Peer review of four surveys conducted in the Mt Gibson area : Muir Environmental (1995), Bennett Environmental Consulting (2000), Armstrong and Associates (2004), A T A Environmental (2004).

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TABLES

Four surveys were reviewed. These were:

Muir Environmental (1995). Observations on the presence and distribution of rare flora, especially *Darwinia masonii*, near Mt Gibson. Unpublished report for Asia Iron Limited, West Perth.

Bennett Environmental Consulting Pty Ltd (2000). Flora and vegetation of Mt Gibson, prepared for Mt Gibson Iron Ltd.

Armstrong, P. and Associates (2004). Vegetation Assessment and Rare Flora Search between Perenjori and Mt Gibson. Conducted September and October 2003. For Mt Gibson Iron Ltd. March 2004.

ATA Environmental. (2004). Targeted search at Mt Gibson for the Declared Rare Flora *Darwinia masonii.* Mount Gibson Mining Limited.

1) SUMMARY

The general findings were:

Darwinia masonii

- The definition of mature plants has varied between surveys and no counts have been made to provide the number of flowering plants, in order to satisfy IUCN criterion that populations should be measured on the number of mature individuals, being those capable of reproduction.
- An estimation of seed production appears to be much too high in view of more recent findings.
- Estimates of the total number of plants in the populations have varied widely.
- There has been insufficient information provided to describe the methods used to count and estimate plant numbers, particularly of seedling counts.
- There is little information on the life history and phenology of *Darwinia masonii*.

Priority Plants

- Many new populations of priority plants found during the surveys have been reported, but some reported previously from the area have not yet been refound, particularly *Rhodanthe collina.*

Vegetation surveys

- Good surveys have been undertaken to provide information on the plant communities of the lease by structural mapping.
- Knowledge of non-dominant species of the lease and the Mount Gibson Range is still poor and more detailed floristic survey needs to be carried out in a good rainfall year to cover the major geographical, geomorphological and floristic variation found within the area.

Voucher Specimens

- No voucher specimens from any of the surveys have yet been lodged at The Western Australian Herbarium to validate identifications and verify the survey findings, to voucher new populations of rare and priority plants and to provide specimens for further taxonomic study.

2. RECOMMENDATIONS

Darwinia masonii

- A count of flowering plants should be made spring 2005 to give a more accurate figure for mature plants in the total population.

- Seedling numbers should not be included in the figure for the total number of plants in the population.

- Fixed quadrats need to be installed on burnt and disturbed sites for future study to determine rates of seedling loss.

Vegetation Surveys

- A detailed floristic survey is required for the Mt Gibson Range, which needs be held in the flowering season and in a year in which there had been sufficient rain to promote growth of annuals.
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- Surveys of this type also need to be carried out on other hills and ridges in the same (Yalgoo) IBRA bioregion in order to allow comparison. Supplementary sampling may be required in the same or following years as part of these surveys according to rainfall and/or flowering periods. (EPA Guidance No.51 3.2.2 & 4. 2004).

Voucher Specimens

- Specimens from the Bennett and Armstrong surveys need to be deposited at the Herbarium, in order to allow taxonomic study of the unidentified taxa. If specimens are in existence from the other surveys, they should also be lodged.

- Sufficient funding needs to be supplied as part of survey funding to provide time for consultants to process specimens and also to pay for lodgement at the W.A. Herbarium.
  It is expected that for flora and vegetation survey - adequate resources are directed to plant specimen processing, identification and subsequent lodgement (EPA Guidance for the Assessment of Environmental Factors No.51 3.2.1. 2004).

Peer review of four surveys conducted in the Mt Gibson area, Muir Environmental (1995), Bennett Environmental Consulting (2000), Armstrong and Associates (2004), A T A Environmental (2004).

S.Patrick

1. INTRODUCTION

1.1 The Mount Gibson Range runs from northwest to southeast on the east side of the Great Northern Highway south west of Paynes Find. The northern part of the range is on Ninghan Station. Most of the range is situated on a Crown Reserve within Mt Gibson Station. Mount Gibson is the highest point of the range and is situated near its southern end.

Four surveys have been conducted in the area, for vegetation and flora. Two of these, Muir Environmental (1995) and A T A Environmental (2004), have been concerned mainly with the declared rare species *Darwinia masonii*, known only from the ridges of the Mt Gibson Range over approx. 6 km, growing in shallow pockets of soil between exposed ironstone and banded ironstone formation, A T A Environmental (2004). The other two surveys, Bennett Environmental Consulting (2000) and Armstrong and Associates (2004), have been more extensive, covering the mining lease, and in the latter survey, the proposed route for the haul road. Muir Environmental (1995) and Armstrong and Associates (2004), have also searched suitable ridges in the area for new populations of *Darwinia masonii.*

1.2 Vegetation.

There are some specimens at the Western Australian Herbarium collected from Mt Gibson. A search of Florabase using Mount Gibson as query field gives 629 records. Using the four co-ordinates 20° 33' S, 29° 37'S, 117° 09' W, 117° 12' W which enclose the range, a search produces 228 records.

When records are removed which are not from the Mount Gibson Range, the list is reduced to 87 taxa. However, many of these records are old, with poor locality information, in some cases the locality is "Mt Gibson" which may indicate the station as a whole and not the banded ironstone ridge. There is therefore little vouchered vegetation information for the Mount Gibson Range.

1.3 Priority Plants. Two Declared Rare Flora are known to occur on the range, *Darwinia masonii* and *Eucalyptus synandra,* both recorded there recently.

