Monitoring and Reporting Framework: Technical Protocols for Program Outcomes

Melbourne Strategic Assessment

Department of Environment, Land, Water & Planning

State Government Victoria

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Introduction

Context and scope

The Victorian Government has committed to a number of measures for the protection and management of threatened ecological communities and populations of threatened plants and animals in the Melbourne region. These commitments include the establishment of the Western Grassland Reserve, a network of Conservation Areas within Melbourne's Urban Growth Boundary and Conservation Areas on the Victorian Volcanic Plains. These commitments form part of the Melbourne Strategic Assessment (MSA), a response to expanded urban growth, and are detailed in the Biodiversity Conservation Strategy for Melbourne's Growth Corridors (DEPI 2013c). The commitments include regular reporting on program outcomes.

The 'Monitoring and Reporting Framework: Melbourne Strategic Assessment' (MRF) has been produced which provides the logic and basis for monitoring (DELWP 2015a). The MRF sets outs how the Victorian Government will monitor and report on activities, processes, program outputs and program outcomes established to deliver and implement the MSA. It also defines the Program Outcomes, which apply to specific species and communities. The MRF does not cover activities and processes that are required under existing legislative obligations, policies or practices and that would have occurred irrespective of the MSA. Two detailed supporting documents sit below this Framework:

- 'Monitoring and Reporting Framework: Technical protocols for Program Outputs' which guides reporting on progress towards outputs (DELWP 2015b)
- The current document, 'Monitoring and Reporting Framework: Technical Protocols for Program Outcomes' which guides reporting on progress towards delivering ecological outcomes for the EPBC-listed species and communities.

The current document sets out, for each outcome:

- Key Performance Indicators (KPIs), against which the progress towards the outcome can be measured. These KPIs have been designed with both the outcome and the natural history of the relevant vegetation community or species in mind
- Protocols for monitoring the KPIs
- Additional measures that will be monitored to inform management, and support future evaluation of the program including understanding changes in the status of the vegetation community or species
- Supporting technical information which provides the context for the selection of KPIs and the monitoring protocols (this information is not intended to function as a comprehensive literature review, and includes only information relevant to the design of monitoring and reporting).

Monitoring Program Outcomes

Definition of outcomes

The over-arching 'Monitoring and Reporting Framework' (DELWP 2015a) defines the Program Outcomes. These Outcomes, listed below, form the structure of the current document. Each Outcome applies to the species or vegetation community across the relevant suite of Conservation Areas protected under the MSA (i.e. at the sites that the species or vegetation community has been confirmed).

- The composition, structure and function of Natural Temperate Grassland of the Victorian Volcanic Plain improves
- The composition, structure and function of Grassy Eucalypt Woodland of the Victorian Volcanic Plain improves

- The composition, structure and function of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains improves
- No substantial negative change to populations of Button Wrinklewort
- No substantial negative change to populations of Large-fruit Groundsel
- No substantial negative change to populations of Maroon Leek-orchid
- No substantial negative change to Small Golden Moths Orchid
- Matted Flax-lily persists
- No substantial negative change to the population of Spiny Rice-flower (*Pimelea spinescens* subsp. *spinescens*) and the population is self-sustaining
- Golden Sun Moth persists
- Growling Grass Frog persists
- Southern Brown Bandicoot persists
- Striped Legless Lizard persists.

Forms and structure of key performance indicators

The choice of KPI is determined by the form of the outcome, the ecological characteristics of the species and vegetation communities (mobility, detectability, temporal variation, etc.), the feasibility and cost of measurement, and the spatial distribution of the species and vegetation communities.

For species, three categories of KPI are commonly used:

- <u>Occupancy</u> – the presence or absence of the species in a defined area. Occupancy is determined by searching until the species is found or the search effort has been such that the chance of a false absence (Type II error) is acceptable (here generally 5%). Search effort is defined in terms of search time (over single or multiple visits)

  Occupancy is most often applied to animals, which are mobile and can be difficult to detect. There are established analytical techniques for analysing presence/absence (occupancy) data which take into account imperfect detection (false absences) and express a probability that a site is occupied (Bornand *et al.* 2014; MacKenzie *et al.* 2006). To allow reporting with appropriate thresholds, this measurement variable requires an *a priori* determination of the search effort required to reduce the probability of false absences to an acceptable level (Garrard 2009b; Garrard *et al.* 2008), which is available from the literature for most species considered here

- <u>Abundance</u> – the number of individuals in a defined area. Counts of the entire population of an area can be conducted for some plant species that are relatively easily detected and occur in sufficiently small defined areas. As these data relate to real numbers of individuals any change represents a real change in the population of that area (Elzinga *et al.* 2001). In many cases full counts are impractical (e.g. where the population covers a large area or the occurrence of detectable individuals fluctuates over time). In these cases, partial counts are conducted within defined areas and the data represent a sample of the total population. KPIs are expressed in relation to changes within sample plots, not estimated changes over the entire population

- <u>Extinction probability</u> – the modelled probability that the species will become extinct within a defined region over a defined time period. This form of KPI applies only to the outcome related to the Growling Grass Frog, which is the subject of a published quantitative meta-population model (Heard *et al.* 2013). The model is described in the section for that outcome.

For vegetation communities, two categories of KPI are used:

- Quality – (or 'condition') this is a complex idea that is assessed in multiple ways (e.g. cover of weeds, diversity of important native species groups (Gibbons and Freudenberger 2006, Keith and Gorrod 2006, Oliver 2002, Sinclair *et al.* 2015)
- Heterogeneity – the variability in structure of the community across space, measured by the proportion of area in different structural categories (Benton *et al.* 2003, Tews *et al.* 2004, Tilman 1994, Tilman and Pacala 1993).

For vegetation communities, monitoring and reporting will generally be structured according to 'states', which are defined by a state-and-transition model for the relevant community. State-and-transition models (STM) present alternative 'states' of species assemblages (or profiles, groups) that could occur at a given site. Which of these actually occurs depends on management and natural events at the site (Westoby *et al*. 1989). The assemblage may change from one state to another –it may undergo a desirable or undesirable 'transition'- if a threshold is crossed.

Assigning a state to a particular site is effectively a shorthand summary of what has happened to that site, what its current ecological status is, what the possibilities are for the site for improvement, and what management tools might be available. The STM for vegetation communities are not presented here, but will be published in full.

The STM approach taken here is endorsed by the Threatened Species Scientific Committee (TSSC) under the EPBC Act (Beeton and McGrath 2009). The TSSC encourages STMs as a means of circumscribing ecosystems while acknowledging their ecological complexity and the legacy of past human impacts. STMs are also encouraged as a means of allowing prioritisation of management.

