Environment Protection and Biodiversity Conservation (Recovery Plan for the Spiny Rice-flower (*Pimelea spinescens* subsp. *spinescens*)) Instrument 2024

We jointly make this recovery plan under subsection 269A(3) of the *Environment Protection and Biodiversity Conservation Act 1999*.

Dated 03/03/2024

Tanya Plibersek

Minister for the Environment and Water (Commonwealth)

Dated 22/01/2024

Steve Dimopoulos

Minister for Environment (Victoria)

Minister for Tourism, Sport and Major Events
Minister for Outdoor Recreation

2.1A Name

This instrument is the *Environment Protection and Biodiversity Conservation (*Recovery Plan for the Spiny Rice-flower (*Pimelea spinescens* subsp. *spinescens*)) *Instrument 2023*.

2.1B Commencement

This instrument commences the day after it is registered.

2.1C Authority

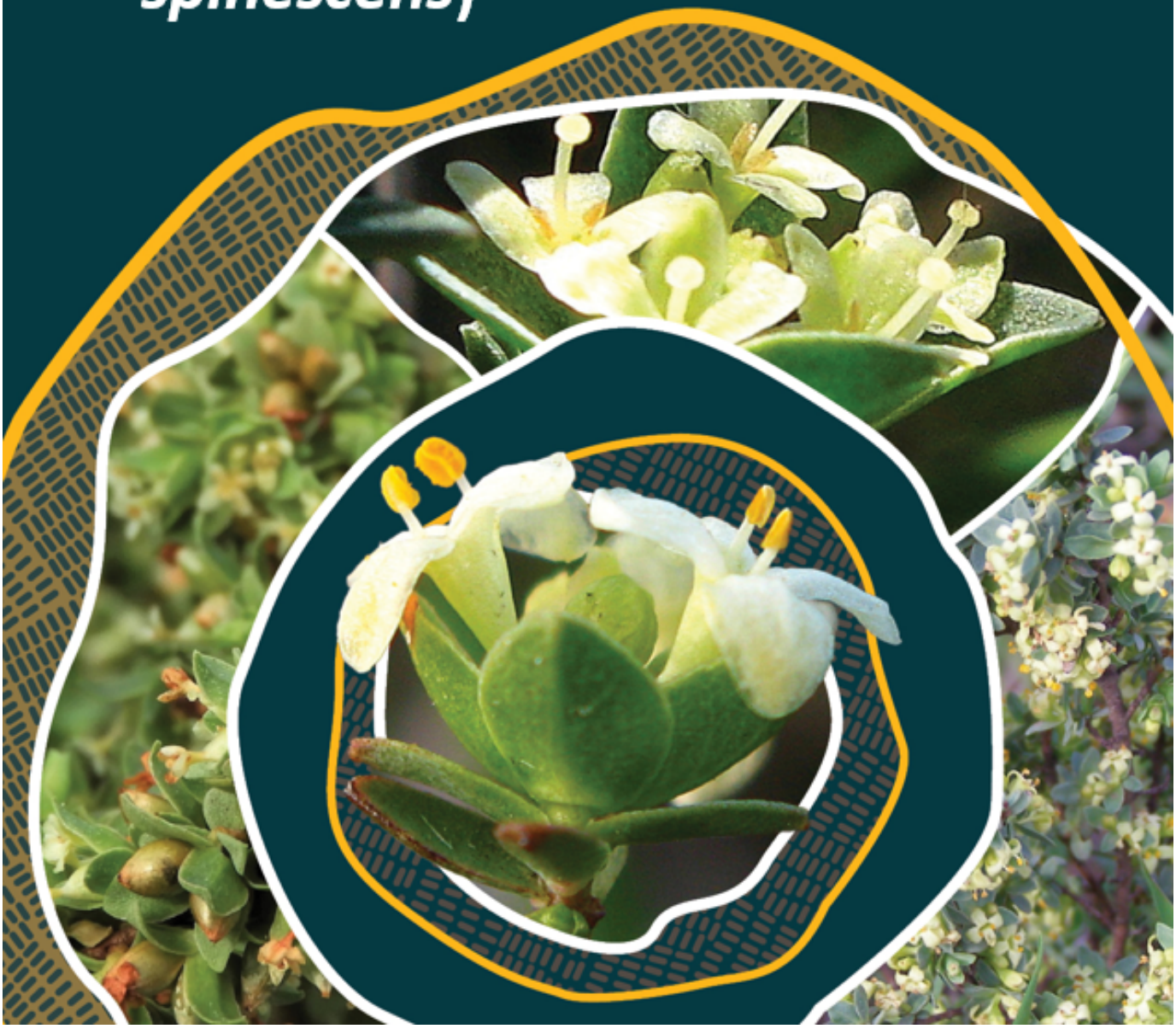
This instrument is made under subsection 269A(3) of the *Environment Protection and Biodiversity Conservation Act 1999*.

Australian Government

Department of Climate Change, Energy, the Environment and Water

VICTORIA State Government

National Recovery Plan for the Spiny Rice-flower (*Pimelea spinescens* subsp. *spinescens*)



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The preparation of this plan was funded by the Commonwealth Government.

Acknowledgement of Country

We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

Images credits

Spiny Rice-flower (*Pimelea spinescens* subsp. *spinescens*). Photo © Debbie Reynolds (Trust for Nature).

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1 Summary

1.1 Conservation status

Pimelea spinescens subsp. *spinescens* (Spiny Rice-flower) is listed as Critically Endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) effective from 1 May 2003 (TSSC 2003).

Spiny Rice-flower is listed as Critically Endangered under the *Victorian Flora and Fauna Guarantee Act* 1988 (FFG Act) (DELWP 2021).

1.2 Species information

Spiny Rice-flower is a sub-shrub endemic to grasslands and grassy woodlands in western and northern Victoria. In 2022, it is known from more than 325 wild populations containing a total of 70,000 to 90,000 mature individuals. Most populations are restricted to small, isolated grassland habitat on roadsides and railway lines in highly fragmented landscapes (DELWP 2021). The term 'viable' is defined within the recovery plan to describe dioecious populations consisting of a minimum of 20 individuals with half of each sex.

1.3 Threats

Principal threats to Spiny Rice-flower include the loss and fragmentation of habitats through clearing for urban and agricultural development, as well as habitat degradation induced by competition from both native and exotic plants. Fire regimes that cause declines in biodiversity, and prolonged drought have also contributed to the species decline (TSSC 2003; DELWP 2021). Overgrazing by livestock, in some sites, is deemed as a large threat to the subspecies (TSSC 2003).

1.4 Recovery Plan objectives, performance criteria, and actions

Objective

The long-term vision for Spiny Rice-flower recovery is to ensure Spiny Rice-flower can survive, flourish and retain its potential for evolutionary development in the wild through the continuation of threat abatement that maintains and/or enhances viable *in situ* populations.

This Recovery Plan sets out actions that will ensure significant progress towards achieving this vision.

The objectives over the 10-year life of this Recovery Plan (by 2032) are to:

- Maintain or increase positive trend in the area of occupancy.
- Maintain or increase the number of viable populations (compared to 2021/22 baseline counts).
- Identify, manage and protect all populations of the Spiny Rice-flower from key threats to ensure its persistence.
- Maintain and enhance community and institutional support.

Performance criteria

This Recovery Plan will be deemed successful if, by 2033, all the following criteria have been achieved:

1. The number of known viable 2021/22 populations (both wild and translocated) has been maintained or increased from 2021/22 baseline counts.
2. The number of individuals in each population has been maintained or increased from 2021/22 baseline counts.
3. All known population records are surveyed and accurately and mapped in 2028 and every 5 years thereafter.
4. All known populations are identified, protected and managed to support recovery.
5. The area of occupancy of Spiny Rice-flower has increased through the establishment and protection of new viable populations.
6. The number of populations subject to formal protection measures has increased by at least 10%.
7. Knowledge of Spiny Rice-flower ecology, recruitment and seedling survivorship, genetic variation, and ecological requirements has increased, and this information has been incorporated into the adaptive management plans.
8. Participation in recovery planning and actions by key stakeholders and Traditional Owners has increased.

Recovery actions

The recovery actions are outlined in Table 2,

Table 3, and Table 4 (see 7.3 Recovery Actions). The actions are categorised in 3 main strategies:

- **Strategy 1: Protecting and managing all populations and habitats.**
- **Strategy 2: Increasing knowledge** of reproductive ecology, population and habitat extent, and disturbance ecology and incorporate this knowledge into adaptive management plans.
- **Strategy 3: Increasing community awareness and involvement and support** for land managers, community and Traditional Owners to include adaptive habitat management in their work supporting the recovery of Spiny Rice-flower.

2 General information

This document constitutes the National Recovery Plan for the Critically Endangered Spiny Rice-flower (*Pimelea spinescens* subsp. *spinescens*). The plan identifies the research and management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long-term survival in nature are maximised. This Recovery Plan replaces the previous National Recovery Plan for the Spiny Rice-flower (Carter & Walsh 2006).

2.1 Historical context

The first Recovery Plan, in effect under the EPBC Act from 16 December 2006, was reviewed in 2012 and in 2020/21 by the Commonwealth Department of Climate Change, Energy, Environment and Water (DCCEEW, previously the Department of Agriculture, Water and the Environment (DAWE)) with the support of the *Pimelea spinescens* Recovery Team. Considerable achievements have been made during the life of the first Recovery Plan including the identification of numerous newly discovered sites resulting in a higher total population estimate. Meaningful research projects have been completed and have contributed to a better understanding of the species biology and conservation requirements (see 6 Implementation of the first Recovery Plan for details). The review of the first Recovery Plan also concluded that all threats and threatening processes described, continue to adversely affect the species. Consequently, a decision was made that a new Recovery Plan should be developed for Spiny Rice-flower. Responding to the review outcomes, this Recovery Plan builds upon the learnings and successes of the first Recovery Plan.

2.2 Conservation status

The Spiny Rice-flower is listed as Critically Endangered under the EPBC Act. It is eligible for listing as Critically Endangered under Criterion 2 based on very restricted geographic distribution and severe population fragmentation (TSSC 2003). The Victorian Department of Energy, Environment and Climate Action (DEECA) (formerly Department of Environment, Land, Water and Planning Victoria (DELWP) assessed the Spiny Rice-flower using International Union for Conservation of Nature (IUCN) Red List criteria, as required by the Common Assessment Method (CAM) memorandum of understanding with the Commonwealth government. The assessment found the species eligible for listing as Critically Endangered, due to the extremely severe past population reduction (DELWP 2021), and it subsequently was listed under the *Victorian Flora Fauna Guarantee Act 1988* (the FFG Act) as Critically Endangered in Australia, in June 2021.

Previously, at the species level, *Pimelea spinescens* was listed as threatened under the FFG Act (SAC 1996). Spiny Rice-flower was categorised as Endangered in the 2014 Advisory List of Rare or Threatened Flora (DEPI 2014), which had no critically endangered category.

2.3 Taxonomy

Conventionally accepted as *Pimelea spinescens* subsp. *spinescens* (Rye) (1990), Family: Thymelaeaceae.

Spiny Rice-flower is a conspecific to *Pimelea spinescens* subsp. *pubiflora* (Wimmera rice-flower). While spiny rice-flower has smooth and hairless flowers, the flowers of Wimmera rice-flower are

covered with soft short hairs (Walsh & Entwisle 1996; DSE 2005a, 2005b; Walsh & Stajsic 2007; TSSC 2009).

A genetic analysis of 459 Spiny Rice-flower samples and 83 Wimmera Rice-flower samples by James & Jordan (2014) confirmed that the two subspecies are genetically distinct and therefore, they should be managed as separate conservation units. Other common names of the species include Plains Rice-flower, and the Prickly Pimelea.

2.4 Community and Cultural Significance

The cultural significance of the Spiny Rice-flower is currently unknown. Acknowledging First Nations Peoples connection to country and importance of biodiversity, 'place', custom and totemic elements of country and species, it is likely that the species has or is associated with some cultural and/or community significance.

Traditional Language Groups

The contemporary distribution of Spiny Rice-flower encompasses the traditional lands of many First Nation groups. These include, but are not necessarily limited to:

Baraba Baraba, Barengi Gadjin, Djab Wurung, Dja Dja Wurung, Djardgurd Wurung, Gadubanud, Gulidjan, Jaadwa, Jadawadjali, Jupagulk, Jardwadjali, Ngurraiillam, Wadawurrung, Wergaia, Woiwurung, Wotjobaluk, Wurundjeri and Yorta Yorta.

Registered Aboriginal Parties

Spiny Rice-flowers distribution is found on lands managed by the following Victorian Registered Aboriginal Parties:

- Eastern Maar Aboriginal Corporation
- Wadawurrung Traditional Owners Aboriginal Corporation
- Wurundjeri Woi Wurrung Cultural Aboriginal Corporation
- Dja Dja Wurrung Clans Aboriginal Corporation
- Berngi Gadjin Land Council Aboriginal Corporation
- Yorta Yorta Nation Aboriginal Corporation
- Taungurung Land and Waters Council Aboriginal Corporation

Parks Victoria Joint Management Agreements

Joint management is a legal agreement between the State and Traditional Owners which empowers Traditional Owners, in partnership with the Victorian Government, to actively participate in the management of land and natural resources within their traditional Country.

The following Registered Aboriginal Parties have joint management arrangements in place. Efforts should be made to engage the following Registered Aboriginal Parties that have joint management arrangements in place:

- Yorta Yorta Nation Aboriginal Corporation – Yorta Yorta Traditional Owner Land Management Agreement 2010

- Dja Dja Wurrung Clans Aboriginal Corporation - Dja Dja Wurrung Recognition and Settlement Agreement 2013
- Taungurung Land and Waters Council Aboriginal Corporation – Taungurung Recognition and Settlement Agreement 2018

2.5 International obligations

Australia is a signatory to the International Ramsar Convention (1971) to halt the worldwide loss of wetlands and to conserve, through wise use and management, those that remain. Spiny Rice-flower is recorded from sites where two Wetlands of International Importance are listed under the Ramsar Convention (Australian Ramsar Wetlands 2022) and thus fall under the international obligations of the treaty:

- Port Phillip Bay (western shoreline) and Bellarine Peninsula (the western water treatment plant at Werribee, Lake Borrie wetlands), and
- Western District Lakes (numerous individuals along roadsides within the Ramsar area).

Australia is also a Party to the international Convention on Biological Diversity (CBD) (1982) to conserve biological diversity and promote sustainable development. The Spiny Rice-flower occurs in areas where urban development is expanding due to rapid human population growth. A sustainable development approach for the species is required to meet the international obligations of this treaty.

The species is not listed under the appendices of the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES).

2.6 Consultation

During the drafting process DCCEEW worked closely with key stakeholders. Consultation on the draft Recovery Plan brought together ideas from species and land management experts to outline the current status of knowledge, information gaps and potential management options.

During the life of the first Recovery Plan, the *Pimelea spinescens* Recovery Team reached out to a representative of the Wurundjeri Traditional Owners to provide updates and progress on recovery actions including the preparation of this Recovery Plan. The Recovery Team also has reached out to the representative from Wadawurrung Traditional Owners Aboriginal Corporation to provide their insights on the draft Recovery Plan.

2.7 Recovery Team

Recovery teams provide advice and assist in coordinating the implementation of Recovery Plans. The *Pimelea spinescens* Recovery Team, originally set up as the *Pimelea* working group in 2005, was formalised in 2007. The *Pimelea spinescens* Recovery Team is a group working towards achieving better conservation and management outcomes for *Pimelea spinescens* including Spiny Rice-flower. The current Recovery Team comprises representation from DEECA, Royal Botanic Gardens Victoria, Parks Victoria (PV), Department of Transport and Planning (formerly called VicRoads), Trust for Nature (TfN), 27 local governments, six Catchment Management Authorities (CMAs), the Country Fire Authority (CFA), environmental and private sector consultancies, Landcare groups and researchers (universities and botanic gardens). The *Pimelea spinescens* Recovery Team is mainly supported by the *Pimelea* Conservation Trust (PCT) through TfN. PCT administers the funds in accordance with the

Conservation Agreement between the Commonwealth and Multiplex Developments No: 8 Pty Ltd with TfN acting as Trustee (Trust for Nature 2014).

The *Pimelea spinescens* Recovery Team coordinated the implementation of the first National Recovery Plan of Spiny Rice-flower and will continue its role in providing advice and coordinating the implementation of this Recovery Plan.

2.8 Affected Stakeholders

Populations of Spiny Rice-flower occur on land owned or managed by government authorities, organisations and private individuals. Conservation of Spiny Rice-flower is dependent upon cooperation through a range of agencies and conservation groups who either manage land or undertake conservation activities, as well as Traditional Owners and their representatives such as, Registered Aboriginal Parties, Indigenous ranger groups, Indigenous land councils, and Indigenous community groups. All recovery actions are to be undertaken in a manner that respects the cultural practices of Traditional Owners. Planned recovery actions include increased support and participation in recovery planning and actions by key stakeholders, including Traditional Owners. Affected stakeholders and potential conservation partners include but are not limited to the following:

Traditional Custodians
Berngi Gadjin Land Council Aboriginal Corporation
Dja Dja Wurrung Clans Aboriginal Corporation
Eastern Maar Aboriginal Corporation
Taungurung Land and Waters Council Aboriginal Corporation
Wadawurrung Traditional Owners Aboriginal Corporation
Wurundjeri Woi Wurrung Cultural Aboriginal Corporation
Yorta Yorta Nation Aboriginal Corporation

Government Authorities	
Australian Rail Track Corporation	Metro Trains Melbourne
Cemetery Trusts	Parks Victoria
Country Fire Authority	Places Victoria
Department of Energy, Environment and Climate Action	Melbourne Water
Department of Transport and Planning	VicTrack

Local Government Authorities		
Ararat Rural City	Ballarat City	Brimbank City

Local Government Authorities		
Campaspe Shire	Central Goldfields Shire	Colac Otway Shire
Corangamite Shire	Golden Plains Shire	Greater Bendigo City
Greater Geelong City	Hepburn Shire	Hindmarsh Shire
Hobsons Bay City	Horsham Rural City	Hume City
Loddon Shire	Melton City	Moonee Valley City
Moyne Shire	Moorabool Shire	Mount Alexander Shire
Northern Grampians Shire	Pyrennees Shire	Southern Grampians Shire
Surf Coast Shire	Wyndham City	Yarriambiack Shire

***Pimelea spinescens* Recovery Team (PsRT)**

***Pimelea* Conservation Trust (PCT) through Trust for Nature (TfN)**

Catchment Management Authorities (CMAs)	
Corangamite CMA	Glenelg Hopkins CMA

Researchers	
Royal Botanic Gardens Victoria	Victoria University

Local communities, Friends groups, NRM bodies, conservation and field naturalist groups	
Ballarat Environmental Network	Cairnlea Conservation Reserves Committee of Management
Friends of Iramoo	Mt Korong Eco-Watch Association

Environmental consultants	
ABZECO	Aus Eco Solutions
Biosis	Ecology and Heritage Partners

Public: private individuals, commercial corporations and businesses

3 Species description and habitat

3.1 Biology

Description

Spiny Rice-flower is a perennial, slow-growing sub-dioecious shrub (DSE 2008; Cropper 2004). It has dull green and hairless oval leaves 2–10 mm long and 1–3 mm wide (Carter & Walsh 2006). New growth is soft, smooth, and almost herbaceous which develops into short spiny (spinescent) divaricate branches and stems. The stem tips become hard, leafless and form a spinescent tip as the plant gets older (Walsh & Entwisle 1996). The flowers are produced in a terminal compact head (inflorescence). The inflorescences are clusters of 6–12 small, unisexual (rarely bisexual) flowers which are hairless and cream in colour. Inflorescences are subtended by four leaf-like bracts 3–7 mm long and 1.5–4 mm wide. The 2–3 mm long flowers are glabrous (hairless) and have four rounded, petal-like lobes (Carter & Walsh 2006). Female flowers are slightly smaller than male flowers and have two small non-functional anthers while the male flowers bear anthers with bright orange pollen. The fruit is ovoid or ellipsoid, 2–3 mm long, and has a thin, initially fleshy layer around a slightly woody 'stone' that encloses the single, oily seed (Walsh & Entwisle 1996; Carter & Walsh 2006).

The majority of individuals observed in the wild are sub-dioceous, although, hermaphroditic (bisexual) individuals are also present (Foreman 2012; Reynolds 2013). Across populations observed, the female phenotype appears to be more abundant than male or hermaphroditic individuals (Dear 2019). A male individual bears all male flowers or predominantly male flowers and conversely, a female individual bears all or predominantly female flowers and there is a clear phenotypic distinction between flowering male and female individuals (**Figure 1**). An individual is considered hermaphroditic when it produces a relatively balanced ratio of male and female flowers. In a hermaphroditic individual, each inflorescence is exclusive to either male or female flowers (**Figure 2**) (Carter & Walsh 2006; Foreman 2012; Reynolds 2013). A hermaphrodite individual could change its presentation of flowers over the season, but it will always have both flower types present (Reynolds 2013). Further investigation on how changes of sex expression may affect maintenance of long-term population viability is required to assist with species recovery planning, such as population monitoring and translocation strategy.

Life cycle

Flowering occurs over winter from April through to August (**Figure 3**), unlike the majority of other grassland plants in this ecosystem (Entwisle 1996; Walsh & Entwisle 1996). Germination *in situ* has been observed between May until November and appears to be stimulated by cool winter and spring temperatures (Foreman 2011; Reynolds 2013), suggesting physiological dormancy. When seeds germinate, the seedlings stay as non-reproductive recruits for one year and will enter the juvenile stage after the second year. Some juvenile plants may start to reproduce but at much lower rates than adult plants. Individuals may remain as juveniles until approximately five years of age before moving on to the adult stage, where reproduction and survival is higher (**Figure 3**; Regan et al. 2021). Individuals remain reproductively active until they senesce (Mueck 2000; Carter & Walsh 2006). Spiny Rice-flower is a long-lived species with a lifespan estimated up to 100 years (Mueck 2000 cited

in Carter & Walsh 2006; Regan et al. 2021). The generation time is estimated to vary between 50 to 80 years (Mueck 2000; Foreman 2005; DELWP 2021).

Figure 1 A contrasting phenotype of male (left) and female plant (right), both in flowering stage. Male plants bear more showy flowers than female (see Figure 2 for flower close-up).

Photo © Debbie Reynolds

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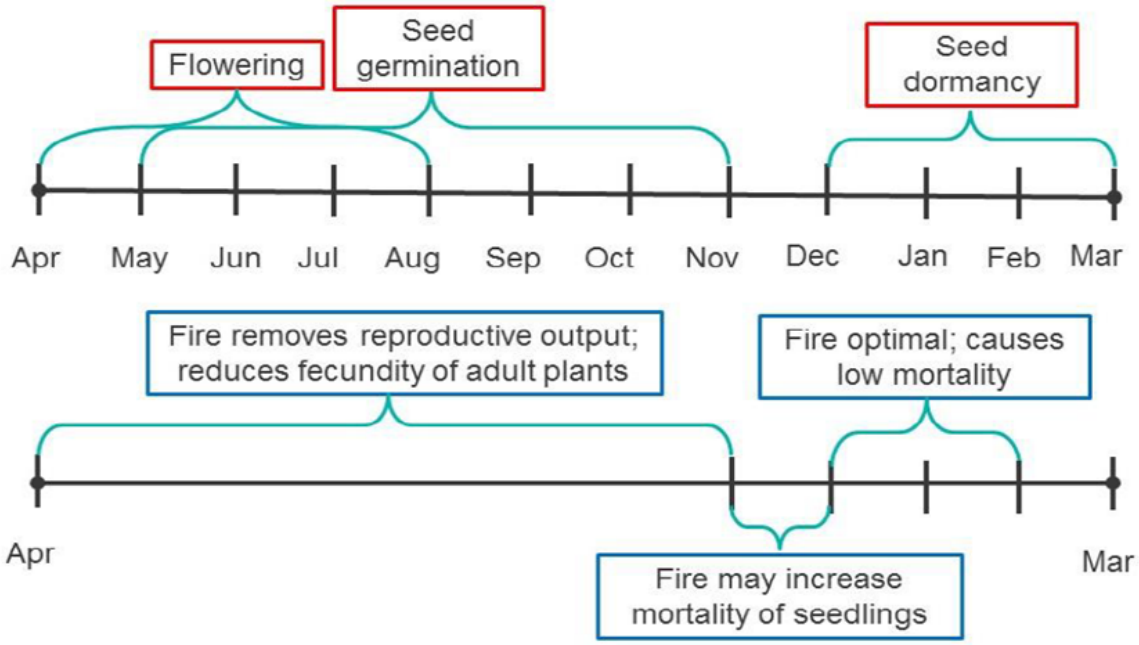
Figure 2 Flowers of Spiny Rice-flower. Left–female inflorescence, Middle–male inflorescence, Right–hermaphroditic individual bearing seeds and male flowers.