Two priority one taxa have also been recorded there, *Acacia cerastes* and *Rhodanthe collina. Acacia cerastes* was recorded from near the summit of Mt Gibson most recently on 1.10.1990, and has been reported from the range since then (Bennett 2000). It is now known from several populations, mainly on Mount Gibson, Ninghan and Whitewells Stations, often on granite outcrops, and can be downgraded to a lower conservation priority.

Rhodanthe collina, however, is known from only five locations. The records were made 1957, 1969, 1984, 1986 and 1996, between Mingenew, Yalgoo and Paynes Find. The species was recorded from Mt. Gibson in 1984 "on hillside, red loam, jasper habitat, with *Acacia* and *Eremophila*." It has not been found there more recently and no surveys have been undertaken on the range or elsewhere to determine the conservation status of this species.

There are three other prority taxa recorded from the area.

Acacia imitans, Declared Rare Flora, was recorded for Mt Gibson in 1993 (A.L.Payne 3859). This record may have been made from Mt Gibson Station, and the habitat is recorded as a basalt hill, indicating that it may have been collected on the Singleton Range on Mt Gibson Station, where it is known to occur.

Hybanthus cymulosus, Declared Rare Flora, was collected at 220 ml peg ie.82 km NE of Wubin on the highway in 1951 by C.A. Gardner no.10209. This locality is approx. 4 km north of the Mount Gibson range on the highway. There are no grid references recorded on the original label. This is a hill south west of the Singleton Range, which has the geological formation abx, mafic flow and sill rocks with pyroxenite or peridotite bases, which is found in both the Mt Singleton and Mt Gibson ranges.

Philotheca nutans, priority one, occurs at the south eastern end of the Mt Gibson range, on a flat close to a large claypan which is on the lease.

1.4. Possible endemic species.

Gastrolobium aff. laytonii. A species of G*astrolobium* occurs on Iron Hill North and Mount Gibson, which has been identified as *G. laytonii*. It has a leaf shape unlike that of *G. laytonii*, which is mainly recorded growing on granite outcrops or sand dunes. There are no records of this taxon from elsewhere, and it requires further taxonomic study.

2. THE SURVEYS.

2.1 Muir Environmental for Asia Iron Ltd (1995). "Observations on the presence and distribution of Rare Flora especially *Darwinia masonii*, near Mt Gibson".

Survey period
A short survey of two days over 10th and 11th May 1995, conducted during heavy rain, when some areas were not accessible by vehicle, and foot search was limited by time constraints.

Area of survey.
This survey included part of the Mt Gibson Range, and five other ridges with similar geology in the surrounding area.

Methods
Three populations of *D. masonii* were surveyed on the Mount Gibson Range.
Five other areas outside the Mount Gibson Range were also searched briefly for *D. masonii*; the northwest slopes of Mt Singleton and Wylacoopin Hill, a hill southwest of Mt Singleton, a complex south east of Yidby Hill and near Mt Harry.

Results

Darwinia masonii
Some research was undertaken on earlier collections of this species although there is no mention of the type collected by D.Mason, cited in the protologue, Gardner (1964). In the type collections of the W.A. Herbarium *D. masonii* is represented by a "co-type" specimen collected by C.A.Gardner August 1952. The whereabouts of Mason's specimen is not known.

Population size.
Darwinia masonii was flowering profusely during the time of survey.
Three populations were surveyed, population 1 on Extension Hill at the north of the ridge, and populations 9 & 10, found during the survey.
Eight populations found by Coates (1994) are included in Fig. 2, which maps all known populations.
At the three populations sampled, a search was made over a 50m radius. Coates' data was used for pop.7. Therefore 630 plants were recorded from 4 populations, 590 plants > 0.5m tall and 40 plants < 0.5m tall. It was assumed that each of the other populations would be of about 180 plants in a 50m radius, and the total population was estimated to be 1,800 plants.
An account of *Darwinia masonii* (Blake 1981) is used to conclude that there are likely to be other populations elsewhere, as Blake states that the species grows on Mt Gibson and Mt Singleton. Blake also states that the species was originally collected by Drummond around 1854, and had been grown in England from seed collected by Drummond and that it grows on deep sandy soils.

Seed Numbers.
Blake's statement that seed had been grown in England, was used to infer that the plants produced viable seed, which could be collected and transported, germinated and grown in different soil and climatic conditions.
A total of 60,480 seeds per population per year was estimated. 70 old flowerheads were examined and only two shrivelled seeds were found. It was assumed that

1. Each flowerhead would produce up to 24 seeds from the 12-15 flowers in each head, with two ovules in each ovary. (*Darwinia* fruits usually produce only one seed per fruit, A. Crawford *pers.comm*.)
2. As the mean number of heads per plant is 14, that potentially 336 seeds set per plant each year.
3. If there is an average of 180 plants in each population (only four populations counted) 60,480 seeds would be produced per population per year
4. Plant life assumed at 20 years, so 1.2 million seeds set over that period.

No examination of flowerheads with ripe, viable seeds could be made at the time of survey to determine a more accurate figure.
Collections of seed of *Darwinia masonii* were made for the Threatened Flora Seed Centre in October 2004. From this material it has been found in a collection sampled from 40 plants that only 21% of fruit contained an apparently viable seed, and that there was only one seed per fruit, (Andrew Crawford *personal communication*). This reduces the potential seed bank considerably if these figures are accurate for the population as a whole.

