Department of Parks and Wildlife

Interim Recovery Plan No. **365**

Paynter's Tetratheca

(*Tetratheca paynterae* subsp. *paynterae*)

Interim Recovery Plan

2016–2021

Department of Parks and Wildlife, Western Australia

October 2016

List of Acronyms

The following acronyms are used in this plan:

BGPA	Botanic Gardens and Parks Authority
BIF	Banded iron formation
CALM	Department of Conservation and Land Management
CCG	Community Consultation Group
CITES	Convention on International Trade in Endangered Species
CR	Critically Endangered
DEC	Department of Environment and Conservation
DAA	Department of Aboriginal Affairs
DAA	Data Analysis Australia
DMP	Department of Mines and Petroleum
DOL	Department of Lands
DOP	Department of Planning
DPaW	Department of Parks and Wildlife
DRF	Declared Rare Flora, now known as Threatened
EIA	Environmental Impact Assessment
EMB	Environmental Management Branch
EN	Endangered
EPA	Environmental Protection Authority
EPBC	Environment Protection and Biodiversity Conservation
GA_3	Gibberellic acid
GRTFRT	Goldfields Region Threatened Flora Recovery Team
IBRA	Interim Biogeographic Regionalisation for Australia
IRP	Interim Recovery Plan
IUCN	International Union for Conservation of Nature
KPCRG	Koolyanobbing Project Community Reference Group (now referred to as CCG)
NRM	Natural Resource Management
PEC	Priority Ecological Community
PICA	Public Information and Corporate Affairs
SCB	Species and Communities Branch
SWALSC	South West Aboriginal Land and Sea Council
TEC	Threatened Ecological Community
TFSC	Threatened Flora Seed Centre
TPFL	Threatened and Priority Flora Database
UCL	Unallocated Crown Land
UNEP-WCMC	United Nations Environment Program World Conservation Monitoring Centre
WA	Western Australia

Foreword

Interim Recovery Plans (IRPs) are developed within the framework laid down in Department of Parks and Wildlife Corporate Policy Statement No. 35 (DPaW 2015*a*) and Department of Parks and Wildlife Corporate Guideline No. 35 (DPaW 2015*b*). Plans outline the recovery actions that are required to urgently address those threatening processes most affecting the ongoing survival of threatened taxa or ecological communities, and begin the recovery process.

Parks and Wildlife is committed to ensuring that threatened flora (also known as Declared Rare Flora (DRF)) are conserved through the preparation and implementation of Recovery Plans (RPs) or IRPs, and by ensuring that conservation action commences as soon as possible and, in the case of Critically Endangered (CR) taxa, within one year of endorsement of that rank by the Minister.

IRP No. 237 Paynter's Tetratheca (*Tetratheca paynterae* subsp. *paynterae*) (Department of Conservation and Land Management 2006) was required under environmental approvals granted to Portman Iron Ore Pty Ltd (now Cliffs Asia Pacific Iron Ore) in 2003 for iron ore mining at the Windarling and Mt Jackson ranges north of Southern Cross. This updated plan, which replaces IRP No. 237 will operate from October 2016 to September 2021 but will remain in force until withdrawn or replaced. It is intended that, if the taxon is still ranked as CR in Western Australia, this plan will be reviewed after five years and the need for further recovery actions assessed.

This plan was given regional approval on 16 May 2016 and was approved by the Director of Science and Conservation Division on 10 October 2016. The provision of funds identified in this plan is dependent on budgetary and other constraints affecting Parks and Wildlife, as well as the need to address other priorities.

Information in this plan was accurate at October 2016.

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Summary

Scientific name:	*Tetratheca paynterae* subsp. *paynterae*	**DPaW district:**	N/A
		Shire:	Yilgarn
Family:	Elaeocarpaceae	**NRM region:**	Wheatbelt
Common name:	Paynter's Tetratheca	**IBRA region:**	Coolgardie
Flowering period:	All year (in response to rainfall); peak September–November	**IBRA subregion:**	Southern Cross (COO02)
		Recovery team:	Goldfields Region Threatened Flora Recovery Team
DPaW region:	Goldfields		

Distribution and habitat: *Tetratheca paynterae* subsp. *paynterae* is currently known only from Windarling Range some 160km north of Southern Cross, growing in shallow, red, loamy soil in rock crevices and also in shallow silty clay soils, generally on northern cliff faces (Butcher 2007; Yates *et al*. 2008; Yates *et al*. 2011). Associated vegetation comprises sparse to open scrub (Butcher 2007).

Habitat critical to the survival of the subspecies, and important populations: It is considered that all known habitat for wild and translocated populations of *Tetratheca paynterae* subsp. *paynterae* are critical to its survival and that the single known wild population is an important population. Areas of similar habitat are present elsewhere and, while *T. paynterae* subsp. *paynterae* is not represented at these sites, some areas may prove suitable for translocation. Habitat critical to the survival of *T. paynterae* subsp. *paynterae* includes the area of occupancy of the known population and areas of similar habitat surrounding the population (these providing potential habitat for population expansion and pollinators). It may also include additional occurrences of similar habitat that may contain undiscovered populations of *T. paynterae* subsp. *paynterae* or be suitable for future translocations.

Conservation status: *Tetratheca paynterae* subsp. *paynterae* was listed as specially protected under the Western Australian *Wildlife Conservation Act 1950* on 17 May 1991. It is ranked as Critically Endangered (CR) in Western Australia under International Union for Conservation of Nature (IUCN) 2001 Red List criteria B1ab(ii,iii,iv) due to its extent of occurrence estimated to be less than 100km^2; it being known to exist at only a single location; and there being a continuing decline in area of occupancy, area, extent and/or quality of habitat and number of mature individuals. The subspecies is currently listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as Endangered (EN).

Threats: Threats to *Tetratheca paynterae* subsp. *paynterae* include clearing and habitat disturbance.

Existing recovery actions: The following recovery actions have been or are currently being implemented and have been considered in the preparation of this plan:

1. Monitoring of the condition of a fixed subsample of *Tetratheca paynterae* subsp. *paynterae* was initiated by Cliffs in 2003 and occurs annually.
2. Between 2004 and 2013 a number of individuals within each *Tetratheca paynterae* subsp. *paynterae* monitoring block were randomly selected for a condition assessment (percentage of stems that are alive within the whole plant).
3. The Koolyanobbing Project Community Reference Group (KPCRG), now referred to as the Community Consultation Group (CCG), operated between 2004 and 2014 with an element of its charter being the review of *Tetratheca paynterae* subsp. *paynterae* research and management programs undertaken by Cliffs.
4. Parks and Wildlife and the Botanic Gardens and Parks Authority (BGPA) have undertaken applied research into the biology and ecology of *Tetratheca paynterae* subsp. *paynterae*. All research was funded and coordinated by Cliffs.
5. Between 2004 and 2006, Cliffs (then Portman) conducted a small scale "translocation" trial to test the feasibility and practicality of establishing new populations of *Tetratheca paynterae* subsp. *paynterae* in the field. Sixteen seedlings were recorded in May 2006, eight of which were still alive in 2008 (1% success rate).

Four of these plants were taken during mining activities between 2010 and 2014

6. In 2014 a proposal was submitted by BGPA to undertake an additional trial research translocation for *Tetratheca paynterae* subsp. *paynterae* (Stevens and Dixon 2014).
7. In total, over 30g of *Tetratheca paynterae* subsp. *paynterae* seed is in storage at the BGPA and 14,579 seeds are stored at –20°C at the Parks and Wildlife Threatened Flora Seed Centre (TFSC).
8. Approximately 2,000 seeds were sent to the Millennium Seed Bank, Royal Botanic Gardens, Kew as part of a risk management strategy for *ex situ* storage of DRF.
9. Approximately 2,500 cuttings collected from 250 plants between September and December 2003 have been propagated by the BGPA and potted on with mixed results.
10. A Fire Protection Plan was developed for Cliffs by Parks and Wildlife (then the Department of Environment and Conservation (DEC)) in 2010. The report examines the threat posed by bushfire around minesites at Koolyanobbing, Mount Jackson and Windarling.

Plan objective: The objective of this plan is to abate identified threats and maintain or enhance the single known population of *Tetratheca paynterae* subsp. *paynterae* to ensure its long-term conservation in the wild.

Recovery criteria

Criteria for recovery success: The plan will be deemed a success if one or more of the following take place.

- The single known population has remained extant and the number of mature plants within that population has remained within 3% range (5,399 ± 162) or has increased by >3% or
- New populations have been found, increasing the number of known populations from one to two or more over the term of the plan with no net loss of mature plants or
- The area of occupancy has increased by >5% over the term of the plan with no net loss of mature plants.

Criteria for recovery failure: The plan will be deemed a failure if one or more of the following take place.

- The single known population has been lost or
- The number of mature plants has decreased by >3% from 5,399 to 5,237 or less or
- The area of occupancy has decreased by >5% over the term of the plan with a net loss of mature plants.

Recovery actions

1. Coordinate recovery actions
2. Undertake a population census
3. Undertake measures to support secure conservation tenure
4. Ensure input to regulatory processes
5. Continue monitoring and condition assessment
6. Continue the implementation of the *Tetratheca paynterae* subsp. *paynterae* research program
7. Collect and store seed
8. Develop and implement translocations
9. Liaise with Aboriginal communities
10. Map habitat critical to the survival of *Tetratheca paynterae* subsp. *paynterae*
11. Promote awareness
12. Review this plan and assess the need for further recovery actions

1. Background

An Interim Recovery Plan (IRP) for this subspecies was published in 2006 by the Department of Conservation and Land Management. This updated plan replaces the previous plan.