Photo © Debbie Reynolds

Figure 3 Conceptual model of the timing of ecological processes including the effect of fire across seasons.



Source: Regan et al. (2021)

Reproduction

Pollination

As the Spiny Rice-flower is predominantly an outcrossing species (DEWHA 2009a; James 2012) there is a need to transport pollen between male and female plants, making it particularly vulnerable to a lack of pollinators (Reynolds 2013). Insect pollinators such as introduced honeybees, lycaenid butterflies (Foreman 2005), beetles (Cropper 2004), Dipteran and Hymenopteran flies (Cropper 2009) have been reported to visit Spiny Rice-flower (Foreman 2012) (**Figure 4**). These insect pollinators have small home ranges and are only able carry pollen over short distances, and thus effective pollination and seed production are affected by the spatial distribution of the individuals and populations, as well as the size and density of the population (Reynolds 2013). Genetic analysis suggests that most seeds result from outcrossing by insect pollinators (James & Jordan 2014) but viable seeds are known to be produced through selfing (pollen from male flowers on the plant fertilising female flowers on the same plant) in hermaphroditic plants through geitonogamy, indicating that there is a degree of self-compatibility in the breeding system (TSSC 2016).

Seed and germination traits

Seed fecundity and viability levels are relatively high and stable (Reynolds 2013). Seed production or fecundity, expressed as number of seeds per stem, is generally dependent on temperature and rainfall. Rainfall was relatively high in 2010, effectively ending a 13-year period of drought, and this was reflected in a lower seed fecundity across Spiny Rice-flower female individuals on the Victoria Volcanic Plains (4–32 seeds per stem in 2010 compared to 15–247 seeds per stem in 2009; Reynolds 2013). Plants are likely to have suffered from pollination limitation due to lower rates of insect pollinator activity during such a wet year.

Seed viability, an indication of maternal plant's ability to access resources, is improved by frequent biomass reduction (for example through burning) of the surrounding vegetation (Reynolds 2013). Spiny Rice-flower seeds possess a 'non-deep physiological dormancy' *sensu* Baskin & Baskin (2004). A period of dry storage followed by at least a month of cold stratification was found to alleviate seed dormancy (Reynolds 2013). Seed germination also positively responds to stimulation by gibberellic acid. Spiny Rice-flower germination follows a staggered germination syndrome (germination is not synchronous, and thus seedlings are produced as different multiple cohorts over time), even under optimal conditions (Reynolds 2013).

While the seed is oily and buoyant and can disperse via seasonal flood events, the seed has no obvious adaptation for long distance dispersal, and germinants (seedlings) commonly cluster close to female or bisexual plants (Foreman 2005, 2011; James & Jordan 2014). Circumstantial observations have found seedlings in a translocated soil plug even in the complete absence of the flowering plant or recent seed introduction. This implies that a persistent soil seed bank exists (Reynolds 2013). Regan et al. (2021) suggested that the Spiny Rice-flower seed bank can remain in the soil while maintaining its viability for approximately 6 years (Figure).

Given the continuing pressure on native species habitat and noting the lack of opportunities for successful *in situ* recruitment, *ex situ* seed conservation is a strategic approach to safeguard native plant species (Martyn Yenson et al. 2021) and would support the recovery of the Spiny Rice-flower when seed is actively used in restoration or translocation programs. In support of *ex situ* seed conservation, a seed collection protocol for Spiny Rice-flower has been developed by the *Pimelea spinescens* Recovery Team (2018). Further, noting that seed supply is key for Spiny Rice-flower translocations as well as grassland habitat restoration, further research should include aspects of securing and use of a genetically diverse seed supply.

Figure 4 Spiny Rice-flower hosts various invertebrate species, including insects that are important as its pollination vector.

Photo © Elspeth Swan (left) and Debbie Reynolds (right)

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Recruitment *in situ*

The majority of Spiny Rice-flower populations consist of mainly mature individuals (McCaw 2014, 2020), which may indicate an obstacle to or failure of recruitment (Mueck 2000; Reynolds 2013). Spiny Rice-flower has been observed to have episodic germination and infrequent successful recruitment, i.e., seedlings are numerous at times but survival rate through summer are extremely low (Reynolds 2013; DELWP 2021). Across multiple sites on the Victoria Volcanic Plains, for example, the recruitment level measured by number of seedlings surviving the first summer was only 14% (Reynolds 2013). Seed production and seedling establishment appears to be inhibited by both drought conditions and higher than average rainfall (Foreman 2011, 2012). Drought limits the reproductive capacity of mature plants, while during wet years, pollinator activity may be limited leading to lower seed production. In addition, high rainfall that leads to floods can adversely affect seedling survival. Understanding the key environmental drivers for successful Spiny Rice-flower recruitment is therefore crucial to inform its management and recovery (Reynolds 2013).

Although the Spiny Rice-flower has a deep (up to 1.5 m) taproot that can form underground stems and facilitate resprouting after biomass removal events (e.g., fire), it does not have the capacity to reproduce vegetatively (Mueck 2000; James & Jordan 2014).

Figure 5 Left-Spiny Rice-flower root formation. Right- close up of tap root and underground stem formation of a mature Spiny Rice-flower.

Photo © Debbie Reynolds

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Fire ecology

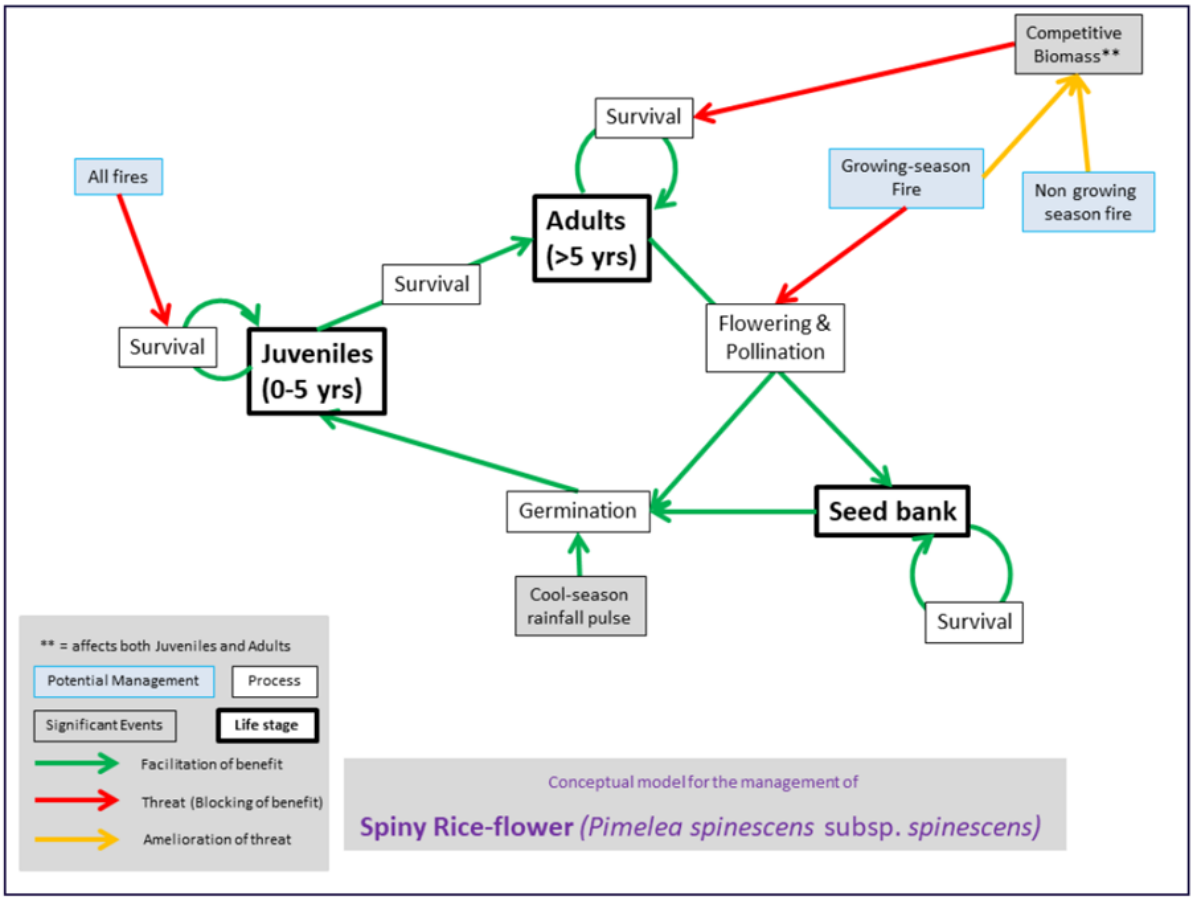
Exposure to differences in fire frequency may contribute to the morphological differentiation between populations. The 'northern form' populations (i.e. those north of the Great Dividing Range) consist of more vigorous adult plants (that have not been exposed to burning) than 'southern form' that are regularly affected by burning. Northern populations have been observed to have almost certainly declined more dramatically than the southern, basalt plain populations (DSE 2008; Appendix 1), indicating that appropriate fire regimes is paramount to support recruitment and population persistence.

Spiny Rice-flower germination and seedling establishment are substantially impeded when inter-tussock space diminishes (Morgan 1998; Lunt & Morgan 2002). Fire opens up the vegetation and creates bare ground and gaps, providing an opportunity for the Spiny Rice-flower to recruit from the soil seed bank. Fire also creates inter-tussock spaces important for seedlings to establish and mediates the coexistence of other native grassland species by interrupting the exclusion of competitors (DAWE 2022). Low competition induced by fire events combined with good seasonal rainfall may promote successful recruitment of Spiny Rice-flower (Mueck 2000; Carter & Walsh 2006; DELWP 2021). Despite the availability of bare ground, recruitment of the Spiny Rice-flower post-fire can be low, particularly following hot summers and low rainfall (Mueck 2000).

While fire can help to reduce competing biomass and promote germination, it can increase individual mortality across various life stages (**Figure 3**; Regan et al. 2021). If fire occurs prior to or during the flowering and seed production season, it removes the reproductive output for that year and consequently reduces the potential for seed accumulation in the soil (Regan et al. 2021). Burning over the summer months has been suggested to have minimal damage to or mortality of adult plants. Adult individuals are, however, quite tolerant of fire due to the large taproot which can readily resprout after fire (Mueck 2000; Carter & Walsh 2006).

The Recovery Team guidelines for burning (*Pimelea spinescens* Recovery Team 2017) suggested that biomass reduction should occur at an interval of at least once every three years. It is important to note though, that in areas of high productivity or during wet years, it may be necessary to burn more frequently, and accordingly, 4 to 5 years or even longer burning intervals may be sufficient for lower productivity sites. Burning from late spring (November) through summer or into early autumn (April) is recommended. Further, in areas where the species is known to occur and fire control lines are required, a native vegetation survey conducted by a qualified botanist must be undertaken at the appropriate time before site preparation commences (Reynolds 2015).

Figure 6 Conceptual life-stage model for Spiny Rice-flower



Source: Regan et al. 2021

Genetics

Genetic diversity and fragmentation

The genetic diversity of Spiny-rice flower has not declined as a result of habitat loss and fragmentation. The retention of genetic diversity may be the result of plant longevity, where older plants reflect the gene flow of previously connected, but now isolated populations. This fragmentation now creates the risk of loss of genetic diversity, as these individuals die out, and fewer individuals contribute to future generations within a population (James & Jordan 2014). Outcrossing enforced by sub-dioecy limits the loss of genetic diversity per generation (Duminil et al. 2009) and is possibly instrumental in maintaining the genetic diversity for Spiny Rice-flower. A relatively high population level genetic diversity is consistent with the hypothesis that in the past populations were interconnected and interbreeding among populations was conspicuous (James & Jordan 2014). The longevity of individual plants, their ability to reproduce for many years and the presence of soil seed banks may contribute to the maintenance of genetic diversity and could buffer deleterious effects of random genetic drift caused by fragmentation and disturbance (Schulz et al. 2018).

Whilst intrinsic factors such as long individual lifespan and soil seed banks may facilitate preservation of a species' genetic diversity (Long et al. 2015; Broadhurst et al. 2017), a recovery action that seeks to ensure the maintenance of genetic diversity into the future is essential. The success of adaptation to changing environments, such as climate change, is underpinned by genetic variation and consequently, reduced genetic diversity may limit the species' evolutionary potential (Jump & Penuelas 2005; Anderson et al. 2011; Hoffmann & Sgro 2011). Strikingly, smaller populations (300–

600 individuals) of Spiny Rice-flower contain levels of genetic diversity similar to larger populations (>1000 individuals), thus stressing the potential importance of smaller populations in the environmental resilience of Spiny Rice-flower (James & Jordan 2014).

Despite the presence of significant genetic diversity, the persistence of Spiny Rice-flower is likely to be compromised if further fragmentation occurs (James & Jordan 2014). Of particular concern is the small size of the majority of populations. Small and disconnected populations are at greater risk of extinction than large populations due to both physical damage and genetic decline. Reduced connectivity may increase inbreeding with detrimental consequences for outcrossing species , and as surrounding habitat is lost, new populations are unlikely to establish (Ellstrand & Elam 1993; Lande 1993; Honnay & Jacquemyn 2007).

Investigation of possible mechanisms for dispersal away from parent plants and populations would assist in the design of vegetation corridors to increase geneflow in areas where populations are surrounded by unsuitable habitat (James & Jordan 2014). Further analysis of genetic variation between and within sites and correlating this with biogeographic variables and investigating the prevalence and importance of vector-driven outcrossing is required.

Sourcing genetic materials for recovery action

Spiny Rice-flower genetic diversity occurs across a cline from the Melbourne area westwards and then to the north and northeast (James & Jordan 2014), rather than as discrete suite of genetic 'groups' correlated with distinct geographic regions (Foreman 2005, 2012). Populations located within a 25–35 km radius among each other are generally more genetically similar than populations further apart (James & Jordan 2014).

The high genetic diversity of Spiny Rice-flower may permit adaptation to novel conditions, and genetic mixing between populations may enhance their adaptive opportunities. For Spiny Rice-flower translocation and conservation purposes, seeds should be collected from a number of different plants from each source population. Mixing genetic material within, but not between, northern and southern populations may provide a benefit for its long-term viability. The proportion of genetic material should reflect the relative distances between source locations (Broadhurst et al. 2008; James & Jordan 2014). Therefore, consideration of habitat (source-recipient) matching should underpin the sourcing of planting material for translocations (James & Jordan 2014). Populations located in the Victorian Riverina bioregion, notably, have unique genotypes different to the other populations and may have different levels of ploidy, and therefore, it is recommended that translocation within the Victorian Riverina only use genetic materials from this bioregion. Genetic material from multiple populations (except for the Riverina bioregion) can be combined for reintroduction or for augmenting populations with a relatively low level of genetic variation. For populations not at risk of inbreeding, the recommendation is to source genetic materials from within 60 km of the recipient site. This recommendation may be subject to review under further consideration of potential climate change impacts.

Assessment of habitat matching and climate-provenancing, and well-designed experimental studies, should be undertaken to ascertain how the long-term persistence of the Spiny Rice-flower populations may be affected by changing environmental conditions. Evolutionary genetics is an important consideration in translocation strategies (Weeks et al. 2011), and therefore it is important quantify the genetic and phenotypic traits and their plasticity, including its intraspecific trait

variation, such as seed and germination traits, in the assessment for the adaptive capacity of Spiny Rice-flower.

3.2 Distribution

The Spiny Rice-flower is endemic to Victoria. It occurs on basalt-derived soils west of Melbourne across the central Victorian Volcanic Plains and on alluvial soils across west and central Victoria (Map 1; Walsh & Entwisle 1996; DSE 2008; DELWP 2021). The species' extent of occurrence (based on 2 x 2 km grids around reliable records) is estimated to be 1,152 km² based on post-1970 records in the Victorian Biodiversity Atlas. Population size is estimated as 70,000 to 90,000 mature individuals, distributed in approximately 275 wild populations (DELWP 2021). The most recent population survey that is currently ongoing discovered that that there are about 325 known populations of Spiny Rice-flower (in Appendix 1).

The Spiny Rice-flower populations are predominantly located in the Victorian Volcanic Plains, Victorian Midlands and Victorian Riverina IBRA (Interim Biogeographic Regionalisation for Australia) Bioregions (DEH 2000). Other populations are also known to occur in the Wimmera Plains, Central Victorian Uplands, Goldfields, and Dundas Tableland bioregions. Based on the modelled distribution, Spiny Rice-flower is known to occur within the following Natural Resource Management regions: Corangamite, Glenelg Hopkins, Port Phillip and Western Port, North Central, Goulburn Broken and Wimmera.

Spiny Rice-flower populations mostly occur in tiny patches of remnant habitat such as on roadsides and rail easements (Carter & Walsh 2006; DELWP 2021) that support small to medium size populations (<500 individuals), although a few large populations (consisting of >1000 individuals) are also known. The recent specific needs elicitation process conducted by DEWLP has found that the persistence of the species is greatest at sites with a large population, and reduced persistence is directly correlated to decreasing population sizes. Management efforts have also been found to be more effective within larger populations. Populations of the Spiny Rice-flower that are particularly large, ecologically distinct, or of particular importance include the following:

- Population on the Mt Mercer – Shelford Road in Golden Plains Shire. This site contains ~20,000 plants and is considered as the largest known population of Spiny Rice-flower.
- Population on McLeods Road in Wimmera. Another roadside population that is very large; contains >11,000 plants.
- Browns Waterholes Bridge Rail Reserve (~5500 plants), and Poorneet West Rail Reserve (~6000 plants) – they are among the largest of rail reserve populations.
- Blacks Creek Nature Conservation Reserve. This is one of the largest grassland reserves on the Victorian Volcanic Plain (234 ha) with a population size of >500 plants.
- Lake Borrie Spit, Western Treatment Plant: contains ~250 plants, and is a secure Ramsar site which is actively managed for its biodiversity values by Melbourne Water.

- Deep Lead Flora Reserve supports relatively small population in high-quality vegetation. The site (dominated by swampy Yellow Gum (*Eucalyptus leucoxylon*) forest) is atypical for Spiny Rice-flower and is at or near the western limit of its range and thus considered important population despite the small population size.

- Truganina Cemetery: contains >300 plants and is an intact small native grassland within an active cemetery. A Public Authority Management Agreement (PAMA) exists between the Cemetery Trust and DEECA.

- A small parcel of private land between the rail reserve and Hamilton Highway, east of Cressy supports ~1,900 plants, and private land at Creswick-Newstead Road, ~2000 plants.

- Skipton Common (~1,416 plants). The population has become a focal area for the local community through school activities and the Ballarat Environmental Network management.

3.3 Habitat

Spiny Rice-flower prefers intact grassland remnants, lowland grasslands, grassy woodlands and open shrublands (DSE 2008, 2005b; Brennan & Herwerth 2005; Barnes et al. 2006; Carter & Walsh 2006; Foreman 2011, 2012). The common ground layers of the habitat consist of *Themeda triandra* (Kangaroo Grass), *Rytidosperma* spp. (wallaby grasses) and *Austrostipa* spp. (spear grasses) (Carter & Walsh 2006; DEWHA 2009). Other species associated with Spiny Rice-flower include *Acaena echinata* (Sheep's Burr), *Calocephalus citreus* (Lemon Beauty-heads), *Chrysocephalum apiculatum* (Common Everlasting), *Eryngium ovinum* (Blue Devil), *Plantago varia* (Variable Plantain), *Ptilotus erubescens* (Hairy Tails), *Schoenus apogon* (Common Bog-sedge) and *Goodenia paradoxa* (Spur Goodenia) (Carter & Walsh 2006). Extant populations of Spiny Rice-flower are observed to persist in a wide range of grassland conditions, including disturbed and degraded patches such as railway lines and roadsides.

Spiny Rice-flower populations are predominantly associated with the Natural Temperate Grassland of the Victorian Volcanic Plain, and the Natural Grasslands of the Murray Valley Plains threatened ecological communities (TECs) (TSSC 2016). They also occur in several other TECs listed under the EPBC Act (Foreman 2005, 2012) including the *Eucalyptus leucoxylon* (Yellow Gum) and *E. microcarpa* (Grey Box) grassy woodland TEC in the Goldfields region, and *Allocasuarina luehmannii* (Buloke) open grassy woodland in the Wimmera region (Table 6).

The populations are established on heavy grey-black clay loam basalt-derived soils in south-western Victoria (southern populations) and red clay complex sedimentary soils in north-central Victoria (northern populations) (DEWHA 2009; TSSC 2016). Populations are often found on a flat topography but may also occur on slight rises or in slight depressions and some populations are exposed to temporary inundation (Foreman 2012).

Habitat critical

Habitat critical to the survival of a species or ecological community refers to the areas that are necessary for activities such as breeding or dispersal; long-term maintenance of the species including the maintenance of pollinators; areas important to maintain genetic diversity and long-term evolutionary development; or necessary for the reintroduction of populations or recovery of the

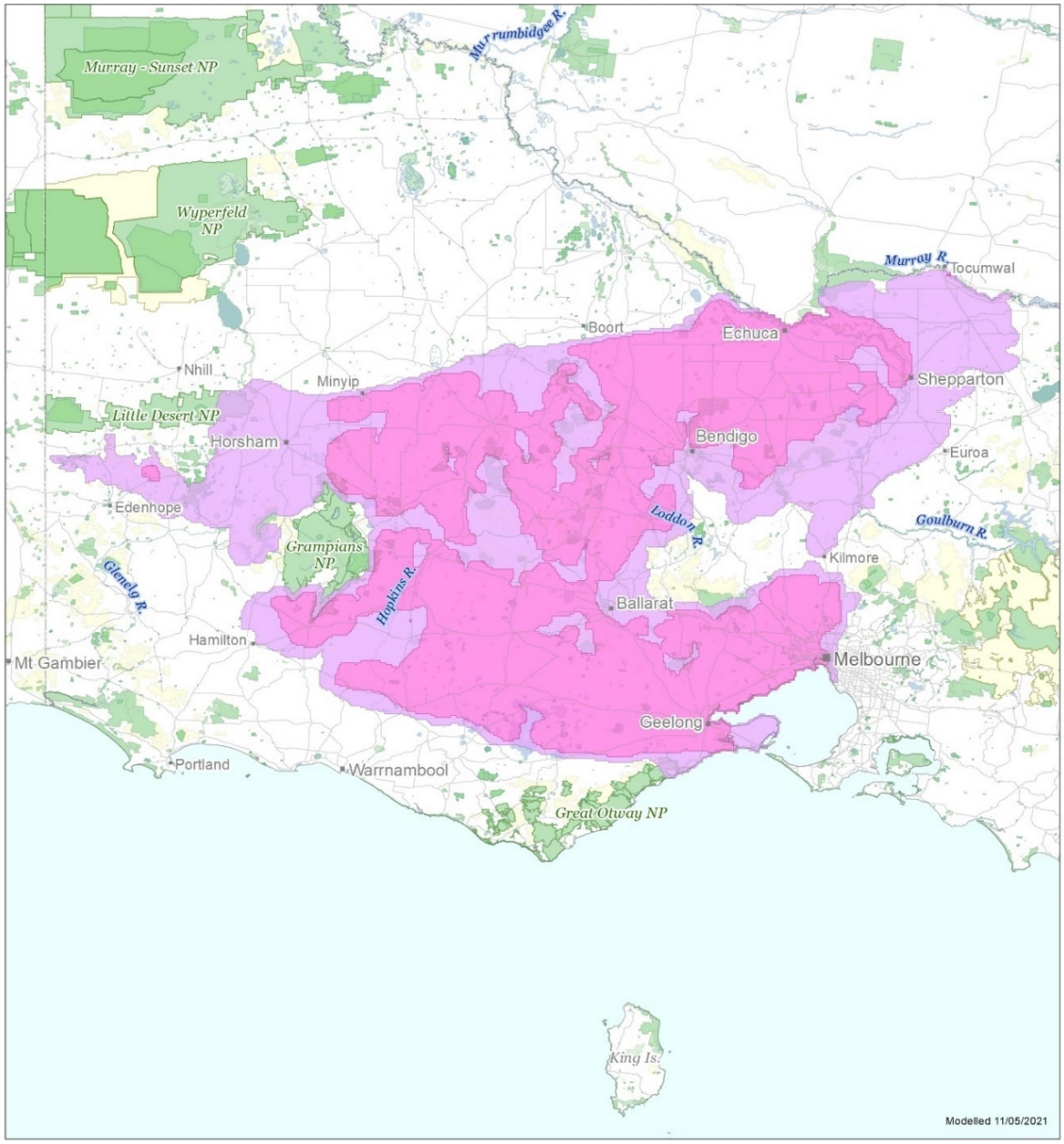
species. All known habitat for wild and translocated populations is critical to the survival of Spiny Rice-flower (see 3.3 Habitat). This includes all grasslands, grassy woodlands and open shrub-lands occupied by all known extant populations, areas of similar habitat surrounding and linking known populations, habitat at sites where plants were known to occur until recently, and additional occurrences of similar habitat that may contain undiscovered populations of the species or be suitable for future translocations.

