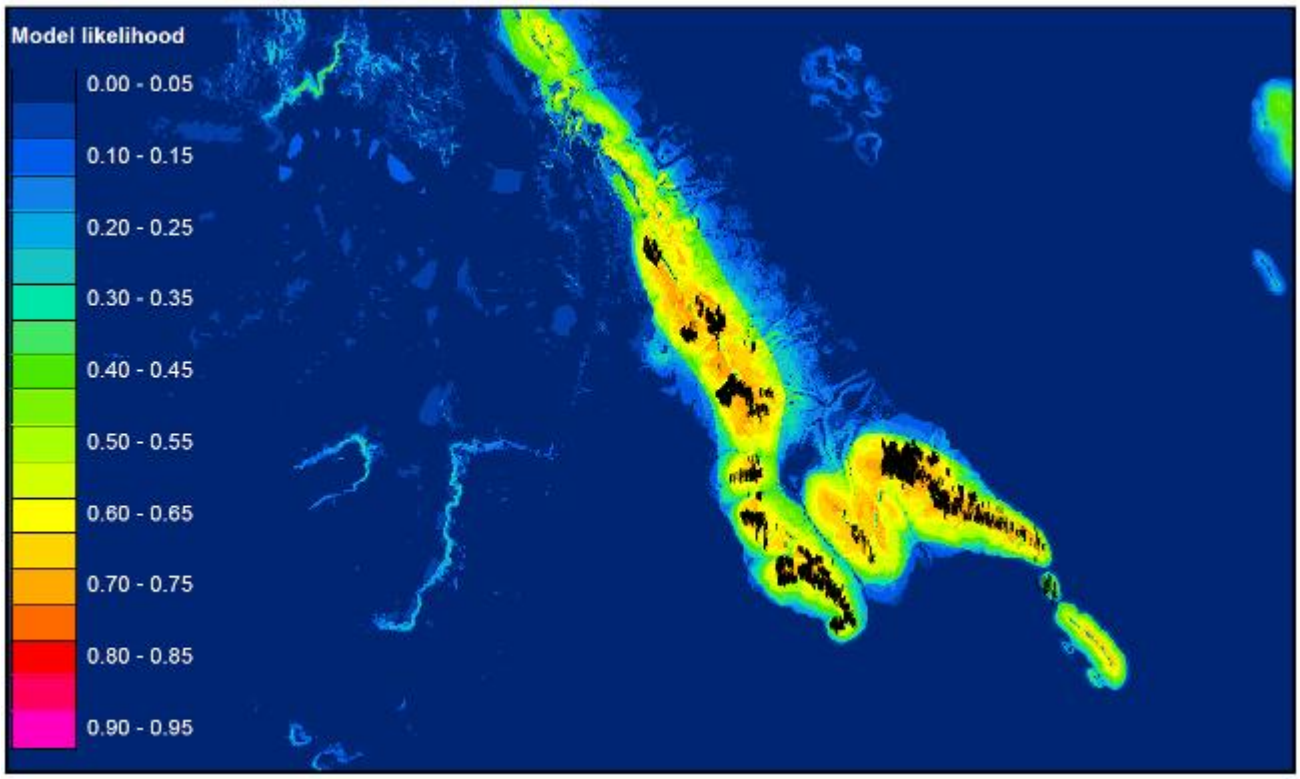

Figure 2: Modelled distribution of *D.masonii* habitat across the Mt Gibson ranges

3. Threatening Processes

Specimens within *D. masonii's* current geographic range may be subjected to the following identified threats. Anthropogenic threats have mitigations and controls that may be readily applied; but less so for natural stressors such as natural fire; drought and effects from drying climates. Failure to address significant threatening processes listed below may contribute to uncontrolled declines in distribution and abundance of the species.

3.1. Recognised Potential Threatening Processes

Potentially threatening processes may have effects in different times and different parts of the species range during its lifecycle. MGM and EHPL have direct influence over threats stated in sections 3.1.1, 3.1.2, 3.1.4, 3.1.5 and 3.1.6.

3.1.1. Mining and Infrastructure Development (MGIOIP)

The majority of the known habitat for *Darwinia masonii* comprises ironstone formations. The current MGIOIP approved Proposal (MS753) entitles up to approximately 2,100 adult plants of *D. masonii* being taken, which represents approximately 14 % of the population known as of June 2008.

If future mining and exploration operations are proposed and approved by government (as approved proposal(s)), then they may have the potential to clear *D. masonii* during ground disturbance. Any such impacts will need to be assessed and approved in the normal government approval processes, which provides opportunity to regulate the proposal through the conditions imposed on the approval. Ground disturbance may be mitigated by restoration activities; surveys to increase the knowledge about species abundance, area of occupancy and/or extent of occurrence; land rehabilitation; and, translocation programs.

3.1.2. Mining Activities (Secondary Threats)

It is possible that specimens at Extension Hill South and Iron Hill North may be at some risk from secondary threats of mining (DEC, 2008) because certain plants are adjacent to mining operations. . The mining operations occurring as part of the MGIOIP are subject to conditions that specifically regulate the operation with a view to minimising these impacts. If other mining operations are proposed and approved, there is opportunity for similar regulation to apply.

Possible secondary threats include dust, inadvertent disturbance such as cracking of rock faces, negative effects on pollinator activity arising from habitat disturbance, and other potential effects on reproductive biology that may be shown to lead to a decline in plant health or recruitment. To address this potential threat, plant health and emissions monitoring is used to indicate effects and further adaptive management actions may be applied as needed. Additionally, further management of this threat, if found to occur, may be through mine site corrective actions and/or restoration activity, such as land rehabilitation and plant translocation programs.

3.1.3. Extent of Habitat

Based on historical and current survey data, *D. masonii* generally appears to be restricted to the slopes and ridges over the length of the Mt Gibson Ranges. While this is strictly not a direct threat, it may magnify the effect of other threats should they occur. However, the IRP (DEC, 2008) also recorded the presence of specimens on a granitic breakaway to the East of Extension Hill and at the base of a valley on granitic substrate. This may have positive implications for other prospective habitat and a possible wider occurrence; and use of this type of area for future plant translocations, if needed.

3.1.4. Weed Populations

No significant weed populations had been observed at the time of the publication of the IRP (Parks and Wildlife, 2008) and known as of June 2014. Weeds, should they profilerate in the future, may be a potential threat to habitats that support *D. masonii*.

3.1.5. Fire

Darwinia masonii is long-lived and killed by fire (Paul Armstrong and Associates, 2004; BGPA, 2010). Regeneration of *D. masonii* is restricted exclusively to germination from seed held in long-lived soil-stored seedbanks (BGPA, 2010). The majority of plants arising from seed germinate in a single cohort post-fire. Furthermore, the youngest age that seedlings have been recorded flowering is at 6 years (except under nursery conditions or when supplemented with a watering regime), but flower number at this age was very low. Large old plants with wide canopies produce the most flowers. Therefore, fire occurring too frequently within habitat colonised by *D. masonii* threatens the long term survival of the taxon.

3.1.6. Potential Grazing Effects

Parks and Wildlife (2014) reported that only very minor grazing pressure from feral goats and rabbits had been observed at the time of publication of the IRP (DEC, 2008). Grazing is a potential threat to *D. masonii*.

3.1.7. Reduced Genetic Diversity

Results of more recent assessment of the genetic survey of *D. masonii* indicates a weak genetic structure in the nuclear microsatellite data, with the groups listed in the IRP exhibiting isolation-by-distance (M Barrett 2013, pers. comm., 16 December). Nearly all groups show unique chloroplast haplotypes, suggesting that seed dispersal is limited, and may have been for a considerable time. These recent findings imply that genetic diversity may be reduced if groups are impacted due to other threats.

3.1.8. Change to Ecosystem Processes

Darwinia masonii is recorded to be pollinated by the bird species, the White-fronted Honeyeater (*Phylidonyris albifrons*) (BGPA, 2010). The role of birds in pollination is apparent. The maintenance of adequate habitat for this and potentially other bird species will factor into the conservation of *D. masonii*. Further details on pollination mechanisms are given in Attachment 1.

3.1.9. Seed Predation

Predation of *D. masonii* seed (by larvae of an unidentified moth species) can be significant (BGPA, 2010), and, when measured, was recorded to vary from 6% to 22%. This has implications for rates of seed production and its quality.

3.1.10. Drought

Mortality among mature (last burnt on or before 1969) *D. masonii* plants is rare over periods of average rainfall. Seedlings and young plants are more susceptible to death during drought conditions than mature plants. BGPA (2010) reported that only 9% of the seedlings which were tagged within recruitment plots of an experimental fire in 2009 were still alive when these plots were revisited in October 2010. They stated “this low survival rate may partly result from the drought experienced over the 2010 winter at Mt Gibson, as well as a likely high failure rate of establishing young seedlings” (p43).

3.1.11. Climate Change

Based on the potential effect of individual droughts (Section 1.3.9), there may be implications for the size of groups if climate change results in increased drying or a greater frequency of dry years in the region (BGPA, 2010).

4. Objective and Recovery Criteria

4.1. Objective of the Plan

This plan guides the recovery of *D. masonii* for the life of the MGIOIP. The overall objective of the Recovery Plan is to maintain or improve the conservation status of *D. masonii* such that its conservation status is more secure in the Mt Gibson area.

MGM and EHPL will implement the management actions set out in section 5.2 of this plan with a view to making a contribution (along with the work being done and to be done by government departments, tenure holders and others) towards achieving the objective of this Recovery Plan.

The Recovery Plan will be implemented through:

- adoption and implementation of specified management actions;
- identifying habitats critical to the long term survival of the species;
- applying relevant mitigations to known threats to the species;
- promotion of research that supports the management or recovery of the species; and,
- assessment against the specified recovery criteria.

4.2. Recovery Criteria

Five levels of recovery are defined in Table 3 to measure progress towards achievement of the objective of this Recovery Plan. The criteria presented are based on 1) Plant abundance, 2) Plant distribution or its area of occupancy, and 3) IUCN category.