The criteria for success in the previous plan was " the number of *in situ* individuals in areas of current occupancy outside of direct mining operations remains stable (i.e. within 10% of 2003 census result) or increase, and at least one self-sustaining translocated population is established." As a population census has not been conducted since 2005 it is not possible to determine if there has been a decline or an increase since that time and it is not therefore possible to determine if the criteria for success and failure have been met.

Table 1: Status of recovery actions listed in the previous plan

Recovery action	Status	Result
1. Coordinate recovery actions and provide an annual report	Ongoing	Recovery actions have been coordinated by the Goldfields Region with assistance from the GRTFRT.
2. Seek to progress acquisition of Diemals Pastoral Lease	Completed	Lease relinquished and reverted to UCL
3. Coordinate the implementation of the research program	Completed	Parks and Wildlife, Botanic Gardens and Parks Authority (BGPA) and Western Botanical undertook applied research into the biology and ecology of *Tetratheca paynterae* subsp. *paynterae*. This research program was coordinated and funded by Cliffs.
4. Continue the implementation of the *Tetratheca paynterae* subsp. *paynterae* research program	Mostly completed	For results see Biology and Ecology page 12.
5. Implement *Tetratheca paynterae* subsp. *paynterae* condition monitoring program	Ongoing	Condition assessment monitoring of a subset of 312 plants in six locations across the range began in 2003 and was undertaken annually until 2010. A number of parameters including the size, life stage and condition of each plant was recorded and a photographic record for each individual taken. In 2011, methods were altered and 139 individuals were randomly selected for condition assessment (percentage of total plant alive) (see biology and ecology section for results).
6. Map habitat critical to the survival of *Tetratheca paynterae* subsp. *paynterae* (existing sites and potential translocation sites)	Partly completed	The known population boundary has been mapped.
7. Continue implementation of translocation trial and develop and implement a full translocation proposal	Ongoing	A small scale "translocation" trial of *Tetratheca paynterae* subsp. *paynterae* was conducted by Cliffs between 2004 and 2006 to assess if seeding into potential unoccupied habitat at Windarling was a viable method of establishing new individuals (Portman 2004). In 2014, a proposal was submitted by Cliffs to undertake a further research trial translocation for the *Tetratheca paynterae* subsp. *paynterae* (Stevens and Dixon 2014).
8. Meet with, and communicate progress on IRP implementation to the Koolyanobbing Project	Completed	The KPCRG (now referred to as CCG) was established, with a core element of its charter related to the review of *Tetratheca paynterae* subsp. *paynterae* research and management programs undertaken by Cliffs. This group met with Cliffs every six months until March

Community Reference Group (KPCRG) every 6 months		2014. Cliffs now meets with CCG annually. This condition is no longer required under the new Ministerial Statement #982.
9. Maintain adequate seed/germplasm collections to ensure material with a broad genetic base is available for translocation and on-going *ex situ* conservation	Ongoing	• Between September and December 2003, approximately 35,000 seeds were collected from a section of the population to be impacted by mining. These collections have been evenly distributed between the BGPA, Parks and Wildlife, and Western Botanical, the latter implementing translocation and propagation trials on behalf of Cliffs. A further 7,100 seeds (estimated) were collected in late 2004 from the area approved for mining. • Approximately 2,500 cuttings taken from 250 plants between September and December 2003 have been propagated by BGPA and potted on by Western Botanical with mixed results. • Several hundred seeds of each *Tetratheca paynterae* subspecies have been sent to the Millennium Seed Bank, Royal Botanic Gardens, Kew as part of a risk management strategy for *ex situ* storage of DRF.
10. Promote awareness of *Tetratheca paynterae* subsp. *paynterae* and IRP initiatives	Completed No longer applicable	Cliffs has prepared a variety of promotional material for different audiences and high level of workforce awareness has been obtained through induction materials.
11. Review the IRP and update as necessary	Completed	The previous IRP was reviewed during the preparation of the updated IRP.

Ongoing recovery actions included in the previous plan are included in this revised plan. New recovery actions include – 'undertake population census'; 'undertake measures to support secure conservation tenure', 'undertake germination trials' and 'liaise with Aboriginal communities'.

History

Tetratheca paynterae was discovered by Ray Paynter in 1988 and was named in her honour in 1995. The type collection was made from the Windarling Range 160km north of Southern Cross by J. Alford in November 1989. The next collection was made from the same range by F. and N. Mollemans in 1990 and several additional collections were subsequently made from the same area between 2000 and 2004. A second subspecies, now named *T. paynterae* subsp. *cremnobata*, is located in the Die Hardy Range 10km north-north-east of Windarling.

Tetratheca paynterae subsp. *paynterae* is restricted to the Windarling Range, a banded iron formation (BIF) which comprises a single main ridge 1.5km long and a number of smaller, shorter ridges. The Range is on the Diemals ex-pastoral lease which has been de-stocked. However, it should be noted that, when stocked, stock did not occupy the outcropping ironstone where *Tetratheca paynterae* subsp. *paynterae* occurs. The area is associated with the Windarling vegetation complex Priority Ecological Community (PEC).

The initial inventory of *Tetratheca paynterae* subsp. *paynterae*, conducted in 2000, identified 2,852 mature plants in three separate locations on Windarling Range. A subsequent inventory, conducted by Cliffs Asia Pacific Iron Ore (previously Portman Iron Ore Ltd) in spring 2003, recorded a revised total of 7,213 individuals from the W3 and W5 orebody deposits (Western Botanical 2004; Western Botanical 2013).

In 2002, Portman applied to expand its mining into the Mount Jackson and Windarling Ranges. In December 2003 the State Minister for the Environment issued a permit to take up to 30% (2,126 *Tetratheca paynterae* subsp. *paynterae* plants), while the area containing 50% of the population was

protected from mining. Environmental approval was also issued by the Commonwealth Minister for the Environment and Heritage in September 2003, under the *Environment Protection and Biodiversity Conservation Act 1999*.

Approximately 5,399 plants were known when last fully counted in 2005. Plants grow on the main ridge (Ridge 3) and on one of the smaller ridges (Ridge 5), which runs parallel to the main ridge.

Mining of the W3/W5 ore bodies commenced in early 2004 with 27% (1,968) plants removed (figures from 2005 census undertaken post-mining). Development of the W3 mine pit consisted of the removal of 600m of the eastern end of Ridge 3. The non-impacted area included a 900m long ridge and a small retained area of the mine edge (10 to 20m wide), referred to as the 'retained area of Ridge 3'. Apart from the western end supporting 92 plants (in 2004), the whole of Ridge 5 (W5) was mined.

Under Ministerial Statement 627 (2003) conditional approval for mining within Area B required the development and approval by the Minister for the Environment and Heritage of a *Tetratheca paynterae* subsp. *paynterae* Research and Management Plan which was to include information on:

- Monitoring of numbers of individuals, their health, viability of the population, and reproductive success;
- Provision of secure conservation tenure for the remaining population of *Tetratheca paynterae* subsp. *paynterae*;
- A detailed risk management plan, incorporating performance criteria to be met, to avoid indirect impacts of mining activities on the remaining population of *Tetratheca paynterae* subsp. *paynterae*;
- Research into the ecology and potential translocation of *Tetratheca paynterae* subsp. *paynterae* with a focus on the specific habitat requirements of the species; and
- Research into the pollination vector(s) of *Tetratheca paynterae* subsp. *paynterae* to identify the vector(s) and the specific ecological requirements.

The conditions also required that a Recovery Plan be prepared and approved by the Minister as part of consideration for approving any ground disturbing activity in Area B, although the content of this plan was not specified in the ministerial statement. These conditions were put in place to ensure that the viability of *Tetratheca paynterae* subsp. *paynterae* was not compromised by any additional development. The Research and Management Plan was never finalised, mainly as a result of the option of accessing Area B for mining not being pursued by Cliffs (the research and management plan was only required where approval to ground disturb in Area B was being sought). The IRP was approved in 2006.

A report and recommendations by the EPA in July 2014 (number 1521), on an inquiry under s46 of the *Environmental Protection Act 1986* into changing the implementation conditions of a number of ministerial statements including 627 recommended the application of a new set of conditions covering protection and conservation of *Tetratheca paynterae* subsp. *paynterae*. The EPA's report indicated that secure conservation tenure for *T. paynterae* subsp. *paynterae* is unable to be provided by the proponent directly, as it can only be achieved through reservation under the *Conservation and Land Management Act 1984*. On this basis the EPA recommended that the direct requirement for the proponent to take action to reserve areas where the species occurs be removed and condition be reworded to include "measures to support the secure conservation tenure for the remaining population of *T. paynterae* subsp. *paynterae*", subject to seeking access to Area B. Seven Ministerial Statement approvals (627, 802, 843, 874, 900, 907 and 909) applying to

the Yilgarn operations were issued between 2003 and 2012. These statements have been consolidated into a single Ministerial Statement (Statement #982) which was published on the 24th September 2014. Under Statement #982, in relation to the *T. paynterae* subsp. *paynterae*, the proponent (Cliffs) are required to prepare and implement a Research and Management Plan and Recovery Plan if the proponent intended to apply for access to Area B for ground disturbing activity. The Research and Management Plan is to include monitoring of numbers of individuals, health, viability and reproductive success, ecological research and potential translocation, pollination vectors, management, and measures to support the secure conservation tenure.