No Critical Habitat as defined under section 207A of the EPBC Act has been identified or included in the Register of Critical Habitat

3.4 Important populations

An important population is a population that is necessary for a species' long-term survival and recovery. Key source populations necessary for breeding or dispersal, or maintaining genetic diversity, and/or populations that are near the limit of the species range are also considered important populations. Given the conservation status, generally small population size, and threats that are present across species range, all known populations (Appendix 1) are considered important populations.

Map 1 Spiny Rice-flower Distribution Map



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4 Threats

4.1 Historical causes of decline

The Spiny Rice-flower's current distribution across multiple linear reserves indicates that it was extremely widespread prior to European settlement (Carter & Walsh 2006; DELWP 2021). Since European settlement, Spiny Rice-flower has undergone widespread and catastrophic decline in range and abundance. The population reduction over the past 150 to 240 years is estimated to be 90–99% (DELWP 2021), primarily as a result of the loss of lowland grassland habitats to settlement and agriculture.

4.2 Current threatening processes

The primary threats to the Spiny Rice-flower are land clearing and habitat degradation (TSSC 2016; DELWP 2021). Habitat fragmentation is predominantly a result of land clearance for urban development, agriculture, settlement, and industry (DELWP 2021). The majority of populations exist in areas that are not managed appropriately or are subject to ongoing changing land use and development (Foreman 2012; Reynolds 2013; TSSC 2016). Sites situated on public land (roadsides, rail reserves and cemeteries) are progressively being lost or disturbed. Populations on private property are vulnerable to change in land use, as many of these private sites are being developed and pasture grasslands are increasingly being cropped. As most populations are small and fragmented, their long-term viability can only be sustained with intensive site management supported by *ex situ* conservation actions where appropriate. The priority Recovery Actions (Table 5) include population monitoring and a state-wide census to inform prioritisation of resource allocation for recovery actions.

The main threats to Spiny Rice-flower are further discussed below.

Habitat loss and fragmentation

Habitat loss and fragmentation due to anthropogenic pressures continues to be the primary threat to the Spiny Rice-flower. The grassland habitats of Spiny Rice-flower have been extensively cleared or modified for agriculture, urban and industrial developments (Reynolds 2019; DELWP 2021). The development around Melbourne urban area led to a massive pressure for grassland habitats and Spiny Rice-flower. The Melbourne Strategic Assessment (MSA), developed to regulate development impacts on certain threatened species, including Spiny Rice-flower, around these urban corridors. An audit by the Victorian Auditor General's Office (VAGO), found that only 5% (72 ha from the targeted 1,138 ha) of highest-priority habitats for Spiny Rice-flower within the Victorian Volcanic Plain Bioregion has been able to be protected under MSA (VAGO 2020). While the level of development pressure on Melbourne's outer western fringe suggests the risk of destruction is greatest in this area (VAGO 2020), the risk of loss is also high throughout the species' range because the majority of populations are small and unprotected.

Roadsides and rail reserves support some of the most important habitats of Spiny Rice-flower, particularly within the Natural Temperate Grasslands of the Victorian Volcanic Plain (Carland & Kennedy 2010). These populations are at great risk of individual loss from any maintenance works such as slashing, grading, clearing, herbicide application, road widening and soil compaction by

vehicle movement (Carter & Walsh 2006; Foreman 2012). Incremental losses of individual plants, without replacement, can rapidly lead to extirpation especially for these small and often isolated populations (Ramalho et al. 2014). Spiny Rice-flower populations located along narrow linear road or rail reserves are also subject to high levels of edge effects and therefore have a greater probability of degradation over time (DSE 2008).

Reduced connectivity that limits gene-flow between sites is another major threat following on from habitat loss and fragmentation. Small populations can retain valuable genetic variation and remain biologically important if close enough to be connected by gene-flow. However, as the distance between populations is greater than its known pollinators' travel capacity, the genetic integrity of Spiny Rice-flower may be at risk of inbreeding depression (Markert et al. 2010; James & Jordan 2014).

Despite the improvement in our understanding of distribution and occurrence of Spiny Rice-flower, the statement in the initial advice from the Threatened Species Scientific Committee (TSSC 2003) to the then Minister is still applicable: "Based on the rate of decline of grassland habitat since the 1980s, it is estimated that the population size of *Pimelea* has declined by as much as 30% over the past 20 years". This conclusion is supported by a study in 2018 which revisited 14 sites which were first surveyed in 2009. The study found that eight of the 14 sites were decreasing in size with mature plants dying and seedlings rare (Reynolds 2019).

Habitat loss associated with land tenure

About 52% of the population (approximately 84% of total individuals; Appendix 1) are located within unreserved public land consisting of roadside and railway corridors which are subject to continuous pressures from traffic disturbances, compaction from vehicles, and management activities (slashing, mowing, runoff of toxicants). Approximately 20% is situated on private land, with 15% of the total population occurring within existing conservation reserves and 10% is in utility sites owned by Melbourne Water, Local Government and other agencies (Appendix 1). Several very large populations (>1,000 individuals each) occur on private properties where the tenure is unsecured, and on other public land not reserved for conservation (Carter & Walsh 2006; Foreman 2012; TSSC 2016; Appendix 1). Regardless the tenure types, the majority of sites support extremely low numbers of individuals (< 10 plants) that are unlikely to survive without intensive management intervention such as prescribed burning and weed control (Appendix 1).

Managing private land is important to ensure that Spiny Rice-flower grassland habitats do not further degrade before formal acquisition or protection. In Victoria, native vegetation clearing controls apply, however there are exemptions for permitted clearing which may result in loss of Spiny Rice-flower plants or populations. Furthermore, planning solutions such as the Melbourne Strategic Assessment (DSE 2009) have not achieved the intended conservation objectives (VAGO, 2020) for species such as the Spiny Rice-flower and its habitat. Grassland habitat on public land has not been managed to protect or enhance its biodiversity assets despite government assurance (VAGO 2020). A strategic program to enact covenants, voluntary acquisitions and implement long-term and appropriate management is critical to avoid the loss of Spiny Rice-flower populations and habitat on private property. This program has been initiated by the *Pimelea spinescens* Recovery Team.

Climate change

Spiny Rice-flower individuals, particularly seedlings, are sensitive to prolonged drought. Populations have been observed to significantly decline over relatively short periods of time when subject drought (Foreman 2012; McCaw 2020). Rainfall in southeast Australia has been declining in recent decades and is projected to decline further, especially in the cooler months of the year (CSIRO & Bureau of Meteorology 2020). Climate change is anticipated to further threaten Spiny Rice-flower populations, but the mechanisms by which persistence may be impacted can only be inferred from the ecology of the species and require further research. For instance, the plant relies on cool autumns and winters to trigger flowering and seed production, and thus, warm nights in autumn may lead to reduced reproduction. Increasingly hot summers will also lead to reduced survival of seedlings, likely from the effect of hot and dry wind and high temperature at night (DELWP 2021). Further, the duration, frequency and intensity of drought periods may increase across the range and will likely have cascading impacts across the life stages of the species including flowering, seed production and recruitment (Hoffman et al. 2010, 2019; Satyanti 2021). Flowering periods may be affected by changing climatic signals, resulting in phenological shifts that may also decouple plant-pollinator interactions (Hoffman et al. 2019). This may ultimately reduce the reproductive capacity of obligate outcrossing taxa, like the Spiny Rice-flower.

Climate change can also drive changes in existing fire regimes, with more frequent and intense fires projected alongside shorter windows of opportunity for individuals to reach maturity before fire recurs (immaturity risk; Westerling et al. 2011). Given that fire severity and frequency are both predicted to continue to increase under climate change (van Oldenborgh et al. 2020), some species may be driven to extinction in coming decades as fire-free periods are reduced (Enright et al. 2015). This has potential ramifications for communities that are adapted to and shaped by fire events including grasslands of the Victoria Volcanic Plain, and species associated with them, including Spiny Rice-flower.

Fire regimes that cause declines in biodiversity

Grassland communities require regular biomass reduction to maintain their habitat structure and species richness (Morgan 1995; DAWE 2022). Historically, biomass reduction has been facilitated by natural fire and low intensity grazing from native herbivores (Lunt & Morgan 1999 cited in DSE 2008). Fire regimes that cause biodiversity decline in temperate grassland communities on the Victoria Volcanic Plain, where the Spiny Rice-flower predominantly occurs, have been identified as low fire frequency and fire-competition interaction (DAWE 2022). Low fire frequency (long intervals between fires) cause decline in these populations directly by failing to trigger essential life-history cues to habitat suitability, or through interactions with other threats such as fragmentation (DEWHA 2009; TSSC 2016; DAWE 2022). Traits sensitive to low fire frequency include a combination of short-lived seed banks and low seed-dispersal range (DAWE 2022); these traits are possessed by Spiny Rice-flower (Foreman 2005, 2011; Reynolds 2013; James & Jordan 2014; TSSC 2016). For natural temperate grassland communities, fire-competition interactions may pose a threat when fire accelerates invasion processes by creating gaps for the entry of invasive competitor or when it promotes the establishment of high-density dominant native species that outcompete other native inhabitants and eventually transform the characterising structure and composition of the communities (DAWE 2022). Too frequent fire may threaten invertebrate populations including those that pollinate Spiny Rice-flower.

For Spiny Rice-flower and many grassland species, fire can support their persistence. Reducing biomass through planned burning promotes germination and seedling establishment of Spiny Rice-flower, although it can also lead to increased mortality of existing plants or removal of reproductive output (soil seed bank) if it is undertaken during flowering seasons (Regan et al. 2021).

Weeds

The invasion of exotic plants which leads to habitat degradation and competitive exclusion Spiny Rice-flower is one of the key threats observed across sites. The risk is greatest in the smaller, more isolated and heavily disturbed sites where populations will almost certainly be lost without active weed and biomass management (Foreman 2012).

In the absence of biomass reduction, the dominant perennial tussock grasses tend to out-compete and suppress the less competitive smaller plants, such as Spiny Rice-flower. Successive years without appropriate biomass reduction will result in loss of many herb species and senescence and death of kangaroo grass tussocks (Lunt & Morgan 1999 cited in DSE 2008). Open spaces may then be colonised by opportunistic perennial weed such as canary-grass (*Phalaris aquatica*), flax-leaf broom (*Genista linifolia*) and tall wheatgrass (*Lophopyrum ponticum*), which are known to be particularly strong competitors to Spiny Rice-flower (DSE 2008). Other weed species including sheep sorrel (*Acetosella vulgaris*), common bent (*Agrostis capillaris*), cock's foot (*Dactylis glomerata*), and perennial ryegrass (*Lolium perenne*) are also detrimental to spiny rice-flower plants (Foreman 2012).

Grazing by domestic stock and native herbivores

Most populations are threatened by introduced herbivores including European rabbits (*Oryctolagus cuniculus*) and hares (*Lepus europaeus*), while populations on private land have the additional pressure of grazing by domestic stock (Carter & Walsh 2006). Effective site management has improved the size of populations−for example at Lake Borrie, plant numbers increased by 33% between 2006 and 2008 following the elimination of rabbits by fencing and weed eradication by spot spraying and routine burning (Cropper 2009; TSSC 2016).

Overgrazing can adversely impact grassland habitats by disrupting habitat structure and increasing nutrient loads and potential disturbance to seedlings. Light grazing regimes (low stocking levels and rotational systems) may provide benefits for spiny rice-flower plants by maintaining an open habitat and by reducing competition from weeds but at a slower rate compared to fire (Foreman 2012). Anecdotal observations suggest that light grazing by native mammals and domestic stock is not detrimental to plants, and may provide benefits through a reduction in surrounding biomass. The digging action of marsupials such as bandicoots create microsites for germination and assist with dispersal of mycorrhizae (which may be beneficial for germination). However, exposed roots have been observed as a result of digging at sites with dense rabbit populations. Grazing of germinants and seedlings by mice and introduced invertebrates (snails, slugs and millepedes) has been observed in the field and laboratory, and may be having a detrimental impact on population recruitment.

4.3 Threat matrix

This risk assessment considers the likelihood of a threat occurring (probability), extent and the level of significance of the threat (consequence). These variables are combined in a matrix to provide an ordinal level of risk associated with particular threatening process ranked from 0 (being circumstances where no threat exists) to 3 (where a catastrophic level of threat exists). The derived risk matrix (Table 1) provides a basis for prioritisation of threats to guide Recovery Actions.

Table 1 Threats impacting the Spiny Rice-flower

Threat	Threatening process	Probability	Extent	Trend	Consequence[b]
Habitat loss and fragmentation	Loss of individuals	Known	Across entire range	Static	Major
	Loss of populations	Known	Across entire range	Static	Catastrophic
	Reduced connectivity and gene flow with genetic consequences	Known	Across entire range	Static	Moderate
	Pollination limit	Known	Across entire range	Static	Major
	Loss of habitat available for establishment	Known	Across entire range	Static	Catastrophic
	Reduced habitat quality	Known	Across entire range	Static	Major
Habitat loss associated with land tenure	Private land with no regulatory controls	Known	Across part of its range	Static	Major
	Public land not amenable for conservation	Known	Across part of its range	Static	Major
Increased frequency and duration of reduced rainfall, or severe rainfall deficiencies induced by climate change	Drought stress and mortality	Known	Across entire range	Increased	Major
	Reduced reproductive output (seed) and recruitment	Known	Across entire range	Increased	Major
	Declining pollinator populations (Sanchez & Wyckhuys, 2019)	Known	Across entire range	increased	Major
	Local extinctions	Likely	Across entire range	Increased	Catastrophic
Fire regimes that cause declines in biodiversity[a]	Habitat loss and degradation	Known	Across entire range	Increased	Major
	Low Fire Frequency	Known	Across entire range	Increased	Major
	Loss of population and increased fire-competition interaction	Possibly	Across entire range	Increased	Major
Weeds	Reduced recruitment	Known	Across part of its range	Increased	Major
	Increased fire risk due to biomass accumulation	Known	Across part of its range	Increased	Major
	Change in habitat structure, composition, and function	Likely	Across part of its range	Increased	Major
	Loss of individuals	Known	Across part of its range	Increased	Major
Herbivory and grazing	Grazing and trampling from livestock	Known	Across part of its range	Static	Major
	Grazing by native herbivores	Likely	Across part of its range	Not known	Not known

Threat	Threatening process	Probability	Extent	Trend	Consequence[b]
	Grazing by introduced herbivores	Known	Across part of its range	Static	Major

Note: [a] **Fire regimes that cause declines in biodiversity** include the full range of fire-related ecological processes that directly or indirectly cause persistent declines in the distribution, abundance, genetic diversity or function of a species or ecological community. 'Fire regime' refers to the frequency, intensity or severity, season, and types (aerial/subterranean) of successive fire events at a point in the landscape (DAWE 2022). Fire regimes that cause biodiversity decline in temperate grassland communities on the Victoria Volcanic Plain, where Spiny Rice-flower predominantly occurs, have been identified as low fire frequency and fire-competition interaction (DAWE 2022). Low fire frequency (long intervals between fires) cause decline in these populations directly by failing to trigger essential life-history cues to habitat suitability, or through interactions with other threats such as fragmentation (DEWHA 2009; TSSC 2016; DAWE 2022). Traits sensitive to low fire frequency include a combination of short-lived seed banks and low seed-dispersal range (DAWE 2022).

[b] **Categories for consequences are defined as follows:**
Not significant – no long-term effect on individuals or populations
Minor – individuals are adversely affected but no effect at population level
Moderate – population recovery stable or declining
Major – population decline is ongoing
Catastrophic – population trajectory close to extinction

5 Guidance for decision makers

Under the EPBC Act, an action will require approval from the Minister if the action has, will have, or is likely to have a 'significant impact' on a matter of national environmental significance, such as a listed threatened species. An action is likely to have a significant impact where it may adversely affect the long-term recovery of the Spiny Rice-flower. The Spiny Rice-flower is sensitive to drastic environmental changes often resulting from development action and is sensitive to certain development activities due to its: isolated, fragmented and restricted distribution, small and declining populations, degraded habitat, and low level of recruitment.

All development proposals and activities within the current (Map 1) and future modelled Spiny Rice-flower distribution that will, or are likely, to result in a decline in the national population should be referred to the Commonwealth government for assessment under the EPPBC Act (see Recovery Actions Table 2). Actions that may require approval under the EPBC Act include but are not limited to actions that result in the loss or reduction of a population or individuals, further clearance, fragmentation or degradation of known or likely and habitat critical to the survival of the species.

The Commonwealth Significant impact guidelines for the critically endangered Spiny Rice-flower (*Pimelea spinescens* subsp. *spinescens*) (DEWHA 2009) have been developed to support stakeholders including decision makers, developers, and assessors, to determine whether a proposed action is likely to have a significant impact on the Spiny Rice-flower across its range. These guidelines should be read in conjunction with the Significant impact guidelines 1.1 - Matters of National Environmental Significance (DEWHA 2013).

Significant impact thresholds for the Spiny Rice-flower are found in the Significant impact guidelines for the Spiny Rice-flower, and include the following:

- Any loss of individuals from any population which occurs on the edge of the Spiny Rice-flower's current known distribution is likely to represent a significant impact.
- Recruitment in Spiny Rice-flower appears to be the overriding limiting factor. Therefore, the following cases are likely to represent a significant impact:
  - the loss of more than 5 individuals from a population
  - removal of between 40% and 60% of the male plants from a population
- Any fragmentation of a population. Fragmentation may include but is not limited to partial clearing that leads to isolated smaller patches and/or the introduction of a physical barrier to plant dispersal (for example solid fences, transport corridors, walking tracks, easements).
- The limited dispersal ability of Spiny Rice-flower pollinators (<100m) will limit its genetic influence and movement between non-habitat to habitat areas.
- Avoidance measures should be the primary strategies for managing the potential impact of a proposed action, followed by mitigation of residual impacts. To counterbalance the residual impacts that remain after avoidance and mitigation measures, offset proposal consistent with the EPBC Offsets Policy must be prepared before the approval a 'controlled action' (DSEWPAC 2012). Any proposed translocation that is a component of a direct offset must be consistent

with EPBC Act Translocation Policy (DSEWPAC 2013a) and other policies and existing guidelines (Section 7.6).

Assessment of actions relating to urban development in those parts of Melbourne within the Melbourne Strategic Assessment boundary is considered under that strategic assessment process, i.e., Melbourne Strategic Assessment (MSA) (DSEWPAC 2013b). Strategic assessments are landscape-scale assessments under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) that allow a big-picture approach to protecting biodiversity (DCCEEW 2022). Actions within MSA must comply with MSA requirements but otherwise do not need the assessment or approval by the Commonwealth Government.

6 Implementation of the first Recovery Plan

The first National Recovery Plan for the Spiny Rice-flower (2006) outlined 7 specific objectives for the recovery of Spiny Rice-flower:

- Acquire accurate information for conservation status assessments.
- Identify habitat that is critical, common or potential.
- Ensure that all populations and their habitat are protected and managed appropriately.
- Manage threats to populations.
- Identify key biological functions.
- Determine the growth rates and viability of populations.
- Build community support for conservation.

There has been considerable recovery activities and progresses made during the life of the first Recovery Plan undertaken by the *Pimelea spinescens* Recovery Team and *Pimelea* Conservation Trust (PCT), included increased knowledge on species biology, habitat management, population monitoring and identification of additional sites, and improved governance. However, the objectives of the first National Recovery Plan have not been fully accomplished. The implementation of the first Recovery Plan that has been ongoing since 2006 until present are briefly summarised below with further details outlined in Appendix 2.

6.1 Conservation status assessments

A state-wide survey and database to acquire baseline population data has been initiated but is incomplete. Based on comprehensive population surveys and monitoring that was undertaken at Skipton Common in 2017 to 2020, population size across the distribution was estimated to have declined by as much as 30% in the past 20 years (2000–2020). It is also projected that the whole population is likely to experience similar declines over the next 10–20 years. Listing assessment to update the Spiny Rice-flower conservation status was undertaken by DELWP in 2021 in compliant with the Common Assessment Method (CAM). The assessment concluded that Spiny Rice-flower is eligible for listing under the FFG Act as Critically Endangered in Australia (DELWP 2021).

6.2 Information on habitat

Comprehensive habitat assessments of all known sites have not been achieved, except for populations located in Skipton Common. Habitat critical to survival in the sense of all habitats within which the populations exist has generally not been fully mapped, and where it has been mapped, the information is often outdated or unreliable as collection method is inconsistent. No bioclimatic indicators have been established but co-occurring species, including threatened species within the habitat, have been identified.

6.3 Populations and habitats are protected

Site protection and management

Most of the objectives to protect populations on public land and private property targeted in the first Recovery Plan have not been achieved. This was partly due to the incomplete state-wide database; a comprehensive and up to date state-wide database is critical for a species recovery planning.

A Public Authority Management Agreement (PAMA) exists between the Cemetery Trust and DEECA for Spiny Rice-flower populations at Truganina Cemetery. Additionally, a number of Local Government Reserves have been established by councils on their lands. Such strategic acquisition, conservation covenants, and improvements in the reservation status of Crown Land have contributed to the conservation of Spiny Rice-flower and TECs that support the species (TSSC 2016).

The Recovery Team have worked with various stakeholders to ensure that populations and habitats are managed appropriately. Management of threats including herbivore and weed control, livestock and rabbit proof fencing installation and vermin eradication have been conducted in multiple sites (see 6.4 Threats management).

Supplementary and enhancement planting for small and isolated populations have been conducted by local councils and management authorities including Glenelg Hopkins CMA, Brimbank Council, Mooney Valley Council, and Wyndham City Council. Ecological burning to promote regeneration has been conducted at various sites including at Ararat Airfield, Glengower Road, Western Highway Dobie, Chatsworth Road Derrinallum, McKenzie Rd Marong, Jasper Rd Tennyson, *Pimelea* Nature Conservation Reserve, Altona Nature Reserves and Pioneer Park (Figure).

The Recovery Team collaborated with conservation partners such as Lismore Landcare group, Ballarat Environmental Network, Friends of Iramoo, Mt Korong Eco-Watch Association and Corangamite CMA to undertake population monitoring and supplemental planting (Figure). Private environmental consultants also actively participated in the implementation of the first Recovery Plan. For example, Aus Eco Solutions conducted recruitment monitoring at Burns Rd Altona site and weed control at Deer Park Boral, Geggies Rd and Ballan Rd, while ABZECO manages six reserves for Brimbank Council. Aus Eco Solutions and Glenelg Hopkins CMA in collaboration with the Recovery Team have conducted seed collection (for enhancement planting) in multiple sites including at Skipton Common, Altona, Sunbury, Deer Park and Mount Mercer (Figure).

The Recovery Team through Pimelea Conservation Trust supports the management of two reserves that hold Spiny Rice-flower populations–Altona Nature Conservation Reserve and *Pimelea* Nature Conservation Reserve. Altona Nature Conservation Reserve is managed by Parks Victoria while *Pimelea* Nature Conservation Reserve on Kirks Bridge Road is managed by Wyndham City Council.

It was envisaged that a conservation prioritisation would drive the strategic investment and determine the most suitable action(s) to protect and manage a population (Foreman 2012). A preliminary assessment was conducted in 2011/12 to determine conservation priority in which a given population is given a priority score based on population size, area, and tenure-type (Appendix 1). However, not all populations have been assigned with a priority score.

Translocation

While translocation has the potential to result in a conservation outcome, it should still be seen as a last resort, with protecting population and avoidance of disturbance impacts should always remain the highest priority (*Pimelea spinescens* Recovery Team 2013; Biosis 2014).

The Recovery Team has developed a protocol for Spiny Rice-Flower Translocation (*Pimelea spinescens* Recovery Team 2013). The protocol includes guidelines for recipient site selection, monitoring requirements, management of a translocated population.