This Recovery Plan will be meeting its objective if any classes of “Yellow” or above are attained.

If the Criteria for Caution (“Amber” light) are met while the MGIOIP is operating, MGM and EHPL will review this Recovery Plan, and its associated management actions.

In the event of a significant fire event, it is expected that population numbers will initially decrease due to death. However, it is anticipated that the population will then increase in time to a number greater than the pre fire population due to abundance of seedlings, but will eventually resume similar to status to the pre-fire population abundance. The timeframe will be taken into account when conducting a post fire population census to avoid over- or under-estimating the recovery success or failure. Prolonged periods of drought may also result in unavoidable reduction in population abundance and/or areas of occupancy. Should either of these distinct natural events occur the *ex situ* conservation material might be used to aid species recovery should natural processes not account for its recovery.

Table 3: Classes and criteria for assessing the recovery plan

Criteria for excellence – Class "Blue light"
The conservation status of the species improves on the status set out on page viii of this plan; and "Green light" status
Criteria for success – Class "Green Light"
The abundance of plants in areas outside of approved Proposal(s) shows a statistical trend of a significant increase over the Plan's term; the extent of the population increases by 25% or more above the number of adults described in Table 1; and "Yellow" light status
Criteria for status quo – Class "Yellow light"
The abundance of plants in areas outside of approved Proposal(s) remains stable# (that is equal to the number of adults in Table 1); and, The conservation category of the species remains at the status set out on page viii of this plan.
Criteria for caution – Class "Amber light"
The abundance of mature plants in the population has statistically decreased by more than 20% below the census number of adults in Table 1; or, There is a statistical trend showing at least a 20% reduction in the known area of occupancy of *D. masonii*.
Criteria for failure – Class "Red light"
The conservation status meets IUCN criteria for listing at a higher threat category than the status set out on page viii of this plan.

Stable means 'original population total abundance (ATA, 2004) plus or minus fifteen percent'. Current insight is that population numbers naturally vary over periods of years, so it is expected to naturally vary within the term of this Plan.

Should classes yellow or above not be met against criteria in Table 3, the management actions and tasks of this Recovery Plan will be reviewed and revised in accordance with Condition 6-7 (MS753).

4.3. Roles and Responsibilities

Implementation of the plan will rely on the management actions and responsibilities of a number of key parties who interact in the recovery of the species through collaboration of some management actions.

MGM and EHPL

The proponents of the MGIOIP have a responsibility to undertake (or to engage suitably qualified consultants to undertake) the specified management actions relevant to the species on the mining tenements and to manage the threats stated to be associated with implementation of the MGIOIP. The proponents will be partly responsible for implementation of a number of recovery actions as specified in section 5.2.

Because of established interactions with parties based on IRP No 282, MGM and EHPL anticipate collaborative contributions that can be made as follows.

Parks and Wildlife

The Department of Parks and Wildlife (Parks and Wildlife) is responsible for administration and enforcement of the *Wildlife Conservation Act 1950*, and the *Conservation and Land Management Act 1984* and undertake a range of activities in relation to identifying, conserving and protecting threatened flora and fauna. Parks and Wildlife may adopt responsibility for implementation of a number of recovery actions as specified in section 5.2 and 5.3, including monitoring of the implementation and performance of the Recovery Plan itself.

Department of Environment

The Department of Environment (DoE) is responsible for administration and enforcement of the *Environment Protection and Biodiversity Conservation Act 1999*. The DoE may liaise with Parks and Wildlife in Geraldton and the WA Environmental Protection Authority about the suitability and implementation of the plan.

Botanic Gardens and Parks Authority (BGPA)

BGPA was contracted to MGM and EHPL to undertake research into the species as per the Conservation and Restoration Research Proposal for *Darwinia masonii* and *Lepidosperma gibsonii*.

Geraldton District Threatened Flora Recovery Team (GDTFRT)

The role of the GDTFRT, which is a non-statutory association of stakeholders committed to the recovery of threatened species, is to support in coordinating the recovery of threatened flora in the Parks and Wildlife, Geraldton District. The GDTFRT may play a role in implementing certain actions where possible.

5. Management Actions for Recovery

5.1. Outcomes from Implementation of the Interim Recovery Plan Actions

This section describes some of the key outcomes of the management actions previously adopted under the Interim Recovery Plan (No. 282). Past and existing management actions are examined and assessed here as to inform the future management actions set out in this Recovery Plan in Section 5.2.

A Conservation Officer was employed at the Department of Parks and Wildlife using funding provided by MGM and EHPL in August 2013 in accordance with the requirements of Offset 4 of Condition 16 of MS753. Among other roles, this officer has the responsibility to assist with "the development and implementation of the interim and full recovery plans; and, coordinating the managing of threatening processes in relation to *D. masonii*.

5.1.1. Research to Date

After the issue of MS753, EHPL and MGM funded a three year research programme, which was undertaken by BGPA, on *D. masonii* to facilitate the continued improvement in the conservation status of *D. masonii* over time and inform the development of this Recovery Plan. The monetary value of the research programme was $1.32 million (to date). The research programme addressed the objectives of Condition 6.1 of MS753 and included studies of:

- conservation genetics;
- population demography;
- breeding biology;
- population viability analysis;
- environmental interactions and plant health;
- restoration and translocation; and,
- *ex situ* conservation.

The research program was completed by BGPA and submitted to MGM and EHPL in October 2010 in the form of a report entitled "*Darwinia masonii* and *Lepidosperma gibsonii* Conservation and Restoration Research. An integrated research program into the ex situ and in situ conservation, restoration and translocation requirements of *Darwinia masonii* and *Lepidosperma gibsonii* May 2007 – June 2010". The major findings and recommendations of this research have been incorporated into the relevant sections of this recovery plan.

Further research topics are considered in Section 5.3.

5.1.2. Management of Secondary Threats of Mining

Management by MGM and EHPL of the non-mining areas occurs on the tenements generally but specifically in areas that include the *D. masonii* population. This management framework has developed in consultation with other parties to the Plans and is consistent with environmental legislation and regulatory framework including Department of Environmental Regulation.

An Environmental Management Plan (**EMP**) was developed using a risk based approach to ensure significant environmental factors were protected from potential threats with a high inherent risk rating. The EMP and associated procedures (used for operational risk management) detail site management actions aimed to control emissions and secondary threats (i.e. inadvertent disturbance, excessive dust deposition, fire, altered hydrology and weed invasion) from mining on *D. masonii*. Mitigation actions identified to reduce threats with a high inherent risk rating to an acceptable residual risk rating include, but are not limited to, the following:

- weed management procedures;
- dust management procedures;
- fire management procedures;
- feral animal management procedures; and
- staff inductions and training.

The EMP was approved in accordance with requirements of MS753, and is currently being implemented. The EMP and associated procedures operate in areas under the control of MGM or EHPL, generally defined by the active mining area and the broader mining tenements.

5.1.3. Fire Management

The Environmental Management Plan (MGM and EHPL, 2008) and associated fire management procedures have been presently adopted and used by MGM at the mine site to-date. Fire management actions, aimed at reducing the risk of unplanned fires resulting from mining activities, include:

- no smoking within 10 metres of bushland rules;
- hot work permit system;
- dangerous goods handling and storage practises;
- housekeeping practices and regular inspections to prevent build-up of rubbish or flammable materials;
- training of emergency response personnel in fire fighting;
- procurement of site based fire fighting equipment;
- vehicle maintenance safety checks to reduce fire hazards,
- fire suppression systems on selected plant and equipment;
- regular fire break maintenance; and
- liaison with neighbours and DFES with regard to bushfires (MGM and EHPL, 2013b).

5.1.4. Grazing Pressure on *D. masonii*

The number of goats on pastoral leases has been reduced in recent years as a result of economic, and environmental reasons. The grazing effect have been assessed based on significantly lower numbers of goats in comparison to historical grazing pressures. Grazing by introduced animals (goats and rabbits) has been assessed as part of plant condition monitoring of *D. masonii* (see Section 5.1.5). Since the time when mining activities started, grazing has not been observed to have a significant effect on plant health or abundance.

5.1.5. Plant Condition Monitoring

The condition of *D. masonii* plants have been monitored since 2007. Parameters monitored include plant height (or length), reproductive status, plant age, plant condition and seedling recruitment and mortality. In addition ambient dust monitoring is undertaken by MGM on a monthly basis to determine if there is any correlation between dust deposition on *D. masonii* plants and their respective condition (i.e. plant health). Eleven dust deposition gauges are monitored in the locality of the Mt Gibson Ranges. The dust deposition

gauges also ensure fugitive dust levels do not exceed the standard: less than 4g/m^2/month of insoluble solids generated by mining activities in the vicinity of *D. masonii* plants (MGM and EHPL, 2008).

Annual plant condition monitoring reports provide a summary of the findings. However, detailed statistical analysis has not been conducted to date due to insufficient data. Statistical analysis of plant condition monitoring data is now planned with at least three years of data collected from the start of mining.

TPFL population 4 is located closest to mining activities on Extension Hill South and is monitored by MGM to assess detectable changes in condition prior to evidence of acute stress or mortality. TPFL population 6 is located on Mt Gibson away from mining activities and is monitored as a control for comparison. At each plot, a photograph is taken, and plants are given a health score.

5.1.6. Plant Demographic Monitoring

Permanently marked plots are currently established. Annual collection of demographic data from *D. masonii* plants in all permanently marked plots are taken; these individual plants are tagged and measured as follows: survival and health score, recruitment (new plants are tagged and recorded as found), and evidence of herbivory are recorded. Information is also collected relating to infructescence production, new seedlings and growth of young plants.