While some states are generally more intact than others, it is important to acknowledge that condition (or 'quality' or 'value') may vary substantially within a given state; and the assignment of a site to a particular state is not the same as a condition assessment. The TSSC has discussed this point, and acknowledges that different states generally have different profiles of condition or value, but that condition may also vary within a state (Beeton and McGrath 2009).

The STM also apply to all areas that once supported the relevant communities, including those that no longer meet the community definitions, and may no longer support any native vegetation. It is important that these areas are included in the model, because they have the potential to be restored (Gibson-Roy *et al*. 2007a; 2007b); however they need not be included in monitoring and reporting activities that exclusively concern the listed communities. The TSSC acknowledges that certain states (or condition classes within a state) may be degraded to the point that they are no longer part of a listed community (Beeton and McGrath 2009).

Baselines and targets for KPI's

In order to track performance against KPIs it is necessary to specify a baseline against which progress is measured. In some cases KPI baselines are set after the first survey, which generally occurs after the Conservation Area is secured. In other cases, the baseline is set after a specified number of surveys to establish a mean. The latter approach is used to dampen fluctuations between monitoring periods that is not related to management or long-term success (e.g. fluctuations in vegetation cover due to recent fires, or responses by animals to weather conditions). Where multiple years of data are required to set the baseline or to report on a KPI, this will be calculated as the mean of the annual means. Targets in most cases are based on increases or decreases from this baseline. In other cases such as some KPIs for the ecological communities, there is a fixed target (e.g. seeking to move to a specified range).

Data management for reporting on key performance indicators

A combination of existing and built for purpose processes and systems will be used to store and retrieve data to measure against outcome KPIs. These include:

Victorian Biodiversity Atlas (VBA) - VBA is a web-based information system used to manage flora and fauna species information across Victoria. All species survey information relevant to the KPIs will be stored and managed in the VBA, and the system will support regular outcome reporting.

Native Vegetation Information Management System (NVIM) - NVIM is a web-based system for the management of native vegetation information and projects. NVIM will store and manage data on vegetation communities such as Natural Temperate Grasslands including the cover of key life forms or soil sample analysis.

Records for the MSA will be managed in line with the Departments Records Management Policy which complies with legislative obligations relating to public records under the Public Records Act (Vic) 1973.

Other measures

Some parameters will be monitored that do not contribute to the KPIs. These may assist in the interpretation of the KPIs, support future evaluation or reveal other changes of interest in the ecosystem. In most cases these additional variables can be collected with little additional effort in the same plots used to assess KPIs, or are already collected when the monitoring protocols are implemented.

Defining areas subject to outcome monitoring

The location of outcome monitoring will be based on the known populations of species and vegetation communities highlighted in the BCS or in property inventory surveys. As land classed as 'Nature Conservation' is secured, inventory surveys will be conducted over crown land in each conservation area to provide a full list and maps of the vegetation communities and species. This may result in monitoring for an expanded list of conservation areas against each outcome in this document. For example, although there are currently no records of Swamp Everlasting (*Xerochrysum palustre*) within the program area, it does occur adjacent to Conservation Area 35 (Clyde Tooradin Rail Reserve). Every five years Conservation Area 35 will be surveyed and if the species is found, a monitoring protocol for Swamp Everlasting will be developed and implemented under the MRF.

In a few cases, further surveys are required to determine the appropriate management category of the Conservation Area (or part thereof). In these cases the area of land included in outcome monitoring and reporting is yet to be determined. Other conservation areas may be subject to boundary changes and as a result may differ from the map series included in this document.

The actual rate and pattern of development (habitat removal) and reserve establishment is unknown, but will occur over several decades. Outcome monitoring will only commence at a given site once DELWP has secured the land for conservation or the implementation program has commenced in that area such as for the Growling Grass Frog, and the Southern Brown Bandicoot.

Reporting on Program Outcomes

A report describing the outcomes for each species and community will be produced every five years. The report will display progress against all the KPIs described in this document, presented in a consistent format from one report to the next. The first report will be published in 2019.

A five yearly reporting cycle is expected to provide sufficiently frequent information for progress to be meaningfully communicated, but also a sufficiently long time period to permit the aggregation of data from multiple years, which is necessary for meaningful reporting against some KPIs.

As described above, outcome monitoring will only occur once a site is secured. This has several implications, firstly it means that newly secured sites could influence the apparent progress towards the outcomes, not because of changes brought about by management, but simply due to their abrupt addition to the dataset. The KPIs have been designed in various ways to counter the perverse impacts of the addition of new sites, meaning that many KPIs are assessed for a given site only since it is secured, and that many baselines are re-balanced to account for new sites. Secondly, the progressive addition of sites means that the statistical power to detect management effects (changes) of a given size will increase over time (and will be initially low)

To ensure that outcome reporting is clear and concise, most KPIs may be reported as aggregated measures across several geographic areas. For example, the KPIs for Natural Temperate Grassland will be reported across all of the relevant Conservation Areas within the UGB, not separately for each area.

Where appropriate however, the five yearly progress reports will contain additional information (aside from the program outcomes) that clarifies or explains the outcomes. It is intended to provide the narrative behind the outcomes, without breaking the clarity of reporting against clear and consistent KPIs. The additional information may include the core data used to describe the outcomes, but presented in a more detailed way that demonstrates further nuance or clarifies any apparent anomalies in the outcome (for example, additional information may explore trends in specific locations). Additional information may also include the ‘other measures’ that are described under each species and community.

The composition, structure and function of Natural Temperate Grassland of the Victorian Volcanic Plain improves

Introduction

The outcome

The Victorian Government has committed to improving the composition, structure and function of Natural Temperate Grassland of the Victorian Volcanic Plain (here after NTG) within the Conservation Areas. This will be achieved through a range of outputs, particularly the establishment and management of a 15,000 hectare grassland reserve and a network of Conservation Areas within the Urban Growth Boundary (UGB).

This outcome will be monitored in the following Conservation Areas:

- Western Grassland Reserve (Figure 1)
- Conservation area[1]: 1, 2, 3 (NC), 4, 5, 10p (NC & PL), 11, 12, 13, Truganina South (Figure 2); 22B and 22C (NC), 23 (NC), 24, 32, 33A (NC), 34B and 34C (NC) (Figure 3).