Biosis (2014) conducted the translocation reviews across 11 translocation sites at Altona Nature Conservation Reserve, Burns Road Altona, Ravenhall Grasslands Nature Conservation Reserve (East), Christies Road Ravenhall, Mt Cottrell Nature Conservation Reserve, Gourlay Road Caroline Springs, and Williams Landing A, B, and C. The review has highlighted ways to improve future translocation activities. The review found that translocation survival rate across the sites was 33% on average. Damage to Spiny Rice-flower's long taproot system during translocation often results in mortality. Notably, the translocation method determines the survival of translocated plants. The review recommendation includes undertaking plant extraction using a tractor-mounted tree spade and transplanting the individual into the prepared recipient site as soon as practicable followed by intensive watering to reduce transplant shock (Figure ; Biosis 2014).

6.4 Threats management

Management prescriptions for sites containing Spiny Rice-flower have been developed, however most of them have not been critically assessed on their effectiveness. The Recovery Team identified that the management plan at Lake Borrie site developed by Melbourne Water is an excellent example of an effective plan. Spiny Rice-flower population at Lake Borrie has increased in size by approximately 30% following rabbit and weed control and improved ecological burning. Progresses and changes in the management strategy were also documented in a series of annual reports.

6.5 Information on key biological traits

An evaluation of reproductive biology, including germination requirements, seed dormancy, seed bank status, fecundity and recruitment have been completed through a PhD project at Victoria University by Debbie Reynolds – who is also the coordinator of the Recovery Team. This PhD project also assessed various supplementary planting methods including direct seeding and strategies for seed sourcing (Reynolds 2013). Building on this knowledge, the Recovery Team has developed guidelines on: Spiny Rice-flower translocation protocol (2013), Spiny Rice-flower monitoring protocol (2015), and Spiny Rice-flower seed collection protocol (2018). Further, an examination of Spiny Rice-flower's genetic diversity and population structure to better inform conservation actions has been conducted by the Royal Botanic Gardens Victoria (James & Jordan 2014).

Figure 7 Prescribed burning at Pioneer Park conducted with Brimbank Council and contractors in attendance.

Photo © Debbie Reynolds

6.6 Population growth rate and viability

Although the state-wide database is incomplete and population data are of variable accuracy, monitoring effort on Spiny Rice-flower populations has greatly increased since 2006 and this has improved our knowledge of population structures and trends (also see 6.5 Information on key biological traits). Building on this knowledge, Arthur Rylah Institute developed a population viability analysis (PVA) that is critical to inform management actions related to maintaining population viability and the long-term persistence of Spiny Rice-flower (**Figure 3** and Figure) (Regan et al. 2021).

Figure 8 Left–The Recovery Team and Mt Korong Eco-Watch Association conducted population monitoring. Right– Supplementary planting and population monitoring at Skipton Common supported by Glenelg Hopkins CMA, Ballarat Environment Network, *Pimelea* Conservation Trust, Skipton Primary school, Wadawurrung Traditional Owners Aboriginal Corporation, Field Naturalist's Club Ballarat and the Snake Valley CFA Brigade. Spiny Rice-flower recovery is part of the Glenelg Hopkins CMA's Victorian Volcanic Plain Recovery Project.

Photo © Debbie Reynolds

Figure 9 Collecting seeds from multiple populations for supplemental planting. Using seeds from different populations help promote genetic diversity within the often isolated and small remnant populations.

Photo © Debbie Reynolds (top) and Aus Eco Solutions (bottom).

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6.7 Community support

The Recovery Team has liaised and built a strong collaboration with Country Fire Authority (CFA), Catchment Management Authorities (CMAs), and key local conservation groups including Skipton CFA, Skipton Landcare, Ballarat Environment Network, Glenelg Hopkins CFA, Corangamite CMA, Glenelg Hopkins CMA, Mt Korong Eco-Watch Association, and Field Naturalists' Club of Ballarat.

The Recovery Team has undertaken various types of community outreach for Spiny Rice-flower including:

- The production of the Pimelea and Her Grassland Friends children's book (2015)
- Chapter in *Recovering Australian Threatened Species* (Garnett et al. 2018) "Spiny Rice-flower: small, unassuming but with many friends" Chapter 6, authors – V Craigie, D Reynolds, N Walsh, S Mueck, L James & P Rudolph
- Digging (up) the Spiny Rice-flower on Soundcloud and on YouTube (2021)
- Doyle et al. (2022) Threatened Plant Conservation for Mitigation: Improving Data Accessibility using Existing Legislative Frameworks. An Australian Case Study. Published in Frontiers in Conservation Science (January 2022)
- Conservation information on State-Wide Integrated Flora and Fauna Teams (SWIFFT) website
- Presentations and talks at community group's meetings, community education days, and workshops.

Overall, there has been substantial efforts that have been undertaken for the recovery of Spiny Rice-flower. Despite the achieved outcomes to date, there is still an urgent need for recovery actions that put a strong emphasis on protecting key sites as well as managing habitats from threats and gather further knowledge to better inform on-ground management of the species and habitat (Recovery Actions Table 2 and

Table 3). It is also evident that continuing the ongoing collaboration with land managers and conservation groups and Traditional Owners, is paramount to progress the species recovery (Recovery Actions Table 4).

Figure 10 Spiny Rice-flower translocation. Top–A tree spade mounted on a tractor is used to extract plant to minimise root damage. Bottom–When the recipient site and salvage site are in a close distant, individual plant is transplanted directly after extraction.

Photo © Debbie Reynolds (top) and © Steve Mueck (bottom).

7 Recovery Plan

The long-term vision for Spiny Rice-flower recovery is to ensure Spiny Rice-flower can survive, flourish, and retain its potential for evolutionary development in the wild through the continuation of threats abatement and maintained or enhanced viable *in situ* populations.

The first Recovery Plan for Spiny Rice-flower has provided a foundation to further promote the ongoing recovery effort needed to meet the vision through enhancing habitat protection, improving habitat quality and connectivity, and improving Spiny Rice-flower's population trajectory.

Within the lifespan of this Recovery Plan (10 years), the objectives for Spiny Rice-flower are:

- A maintained or increasing positive trend in the area of occupancy
- A maintained or increasing number of viable populations (compared to 2021/22 baseline counts).
- All populations of the Spiny Rice-flower are identified, managed and protected from key threats to ensure its persistence.
- Community and institutional support are maintained and enhanced.

7.1 Performance criteria

This Recovery Plan will be deemed successful if by 2032, all the following have been achieved:

1. The number of known viable 2021/22 populations (both wild and translocated) has been maintained or increased from 2021/22 baseline counts.
2. The number of individuals in each population has been maintained or increased from 2021/22 baseline counts.
3. All known populations records are surveyed and accurately and mapped in 2028 and every 5 years thereafter.
4. All known populations are identified, protected and managed to support recovery and persistence.
5. The area of occupancy of Spiny Rice-flower has increased through the establishment and protection of new viable populations.
6. The number of populations subject to formal protection measures has increased by at least 10%.
7. Knowledge of Spiny Rice-flower ecology, recruitment and seedling survivorship, genetic variation, and ecological requirements has increased, and this information has been incorporated into the adaptive management plans.
8. Participation in recovery planning and actions by key stakeholders and Traditional Owners has increased.

7.2 Actions

The recovery actions will respond to on-ground threats to stop the decline of Spiny Rice-flower. The recovery actions are designed to meet these objectives within the lifespan of this Recovery Plan and can be categorised under the following strategies.

- **Strategy 1: Protecting and managing all populations and habitats** (Strategy 1: Protecting and managing all populations and habitats

This strategy mainly consists of two dimensions – to secure populations or habitat from incompatible use and catastrophic loss (**protect**); and to appropriately manage threats to all populations and habitat to maintain or improve extent and condition of habitat and genetic integrity (**manage**) at local, regional and landscape scales

- Table 2).
- **Strategy 2: Increasing knowledge** of reproductive ecology, population and habitat extent, and disturbance ecology, and incorporate this knowledge into adaptive management plans (

  Table 3).
- **Strategy 3: Increasing community awareness and involvement** and support of and managers, community, and Traditional Owners to include adaptive habitat management planning in their work which will ultimately support the recovery of Spiny Rice-flower (Table 4).

Strategy 1: Protecting and managing all populations and habitats

This strategy mainly consists of two dimensions – to secure populations or habitat from incompatible use and catastrophic loss (**protect**); and to appropriately manage threats to all populations and habitat to maintain or improve extent and condition of habitat and genetic integrity (**manage**) at local, regional and landscape scales

Table 2 Actions to ensure all Spiny Rice-flower populations and habitat are adequately protected and managed (Strategy 1).

Action No.	Action	Action Details	Performance criteria	Potential partners
1.1	Determine population sizes and trends and establish a state-wide database.	Monitor population and maintain a state-wide census of numbers, localities, and trends. Subsequently, undertake a biogeographic and population classification (based on regions, genetics, minimum population size, and reservation potential) to determine priority site and prioritise resource allocation for recovery actions (see Action 1.7 and 2.2)	All known populations accurately assessed and mapped. Conservation prioritisation framework (including priority sites if applicable) is established for all known populations to inform the management action.	• Local, State and Commonwealth Planning and Environment Departments • *Pimelea spinescens* Recovery Team • Trust for Nature (TfN) • National Reserve System (NRS) • Private conservation organisations
1.2	Review the land tenure of all sites and determine the conservation action of all populations, particularly those on public sites.	Identity changes in land tenure of all public sites* and target sites to provide increased security for the population. (*Including consideration of reservation for conservation purposes, where consistent with *Australia's Strategy for the National Reserve System 2009-2030*)	All populations have land tenure that provides protection.	• Local, State and Commonwealth Planning and Environment Departments • *Pimelea spinescens* Recovery Team • TfN • Natural Reserve System • Private conservation organisations
1.3	Implement a strategic program of covenanting private property sites.	In collaboration with TfN, DEECA and NRS, the Recovery Team implements a strategic program of covenanting Spiny Rice-flower populations on private property sites. Conservation land handed over to councils (established under Sect. 173 agreements) could be upgraded to TfN covenants to ensure they are permanently protected.		• Local, State and Commonwealth Planning and Environment Departments • *Pimelea spinescens* Recovery Team • Parks Victoria • LGAs • TfN and other private conservation organisations • Private individuals

Action No.	Action	Action Details	Performance criteria	Potential partners
1.4	Implement a strategic program of voluntary acquisition to protect important sites on private land	Private land acquired for conservation would likely go to either TfN or Parks Victoria (via DEECA). Acquisition can potentially be done through private conservation organisations and local governments	Important private land sites are protected through land acquisition.	• DEECA • Parks Victoria • Melbourne Strategic Assessment program
1.5	Establish suitable agreements over all significant public land sites not amenable for conservation reservation.	For public land sites that cannot otherwise be reserved (rail, roadsides, and cemeteries), management agreements under the FFG Act 1988 through Public Authority Management Agreements (PAMAs or improved PAMAs) or other suitable mechanisms must be used to ensure protection of the sites.	The establishment of suitable agreements through Public Authority Management Agreements (PAMAs) over key public land sites not amenable to reservation.	• Local, State and Commonwealth Planning and Environment Departments • *Pimelea spinescens* Recovery Team • Parks Victoria • Cemetery Trusts • Melbourne Water • VicTrack • Department of Transport and Planning • VicUrban • TfN and other private conservation organisations
1.6	Further investigate Spiny Rice-flower disturbance ecology by monitoring populations across different habitats and management regimes.	Establish a standard population performance monitoring protocol derived from permanently established plots across a broad biogeographic range of representative sites. Subsequently, use the population data and disturbance ecology to inform management plan of the respective site. The management plan should provide prescription on, for example, controlling threats from pest plants, animals, and predators by preventing access, rerouting tracks, application of herbicide, hand removal of weeds, fencing sites and caging plants.	• Population monitoring protocol and permanent plots are established. • Improved understanding on threats across populations to establish suitable management regimes. • Detail prescription of threats mitigation and control in the management plan.	• Local, State and Commonwealth Planning and Environment Departments • *Pimelea spinescens* Recovery Team • Private conservation organisations • Traditional Owners

Action No.	Action	Action Details	Performance criteria	Potential partners
1.7	Document and promote the details of examples of best practice management of Spiny Rice-flower and to replicate the practice elsewhere.	Document and promote examples of best practice for both Spiny Rice-flower and grassy ecosystem conservation management (e.g., Melbourne Water's Lake Borrie population).	Best practice conservation management, including Indigenous fire management practice, identified and translated to other sites as appropriate.	• Local, State and Commonwealth Planning and Environment Departments • *Pimelea spinescens* Recovery Team • Melbourne Water • Private conservation organisations • Traditional Owners
1.8	Ensure at least all priority sites are managed under the appropriate disturbance regime and threat mitigation strategies via a suitable property, reserve or population/site prescription or management plan/system (see Action 1.1 and 2.2).	For at least high priority sites, develop site-specific management plans and implement as resources allow. Ideally, all public land supporting Spiny Rice-flower must have an active management plan approved of by the *Pimelea spinescens* Recovery Team including annual census and a process for adaptive improvement over time. For roadsides and rail reserves in particular, wider consultation will be necessary for the development of these plans (e.g., municipal fire prevention committees).	All sites (at least priority and public land sites) have adaptive management plan endorsed by the Recovery Team and are actively managed accordingly.	• Local, State and Commonwealth Planning and Environment Departments • *Pimelea spinescens* Recovery Team • Private conservation organisations • Traditional Owners
1.9	Reintroduce populations in suitable habitat adjoining or near existing populations or supplement populations on secure land tenure.	Reintroduce new populations in suitable habitat adjoining or near existing populations on secure land (reserves or covenanted properties) where appropriate using appropriate translocation measures. Augment existing populations to increase population size where appropriate.	All populations survive and are self-sustaining.	• Local, State and Commonwealth Planning and Environment Departments • *Pimelea spinescens* Recovery Team • Private conservation organisations • Traditional Owners

Action No.	Action	Action Details	Performance criteria	Potential partners
1.10	Assess all development proposals and referred actions within the modelled Spiny Rice-flower distribution and adjacent areas.	Under section 139 of the EPBC Act, the Minister must not act inconsistently with a Recovery Plan when deciding whether or not to approve the taking of an action. All referred actions within the modelled Spiny Rice-flower distribution must be assessed against the information and actions outlined in this Recovery Plan (also see Guidance for decision makers). The compounding impacts of urban development must be addressed when considering potential impacts on the Spiny Rice-flower, and sufficient consideration must be given to the following Spiny Rice-flower knowledge gaps (Table 3): • population attributes and threats (Action 2.2); • the capacity for other areas currently not supporting the Spiny Rice-flower and degraded grasslands to become habitat in the future (Action 2.2); and • pollination, dispersal capacity, and habitat connectivity to maintain gene flow and population viability (Action 2.3).	• All development referrals within the modelled Spiny Rice-flower distribution are appropriately assessed and regulated by considering all information outlined in this Recovery Plan.	• Commonwealth and State Environment Departments • *Pimelea spinescens* Recovery Team

Strategy 2: Research on population and management requirements

Closing the knowledge gap strategy involves actions to acquire accurate information for conservation status and assessments of populations' growth rate and viability; to rigorously define habitat that is critical to the survival; and to identify key biological functions, ecology and management requirements with emphasis on seed and seedling ecology, fire-recruitment dynamics, pollinator and dispersal ecology and impacts of drastic climate change.

Table 3 Actions to address knowledge gap to better inform adaptive management plans for the Spiny Rice-flower (Strategy 2).

Action No.	Action	Action Details	Performance criteria	Potential partners
2.1	Review the past and ongoing research and formulate future research, population monitoring and long-term strategy for the recovery of Spiny Rice-flower.	• Establish the Monitoring and Research Sub-committee of the *Pimelea spinescens* Recovery Team to develop long term research milestones to inform adaptive management plans for Spiny Rice-flower. • Review the monitoring and research strategy to clarify what questions are being addressed; develop standardised protocols and survey methods; ensure appropriate reporting, analysis and documentation. • Ensure that novel findings and knowledge of Spiny Rice-flower ecology, reproductive ecology, habitat critical to the survival of the species, and management requirements can inform adaptive management plans of any recovery actions (for example refining the information details of genetic variation will better-inform seed sourcing strategy for translocation and enrichment planting).	• Improved coordination and standardisation of monitoring and research. • Long term research plan and milestones for Spiny Rice-flower to inform adaptive management plans are established. • Knowledge of Spiny Rice-flower ecology, reproductive ecology, habitat critical to the survival of the species, and management requirements has increased, and this information has been incorporated into the adaptive management plans.	• *Pimelea spinescens* Recovery Team and DEECA

Action No.	Action	Action Details	Performance criteria	Potential partners
2.2	Understanding the population attributes and threats, that can be useful to inform the management action specific for each site.	• Collect information about population, threats, land tenure, and opportunities for expanding the population (see Action 1.1). • Fully assess records from all data sources to obtain all information required to pinpoint or locate recorded populations in the field. • Determine the likely impacts of climate warming on current populations and ensure that genetics are both collected from and added into the most at risk sites from populations which are already more adapted to these conditions. • Map all sites in a GIS and describe population size, extent and actions required to protect or expand population to prioritise resource allocation and recovery actions (Action 1.1 and 1.7). • Compile results and enter all data into the Spiny Rice-flower State-wide database (see Action 1.1). • Establish responsibilities and protocols for on-going update and curation of the State-wide database. • Develop a simple protocol for field assessment of existing and possible new sites. Population information should include: o site number and name (and note whether it is a new site or an extension of an existing site) and brief location description, o description of land tenure, land use and current threats from standard list in this Recovery Plan, o record of accurate geographic reference (datum) of the population, and o an accurate population census (must be conducted during the flowering season) and estimates of sex structure and population demography (e.g., Dear 2019). •	• All known populations accurately assessed, mapped and stored under state-wide database to determine population growth, assess long-term viability and inform assessment of conservation priority.	• Local and State Environment Departments • *Pimelea spinescens* Recovery Team • Private conservation organisations • Universities and botanic gardens • Local communities

Action No.	Action	Action Details	Performance criteria	Potential partners
2.3	Identify knowledge gaps on key biological processes to facilitate a better and shared understanding of the ecology and the preferred management of the Spiny Rice-flower among experts and managers.	Population Viability Analysis for the Spiny Rice-flower has been developed that represent a repository of data and expert knowledge will help facilitate management of the Spiny Rice-flower (Regan et al. 2021). Further steps to enhance the management including prioritising monitoring and other recovery actions will need to be informed by detailed information on species biology. The action should include closing knowledge gaps on key biological attributes such as: • reproductive biology (key variables that drive seed production and seed viability, which will be useful to develop strategy for seed orchard and seed supply for translocation and grassland restoration), • germination ecology, including potential seasonal dormancy and fire-related cues, and seedling establishment, including fire-recruitment dynamics, • pollinator and seed dispersal ecology, investigation of breeding system to determine the prevalence and importance of vector-driven outcrossing, • genetic sampling and further analysis of within and between site variation (correlations with biogeographic variables) and the implications for restoration and translocation, • survivorship and the factors that influence it throughout the life cycle, • impacts of drastic environmental change (both in translocated and wild populations), • effectiveness of disturbance treatments for vegetative renewal and reproduction .	Improved understanding on species biology to inform on-ground management actions, *in situ* and *ex situ* conservation, and translocations.	• State Environment Departments (Arthur Rylah Institute, DEECA) • *Pimelea spinescens* Recovery Team • Universities and botanic gardens (Royal Botanic Gardens Victoria) • Parks Victoria • Research Partners

Strategy 3: Enhanced local community, land managers and Traditional Owners engagement

The actions under this strategy focuses on community or site-based collaboration to ensure the practice of Spiny Rice-flower conservation is adaptive and integrated into local management routines.

Table 4 Actions to support community-based collaboration for the recovery of Spiny Rice-flower (Strategy 3).

Action No.	Action	Action Details	Performance criteria	Potential partners
3.1	Ensure ongoing funding support for a coordinator role	• Support a central coordination role to collaborate with all relevant stakeholders and community organisations involved with conservation of Spiny Rice-flower	Community groups, landowners, managers and Land Custodians fully informed and engaged in recovery actions.	• *Pimelea spinescens* Recovery Team • *DEECA* • *LGAs*
3.2	Work with community groups actively engaged in Spiny Rice-flower management (directly or indirectly) to codify management, at least for the priority sites and/or important populations.	• Identify current land managers and Custodians and link all community groups actively involved with the management of Spiny Rice-flower populations or habitat (such as through a website or social media group). • Identify all priority sites where there is scope for community group involvement. Indigenous communities will also be invited to review and advise on changes to the Recovery Plan and be a part of the implementation of the Recovery Plan. All recovery actions are to be undertaken in a manner that respects the cultural traditions of the Traditional Owners. • Describe the nature of the group involvement, as well as the risks and opportunities. Note: some of the key risks are inappropriate burning, inadvertent destruction or damage due to social, technological or procedural changes in activities. • Codifying best practice management, providing operational support and good relationship management will be the primary means of managing this risk.	Community groups, landowners, managers and Land Custodians fully informed and engaged in recovery actions.	• *Pimelea spinescens* Recovery Team • Universities and botanic gardens • Parks Victoria • Traditional Owners

Action No.	Action	Action Details	Performance criteria	Potential partners
3.3	Wider consultation to develop and implement adaptive and effective management plans.	• Support Indigenous communities to plan and implement Spiny Rice-flower conservation actions where desired. • Ensure Traditional Owners are invited to be a part of the development and implementation of adaptive management plans that include Spiny Rice-flower and future iterations of the National Recovery Plan for Spiny Rice-flower. • Engage with community groups to lead/assist with the conservation management for sites outside the interest of Traditional Owners. • Strengthen existing community involvement, e.g., municipal fire prevention committees. • Recommend actions including the need to prescribe/codify management; formal protection mechanisms such as PAMAs and covenants; key contacts and relationship management; capacity and resourcing needs; monitoring and reporting.	Existing community management of priority sites are improved, and new initiatives are established. Land managers, Custodians and other stakeholders are supported to develop and implement effective adaptive management plans that include Spiny Rice-flower and address known or likely threats of the local sites.	• State Environment Departments (DEECA Indigenous Facilitator) and local governments • *Pimelea spinescens* Recovery Team • Traditional Owners

7.3 Implementation and evaluation

This Recovery Plan guides recovery action for the Spiny Rice-flower, its implementation to be coordinated by the national recovery team with identified partners working collaboratively to achieve positive and lasting conservation outcomes for the species. The technical, scientific, habitat management or education components of the Recovery Plan will be referred to specialist groups for research, *in situ* management, or community education as required.

The Recovery Plan will guide recovery effort for 10 years and will be reviewed within 5 years from the date it's made under the EPBC Act. Actions and recovery progress will be regularly reviewed by the Recovery Team through a structured review process throughout this period. This will include compiling all information, assessing progress against the performance criteria and objectives to allow adaptive management for the species consistent with national reporting guidelines for recovery teams. The review outcome will determine:

- whether the plan continues unchanged, is varied to remove completed actions, or varied to include new conservation priorities; or
- whether a Recovery Plan is no longer necessary for the species, as either conservation advice will suffice, or the species is removed from the threatened species list.

As part of this review, the listing status of the species will be reviewed to determine whether it needs to be reassessed (down listed) against the EPBC Act species listing criteria.

7.4 Priorities, timeframes and funding

Spiny Rice-flower requires interventions including control and mitigation of threats, habitat protection, and better understanding of its ecology to support its recovery. Significant progress in recovering Spiny Rice-flower populations is likely to occur if the actions outlined in this Recovery Plan are comprehensively funded and implemented over the next 10 years. The cost of implementing this plan should be incorporated into the core business expenditure of partners, including funding, bodies, to ensure those partners who are responsible for implementing relevant actions can effectively collaborate, prioritise and implement actions to protect the species and ensure its long-term persistence (Garnet et al. 2018). Anticipated funding sources include the Commonwealth, state, and local governments and the *Pimelea* Conservation Trust fund.

Table 5 outlines the action priorities, timeframes, partners, primary funding sources and costs (where estimable) required to achieve the objectives of the Spiny Rice-flower Recovery Plan. It is expected that Commonwealth and state agencies will use this plan to prioritise investment and actions to protect the species and enhance its recovery, and that projects will be undertaken according to agency priorities and available resources. All actions are considered important steps towards ensuring the long-term survival of Spiny Rice-flower. The recovery process of Spiny Rice-flower is anticipated to be continually evolving and therefore recovery actions of the species may still be required beyond the 5-year review of the Recovery Plan.

Table 5 Priorities, actions, timeframes, estimated costs for Spiny Rice-flower recovery within the 5-year review[a].