5.1.7. Translocation Trials

BGPA (2010) described biotic and abiotic environments and habitat requirements for *D. masonii* and used a species distribution model to identify localities for possible *D. masonii* translocation sites (see Sections 1.2.2 and 1.2.3). They concluded that of the environmental parameters interrogated by distribution modelling for *Darwinia masonii*, slopes over 7-8^o, elevation over 380m and all but one of the geology types within the Mt Gibson Ranges were the principal environmental parameters predicting the distribution of D. masonii. The modelling predicted *D. masonii* to occur broadly across the Mt Gibson ranges with a high probability (60-75%) of occurrence (BGPA, 2010). Further research may determine whether the distribution of D. masonii may also be limited by other factors such as regolith (soil depth, underlying rock structure) and fire history patterns.

In situ planting methods using cuttings were trialled on four differing soil substrates (BGPA, 2010; and see Section 1.2.3). Plantings were successful on BIF rock and BIF gravel sites, and texture, gravel/rock content, patterns of moisture content and Total Nitrogen may be the key soil properties to consider in selection of translocation sites. Plants on clay and sand to the east and west of the Mt Gibson Ranges, respectively, were not successful for growth. Further research was recommended by BGPA (2010) to investigate variation of composition of BIF rock and BIF gravel substrate, and varying degrees of soil depth and rockiness.

Irrigation during establishment of translocations may improve growth and survival of seedlings. A preliminary planting trial of 206 *D. masonii* plants grown from cuttings and planted in a ripped drill pad at Iron Hill East, was fenced to exclude herbivores and irrigated for an hour at a time twice a month over the first two summers. Twenty additional plants were planted outside of the fenced irrigated area. Only two of the original twenty ‘unwatered’ plants survived to 2010, while 89% of the watered plants survived for the same period. Half of the plants within the watered plot flowered within their first year, and all had tripled in size in the first 18 months after they were planted. This plot was re-visited in March 2014 and 168 plants (81%) within the fenced plot (previously watered) were still alive, despite having not been watered for 7 years (J. Sackmann 2014, pers comm., 6 May). The plants outside the fenced area had died, however a new seedling was recorded outside the fenced plot too (J. Sackmann 2014, pers comm., 6 May).

Figure 3: 2014 photograph of several living and dead *D. masonii* plants

Establishing Seed/Germplasm Collections

Darwinia masonii has been successfully cultivated, and a stock of 122 genotypes from the Extension Hill mine footprint is stored in cultivation at Nuts About Natives (NAN), a specialist native plant nursery. Cuttings were collected (under DRF collection permits held by EHPL and BGPA) from 300 genotypes of *D. masonii* from within the mine footprint on Extension Hill and transported to NAN in October 2008. After three months, 12% of the total cuttings (385 *D. masonii* cuttings) from 50% of the genotypes (150 different genotypes) had successfully initiated root growth. In March 2013, it was reported that a stock of 122 genotypes of *D. masonii*, were still maintained at Nuts about Natives (J Sackmann 2013, pers. comm., 23 September). It is likely that a few of these genotypes have been lost since the last recording and those remaining will be reported in 2014 (B. Croxford 2014, pers. comm., 27 January).

The intention of the germplasm collection was to create and maintain clones of *D. masonii* genotypes as tube stock in two collections, with three clones of each genotype in each collection. However, some clones have not grown well and it has been necessary to pot up and maintain plants as new cuttings have not always been successful or numbers are low (B. Croxford 2014, pers. comm., 27 January). The plants and clones are kept on unshaded external benches, regularly monitored, and watered at moderate intervals. The genotypes are subcultured annually from the parent stock. Flowers from the clones have been manually removed and disposed of before maturation, but some did reach maturation in 2013, and the seed has been collected and stored on site (B. Croxford 2014, pers. comm., 27 January). At present, clones in excess of those required for maintenance of the genotypes are disposed.

Collections of seed and germplasm have been reported by BGPA (2010). MGM and EHPL have requested information relating to the current status and location of seed. This information will be forthcoming in the near future. Accurate records will be maintained by MGM, EHPL, and Parks and Wildlife.

5.1.8. Conduct Surveys and Report any New Occurrence of *Darwinia masonii*

The population of *D. masonii* stated in the IRP as having recently been found on a granite breakaway to the East of Extension Hill and at the base of a valley on granitic substrate has been included in this Recovery Plan as TPFL population 10 (Table 1). As the size and extent of this population has not yet been fully surveyed, it will be surveyed as part of the population census of *D. masonii* which is underway as of June 2014.

A broader regional survey for *D. masonii* is scheduled to be undertaken and completed in winter 2014.

Figure 4: 2014 photograph of *D. masonii* seedling on Mt Gibson

5.1.9. Review IUCN Ranking of the Species and Need for a Full Recovery Plan

Parks and Wildlife have reviewed the relevance and effectiveness of the IRP in the latest 2014 *Darwinia masonii* Review Paper (Parks and Wildlife, 2014).

Surveys relating to the occurrence and abundance of *D. masonii* are currently underway. New records, including population area of occupancy and total abundance, will be used to inform a review of the IUCN ranking of the species.

There are early indications that the total number of individuals (R. Browne-Copper; pers.comm; 20 June 2014) is greater than those of the last population census conducted by ATA (2004). Potential reasons for this include:

- Natural fluctuations in population sizes;
- Effective environmental management to reduce the risk of secondary threats from mining (Section 5.1.2);
- Effective fire management procedures since the time of mining (Section 5.1.3);
- Historical reduction in grazing pressures (Section 5.1.4);
- Additional populations found (Section 5.1.9); and
- Success of a translocation trial (Section 5.1.7).

5.2. Management Actions for Recovery

This section describes the management actions that MGM and EHPL will undertake to meet condition 6-3 of MS753. They have been informed by the outcomes of the research and the IRPs implemented to date (as summarised in Section 5.1).

MGM and EHPL are required to manage secondary threats from mining and threats of fire to *D. masonii* through the conditions that apply to the MGIOIP under MS753. The management actions below will be undertaken alongside those obligations that already apply under MS753.

MGM and EHPL will consult with and seek advice from Parks and Wildlife and other entities during implementation of the management actions for *D. masonii*. MGM and EHPL will also seek assistance from the officer at Parks and Wildlife that it is funding (as set out in the schedule of MS753) to assist with implementation and review of this recovery plan and to coordinate management of threatening processes for *D. masonii.*

Budget allocations relating to management actions are listed in **Attachment 2**.

Parks and Wildlife have informed MGM and EHPL that as part of their broader conservation objectives, they will:

- coordinate recovery actions for *D. masonii* that are occurring more broadly (and independently of MGM and EHPL) and liaise with all stakeholders.
- summarise the achievements and progression of all recovery actions for *D. masonii* and include a report in an annual reports to Parks and Wildlife's Corporate Executive and funding bodies.
- promote awareness of *D. masonii*.
- provide assistance to MGM and EHPL as requested.

These above actions are not actions that are the direct or sole responsibility of MGM and EHPL. Sections 5.2.9 – 5.2.10 outline management actions and responsibilities assigned to parties other than only MGM and EHPL. The proponents take responsibility for implementing those actions in Sections 5.2.1-5.2.8.

5.2.1. Implement *D. masonii* Condition Monitoring Programme

MGM and EHPL will implement a program for *D. masonii* condition monitoring as described in Section 5.1.5. Key monitoring parameters would include: survival, recruitment (new plants should be tagged and recorded as found), health, herbivory, infructescence production, appearance of new seedlings, and growth of young plants.

The condition of *D. masonii* specimens will be monitored for effects from excessive dust deposition, and other potential threats such as grazing by introduced or native animals and weeds. In addition, dust monitoring will be undertaken on a monthly basis in a fixed number of permanent quadrats to assess for evidence of dust deposition on *D. masonii.* Representative plants closest to the mine (i.e. Extension Hill South as a putative impact sites) will be monitored monthly to assess any changes in condition prior to evidence of acute stress or mortality. Fixed specimens in groups located further away from the mine (at Mt Gibson as reference sites) will also be monitored monthly for comparison with the data collected from Extension Hill South. The results of the monitoring program will be used to assess the effectiveness of management actions.

Tasks would include:

- On-going monitoring of tagged plants in established plots (refer MGM and EHPL 2013; Annual Compliance Report). A representative subset of 715 individual plants will continue to be monitored in detail on an annual basis.
- On-going monitoring of plants in 'fire' plots.

Action: Undertake condition monitoring and report annually.

Timing: Annually (September – November each year) and monthly as described above

Commencement date:	2014 and ongoing
Completion date:	life of MGIOIP

5.2.2. Implement Fire Management Strategy

MGM and EPHL are required to manage secondary threats from mining and threats of fire to *Darwinia masonii* through the conditions that apply to the MGIOIP under MS753. The management actions below will be undertaken alongside those obligations that already apply under MS753.

Timing: ongoing for life of MGIOIP

Commencement date:	2014 and ongoing
Completion date:	life of MGIOIP

5.2.3. Manage Risks from Secondary Threats of Mining

The size and condition of the *D. masonii* population may be affected by secondary threats including excessive dust deposition on plant surfaces, introduction or spread of weeds, unauthorized access causing ground disturbance and altered hydrology.

MGM and EPHL are required to manage secondary threats from mining and threats of fire to *Darwinia masonii* through the conditions that apply to the MGIOIP under MS753. The management actions below will be undertaken alongside those obligations that already apply under MS753.

Timing: ongoing for life of MGIOIP.

Commencement date:	2014 and ongoing
Completion date:	life of MGIOIP

5.2.4. Manage the Effects of Grazing on *D. masonii*

As of 2014, minimal grazing pressure has been observed to date. In the event that grazing pressure significantly affects the health of *D. masonii*, the feral animal population will be controlled on the mining tenements as set out below. Any measures to reduce grazing pressures by feral animals will be to the benefit of *D. masonii* as well as the broader ecological community in the region.

Tasks would include:

- Identify effects of grazing on *D. masonii* (refer Section 5.2.1);
- If significant impacts to *D. masonii* plants are observed then implement goat and/or rabbit control programs.