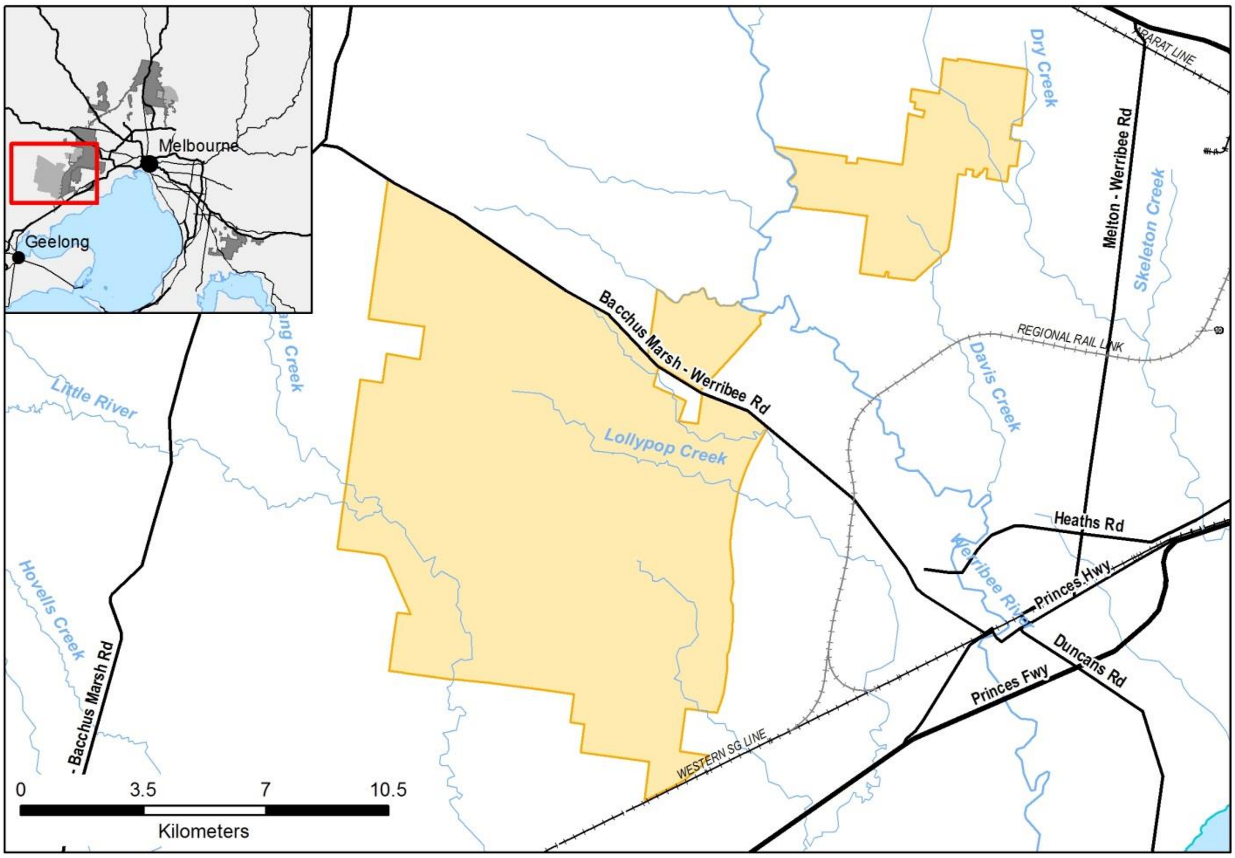

Figure 1: NTG- Western Grassland Reserve

[1] Brackets refers to the part of the Conservation Area that the outcome monitoring will apply if the Conservation Area is split into multiple categories under the BCS. (NC) – Nature Conservation, (PL) – Existing Public Land