Other Priority plants.
A list of 29 rare and priority taxa for the area included *Darwinia masonii, Eucalyptus synandra, Hybanthus cymulosus* and *Eriostemon (Philotheca) nutans.*
Rhodanthe collina, Acacia cerastes and *A. imitans* were not listed.
Rhodanthe collina was described in 1992 and was added to the Priority List in October 1992. It has been recorded flowering late August to early October, so it is unlikely that it would have been flowering at the time of this survey.
Eucalyptus synandra. A plant thought possibly to be this species was found at the northern end of the range, where it is not known to occur.

Full vegetation survey
A full survey was not made, but 14 taxa occurring with *D. masonii* were recorded.

Vouchers
No voucher specimens were lodged at the W A Herbarium. Further taxonomic examination of the specimen of *Eucalyptus synandra* might have proved valuable.

2.2 Bennett Environmental Consulting Pty Ltd for Mt Gibson Iron Ltd. (2000). "Flora and Vegetation of Mt Gibson".

Survey Period
Six days from 11th to 16th September 2000. States that early 2000 received higher than average cyclonic rainfall, but did not receive typical winter rainfall, therefore annuals were not apparent during the spring months.

Area of survey.
The Mt Gibson Iron Ltd lease, bounded approx. by the highway to the west, the Emu Fence to the east and south of the homestead track. The area was approx. 12 km north to south and 6 km east to west.

Methods
Objectives were to describe and map the vegetation communities of the lease, locate rare and priority species, provide a list of taxa, make two sets of specimens recorded from the lease, one for lodging at the Western Australian Herbarium, the other for the Wubin Community Herbarium.
All tracks were traversed by vehicle and where vehicle access not accessible, different veg units were traversed on foot.

Results

Darwinia masonii.
2380 plants approx. were listed in ten locations. Nine locations are mapped in Appendix F.

Other Priority plants.
A list of 30 taxa for the area is provided from CALM records.
Four taxa are recorded with population accounts of each; *Acacia acanthoclada* subsp. *glaucescens, Acacia cerastes, Eucalyptus synandra, Prostanthera magnifica.*
Philotheca nutans was not listed and was not found in T7, the lakeside vegetation community, where it is known to occur.
Rhodanthe collina was not found, although the survey was during flowering time, but it was a poor year for annuals.

Full vegetation survey
24 communities are described (Beard 1990.). 62 sites were sampled.
The sandplain vegetation system Joseph was not included with the four listed for the lease (Payne *et al*.1998) although it covers a significant area.

Vouchers
It was stated that two collections were made for each taxon recorded within the vegetation communities, one for the Wubin Community Herbarium, and another for the WA Herbarium. The set for the WA Herbarium has not yet been lodged although the specimens are being processed (E.Bennett *personal communication).* They are an important record of the vegetation of the area.
There are ten taxa in Appendix A, taxa recorded from the lease, which are not fully identified. Some may not be identifiable to species, if the specimens were poor or not flowering. Others however may represent rare, new, endemic or restricted taxa, and it is important that they are vouchered at the W.A. Herbarium for future taxonomic study.

2.3. Paul Armstrong & Associates March 2004, for Mt Gibson Iron Limited. "Vegetation assessment and rare flora search between Perenjori and Mt Gibson, conducted September and October 2003".

Survey Period.
The eastern part of haul route was surveyed 24th-30th Sept. The agricultural part of haul route and portions of the Mt Gibson Range were surveyed 8th-17th Oct. It was a year of good winter rainfall with annuals present.

Area of survey.
Vegetation survey was carried out along the proposed haul road from Mt Gibson to Perenjori, and on portions of Mt Gibson.
Hills with similar geology to the Mt Gibson Range, BIF or chert, were searched for *Darwinia masonii.* These were hills west of Mt Singleton and south of Ninghan homestead, also hills north of Ninghan homestead, hills west of Warro Well, hills south of Warro Well, andYandhanoo Hill.

Methods
Broad objectives were vegetation and flora surveys and a rare flora search.
The flora survey was to identify as many plant species as was practical in the project area.
Vegetation survey was to identify the different plant communities along the proposed haul road from Mt Gibson to Perenjori, and on portions of Mt Gibson, and to produce a map showing these communities.
Rare and significant flora was mapped and plant numbers were estimated.
Traverses on foot were made on the Mt Gibson Range using an estimated visibility of 4m, 2m on each side, and length of traverses, to estimate population numbers of *Darwinia masonii.* GPS locations were regularly recorded along the traverses.
Hills with similar geology, BIF or chert, were searched for *Darwinia masonii.*
A search was also made on the TEC listing for threatened ecological communities (English 2002).
The current botanical survey was to integrate with previous surveys of the Mt Gibson Range (Bennett Environmental Consulting 2000), (Muir Environmental 1995), (Payne *et al.* 1998).

Results

Darwinia masonii.
Foot traverses were made to estimate *Darwinia masonii* numbers.
The population numbers counted at each site by four studies were presented in Figure 6. These were Muir Environmental (1995), Bennet Environmental Consulting (2000), the current study, and an unpublished study by Coates, Curtin University (1996). Armstrong's survey estimated a total population of 1,283 plants, but the highest figures at each population from all four surveys were used to give an estimate of a total population of 6,107 plants. These were in five populations, as some of the original populations have been combined as more plants were found between them.

Other Priority plants.
A list of 62 rare and priority flora was identified as potentially occurring in the project area, which included the haul road to Perenjori and was therefore larger than in previous studies.
Populations of eighteen of these taxa were found during the survey, as well as three taxa which may be new. *Rhodanthe collina* was not found. Survey in the Mt Gibson area was carried out during October, but may have been too late for flowering.
Vouchers for this work are not yet in WAHerb, but 30-40 specimens are to be submitted.