Action	Priority (1-3)[b]	Description	Timeframe[c]	Indicative total cost for 5 years (A$)
1.1	1	Determine population sizes and trends and establish a state-wide database.	Ongoing	52,000
1.2	1	Review and reclassify the status of all populations particularly those on public sites to determine the conservation priority and status relating to habitat critical to the survival of the Spiny Rice-flower or important populations.	Ongoing	52,000
1.3	1	Implement a strategic program of covenanting of private property sites.	Ongoing	800,000[d]
1.4	1	Implement a strategic program of voluntary land acquisition for sites with very high grassland values and significant population of Spiny Rice-flower	Ongoing	1,000,000
1.5	1	Establish suitable agreements over all public land sites not amenable for conservation reservation.	Ongoing	200,000
1.6	1	Further investigate Spiny Rice-flower disturbance ecology by monitoring populations performance across different habitats and management regimes.	Ongoing	200,000
1.7	3	Document and promote the details of example of best practice Spiny Rice-flower management to be translated to other sites.	Ongoing	52,000
1.8	1	Ensure at least all priority sites are managed under the appropriate disturbance regime and threat mitigation strategies via a suitable property, reserve or population/site prescription or management plan/system.	Ongoing	432,000
1.9	2	Establish new populations in suitable habitat adjoining or near existing populations on secure land.	Ongoing	224,000[e]
1.10	1	Review development proposals and actions within the modelled Spiny Rice-flower distribution and adjacent areas.	Ongoing	50,000
2.1	2	Review the research, its monitoring and long-term strategy for the recovery of Spiny Rice-flower.	Year 1, reviewed every 2 years	50,000
2.2	1	Complete State-wide database to assess conservation priority.	Every 2–3 years	118,000
2.3	1	Improve our understanding on key biological functions to facilitate a better and shared understanding of the ecology including breeding system, recruitment, disturbance ecology and the best-practice management of the Spiny Rice-flower.	Year 1–5	345,000

Action	Priority (1-3)[b]	Description	Timeframe[c]	Indicative total cost for 5 years (A$)
3.1	1	Coordination role for recovery team and recovery actions	Ongoing	250,000
3.2	1	Work with community groups actively engaged in Spiny Rice-flower management (directly or indirectly) to codify management, at least for the priority sites.	Ongoing	150,000
3.3	1	Engage with new community groups to lead/assist with adaptive conservation management of other priority sites not traditionally managed at all.	Ongoing	150,000

[a] The action and corresponding priority and cost will be assessed at the 5-year review and adjusted accordingly for the remaining lifespan of this Recovery Plan.

[b] Values 1-3 are in decreasing order of priority with 3 being lowest priority. The action's priority was based on the threat risk (Table 1) and implementation of the previous Recovery Plan Appendix Table 2

[c] Year of the new Recovery Plan. Recovery Plan commencement year = Year 1.

[d] Indicative amount, based on assumption that this task would be undertaken by a dedicated officer or a number of officers with part of their role dedicated to this specific task (the figure is the approximate costs for the 5 year period based on an estimated percentage of person's full time equivalent (FTE).

[e] Indicative amount for one site only.

7.5 Interactions with existing plans, policies and programs

This Recovery Plan is influenced by, responds to, complements and/or overlaps with a range of other strategic policies and plans. The Recovery Plan seeks to identify common approaches and actions between these existing plans and programs to provide an integrated and efficient approach to the management and recovery of the species. In addition to Commonwealth, State and local government plans and policies, there are protocols that have been developed and/or endorsed by the Recovery Team to guide the recovery actions for Spiny Rice-flower.

Commonwealth government:

- Commonwealth listing advice on *Pimelea spinescens* subsp. *spinescens* (Plains Rice-flower, Spiny Rice-flower, Prickly *Pimelea*) (TSSC 2003)
- Commonwealth listing advice on the Natural Temperate Grasslands of the Victorian Volcanic Plain (TSSC 2008)
- EPBC Act policy statement - translocation of listed threatened species - assessment under chapter 4 of the EPBC Act (DSEWPAC 2013).
- Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy (DSEWPAC 2012).
- Strategic assessments: policy statement for EPBC Act referrals (DSEWPAC 2013)
- Significant impacts guidelines 1.1 - Matters of National Environmental Significance (DEWHA 2013).
- Significant impact guidelines for the critically endangered Spiny Rice-flower (P*imelea spinescens* subsp. *spinescens*)–EPBC Act policy statement 3.11 (DEWHA 2009b)
- Significant impact guidelines for the critically endangered Spiny Rice-flower (*Pimelea spinescens* subsp. *spinescens*)–Background Paper to EPBC Act Policy Statement 3.11 - Nationally Threatened Species and Ecological Communities (DEWHA 2009c)
- Commonwealth Conservation Advice on Natural Grasslands of the Murray Valley Plains (TSSC 2012)
- Conservation Advice *Pimelea spinescens* subsp. *spinescens* (Spiny Rice-flower) (TSSC 2016)
- Threat abatement plan for competition and land degradation by rabbits (Department of the Environment and Energy 2016b)

Victoria government:

- Spiny Rice-flower *Pimelea spinescens* subsp. *spinescens*: A nationally threatened species of the grassland community (DELWP 2005)
- Flora and Fauna Guarantee Action Statement 132 (revised 2008)–Spiny Rice-flower *Pimelea spinescens* subsp. *spinescens* (DSE 2008)
- Melbourne Strategic Assessment Biodiversity Conservation Strategy (2010)

- Melbourne Strategic Assessment–Spiny Rice-flower prescription [Management plan] (DSE 2010)
- Victorian Auditor General's Office report into Protecting Critically Endangered Grasslands (2020)

Protocols and other guidelines relevant to the recovery actions:

- Spiny Rice-flower translocation protocol (*Pimelea spinescens* Recovery Team 2013)
- Spiny Rice-flower long-term monitoring protocol (*Pimelea spinescens* Recovery Team 2014)
- Spiny Rice-flower guidelines for monitoring (*Pimelea spinescens* Recovery Team 2015a)
- Management in a fire control line for *Pimelea spinescens* (*Pimelea spinescens* Recovery Team 2015b)
- Burning *Pimelea spinescens* (*Pimelea spinescens* Recovery Team 2017)
- Spiny Rice-flower seed collection protocol (*Pimelea spinescens* Recovery Team 2018)
- Guidelines for the translocation of threatened plants in Australia–third edition (Commander et al. 2018)
- Plant germplasm conservation in Australia–third edition (Martyn Yenson et al. 2021)

7.6 Ecological co-benefit

Spiny Rice-flower is a significant flagship species for the conservation of the Critically Endangered Natural Temperate Grassland and other TECs (Figure ; Table 6). Temperate grasslands and grassy woodlands of the Victorian Volcanic Plain are identified as one of Australia's most threatened ecosystems where more than 99% and 95%, respectively, have been lost and the remaining pieces are in poor condition (Kirkpatrick et al. 1995; VAGO 2020). Protection of Spiny Rice-flower habitats on public land have contributed to the conservation of multiple TECs supporting the subspecies, i.e., the Endangered Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions (Cheal et al. 2011), the Critically Endangered Grassy Eucalypt Woodland of the Victorian Volcanic Plain (DEWHA 2009a, b, c); the Endangered Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia (DEWHA 2010); the Critically Endangered White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland (DECCW 2010); the Critically Endangered Natural Temperate Grassland of the Victorian Volcanic Plain (TSSC 2008); and the Critically Endangered Natural Grasslands of the Murray Valley Plains (SEWPAC 2012; TSSC 2012).

The Victorian Volcanic Plain bioregion is also one of 15 biodiversity hotspots in Australia and home to more than 65 threatened species listed nationally and 173 threatened species listed in Victoria (DSEWPAC 2011; VAGO 2020). Threatened plant species co-occurring with Spiny Rice-flower in the Natural Temperate Grasslands of the Victorian Volcanic Plain include: *Dianella amoena* (Matted flax-lily, Endangered), *Diuris basaltica* (Small Golden Moths, Endangered), *D. fragrantissima* (Sunshine Diuris, Endangered), *Lepidium hyssopifilium* (Basalt Pepper-cress, Endangered), *Leucochrysum albicans* var. *tricolor* (Hoary Sunray, Endangered), *Prasophyllum diversifolium* (Gorae Leek-orchid, Endangered), *P. frenchii* (Maroon Leek-orchid, Endangered), *P. suaveolens* (Fragrant Leek-orchid, Endangered), *Pterostylis basaltica* (Basalt Greenhood, Endangered), *Rutidosis leptorrhynchoides* (Button Wrinklewort, Endangered), *Dodonaea procumbens* (Trailing Hop-bush, Vulnerable), *Glycine latrobeana* (Clover Glycine, Vulnerable), *Lepidium aschersonii* (Spiny Pepper-cress), *Senecio*

macrocarpus (Large-fruit Groundsel, Vulnerable), *Xerochrysum palustre* (Swamp Everlasting, Vulnerable) (DSEWPAC 2011). Spiny Rice-flower grasslands habitat also support a wide range of threatened fauna including the *Synemon plana* (Golden sun moth, Vulnerable)*, Delma impar* (Striped Legless Lizard, Vulnerable) and *Litoria raniformis* (Growling Grass-frog, Vulnerable). Incorporating threats mitigation and habitat management for Spiny Rice-flower into the current recovery actions will provide broader and continuous biodiversity benefit and will culminate in the formulation of best practice for the management of grassland ecosystems and the associated species.

Figure 11 Spiny Rice-flower plant growing in its grasslands habitat.

Photo © Debbie Reynolds

Table 6 Threatened Ecological Communities (TECs) known and likely supporting the Spiny Rice-flower

Listed TEC (EPBC Act)	Conservation status
Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions	Endangered
Grassy Eucalypt Woodland of the Victorian Volcanic Plain	Critically Endangered
Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia	Endangered
Natural Grasslands of the Murray Valley Plains	Critically Endangered
Natural Temperate Grassland of the Victorian Volcanic Plain	Critically Endangered
Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	Critically Endangered
Subtropical and Temperate Coastal Saltmarsh	Vulnerable
White-Box Yellow-Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered

7.7 Social and economic impacts

Land on which the grasslands and grassy woodland occur, where Spiny Rice-flower habitats are predominantly situated, is fertile and productive. It now supports a diversity of agricultural industries, which are essential to the economic and social viability of towns and communities across Victoria. Many populations are found within Melbourne growth boundary. The expansion of the urban will also bring substantial economic and social benefits to Melbourne but will potentially impact Spiny Rice-flower. Where conflict occurs between actions outlined in this Recovery Plan and the interests of others, consultation between parties must occur. Any development actions must consider that Spiny Rice-flower is listed as Critically Endangered under the EPBC Act, and actions that have or likely have significant impacts on the entity must be referred for an assessment under the EPBC Act (see also Guidance for decision makers).

Social Impacts

Numerous social benefits will flow from building and maintaining relationships with a diverse array of stakeholders through the implementation of this Recovery Plan:

- Fulfilment of broad community expectations for the maintenance of biodiversity, and the long-term protection of grasslands and grassy woodlands for the enjoyment of present and future Australians.
- Informing and supporting community groups like Traditional Owners and Custodians, environmental-based and agricultural-based networks with a passion for protecting and restoring natural landscapes, while fostering a sense of pride in their contribution to conservation programs.
- Acknowledgement and respect of the various Indigenous communities and their history, with on-going connections to traditional lands and cultural practices including natural resource management.
- Identification of landholder motivations and the range of extension measures required to effectively educate landholders in wider conservation issues (i.e., a consistent message across

various sources); that inspires positive changes in landholder perceptions and actions regarding biodiversity conservation.

- Demonstrating sustainable farm practices and the value of ecosystem services, while enhancing the long-term productivity of agricultural systems to hand to following generations of farmers.
- Addressing landholder/farmer concerns about the control of weeds and other pests.
- Negotiating with private landholders to adopt voluntary conservation measures for sites with populations of threatened species and ecological communities.
- Negotiating with public land managers such as the Victorian Catchment Management Authorities (CMA), local government areas, and various water, road, rail, and cemetery authorities to adopt best practice management guidelines, or supported by legal instruments such as PAMAs, for the protection of key sites and populations.
- Promoting the work of community-based organisations, such as the Country Fire Authority (CFA) who by conducting fuel reduction burns are helping to protect local communities from fire, as well as providing ecological benefits for grasslands.
- Any protection measures required at sites (e.g., fencing, signage, track closures) will generally have minimal impact on current recreational activities; the way some reserves are managed in relation to public recreational activities may also be affected.
- Improving the intrinsic natural values and visual amenity enjoyed by visitors to such areas and increasing opportunities for tourism and education.

The negative social impacts are mostly associated with the restriction of rural and residential, agricultural and infrastructure development on land containing threatened populations or ecological communities:

- Where any alteration or rejection of development proposals will prevent or reduce the delivery of essential services that are required by the community, although the extent of this impact will vary from site-to-site and will depend upon the type of proposed development and the availability of alternatives.
- Where there is a need to conserve remnant grasslands on cemeteries, this may limit the availability of burial plots.

Economic Impacts

The recovery actions stated in this Recovery Plan primarily related to the establishment of a network of reserves or managed lands for the long-term conservation have various economic implications. Any land acquisitions or rejection or alteration of proposed developments will have economic impact on government authorities, land holders, developers and parties serviced by the land and/or development. Some economic and conservation trade-offs potentially emerge from the actions includes the following:

- Habitat conservation may increase restrictions on particular land-uses such as reduced grazing opportunities or prevent some agricultural enterprises from converting to cropping or introduced pastures.

- Adequate protection and conservation of habitat critical for the survival of the Spiny Rice-flower, that is also prime land for development, will be expensive to acquire for the parks and reserve system. The need to establish buffer zones around habitat critical for the survival of the species may also cause a trade-off in economic returns.
- Population protection and threat mitigation can be expensive due to the extent of threats (e.g., weed diversity and coverage), and the on-going need for management.
- Reserve management costs are likely to be much higher per unit area due to the patchy quality and degraded condition of many remaining sites. Remnants are often isolated and present logistical issues, such as the distance and time to travel to sites.
- Surveying for the presence of threatened species can be costly and time consuming, and access to private lands for this purpose is sometimes problematic. Therefore, it may not be practical to survey all potential sites and habitats within the time frame of this Recovery Plan. Conservation agencies should use all other means at their disposal for obtaining this information, including the survey work undertaken by consultants and students, and then incorporate this information into relevant databases.
- Some of the costs of retaining native grasslands on farms include lower economic returns, a decrease in pasture production over winter, under-employed resources, and research and marketing needs to establish and run new enterprises.
- There are also considerable investment costs involved in establishing a grasslands restoration industry, including the need to purchase or retire farmland, develop specialist equipment for soil bed preparation, sowing and harvesting, along with procuring sufficient seed and the skilled labour required. But this initial significant investment would reduce the long-term costs of restoration, which are required if large tracts of grasslands and grassy woodlands are to be created.

However, there are considerable economic benefits to also take into account:

- Many populations of threatened species or remnants of the ecological communities are at sites (e.g. parks and reserves) where management for biodiversity conservation is already a high priority.
- An asset-based approach is normally taken by natural resource management agencies, where a cost-benefit analysis can reveal the greatest biodiversity outcomes for the least investment. Management efforts that take a whole-of-ecosystem perspective naturally tend to benefit numerous co-existing species.
- Protection measures such as providing information to managers, installation and maintenance of fencing and signposts can generally be achieved at minimal cost.
- Financial and other incentives are available through various schemes run by regional natural resource management authorities to assist conservation measures. These funds provide assistance and help offset costs associated with protection (e.g. fencing and signage), and/or reduced grazing opportunities. Some councils also have rate rebate schemes for landholders who undertake weed control.

- Visitors to these natural areas provide economic benefits for the local districts, and the landscape amenity can also help increase property re-sale values.
- Other economic benefits of maintaining native grasslands on farms include: their low use of inputs such as fertilisers, enhanced response to summer rain, improved animal health, reduced need for supplementary feeding, production of finer wool, reduced drought risk, reduced fire risk, enhanced land and water protection, improved human health through reduced use of chemicals and reduced stress, opportunities for new farming enterprises such as seed collection and native plant harvesting, and enhanced opportunities for recreation, tourism, and biodiversity conservation.
- Finally, any investment in the protection and enhancement of grasslands and the grassy woodlands will be more than compensated by the value of the ecosystem services provided, including: habitat for beneficial native species, maintenance of soil structure, fertility and prevention of erosion, maintenance of water quality, prevention of soil and water salinity, provision of a carbon sink, shade and shelter for crops and livestock, drought resistant low-input grazing resources, provision of resources for the apiary industry, a source of seeds for regeneration, and maintenance of wild gene pool.

References

Anderson JT, Willis JH & Mitchell-Olds T (2011) Evolutionary genetics of plant adaptation. *Trends in Genetics* 27(7), 258–266.

Barnes N, Mueck S & Schnittler N (2006) *City of Hobsons Bay: Assessment of Plains Grasslands and habitat for Plains Rice-flower, Victoria*. A consultant report prepared by Biosis Research for the City of Hobsons Bay.

Baskin JM & Baskin CC (2004) A classification system for seed dormancy. *Seed Science Research,* 14**,** 1–16.

Biosis (2014) *Review of Spiny Rice-flower translocations in Victoria. Report for Pimelea spinescens Recovery Team*. Biosis Pty Ltd, Melbourne. Project no. 15814.

Broadhurst LM, Lowe A, Coates DJ, Cunningham SA, McDonald M, Vesk PA & Yates C (2008) Seed supply for broadscale restoration: maximising evolutionary potential. *Evolutionary Applications* 1(4), 597–597.

Broadhurst L, Breed M, Lowe A, Bragg J, Catullo R, Coates D, Encinas-Viso F, Gellie N, James E, Krauss S, Potts B, Rossetto M, Shepherd M, Byrney M (2017) Genetic diversity and structure of the Australian flora. *Diversity and Distribution* 23(1), 41–52.

Brennan A & Herwerth T (2005) *Known occurrences of Spiny Rice-flower (Pimelea spinescens* subspecies *spinescens) and Small Scurf-pea (Cullen parvum) in the Shire of Melton, Victoria, Australia in 2005*. A Report to the Department of Sustainability and Environment by Melton Shire Council, Melton.

Carland F & Kennedy N (2010) Restoring critically endangered grassland on roadsides in the Victorian Volcanic Plain. *Australasian Plant Conservation* 19, 22–23.

Carter O & Walsh N (2006) *National Recovery Plan for the Spiny Rice-flower Pimelea spinescens* subsp*. spinescens*. Department of Sustainability and Environment, Melbourne.

Cheal D, Lucas A & Macaulay L (2011) *National Recovery Plan for the Buloke Woodlands of the Riverina and Murray Darling Depression Bioregions*. Department of Sustainability and Environment.

Commander LE, Coates D, Broadhurst L, Offord CA, Makinson RO & Matthes M (2018) *Guidelines for the translocation of threatened plants in Australia*. Third Edition. Australian Network for Plant Conservation, Canberra.

Craigie V & Doherty M (unpublished) Draft National Recovery Plan for the Natural Temperate Grassland of the Victorian Volcanic Plain and the Grassy Eucalypt Woodland of the Victorian Volcanic Plain. Department of Sustainability and Environment, Melbourne.

Cropper S (2003) *The Distribution of Pimelea spinescens* subsp*. spinescens (Spiny Rice-flower) on Lake Borrie Spit and a Discussion on the Appropriate Management of the Population*. Report (Technical

Document 2003-130) prepared for Melbourne Water by Botanicus Australia Pty Ltd, Sunshine, Victoria.

Cropper S (2004) *Monitoring of Pimelea spinescens* subsp*. spinescens (Spiny Rice-flower) on Lake Borrie Spit during December 2004 and a Discussion on the Appropriate Management of the Population*. Report (Technical Document 2003-133) prepared for Melbourne Water by Botanicus Australia Pty Ltd, Sunshine, Victoria.

Cropper S (2009) *Monitoring of Pimelea spinescens* subsp*. spinescens (Spiny Rice-flower) on Lake Borrie Spit in 2008 and a Discussion on the Appropriate Management of the Population*. Report prepared for Melbourne Water by Botanicus Australia Pty Ltd, Sunshine, Victoria.

CSIRO and Bureau of Meteorology (2015) *Climate Change in Australia Information for Australia's Natural Resource Management Regions: Technical Report*. CSIRO and Bureau of Meteorology, Commonwealth of Australia.

CSIRO and Bureau of Meteorology (2020) State of the Climate 2020. CSIRO and Bureau of Meteorology, Commonwealth of Australia.

Dear E (2019) *Pimelea Conservation Trust Fund – Final report* [Unpublished report].

DAWE (2022) *Fire regimes that cause biodiversity decline: amendments to the list of key threatening processes.* Department of Agriculture, Water and the Environment, Canberra,

DECCW (2010) *National Recovery Plan for White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland*. Department of Environment, Climate Change and Water NSW, Sydney.

DCCEEW (2022) : Strategic assessment overview. Accessed: 18 July 2022. Department of Climate Change, Energy, the Environment and Water.

DEH (2000) *Revision of the Interim Biogeographic Regionalisation of Australia (IBRA) and the Development of Version 5.1 Summary Report*. Department of the Environment and Heritage, Canberra.

DELWP (2021) *Threatened Species Assessment Pimelea spinescens spinescens Spiny Rice-flower*. Conservation Status Assessment Project, Biodiversity Division. Department of Environment, Land, Water and Planning, Victoria.

DEPI (2013) *Spatial definition of habitat for Spiny Rice-flower and Matted Flax-lily across the Victorian Volcanic Plain Bioregion*. Department of Environment and Primary Industries, East Melbourne.

DEPI (2014) *Advisory list of rare or threatened plants in Victoria–2014.* Department of Environment and Primary Industries, Melbourne.

DELWP (2017) Melbourne Strategic Assessment Progress Report 2016-17. Department of Environment, Land, Water and Planning, Victoria

DELWP (2018) Melbourne Strategic Assessment Progress Report 2017-18. Department of Environment, Land, Water and Planning, Victoria.

DELWP (2019) Melbourne Strategic Assessment Progress Report 2018-2019. Department of Environment, Land, Water and Planning, Victoria.

DEE (2016a) Improving the trajectories of 30 plants by 2020. Department of the Environment and Energy, Canberra.

DEE (2016b) *Threat abatement plan for competition and land degradation by rabbits*. Department of the Environment and Energy, Canberra

DSE (2005a) *Fact Sheet Wimmera Rice-flower Pimelea spinescens* ssp. *pubiflora*. Department of Sustainability and Environment, East Melbourne.

DSE (2005b) *Fact Sheet Spiny Rice-flower Pimelea spinescens* ssp. *spinescens*. Department of Sustainability and Environment, Victoria

DSE (2008) *Flora and Fauna Guarantee Action Statement No. 132: Spiny Rice-flower* (*Pimelea spinescens* subsp. *spinescens*). Department of Sustainability and Environment, East Melbourne.

DSE (2010) *Spiny Rice-flower prescription – Melbourne Strategic Assessment Management Plan*. Department of Sustainability and Environment, East Melbourne

DSE (2005b) *Spiny Rice-flower Pimelea spinescens subsp. spinescens: A Nationally Threatened Species of the Grassland Community*. Department of Sustainability and Environment, East Melbourne

DSEWPAC (2011) *Nationally Threatened Ecological Communities of the Victorian Volcanic Plain: Natural Temperate Grassland & Grassy Eucalypt Woodland*. Department of Sustainability, Environment, Water, Population and Communities, Canberra.

DSEWPAC (2012) *Approved Conservation Advice for Natural Grasslands of the Murray Valley Plains ecological community.* Department of Sustainability, Environment, Water, Population and Communities, Canberra.

DSEWPAC (2012) *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy*. Department of Sustainability, Environment, Water, Population and Communities, Canberra.

DSEWPAC (2013a) *EPBC Act Policy Statement – Translocation of Listed Threatened Species*. Department of Sustainability, Environment, Water, Population and Communities, Canberra.

DSEWPAC (2013a) *Strategic Assessments: Policy Statement for EPBC Act referrals*. Department of Sustainability, Environment, Water, Population and Communities, Canberra.

DEWHA (2008) *Approved Conservation Advice for the Natural Temperate Grassland of the Victorian Volcanic Plain*. Department of the Environment, Water, Heritage and the Arts, Canberra.

DEWHA (2009a) *Approved Conservation Advice for the Grassy Eucalypt Woodland of the Victorian Volcanic Plain*. Department of the Environment, Water, Heritage and the Arts, Canberra.