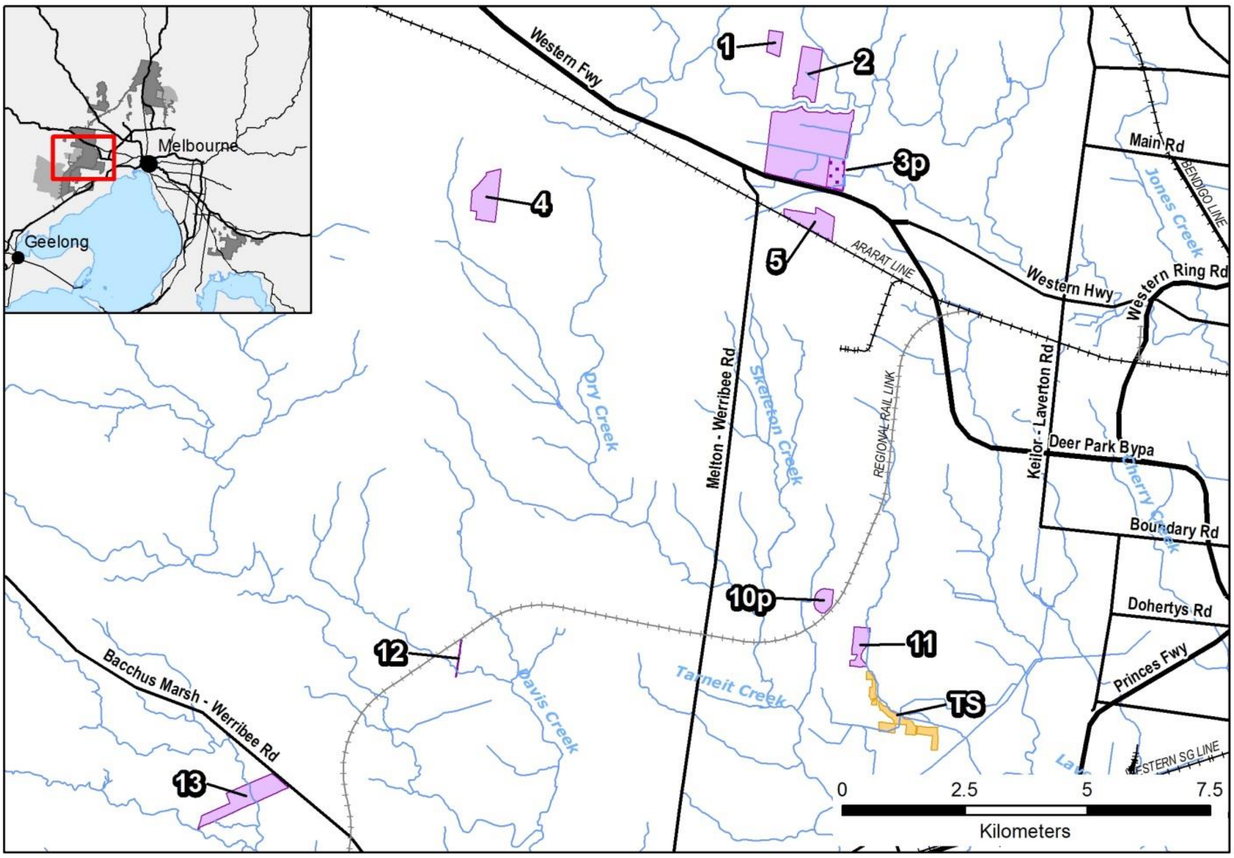

Figure 2: NTG- Conservation Areas, Western Growth Corridor

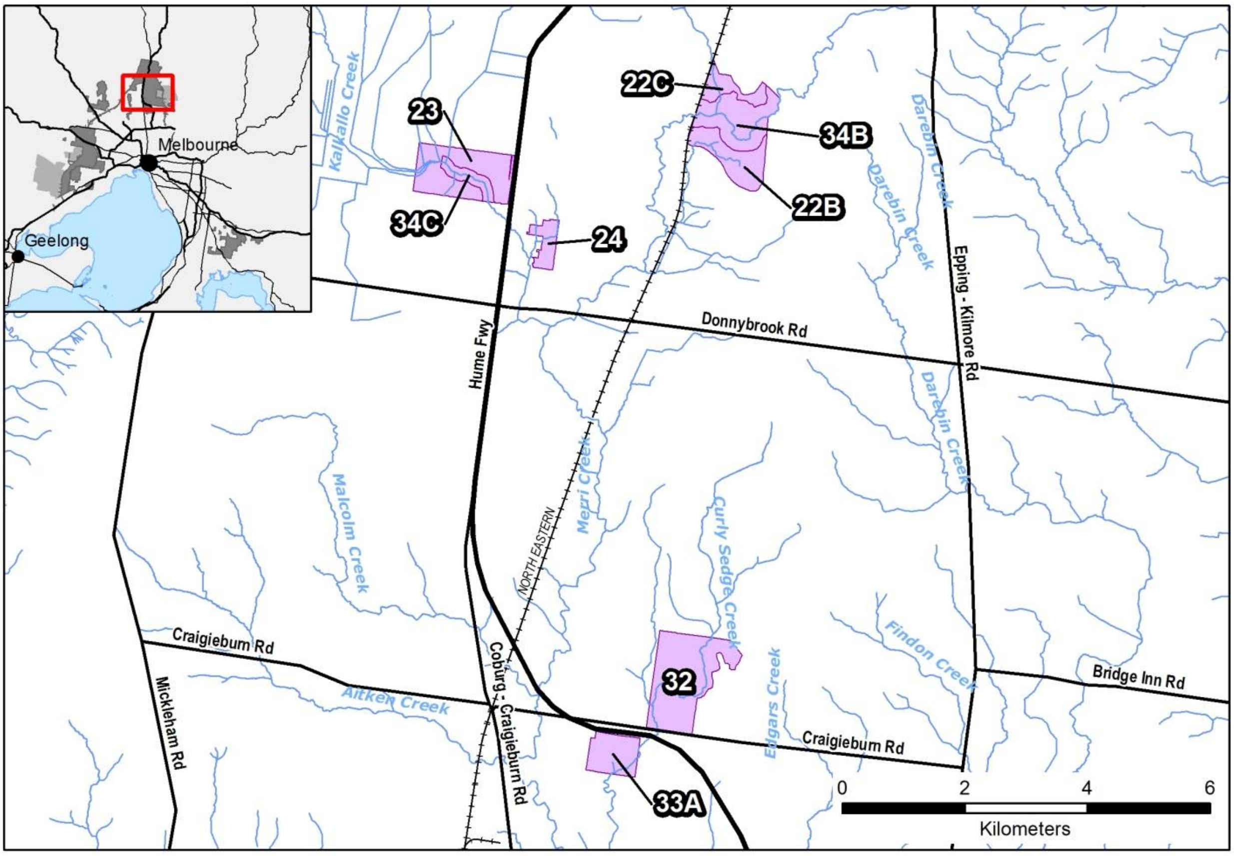

Figure 3: NTG- Conservation Areas, Northern Growth Corridor

Description of the community

NTG is a grassland community occurring on heavy soils on basalt terrain, dominated by one or more native tussock-forming grasses. This community also contains a variety of native herbs (notably daisies - Family Asteraceae), which may be dominant in some cases. Sparse or absent tree cover is characteristic of this community (DSEWPAC 2011).

Distribution of the community

This community formerly covered much of the Victorian Volcanic Plain (apart from forested areas in the far west and south, and isolated woodlands and wetlands elsewhere). It is now restricted to small, scattered remnants throughout its former range, with a concentration of remnants immediately west of Melbourne (DSEWPAC 2011).

Conservation status of the community

NTG is listed as Critically Endangered under the EBPC Act (Department of the Environment 2009b). It corresponds to the 'Western (Basalt) Plains Grassland Community' listed as threatened under the FFG Act (DSE 2012).

Key performance indicators

Table 1 KPIs to demonstrate an improvement in the composition, structure and function of NTG

KPI:	**Hectares making transition between states**	
Measure	Baseline	0 ha
	Data collection	Mapping undertaken between August and December undertaken every five years compared to previous reporting period
	Data management	Native Vegetation Information Management System (NVIM)
	Target	0 hectares make undesirable transitions between states
	Frequency	Every five years
Reporting	Forum	Five yearly Report
	Start Date	Five years after securing land
	Responsibility	Department of Environment, Land, Water and Planning
KPI:	**Cover of native perennial herbs**	
Measure	Baseline	Mean cover of native perennial herbs in all 20 x 20m plots in NTG states over the first five years after land is secured
	Data collection	Estimated cover of native perennial herbs in all 20 x 20 m plots in NTG states monitored in spring annually
	Data management	Native Vegetation Information Management System (NVIM)
	Target	The mean cover of native perennial herbs in each NTG state remains above the baseline
	Confidence intervals	The upper 95% confidence interval of the mean cover of native perennial herbs remains above the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Ten years after securing land
	Responsibility	Department of Environment, Land, Water and Planning