Figure 1: Aerial photo of Windarling Range and mine showing the location of Area B

Description

Elaeocarpaceae (formerly Tremandraceae) is an endemic Australian family which comprises three genera, *Platytheca*, *Tremandra* and *Tetratheca*. While *Platytheca* and *Tremandra* are confined to south-western Australia, *Tetratheca* is widespread across southern Australia. Currently, 51 species are recognised *c.* 70% of which are endemic to Western Australia. One of these, *Tetratheca paynterae* is confined to banded ironstone formations north of Southern Cross. The species comprises two subspecies, subsp. *paynterae* and subsp. *cremnobata*.

Tetratheca paynterae subsp. *paynterae* is a clumped sub-shrub, 0.15 to 0.5m high by 0.4 to 0.8m wide with a woody rootstock and alternate branches that often end in a brown or silver point. The leaves are stalkless, narrowly triangular, 0.8 to 2.5mm long by 0.3 to 0.9mm wide, and are sparsely scattered along the stems. The leaves are deciduous and usually absent from stems. The flowers have a distinctly musky odour, occur singly in the axils of leaf bases, and are on stalks which are often slightly recurved, 1.5 to 11mm long. The 5 or 6 petals are inversely egg-shaped to elliptic, 5.5 to 13mm long by 3 to 8mm wide and deep pink with a yellow spot at the base (Butcher 2007).

Flowering occurs opportunistically when water is available, but peak flowering is from September to November (Butcher 2007).

Tetratheca paynterae subsp. *paynterae* differs from *T. paynterae* subsp. *cremnobata* in having shorter, erect stems; leaves that are more pubescent with hairs longer and denser on the upper and lower surfaces; an ovary which is densely covered in patent, white hairs and scattered, short, red glandular hairs, with the simple hairs extending to 2/3 the length of the style; stamens are 0.4 to 0.7mm long, with the filaments generally fused along their entire length and yellow, and anther tubes yellow; and an angled to lobed appearance to the rim of receptacle. In contrast, subsp. *cremnobata* is larger and more intricately branched with a sprawling habit, characteristically hanging down rock faces; glabrous to glabrescent leaves, with occasional sparse hairs underneath and towards the apex, and a few apical hairs above; a red, glossy ovary with scattered glandular hairs and a few simple hairs restricted to a small region at the base of the style and ovary; slightly longer stamens (0.4 to 0.9mm), with less fused, red filaments, and dull red-purple to mauve anther tubes; and a circular to angled appearance to the rim of receptacle (Butcher 2007; Butcher *et al*. 2007b).

Illustrations and/or further information

Alford, J.J. (1995) Two new species of *Tetratheca* (Tremandraceae), from the Coolgardie and Austin Botanical Districts, Western Australia. *Nuytsia* 10(2): 143–149; Brown, A., Thomson-Dans, C. and Marchant, N. (Eds) (1998) Western Australia's threatened flora. Department of Conservation and Land Management, Western Australia; Butcher, R. (2007) New taxa of 'leafless' *Tetratheca* (Elaeocarpaceae; formerly Tremandraceae) from Western Australia. *Australian Systematic Botany* 20: 139–160; Western Australian Herbarium (1998–) *FloraBase—the Western Australian Flora*. Department of Parks and Wildlife. http://florabase.dpaw.wa.gov.au/.

Distribution and habitat

Tetratheca paynterae subsp. *paynterae* is found only on the Windarling Range some 160km north of Southern Cross. The climate of the region is semi-arid Mediterranean, characterised by hot, dry summers and mild winters. Rainfall occurs predominantly during the winter months but may also occasionally fall during summer due to the influence of tropical cyclones from the north. The average annual rainfall for the Windarling Range is 273mm (Western Botanical 2013; Yates *et al*. 2011).

The region of the Windarling Range is described by Yates *et al*. (2011) as having a complex geology of extensive metamorphosed mafic volcanic and intrusive rocks (greenstone belts) within a broader landscape of Archean granitic and gneiss rocks. The BIF originated from these greenstone belts and is composed of bands of iron-rich rocks that resisted erosion to protrude as hills and low ranges. Faulting and weathering have created a range of cliffs, peaks and fractured rock surfaces, with various slopes and aspects. *Tetratheca paynterae* subsp. *paynterae* has established in rock crevices or fissures of the BIF (Yates *et al*. 2011).

Tetratheca paynterae subsp. *paynterae* grows in very shallow (21±6mm), red, loamy soil which is organic-rich, acidic, and has high levels of phosphorus and ammonium (NH_4^+) (Jasper and Braimbridge 2002). It occurs in ironstone massif and jasperlite rock crevices along the peak of the

range, generally on northern cliff faces, and in shallow silty clay soils in mid-slope positions (Butcher 2007; Yates *et al*. 2008; Yates *et al*. 2011). *Tetratheca paynterae* subsp. *paynterae* does occur on some non-north facing ironstone outcrops. It is therefore inferred that the occurrence on north facing outcrops is more a function of the bedding and erosion of the ironstone than an intrinsic requirement for north-facing slopes. The physical characteristics of the rock faces are also likely to be one of the most important factors determining the occurrence of this species, rather than any particular soil property; the complex of cracks in the rock strata captures moisture, which is an important constraint to plant growth in an arid environment (Jasper and Braimbridge 2002).

Associated vegetation on the ridge areas is sparse to open scrub including *Calycopeplus paucifolius*, *Acacia tetragonophylla* and *Callitris glaucophylla*, over *Exocarpos aphyllus*, *Spartothamnella teucriiflora*, *Scaevola spinescens*, *Ricinocarpos brevis*, *Melaleuca leiocarpa*, *Acacia minyura* and *Alyxia buxifolia* over *Dodonaea viscosa* subsp. *mucronata*, *Olearia stuartii*, *Isotoma petraea*, *Ptilotus obovatus*, *Austrostipa scabra*, *Rhodanthe battii*, *Austrodanthonia caespitosa*, *Chenopodium* sp. and ferns. Rock surfaces have varying amounts of lichen, with non-north facing surfaces supporting a broader range and greater cover. Mid-slope vegetation comprises open woodland of *Eucalyptus griffithsii* with *Casuarina pauper*, *Eremophila oppositifolia*, *E. glabra* subsp. *tomentosa*, *Acacia andrewsii* and *Dodonaea lobulata* (Butcher 2007).

Table 2. Summary of *Tetratheca paynterae* subsp. *paynterae* population, land vesting, purpose and manager

TPFL population number & location	DPaW region	LGA	Vesting	Purpose of land tenure	Tenement holder
1. Windarling Range	Goldfields	Shire of Yilgarn	Non vested	UCL (former pastoral lease)	Cliffs Asia Pacific Iron Ore Pty Ltd

Biology and ecology

Monitoring and condition assessment

Monitoring of the condition of a fixed subsample of *Tetratheca paynterae* subsp. *paynterae* was initiated in 2003 and has occurred annually. The monitoring program was reviewed by Data Analysis Australia (DAA) in 2011 and the design modified to improve its ability to detect changes in population dynamics. Monitoring since 2011 has been undertaken at seven randomly selected blocks. All *T. paynterae* subsp. *paynterae* plants in each block were tagged and the following information recorded:

- Block number
- Unique plant identification number
- Width (cm) (recorded for adults only)
- Presence of flowers/fruits/buds
- Plant status (dead or alive, reproductive, vegetative, juvenile (1 to 3 years old) or seedling (<1 year old) (Cliffs 2014).

Between 2011 and 2014, 27 new individuals were recorded; however, deaths outstripped recruitment and there was a decrease in the total number of living plants recorded each year (Cliffs 2014 - see Table 3 below). Most of the decline occurred between 2013 and 2014, mainly in plants on the north face. The number of seedlings observed was considerably lower in 2012 and 2013

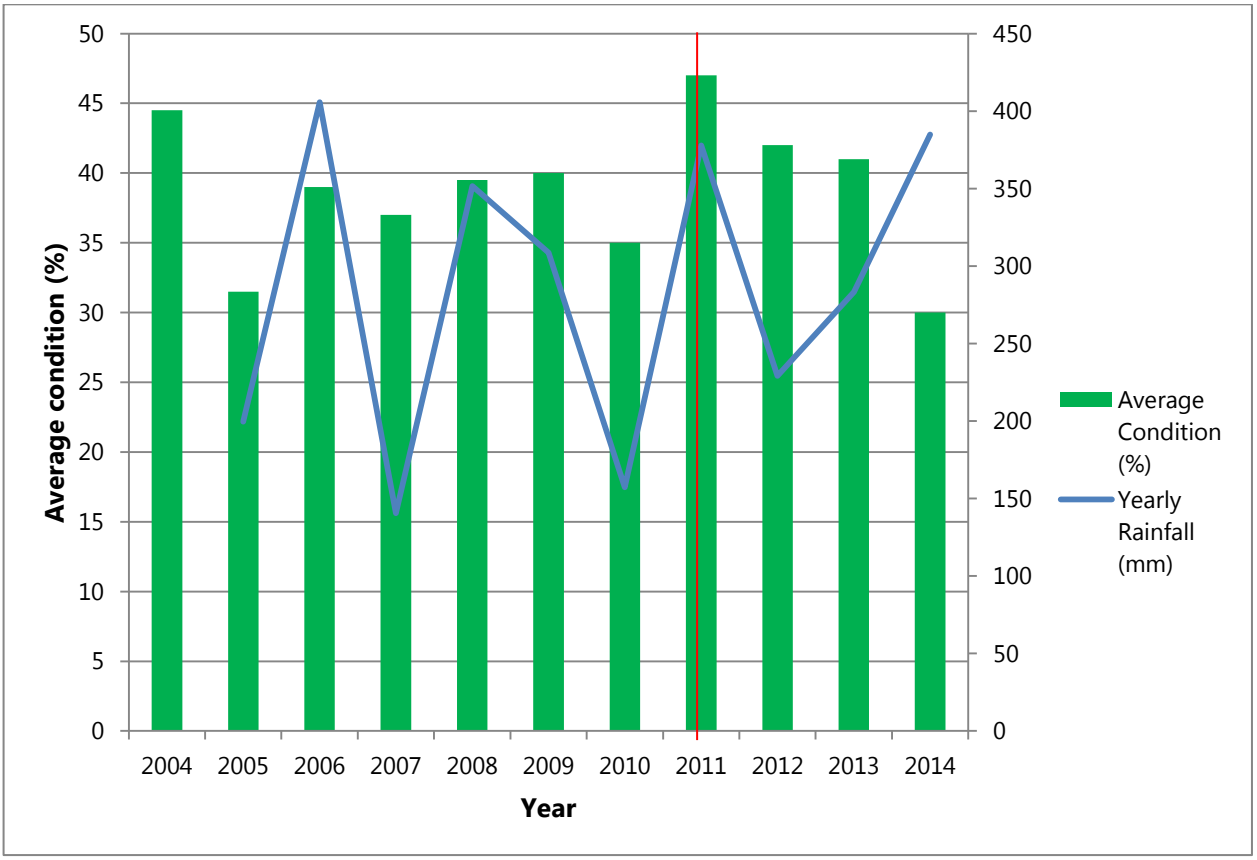
than in 2011, suggesting comparatively poor germination in those years, however, the higher number of juvenile and vegetative plants in 2012 compared to 2011 suggests those seedlings and juveniles first observed established successfully. The increase in the number of vegetative adult plants and decrease in the number of reproductive adult plants between 2011 and 2014 is not easily explained.