Full vegetation survey.
A number of hills in the area with similar geology, banded ironstone formation or chert, were searched for *Darwinia masonii.* The vegetation on all these hills and ridges was mostly similar in dominant species composition to Mt Gibson, but differed slightly to greatly in the non-dominant species in both composition and vegetation canopy cover. In addition, all sites inspected were more arid with lower canopy cover and of a lower stature.
A total of 33 vegetation communities were described along the proposed haul route. A total of 354 taxa were identified from the haul road and Mt Gibson Range, during this study, which when combined with the list recorded by Bennett Environment Consulting (2000), gave 493 taxa.

TEC information.
None of the communities mapped are classified as Threatened Ecological Communities.

Vouchers
Not yet in WAHERB, but 30-40 will be submitted when processed (P.Armstrong *personal communication*).

2.4. ATA Environmental (2004). Mount Gibson Mining Ltd. Targeted search at Mt Gibson for the Declared Rare Flora *Darwinia masonii*

Survey Period.
The work was carried out during two periods, fourteen days from 26th June to 9th July and eight days from 19th July to 26th July 2004.

Area of survey.
The crests or ridges of the ten major hills in the Mt Gibson Ranges.

Methods
Parallel east-west transects were made between between 10m and 40m wide, (depending on the density of the associated vegetation) over the crests or ridges of the ten major hills in the Mt Gibson Ranges. (Armstrong made transects of 4m apart, giving visibility of 2m on each side). The transects were between 100m and 400m. long.
The location of each plant or group of plants was recorded by GPS co-ordinates, datum not recorded, and was flagged to avoid recounting. There is no other explanation of the methods used. In view of the very high numbers of plants recorded in comparison with previous surveys and estimates, it is important to have a full account of the methods used. Were estimates made of the seedling numbers? If so, how were these estimates made?
Seedlings were defined as less than 20 cm in height with no flowering material.
There is no mention of examination of herbarium specimens before commencement of the search, and no specimens have been submitted to confirm that identification of all stages of growth of the species have been correctly identified.

Results

Darwinia masonii
The majority of seedlings appeared to be less than two years old, and more than half the total seedlings recorded were from Iron Hill, partially burnt 2003. It was reported that the greater numbers of seedlings were on disturbed areas.
16,573 plants were recorded, of which 14,307 were described as mature, 1725 seedlings, 541 killed by fire (recorded as senescent).
Seedlings were recorded as 10.6% of total population.
There is no definition of mature plants. It is stated that the time of survey coincided with the most favourable time to identify *D. masonii* from its flowering material.
Plants are described as being 1.5 to 2.5 m tall, (Brown *et al.* 1998). If seedlings are defined as < 20 cm tall, would all plants above this height be mature? Mature plants could have been identified more accurately as only those which were flowering when surveyed, but there is no mention of recording which plants were flowering.
There is no mention of previous fire history apart from the fire of January 2003. It may be possible that there are generations of immature plants taller than 20 cm which have been counted as mature plants. Muir states that there was a notable scarcity of young plants in long unburnt wheatbelt vegetation and that examination of size-class distributions in trees demonstrated that there tended to be “stepped” age/size classes. This was believed to be primarily related to fire, with abundant germination after fire, with these plants growing at approximately the same rate, resulting in a suite of plants all about the same size. (Muir 1979).
We have no knowledge of the life history of this species which would tell us what percentage of seedlings resulting from fire or disturbance is likely to survive to maturity, ie long enough to flower and produce mature seed, or at what size or age maturity would be reached.
It was stated that regeneration appears to be only from seed, and that no regeneration from rootstock was observed by Armstrong & Assoc.2004. However, Muir 1995 observed swollen rootstocks, and several plants with multiple stems clearly derived from post-fire suckering.
It was stated that the survey found difficulties in discriminating readily between winter grass (possibly *Poa annua*) and *Darwinia* seedlings, so the western slopes of Mt Gibson and Iron Hill were not surveyed in detail for seedlings. (Bennett states that there were two areas of concentration of introduced species, Harp Mine and the southern crest of Mt Gibson, but neither Bennett or Armstrong recorded any species of *Poa*).
A search was made Feb. 2005 for 597 seedlings recorded from Iron Hill North. The search used GPS co-ordinates for a group of 72 seedlings, and although both WGS 84 and AGD 84 were used, only four seedlings were found. The burnt area was searched but no further seedlings found although there were many seedlings of other taxa superficially similar to those of *Darwinia masonii.* Possibly there has been a high

mortality of seedlings since the count was made. Two seedlings were ringed by flagging tape on Iron Hill South. One seedling was *Darwinia masonii,* the other *Philotheca* sp.
Most significant populations as a whole for the survey were recorded on the crests and east facing slopes of Mount Gibson.

Priority taxa
Only *Darwinia masonii* was recorded.

Full vegetation survey
Descriptions of vegetation communities in which *Darwinia masonii* was found were taken from the work of Bennett Environmental Consulting Pty Ltd (2000).