DEWHA (2009b) *EPBC Act Policy Statement 3.11 - Significant Impact Guidelines for the Critically Endangered Spiny Rice-flower (Pimelea spinescens* subsp. *spinescens)*. Department of the Environment, Water, Heritage and the Arts, Canberra

DEWHA (2009c) *Background Paper to EPBC Act Policy Statement 3.11 - Nationally Threatened Species and Ecological Communities: Significant Impact Guidelines for the Critically Endangered Spiny Rice-flower (Pimelea spinescens* subspecies *spinescens)*. Department of the Environment, Water, Heritage and the Arts, Canberra

DEWHA (2010) *Approved Conservation Advice for the Grey Box (Eucalyptus microcarpa) Grassy Woodlands and Derived Native Grasslands of South-east Australia*. Department of the Environment, Water, Heritage and the Arts. Canberra, ACT

Doyle CA, Pellow BJ, Bell SAJ, Reynolds DM, Silcock JL, Commander LE, Ooi MKJ (2022) Threatened Plant Translocation for Mitigation: Improving Data Accessibility Using Existing Legislative Frameworks, An Australian Case Study. *Frontiers in Conservation Science* 2.

Duminil J, Hardy OJ & Petit RJ (2009) Plant traits correlated with generation time directly affect inbreeding depression and mating system and indirectly genetic structure. *BMC Evolutionary Biology* 9, 177.

Ellstrand NC & Elam DR (1993) Population genetic consequences of small population size: Implications for Plant Conservation. *Annual Review of Ecology and Systematics* 24, 217-242.

Enright NJ, Fontaine JB, Bowman DMJS, Bradstock RA & Williams RJ (2015) Interval squeeze: Altered fire regimes and demographic responses interact to threaten woody species persistence as climate changes. *Frontiers in Ecology and the Environment* 13(5), 265-272.

Entwisle TJ (1996) *Thymelaeaceae,* in NG Walsh & TJ Entwisle (eds) *Flora of Victoria*, Vol. 3: Dicotyledons Winteraceae to Myrtaceae. Inkata Press, Melbourne. pp. 912–930.

Foreman PW (1996) *The ecology of remnant indigenous grasslands of Victoria's northern Riverina Plain*. Unpublished M.Sc. Thesis, La Trobe University, Bundoora.

Foreman PW (2005) *Habitat condition and demographic structure of 16 populations from the Victorian Riverina and Volcanic Plains*. Department of Sustainability and Environment, East Melbourne.

Foreman PW (2010) Recovery of the Northern Plains Grassland Community – an overview. *Proceedings of the Royal Society of Victoria* 122(2), 92-99.

Foreman PW (2011) *Assessment of the Spiny Rice-flower populations at 16 sites on Victoria's northern and volcanic plains in 2004 and 2009*. Unpublished Report, Blue Devil Consulting, Castlemaine.

Foreman PW (2012) *Draft National Recovery Plan for the Spiny Rice-flower Pimelea spinescens Rye. subsp. spinescens* [Unpublished report]. Prepared by Blue Devil Consulting for the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

Gallagher RV, Allen S, Mackenzie BDE, Yates CJ, Gosper CR, Keith DA, Merow C, White MD, Wenk E, Maitner BS, He K, Adams VM & Auld TD (2020) High fire frequency and the impact of the 2019-2020 megafires on Australian plant diversity. *Biodiversity Research* 27, 1166-1179.

Garnett S, Latch P, Lindemayer & Woinarski J (eds) (2018) *Recovering Australian Threatened Species – A book of hope*. Chapter 6, pages 43 – 53, CSIRO publishing, Clayton, Victoria.

Hoffmann AA, Camac J, Williams RJ, Papst W, Jarrad FF, Wahren C-H (2010) Phenological changes in six Australian sub-alpine plants in response to experimental warming and year-to-year variation. *Journal of Ecology* 98, 927-937.

Hoffmann AA, Rymer PD, Byrne M, Ruthrof KX, Whinam J, McGeogh M, Bergstrom DM, Guerin GR, Sparrow B, Joseph L, Hill SJ, Andrew NR, Camac J, Bell N, Riegler M, Gardner JL & Williams SE (2019) Impacts of recent climate change on terrestrial flora and fauna: Some emerging Australian examples. *Austral Ecology* 44, 3–17.

Hoffman AA & Sgro C (2011) Climate change and evolutionary adaptation. *Nature* 470, 479–485.

Honnay O & Jacquemyn H (2007) Susceptibility of Common and Rare Plant Species to the Genetic Consequences of Habitat Fragmentation. *Conservation Biology* 21(3), 823-831.

James EA (2012) Conservation of *Pimelea spinescens*: Population genetic analysis and identification of maternal lineages. Royal Botanical Gardens Melbourne, South Yarra, Melbourne.

James EA & Jordan R (2014) Limited structure and widespread diversity suggest potential buffers to genetic erosion in a threatened grassland shrub *Pimelea spinescens* (Thymelaeaceae). *Conservation Genetics* 15(2), 305-317.

Jump AS & Penuelas J (2005) Running to stand still: adaptation and the response of plants to rapid climate change. *Ecology Letters* 8, 1010–1020.

Kirkpatrick JB, McDougall K & Hyde M (1995) *Australia's most threatened ecosystem - the south-eastern lowland native grasslands*. Surrey-Beatty & Sons. Chipping Norton, Sydney, pp. 116.

Lande R (1993) Risk of population extinction from demographic and environmental stochasticity and random catastrophes. *American Naturalist* 142, 911-927.

Long RL, Gorecki MJ, Renton M, Scott JK, Colville L, Goggin DE, Commander LE, Westcott DA, Cheery H, Finch-Savage WE (2015) The ecophysiology of seed persistence: a mechanistic view of the journey to germination or demise. *Biological Reviews* 90(1), 31-59.

Lunt ID & Morgan JW (2002) The role of fire regimes in temperate lowland grasslands of southeastern Australia, in RA Bradstock, JE Williams & AM Gill (eds) *Flammable Australia: The fire regimes and biodiversity of a continent*. Cambridge University Press. pp. 177–196

Markert JA, Champlin DM, Gutjahr-Gobell R, Grear JS, Kuhn A, McGreevy Jr TJ, Roth A, Bagleey MJ & Nacci DE (2010) Population genetic diversity and fitness in multiple environment. *BMC Evolutionary Biology* 10, 205.

Martyn Yenson AJ, Offord CA, Meagher PF, Auld TD, Bush D, Coates DJ, Commander LE, Guja LK, Norton SL, Makinson RO, Stanley R, Walsh N, Wrigley D, Broadhurst L (eds) (2021) *Plant Germplasm Conservation in Australia strategies and guidelines for developing, managing and utilising ex situ collections in Australia.* Third Edition. Australian Network for Plant Conservation, Canberra.

McCaw TM (2014) Spiny Rice Flower (*Pimelea spinescens* subsp. *spinescens*) Population at McKenzie Road. What is the population size and will the population be self-sustainable in the long term? Unpublished report.

McCaw TM (2020) Spiny Rice Flower (*Pimelea spinescens* subsp. *spinescens*) population at McKenzie Road. Have there been any significant changes to the population since 2014? And has reducing biomass with prescribed burning been successful in triggering germination? Unpublished report.

Morgan JW (1995) Ecological studies of the endangered *Rutidosis leptorrhynchoides*. I. Seed production, soil seed bank dynamics, population density and their effects on recruitment. *Australian Journal of Botany* 43, 1–11.

Morgan JW (1998) Importance of canopy gaps for recruitment of some forbs in *Themeda triandra*-dominated grasslands in south-eastern Australia. *Australian Journal of Botany* 46, 609–627.

Mueck SG (2000) Translocation of Plains Rice flower (*Pimelea spinescens* ssp. *spinescens*), Laverton, Victoria. *Ecological Management and Restoration* 1(2), 111-116.

Pimelea spinescens Recovery Team (2007) *Pimelea spinescens* Recovery Team Terms of Reference. Unpublished document, Department of Sustainability and Environment, Bendigo.

Pimelea spinescens Recovery Team (2013) Translocating *Pimelea spinescens*. Trust for Nature, Melbourne.

Pimelea spinescens Recovery Team (2014) Long term monitoring protocols *Pimelea spinescens*. Trust for Nature, Melbourne.

Pimelea spinescens Recovery Team (2015a) Guidelines for monitoring *Pimelea spinescens*. Trust for Nature, Melbourne.

Pimelea spinescens Recovery Team (2015b) *Pimelea spinescens* - Management in a fire control line. Trust for Nature, Melbourne.

Pimelea spinescens Recovery Team (2017) Burning *Pimelea spinescens*. Trust for Nature, Melbourne.

Pimelea spinescens Recovery Team (2018) Seed collection protocol *Pimelea spinescens*. Trust for Nature, Melbourne.

Ramalho CE, Laliberte E, Poot P & Hobbs RJ (2014) Complex effects of fragmentation on remnant woodland plant communities of a rapidly urbanizing biodiversity hotspot. *Ecology* 95 (9), 2466-2478.

Regan T, Bruce M, Batpurev K, Farmilo B, Scroggie M, Geary B & Cadenhead N (2021) Melbourne Strategic Assessment – Population Viability Analysis Models for Threatened Species Version 1.0. *Arthur Rylah Institute for Environmental Research Technical Report Series No. 327*. Department of Environment, Land, Water and Planning. Heidelberg, Victoria.

Reynolds DM (2013) Factors affecting recruitment in populations of Spiny Rice-flower (*Pimelea spinescens* Rye subspecies *spinescens*) in Victoria's natural temperate grasslands: relationships with management practices, biological and ecological characteristics. PhD thesis, Victoria University.

Reynolds DM (2014) Monitoring Protocol for *Pimelea spinescens* Version 1.2_01_2014. Prepared for the *Pimelea spinescens* Recovery Team. Trust for Nature, Melbourne.

Reynolds D (2015) Recommendations for the management of *Pimelea spinescens* subsp. *spinescens* occurring in a fire control line. Commissioned by VicRoads. Prepared for the *Pimelea spinescens* Recovery Team. Trust for Nature, Melbourne.

Reynolds DM (2019) *Spiny Rice-flower propagation project* [Unpublished report]. Victoria University, Melbourne.

SAC (1996) Flora and Fauna Guarantee Scientific Advisory Committee: Final Recommendation on a Nomination for Listing. Nomination No. 391 *Pimelea spinescens*. Department of Environment and Primary Industries, Victoria.

Sanchez-Bayo F & Wyckhuys K.A.G (2019) Worldwide decline of the entomofauna: A review of its drivers. *Biological Conservation* 232 (8-27).Satyanti A, Liantoro T, Thomas M, Neeman T, Nicotra AB, Guja LK (2021) Predicting effects of warming requires a whole-of-life cycle perspective: a case study in the alpine herb *Oreomyrrhis eriopoda*, *Conservation Physiology*, 9(1) coab023

Schulz B, Durka W, Danihelka J, Lutz Eckstein R (2018) Differential role of a persistent seed bank for genetic variation in early vs. late successional stages. *PLoS One* 13(12):e0209840.

Trust for Nature (2014) Pimelea Conservation Trust Fund. Melbourne

TSSC (2003) Commonwealth Listing Advice on *Pimelea spinescens* subsp. *spinescens* (Plains Rice-flower, spiny rice-flower, Prickly Pimelea). Threatened Species Scientific Committee, Department of the Environment, Water, Heritage and the Arts.

TSSC (2008) Commonwealth listing advice on the Natural Temperate Grasslands of the Victorian Volcanic Plain. Threatened Species Scientific Committee. Department of the Environment, Water, Heritage and the Arts.

TSSC (2009) Commonwealth Listing Advice on Grassy Eucalypt Woodland of the Victorian Volcanic Plain. Threatened Species Scientific Committee, Department of the Environment, Water, Heritage and the Arts.

TSSC (2009) Commonwealth Conservation Advice on *Pimelea spinescens* subsp. *pubiflora* (Wimmera Rice-flower). Threatened Species Scientific Committee, Department of the Environment, Water, Heritage and the Arts.

TSSC (2012) Commonwealth Conservation Advice on Natural Grasslands of the Murray Valley Plains. Threatened Species Scientific Committee. Department of the Environment, Water, Heritage and the Arts.

TSSC (2016) Conservation Advice *Pimelea spinescens* subsp. *spinescens* Spiny Rice-flower. Threatened Species Scientific Committee: Department of the Environment and Energy, Canberra.

VAGO (Victorian Auditor General's Office) (2020) Protecting Critically Endangered Grasslands. Victorian Government Printer, Melbourne.

Van Oldenborgh GJ, Krikken F, Lewis S, Leach NJ, Lehner F, Saunders KR, van Weele M, Haustein K, Li S, Wallom D, Sparrow S, Arrighi J, Singh RK, van Aast MK, Philip SY, Vautard R & Otto FEL (2021) Attribution of the Australian bushfire risk to anthropogenic climate change. *Natural Hazards and Earth System Sciences* 21, 941-960.

Walsh NG & Entwisle TJ (1996) Thymelaeaceae, in *Flora of Victoria Vol. 3, Dicotyledons Winteraceae to Myrtaceae*. Inkata Press, Melbourne.

Walsh NG & Stajsic V (2007) A Census of the Vascular Plants of Victoria, South Yarra, Victoria, Royal Botanic Gardens.

Westerling AL, Turner MG, Smithwick EAH, Romme WH & Ryan MG (2011) Continued warming could transform Greater Yellowstone fire regimes by mid-21st century. *Proceedings of the National Academy of Sciences of the United States of America* 108(32), 13165-13170.

Appendix 1

Table A1 Population information for the Spiny Rice-flower (November 2021)

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
2	Banyena-Burrum Road	Rupanyup	Wimmera	Roadside	206*	Low	North
3	Baringhup West Road	Baringhup West	Victorian Volcanic Plain	Roadside	349*	Low	North
4	Baringhup-Havelock Road	Baringhup West	Victorian Volcanic Plain	Roadside	5*	Very Low	North
5	Baringhup-Havelock Road (east)	Barringhup	Victorian Volcanic Plain	Roadside	2	Very Low	North
6	Bendigo-Tennyson Road (north)†	Pine Grove	Riverina	Roadside	1	Very Low	North
7	Bendigo-Tennyson Road (south)†	Tennyson	Riverina	Roadside	1*	Very Low	North
8	Brownes Lane†	Axedale	Riverina	Roadside	144*	Low	North
9	Canfields Lane	Wedderburn Junction	Goldfields	Roadside	215	Medium	North
10	Cant Road†	Mitiamo	Riverina	Roadside	1	Very Low	North
11	Cantwell Road†	Wharparilla	Riverina	Roadside	165*	Low	North
12	Carisbrook-Baringhup Road	Carisbrook	Victorian Volcanic Plain	Roadside	9*	Low	North
13	Chris Peats (Old Pine Grove Township)†	Pine Grove	Riverina	Private–rural	264	High	North
14	Clays Road†	Bagshot North	Riverina	Roadside	1*	Very Low	North
15	Clayton Road†	Pine Grove	Riverina	Roadside	44*	Very Low	North
16	Crossman Road (north)†	Pine Grove	Riverina	Roadside	84*	Medium	North
17	Crossman Road (south)†	Tennyson	Riverina	Roadside	169	Medium	North
18	Glengower Road	Glengower	Victorian Volcanic Plain	Roadside	748*	Medium	North
19	2 Glenorchy-Donald Road (north of Highway)	Rupanyup	Wimmera	Roadside	613*	Low	North

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
20	3 Glenorchy-Donald Road (south of Highway)	Rupanyup	Wimmera	Roadside	161*	Very Low	North
21	Green Lane	Baringhup West	Victorian Volcanic Plain	Roadside	73*	Low	North
22	Hands Road†	Dingee	Riverina	Roadside	353	Medium	North
23	Hard Hill Public Recreation Reserve (Race track)	Talbot	Goldfields	Conservation	3827	High	North
24	Harris'	Guildford	Goldfields	Private–rural	120	High	North
25	Heathcote-Moora Road	Gobarup	Goldfields	Roadside	61	Medium	North
26	Hunter Flora Reserve†	Hunter	Riverina	Conservation	5*	Low	North
27	James Road†	Pine Grove	Riverina	Roadside	1*	Very Low	North
28	Jasper Road (east)†	Tennyson	Riverina	Roadside	365	Low	North
29	Jasper Road (west)†	Tennyson	Riverina	Roadside	1080	Medium	North
30	Lowrie Road†	Pine Grove	Riverina	Roadside	1	Very Low	North
31	Lynch Road†	Mitiamo	Riverina	Roadside	105*	Low	North
32	McBeath Road†	Pine Grove	Riverina	Roadside	18	Very Low	North
33	McElwains Road†	Dingee	Riverina	Roadside	112	Medium	North
34	McKenzie Road	Marong	Goldfields	Roadside	5961*	High	North
35	McLeod Road	Rupanyup	Wimmera	Roadside	12235*	High	North
36	McSwains (Echuca west)†	Echuca West	Riverina	Private–rural	2500	High	North
37	Meins Lane	Yapeen	Goldfields	Roadside	349*	Medium	North
38	Mitchell Road†	Terrick Terrick East	Riverina	Roadside	2*	Very Low	North
39	Mitiamo Elmore Road†	Tennyson	Riverina	Roadside	10	Very Low	North
40	Mitiamo Rail Siding†	Mitiamo	Riverina	Rail reserve	170*	Low	North
41	Muckleford-Yapeen Road	Muckleford South	Goldfields	Roadside	155*	Low	North

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
42	Muller Road†	Echuca	Riverina	Roadside	681*	Low	North
43	Olds Road†	Prairie	Riverina	Roadside	105	Low	North
44	Orchard Road†	Tennyson	Riverina	Roadside	82	Low	North
45	Phylands (Patho)†	Patho	Riverina	-	1117*	High	North
46	Pine Grove Road†	Pine Grove	Riverina	Roadside	0*	Very Low	North
47	Prairie-Rochester Road†	Tennyson	Riverina	Roadside	23	Low	North
48	Pyrenees Highway	Bung Bong	Goldfields	Roadside	16*	Very Low	North
49	Raywood-Durham Ox Road†	Tandarra	Riverina	Roadside	312	Medium	North
50	Sheedys Lane	Derrinal	Goldfields	Roadside	3*	Very Low	North
51	Tait Hamilton Road†	Gobarup	Riverina	Roadside	886	Medium	North
52	Tonkins Road†	Prairie	Riverina	Roadside	277	Very Low	North
53	Tripconys Road†	Pompapiel	Riverina	Roadside	109	Low	North
54	Wason Road†	Mitiamo	Riverina	Roadside	0*	Very Low	North
55	Wimmera Highway	Banyena	Wimmera	Roadside	3663	Medium	North
56	Matthews Road	Rupanyup	Wimmera	Roadside	57*	-	North
57	Merrifield Road	Clunes	Victorian Volcanic Plain	Roadside	4*	-	North
58	McKenzies Road	Clunes	Victorian Volcanic Plain	Roadside	140	-	North
59	Ararat Airfield	Ararat	Victorian Volcanic Plain	Utility (airport)	562*	High	North
60	Bannockburn Rail Reserve	Bannockburn	Victorian Volcanic Plain	Rail reserve	440	Medium	South
62	289 Bences Road central	Merrimu	Victorian Volcanic Plain	Private–rural	758	Medium	North
63	Bences Road central 2	Merrimu	Victorian Volcanic Plain	Private–rural	2	Low	North
64	Bences Road south	Merrimu	Victorian Volcanic Plain	Private–rural	200	High	North

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
65	Cross Street	Deep Lead	Goldfields	Conservation	246*	-	North
66	Deep Lead Park Rd	Deep Lead	Goldfields	Conservation	258	-	North
67	Ironbark Road	Ingliston	Victorian Volcanic Plain	Rail reserve	150*	Very Low	South
68	Blacks Creek Nature Conservation Reserve	Stockyard Hill	Victorian Volcanic Plain	Conservation	640	High	South
69	Browns Waterholes Bridge Rail Reserve	Lismore	Victorian Volcanic Plain	Rail reserve	5450	Medium	South
70	Creswick-Newstead Road	Smeaton	Victorian Volcanic Plain	Private–rural	2000	High	North
72	Cressy-Shelford Road	Cressy	Victorian Volcanic Plain	Roadside	1150	Medium	South
73	Cressy-Shelford Road, between Rokewood-Shelford and Mt Gow Road	Shelford	Victorian Volcanic Plain	Roadside	321	Medium	South
74	Cressy-Shelford Road, between Mt Gow Road and Wingeel Road	Barunah Park	Victorian Volcanic Plain	Roadside	1543	Medium	South
75	Cressy-Shelford Road, between Bells Road and Geggies Road	Barunah Park	Victorian Volcanic Plain	Roadside	177	Low	South
77	Cressy Road	Winchelsea	Victorian Volcanic Plain	Roadside	13	Low	South
78	Chatsworth Road	Derrinallum	Victorian Volcanic Plain	Roadside	244*	Medium	South
80	Dunkeld-Cavendish Road	Moutajup	Victorian Volcanic Plain	Roadside	1*	Medium	South
81	Geggies Road	Rokewood	Victorian Volcanic Plain	Roadside	2068	Medium	South
82	Gilletts Road	Avalon	Victorian Volcanic Plain	Roadside	20	Low	South
83	Gnarkeet Station	Lismore	Victorian Volcanic Plain	Rail reserve	450	Low	South
84	Haddon Rail Reserve (Grass SWGR001)	Haddon	Victorian Volcanic Plain	Rail reserve	-	-	South
85	Hamilton Highway, ~2km east of Darlington	Darlington	Victorian Volcanic Plain	Roadside	157	Very Low	South
86	Johns Road	Glenorchy	Wimmera	Roadside	327	Low	North
87	Lismore - Scarsdale Road	Lismore	Victorian Volcanic Plain	Roadside	95	Low	South
88	Lower Darlington Road	Lismore	Victorian Volcanic Plain	Roadside	382	Medium	South

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
90	McIntyres Road	Inverleigh	Victorian Volcanic Plain	Roadside	30	Low	North
91	Middle Creek	Middle Creek	Victorian Volcanic Plain	-	29	Low	North
92	Mt Mercer-Shelford Road	Shelford	Victorian Volcanic Plain	Roadside	35448	High	South
93	Nerrrin Nerrin-Woordoo Road	Woorndoo	Victorian Volcanic Plain	Rail reserve	142*	-	South
94	North Poorneet Road	Barunah Plains	Victorian Volcanic Plain	Roadside	2*	Very Low	South
95	Old Glenorchy Road	Deep Lead	Goldfields	Roadside	0*	Low	South
96	Peak School Road and Farrars Road area	Lara	Victorian Volcanic Plain	Roadside	59	Low	South
97	Pitfield-Cressy Road	Werneth	Victorian Volcanic Plain	Roadside	300	Medium	South
98	Poorneet Rail	Cressy	Victorian Volcanic Plain	Rail reserve	1583	Medium	South
99	Poorneet West Rail	Weering	Victorian Volcanic Plain	Rail reserve	4637	High	South
100	Private property off Urches Road, Wallinduc	Wallinduc	Victorian Volcanic Plain	Private–rural	226	Medium	South
101	Private property off Hamilton Highway, Berrybank	Berrybank	Victorian Volcanic Plain	Private–rural	115	High	South
102	Pura Pura Station	Pura Pura	Victorian Volcanic Plain	Utility	4*	Low	South
103	Rokewood-Shelford Road	Corindhap	Victorian Volcanic Plain	Roadside	514	Medium	South
104	Rokewood-Shelford Rd, east of Gumley Road	Rokewood	Victorian Volcanic Plain	Roadside	60	Low	South
105	Rokewood-Shelford Rd, east of Lonies Road	Shelford	Victorian Volcanic Plain	Roadside	13	Very Low	South
106	Rokewood-Shelford Rd, east of Mt Gow Road	Shelford	Victorian Volcanic Plain	Roadside	73	Low	South
107	Rokewood-Shelford Rd, west of Mt Gow Road	Shelford	Victorian Volcanic Plain	Roadside	129	Medium	South
108	Rokewood-Shelford Rd, west of Mt Mercer Road	Rokewood	Victorian Volcanic Plain	Roadside	683	Medium	South