Action: If the plant condition monitoring referred to in section 5.2.1 demonstrates that grazing is having an adverse impact on the *D. masonii* population on the mining tenements, MGM and EHPL will implement an appropriate feral animal control program within the Mt Gibson Area.

Commencement date:	2014
Completion date:	life of MGIOIP

5.2.5. Maintain and Use Seed/Germplasm Collections

Seed/germplasm collections with a broad genetic base should be made available for on-going ex situ conservation and for future use in restoration programs.

In vitro culture and cryostorage are options for long-term storage of key clonal germplasm if required (BGPA, 2010). *In vitro* culture has successfully been achieved for this species (BGPA, 2010). This may be a necessary option if the IUCN status changes as a result of the identified threats in Section 3.

However, in the short-medium term, propagation of live *D. masonii* plant material from wild collections and nursery stock may pose a cost-effective approach for storage as well as production of new plants for restoration purposes. Maintenance of the *D. masonii* germplasm collection, particularly from those plants which have been cleared for the MGIOIP footprint, should continue until such a time as viable plants are re-established from these collections. Multiple (>100) genotypes of live plants (BGPA, 2010) should be maintained, monitored and supplemented in the mid-west region to represent each of the groups (TPFL 2 and 3) cleared during mining activities under MS753.

A review of the seed held in storage, its quality, and the groups from which it originates, is necessary. Collection of seed from groups which do not have representations of seed, or seed of good quality, will be necessary with the aim of maintaining an adequate supply of seed in storage for each of the groups of *D. masonii*.

Tasks would include:

- Collate and annually check records of retained seed stock in storage (2014).
- One-off test of retained seed stock in storage (2015)
- Targeted seasonal collection of seeds from key Mt Gibson Ranges groups (mid-November) including those which do not have seed representation (late Spring 2015-2016).
- Propagation of live *D. masonii* plants from wild collection seedstock (2015-2017).
- Provision of nominated seed samples to Parks and Wildlife (2014-2017)
- Review adequacy of ex situ collection to inform future actions (2017)

Action: Maintain adequate seed/germplasm collections

Timing: Applicable seasonal timing for germplasm collection and handling

Commencement date:	2014
Completion date:	2017 initially**;** life of MGIOIP as required

5.2.6. Report Existing and any New Occurrences of *D. masonii*

MGM and EHPL will report to Parks and Wildlife any new plants of *D. masonii* that MGM and EHPL may purposefully or opportunistically find, in accordance with the Threatened and Priority Flora Report Form to ensure Parks and Wildlife have accurate data on the species.

Tasks would include:

- Complete plant population census survey of Mt Gibson Ranges and immediate surrounds (2014).
- Undertake a dedicated regional survey of plant occurrence on ironstone and granitic ridges within a 50 km radius of Mt Gibson Ranges (2014).
- If the population is estimated at 'Amber light' (or lower class), conduct plant population census within one year and at a rate of every three years; otherwise a rate of every five years.
- Report opportunistic observation of any 'new' plant occurrence to Parks and Wildlife.

Action: MGM and EHPL to monitor the abundance of *D. masonii* and report any new occurrences to Parks and Wildlife.

Commencement date:	2014
Completion date:	life of MGIOIP

5.2.7. Plant Translocation and Population Restoration Planning

BGPA modelled the distribution of *D. masonii* against spatially mapped habitat characteristics (Sections 1.1.4 and 1.1.5). The model identified habitat that is suitable to the species, but is not currently inhabited by it. The distribution of *D. masonii* may be limited by unknown factors, such as regolith (soil depth, underlying rock structure), long-term fire history patterns or other ecological factors (e.g. seed dispersal distances) which would likely refine potential habitat mapping. The predicted habitat is shown in Figure 2.

Translocation trials using *D. masonii* cuttings, previously established under nursery conditions, have varied levels of survival. Trials that have been conducted on relatively undisturbed sites of rocky soils were more successful than those translocated in similar conditions but on sandy or loamy soils. The overall seedling survival rate decreased as a result of drought. Other translocation trials have, however, resulted in significant survival rates as a result of watering the plants during their first two summers. A high survival rate, reproductive success, and recruitment, was observed in the plants of this trial (refer to Section 5.1.7). Future translocations should include an allowance for irrigation of translocated plantings.

Suitable habitat for the survival of *D. masonii* may also include additional nearby areas that do not currently support the species but may have done so in the past and may be suitable in the future. The knowledge gained from the habitat modelling (BGPA, 2010) and translocation trials (BGPA, 2010) will assist in identifying suitable habitat for *D. masonii* recovery actions. These findings will also be used in the rehabilitation of areas disturbed by mining.

A research project, funded by MGM, investigating soil plant atmosphere interactions and their influence on mine waste cover system performance is currently underway. Earthworks and plot preparation were completed in June 2014. Among other objectives, this research will investigate how topsoil thickness (comprised of a 2:1 waste rock: topsoil mix) and rooting depth influence the physiological performance of the taxa in the project. It is anticipated that *D. masonii* will be used as one of the species in the trials pending Parks and Wildlife approval (J Sackmann 2014, pers. comm., 28 January).

Propagation of live plant material from wild collections and nursery stock are likely the most cost effective approach for the short-medium term production of plants for restoration purposes. Seed germination and seedling establishment under glasshouse or field conditions may also provide an approach for a genetically diverse and numerous sources of restoration plants (BGPA, 2010).

Tasks would include:

- For rehabilitated landforms, further assessment of patterns of rock and gravel substrate, and varying degrees of soil depth and rockiness and growing media will be made to support growth of *D. masonii* on Mt Gibson Ranges (2014-2016).
- Monitor the survival and sustainable establishment of the plants remaining from the preliminary translocation trial of *D. masonii* at the disused drill pad on Iron Hill East (2014-2017).
- Prepare species restoration strategy and program (2014).
- Collect seed, cuttings and/or use existing *ex situ* germplasm for restoration programs (2014/2015).
- Derive and apply quantitative completion criteria, which demonstrate viable and sustainable population dynamics in translocated *D. masonii* (2015).
- Commence Restoration Strategy (2015/2016).

Action: Establish a plant restoration program.

Timing: 2014 – 2017 (as above)

Commencement date:	November 2014
Completion date:	life of MGIOIP

5.2.8. Promote Awareness of *Darwinia masonii*

The status of *D. masonii* and measures to manage risk and threats to the species will be promoted to staff at the MGIOIP. The significance of the species will continue to be communicated to personnel working at and around the mine site (i.e. environmental induction).

Note that Parks and Wildlife may lead on these matters for external extension.

Actions:

- Promote need for protection through poster displays; and
- Continue environmental inductions.

Commencement date:	2014
Completion date:	life of MGIOIP

5.2.9. Coordinate Recovery Actions and Liaise with Stakeholders

MGM and EHPL will continue to liaise with stakeholders in relation to requirements of MS753 for the Mt Gibson Iron Ore Mine and Infrastructure Project. Parks and Wildlife has indicated its oversight of recovery actions for *D. masonii*.

Parks and Wildlife tasks may include:

- Coordinate recovery actions, liaise with stakeholders and provide an annual review report.
- Summary of achievements and progression of recovery actions will be included in recovery team annual reports to Parks and Wildlife's Corporate Executive and funding bodies.

Actions:

- Coordinate recovery actions, and liaise with stakeholders.
- Provide an annual review report on the species including guidance on research and its directions.

Responsibility: Parks and Wildlife

Timing: Annually for the Species Review Paper

Commencement date:	On adoption of the Recovery Plan
Completion date:	Life of Recovery Plan

5.2.10. Review Assigned Conservation Status of the Species

The IUCN category of the species is currently 'Vulnerable' and it will be reviewed as part of the Recovery Plan.

Actions:

1. Review the conservation status of the species; and every 5 years thereafter.

Responsibility: Parks and Wildlife

Timing: 2015

Commencement date:	2015
Completion date:	Life of Recovery Plan

5.3. Further Research to benefit Recovery

There are emerging research outcomes about certain biological processes and ecophysiological interactions that may contribute to recovery of the species in some way. These processes and interactions may be important over the course of the Recovery Plan. Given the extensive research investment and knowledge gained from this, on-going nascent factors need to be prioritised in order to deliver effective management for recovery of the species. It is recommended that such research tasks and actions commence after the Parks and Wildlife Annual Review Paper is written that collates the most recent findings and information gaps from the completion of the IRP and all preceding works.

A number of potential research considerations are as follows:

- Recent assessment of genetics of *D. masonii* shows some geographic structure in the nuclear microsatellite data, with those groups listed in the IRP exhibiting isolation-by-distance (M Barrett 2013, pers. comm., 16 December 2013). However, between populations, genetic structuring in *D. masonii* is reported to be low (BGPA, 2010).

- *Darwinia masonii* is recorded to be pollinated by the white-fronted honeyeater (BGPA, 2010). While the habitat of this pollinator extends beyond the Midwest region, its local habitat requirements may need to be understood if there is a concern that the bird or its habitat may become scarce in the region. Conservation, restoration and translocation efforts should consider *D. masonii* in the context of its vegetation community and habitat and, should it be necessary, measures should be developed to manage suitable habitat for birds such as the white-fronted honeyeater.

- Predation of *D. masonii* seeds (by larvae of an unidentified moth species) may have implications for seed production and quality. Little is known about moths, and their role in plant ecology and health. It may be necessary to quantitatively assess seed predation by moth larvae.

- Mycorrhizal formation is potentially important for the restoration success of *D. masonii* (e.g. for seeding survival and growth rate, as has been shown for a variety of VAM and ECM-forming species).

Research tasks include:

Genetic structure and gene flow dynamics

- Reporting on the mapping of gene loci, gene exchange rates and interpreting potential isolation effects areas.
- Publication and peer review of results to provide a better understanding of genetic diversity across the population, its occurrence in nature and implications for future management.