KPI:	**Diversity of native perennial herbs**	
Measure	Baseline	Mean diversity of native perennial herbs in all 20 x 20m plots in the states over the first five years after land is secured
	Data collection	Estimated diversity of native perennial herbs in all 20 x 20 m plots in NTG states monitored in spring annually
	Data management	Native Vegetation Information Management System (NVIM)
	Target	The mean diversity of native perennial herbs in each NTG state remains above the baseline
	Confidence intervals	The upper 95% confidence interval of the diversity of native perennial herbs remains above the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Ten years after securing land
	Responsibility	Department of Environment, Land, Water and Planning
KPI:	**Cover of Kangaroo Grass (*Themeda triandra*)**	
Measure	Baseline	Mean cover of Kangaroo Grass in all 20 x 20m plots in NTG states over the first five years after land is secured
	Data collection	Estimated cover of Kangaroo Grass in 20 x 20 m plots in NTG states monitored in spring annually
	Data management	Native Vegetation Information Management System (NVIM)
	Target	The mean cover of Kangaroo Grass in each NTG state remains above the baseline
	Confidence intervals	The upper 95% confidence interval of the cover of Kangaroo Grass remains above the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Ten years after securing land
	Responsibility	Department of Environment, Land, Water and Planning
KPI:	**Cover of native perennial grasses (excluding Kangaroo Grass)**	
Measure	Baseline	Mean cover of native perennial grasses (excluding Kangaroo Grass) in all 20 x 20m plots in NTG states over the first five years after land is secured
	Data collection	Estimated cover of native perennial grasses (excluding Kangaroo Grass) in all 20 x 20 m plots in NTG states monitored in spring annually
	Data management	Native Vegetation Information Management System (NVIM)
	Target	The mean cover of native perennial grasses (excluding Kangaroo Grasses) in each NTG state remains above the baseline
	Confidence intervals	The upper 95% confidence interval of the cover of native perennial grasses (excluding Kangaroo Grass) remains above the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Ten years after securing land
	Responsibility	Department of Environment, Land, Water and Planning
KPI:	**Per cent of plots that have bare ground cover between 25 – 75%**	
Measure	Baseline	Not applicable
	Data collection	Per cent of rapid monitoring plots in the target cover range monitored in spring annually
	Data management	Native Vegetation Information Management System (NVIM)
	Target	5– 30% (inclusive) of plots have per cent cover of bare ground between 25-75% every year

KPI:	Per cent of plots that have bare ground cover between 25 – 75%	
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Five years after securing land
	Responsibility	Department of Environment, Land, Water and Planning

KPI:	Per cent of all perennial vegetation comprised of weeds	
Quantity	Baseline	0%
	Data collection	Per cent of perennial vegetation which is composed of weeds in permanent 20 x 20 m plots collected in spring annually compared to the original per cent cover in that plot in the year of acquisition
	Data management	Native Vegetation Information Management System (NVIM)
	Target	Mean change in per cent cover of perennial vegetation that is comprised of weeds across all permanent plots in each NTG state remains below the baseline
	Confidence Intervals	The lower 95% confidence interval of the mean change in per cent cover in each NTG state remains below the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Five years after securing land
	Responsibility	Department of Environment, Land, Water and Planning

Other data collection

Table 2 Other data collection to support analysis of cause of change in NTG

Data	'Quality' of the grassland in each plot, using the NTG metric
Frequency	Annually, calculated from plot data
Data management	Native Vegetation Information Management System (NVIM)
Data	Cover of native annual herb species
Frequency	Annually, calculated from plot data
Data management	Native Vegetation Information Management System (NVIM)
Data	Cover of annual dicot and monocot weeds
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM)
Data	Relative abundance of cool-season active (C3) and warm-season active (C4) grasses
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM)
Data	Cover of organic litter, moss and rock
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM)
Data	Level of Soil nitrate and other soil chemical properties
Frequency	Every 5 years
Data management	Native Vegetation Information Management System (NVIM)

Data	Level of Soil Phosphorus (measured as parts per million Colwell extraction)
Frequency	Every 5 years
Data management	Native Vegetation Information Management System (NVIM)
Data	Fauna inventory (Diurnal and nocturnal birds and mammals (including bats), reptiles, amphibians, spiders)
Frequency	Every five years
Data management	Victorian Biodiversity Atlas (VBA)
Data	Kangaroo abundance (in areas where relevant to management)
Frequency	Annually (subject to review, as required)
Data management	Victorian Biodiversity Atlas (VBA)
Data	Pest animal abundance (in areas where relevant to management; including foxes, cats and rabbits)
Frequency	Annually (subject to review, as required)
Data management	Victorian Biodiversity Atlas (VBA)
Data	Flora inventory (Vascular species)
Frequency	Every five years (in areas identified in the initial inventory report)
Data management	Victorian Biodiversity Atlas (VBA)

Monitoring protocol

Background

A mixture of permanently marked and annually re-allocated plots will be employed (to manage the trade-off noted below, under 'Supporting Information'). It is expected that 75% of the plots in each state will be permanent, and 25% will be re-allocated annually; however this allocation may be altered if required.

Many KPIs could be addressed using a range of field plot designs. There is trade-off between the number of plots and the degree of data resolution and time spent within each plot (i.e. for a given cost, many plots using rapid estimates vs fewer plots with more detailed quantitative information). Below, two plot designs are given, one intensive, the other rapid. One plot design is chosen for each KPI, but the alternative design may be reported as a supplementary measure.

Intensive point-intercept plots

This sampling method addresses the following KPIs:

- Cover of native perennial herbs in NTG states
- Diversity of native perennial herbs in NTG states
- Cover of Kangaroo Grass in NTG states
- Cover of native perennial grasses (excluding Kangaroo Grass) in NTG states
- Cover of perennial weeds in NTG states.

Sampling will be repeated every year in spring (1 September – 30 November).

Each plot will be a square 400 m2 in area (20 x 20 m). The edges of the plots will be aligned with the points of the compass, and those plots which are permanent will be marked with a short metal peg at the north-west corner.

Five 20 m lines will be laid out across the plot (meeting the sides at 2, 6, 10, 14, 18 m). These lines will each define a set of 50 sampling points, located 40 cm apart. In total, the plot will contain 250 sampling points.

At each point, a narrow metal pin will be held vertically, and any vascular plant species, exposed rock, detached plant litter, bare ground or moss intersecting the pin recorded. Multiple items may be recorded at a single point (including multiple plant species, rock and plants; excluding bare ground, which is only recorded when no plant material intercepts the point), meaning that when the values for all plants are summed, the total cover may exceed 100%. Every data point for plant species will be recorded as 'basal area' (a point where the plant contacts the ground; a stem or tiller), or 'cover' (a point where any plant part touches the pin, including leaves held away from the base of the plant). Every 'basal' point also contributes to 'cover' (i.e. basal area is a subset of cover). For the purposes of assessing the per cent bare ground, any points that recorded no live vegetation cover will be included as "bare" (Whether bare soil, rock or detached litter). For this reason it is important to distinguish rock and litter which occur beneath vegetation cover from rock and litter that are not covered by vegetation.

After the point intercept measurements are complete, an unstructured 3 minute search of the plot will be undertaken, to record all native herb species. Native herbs are defined here as any native species not in the families Poaceae, Juncaceae or Cyperaceae. Only perennial herbs contribute to the relevant KPI.

Pilot sampling in grassland suggests that each plot will take 2 people 30 – 80 minutes to complete, depending on the density and complexity of the vegetation.

Within the WGR, the intensive plots will be positioned randomly (some permanent, some re-allocated), but stratified according to state, as shown in Table 3. The stratification will also require that one or more plots fall within populations of Spiny Rice-flower (see entry for that species). In total, it is anticipated that approximately 260 intensive plots will be used across the WGR when it is fully acquired and managed, with plots being added on a pro rata basis as lands are brought into the reserve. The allocations shown in Table 3 may change if required to adequately detect important trends.