Vouchers
No voucher specimens have been lodged at the Western Australian Herbarium. In view of the large size of the populations of *Darwinia masonii* indicated by this study, it would have been appropriate to obtain a licence to take voucher specimens of this Declared Rare Flora from each population to be lodged at the W A Herbarium. We have no vouchers to ensure that the large numbers of plants counted are all of the target species. Herbarium specimens at present indicate only that *D. masonii* occurs on Extension Hill and Mount Gibson. There are eight collections made in the 1950's, two 1968, four in the 1980's and three in the 1990's. It would also have been appropriate to take voucher specimens of seedlings to confirm identification from the burnt areas where many seedlings were recorded.
There are no specimens collected by Grein in the collections of the W A Herbarium.

3. SUMMARY OF SURVEYS

3.1. Muir Environmental 23.5.1995.
A two day survey was conducted during poor conditions (heavy rain) in May 1995, when *Darwinia masonii* was not flowering.
Five other ridges surveyed briefly and unsuccessfully for other populations of *D. masonii.*
Three populations of *D. masonii* surveyed on the Mt Gibson Range.
All populations mapped with inclusion of information from Coates (1994).
Estimated total population to be 1,800 plants and estimated seed production with inferred information, but this estimate appears to be too high from recent information on seed production of the species made by the Threatened Flora Seed Centre at the Western Australian Herbarium.
No vouchers from this survey are present in the collections of the Western Australian Herbarium.

3.2. Bennett Environmental Consulting Pty Ltd 2000
A six day survey in mid September 2000, a year with no annuals apparent owing to insufficient winter rain.
The vegetation communities of the lease were described and mapped and populations of four priority taxa were found.
2380 plants of *D. masonii* listed at ten locations (nine mapped).
No vouchers from this survey are present in the collections of the Western Australian Herbarium.

3.3. Paul Armstrong & Associates March 2004,
A seventeen day survey conducted in late September and early October 2003.
Vegetation communities along the proposed haul road route to Perenjori and on portions of Mt Gibson were identified and mapped.
Rare and significant flora were mapped including new populations of eighteen priority taxa.
Hills in the area with similar geology to the Mt Gibson Range were searched unsuccessfully for new populations of *D.masonii.*
Figures from earlier surveys were used to estimate a total population of 6,107 plants of *D.masonii*.
No vouchers from this survey are present in the collections of the Western Australian Herbarium, but 30 to 40 specimens to be submitted when processed.
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3.4. ATA Environmental (2004).

A survey of 22 days in June and July to survey all plants of *Darwinia masonii.*
Transects were walked along over the crests and ridges of the Mt Gibson Range.
16,573 plants were recorded, of which 14,307 were described as mature, 1725 as seedlings and 541 killed by fire. Plants under 20 cm in height and not flowering were recorded as seedlings.
It was stated that there were difficulties in readily discriminating between winter grass and seedlings on the burnt western slopes of Mt Gibson. Some of the seedling counts could not be confirmed.
No vouchers from this survey are present in the collections of the Western Australian Herbarium.

4. DISCUSSION.

4.1. *Darwinia masonii*

4.1.1 *Life History and Phenology of Darwinia masonii*

Mature plants are reported to vary between 1.5 and 2.5 m tall (Patrick 2001, Brown *et al.* 1998). There is little other information recorded for the life history of the species.
We do not know how long plants take to reach maturity, what percentage of the seedlings are likely to die before reaching maturity, or the height range of mature plants in first year of flowering.
As we do not know the percentage of plants that will not survive to maturity after fire has stimulated mass germination, it does not seem accurate to include immature plants in the total population number. The definition of mature and immature plants has varied between the surveys carried out to determine the total population of *Darwinia masonii* (Table 1.).

Table 1. Definitions of immature plants

Survey	Small or seedling plants	Large or mature plants
Muir Environmental 1995	small plants <0.5m	large plants >0.5m
Coates 1996	immature plants< 20-30 cm	mature plants > 20-30 cm
Bennett Environmental Cons. 2000	not differentiated	
Armstrong and Assoc. 2004	not differentiated	
ATA Environmental 2004	seedlings <20 cm with no flowering material	

None of the surveys has recorded number of plants with flowers. If mature plants are defined as those with flowers a more accurate total of mature plants would be obtained by recording flowering plants as well as non-flowering plants.
It may be that there are other generations of non-flowering plants from earlier fires which are over 20 cm high, but which are still immature and subject to reduction in numbers before reaching maturity.
It is possible to see remains of flowerheads on the plants in summer. Those from the previous year have a brown receptacle from the base of the fallen flowerhead at the tip of the peduncle. This is black where flowerheads have fallen in previous years.
In Feb 2005 on Extension Hill North, plants which had not flowered were found up to 49 cm tall at one site. In the same location in an area 10m x 10m, which had been cleared c. 1996, 31 plants were counted. Of these 11 plants had not flowered. These ranged from 39 cm to 76 cm in height.
Muir noted in 1995 that several plants had multiple stems which appeared to have arisen from an enlarged stem base, and several were clearly derived from post-fire suckering. Suckering was also found in several plants where the vegetative upper portion had been removed during track construction.
It was reported that plants would resprout from rootstock following fire (Brown *et al.* 1998), however, it was reported by Armstrong and Associates 2004, that no burnt plants had survived the fire at Iron Hill in Jan 2003, although scorched plants had survived and flowered the following spring. In early October 2003, seedlings resulting from that fire were 1-2 cm tall.

4.1.2. *Numbers of plants*

An unpublished mapping study of portions of the Mt Gibson Range by Sheldon Coates, Senior Project Geologist for Asia Iron Ltd, 1996 mapped the distribution of *D. masonii* on Extension Hill, Extension Hill South, Mt Gibson and Mt Gibson South. Botany students from Curtin University of Technology located and recorded the populations. These figures were used with those from the other studies by Armstrong to estimate the most accurate population size.