Avian pollinators

- Identify the diversity of birds on the Mount Gibson ranges and whether White-fronted Honeyeater has a specialised function in *Darwinia* pollination. Review the role of birds including the white fronted honeyeater in plant pollination.

Seed predation by moths

- Identify seed-eating moth species and examine its occurrence in co-occurring species and related *Darwinia* species. Collect samples of infructescences from each major *Darwinia* group to assess rates of seed predation and seed fill.

Microbiological vectors

- Determine risks and management measures to control vectors associated with revegetation from *ex situ* stock.
- Based on proposed restoration plantings, establish comparative restoration trials, such as whether restoration-planted seedlings are spontaneously able to form mycorrhizal associations in restoration surfaces, or whether inoculation is required and/or beneficial.

Land rehabilitation trials

- MGM / EHPL have commenced testing of substrate variables on waste landform trial plots.
- A research based approach will be engaged to determine the ability for *D. masonii* to establish on waste landforms (see also Section 5.2.8).

Actions: Prioritise the above tasks and implement according to resourcing and budget considerations over a three year period.

Responsibility: MGM and EHPL, in association with Parks and Wildlife and scientific research agencies

Commencement date:	2015
Completion date:	2017

6. Plan Implementation and Evaluation

MGM and EHPL will review this plan:

- after results of the Parks and Wildlife annual report (2015) become available and justifies need for a review;
- if Criteria for Caution ("Amber" light) are met while the MGIOIP is operating; and
- if directed to do so by the CEO of the EPA in accordance with condition 6-7 of MS753.

This plan will continue to apply unless and until the Minister for Environment approves a revised plan under condition 6-3 of MS753.

The Plan may be evaluated upon submission to the requirements of WA Minister for the Environment by Environmental Protection Authority and Parks and Wildlife. The Commonwealth Department of Environment may evaluate the Recovery Plan.

MGM and EHPL will review the management actions based upon regularly obtaining data that enables the 'recovery criteria' to be assessed and for that assessment to occur. In addition to annual reporting on progress and evaluation against the criteria, the plan will be reviewed following five years of implementation.

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ATTACHMENT 1 – SUPPORTING TECHNICAL INFORMATION

A1.1. History, Nomenclature and Taxonomic Relationships

Charles Gardner (1964) described Mason's Darwinia in 1964 from specimens collected by D Mason of Whitewells Station in about 1960.

A comprehensive phylogeny of the related genera Chamelaucium, Darwinia, Verticordia, Actinodium, Homoranthus and Pileanthus has been completed to more accurately assess the taxonomic status and phylogenetic position of Darwinia (in particular D. masonii). This complex of genera has been difficult taxonomically, and relationships between species, groups and genera were particularly poorly understood.

Key results of these investigations are:

- Generic status of Chamelaucium, and Pileanthus is confirmed (ie. they are monophyletic).
- Eastern and Western Australia Darwinia species belong in separate groups, the latter including Actinodium
- The genera Chamelaucium, Pileanthus, Darwinia, Homoranthus and Actinodium are nested within Verticordia as currently circumscribed.
- D. masonii has been shown to be very closely related to three other species, D. acerosa, D. purpurea and D. species Chiddarcooping, rather than close to either *D. leiostyla or D. helichrysoides* as has been previously speculated. All four species have similar geographic distribution north and east of Perth, mostly in the drier Wheatbelt.

Darwinia purpurea, *D. acerosa* and *D*. Chiddarcooping (S.D. Hopper 6944) are most closely related to *D. masonii* (BGPA, 2010). The Botanic Parks and Gardens Authority undertook a thorough analysis of phylogenetic relationships in the genus *Darwinia* in order to identify appropriate comparisons for the assessment of genetic diversity and comparative ecology in *D. masonii*. The *D. masonii* species group resolved through analysis of chloroplast and nuclear genes with a group of *Darwinia* species from the WA Northern Sandplain and Wheatbelt regions, including *Darwinia purpurea*, *D. acerosa*, and the undescribed species, *D*. sp. Chiddarcooping (S.D. Hopper 6944). While these species differ today in their morphological features including their habit and floral characteristics, the analysis indicated that they are closely related, and possibly speciated allopatrically, through isolation and subsequent adaptation of a previously widespread species.

These findings provide insight into the origins of *D. masonii* and allow selection of appropriate comparison species during further research, in particular comparing levels of genetic variation, root growth patterns and seed biology. As a side benefit, relationships between genera and some within-generic groups can now be accurately assessed (BGPA, 2005b).

A1.2. Illustrations and/or Further Information

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A1.3. Further Details on Species Biology and Ecology

Population Demography

BGPA (2010) studied the demography of *D. masonii* population on Extension Hill South, Iron Hill South, Mt Gibson Hill and Mt Gibson Hill South between 2007 and 2010 (2010). Tagged plants were monitored in fifteen 10 by 10m plots, with 5 plots each within vegetation characterised by 3 fire histories (2003; 1969; or, older – pre-1968). Four additional plots with total area of 250m^2 were added in May 2009 within the boundary of an experimental fire at the northern end of Extension Hill South. Parameters measured in the plots included: location of plant within the plot; plant structure (seedling, adult); height (or length for reclining or prostrate plants); canopy diameter in 2 perpendicular dimensions; stem basal diameter in 2 perpendicular dimensions; inflorescence numbers; and, 'health'.

Growth

The growth rate of *D. masonii* seedlings in plots burnt in 2003 averaged 3.4 cm / year, while the rate of mature and old plants was neutral or negative with an average of -0.9 cm / year during the period between 2007 and 2009 (BGPA, 2010). The average growth rate also varied for each year in this range, demonstrating that the plant growth responded to the annual growing conditions.

The growth patterns of *D. masonii* change once the plants become reproductive, and can be used to explain differences in growth rate. Seedlings have a vertical growth direction, and the growing tip persists from year to year. BGPA (2010) found that this pattern of growth persisted until the plants were between 50 and 70cm tall. Once *D. masonii* starts to reproduce, the flowering heads form on the terminal end of the branches, and new vegetative shoots are produced laterally from below the terminal flowering head. Older plants therefore are characterised by spreading, laterally branched canopies, with ever increasing levels of branching complexity. Their height (or length for reclining or prostrate plants) varies from year to year dependant on the growth conditions experienced.

Seedling growth forms of *D. masonii* display a correlation between stem diameter and growth patterns (BGPA, 2010). In contrast, stem diameter of mature and old plants was found to be unsatisfactory as an

assessment measure of growth rate on an annual basis. The stems of seedlings are regular in shape, and the change in stem diameter of *D. masonii* seedlings in plots burnt in 2003 averaged 0.34 mm / year during the period between 2007 and 2009. This varied for each year within this range, indicating that stem diameter responded to annual growing conditions. The stems of mature and old plants are often irregularly shaped, having cracks, swellings, or a presence or absence of spongy bark. Furthermore, the bark can swell, shrink or be sloughed off. These are all characteristics which elucidate why stem diameter is an unsatisfactory parameter for measuring growth of mature and older individuals of *D. masonii*.

Population Structure

Darwinia masonii is long-lived and killed by fire (Paul Armstrong and Associates, 2004; BGPA, 2010). A wildfire burnt out a significant area in southern and eastern portions of the Ranges in January 2003. None of the *D. masonii* plants burnt during this fire were observed to have survived during the spring of 2003 by Paul Armstrong and Associates (2004). Regeneration is restricted exclusively to germination from seed held in long-lived soil-stored seedbanks (BGPA, 2010). Plants arising from seed germinate in a single cohort post-fire. There is also evidence of limited post-fire recruitment of *D. masonii* in older groups. Plant sizes from data collected in 2007 during BGPA's (2010) demographic study ranged in height up to 240 cm and 2.5 m in canopy width. The largest stem diameter was 74 mm. Plant size correlated with population age in frequency distribution graphs of the young (2003) and mature (1969) plots which showed distinct peaks in size and a narrow size range. The older (pre-1968) plots were estimated to have been unburnt for over 85 years and had the oldest and largest plants in them. However, the frequency distribution graphs did not have distinct peaks in size, but rather a spread of plant sizes. The data from the older plots confirmed that *D. masonii* is long-lived and that limited recruitment occurs at infrequent intervals in the absence of fire.

Environmental Adaptations

Darwinia masonii shares with co-occurring species the drought strategy of closing down transpiration and photosynthetic function to enter a period of physiological dormancy through drought with the capacity to restore tissues as soils wet.

Roots of *D. masonii* have a capacity to enter large cracks, pores and fissures in regolith and may achieve considerable root depths (perhaps to >10m), but the species showed root growth adaptations that were significantly different from close relatives from other habitats.

Biotic Interactions

The IRP (DEC, 2008) stated that "only very minor grazing pressure from feral goats and rabbits of D. masonii has been observed to date" (p10). However, BGPA (2010) found that grazing by vertebrates (presumed to be goats and rabbits) had a negligible impact on *D. masonii*. They conducted monitoring of 378 seedlings and adult plants between 2007 and 2010 in demography plots, and a further 277 seedlings in plots established in an area subjected to an experimental burn. No evidence of mammalian herbivory was observed on any plant (seedling or adult) monitored. Branch tip pruning of 4 tagged plants was observed in 2007 and was presumed to have been caused by parrots eating flowers or seeds.

Darwinia masonii has a clear association with Vesicular-Arbuscular Mycorrhizae (VAM) (BGPA, 2010). No obvious Ectomycorrhizal (ECM) formation was recorded in field-collected root systems of the plant. BGPA (2010) suggested that comparative restoration trials be used to further investigate the importance of mycorrhizal formation to the restoration success of *D. masonii*.

Competition or facilitation was not observed by BGPA (2010), but they suggested that future restoration research include manipulative experiments under field conditions to best determine the extent of these interactions.