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
110	Streatham-Woorndoo Road (Grass SWMO001)	Woorndoo	Victorian Volcanic Plain	Roadside	-	-	South
111	Urches Road	Werneth	Victorian Volcanic Plain	Roadside	410	Medium	South
112	Vite Vite Station	Vite Vite	Victorian Volcanic Plain	Rail reserve	60*	Low	South
113	Western Highway, Dobie	Dobie	Victorian Volcanic Plain	Roadside	77	Medium	South
114	Hamilton Highway, Duverney	Cressy	Victorian Volcanic Plain	Roadside	10	-	South
115	Wilgul-Werneth Road	Werneth	Victorian Volcanic Plain	Roadside	58	Very Low	South
116	Willowvale Road (1 of 2 Lismore-Pittong Rds) (Grass SWGR012)	Mount Bute	Victorian Volcanic Plain	-Unknown	-	-	South
117	Wingeel Station	Wingeel	Victorian Volcanic Plain	Rail reserve	94	Medium	South
120	Skipton common	Skipton	Victorian Volcanic Plain	Conservation	1416	High	South
121	Birregurra-Private property, Princess Highway	Birregurra	Otway Plain	Private–rural	2	-	South
122	Mortlake-Ararat Road	Lake Bolac	Victorian Volcanic Plain	Roadside	48*	-	South
124	Waldrons Road			Private–rural	709	-	North
125	Lees Road	Karnak	Wimmera	Roadside	350*	-	North
126	Baldwin Avenue Solomon Heights (Baldwin Avenue Private (Grass PPSU001))	Sunshine North	Victorian Volcanic Plain	Private–urban	313	High	South
129	Bon Thomas Grassland Reserve	Deer Park	Victorian Volcanic Plain	Conservation	126*	-	South
130	Calder Park Rail Reserve	Calder Park	Victorian Volcanic Plain	Rail reserve	25	Medium	South
131	Calder Rise Rail Reserve	Diggers Rest	Victorian Volcanic Plain	Rail reserve	399	-	South
132	Denton Grassland (Denton Avenue)	St Albans	Victorian Volcanic Plain	Conservation	312*	High	South
133	Derrimut Grassland	Derrimut	Victorian Volcanic Plain	Conservation	30	-	South
134	Gilbertson's Grassland Reserve (Grass PPSU006)	Derrimut	Victorian Volcanic Plain	Conservation	2*	-	South

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
135	Holden Road Rail Reserve (south side of Line)	Diggers Rest	Victorian Volcanic Plain	Rail reserve	4	-	South
136	Iramoo Wildflower Grassland Reserve	Cairnlea	Victorian Volcanic Plain	Conservation	54*	Medium	South
137	Pimelea Grassland (South reserve)	St Albans	Victorian Volcanic Plain	Conservation	15	-	South
138	Featherheads Wildflower Grassland	Cairnlea	Victorian Volcanic Plain	Conservation	1*	-	South
139	Isabella Williams Memorial Reserve	Albanvale	Victorian Volcanic Plain	Conservation	59*	Low	South
140	Kings Road, Watergardens	Taylors Lake	Victorian Volcanic Plain	Private	-	-	South
141	Kings Road, Taylors Lakes, behind the Lakes Retirement Estate	Taylors Lake	Victorian Volcanic Plain	Conservation	0*	-	South
142	River Valley Estate (borders Solomon Heights)	Sunshine North	Victorian Volcanic Plain	Private–urban	14	-	South
143	Organ Pipes National Park	Keilor North	Victorian Volcanic Plain	Conservation	-	-	South
144	Pioneer Park	Sydenham	Victorian Volcanic Plain	Conservation	19*	Low	South; translocated and plants and seedlings added in 2020.
145	St Albans Rail Reserve (west)	St Albans	Victorian Volcanic Plain	Rail reserve	327	Low	South
147	Sydenham Rail Reserve	Sydenham	Victorian Volcanic Plain	Rail Reserve	15	Very Low	South
148	Watergardens, Keilor-Melton Road in Carpark	Taylors Lakes	Victorian Volcanic Plain	Private–urban	78	Medium	South
149	Melton Highway Road Reserve adjacent to 1080-1286 Melton Highway	Plumpton	Victorian Volcanic Plain	Roadside	7	-	South
150	Mt Derrimut Nature Conservation Reserve	Derrimut	Victorian Volcanic Plain	Conservation	42*	Medium	South
151	O'Brien Park, Matthews Hill, grassland (Grass PPSU007)	Sunshine	Victorian Volcanic Plain	Rail reserve	15*	Low	South

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
152	Broadcast Australia Site	Delahey	Victorian Volcanic Plain	Private–urban	19	-	South
153	103 Reid Street Grassland (south side of Western Ring Road)	Ardeer	Victorian Volcanic Plain	Private–urban	50*	Medium	South
154	18A Jones Field Corner (north side of Western Ring Road)	Ardeer	Victorian Volcanic Plain	Private–urban	0*	Medium	South
155	Banchory Grove Nature Conservation Reserve	Hillside	Victorian Volcanic Plain	Conservation	85*	-	South
156	Boundary Road, 1910-1968	Mount Cottrell	Victorian Volcanic Plain	Private	5	-	South
157	Ravenhall East Grassland Nature Conservation Reserve	Ravenhall	Victorian Volcanic Plain	Conservation	30*	Medium	South
158	Burnside North Residential Development Site Rockbank Middle Road	Burnside	Victorian Volcanic Plain	Private–urban	59	High	South
159	Gourlay Road & Becca Way	Caroline Springs	Victorian Volcanic Plain	Conservation	33*	-	South
160	Caroline Springs Northern Residential Development Site, North-West Corner of Gourlay Road and Taylors Road	Caroline Springs	Victorian Volcanic Plain	Private	50	Medium	South
161	Christies Road, 408-546, Ravenhall	Truganina	Victorian Volcanic Plain	-	4	-	South
162	Ravenhall North Grassland Reserve (previously Christies Road, 1127-1175, Ravenhall)	Ravenhall	Victorian Volcanic Plain	Conservation	204*	Medium	South
163	Clarke Road Grassland Private (Grass PPME001)	Deanside	Victorian Volcanic Plain	Private–urban	3	Low	South
164	Corner Clarke Road and Western Highway, Rockbank	Deanside	Victorian Volcanic Plain	Private	10	-	South
165	Dame Phyllis Frost Centre Womens Prison, 281-349 (Port Phillip Prison Grassland Reserve	Ravenhall	Victorian Volcanic Plain	Conservation	20	Medium	South

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
166	Ravenhall South Grassland Nature Conservation Reserve	Ravenhall	Victorian Volcanic Plain	Conservation	12*	-	South
167	Downing Street, 161-229, Mt Cottrell	Mt Cottrell	Victorian Volcanic Plain	Private	20	-	South
168	Faulkners Road, 112a, Mt Cottrell	Fieldstone	Victorian Volcanic Plain	Private	12	-	South
169	Greigs Road Roadside, Rockbank	Rockbank	Victorian Volcanic Plain	Roadside	63	-	South
171	Greigs Road East, 653-701, Mt Cottrell	Fieldstone	Victorian Volcanic Plain	Private–urban	700	-	South
172	Mt Cottrel Recreation Reserve	Mt Cottrell	Victorian Volcanic Plain	Conservation	68	-	South
173	Greigs Road, 703-735, Mt Cottrell	Fieldstone	Victorian Volcanic Plain	Private	182	-	South
174	Leakes Rd, 215-317, Plumpton	Plumpton	Victorian Volcanic Plain	Private	1	-	South
175	Melbourne to Ballarat Railway Reserve	Ravenhall	Victorian Volcanic Plain	Rail reserve	10	-	South
176	Melton Highway, 1080-1286, Plumpton	Plumpton	Victorian Volcanic Plain	Private–urban	20	-	South
177	Palm Springs	Ravenhall	Victorian Volcanic Plain	Private–urban	40	Low	South
178	Saric Circuit	Fraser Rise	Victorian Volcanic Plain	Private–urban	1	Very Low	South
179	Sinclairs Road, 22-26, Plumpton	Deanside	Victorian Volcanic Plain	Private–urban	10	-	South
180	Skeleton Creek - upper reaches	Tarneit	Victorian Volcanic Plain	Private	-	-	South
181	Taylors RD 961 - 1025, Plumpton 3335	Deanside	Victorian Volcanic Plain	Private–urban	40	-	South
182	Western Highway, 1067-1125, Ravenhall	Ravenhall	Victorian Volcanic Plain	Private	20	-	South
183	Western Highway, 1183-1199, Ravenhall	Ravenhall	Victorian Volcanic Plain	Private	1	-	South
184	Western Highway, 1201-1227, Ravenhall	Ravenhall	Victorian Volcanic Plain	Private	2	-	South
185	Palm Springs Rd Development area	Ravenhall	Victorian Volcanic Plain	Private–urban	20	-	South
186	Western Highway, 1385-1463, Rockbank	Rockbank	Victorian Volcanic Plain	Private	20	-	South
187	Mobil Service Station (Grass VPME07)	Derrimut	Victorian Volcanic Plain	Roadside	24*	-	South
188	Maloneys Road Reserve	Mount Cottrell	Victorian Volcanic Plain	Conservation	20	-	South

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
189	Ballan Road	Moorabool	Victorian Volcanic Plain	Roadside	3	-	South
190	BHP (Coogee) methanol plant (Grass VPME01) 171 Fitzgerald Road	Laverton North	Victorian Volcanic Plain	Private–urban	35	-	South
191	Bulban Road Rail Reserve	Werribee	Victorian Volcanic Plain	Rail reserve	2822	-	South
192	Davis Road	Mount Cottrell?	Victorian Volcanic Plain	Private	20	-	South
193	Kirks Bridge Road	Mambourin	Victorian Volcanic Plain	Conservation	2518	High	South
194	Laverton RAAF (Westpoint Business Park)/Cedar Woods	Williams Landing	Victorian Volcanic Plain	Conservation	400	High	South
195	Live Bomb Range Road	Mambourin	Victorian Volcanic Plain	Roadside	9	Very Low	South
196	Lollypop Creek	Wyndham Vale	Victorian Volcanic Plain	-	6	-	South
197	McPhersons Road	Little River	Victorian Volcanic Plain	Roadside	256	Medium	South
198	Manor Rail Reserve	Werribee	Victorian Volcanic Plain	Rail reserve?	100	Low	South
199	Newtons Road, Narraburra Road	Little River	Victorian Volcanic Plain	Roadside?	48*	Low	South
200	Sewells Road to Mt Cottrell Road (private)	Mt Cottrell	Victorian Volcanic Plain	Private?	-	-	South
201	Shanahans Road	Mt Cottrell	Victorian Volcanic Plain	Roadside	172*	Low	South
202	Truganina Cemetery	Truganina	Victorian Volcanic Plain	Utility	805*	High	South
204	Western Treatment Plant (Melbourne Water)	Point Wilson	Victorian Volcanic Plain	Utility	840*	High	South; Ramsar wetland site
205	Upstream of Tuckers Hole	Wimmera?	Victorian Volcanic Plain	-	46	-	South
206	Angliss Grassland Nature Conservation Reserve	Laverton North	Victorian Volcanic Plain	Conservation	1*	-	South
207	Quarry Sites South Rail Reserve (2.8)	?	Victorian Volcanic Plain	Rail reserve	-	-	South
209	Laverton North Grassland Reserve (Grass PPAL006)	Altona North	Victorian Volcanic Plain	Conservation	16*	-	South

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
210	Laverton Rail Reserve	Hoppers Crossing	Victorian Volcanic Plain	Rail reserve	106	Low	South
211	Maidstone St (cnr Jordan Close)	Altona	Victorian Volcanic Plain	Private Land	67*	-	South
212	Multiplex site, Altona Nature Conservation Reserve	Altona	Victorian Volcanic Plain	Conservation	53	-	South
213	Salta Land, Altona	Altona	Victorian Volcanic Plain	Private–urban	7	-	South
214	SCT grassland Reserves (A)	Altona	Victorian Volcanic Plain	Conservation	5*	-	South
215	S.J. Clement Reserve	Altona	Victorian Volcanic Plain	Conservation	18	-	South
216	Arcade Way Reserve	Keilor East	Victorian Volcanic Plain	Conservation	5*	-	South
217	JH Allen Reserve	Keilor East	Victorian Volcanic Plain	Conservation	2*	-	South
218	Mt Rothwell, Earth Sanctuaries, Little River	Little River	Victorian Volcanic Plain	Conservation	16	-	South
219	Lara Rail Reserve	Lara	Victorian Volcanic Plain	Rail reserve	-	-	South
220	Little River Rail Reserve North	Little River	Victorian Volcanic Plain	Rail reserve	1	-	South
221	Little River Rail Reserve South	Little River	Victorian Volcanic Plain	Rail reserve	6	-	South
222	Peak School Road Rail Reserve Little River	Little River	Victorian Volcanic Plain	Rail reserve	100	Low	South
223	Old Melbourne Road (Lara Road)	Lara	Victorian Volcanic Plain	Roadside	90	-	South
225	Frying Pan Road	Marnoo West	Wimmera	Roadside	1736	-	North
226	Soldier Road	Marnoo	Wimmera	Roadside	695	-	North
227	Gwenap Road	Marnoo	Wimmera	Roadside	545	-	North
228	4 Glenorchy-Donald Road (?)	Rupanyup	Wimmera	Roadside	989	-	North
229	Warranooke Road	Rupanyup	Wimmera	Roadside	612	-	North
230	Hazeldene Road	Rupanyup	Wimmera	Roadside	699	-	North
231	Carrs Plain Road (Site 1)	Marnoo West	Wimmera	Roadside	1413*	-	North
232	Carrs Plain Road (Site 2)	Marnoo West	Wimmera	Roadside	1584*	-	North

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
233	Bolagum-Silo Road	Wallaloo	Wimmera	Roadside	53*	-	North
234	Banyena-Silo Road	Banyena	Wimmera	Roadside	-	-	North
237	Quandong	Quandong	Victorian Volcanic Plain	Private-rural	303	-	South
241	Merton St	Altona	Victorian Volcanic Plain	Private–urban	-	-	South
242	102-120 Modal Place	Altona	Victorian Volcanic Plain	Private–urban	-	-	South
243	Ajax Road (North)	Altona	Victorian Volcanic Plain	Private–urban	30*	-	South
244	Truganina Swamp	Altona	Victorian Volcanic Plain	Private–urban	456*	-	South
247	Truganina Park	Altona	Victorian Volcanic Plain	Conservation	160*	-	South
248	1 Galvin Street	Altona	Victorian Volcanic Plain	Conservation	38*	-	South
249	Ajax Road (south)	Altona	Victorian Volcanic Plain	Conservation	10*	-	South
250	Horsburgh Drive	Altona	Victorian Volcanic Plain	Roadside	-0	-	South
251	SCT Grassland Reserves (B)	Altona	Victorian Volcanic Plain	Conservation	13*	-	South
252	SCT Grassland Reserves (C)	Altona	Victorian Volcanic Plain	Conservation	33*	-	South
255	Duggan Lane	Lal lal	Victorian Volcanic Plain	Roadside	0*	-	South
256	Murphys Road	Elaine		Roadside	0*	-	South
257	Sunshine Rail Reserve	Sunshine	Victorian Volcanic Plain	Rail reserve	23*	-	South
259	Wimmera Highway (east)	Rupanyup	Wimmera	Roadside	-	-	North
260	Wimmera Highway (west)	Rupanyup	Wimmera	Rail reserve?	2	-	North
262	Paramount Grassland	Derrimut	Victorian Volcanic Plain	Private–urban	65*	-	South
263	Slough Road	Altona	Victorian Volcanic Plain	Conservation	20*	-	South
264	Magpie Parks Victoria Conservation Reserve	Mount Cottrell	Victorian Volcanic Plain	Conservation	5	-	South
266	Deer Park Railway Station	Deer Park	Victorian Volcanic Plain	Conservation	26*	-	South

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
268	Bells Road	Smythes Creek	Victorian Volcanic Plain	Conservation?	0*	-	South
269	Mt Cottrell Nature Conservation Reserve	Mount Cottrell	Victorian Volcanic Plain	Conservation	0	-	South
270	Nolans Road	Clunes	Victorian Volcanic Plain	Roadside	-	-	North
273	Hills Road	Barraport West	Victorian Volcanic Plain	Roadside	-	-	North
274	Bon Thomas east	Deer Park	Victorian Volcanic Plain	Roadside	10	-	South
276	Back Eddington Road	Carisbrook	Victorian Volcanic Plain	Private–rural	26	Very low	North
281	Clayton Road Mitiamo†	Mitiamo	Wimmera	Roadside	2	-	North
282	Finns Paddock†	Terrick Terrick East	Wimmera	Roadside?	6	-	North
283	Prairie Nature Conservation Reserve†	Prairie	Wimmera	Conservation	126	-	North
284	Tang Tang Swamp Wildlife Reserve†	Dingee	Wimmera	Conservation	51	-	North
285	Anderson Road	Grays Bridge	Wimmera	Roadside	397*	-	North
287	Richardson Valley Road	Wallaloo	Victorian Volcanic Plain	Private–rural	7*	-	North
288	Hemley Evans Road	Callawadda	Victorian Volcanic Plain	Private–rural	798*	-	North
289	Joyce Road	Callawadda	Victorian Volcanic Plain	Roadside	62*	-	North
290	West Road	Callawadda	Victorian Volcanic Plain	Roadside	1450*	-	North
291	Green Hill Lake Road	Ararat	Victorian Volcanic Plain	Roadside	2*-	-	North
292	Read Grassland (2)	Stoneleigh	Victorian Volcanic Plain	Roadside	709	-	South
293	Read Grassland (3)	Stoneleigh	Victorian Volcanic Plain	Roadside	5	-	South
294	Cahills Lane	Mannibadar	Victorian Volcanic Plain	-	3	-	South
295	Rokewood-Skipton Rd (Mannibadar)	Mannibadar	Victorian Volcanic Plain	Private–rural	1	-	South
296	Rankin Road	Mannibadar	Victorian Volcanic Plain	Private–rural	-	-	South
298	Lismore-Pittong Road	Mannibadar	Victorian Volcanic Plain	Private–rural	3	-	South
299	Lismore-Scarsdale Road	Pitfield	Victorian Volcanic Plain	Roadside	5	-	South

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
300	1785 Linton Road	Bradvale	Victorian Volcanic Plain	Unknown	-	-	South
301	1420 Linton Road	Bradvale	Victorian Volcanic Plain	Unknown	-	-	South
303	1182 Lismore-Pitfield Road	Wallinduc	Victorian Volcanic Plain	Roadside	15	-	South
304	Boyles Road	Werneth	Victorian Volcanic Plain	Private–rural	1	-	South
305	Gumley Road	Mount Mercer	Victorian Volcanic Plain	Roadside	12	-	South
306	Lonies Road	Shelford	Victorian Volcanic Plain	Roadside	0	-	South
308	Rokewood-Shelford Road (west of Geggies Road)	Rokewood	Victorian Volcanic Plain	Roadside	15	-	South
311	Padgetts Lane	Werneth	Victorian Volcanic Plain	Roadside	30	-	South
312	Bennetts Road	Werneth	Victorian Volcanic Plain	Private–rural	1	-	South
313	Boundary JW Road	Werneth	Victorian Volcanic Plain	Private–rural	7	-	South
314	Matthews Road (Werneth)	Werneth	Victorian Volcanic Plain	Roadside	1	-	South
315	705 Meadows Road	Rokewood	Victorian Volcanic Plain	Roadside	5	-	South
316	Ledwells Road	Cressy	Victorian Volcanic Plain	Roadside	80*	-	South
317	Taylors Paddock	Shelford	Victorian Volcanic Plain	Private–rural	-	-	South
318	1541 Rokewood Shelford Road	Rokewood	Victorian Volcanic Plain	Private–rural	500	-	South
319	Beatone Ln	Shelford	Victorian Volcanic Plain	Private–rural	96*	-	South
320	Brocks Road	Inverleigh	Victorian Volcanic Plain	Roadside	91*	-	South
321	Glenmore Road	Rowsley	Victorian Volcanic Plain	Roadside	1*	-	South
324	Crambs Road	Mount Bute	Victorian Volcanic Plain	Roadside	-	-	South
325	Calverts Road	Mount Bute	Victorian Volcanic Plain	Roadside	-	-	South
326	Vite Vite-Skipton Road	Vite Vite	Victorian Volcanic Plain	Roadside	0	-	South
328	Terrinallum Road	Derrinallum	Victorian Volcanic Plain	Roadside	7*	-	South

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
330	Cahills Road	Werneth	Victorian Volcanic Plain	Roadside	-	-	South
331	Gnarkeet Road	Lismore	Victorian Volcanic Plain	Roadside	-	-	South
333	Four Tree Road	Four Tree Road	Victorian Volcanic Plain	Roadside	-	-	South
334	Collins Road	Berrybank	Victorian Volcanic Plain	Roadside	21	-	South
337	Leslie Manor	Leslie Manor	Victorian Volcanic Plain	Roadside	0	-	South
340	Peak School Road B	Lara	Victorian Volcanic Plain	Private–rural	61	-	South
342	Peak School Road C	Little River	Victorian Volcanic Plain	Rail reserve	1	-	South
343	Peak School Road ext	Anakie	Victorian Volcanic Plain	Roadside	3	-	South
344	Farrars Road	Little River	Victorian Volcanic Plain	Roadside	14	-	South
345	NE Peak School Road Rail Reserve	Little River	Victorian Volcanic Plain	Rail reserve	45	-	South
346	Corio Grasslands	Corio	Victorian Volcanic Plain	Private	1	-	South
347	Mill Road (Rail Reserve-north and south)	Lara	Victorian Volcanic Plain	Rail reserve	46	-	South
348	Dundonnell-Derrinallum Road	Dundonnell	Victorian Volcanic Plain	Roadside	2640*	-	South
349	The Lake Grassland	Taylors Lake	Victorian Volcanic Plain	Conservation	2	-	South
355	Derrimut Retarding Basin	Derrimut	Victorian Volcanic Plain	Conservation/ Utility	1*	-	South
358	Bon Thomas (East)	Deer Park	Victorian Volcanic Plain	Conservation	52*	-	South
360	Sydenham Rail Reserve	Sydenham	Victorian Volcanic Plain	Rail Reserve	81		South
361	Oakwood Road	Albanvale	Victorian Volcanic Plain	Private (urban)	23*	-	South
362	Dohertys Road, Amora	Truganina?	Victorian Volcanic Plain	Private (urban)	58*	-	South
363	Ginifer Rail Reserve Biosite	North Sunshine	Victorian Volcanic Plain	Rail Reserve	8*		South
365	Cherry Creek (Rail Reserve)	Werribee	Victorian Volcanic Plain	Rails Reserve	1		South

Site ID	Site name	Location	Bioregion	Land-use category	Population size (2000 to 2023 survey)	Conservation Priority[a]	Population form
366	Black Forest Road	Little River	Victorian Volcanic Plain	Roadside	8		
369	Shanahans Road	Mt Cottrell	Victorian Volcanic Plain	Roadside	7*		South
370	Leakes Road	Tarneit	Victorian Volcanic Plain	Roadside	0*		South
373	Conservation Area 11				0		
374	Kayes Drain	Laverton North	Victorian Volcanic Plain	Conservation	85*		South
375	Boral	Ravenhall	Victorian Volcanic Plain	Private (urban)	9		South
376	Diggers Rest Rail Reserve (number 1)	Diggers Rest	Victorian Volcanic Plain	Rail Reserve	46*		South
377	Greigs Road (south)	Fieldstone	Victorian Volcanic Plain	Roadside	212*		South
378	Dohertys Road	Mount Cottrell	Victorian Volcanic Plain	Roadside	58*		South
394	Gnarwarre Road	Inverleigh	Victorian Volcanic Plain	Roadside	1*		South
395	Chatsworth Road	Derrinallum	Victorian Volcanic Plain	Roadside	75*		South
396	Lonies Rd (south)	Shelford	Victorian Volcanic Plain	Roadside	0*		South
397	Holden Rd Biosite 3569	Diggers Rest	Victorian Volcanic Plain	Rail Reserve	224*		South
398	Calder Rise Rail Reserve Biosite 3570	Diggers Rest	Victorian Volcanic Plain	Rail Reserve	35*		South
399	Mill Road	Lara	Victorian Volcanic Plain	Roadside	103*		South
400	Deep Lead Conservation Reserve (No.1)	Deep Lead	Goldfields	Conservation	980*		

Note:

[a]The prioritisation score was based on population size, population area, and tenure reservation. For example, a large population (number of individual) and greater area and located in private land is given a higher rating (Foreman 2012). The determination of conservation priority was conducted in 2011 and therefore, conservation priority for populations discovered post-2012 were labelled as. - unknown [†]Victorian Riverina populations with unique genotype *Population size in 2022 ** Population size in 2023

Appendix 2

Review of the first Recovery Plan for the Spiny Rice-flower (Appendix Table 2)

There were 7 specific recovery objectives in the first National Recovery Plan for Spiny Rice-flower. The objectives are:

Objective 1: Acquire accurate information for conservation status assessments.