Table. 2. Numbers of plants and populations provided by surveys.

Survey	No. of Plants counted	No. of plants estimated	No. of populations
Coates 1994	-	-	8
Muir Environmental 1995	621 in four populations	1800 (to 2000)	10
Coates 1996	3647	6000+	-
Bennett Environmental Cons. 2000		2380+	10
Armstrong and Assoc. 2004		6107	5
ATA Environmental 2004	16, 573, of which 14,307 mature, 1725 seedlings, 541 killed by fire.	-	9

Methods used to count plants.

There is little information on the methods used to count plants by any of the surveys.
Muir counted plants in a 50m radius at three locations then made estimates based on earlier work by Coates (1994).
Bennett (2000) made foot traverses and made estimates of plant numbers at ten locations.
Armstrong (2004) made traverses on foot using an estimated visibility of 4m, 2m on each side, and the length of traverses, to estimate population numbers.
ATA (2004) Made parallel east-west transects between 10m and 40m wide. It is stated that plants or groups of plants were marked after counting.

There are no explanations of how estimates were made, for example, how was the area covered on a wide transect of 40 m width? Were quadrats used? Were estimates made when there were large numbers of seedlings?
It is recommended that if a population is very large or spread over a large area, that the use of smaller, defined subunits could be considered. Several macroplots can be marked in which to estimate the number of plants. These should be small enough so that the entire plot can be viewed from a single vantage point. Elzinga *et al.* 2001.
There is no explanation of the how the locations of plants are arranged in Appendix 1. ATA Environmental (2004).
It would be very difficult to gain any extra information from the latter survey, such as future work on life history studies as it would not be possible to check population numbers at specific locations in future years, in order to record changes in plant numbers. The map at Figure 2 should have been on a much larger scale. For example, the data for Iron Hill East records 370 mature plants, 33 seedlings, 34 dead. Some symbols represent values such as >50, 6-20, 21-50, so that it is not possible to reproduce the numbers of plants represented on that hill from the map.
It would have been more useful to use a larger scale map, to number each site listed in Appendix 1, and plot each site number.
E.P.A. Guidance No. 51 at 3.1.1.states that the environmental objectives are to ensure that: survey data are capable of underpinning long-term observation and measurement for later compliance and audit purposes (E.P.A. 2004).

4.1.3.

Table 3. Aspect of slope on which plants most common

Survey	Areas in which plants most common
Coates 1994	Not stated
Muir Environmental 1995	On crest-line or upper one third of south western side of the ridges, only a few on north eastern side of the ridges.
Bennett Environmental Cons. 2000	On both southeastern and southwestern slopes, and not restricted to south western slopes as recorded by Muir (1995) or dominant on the south western slope as recorded by Brown *et al.* (1998).
Armstrong and Assoc. 2004	Not stated.
ATA Environmental 2004	Most significant populations on the crests and east facing slopes of Mount Gibson.

4.1.4. *Fire history*

It is important to know how long it takes for seedlings to reach maturity and what percentage of the young plants die before reaching maturity. Although it has been reported that *Darwinia masonii* seedlings are found in disturbed areas, it has also been reported that large numbers of seedlings were found after the fires of January 2003.

It has been found that there is a notable scarcity of young plants in long unburnt wheatbelt vegetation and that there was a distinct bias towards mature or senescent plants even in associations which had not experienced fire for very long periods Muir (1979).

It is possible that there may be generations of immature plants in the range resulting from earlier fires, and which are more than 20 cm tall so have been recorded as mature. There is little information in the surveys with regard to fire history of the range.

Reports of fires in the range.

Muir	At population 1, the majority of *D.masonii* plants were growing in post-fire regrowth believed to be 5-10 years old (in 1995).
Bennett	No records
Armstrong	January 2003, Iron Hill
ATA	January 2003 south and eastern part of the range, Iron Hill partially burnt, Iron Hill East completely burnt, western slopes of Mt Gibson.

ATA reports largest numbers of seedlings on Iron Hill North and Iron Hill, but did not record them on Iron Hill East or Mt Gibson due to time restrictions and difficulties distinguishing them from winter grass on Mt Gibson.

4.1.5. *Geology on which plants grow*

The northern ridgeline of the range and Extension Hill are mapped at 1:250 000 as Asp, pelitic to semi-pelitic quartz-feldspar rocks-includes siltstone, shale, phyllite and schist; may be laminated, graded or massive; andalusite and almandine present locally-, whereas the summit of Mt Gibson is mapped as Aih, haematite-magnetite-quartz banded iron-formation. (Lipple et al., 1983). None of the surveys makes reference to differences between these areas as habitat for *Darwinia masonii.*

4.2.Vegetation survey of the Mount Gibson Range

The most extensive survey of the Mount Gibson range was conducted by Bennett (2000), in which the vegetation communities of the range and the mining lease as a whole were described and mapped. This structural mapping identified the main elements of the plant communities and resulted in a list of 285 taxa from the lease area as a whole. This was conducted in a year when insufficient rain had resulted in poor representation of annual species. *Rhodanthe collina* a priority one species, recorded previously from Mount Gibson is an example of a poorly known species of importance which would have been absent or represented by few plants in such a year.

As stated in the introduction only 87 or fewer plants are recorded from the Mount Gibson Range at the Western Australian Herbarium.