Table 3: Results of the 2011 to 2014 annual *Tetratheca paynterae* subsp. *paynterae* subsample monitoring (from Cliffs 2014).

Plant status/category	2011	2012	2013	2014	Change from 2011 to 2014
Dead	189	195	209	301	112
Seedling	26	4	3	4	-22
Juvenile	10	31	26	19	9
Vegetative	95	108	152	405	310
Reproductive	797	784	742	414	-383
Not located	0	1	1	1	1
Total population	1117	1123	1133	1144	27
Total alive	**928**	**927**	**923**	**842**	**-86**

A number of individuals within each *Tetratheca paynterae* subsp. *paynterae* block were also randomly selected for condition assessment (percentage of stems that are alive within the whole plant) between 2004 and present (see DAA 2011; Cliffs 2014 for methods). A decline in condition was observed in 2005, 2007, 2010 and 2012 to 2014. The average annual rainfall at Windarling, calculated from 2005 to 2014 data (Figure 2) was 284mm, with 2005, 2007, 2010 and 2012 recording below average rainfall. Average condition generally appeared to coincide with periods of low rainfall (Figure 2), except for 2013 and 2014 which showed a decline in average condition but above average rainfall. Below average plant condition may not mean the population is unhealthy, however, as plants appear to retain much of their dead material for long periods of time, and older plants are often seen with large 'skirts' of dead material attached to very healthy reproductive live material (Cliffs 2014; Western Botanical 2013). Recruitment is generally dependent on winter rainfall and significant mortality can occur following drought (Butcher *et al*. 2009).

Figure 2: Average condition of monitored *Tetratheca paynterae* subsp. *paynterae* plants and annual rainfall from Windarling from 2004 to 2014 (data supplied by Cliffs, Bureau of Meteorology). Note- red line denotes change in monitoring methods.



Genetic diversity, mating systems and pollen flow

Morphological and molecular investigations by Butcher *et al*. (2007b) for rare species of *Tetratheca* in the Mount Manning Region, confirmed the distinctness of *T. aphylla*, *T. harperi* and *T. paynterae* and identified three new rare taxa from collections affiliated with *T. aphylla* and *T. paynterae*; two of these were described as new subspecies. The DNA analysis also showed that *T. harperi*, *T. aphylla* and *T. paynterae* belonged to three separate evolutionary lineages (Butcher *et al*. 2007b). The endemism displayed among the taxa in small, disjunct ranges within the same geographic area, was considered likely to be a result of *in situ* speciation due to historical fragmentation. Furthermore, molecular genetic analysis of *T. paynterae* subsp. *paynterae* and *T. paynterae* subsp. *cremnobata* and related taxa including *T. aphylla* subsp. *aphylla* and *T. harperi*, undertaken by Butcher *et al*. (2007a), found these taxa were genetically distinct with *T. harperi* being most divergent from *T. paynterae* subsp. *paynterae* and *T. paynterae* subsp. *cremnobata* most similar.

Dispersal and colonisation of *Tetratheca paynterae* subsp. *paynterae* appears to be limited by the availability of suitable habitat, and long-term viability may depend on conservation of populations of sufficient size to maintain genetic diversity. An assessment of genetic variation within *T. paynterae* subsp. *paynterae* populations by Butcher *et al*. (2009) revealed significant genetic differentiation among subpopulations, with small populations having lower genetic diversity than a large population. A significant decline in allelic richness was found from the largest population (W3east) consisting of 4,800 plants, to the small populations (W5), consisting of 50 and 500 plants, suggesting that diversity cannot be maintained in populations below a threshold size and that

populations of over 500 plants may be required to maintain genetic diversity over the long term. Butcher *et al*. (2009) also found that the small populations (those on W5) are particularly vulnerable, given evidence of recent bottlenecks in W5west, which are likely to result in low genetic diversity. Small, isolated populations of *T*. *paynterae* subsp. *paynterae* (such as on the W5 ore body) are therefore of high conservation value. While their removal would reduce plant numbers by less than 5%, an analysis of the impact of possible expansions in mining revealed unique genotypes will be lost resulting in a 30% decline in genetic differentiation. The level of genetic divergence among populations was unexpected given the species' narrow geographic range and small distances between populations. Gaps of 80 to 120m between plants on ore bodies (W5east and W5west; W3east and W3west) have provided effective barriers to gene flow (Butcher *et al*. 2009).

The capacity of smaller populations with lower levels of genetic diversity to recover following disturbance or reductions in size, such as through mining, will depend on the species' mating system. A reduction in reproductive output would be expected if the species is self-incompatible, while increased inbreeding and fixation of deleterious alleles may occur if the species is at least partially self-compatible. *Tetratheca paynterae* subsp. *paynterae* showed evidence of inbreeding although hand pollination revealed pre-zygotic self-incompatibility which limited the production of seed from self-pollen (Butcher *et al*. 2011).

Environmental variables, including the availability of suitable sites for population expansion, high summer temperatures and low and variable rainfall (<300mm per year), and/or genetic variables and floral morphology may limit gene flow in *Tetratheca paynterae* subsp. *paynterae*. Butcher *et al*. (2011) found the subspecies dependence on pollinators for seed set, its floral structure (which is adapted for buzz pollination and thereby dependent on specific pollinators), partial pre-zygotic self-incompatibility (which limits production of seed following self-pollination), its dependence on seed for dispersal, and a limited number of suitable sites for population expansion, suggests the subspecies is at high risk of extinction. Its dependence on seed for reproduction also suggests that seedling recruitment is unlikely in the hot summer months when surface temperatures on rock faces often rise above 50°C (Butcher *et al*. 2011). Butcher *et al*. (2011) also found that these limiting factors are compensated to some degree by the taxon's capacity to re-sprout from a woody rootstock, partial self-incompatibility, physiological dormancy of seeds, and a seed bank which they found remains viable for at least three years.

The mating system and patterns of pollen dispersal of *Tetratheca paynterae* subsp. *paynterae* were characterised in November 2004 and 2005 by Butcher *et al*. (2011). Outcrossing rates were found to be high (95–100%) at W5 (east and west) and W3 (east), and generally remained constant between years, with the exception of plants from the W3 west area. The level of correlated paternity, however, increased significantly from 20% in 2004 to 35% in 2005, which may have resulted from reductions in the density and/or number of flowering plants or changes in pollinator behaviour. One exception was W3 west where correlated paternity was higher in 2004, reflecting significantly higher inbreeding in that year. Differences in outcrossing rates suggest differences in self-compatibility among plants. The ability to produce selfed seed ensures reproduction when outcross pollen is not available but can result in a reduction in genetic diversity (inbreeding depression) in subsequent generations (Butcher *et al*. 2007a).

Pollen flow between *Tetratheca paynterae* subsp. *paynterae* plants on the W5 deposit was estimated over two years (2004 and 2005), and paternity analysis of seedlings from W5 revealed 30% of pollen was dispersed less than 3m and 90% less than 15m. This suggests that if enough flowers are present, pollinators will generally forage in a small area rather than moving across areas

devoid of plants (Butcher *et al*. 2007a; Butcher *et al*. 2011). Ladd *et al*. (2012) however, recorded a species of bee carrying a small amount of *Tetratheca* pollen several hundred metres away, indicating that the bee species may be quite wide ranging.

As a consequence of preferential outcrossing, any reduction in effective population size, flowering plant density and/or the abundance and activity of pollinators may impact negatively on population viability through reduced seed set, increased inbreeding and increased correlated paternity (Butcher *et al*. 2011). This is of particular importance in translocations which will require a population to be established that has a broad genetic base, and be of sufficient size and plant density to attract pollinators and to promote outcrossing (Butcher *et al*. 2007a).