The impact of termites on *D. masonii* has not appeared to be significant. Proportionally, they have been recorded on a small number of plants – they were observed on the stems of 15 tagged individuals in demography plots burnt during or before 1969 (BGPA, 2010). The mean growth rates and health scores of these individuals did not vary greatly from other termite-free individuals in the same areas.

Foliar loss or damage by insect attack was only noted in the form of galls on a very small number of *D. masonii* individuals during BGPA's (2010) research.

Wood rots are likely to have a very minor impact on *D. masonii* (BGPA, 2010). No evidence of fungal rotting was recorded on wood of dead or burnt plants which had persisted for many years after death. An unidentified fruiting bracket fungus was found on the trunks of live plants during BGPA's research.

Abiotic Associations

BGPA (2010) used two approaches to determine the environmental associations of *D. masonii*: an analysis of site factors at demographic and physiological monitoring plots; and, modelling of species distributions against spatially mapped environmental data. The environmental parameters interrogated by the modelling were geology, short term fire history (since 1968), solar radiation receipt, aspect, slope, curvature and elevation. Of these, slopes over 7-8^{o}, elevation over 380m and all geology types within the Mt Gibson Ranges except "White Rock (unclassified, including granite and its group, acidic dyke rocks, feldspar porphyry and meta-sediments phyllitic rock)" were the principal environmental parameters predicting the distribution of *D. masonii*. When each of these was considered alone they had an associated probability of 50 to 60% of predicting the *D. masonii* distribution.

The modelling predicted *D. masonii* to occur broadly across the Mt Gibson ranges with a high probability (60-75%) of occurrence (BGPA, 2010). It is interesting to note that the modelling also predicted suitable habitat for *D. masonii* on Yandanhoo Hill to the east of the Mt Gibson Ranges. Many areas in the Mt Gibson Ranges where groups were predicted to occur by the modelling were not found to support *D. masonii* during initial surveys. BGPA concluded that the distribution of *D. masonii* may have an association with unmapped sub-surface features such as regolith (soil depth, underlying rock structure) and longer-term fire history patterns. They postulated that some areas of the Mt Gibson range are more prone to fire than others.

In situ planting methods using cuttings were trialled by BGPA (2010) at Mt Gibson on 4 differing field soil substrates. These were on the deep red loam/clay plains east of Extension Hill (clay), white-yellow sands of sandplains west of Extension Hill (sand), and gravelly and rocky loams of the north Extension Hill slope and ridge (BIF gravel and BIF rock respectively). *D. masonii* survival after 9 months of planting was only successful in sites with BIF rock and BIF gravel substrate. The highest survival was at the BIF rocky loam site which averaged under 40%. Both sites had significantly higher Organic Carbon (%) and Total Nitrogen (%) than the clay and sand sites. The BIF rock and BIF gravel sites had slower soil drying curves than the sand and clay sites. *D. masonii* is not currently known from sandy or clayey sites like those selected for the restoration trial, and perhaps the factors contributing to the lack of success of the cuttings planted provides some explanation for this. Conversely, BGPA (2010) concluded that sites with BIF rock and BIF gravel are suitable for translocations, and texture, gravel/rock content, patterns of moisture content and Total Nitrogen may be the most critical soil properties to consider in site selection. These properties may also contribute more broadly in defining the current and potential habitat of *D. masonii*.

Plant Fecundity

Flowering of *D. masonii* has been recorded in plants as young as six years (BGPA, 2010) or less when supplemented with water or grown under nursery conditions. Six of 115 plants recorded in plots burnt in 2003 at Iron Hill South were recorded to be flowering for the first time in 2009. These plants were in the tallest height category (51 to 95cm), but only represented 13% of the individuals within that category.

Tall (old) individuals of *D. masonii* that have a wide canopy are more likely to produce flowers, and in greater numbers, than smaller (young) individuals with narrow canopy diameter (BGPA, 2010). The proportion of plants recorded to be flowering during the period between 2007 and 2009 increased with plant height (or length, for reclining or prostrate individuals). This proportion was comparable for all plants with a canopy diameter of over one metre wide. However, the number of flowers per plant was proportional to canopy diameter.

The percentage of plants flowering and the number of inflorescences varied for each year within the period between 2007 and 2009 (BGPA, 2010), but the reason for this has not been determined. 62% of all plants in older sites (burnt during or before 1969) flowered in 2007, while this dropped to 36% in 2008, and increased once more to 90% in 2009. The number of flowers per plant displayed the same pattern.

Pollination

BGPA (2010) reported that *D. masonii* is able to self-pollinate at a low rate (6.6%) in the absence of pollinators, however pollinator activity significantly increases seed set. The study was not powerful enough to unambiguously separate the actions of pollinator classes, however the trend agrees well with pollinator observations: rare insect visitation increases the outcrossing rate (and seed set), however birds are much more effective pollinators and more common visitors, resulting in a higher seed set. Figure A.1 shows that (1) plants can set a lowered level of self seed in the absence of pollinators,(2) that birds are significant pollinators, almost doubling the seed-fill rate compared to insect-only pollination, and (3) insect activity appears to have a weaker contribution (however the last result is not significantly different from zero).

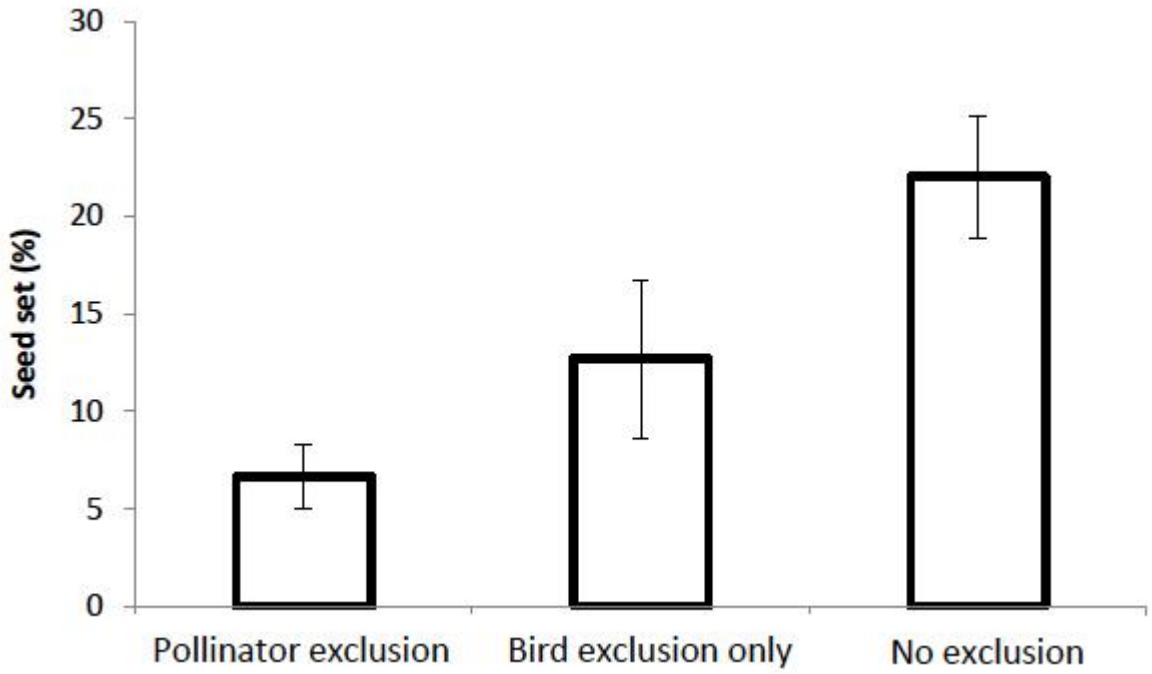

Figure A.1. Effects of pollinator activity on rates of seed setting (from BGPA, 2010)

Recruitment

Recruitment in the plots within the boundary of the experimental fire of May 2009 confirmed that *Darwinia masonii* germinates strongly after fire, with a seedling density in burnt areas of 1.2 per m^2 and 3.2 seedlings per pre-fire adult (BGPA, 2010). The fire on 12 May 2009 was not as intense as anticipated and was patchy, such that 73 of the 93 pre-fire adults were burnt. However, the fire achieved what was intended: It killed the canopy; there was a good amount of ash produced; and, seedlings emerged. Soil temperature at some of the probe sites did reach 250^{o}C (B Miller 2013, pers. comm., 17 December). 233 seedlings were counted

within the area previously burnt in the experimental fire plots. In comparison, recruitment of only one seedling in the 15 unburnt plots was reported over the course of the study (May 2007 to June 2010). This seedling was recorded in an older (pre-1968) plot on Mt Gibson South in July 2009. This corroborates the findings of the population structure study - that post-fire recruitment is limited in older groups but does occur.

Survival/Mortality

BGPA (2010) reported that, "While mortality is rare among mature *D. masonii* plants, drought over the winter of 2010 contributed to a significant level of mortality (>10% in one site)" (p6). Two plants out of 249 recorded in the older (pre-1968) plots died between 2007 and 2009. This equates to an average of 0.5% deaths per year. The rainfall total over 2010 was one of the lowest on record, and mortality in a sample of 261 plants resurveyed at Mt Gibson South during BGPA's pollination study was 10.3%. The magnitude of the mortality after this single drought year is of concern, as it indicates that the population of *D. masonii* could be significantly impacted by drought, and there may be implications for the taxon if climate change results in increased drying or a greater frequency of dry years in the region.

There is significant spatial and temporal variation in mortality of *D. masonii* seedlings (BGPA, 2010). Drought conditions in 2010 significantly impacted the *D. masonii* seedlings in the recruitment plots within the boundary of the experimental fire of May 2009. Of approximately 200 seedlings tagged in these plots, only 9% were still alive when these plots were revisited in October 2010. BGPA (2010) stated "this low survival rate may partly result from the drought experienced over the 2010 winter at Mt Gibson, as well as a likely high failure rate of establishing young seedlings" (p43). Between 2007 and 2009, 33 seedlings died out of the 128 seedlings recorded in 5 plots which were last burnt at Iron Hill South in 2003. The death rate for these plots varied each year, ranging from 2.5% to 15% per year. It also varied between the plots at Iron Hill South. BGPA (2010) suggest possible reasons for the variation in seedling mortality, including seasonal variation in rainfall, soil water holding capacity and microclimate of the plots.