Table 3 Distribution of monitoring effort in the Western Grassland Reserves according to NTG state.

State	Area (ha)	Number of patches	Approximate percent effort
Herb-rich Grassland (HG)	84	<10	15%
Themeda Grassland (TG)	50	<10	15%
C3* Grassland (C3G)	6,996	>100	30%
De-rocked Grassland (DG)	538	>100	15%
Nutrient-enriched Grassland (NG)	3,248	>100	25%

***** C3 is a metabolic pathway for carbon fixation (photosynthesis) possessed by most plants. Grasses with C3 carbon fixation are thus cool season growing. C4 is an alternative pathway for carbon fixation that is more competitive under warmer conditions and C4 plants are thus warm season growing**.**

Conservation Areas outside the WGR will be sampled by at least 2 plots, with an extra plot added for every 50 ha of grassland vegetation (50-100 ha: 3 plots, 100-150 ha: 4 plots, etc.). Half will be annually re-allocated (at least one of each kind in each relevant area). The stratification will also require that one or more plots fall within populations of relevant plant species (Spiny Rice-flower, Small Golden Moths Orchid, Large-fruit Groundsel, Matted Flax-lily, Button Wrinklewort).

Rapid plots

This sampling method may address the following KPI:

- Percent of plots that have bare ground cover between 25 – 75%.

Sampling will be repeated every year in spring (1 September – 30 November). All rapid assessment plots will be re-allocated each year. The plots will not be stratified by state (unlike the larger plots), to allow them to address the KPI "Percent of plots that have bare ground cover between 25 – 75%" without bias towards those states that are most heavily sampled.

Each plot will be a square 1 m^2 in area (1 x 1 m).

Within each plot, rapid visual estimates will be made of the cover of the following important elements. Some of these measures do not relate to the KPIs, but refer to the additional measures that are useful for describing grassland dynamics. All of these measures can also be derived from the point intercept data in the intensive point-intercept plots:

- *Themeda triandra*
- Native herbs
- C4 native grasses
- C3 native grasses
- Exotic perennial monocots
- Exotic perennial dicots (with *Romulea* assessed separately, given its highly-seasonal growth pattern)
- Exotic annuals
- Bare ground and exposed rock
- Litter.

The number of native herb species will also be recorded.

The 'golf ball' method of estimating bare ground will also be employed in these small plots (Parks Victoria 2008; Schultz 2006). Within each small plot 18 golf balls are dropped from the centre of the plot at eye-line to land within the 1m x 1m plot. Balls that fall outside the plot are redropped until all 18 balls sit within the plot. Standing directly over the plot, balls are visually assessed and allocated to one of three categories based on the percentage of the total ball visible to the eye (not covered by biomass). The category of visibility for each ball corresponds to a numeric value, and the sum of all values of all balls provides the final score for the plot.

- More than 90% of the golf ball visible= score of 1
- Between 33-90% of the golf ball visible= score of 0.5
- Less than 33% of the golf ball visible = score of 0.

For example 10 balls with greater than 90% visibility, 6 balls with between 33-90% visibility, and 2 balls with less than 33% visibility provide a quadrat score of 13 (10 x 1 + 6 x 0.5 + 2 x 0 = 13)

In addition to re-allocated plots, rapid plots may also be used to check trends across conservation areas and ensure permanent plots are not the focus of management.

State mapping

This monitoring approach addresses the following KPI:

- Hectares making transition between grassland states.

Every five years, in line with the reporting, grassland states will be re-mapped, and compared to the map from the previous period. The area of sites that remain in the same state, or make a transition to a more or less valuable state will be recorded according to table 4 below. Any transition not listed as a feasible positive transition is considered a negative transition or not possible for the purposes of this reporting framework.

It is noted that the states cannot be reliably mapped using remote sensing, and mapping large areas manually can be labour-intensive and is not precisely repeatable. To control the intensity and consistency of mapping, the following procedure will be followed:

- The NTG state-and-transition model developed by DELWP will guide the identification of states. It is acknowledged that some areas may have characteristics close to a state threshold (e.g. Colwell P

approximately 15 ppm) for many years, making the precise 'moment' of transition difficult to define. The state-and-transition model description will provide guidance on dealing with such cases

- Up-to-date aerial photographs will be used first to distinguish cropped and non-cropped land
- The previous polygon boundaries will be used and re-annotated in all cases (commencing with the map produced at the first inventory), except where the observer notices an obvious change in state within the polygon; subsequently that polygon will be divided or re-assigned.

Table 4 NTG states and positive transitions

State	'NTG state' for monitoring purposes	Feasible positive transitions
Herb-rich Grassland (HG)	Yes	n/a
Themeda Grassland (TG)	Yes	HG
C3 Grassland (C3G)	Yes	TG, HG
Nutrient-enriched Grassland (NG)	Yes	C3G, TG, HG
Derocked Grassland (DG)	Yes	n/a
Derocked Nutrient-enriched Pasture (DNP)	No	DG

Vegetation and plant inventory

Soon after securing a Conservation Area (or in the case of the Western Grassland Reserve, a large section or property), a complete survey will be made of all vascular plant species. Surveys will be done mostly between September and January, by a qualified and experienced botanist.

The aim of the survey is to compile a list of species for the Conservation Area that is as exhaustive as possible. Each Conservation Area to be surveyed will be walked so that no sizable area remains unsurveyed. For large Conservation Areas, this will be done by dividing the site arbitrarily into ~50-100 ha units before the survey commences, and treating each unit as an individual patch. For grassland patches where total grass cover is >30%, an effort of 1.5 hours per hectare will be spent searching for plants; until no new plant taxon for the Conservation Area has been detected for over 30 mins within the patch. For grassland patches where total grass cover is <30%, 1 hour per hectare will be spent searching for plants; until no new plant taxon for the Conservation Area has been detected for over 30 mins within the patch (preliminary surveys suggest most patches are 'completed' after a 30 minute break in species detection, long before 1.5 hours per hectare is expended). Every discrete patch of un-cultivated grassland (i.e. states HG, TG, C3G, and NG) in a Conservation Area will be visited. Cultivated sites display much lower species diversity and are thus a lower priority for flora inventory. Every wetland or drainage line visible on the aerial imagery will be visited and surveyed with intensity similar to that for grasslands. For non-native vegetation 5 min per hectare should be spent searching.

The flora inventory surveys apply to defined areas (Conservation Areas, properties), and will inevitably include areas that do not conform to the definition of NTG. Such areas may be former-NTG that has been degraded, or other types of vegetation that have never been referrable to NTG (including other EPBC-listed ecological communities). These non-NTG areas will be clearly marked. Similarly, areas that are not 'native vegetation' will be marked.