Flower, fruit and seed production

Flowering can occur any time of the year following substantial rainfall but is mainly at the end of the winter wet season between August and October (Yates *et al*. 2008). The number of flowers produced appears to be related to canopy size where those plants with a larger canopy produce more flowers (Yates *et al*. 2008). Flowers appear to be pendulous and open for at least three days, usually longer, staying open overnight (Ladd *et al*. 2012).

Tetratheca paynterae subsp. *paynterae* flowers produce no nectar and pollen is held within poriform anthers that surround the flower style. The flowers are likely to need an insect vector for pollination and are more suited to buzz pollination (Yates *et al*. 2008; Butcher *et al*. 2009). In a study of pollination biology by Ladd *et al*. (2012), five bee species (*Megachile hackeriapis* and four others from the genus *Lasioglossum*), out of 19 species identified from the Windarling Ridge, were found to visit plants of *T. paynterae* subsp. *paynterae* and are likely therefore to effect pollination. Bee visits appeared to be dependent on temperature, with few to no bees observed on flowers when the midday temperature was below 20°C. The number of flowers on a plant does not appear to affect the frequency of insect attendance, with bees often moving between flowers on the same plant (Ladd *et al*. 2012). It is thought that the pollen is used as a food source for juvenile bees when they emerge from the egg (McNee 2005).

Tetratheca paynterae subsp. *paynterae* flowers produce four ovules and fruits may contain up to four seeds. At peak flowering in spring, most flowers are pollinated. This was apparent in a study of 70 *T. paynterae* subsp. *paynterae* plants sampled in 2003 and 2004, where 92% of flowers in 2003 and 83% of flowers in 2004 had at least one pollen tube at the base of the style (Yates and Dillon 2005). Although high rates of pollination were observed, this is not reflected in similarly high rates of seed production. In 2004 only 52% of flowers produced a fruit, and 72% of fruits did not contain viable seed. The number of seeds produced per fruit may vary substantially among years (Yates and Dillon 2005).

The number of fruit produced by a *Tetratheca paynterae* subsp. *paynterae* plant is significantly increased as canopy width and condition increase. This was apparent in Yates *et al*. (2011) where the highest mean number of fruit produced per plant (26.9) occurred in 2004, when mean canopy width (40.6cm) and condition score (2.4) (1 poor to 5 healthy) were also the highest, compared to 2005 (canopy width = 36.2cm; condition score = 2.0; mean number of fruit produced = 17.8 per plant) and 2006 (canopy width = 38.6cm; condition score = 2.3; mean number of fruit produced = 24.6 per plant). This may be a result of below average rainfall from May 2004 to 2005, placing the plants under considerable stress, resulting in a decline in canopy condition (Yates *et al*. 2011).

Seeds are shed from fruits when mature (usually November to December) and are gravity and ant-dispersed. The seeds have a prominent elaiosome which ensures that ants transport the seeds into rock fissures, and that this usually occurs in close proximity to the parent plant (Butcher *et al*. 2007b; 2009). Seed dispersal is likely to be limited by the availability of suitable sites for germination within distances covered by ants. Observations by Butcher *et al*. (2009) found that when an adult plant dies, seedling recruitment occurred in the same rock crack or an adjacent crack, suggesting limited seed dispersal from mature plants and/or limited availability of suitable sites for germination (Butcher *et al*. 2009).

Population dynamics

The amount and season of rainfall is known to effect population dynamics and plant growth in *Tetratheca paynterae* subsp. *paynterae*. Yates *et al*. (2008; 2011) found that successful seedling recruitment requires above average rainfall between May and September to stimulate seed germination and follow-up summer rainfall to increase survival rates of seedlings, particularly during the critical first summer. This strategy is referred to as 'pulse recruitment'. Yates *et al*. (2008; 2011) also reported varying mortality among lifestages of *T. paynterae* subsp. *paynterae*, the highest and most variable being for young seedlings, then one-year old seedlings, juveniles, vegetative adults, and the lowest for reproductive adults. The amount of rainfall falling in the first summer after germination and the suitability of rock fissures may both contribute to the high rates of seedling mortality. Once plants reach adult stage the mortality rate is lower suggesting greater resilience to stress in mature plants (Yates *et al*. 2008; 2011). Physical traits that provide considerable drought tolerance include a leafless habit and ability for dormancy over extended dry periods, with new shoot growth following rain (Yates *et al*. 2011).

Population viability analysis by Yates *et al*. (2008) predicts that, relative to the base model, *Tetratheca paynterae* subsp. *paynterae* may decline substantially over the next 50 years, unless periods of pulse recruitment occur. Once periods of pulse recruitment are included, relative to the base model, the probability of seedling survival increases and the probability of population decline is hence reduced. Yates *et al*. (2008) also concluded that events which increase the mortality of adult plants may have a significant impact on the viability of the population.

Germination, propagation and storage

Many different treatments can be used to stimulate the germination of *Tetratheca paynterae* subsp. *paynterae* seed and include variation of temperature, light and moisture conditions, thermal shock, aqueous smoke solution application, application of gibberellic acid (GA_3), manual nicking of the seed testa and a combination of any of these (Butcher *et al*. 2007a). Butcher *et al*. (2007a) found when comparing methods of pre-treatments for *T. paynterae* subsp. *paynterae* seed collected in 2004 and 2005, GA_3 was the most effective in maximising germination in both fresh and old seeds. A higher germination rate of 77% was achieved for soil-stored seed (from 2005) compared to fresh seed (40%).

Tetratheca paynterae subsp. *paynterae* appears to be readily propagated from cuttings. Trials conducted by Western Flora, Coorow in 2006 found that hard wood cuttings exhibited higher rooting percentages (>80%) than soft wood cuttings, and a subset of cuttings re-potted into a mix of red clay loam and red gravel showed superior growth to those growing in a sand, cocopeat, perlite mix (Butcher *et al*. 2007a). Although readily propagated from cuttings, the survival rate is low. Of 2,278 *T. paynterae* subsp. *paynterae* cuttings propagated in October 2003 by Botanic

Gardens and Parks Authority (BGPA) only 8.6% (196) remained alive in March 2006. Propagation of seed using tissue culture was also found not to be a successful technique (Butcher *et al*. 2007a).

Recommendations made by Butcher *et al*. (2007a) for establishing *Tetratheca paynterae* subsp. *paynterae* from seed are to use soil-stored seed; pre-treat seed by soaking in GA_3 for 24 hours; sow directly in 'forest' pots with a free-draining potting mix; avoid transplanting seedlings which increases mortality; pre-treat seeds for germination in late winter to take advantage of spring growing conditions; apply fertilizer regularly to young plants; avoid waterlogging young plants; and maintain potted plants on capillary matting or with drip irrigation.

An assessment of root tissue by Butcher *et al*. (2007a) from *Tetratheca paynterae* subsp. *paynterae* identified mycorrhizal root symbionts, including arbuscles, vesicles, spores and hyphae of mycorrhizal fungi. They recommend that seedling survival and growth may be enhanced by inoculating the growing medium with mycorrhizal spores from the mine site. These mycorrhizal associations are common in Australian plants and are likely to provide a substantial benefit on infertile sites (Butcher *et al*. 2007a).

Optimal storage conditions of seed are recommended by Butcher *et al*. (2007a) to ensure the viability of *Tetratheca paynterae* subsp. *paynterae* seed. Replicated trials on approximately 2,000 seed collected in 2004 showed that seed should be stored at -18ºC and 50% relative humidity to maximise germination and genetic diversity of the collection. Under these conditions, seed could be successfully stored for at least two years with no loss in genetic diversity or germination. Seeds from genetically differentiated groups of plants should also be stored separately to ensure representatives from all groups are included in translocated or *ex situ* plantings. Cryostorage can also be used on freshly collected seeds in the short-term (for at least four months) without significant loss of viability (Butcher *et al*. 2007a).

Conservation status

Tetratheca paynterae subsp. *paynterae* was specially protected under the Western Australian *Wildlife Conservation Act 1950* on 17 May 1991. It is ranked as Critically Endangered (CR) in Western Australia under International Union for Conservation of Nature (IUCN) 2001 Red List criteria B1ab(ii,iii,iv) due to its extent of occurrence estimated to be less than 100km^2; it being known to exist at only a single location; and there being a continuing decline in area of occupancy, area, extent and/or quality of habitat and number of mature individuals. The subspecies is currently listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as Endangered (EN).

Threats

- **Clearing due to mining.** *Tetratheca paynterae* subsp. *paynterae* occurs on BIF which is highly prospective for iron ore. Mining leases (M77/999, M77/1000 and M77/1001) are held by Cliffs Asia Pacific Iron Ore and mining of the W3/W5 ore bodies commenced in early 2004 with a total of 1,968 plants (27.3%) taken since that time (Western Botanical 2013). Mining of Area B, supporting a further 20% of the *Tetratheca paynterae* subsp. *paynterae* population is possible pending further Ministerial approval.

- **Habitat disturbance.** Secondary threats including dust from mining operations, cracking of rock faces, changes in microclimate (increased exposure and changes to hydrology) and negative impacts on reproductive biology (reduction in pollinator activity arising from habitat disturbance and removal of food plants) may lead to a decline in population size and recruitment.
- **Weed invasion**. Although a potential threat there is currently no significant weed invasion. A Weed Management Plan was developed and implemented by Cliffs. Weeds will be monitored and if seen to be a threat, action will be undertaken.
- **Grazing.** Evidence of Euro (*Macropus robustus*) grazing on *Tetratheca paynterae* subsp. *paynterae* has been observed (as stated in previous IRP 2006). Grazing heavily impacted on some plants, with stems chewed to short stumps and minimal green live foliage remaining. It was noted, however, that grazed plants produce a new flush of growth following rainfall. Some grazing by native grasshoppers was noted in June 2004, where parts of the stem cuticle was damaged. No grazing or impacts on plants has been observed recently.