It is also possible that seedlings of *D. masonii* are less resilient to drought conditions than mature plants.

Seed Biology

Darwinia masonii is known to be pollinated by the White-fronted Honeyeater (*Phylidonyris albifrons*) (BGPA, 2010). *Darwinia masonii* is capable of producing low-viability, selfed seeds but the production of outcrossed seed is a critical requirement for a self-sustaining population. There was weak evidence that selfed seed was less fit than outcrossed seed.

- *Darwinia masonii* flowering and seed production takes place in spring and early summer with the peak of ripe seed production occurring around mid-November. Seed fill rates varied between years from 15 to 30% and predation rates from 6 to 22%. Seed dispersal is known to occur by ants. *Darwinia masonii* seed production is moderately low, varying between years from 9 to 59 seeds per plant in mature groups. Inbreeding and predation by moth larvae contribute to reduced seed quality.

Large scale production of seedlings of *D. masonii* via germination of fresh or stored seed involves physical manipulation of small seeds for seed coat nicking or removal, or retrieval of seed buried for months or years.

Germination of fresh *D. masonii* is low but can be improved by a combination of detailed physical treatments and smoke application. Germination rates of 90% have been achieved with filled seed exhumed after 9 months of burial and treated with smoke water.

Seed bank demography trials established for *D. masonii* are ongoing. Buried seed is in place with experiments designed to continue for up to five years. Results to date indicate complex germination / dormancy strategies for the species, combining a requirement for physical degradation of the seed coat,

environmental (seasonal temperature) cuing – with seeds cycling in and out of dormancy, and heat- and smoke-related physiological responses.

The genotypes of *D. masonii* currently held in parent stock are not all healthy. The leaf tips of many specimens are yellowed, and it is possible that this is due to a physical or chemical factor. This observed response to nursery conditions was also reported by BGPA (2010). They found that while *D. masonii* cuttings survive and flower, they have not done so vigorously.

A small number of genotypes of *D. masonii* are still maintained in glasshouses at Kings Park for experimental purposes.

While propagation of live plant material from wild collections and nursery stock may pose the most cost effective approach for the short-medium term storage and production of plants for restoration purposes, BPGA (2010) recommended further research into seedling production appears promising and may provide a preferable approach to providing genetically diverse and numerous source of restoration plants. Drawbacks to the use of clones for population restoration were outlined by BGPA (2010).

Seed collections were carried out by BGPA in late October 2004 (also in November 2007). Counts of viable seed by cut test revealed 19% viable seed from the 2004 collections. After 3 years of storage, the 2004 collection retained equivalent levels of viability when compared to seed collected and tested in 2007 (BGPA, 2010). In addition, further analysis of the 2004 seed collection was undertaken to evaluate requirements for breaking dormancy and optimal germination conditions (BGPA, 2005a). It was concluded that *D. masonii* is readily propagated by standard germination techniques.

The optimal time for collection of seed of *D. masonii* is from late October to early November, when the seed is still held on the plant (Landcare Services, 2007; BGPA, 2010), and this direct collection is also the most economical method of collection. Landcare Services (2007) carried out seed collection over 5 days within the footprint of the Extension Hill hematite pit as part of a pre-clearance salvage operation to collect seed material and determine the most efficient way to salvage seed from *D. masonii*. Landcare Services subsequently were contracted to collect and retain seed from that area again in November and December 2008. The seed and material is stored at a constant temperature controlled (19^{o}C) seed storage facility in Bassendean.

Batches of 1,000 filled seeds of *D. masonii* have been deposited at the WA Seed Technology Centre in BGPA at Kings Park, Parks and Wildlife's Threatened Flora Seed Centre, and Kew Garden's Millenium Seedbank at Wakehurst Place in the UK (BPGA, 2010).

Also Parks and Wildlife's Threatened Flora Seed Centre currently has three collections of seed from *D. masonii* (Table A1).

Table A1. Details of *Darwinia masonii* seed collections held by Parks and Wildlife's Threatened Flora Seed Centre

Accession	Collection date	Location	TPFL Pop	Seeds/fruit in storage	Germination (%)
01502	11/11/2004	Extension Hill North	3	466 seed	90%
01503	11/11/2004	Mt Gibson South	7	1634 fruit	Not yet tested
01519	11/11/2004	Mt Gibson	6	4941 fruit	Not yet tested

Fire

Fire history mapping indicates four major fires have occurred over the extent of occurrence of *D. masonii* (BGPA, 2010). These have been dated at 1969, 1972, 7 to 10 February 2003 and December 2005. The dating of the former two fires may be imprecise and vary by a year or two, but is considered insignificant relative to the long time since these fires. No information has been reviewed regarding the intensity of the fires, completeness of the fires or the timing of the fires dated 1969 or 1972.

Darwinia masonii is fire-killed, so the fire history across the population can be used to determine the population age. The age since fire of the individuals within the population of *D. masonii* varies from 4 years (seedling status) to greater than 50 years (old status) (Table A.2; Figure A.2). Population 7 on Mt Gibson Hill south is old and has not been burnt for over 50 years, while the majority of sub-populations 2a, 2b and 4 on Extension Hill South are mature and were last burnt in 1969. A small experimental fire was conducted in population 2a in 2009, but the remainder of the population has not been burnt since 1969. The western part of population 1b on Iron Hill North is mature, having not been burnt since 1972, while the eastern part of population 6 (a, b and c) on Mt Gibson Hill has not been burnt since 1969 and is also mature.

Part or all of five sub-populations (1a; 1b; 3; 5a and b; 6a, b and c) are young, having been last burnt in 2003 or 2005 (Table A2; Figure A.1). Of the five young sub-populations, only sub-population 1a on Iron Hill South has been burnt once within the last 50 years (in 2003). The other four sub-populations (1b; 3; 5a and b; 6a, b and c) have been burnt twice. Within sub-population 1b on Iron Hill Middle and North, the boundaries of the fires in 1972 and 2003 did not overlap to a large degree, so only a small proportion of this sub-population has been burnt twice. A majority of sub-population 3 on Extension Hill North was burnt in both of the fires in 1969 and 2005. This sub-population has been taken during mining activities. A majority of sub-populations 5a and 5b on Iron Hill East have been burnt in fires in 1969, and again about 10 years ago, in 2003. The western side and part of the top of Mt Gibson Hill (populations 6a, b and c) was burnt in these same fires.

Table A2. Fire History of *Darwinia masonii* groups

DEC Pop'n No	Fire year/s	Age since fire (years)	Fire history status	Fire impacts
1	2003 (7-10 Feb) Pre-1968	10 >50	Young Old	Majority of population within fire boundary
8 & 9	2003 (7-10 Feb) 1972 Pre-1968	10 41 >50	Young Mature Old	Not all burnt Fire boundary includes west side of Iron Hill North only
2	2009 (12 May) 1969 Pre-1968	4 44 >50	Seedling Mature Old	<2ha (small) experimental fire at track junction – patchy, but achieved intended result – killed canopy, ash produced, seedlings emerged. Majority of population within fire boundary
10	1969 Pre-1968	44 >50	Mature Old	Population boundary unknown
3	2005 (Dec) 1969 Pre-1968	8 44 >50	Young Mature Old	Majority of population within fire boundary Majority of population within fire boundary
4	1969	44	Mature	Entire population burnt
5a, b	2003 (7-10 Feb) 1969	10 44	Young Mature	Entire population burnt Majority of population within fire boundary
6a, b, c	2003 (7-10 Feb) 1969	10 44	Young Mature	Fire boundary includes west side of Mt Gibson and top of part of the Hill only Entire population burnt
7	Pre-1968	>50	Old	