The work by Armstrong indicates that on surrounding hills with similar geology, the vegetation was mostly similar in dominant species to Mt Gibson, but differed slightly to greatly in the non-dominant species in both composition and vegetation canopy cover. In addition, all sites inspected were more arid with lower canopy cover and of a lower stature (Armstrong 2004).

In view of this all non-dominant species need to be fully recorded. A detailed floristic survey needs to be carried out in a good rainfall year, by establishment of a series of quadrats on the range, its slopes and outwash plain, selected to cover the major geographical geomorphological and floristic variation found within the area. Vouchers from the survey need to be lodged at the State Herbarium.

A list of 324 taxa was recorded from a range of banded ironstone and basalts in the Goldfields, of which four taxa were thought to be endemic to that range and a further five restricted to banded ironstone ranges (Gibson *et al.* 1997).

This type of survey is also required before it can be determined whether the system includes threatened ecological communities. The surveys so far have not been this detailed.

4.3 Voucher Specimens

There are at present no voucher specimens from any of the surveys lodged at the Western Australian Herbarium.
In addition to Threatened and Priority Flora, other significant taxa should be highlighted, vouchered in the State Herbarium and brought to the attention of relevant authorities. (EPA Guidance No.51 3.4. 2004).
No voucher specimens have been lodged from any of these surveys for any of the populations of *Darwinia masonii,* and there is only one Rare Flora Report Form of Bennett 2000.
All the work on population numbers of *Darwinia masonii* is therefore unvouchered. There is no scientific evidence to ascertain that the identification of the species is correct. Photographs especially without closeups of flowers and leaves are not sufficient.

Material from the surveys of Bennett and Armstrong is intended for lodgement but has not yet been processed. Muir, Bennett and Armstrong regularly contribute specimens to the collections of the Western Australian Herbarium, but there appear to be none submitted by Grein or ATA Environmental.
It is important that information from such surveys is not lost, and sufficient funding should be supplied as part of the survey so that the cost of processing specimens by the consultant and the cost of lodgement of specimens at the State Herbarium at $25.00 per specimen can be met.
It is expected that adequate resources are directed to plant specimen processing, identification and subsequent lodgement. (EPA Guidance No.51 3.2.1 2004).

5. CONCLUSIONS

5.1. *Darwinia masonii*

The total population number recorded by ATA Environmental appears to be high, in relation to estimates by earlier surveys, which have been based on some counts.
All plants above 20 cm in height have been recorded as mature, when we have little information regarding size and age at which plants reach maturity. Adult plants are described as 1.5 to 2.5 m tall (Brown et al.1998). It is misleading to include all seedlings in the final total of plant numbers for the species, when we do not know how many will reach maturity. The total of mature plants may also be too high, as this includes all plants above 20cm tall. Some of these may be immature and it was noted in Feb. 2005 that some plants up to 76 cm tall had not flowered. The count of mature plants therefore appears to be too high as it includes plants which have not yet flowered and should therefore be regarded as immature. Population numbers are expressed as numbers of mature individuals only, and mature individuals are defined as the number of individuals known, estimated or inferred to be capable of reproduction (Hilton –Taylor 2000).

There is also concern that there were difficulties in distinguishing seedlings of *Darwinia masonii* from winter grass. Is there a possibility that seedling numbers may be inaccurate because of this difficulty? This requires clarification.

Before the population of mature plants can be recorded accurately, there is need for studies to be made on the burnt populations to determine the rate of loss of seedlings after successive periods of dry conditions, which will depend in this area on both summer and winter rainfall.
We have little information on the life history of this species. Would all those seedlings which survived the first summer then grow to mature plants.

- Fixed quadrats need to be installed on burnt and disturbed sites for future study to determine rates of seedling loss.

A further survey of *Darwinia masonii* is required in spring 2005, to determine mortality rates amongst seedlings after their second summer. However, it will be difficult to return to locations of plants recorded by ATA Environmental 2004, as the plant groups are mapped on too small a scale and GPS datum is not recorded. The coordinates are not grouped into localities, to coincide with groupings on the map, but are presented as a single list.

- A count of flowering plants should be made spring 2005 to give a more accurate figure for mature plants in the total population.

- Seedling numbers should not be included in the figure for the total number of plants in the population.

5.2. Vegetation Survey

A full survey of the Mt Gibson Range is required, which goes further than structural mapping which identifies only the main elements of the plant communities. There is a need to determine whether there is compositional variation between this range and other banded ironstone ranges in the bioregion, so that it can be classified in a regional context.

The work by Armstrong indicates that on surrounding hills with similar geology, the vegetation was mostly similar in dominant species to Mt Gibson, but differed slightly to greatly in the non-dominant species in both composition and vegetation canopy cover. In addition, all sites inspected were more arid with lower canopy cover and of a lower stature (Armstrong 2004).

Non-dominant species need to be fully recorded. A detailed floristic survey needs to be carried out by establishment of a series of quadrats on the range, its slopes and outwash plain, selected to cover the major geographical geomorphological and floristic variation found within the area. (Gibson *et al.* 1997).
This type of survey is also required before it can be determined whether the system includes threatened ecological communities. The vegetation surveys carried out so far have not been sufficiently detailed.

- A detailed floristic survey is required for the Mt Gibson Range, which needs be held in the flowering season and in a year in which there had been sufficient rain to promote growth of annuals.
- Surveys of this type need also be carried out on other hills and ridges in the same (Yalgoo) IBRA bioregion in order to allow comparison. Supplementary sampling may be required in the same or following years as part of these surveys according to rainfall and/or flowering periods. (EPA Guidance No.51 3.2.2 & 4. 2004).