The intent of this plan is to provide actions that will mitigate immediate threats to *Tetratheca paynterae* subsp. *paynterae*. Although climate change and drought may have a long-term effect on the subspecies and its habitat, actions taken directly to prevent the impact of climate change are beyond the scope of this plan.

Table 4. Summary of population information and threats

TPFL population number & location	Land status	Year	Number of plants			Condition		Current threats
			Total	S/J	Dead	Plants	Habitat	
1. Windarling Range	UCL	2000 2003 2005	2,852 7,213 5,399	 52 24	 264 771	Healthy / Poor	Healthy / Poor (partly mined)	Mining (direct removal and secondary threats)

Note: S/J = seedlings/juveniles. Total population counts were undertaken in 2003 and 2005 (Western Botanical 2004 and 2013). Between 2011 and 2013 a subset of plants were selected and monitored yearly. These results are shown in Table 3.

Guide for decision-makers

Section 1 provides details of current and possible future threats. Actions that include disturbance and/or land clearing in the immediate vicinity of *Tetratheca paynterae* subsp. *paynterae* may require assessment. Actions that result in any of the following could have a significant impact on the subspecies:

- Damage or destruction of occupied or potential habitat;
- Alteration of the local surface hydrology;
- Reduction in population size; and
- Reduced connectivity between subpopulations limiting pollen flow (gene flow).

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

It is considered that all known habitat for wild and translocated populations of *Tetratheca paynterae* subsp. *paynterae* are critical to its survival and that the single known wild population is

an important population. Habitat critical to the survival of *T. paynterae* subsp. *paynterae* includes the area of occupancy of the known population and areas of similar habitat surrounding the population (these providing potential habitat for population expansion and pollinators). It may also include additional occurrences of similar habitat that may contain undiscovered populations of *T. paynterae* subsp. *paynterae* or be suitable for future translocations.

Benefits to other species or ecological communities

Recovery actions implemented to improve the quality or security of the habitat of *Tetratheca paynterae* subsp. *paynterae* will also improve the status of associated native vegetation. One rare and five Priority flora species that occur near *T. paynterae* subsp. *paynterae* are listed in the table below.

Table 5. Conservation–listed flora species occurring near *Tetratheca paynterae* subsp. *paynterae*

Species name	Conservation status (WA)	Conservation status (EPBC Act)
Ricinocarpos brevis	DRF (EN)	EN
Austrostipa blackii	Priority 3	-
Lepidosperma ferricola	Priority 3	-
Banksia arborea	Priority 4	-
Eucalyptus formanii	Priority 4	-
Grevillea erectiloba	Priority 4	-

For a description of conservation codes for Western Australian flora and fauna see https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened species/Listings/conservationcode_definitions.pdf

Tetratheca paynterae subsp. *paynterae* occurs within the Windarling Range vegetation complex (banded ironstone formation) PEC. The community is listed as Priority 1. For a description of Threatened and Priority Ecological Community categories see DEC (2010).

International obligations

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

Aboriginal Consultation

A search of the Department of Aboriginal Affairs (DAA) Aboriginal Heritage Sites Register revealed one site of Aboriginal significance near *Tetratheca paynterae* subsp. *paynterae* (Table 6). Input and involvement has been sought through the DAA to determine if there are any issues or interests with respect to the management of this subspecies. Aboriginal involvement in management of land covered by an agreement under the Western Australian *Conservation and Land Management Act 1984* is also provided for under the joint resting and joint management arrangements in that Act,

and will apply if an agreement is established over any lands reserved under the Act on which this species occurs.

Table 6. Site registered with Department of Aboriginal Affairs that occurs adjacent to *Tetratheca paynterae* subsp. *paynterae*

Site identification	Access	Restriction	Site name	Site type
20090	open	none	W3.1 – Windarling	Artefacts/scatter

Social and economic impacts

The population of *Tetratheca paynterae* subsp. *paynterae* occurs on UCL subject to an active mining lease. Mining has been undertaken by Cliffs Asia Pacific Iron Ore Pty Ltd and mineral mining leases cover all habitat containing *Tetratheca paynterae* subsp. *paynterae*. There is existing and potential economic impact where restrictions are applied to underlying iron ore deposits.

Affected interests

The implementation of this plan has implications for mining tenement holders (Cliffs Asia Pacific Iron Ore Pty Ltd) which may be affected by actions referred to in this plan.

Evaluation of the plan's performance

Parks and Wildlife, with assistance from the Goldfields Region Threatened Flora Recovery Team (GRTFRT), will evaluate the performance of this plan. In addition to annual reporting on progress and evaluation against the criteria for success and failure, the plan will be reviewed following five years of implementation.

2. Recovery objective and criteria

Plan objective

The objective of this plan is to abate identified threats and maintain or enhance the single known population of *Tetratheca paynterae* subsp. *paynterae* to ensure its long-term conservation in the wild.

Recovery criteria

Criteria for recovery success: The plan will be deemed a success if one or more of the following occur.

- The single known population has remained extant and the number of mature plants within that population has remained within 3% range (5,399 ± 162) or has increased by >3% or
- New populations have been found, increasing the number of known populations from one to two or more over the term of the plan with no net loss of mature plants or
- The area of occupancy has increased by >5% over the term of the plan with no net loss of mature plants.

Criteria for recovery failure: The plan will be deemed a failure if one or more of the following occur.

- The single known population has been lost or
- The number of mature plants has decreased by >3% from 5,399 to 5,237 or less or
- The area of occupancy has decreased by >5% over the term of the plan with a net loss of mature plants.

3. Recovery actions

Existing recovery actions

Monitoring of condition of a fixed subsample of *Tetratheca paynterae* subsp. *paynterae* was initiated by Cliffs in 2003 and continues annually. The design was changed in 2011 to capture changes in population dynamics with monitoring since then undertaken at seven randomly selected plots. All *T. paynterae* subsp. *paynterae* plants within each block have been tagged with the following information recorded for each plant:

- Block number
- Unique plant identification number
- Width (cm) (recorded for adults only)
- Presence of flowers/fruits/buds
- Plant status (dead or alive, reproductive, vegetative, juvenile (1 to 3 years old) or seedling (<1 year old)) (Cliffs 2014).

Between 2004 and 2013 some plants within each *Tetratheca paynterae* subsp. *paynterae* monitoring plot were randomly selected for condition assessment, i.e. percentage of live stems within each plant (see DAA 2011; Cliffs 2014 for methods).

The Koolyanobbing Project Community Reference Group (KPCRG), now referred to as Community Consultation Group (CCG) operated between 2004 and 2014, with an element of its charter being the review of the *Tetratheca paynterae* subsp. *paynterae* research and management programs undertaken by Cliffs.

Applied research into the biology and ecology of *Tetratheca paynterae* subsp. *paynterae*, including conservation genetics, population ecology and viability, propagation studies, *ex situ* storage of germplasm, and restoration and translocation, has been undertaken by Parks and Wildlife and BGPA. All research was coordinated and funded by Cliffs with some components of this research ongoing.

Between 2004 and 2006, Cliffs (then Portman) conducted a small scale "translocation" trial to test the feasibility and practicality of establishing new populations of *Tetratheca paynterae* subsp. *paynterae* in the field. The site selected was outside the range of the naturally occurring population but appeared to offer similar rock crevice microhabitat. Approximately 800 *T. paynterae* subsp. *paynterae* smoke treated seeds (seeds wetted with smoke water and allowed to dry prior to planting), that had been harvested from W3 and W5 orebodies in 2003, were placed 1 to 2cm deep into crevices in rocks at the W1 site on Windarling Range. The seeds were then covered with a small amount of leaf litter/detritus. Seeded sites were marked in the field and the location of each site was recorded using hand held GPS (Portman 2004). Sixteen seedlings were recorded in May 2006, eight of which were still alive in 2008 (1% success rate). Four of these plants were taken during mining activities between 2010 and 2014.

A proposal prepared by BGPA for Cliffs to undertake a further trial translocation for *Tetratheca paynterae* subsp. *paynterae* (Stevens and Dixon 2014) was endorsed by Parks and Wildlife's Director of Science and Conservation Division on 1 August 2014. The aim of the proposal is to gain additional knowledge that can be applied on a broader scale to restock and enhance populations of the subspecies. The objectives of the trial translocation are:

- To determine whether *Tetratheca paynterae* subsp. *paynterae* can be established in naturally-occurring rock crevices within the area in which they are naturally distributed;
- To determine whether *Tetratheca paynterae* subsp. *paynterae* can be established in "artificial" rock crevices created by the mining of banded ironstone;
- To determine the micro-habitat characteristics that promote the establishment of translocated *Tetratheca paynterae* subsp. *paynterae*; and
- To identify translocation techniques that promote establishment of translocated *Tetratheca paynterae* subsp. *paynterae*.