Occurrences of any 'significant' native species will be mapped, including any EPBC or FFG listed species, species considered rare or threatened by either the DELWP advisory list (DEPI 2014d) or by Walsh and Stajsic (2007), or any species considered by the botanist to be locally significant.

Occurrences of any ‘significant’ exotic species will also be mapped, (unless they are so widespread as to make mapping unhelpful), including all species listed under the *Catchment and Land Protection Act 1994*, all species identified as emerging weeds, or any species considered by the botanists to pose a significant threat.

The initial inventory reports will be published for each property. They will identify any areas that warrant repeat surveys for future reporting. Repeat surveys are appropriate in the following circumstances:

- Populations of serious weeds, or suspected emerging weeds
- Populations of significant species
- Mapped ‘hot spots’ which contain concentrations of biological values which are considered important in aggregate.

Fauna inventory

Soon after the acquisition of a property, surveys will be conducted for some fauna groups. These groups have been chosen to represent the major vertebrate groups, the major groups of pest animals (e.g. Foxes and Rabbits), important elements of ecosystem function (e.g. Spiders) or notable elements of ecosystem composition or diversity (e.g. Plains-wanderer). As a range of survey techniques will be required, detailed inventory approaches will be developed for each property based on inventory guidelines that outline the requirements and techniques for each taxon. The guidelines will be adapted to reflect the size of the property and the occurrence and distribution of micro-habitats (e.g. rocky rises, drainage lines). Some taxa require multiple techniques (e.g. reptiles) and some techniques can be deployed to concurrently survey different groups (e.g. camera traps). Table 5 details the suite of fauna groups for inventory in the grassland community. Surveys will be conducted at the appropriate time of year for the particular taxon and by experienced taxon experts.

Table 5: Fauna groups for inventory in NTG properties

Group	Potential survey techniques	Reason for survey
Reptiles	Pitfall traps Funnel traps Active searches Camera traps	Significant component of vertebrate fauna, may contain significant species
Amphibians	Acoustic detectors Spotlighting Pitfall traps	Significant component of vertebrate fauna, may contain significant species
Ground-dwelling mammals	Camera traps	Significant component of vertebrate fauna, may contain significant species
Kangaroos and wallabies	Incidental observations Camera traps	Significant component of vertebrate fauna, may present management issues.
Spiders	Pitfall traps Sweep nets	Feeding guild structure likely independent indicator of grassland state and condition
Diurnal birds	Timed area searches	Significant component of vertebrate fauna, may contain significant species
Nocturnal birds	Vehicle based transects	Significant component of vertebrate fauna, may contain significant species
Foxes	Vehicle based transects	Significant threat to native vertebrate fauna

Group	Potential survey techniques	Reason for survey
	Incidental observations Camera traps	
Rabbits	Identification of active burrows Incidental observations Camera traps	Cause damage to habitat, threat to native plants
Insectivorous bats	Acoustic detectors	Significant component of vertebrate fauna, may contain significant species

Occurrences of any 'significant' species will be mapped, including any EPBC or FFG listed species or any species considered by subject experts to be locally significant.

The initial inventory reports will be published for each property. They will identify any areas that warrant repeat surveys for future reporting. Repeat surveys are appropriate in the following circumstances:

- Populations of invasive or overabundant species that require management
- Populations of significant species
- Mapped 'hot spots' which contain concentrations of biological values which are considered important in aggregate.

NTG quality

The KPIs all provide good indications of NTG change under management, but they address separate aspects of the community, and no single KPI is a direct and all-encompassing measure of "composition, structure and function" for the community (see the Program Outcome). Management may, however, cause changes in multiple variables simultaneously (e.g. Kangaroo-grass abundance and weed abundance) and it is not always obvious how one set of changes (relevant to one KPI) compares with another (relevant to a different KPI). To address this issue, overall NTG 'quality' will be determined using the metric described in Sinclair *et al.* (2015). The NTG quality metric combines eight measurable on-ground variables into a single value. These eight variables correspond closely with the KPI variables, and the metric will help us make sense of changes among the multiple KPIs. This NTG quality metric has been created specifically for NTG in contrast to similar existing metrics like Habitat Hectares (Parkes *et al.* 2003) that aims to compare condition across ecosystems.

Soil chemistry

Every five years, twenty soil samples will be taken from each plot (each a cylinder approximately 2 cm diameter and 5-10 cm deep), then pooled to form a single soil sample representative of the plot. Soil samples will be stored in a cold box for the day, and placed in the freezer at the conclusion of the day's work. Soil samples will be tested for Phosphorous levels using the Colwell extraction (Colwell 1963), and a range of other soil chemical parameters.

Supporting information

General ecology

The ecology of NTG is very well understood; being the subject of more published material than any other community or species considered in this document (e.g. Carr 1999; Lunt 1991; Morgan and Lunt 1999; Patton 1935; Stuwe and Parsons 1977; Sutton 1916-1917).

The community occurs on relatively recent lava flows, generally between 4.5 and 2.2 million years old. These form flat or undulating plains with poorly defined drainage systems. The soils are relatively fertile, shallow and heavy (small-particles), with many rocks at or near the surface (Sinclair and Atchison 2012).

Perhaps the most obvious feature of the grasslands is the scarcity of trees, which has been a feature since before colonisation (Sinclair and Atchison 2012). It is generally agreed that moisture stress excludes trees. This is a function of rainfall and the heavy soils, which make water less available for uptake by plants. Soil cracking in summer, a common feature of heavy soils, exacerbates summer drought stress (Patton 1935; Sutton 1916-1917; Willis 1964). The frequent use of fire by aboriginal people is also likely to have played a role in preventing the establishment of woody plants (Lunt 1997; Sinclair and Atchison 2012).

The natural vegetation is a tussock grassland dominated by Kangaroo Grass *Themeda triandra*, Spear-grasses *Austrostipa* spp., Tussock-grasses *Poa* spp. and Wallaby-grasses *Rytidosperma* spp. Between the tussocks grow a diversity of other plants, notably broad-leaved native herbs, including many daisies (Asteraceae), geophytes (Lileacae, Orchidaceae), and some deep-rooted perennial sub-shrubs (such as *Pimelea* spp.). In drier locations Chenopod shrubs may be common. The prominence of the Poaceae and Asteraceae are a recurring feature of temperate grasslands world-wide (Coupland 1979). The fertile soils favour the growth of those families at the expense of some otherwise prominent Australian plant groups which prefer lower Nitrogen and Phosphorous levels (the families Ericaceae, Myrtaceae, Proteaceae and Restionaceae are not well represented (Stock and Verboom 2012). Although grasses make up the bulk of the biomass, herbs contribute the bulk of the diversity, and grassland sites are often valued for containing high herb diversity (Sinclair *et al*. 2015). The non-vascular flora is not well known. A crust of native, tiny photosynthetic organisms often forms on the soil. It is made up of bryophytes (mosses, liverworts), lichens and algae (Morgan 2004; Scarlett 1994).