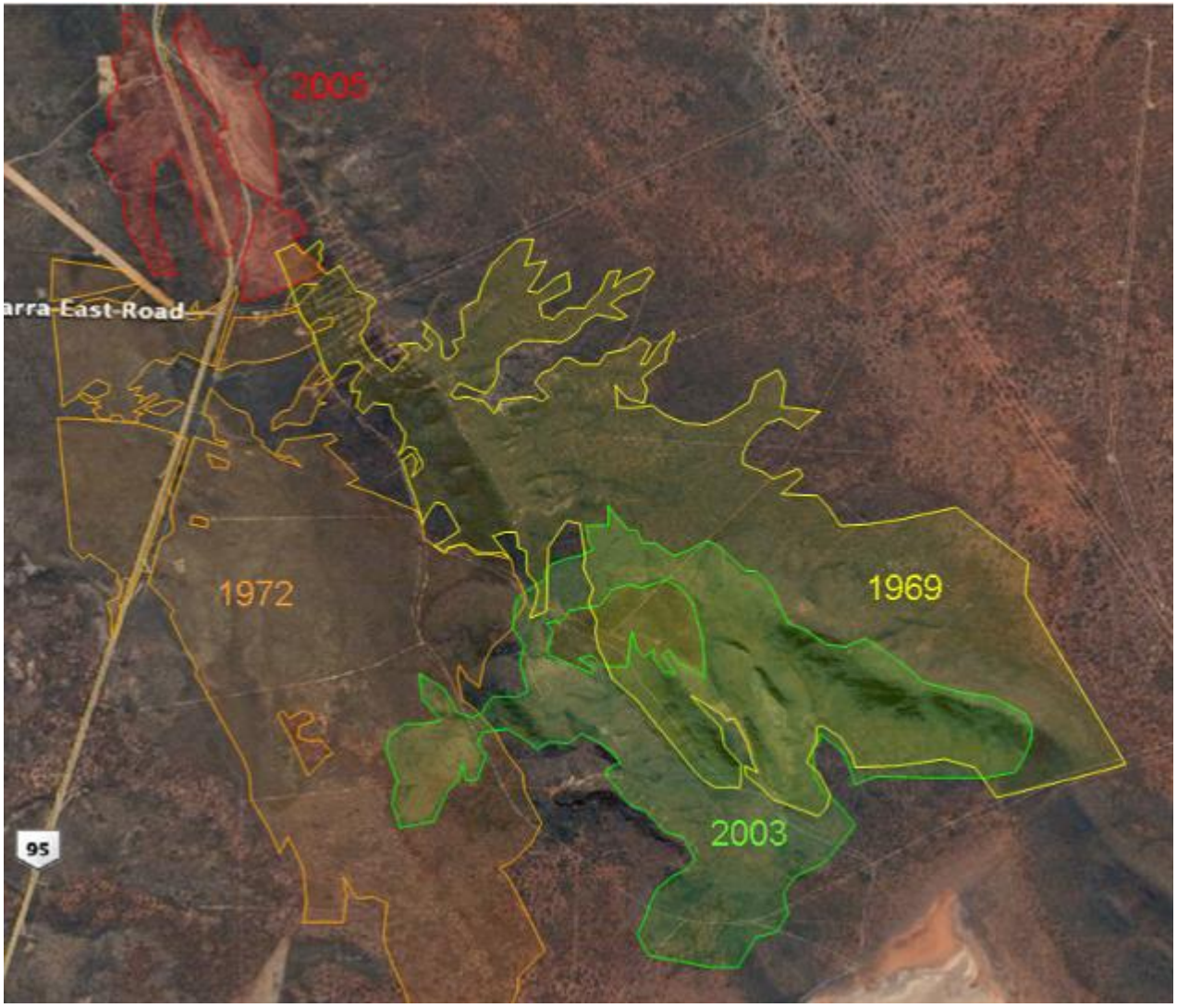

Figure A.2. Known fire history of the Mt Gibson Ranges

ATTACHMENT 2 – MANAGEMENT ACTION ESTIMATES

Action item	Responsibility	Estimate (p.a. unless stated otherwise)
5.2.1 Program for D. masonii condition monitoring	MGX/EHPL	MGX/EHPL site operational budgets
5.2.2. Implement fire management	MGX/EHPL	MGX/EHPL site operational budgets
5.2.3. Manage risks from secondary threats of mining	MGX/EHPL	MGX/EHPL site operational budgets
5.2.4. Manage effects of grazing on D. masonii	MGX/EHPL	MGX/EHPL site operational budgets
5.2.5. Maintain and use seed/germplasm collection	MGX/EHPL	$7,500
5.2.6. Report existing and any new occurrences of plants	MGX/EHPL	$180,000 (2014 only)
5.2.7. Plant translocation and population restoration planning	MGX/EHPL	$30,000 (2015-17); MGX/EHPL site operational budgets
5.2.8. Promote awareness	MGX/EHPL	MGX/EHPL site operational budgets
5.2.9. Coordinate recovery actions, liaise with stakeholders	-	MGX and EHPL fund $110,000 for officer position for this species and *L.gibsonii*.
5.2.10. Review assigned conservation status	-	MGX and EHPL will conduct work in 2014 only; $10,000
5.3. Further Research	MGX/EHPL	$30,000 per annum (2015-17)

ATTACHMENT 3 – SUPPLEMENTARY INFORMATION

International Obligations

This plan is intended to be consistent with the aims and recommendations of the Convention on Biological Diversity, ratified by Australia in June 1993, and assist in implementing Australia's responsibilities under that Convention. The species is not listed:

- under Appendix II in the United Nations Environment Program World Conservation Monitoring Centre (UNEP-WCMC) Convention on International Trade in Endangered Species (CITES), nor
- under International Union on Conservation of Nature (2012) Red List.

This plan is not known to adversely affect Australia's obligations under any other international agreements.

Role and Interest of Aboriginal Groups

There is one Native Title claim over the Mt Gibson area (the Badimia People WC96/98, registered) which is the area that includes the habitat and potential habitat of *D. masonii*. In agreements with MGM and EHPL, the claimant group has recorded a general interest in the environment and natural history of the area. There are registered ethnographic and / or archaeological sites which are of cultural significance within the known habitat of *D. masonii*.

MGM and EHPL has undertaken regular consultation through stakeholder meetings since commencement of the IRP and including in the period during the preparation of this Recovery Plan. The joint proponents will continue to consult with Aboriginal groups in the region identified in this plan and consider their role and interests in its implementation. Input and involvement will be welcome from Aboriginal groups of standing that have an active interest in areas that *D. masonii* occurs, and their involvement in recovery team representation may be sought.

The works of Tehnas (2010) should be referenced to obtain information of the existence and status of aboriginal heritage sites and regional ethnography.

The Aboriginal Heritage Sites Register, maintained by the Department of Aboriginal Affairs, will be used to identify significant sites near recorded and any new plant population. However, not all potential heritage sites are listed on the Register, and on-going liaison will be maintained with local Aboriginal community representatives.

Potential Social and Economic Effects

The implementation of this RP will have some impact through MGM and EHPL funding the development and implementation of certain management actions in this plan. The Plan does not and should not enhance or impede entitlements or restrictions that derive from other existing operating approvals or new applications. That is, proponents for particular land uses, such as mining, may be required through statutory assessments to demonstrate that they will not have a significant impact on *D. masonii* and that the future risks of detrimental effects can be adequately mitigated. Such requirements would be in place irrespective of this plan, because of environmental legislation, and this plan would provide guidance for the adoption of management actions and their implementation.

Guide for Decision Makers

Preceding sections of this Plan provide details of current and possible future threats to the species. Any further development in the vicinity of existing or potential habitat would require further assessment under established referral and/or environmental impact assessment mechanisms of State and Commonwealth governments.

Under the Commonwealth EPBC Act, any person proposing to undertake an action which may have a significant impact on listed threatened species (including *D. masonii*) may be required to refer the action to the Minister for Environment. The Minister will determine whether or not the activity is a controlled action under the EPBC Act.

The known population of *D. masonii* occur across a variety of land tenures including pastoral leases, Crown Reserve (Reserve 17367), unallocated Crown land, mining leases and native title areas. Based on the current records and known area of occurrence of *D. masonii*, interests potentially affected by, or involved in the implementation of this recovery plan include:

- MGM, EHPL, Pindiddy Aboriginal Corporation (Ninghan Station), Australian Wildlife Conservancy (Mt Gibson Station) and the Badimia People.

Interests of others may be potentially affected by this plan. Further details are provided in Attachment 3. In most cases, no undue impediment or restriction on current land use is apparent or likely to arise because of this recovery plan. Landholders and land management agencies may be affected through statutory planning and approval processes outside this plan when seeking to alter the landscape or undertake actions that may cause certain detrimental effects on *D. masonii*.

Permission has been, or will be, sought from the managers and those with entitlements to lands where *D. masonii* occurs or may occur before recovery actions are undertaken on any such land.

Recovery actions implemented to maintain the quality and occurrence of the habitat of *D. masonii* will also support vegetation and habitat in which it is located and may also support the Declared Rare Flora (DRF) taxon *Lepidosperma gibsonii* and other priority flora. Fauna species may also benefit where recovery actions improve their habitat. No negative effects of the recovery actions for *D. masonii* have been identified, however, should they be, they should be allied with those of extant taxa.

ATTACHMENT 4 – LEGISLATIVE REQUIREMENTS

The Recovery Plan has been developed using the structure and addresses the matters outlined in the "Recovery Plan Guidelines for Nationally Listed Threatened Species and Ecological Communities" under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (Recovery Plan Guidelines). The following table is a condensed version of the Department of the Environment's compliance checklist:

Requirements of the Recovery Plan Guidelines	**Section of this Plan**
1. Consultation with relevant departments	Consultation with relevant government departments and Decision Making Authorities has been on-going since MGIOIP was Referred under the EPBC and EP Acts. Since that time, on-going consultation has occurred in the development and implementation of the IRP, through the funding of a Parks and Wildlife officer positions, and through the development of this Recovery Plan.
2. Consultation with other stakeholders	Consultation with scientists and specialists has also occurred during the MGIOIP development, approvals and operations with regard to *D. masonii*. Section 5
3. Public consultation	The Public Environmental Review document was made available for public comment and the IRP is publically available. This Recovery Plan will also undergo a 3 month advertisement period to encourage feedback from the public.
4. Objects of the Act	Objects a-c: the *Darwinia masonii* Recovery Plan Object d: Consultation (as above (1), Attachment 3) Object e: International responsibilities (Attachment 3) Objects f & g: The role and interests of indigenous people (Attachment 3)
5. International agreements	Attachment 3
6. Indigenous People	Attachment 3
7. Social and economic impacts	Attachment 3
8. Efficient and effective use of resources	Section 5.1; Attachment 2
9. Species listed as threatened (EPBC	*Darwinia masonii* is listed as Vulnerable under the EPBC

Requirements of the Recovery Plan Guidelines		Section of this Plan
	Act)	Act.
10.	Taxonomic or common names used	The taxonomic name, *Darwinia masonii*, is used throughout the document.
11.	Distribution of the species	Section 1.2.3
12.	Population(s)	Section 1.3
13.	Define habitat critical to survival	Section 1.2.3, Section 2
14.	Description of habitat - spatial	Section 2
15.	Threats	Section 3
16.	Areas affected by threats	Section 3
17.	Population(s) under pressure of survival	Section 3, Section 1.2.3
18.	Recovery objectives	Section 4.1
19.	Measurable criteria	Section 4.2
20.	Evaluation of performance	Section 6, Section 4.3
21.	On-ground actions	Section 5
22.	Cost	Attachment 2
23.	Management practices	Section 5
24.	Biodiversity benefits/impacts	Section 5
25.	Affected interests	Attachment 3
26.	Social and economic benefits/impacts	Attachment 3