The translocation research compares three critical stages – germination, emergence and seedling survival – across the following experimental treatments:

- Naturally occurring versus "artificial" (mining-created) rock crevices. This will test if *Tetratheca paynterae* subsp. *paynterae* can be established on post-mining landforms and if there are differences in the suitability of rock crevices created as a result of mining compared to naturally-occurring rock crevices.
- With and without the addition of soil collected *in situ* from locations where *Tetratheca paynterae* subsp. *paynterae* naturally occurs. This will test if the presence or absence of soil (possibly including abiotic factors e.g. nutrients, and/or biotic factors e.g. mycorrhiza, and/or water retention) promotes the germination and survival of *T. paynterae* subsp. *paynterae*.
- Availability and timing of artificial irrigation to test factors associated with pulse recruitment, comparing four treatments: winter irrigation only (promoting seedling germination); winter plus spring irrigation (promoting both winter germination and emergence); winter plus spring plus summer irrigation (promoting winter germination, emergence and summer survival); and no irrigation (control i.e. natural rainfall conditions).

An experimental design testing each of these treatments will be implemented during the translocation trial for *Tetratheca paynterae* subsp. *paynterae* (as per Stevens and Dixon 2014). For seed germination fine nylon mesh bags containing 20 seeds (and a small volume of soil) will be inserted into ten cracks or crevices within each site treatment with a minimum of 10 replicates of 20 seeds. Mesh bags would be withdrawn after two months and seed fill and percentage seed germination assessed. For the seedling emergence and survival experiment 200 replicates (seeds) per treatment will be established, requiring the planting of 3,200 seeds. Individual seeds will be

inserted into cracks or crevices within each site treatment (n>20) and percentage emergence and seedling survival reported. Sufficient rock crevices in both naturally-occurring and "artificial" substrata will be selected to facilitate the testing of treatment levels. Soil material would be collected from areas immediately adjacent to where *T. paynterae* subsp. *paynterae* currently occurs. Basic soil properties will be assessed to ensure suitability of soil. The seeds would be placed within rock crevices of less than 10mm wide. A small amount of soil will be added to half of the treatments in accordance with the experimental design. The effects of irrigation will be tested on a subset of planted seeds. Irrigation will be applied by means of a portable water sprayer (Stevens and Dixon 2014). Naturally occurring rock crevices within the *T. paynterae* subsp. *paynterae* were seeded in July 2014. The intended pit crevices around the W3 pit edge were found to be unsuitable habitat and therefore the site moved to near the W1 pit. When first monitored in September 2014, no seedling emergence was observed.

Between September and December 2003 approximately 35,000 *Tetratheca paynterae* subsp. *paynterae* seeds were collected from a section of the population to be impacted by mining. These seeds were evenly distributed between BGPA, Parks and Wildlife, and Western Botanical, the latter implementing translocation and propagation trials on behalf of Cliffs. A further 7,100 seeds (estimated) were collected in late 2004 from an area approved for mining. In total, this equates to over 30g of seed in storage at BGPA, and an estimated 14,579 total germinable seed, being stored at –20°C at the Threatened Flora Seed Centre (TFSC) (see Tables 7 and 8). Approximately 2,000 seeds were also sent to the Millennium Seed Bank, Royal Botanic Gardens, Kew as part of a risk management strategy for *ex situ* storage of DRF (Butcher *et al.* 2007a).

Table 7. TFSC seed collection details for *Tetratheca paynterae* subsp. *paynterae*

Accession number	Date Collected	Type	Seed in storage	Germination
02473	Sept-Oct 2003	B/?	325	not yet conducted
02474	Sept-Oct 2003	B/?	5,440	not yet conducted
02475	Oct-Dec 2003	B/?	969	not yet conducted
02476	Nov 2003	B/?	1,488	not yet conducted
02477	Oct-Nov 2003	B/?	1,472	not yet conducted
03272	9/02/2009	B/?	3,353	not yet conducted
03273	9/02/2009	B/?	76	not yet conducted
03274	9/02/2009	B/?	365	not yet conducted
03708	26/02/2012	B/6	628	not yet conducted
03827	21/12/2012	B/15	333	not yet conducted
04269	19/12/2013	B/10	not yet processed	
04358	22/06/2014	B/15	100	not yet conducted

Note: 'B' = a bulked collection and the number of plants sampled. Collections flagged as 'not yet conducted' have a sample set aside for testing but the test hasn't yet been conducted.

Table 8. BGPA seed collection details for *Tetratheca paynterae* subsp. *paynterae*

Accession number	Current amount left	Store date	Collection information
20080898	16.6165g	28/8/2008	Penny Butcher, 2006, 200 plants sampled
20090001	96 vials	Not recorded	Penny Butcher, 2004, single plant sampled
20090002	100 vials	Not recorded	Penny Butcher, 2005, single plant sampled
20090003	72 vials	Not recorded	Penny Butcher, 2006, single plant sampled
20090004	100 vials	Not recorded	Penny Butcher, 2004, single plant sampled
20090913	2.676g	11/6/2009	Penny Butcher, Nov 2005, number of plants sampled unrecorded
20090914	11.912g	11/6/2009	Penny Butcher, 2003, number of plants sampled unrecorded. Seed collected by 'vacuuming rock face and in gravel litter'

Approximately 2,500 cuttings, collected from 250 plants in the period September to December 2003 were propagated by BGPA and potted on with just 196 (9%) still surviving in 2006 (Butcher *et al*. 2007a).

A Fire Protection Plan was developed for Cliffs by Parks and Wildlife (then DEC) in 2010. The report examines the threat posed by bushfire in an area of approximately 20km around the minesites at Koolyanobbing, Mount Jackson and Windarling. A minimum inter-fire period of 2.5 times the juvenile period was recommended for all Threatened and Priority species, including *Tetratheca paynterae* subsp. *paynterae*, in order for them to remain viable in the long term.

Future recovery actions

The following recovery actions are generally in order of descending priority, influenced by their timing over the life of the plan. However this should not constrain addressing any of the actions if funding is available and other opportunities arise. Costs are approximate and may change when the recovery action is implemented. Where recovery actions are on lands other than those managed by Parks and Wildlife, permission has been or will be sought from appropriate owners/land managers prior to recovery actions being undertaken.

1. Coordinate recovery actions

Parks and Wildlife with assistance from the GRTFRT will coordinate the implementation of this plan and include information on progress in annual reports. Parks and Wildlife will also liaise with tenement holders as necessary to coordinate recovery actions.

Action:	Coordinate recovery actions
Responsibility:	Parks and Wildlife (Goldfields Region), with assistance from the GRTFRT and Cliffs
Cost:	$8,000 per year

2. Undertake a population census

A full population census should be undertaken in the first year to determine the success/failure of the previous plan and should be undertaken again at the end of the fifth year to show trends over the term of this plan. Methods used should be consistent with those previously used.

Action:	Undertake a population census
Responsibility:	Parks and Wildlife (Goldfields Region), in consultation with Cliffs
Cost:	$50,000 in years 1 and 5

3. Support secure conservation tenure

Parks and Wildlife in consultation with the Departments of Land and Mines and Petroleum will support the creation of a conservation reserve containing the Windarling Range.

Action:	Support secure conservation tenure
Responsibility:	Parks and Wildlife (Goldfields Region), in consultation with DOL and DMP
Cost:	$4,000 per year

4. Have input into regulatory processes

Parks and Wildlife will have input into regulatory processes aimed to reduce the long term impacts from mining on populations of *Tetratheca paynterae* subsp. *paynterae*.

Action:	Have input into regulatory processes
Responsibility:	Parks and Wildlife (Goldfields Region, Environmental Management Branch)
Cost:	$4,000 per year

5. Monitor plant health and undertake condition assessment

As per the agreed Flora Management Plan, monitoring of a fixed subsample of *Tetratheca paynterae* subsp. *paynterae* plants will continue.

Condition assessment will also be undertaken annually and will include grazing, weed invasion, habitat degradation, population stability (expansion or decline), pollinator activity, seed production, recruitment, and longevity.

Action:	Monitor plant health and undertake condition assessment
Responsibility:	Cliffs in consultation with Parks and Wildlife and the Office of the Environmental Protection Agency
Cost:	$20,000 per year

6. Continue the *Tetratheca paynterae* subsp. *paynterae* research program

Research into the biology and ecology of *Tetratheca paynterae* subsp. *paynterae* including conservation genetics, population ecology and viability, propagation studies, ex situ storage of germplasm, and restoration and translocation has been undertaken. Some components of this research identified in the previous plan are ongoing or have not been completed. These are:

1. Characterise seed movement (recovery action 4.1.3 in previous plan).
2. Quantify seed bank dynamics of *Tetratheca paynterae* subsp. *paynterae*, *T. paynterae* subsp. *cremnobata*, *T. aphylla*, *T. erubescens* and *T. harperi* (recovery action 4.2.1 in previous plan).
3. Study the ecological interactions that affect the population of *Tetratheca paynterae* subsp. *paynterae* including seed predation, seed dispersal, herbivory and fire (recovery action 4.2.2 in previous IRP).

4. Derive quantitative completion criteria which demonstrate maintenance of viable population dynamics and resilience in *Tetratheca paynterae* subsp. *paynterae* (recovery action 4.5.4 in previous IRP).
5. Identify critical parameters for the long-term viability of translocated and re-established populations of *Tetratheca paynterae* subsp. *paynterae* and related species (recovery action 4.5.2 in previous IRP).
6. Identify an optimal arrangement of genotypes for translocated populations of *Tetratheca paynterae* subsp. *paynterae* (recovery action 4.5.3 in previous IRP).
7. Determine dust impacts on the ecophysiology of *Tetratheca paynterae* subsp. *paynterae*.