Objective 2: Identify habitat that is critical, common or potential.

Objective 3: Ensure that all populations and their habitat are legally protected.

Objective 4: Manage threats to populations.

Objective 5: Identify key biological functions.

Objective 6: Determine the growth rates and viability of populations.

Objective 7: Build community support for conservation.

As part of the performance evaluation each recovery action was assessed according to the performance indicators and scored between 0-3 using the following criteria:

- 0 no progress/cannot be assessed;
- 1 insufficient action to meet criteria;
- 2 action underway – most elements of action met, or it is anticipated that they will be; and
- 3 criteria met – further action may or may not be required.

The information on implementation details, review recommendation and performance evaluation are supplied by the *Pimelea spinescens* Recovery Team in 2019.

Table A2. Objectives and implementation of the first Recovery Plan for the Spiny Rice-flower

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation
1.1	Acquire baseline population data by conducting detailed field surveys including (a) identification of the area and extent of populations; (b) estimates of the number, size and structure of populations; and (c) inference or estimation of population change.	• Determination or update of conservation status for inclusion on state and national threatened species lists. • Target populations accurately mapped.	• A State-wide population database was compiled from a wide variety of sources and records, but it is incomplete and of variable accuracy. Most populations have only been assessed once, 30 sites are without population counts, 125 sites are without rudimentary area estimates, 36 sites are without tenure classification, and 43 sites are without coordinates. • In addition, another 67 sites recorded from herbarium collections, i.e., Australian Virtual Herbarium (AVH) and the Victorian Biodiversity Atlas (VBA) remain to be assessed for possible addition to this database although it is likely that some of these, including data from historical herbarium specimens, represent populations that are extirpated (Foreman 2012). • Population monitoring at Skipton Common by Ballarat Environment Network in 2017-2020 suggests that population size of Spiny Rice-flower has declined by as much as 30% over the past 20 years and is likely to experience a similar decline over the next 10–20 years and therefore, the conservation status of the Spiny Rice-flower remains as Critically Endangered.	• Completion of the State-wide database. The completion of a State-wide database will enable a comprehensive review of the site status that will better inform conservation priority for each known site – see the note in Appendix Table 1. • Further systematic searches, especially on potentially suitable private land throughout the species range.	2
2.1	Accurately survey known habitat and collect floristic and environmental information describing community ecology and condition.	• Requirements for completion of essential life history stages, recruitment and dispersal identified at known sites.	• A comprehensive habitat assessment has not been completed for all known sites. • The State-wide database remains incomplete. The spatial coverage/extent of all sites has not been accurately mapped (see Action 1.1 for further details).	• Undertaking targeted searches based on Victorian Biodiversity Atlas (VBA), the Australasian Virtual Herbarium (AVH) and other records to	2

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation
		• Habitat critical to the survival of the species is mapped.	• In 2019, the Ballarat Environment Network undertook a comprehensive survey of all the Spiny Rice-flower sites within Skipton Common.	locate potential or new sites. • (Re-) assessing all known populations using standard census and monitoring methods including accurate mapping of population extent and critical habitat, and accordingly, identify current and potential involvement of the local community groups. • Establishing responsibilities and protocols for on-going update and curation of the Spiny Rice-flower State-wide database.	
2.2	Identify and survey potential habitat, using ecological and bioclimatic information indicating habitat preference.	• Predictive model for potential habitat developed and tested.	• The majority of sites found since 2006 have been located in grassland remnants within the known range of the species, with many being found on the Keilor Plains in the outer west of Melbourne. • Critical habitat in the sense of all habitats within which the populations exist has generally not been mapped (most sites are recorded only by coordinates and spatially unspecified area estimates), and where it has been mapped, the information is often inconsistently collected, difficult to obtain and was not collated into a centralised database. • No bioclimatic indicators or co-extensive species indicators have been found, however a rough group of species that are	• Currently all sites are referenced as single or multiple points and it is difficult to know with any confidence where populations and critical habitat begins and ends. Therefore, accurate mapping of population/critical habitat extent as polygons needs to be established because it will be vitally important for long term conservation of the species.	2

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation
			known to frequently co-occur with the species are known practices.		
3.1	Protect populations on public land.	• Negotiate Public Authority Management Agreements (PAMAs) under the FFG Act 1988 at Mt Mercer – Shelford Rd, Durham Ox – Rayburn Rd, 8 km WNW of Tandarra, and Chatsworth Rd, Derinallum sites.	• It is envisaged that the best measure of performance would be the quantity of populations on public land reclassified to provide greater legal protection. Once the State-wide database is complete, specific quantitative targets could be established. Recent discovery of many new sites for Spiny Rice-flower provides valuable conservation opportunities and creates a need for significant expansion of a formal protection program. • Only a handful of management plans have been developed for various sites containing Spiny Rice-flower populations, including the work done by Melbourne Water at Lake Borrie. Through sustained and informed management, including rabbit and weed control and improved ecological burning, Spiny Rice-flower numbers increased on the site by 33%. The Lake Borrie management program is a good case study when developing management plans for elsewhere. • Brimbank City Council manages the Bon Thomas Reserve that supports Spiny Rice-flower. The management activities include fencing, and prescribed burning. • Wyndham City council manages Spiny Rice-flower population at Kirk's Bridge. In addition to prescribed burning, seed collection is targeted from this site. • Plant monitoring after unexpected longer burning in Southern Grampians Shire.	• Roadsides and rail easements have been identified as dominant tenure types, and hence the future Recovery Plans, should include a recommendation on adequate protection of at least a subset of populations across these sites. Greater effort is needed to ensure as many of these sites are afforded effective conservation as possible. • Review and reclassify the status of all public reserves with Spiny Rice-flower populations, accordingly. • The establishment of suitable agreements (i.e., PAMAs or improved PAMAs) over all public land sites not amenable to reservation. Priority will be given to the populations identified in 1.1 of the current Recovery Plan. • The best measure of performance would be the quantity of sites reclassified to provide	2

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation
			• Management of sites in Moonee Valley, including new signage instalment and grasslands enrichment planting, prescribed burning. • Aus Eco Solutions conducted recruitment monitoring at Burns Rd Altona site and weed control at Deer Park Boral, Geggies Rd and Ballan Rd. • ABZECO manages six reserves that contain Spiny Rice-flower for Brimbank Council. • Trust for Nature (TfN), working closely with DEWLP, is managing about $131,500 Threatened Species Recovery Fund (2020) that was allocated for the propagation of Spiny Rice-flower and Turnip Copperburr. Covenanted sites with these species are going to be targeted for augmentation. **Translocation** • Burnside: at least 15 from 21 have survived the translocation (October 2017) and at least 13 from 20 have survived the previous one (May 2017). • Watergardens-Sydenham Park/Pioneer Park (The Sydenham Park): translocated plants has remained stable with no losses since November 2018 while the Pioneer Park population has lost three individuals. The Sydenham site has been mowed and a watering regime at both sites has continued throughout the 2017/2018 summer period) • Ballarat Railway upgrade: ABZECO was involved in the translocation of 369 individuals (November 2017) from the Ballarat line upgrade area to an area in the Western Grassland Reserve called Magpie.	greater legal protection and the quality of the new level of legal protection offered. Once the State-wide database is complete, specific quantitative targets could be established.	

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation
			Currently the survival rate is about 62% after 2 years). • Caroline Springs Railway Station: In June 2014, 23 plants were translocated, 61% of them have survived and in 2017, 3 were translocated 33% of them survive.		
3.2	Protect populations on private property.	• Initiate private land management agreements in consultation with private landowners Farm South of Echuca Sewerage Farm and farm in Patho, adjoining Murray Valley Hwy. under *the Victorian Conservation Trust Act* 1972, *the Conservation, Forests and Lands Act* 1987 and *the Wildlife Act* 1975	• Neither of the private land populations listed in the first Recovery Plan have been legally protected. However, several Local Government Reserves have been established by councils on their private land. • Improving the protection of sites is an ongoing priority action to be developed in collaboration between Trust for Nature (TfN), the Department of Primary Industries and the National Reserve System.	• Protection of sites on private land through a combination of TfN conservation covenants and strategic acquisition. • Further systematic searches, especially on potentially suitable private land throughout the species range is also worth consideration. It is possible that such targeted search effort could stretch the known natural range of this Victorian endemic, but geographic gap-filling (especially across central, western Victoria) is more likely to yield results (Foreman 2012).	1
4.1	Identify disturbance regimes to maintain habitat.	• Preparation of management prescriptions for ecological burning at Laverton RAAF Grassland Reserve, Wingeel Rail Siding, Mitiamo Rail Siding and Mt Mercer – Shelford Road sites.	• Reynolds (2013) investigated the reproductive biology and disturbance ecology of Spiny Rice-flower. The studies found that: • The best performing populations occur in higher quality remnant vegetation containing high native species richness, low cover of exotics	• Further investigation is warranted over a wider biogeographic range, in marginal habitats such as grassy woodlands, or where changes in disturbance appear necessary for long term conservation (e.g.	2

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation
		• Preparation of management prescriptions for ecological slashing or burning at Durham Ox – Rayburn Road, 8 km northwest of Tandarra and Chatsworth Road, Derinallum sites. • Preparation of management prescriptions for ecological grazing at the farm south of Echuca and farm in Patho, adjoining Murray Valley Highway.	and subject to 'natural' disturbance regimes such as frequent fire in the absence of disturbances. • Flowering and seed production is obviously positively influenced by biomass reduction events especially burns. • Bare soil percentage that also reflects burn frequency was the best indicator for plant health and seedling survival. • Germinant (seedling) survival was greatest when a biomass reduction event had occurred recently, which means there is a greater percentage of bare soil, less leaf litter and weeds. The ploughed forb field at Quandong had the most optimal conditions for seedlings establishment. • Timings and frequency of biomass reduction events are the issues confronting grassland managers in their planning and daily operations. There is no clear answer from this research but if there is no bare ground in a grassland, a burn is required as soon as possible. Unfortunately conducting a burn in the currently climate is difficult and must be pre-planned often up to a year in advance. • Grassland managers should schedule burns at least biannually and incorporate a spring burn in at least one in every three to promote seed production and seedling survival in their Spiny Rice-flower population.	introducing burning to sites previously grazed or unburnt). • Monitoring across different habitats, geographic ranges and management regimes will help us to better understand the mechanisms at play and how best to respond with management. • Although managing biomass is of the highest importance for Spiny Rice-flower, a range of measures tailored to each site is needed. It is critical that at least the most important sites are actively managed under an appropriate disturbance regime and threat mitigation strategies via a suitable property, reserve or site prescription or management plan. • Grassland managers should schedule burns at least biannually and incorporate a spring burn in at least one in every 3 years to promote seed production and seedling	

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation
			• Glenelg Hopkins CMA received funding from the Australian Government's National Landcare Program in 2012–2013 (GHCMA 2018) to deliver a 5-year Victorian Volcanic Plains Recovery Project aimed at protecting 3 critically endangered Ecological Communities which occur on the Victorian Volcanic Plain Bioregion, and some equally endangered plants and animals, including the button wrinklewort, Spiny Rice-flower and eastern barred bandicoot. Glenelg Hopkins CMA provided the bulk funding for *Pimelea* planting day at Skipton Common (2017), the activity was supported by Pimelea Conservation Trust, Ballarat Environment Network, Victoria University, Commonwealth Department of Agriculture, Water, and the Environment, Fields Naturalists' Club Ballarat, CFA-Snake Valley Brigade, Skipton Primary School and Wadawurrung Traditional Owners Aboriginal Corporation. • Ballarat Environment Network contractors, DEECA staff volunteers and La Trobe University students (John Morgan lab) undertook before, during and after-burn monitoring. • Biosis assessed potential sites for Spiny Rice-flower offset at Warrambeen.	survival in their Spiny Rice-flower population. • Further investigation into the effects of disturbance could be done, especially into the effects of grazing.	
4.2	Control threats from pest plants, animals, and predators by preventing access, rerouting tracks, application of herbicide, hand removal of weeds, fencing sites and caging plants.	• Measurable seedling recruitment/vegetative regeneration and a measurable reduction in plant mortality at Laverton RAAF Grassland Reserve, Mt Mercer–Shelford Road:	• Only a handful of management plans have been developed for various sites containing Spiny Rice-flower populations, however none have been critically assessed on their effectiveness in conserving Spiny Rice-flower and there is great variation between them. However, the work done by	• Focus on closing knowledge gaps and placing more emphasis on protecting sites by promoting regeneration and maintaining/restoring	1

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation
		Durham Ox–Rayburn Road, 8 km WNW of Tandarra, Chatsworth Road, Derinallum, Farm South of Echuca Sewerage Farm, Farm in Patho, adjoining Murray Valley Highway, Wingeel Rail Siding and Mitiamo Rail Siding sites.	Melbourne Water at Lake Borrie is a great example of an effective management plan. Through sustained and informed management, including rabbit and weed control and improved ecological burning, Spiny Rice-flower numbers increased on the site by 33%. The management of the site has also been well documented, with a series of annual reports being produced outlining monitoring, progress and the changes that have occurred in the management strategy. • Seedling survival was greatest when a biomass reduction event had occurred recently, which means there is a greater percentage of bare soil. Seedlings were also found to survive in greater numbers where there was less leaf litter and weeds. The ploughed forb field at Quandong had the most optimal conditions for establishing seedlings. • Naturelinks is contracted by Wyndham City Council (in 2018) to improve the viability of the population at Kirksbridge Road, Mambourin and enhance the long-term environmental condition of the Reserve by providing seasonal weed control (herbicide and hand removal), revegetation, and prescribed burning. • Management activities conducted by Parks Victoria at Altona Nature Conservation Reserve includes monitoring, rubbish removal, nature strip slashing, spot spraying weeds (Chilean needle grass and serrated tussock), hand weeding, fire break mowing, and prescribed burning.	habitat free from key threats (Foreman 2012). • The Lake Borrie management program can be used to develop management plans for elsewhere.	

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation

5.1	Evaluate current reproductive/regenerative status, seed bank status and longevity, fecundity and recruitment levels.	• Seed bank/regenerative potential quantified for target populations.	• Reynolds (2013) assessed the production, seed viability and germinability, *in situ* germination and survival of the Spiny Rice-flower across 16 populations and found the following:
			  • Spiny Rice-flower seed has an endogenous non-deep physiological seed dormancy (Baskin & Baskin 2001, & 2004). Treating the seed with 0.1 % gibberellic acid consistently promote germination following progression into cooler conditions.
			  • Seedling survival is the critical stage for recruitment success of the species.
			  • Spiny Rice-flower has the ability to flower and set seed within the first year following germination.
			  • Collection of seed, propagation and supplemental planting into the seed orchard.
			• Establishment of a seed orchard (Reynolds 2014). Planting in the seed orchard commenced in 2014 – 2019 using collected seed (2013 – 2015) representing 14 discrete populations. Each year number of planting and survival were recorded (Reynolds 2014).
			  • This seed orchard site was to be purchased by the State Government under an agreement with the Federal Government (through MSA) to become the future Western Plains Grassland Reserve.
			  • The land where the *Pimelea spinescens* seed orchard and two
				• As understanding the recruitments dynamics across temporal and spatial scales holds the key to long term conservation and recovery (Foreman 2012), further research is required into the seed production, seed bank and seed viability, particularly on the aspects on intraspecific among-population variations, inter-regional variations and inter-seasonal variations and correlations with biogeographic variables such as parental genotype, soil type and rainfall.
				• Further investigation into breeding system is needed to determine the prevalence and importance of vector-driven outcrossing to better inform conservation actions for the species, e.g. seed sourcing.
				• Further study to understand environmental and management factors that influence different recruitment stages.
					2

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation
			nearby research plots containing ~300 plants are located was privately sold in 2019/20. In December 2020, access to the property was denied without an annual payment ($5,000). There has been no access to the site since December 2020 and the seed orchard's condition is currently unknown. • An examination of the species' genetic diversity and population structure was conducted by the Royal Botanical Gardens. This is helping to optimise conservation activities by maintaining genetic diversity to help and ensure its long-term survival. • The development of a Spiny Rice-flower monitoring protocol to quantify the reproductive performance of sites was introduced by Foreman in 2011 and 16 sites have been assessed using this method. The study suggests changes in the score of the metric mostly reflect habitat condition and management rather than seasonal variation. Further works that are still required include: quantification of seed production, seed banking and seed viability. • An examination of the species' genetic diversity and population structure was conducted by the Royal Botanical Gardens Victoria has helped optimising conservation activities. Research priorities for an extension of the Royal Botanical Gardens Victoria genetics program have been identified. • Dear (2019) completed a study that involved tracking the gender presentation		

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation
			of individuals during a flowering season and then accessing the female's and hermaphrodite's seed quality has been established.		
5.2	Determine seed germination requirements by conducting laboratory and field trials aimed to identify key stimuli and determine stimuli for recruitment.	• Stimuli for recruitment/regeneration identified. • Management strategies identified to maintain, enhance or restore processes fundamental to reproduction and survival.	• Reynolds (2013) study looking into the seed germination requirements of Spiny Rice-flower has greatly contributed to our knowledge of the species' life-history and key stimuli for recruitment. The study also examined how management drives population ecological attributes. Among the key findings is the Spiny Rice-flower seeds germination was stimulated by the progression into cooler temperature in the presence of gibberellic acid, noting that dormancy could delay the germination of viable seed by at least a year. • Supplemental planting of small and isolated populations at four sites in Brimbank Council. • A direct seeding project has been implemented to determine the best method to germinate the Spiny Rice-flower from seed in the field. • An assessment of all the Spiny Rice-flower translocations that have been carried out (Biosis 2014). This has highlighted ways to improve future translocation activities.	• Given we know that seed fecundity and viability levels are relatively high and stable, the focus for future germination research should be on understanding the mechanisms of dispersal, dormancy, soil seed bank dynamics and germination. This work will not only benefit the *in situ* conservation effort but will also drive improvement of translocation technology. • Further examinations on seed dynamics and germination requirements will help better understand recruitment processes as well as improve translocation techniques. • Survivorship study to aid in understanding population dynamics, but particularly recruitment, longevity and mortality. Understanding the factors that drive survivorship and mortality will help	2

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation
				improve the management of *in situ* and *ex situ* populations. • Ecological study to support successful *in situ* population management including on understanding the relationships between Spiny Rice-flower and associated flora, and its response to disturbance and broader ecological processes. The study will help improve routine monitoring and communication. • Developing, parameterising and testing an agreed conceptual model of the life-cycle and population structure of Spiny Rice-flower (see Action 2.3 of the new Recovery Plan) would help standardise monitoring, improve communication and species research in general. • Develop best practice and technique for Spiny Rice-flower translocation. While translocating plants/populations should remain an option of last resort, there is scope to develop a range of	

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation
				techniques (as per Commander et al. 2018) that would have broader utility for the recovery effort.	
6.1	Measure population trends and responses against recovery actions by collecting demographic and morphological data.	• Techniques for monitoring developed and implemented. • Census data for target populations.	• To this date, no consistent approach to population monitoring has been developed for Spiny Rice-flower, although it is generally agreed that one is needed. The State-wide database is incomplete and of variable accuracy (see 1.1). • Several monitoring programs have been implemented however these have all been quite variable and majority have been poorly documented. The recovery team has developed and endorsed a *Pimelea spinescens* monitoring protocol which has been utilised over the last 5 to 6 years.	• Database update and validation is a priority action. More accurate censuses will require not just significantly greater search times, but also experienced surveyors and an up-to-date census method. • In order to reverse the overall declining trend, reliable population monitoring and reporting must be complemented with efforts to prevent site destruction and maximise population protection.	2
6.2	Collate, analyse and report on census data and compare with management histories.	• Population growth rates determined and Population Viability Analysis (PVA) completed for target populations.	• Even though the state-wide database and demographic monitoring remain incomplete, information on Spiny Rice-flower population has greatly increased since 2006 and this has improved our knowledge of population structure and trend. • PVA has been developed by the Arthur Rylah Institute in 2021 (Regan et al. 2021).	• Establishing Monitoring and Research Sub-committee of the *Pimelea spinescens* Recovery Team, to provide direct advise the *Pimelea spinescens* Recovery Team. The tasks of the sub-committee include: (a) Refining the priority monitoring and research questions; (b) Identifying actions that are required to address the questions;	2

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation
				(c) Identifying resources needed for implementation of Recovery Plan; (d) Determining suitable research personnel; (e) Developing standardised methods; and (f) Ensuring appropriate analysis and reporting.	
7.1	Identify opportunities for community involvement in the conservation of *Pimelea spinescens* subsp. *spinescens*	• Presentation(s) to community nature conservation groups.	• Presentations to several community groups. Educational/presentation material is up to date and used regularly. • The Recovery Team gave a presentation on Spiny Rice-flower and grassland values at the World Environment Day hosted by Moonee Valley council and attended by local schools (2018). • Ballarat Environment Network along with the Glenelg Hopkins CMA hosted a visit to the *Pimelea* conservation project for public (2020). • Ballarat Environment Network and Field Naturalists' Club of Ballarat members have been integral to achieving the labour-intensive baseline survey and have contributed many hours of skilled weed control. Their contribution was subsequently written-up in the Club's newsletter which is distributed to more than 80 people each month (2020). • Ballarat Environment Network coordinated the much-anticipated installation of the rabbit-proof fence at *Pimelea* Conservation	• Targeted dissemination, such as engagement with landowners and site managers, is regarded as the best way to raise community involvement. Engagement method (presentation materials) should be customised for the target audience. • Codify the best management practices by continue working with the community groups. Resources should be allocated towards community groups' capacity building. • Success should be measured by the quality and quantity of community groups involvement. • For roadsides populations, there is also a great	2

Action No.	Action	Performance criteria	Implementation details	Review recommendations	Performance evaluation
			Zone, Skipton (2020). Project update was uploaded to the State Wide Integrated Flora and Fauna Teams (SWIFFT) website. At the Ballarat Environment Network annual general meeting, this project was featured as a Flagship Project. A new project set up in iNaturalist is aimed to serve as a useful tool in building community support for conservation. • Liaison with key local community members, e.g., community from Skipton CFA and representatives of the Skipton Landcare regarding the planned burn and providing updates on the conservation-focused works being undertaken. • The *Pimelea spinescens* Recovery Team as well as the *Pimelea* Trust continues to actively operate the implementation of actions to conserve the species.	potential for getting councils to be more actively involved, potentially in conjunction with community groups.	

Note: The review was undertaken by the *Pimelea spinescens* Recovery Team in 2019.

Appendix references

Baskin C, Baskin J (2001). *Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination,* San Diego, Academic Press.

Baskin JM, Baskin CC (2004) A classification system for seed dormancy. *Seed Science Research,* 14**,** 1 - 16.

Biosis (2014) Review of Spiny Rice-flower translocations in Victoria. Report for *Pimelea spinescens* Recovery Team. Authors: Westcott V & Mueck S. Biosis Pty Ltd, Melbourne. Project no. 15814.

Commander LE, Coates D, Broadhurst L, Offord CA, Makinson RO & Matthes M (2018) Guidelines for the translocation of threatened plants in Australia. Third Edition. Australian Network for Plant Conservation, Canberra.

DSE (2009) *Delivering Melbourne's Newest Sustainable Communities: Strategic Impact Assessment Report for the Environment Protection and Biodiversity Conservation Act 1999*. Department of Sustainability and Environment Victoria, East Melbourne.

Foreman PW (2012) National Recovery Plan for the Spiny Rice-flower *Pimelea spinescens* Rye. subsp. *spinescens*, 2012 to 2016. Report prepared by Blue Devil Consulting for the Department of Sustainability, Environment, Water, Population and Communities, Canberra.

James EA (2012) Conservation of *Pimelea spinescens*: Population genetic analysis and identification of maternal lineages. Royal Botanical Gardens Melbourne, South Yarra, Melbourne.

James EA & Jordan R (2014) Limited structure and widespread diversity suggest potential buffers to genetic erosion in a threatened grassland shrub *Pimelea spinescens* (Thymelaeaceae). *Conservation Genetics* 15(2), 305-317

Regan T, Bruce M, Batpurev K, Farmilo B, Scroggie M, Geary B & Cadenhead N (2021) Melbourne Strategic Assessment – Population Viability Analysis Models for Threatened Species Version 1.0. *Arthur Rylah Institute for Environmental Research Technical Report Series No. 327*. Department of Environment, Land, Water and Planning. Heidelberg, Victoria.

Reynolds DM (2014) Conservation Research Project V3_4/14, Melbourne, Victoria (Unpublished report).

Reynolds DM (2019) “Spiny Rice-flower propagation project” [Unpublished report], Victoria University, Melbourne.