5.3. Voucher Specimens.

Voucher specimens for the surveys carried out so far need to be lodged at the Western Australian Herbarium so that a record of the flora of the area is available for further study and so that nomenclature of the species list resulting from the surveys can be updated.

- Specimens from the Bennett and Armstrong surveys need to be deposited at the Herbarium, in order to allow taxonomic study of the unidentified taxa. If specimens are in existence from the other surveys, they should also be lodged.
- Sufficient funding needs to be supplied as part of survey funding to provide time for consultants to process specimens and also to pay for lodgement at the W.A. Herbarium.

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Response to ATA Environmental comments regarding Peer Review, (Patrick 2005).

Response to Covering Letter.

Vegetation Surveys

I consider that the comment that detailed floristic survey is required for the Mount Gibson Range is part of the peer review and is not an issue. The information for the plant communities of the area provided by structural mapping does not provide sufficient information on the floristic values of the range, even though that work was well carried out. It would then follow that comparison should be made with other ranges in the Yalgoo IBRA Bioregion.

Targeted survey for *Darwinia masonii.*

Estimates.

I did not find it clear from the account of methods used whether the plants in groups, which were recorded and flagged, were always individually counted rather than estimated. There is not usually an indication of the area that a group covered and as the transects varied between 10 and 40m wide and some groups were large with between 50-200 plants, I did not know therefore whether some estimates might have been made.

Definition of mature plants.

The definition of seedlings was given as plants less than 20 cm tall with no flowering material. There was no mention of mature plants being defined as plants greater than 20 cm with flowering material. This made it unclear as to how plants over 20 cm with no evidence of flowering would be categorised.
In the response it is said that plants over 20cm tall without flowering material were classified as seedlings. In Feb. 2005 a quadrat of 10 x 10 m on Extension Hill North was examined. The area had been cleared c. 10 years previously. 31 plants were counted within the quadrat. Of these 30 were over 20 cm tall and 11 of these had not flowered. The population at Extension Hill North is recorded as 545 mature plants, 12 seedlings, and one dead plant. If the 11 non flowering plants recorded in the quadrat had been recorded as seedlings in the whole population survey, it seems unlikely that we happened to find most of those in this small area of quadrat. Even if a further count of the total population is not considered necessary, I consider that a recount at this location would be helpful.

Response to Document.

Section 2.4

Methods

It is important to submit voucher material. *Darwinia masonii* has been collected only four times in the last 20 years so there is little material in the Western Australian Herbarium with good locality information. A voucher specimen from each of the ten centres of population recorded by this survey would have provided more information and vouchered this important survey. See EPA, Guidance No.51, 3.4. 2004.

An application for a permit to take Declared Rare Flora should have been made in order to do this.

Results.

Even though it is stated in the response that it would be obvious that mature plants would be those greater that 20 cm with flowering material, there was no mention in the Report as to how plants over 20 cm without flowering material were classified.
It would have been useful to have divided plants into three classes:

Seedlings, less than 20 cm tall without flowers
Juveniles, more than 20 cm tall without flowers
Mature individuals with flowers.

Population numbers should be expressed as numbers of mature individuals only, and mature individuals are defined as the number of individuals known, estimated or inferred to be capable of reproduction. IUCN guidelines state that a population of a threatened species should be expressed as the number of mature individuals present, ie those plants which produce flowers and fruits. (Hilton –Taylor 2000).

The ring of tape surrounding a seedling of *Darwinia masonii* and a *Philotheca* seedling was weighted down with stones and had not been wind blown. However, seedling counts are not relevant. See above.

Vouchers

An application for a permit to take Declared Rare Flora should have been made, particularly as a full survey may have discovered new populations not previously recorded which should have been vouchered.

3. Summary of Surveys.

3.4. ATA Environmental (2004).

The statement “difficulties in readily to discriminating between winter grass and seedlings” was misinterpreted by me. It would have helped to clarify the statement by explaining that the dominant winter grass layer made detection of *Darwinia* seedlings difficult.

4. Discussion.

4.1.1. Life History and Phenology of *Darwinia masonii.*

It was not stated in the report that mature plants were recorded as those plants greater than 20 cm with flowering material, only that seedlings were defined as plants under 20 cm tall without flowering material. This left doubt as to how plants over 20 cm in height without flowering material had been categorised. If these had been included as mature plants the size of the population of mature plants would not have been correct.

4.1.2. Numbers of plants.

As plants in patches were not flagged individually I was uncertain whether some estimates had been made.

The location of plants in Appendix 1 would have been more useful if grouped to correspond with the population groups on the hills of the range.

4.3. Voucher specimens.

As stated above, the EPA guidelines expect that persons engaged in vegetation and flora surveys will bring new information arising from surveys to the scientific, government and public arenas. Even though it was not known that vouchers had not been submitted from previous surveys of *Darwinia masonii* a permit should have been sought in the event that vouchers for new populations were required. It would have been possible to check whether voucher specimens from previous surveys had been lodged at the W.A.Herbarium when undertaking preliminary studies on *Darwinia masonii* at the Herbarium before commencement of the survey.

The cost of submitting specimens to the Western Australian Herbarium should be estimated and included in the costs required for the survey as per EPA Guidance No.51 3.2.1 2004. Few specimens would have been required as vouchers for the work, and the cost of submitting these would have been small compared to the cost of the survey as a whole.

5. Conclusions.

5.1 *Darwinia masonii.*

I understand that no estimates were made, but that all plants were counted.

References.

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