Action:	Continue the *Tetratheca paynterae* subsp. *paynterae* research program
Responsibility:	Parks and Wildlife (Science and Conservation Division, Goldfields Region), in consultation with BGPA, Cliffs
Cost:	To be determined (research projects will be costed as scopes of work are prepared)

7. Collect and store seed

Preservation of genetic material is essential to guard against extinction of the species if the wild populations are lost. The standard targets for germplasm conservation should aim to capture as much diversity as possible in a collection, ideally 90 to 95% of the existing genetic variability found within a population. Material should be collected from at least 50 individuals if a population consists of more than 50 individuals (as for the *Tetratheca paynterae* subsp. *paynterae*), and from all plants if a population consists of fewer than 50 individuals. These guidelines are outlined in 'Plant germplasm conservation in Australia: Strategies and guidelines for developing, managing and utilising ex-situ collections' (Cochrane *et al*. 2009). The commonly accepted target for collection size is 10,000 to 20,000 seed, providing that it can be obtained without threatening the survival of natural populations. Although this target is for an individual collection it can be applied as a target for a population. This seed should be viable and meet the sampling requirements outlined. The total amount of seed collected so far equates to over 30g of seed in storage at BGPA, and an estimated 14,579 total germinable seed being stored the TFSC. It is not certain however, how much of this is viable as no germination testing has yet been conducted. Further collections are required to ensure material with a broad genetic base is available for translocation and on-going *ex situ* conservation and research. It is recommended that seed be collected and stored in the TFSC and BGPA.

Action:	Collect and store seed
Responsibility:	Parks and Wildlife (Goldfields Region, TFSC), BGPA
Cost:	$20,000 per year

8. Continue to develop and implement translocations

A translocation may be needed when a species is represented by few populations and the creation of additional self-sustaining, secure populations may decrease its susceptibility to catastrophic events and environmental stochasticity. For small populations which may be declining in size or subject to high levels of inbreeding, successful population enhancement may increase population stability and hence long-term viability. Vallee *et al*. (2004) recommends that translocation not be an alternative to *in situ* conservation, nor a suitable ameliorative, compensatory, or mitigating measure

for development, and should be considered as a last resort when all other options are deemed inappropriate or have failed.

Depending on the characteristics of the species, Vallee *et al*. (2004) suggest a minimum viable population size estimated between 50 and 2,500 individuals will be required. Suitable translocation sites may include where the taxon occurs; where it was known to have occurred historically; and other areas that have similar habitat (soil, associated vegetation type and structure, aspect etc.), within the known range of the taxon (Vallee *et al*. 2004).

A trial translocation proposal for *Tetratheca paynterae* subsp. *paynterae* was prepared by BGPA for Cliffs (Stevens and Dixon 2014) and was endorsed by Parks and Wildlife's Director of Science and Conservation Division on 1 August 2014 (see page 23 for further details). A methodology for *in situ Tetratheca paynterae* subsp. *paynterae* population enhancement would be an output of this trial translocation. The longer-term establishment and reproductive success of translocated *T. paynterae* subsp. *paynterae* plants would be an ultimate measure of success (Stevens and Dixon 2014).

Pending the outcome of the trial translocation, further translocations may be developed and implemented. Monitoring of translocations is essential and will be undertaken as per the Translocation Proposal.

Information on the translocation of threatened plants and animals in the wild is provided in Parks and Wildlife's Corporate Policy Statement No. 35 (DPaW 2015*a*); Corporate Guideline No. 35 (DPaW 2015*b*) and Corporate Guideline No. 36 (DPaW 2015*c*), and the Australian Network for Plant Conservation translocation guidelines (Vallee *et al*. 2004). All translocation proposals require endorsement by the Department's Director of Science and Conservation. Monitoring of translocations is essential and will be included in the timetable developed for the Translocation Proposal.

Action:	Continue to develop and implement translocations
Responsibility:	The proponent (with advice from Parks and Wildlife)
Cost:	Cost (to be determined) to be covered by proponent of translocation proposal

9. Liaise with Aboriginal communities

Aboriginal consultation will take place to determine if there are any issues or interests in areas that are habitat for *Tetratheca paynterae* subsp. *paynterae*.

Action:	Liaise with Aboriginal communities
Responsibility:	Parks and Wildlife (Goldfields Region)
Cost:	$4,000 per year

10. Map habitat critical to the survival of *Tetratheca paynterae* subsp. *paynterae*

Habitat critical to the survival of the species is alluded to in Section 1. Although the distribution and area of the population of the subspecies has been mapped, habitat critical to the species survival usually contains a larger area, ie. habitat required to retain a healthy, viable population of a species. This should also include the habitat required for pollinators, the habitat required for adequate water relations, characterisation of suitable rock crevices as habitat, and the habitat required for population expansion etc. Although much of this has been completed, the area of habitat required as habitat critical to the survival of the taxon has not been documented. Mapping of the subspecies will therefore be addressed under this action and can be done by looking at available data. If additional populations are located, then habitat critical to their survival will also be determined and mapped.

Action:	Map habitat critical to the survival of *Tetratheca paynterae* subsp. *paynterae*
Responsibility:	Parks and Wildlife (SCB, Goldfields Region)
Cost:	$6,000 in year 2

11. Promote awareness

The status of *Tetratheca paynterae* subsp. *paynterae* and measures to preserve the subspecies will be promoted to the public. The significance of the subspecies will continue to be communicated to personnel working at and around the Windarling minesite, through an environmental induction and Environmental Handbook.

Action:	Promote awareness
Responsibility:	Parks and Wildlife (Goldfields Region, Public Information and Corporate Affairs), in consultation with Cliffs
Cost:	$5,000 per year

12. Review this plan and assess the need for further recovery actions

If *Tetratheca paynterae* subsp. *paynterae* is still ranked as CR at the end of the five-year term of this plan, the need for further recovery actions, or a review of this plan will be assessed and a revised plan prepared if necessary.

Action:	Review this plan and assess the need for further recovery actions
Responsibility:	Parks and Wildlife (SCB, Goldfields Region)
Cost:	$20,000 at the end of year 5

Table 9. Summary of recovery actions

Recovery action	Priority	Responsibility	Completion date
Coordinate recovery actions	High	Parks and Wildlife (Goldfields Region), with assistance from the GRTFRT and Cliffs	Ongoing
Undertake population census	High	Parks and Wildlife (Goldfields Region), in consultation with Cliffs	2021
Undertake measures to support secure conservation tenure	High	Parks and Wildlife (Goldfields Region), in consultation with DOL, DMP	2021
Ensure input into regulatory processes	High	Parks and Wildlife (Parks and Wildlife (Goldfields Region, EMB)	Ongoing
Continue monitoring and condition assessment	High	Cliffs	Ongoing
Continue the implementation of the *Tetratheca paynterae* subsp. *paynterae* research program	High	Parks and Wildlife (Science and Conservation Division, Goldfields Region), in consultation with BGPA, Cliffs	2021
Collect and store seed	High	Parks and Wildlife (Goldfields Region, TFSC), BGPA	2021
Develop and implement translocations	High	The proponent (with advice from DPaW)	2021
Liaise with Aboriginal communities	High	Parks and Wildlife (Goldfields Region)	Ongoing
Map habitat critical to the survival of *Tetratheca paynterae* subsp. *paynterae*	Medium	Parks and Wildlife (SCB, Goldfields Region)	2018
Promote awareness	Medium	Parks and Wildlife (Goldfields Region, PICA), in consultation with Cliffs	Ongoing
Review this plan and assess the need for further recovery actions	Medium	Parks and Wildlife (SCB, Goldfields Region)	2021

4. Term of plan

This plan will operate from October 2016 to September 2021 but will remain in force until withdrawn or replaced. If *Tetratheca paynterae* subsp. *paynterae* is still ranked CR after five years, the need for further recovery actions will be determined.

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6. Taxonomic description

Tetratheca paynterae* subsp. *paynterae

Butcher (2007)

Clumped *sub-shrub* 0.15–0.5 m in height, 0.4–0.8 mm wide, erect to decumbent. *Stems* divaricate, 0.6–2.3 mm wide in the flowering region. *Leaves* hispidulous adaxially and abaxially, adaxial hairs somewhat villous. *Pedicels* 1.5–11.0 mm long, scabrous from base to *c.* 3/4 length, sparsely to densely hispidulous, usually with very sparse to scattered glandular hairs; receptacle 1.0–1.9 mm diameter, rim thickened between each calyx segment, appearing angled to lobed when viewed from below. *Calyx* segments 5, less commonly 6, rarely 4, 2.1–5.5 mm long, 0.9–2.0 mm wide, short stiff hairs and strigose hairs on both surfaces, scattered sparse glandular hairs externally, these concentrated near margins. *Petals* 5, less commonly 6, rarely 4, 5.3–12.8 mm long, 3.2–7.8 mm wide. *Stamens* 10, less commonly 12, rarely 8, 2.9–5.1 mm long, pairs of stamens strongly fused from base; filament 0.4–0.7 mm long, yellow, scattered simple hairs at base; body of anther 1.8–3.4 mm long, sparsely hispidulous with hairs concentrated along edges in lower 1/2; anther tube 0.7–1.2 mm long, yellow, sparsely hispidulous on inner edge and at base. *Ovary* densely hispidulous and sparsely glandular-pilose; *style* 1.3–3.2 mm long, red at base, yellow in upper 1/3, hispidulous to *c.* 2/3 length. *Fruits* compressed-obovoid to ovoid; 4.7–8.4 mm long, 3.9–6.0 mm wide, sparsely to densely hispid with scattered glandular hairs; rim of receptacle thickened between calyx segments giving a distinctly lobed appearance. *Seeds* 2.2–3.6 mm long, 1.1–1.5 mm wide.