Grassland vegetation is well-adapted to the removal of surface biomass by fire, prolonged drought or grazing by some herbivores. In fact, the lack of biomass removal is a threat: when good rainfall promotes vigorous grass growth, herbaceous species may be excluded (Stuwe and Parsons 1977). After fire, most plants re-sprout quickly from underground storage organs such as tubers and corms. The subterranean energy stores of fire-tolerant non-grass species were an important food source for aboriginal people, promoting the use of fire as a management tool (Gott 1999). Relatively few grassland species regenerate from a persistent soil seed bank, and regeneration is for many species dependent on the standing population of adults at the time of disturbance (Morgan 1998b).

While the listed ecological community is essentially defined as a vegetation community, animals are diverse and numerous, play vital roles in grassland function, and must be considered integral components of the ecosystem. For example, many small mammals such as bandicoots formerly inhabited the plains and it is safe to presume that their digging activity impacted the soil structure, and that their removal has had impacts on plant recruitment and soil crust formation. Some vertebrate animal species are virtually restricted to grasslands. These include a number of reptiles (including the Striped Legless lizard (*Delma impar*), discussed below) and birds. Of particular note is the Plains-wanderer (*Pedionomus torquatus*), a small nocturnal ground-dwelling bird that is endemic to Australia, the sole member of its family, and one of the most 'evolutionarily distinct' birds on earth (Jetz *et al*. 2014). Plains-wanderer is listed as vulnerable under the EPBC Act.

Invertebrates are often overlooked, but they may play important ecological roles in grasslands, and the structure of invertebrate communities may provide useful insights into ecosystem function or condition (Yen 1999). Many grassland wildflower species are insect pollinated (virtually none are bird pollinated), and invertebrates probably influence seedling survival. Several introduced invertebrates pose potential threats to the grassland ecosystem, including the highly-abundant Portuguese Millipede (*Ommatoiulus moreleti*) which consumes plant and lichen material (Paoletti *et al*. 2007). Spiders are generally the top predator in the invertebrate food chain. Members of each spider family have similar hunting strategies, and consequently a system of classifying spiders to an ecological guild is possible with spiders identified only to family level (regardless of gender or age). The guild structure should reflect the successional state and fine structure of the grasslands, and the amount and diversity of potential invertebrate prey available.

Grassland structure changes markedly over time, as fires and droughts remove biomass and encourage certain species to proliferate at different times. Different animal and plant species make use of these changing patterns, with some species preferring an open structure, others a dense sward, or others (presumably) a particular suite of plant species. Under natural conditions, many plants and animals probably moved around the community in response to changes in biomass and species composition. In a confined system of reserves, it is important to manage the spatial distribution of dense and low patches of grassland, hence goals related to structural heterogeneity are considered important. It is also important to consider the degree of natural fluctuation in vegetation cover when designing goals and monitoring. The use of proportional measures (target species group as a proportion of all plant material) is useful as a measure of prominence that is relatively stable over time.

Land use legacies and threats

Being open, flat and fertile, native grasslands have long been attractive for agriculture and development, and have suffered many changes since colonisation in 1835. Many threats continue to act on the remaining areas of grassland.

- Inappropriate grazing by stock changes the composition of grasslands in ways that are not easily reversible: palatable species are quickly depleted; tolerant species proliferate, nutrients are shifted and concentrated in paddocks, and the soil is compacted by hard-footed stock (Dorrough *et al.* 2004a; Lunt and Morgan 1999; Scarlett 1994; Stuwe and Parsons 1977; Zimmer *et al.* 2008). The current lack of the once-dominant *Themeda* in many native paddocks in the western Melbourne area is an artefact of grazing management, evidenced by the fact that roadsides across the area support this species (Sinclair and Atchison 2012)
- Exotic plants have been introduced deliberately (e.g. for pasture, as ornamentals, etc.) and inadvertently. These plants compete with and displace native species, and may affect the productivity of grassland paddocks (Carr *et al*. 1992; Mclaren *et al*. 2004)
- Most native species compete best under lower nutrient levels than pasture species, and are generally out-competed when fertilizer is applied and nutrients accumulate. Data from temperate grassland sites across south-eastern Australia show clearly that native plant abundance and diversity decreases as soil nutrients increases (Allcock 2002; Dorrough and Scroggie 2008; Dorrough *et al.* 2004b; Fisher 1974; Garden *et al.* 2003; Gibson-Roy *et al.* 2007a; b; Morgan 1998b). Among all of the changes in soil composition brought about by agriculture, changes in phosphorous seem to be most closely linked to vegetation composition. Nitrate levels are also closely linked to plant species composition, but nitrate is a less stable measure of soil conditions than phosphorous, being substantially incorporated into plant tissues and fluctuating along with plant biomass
- The disturbance of the original soil and rock layer is highly destructive, leading to the removal of fauna habitat, the disturbance of soil invertebrate communities, and the removal of most native vegetation. Recent technological advances in rock removal are allowing cropping to spread into areas once considered too rocky
- A lack of burning has in places resulted in the over-growth of Tussock-grasses (notably *Themeda triandra*) at the expense of herbs and also encouraged increased dominance by some exotic perennial grass species (Lunt and Morgan 2002; Morgan and Lunt 1999; Stuwe and Parsons 1977).

DELWP has produced a ‘state-transition’ model which describes the shifts in structure and composition that occur to NTG when it is perturbed by human intervention (or lack of intervention). The states can be recognised and mapped in the field, and can be used to summarise the series of ecological changes that have occurred in the past, and the constraints that this legacy puts on management and restoration for the future. Some states are considered desirable, others merely tolerable, and others undesirable. The transitions represent paths or hypotheses about how sites can move between states. Management can be conceived as the act of encouraging desirable transitions and preventing those that are undesirable. For monitoring purposes ‘NTG states’ are distinguished from other states in the state-transition model (see table 4). This ensures monitoring focuses on states that are likely to classify as NTG.

Monitoring techniques

Virtually all field studies that monitor cover (or basal area) of herbaceous species use some form of 'point-intercept' method (Godínez-Alvarez *et al*. 2009), where a standardised line or grid defines a set of points, and each point is scored according to what it intercepts (the foliage of a particular species, bare soil, rock, etc.). The data allows the 'percentage cover' of each attribute (e.g. a species) to be determined. The arrangement of the points (coverage, density) is usually determined by the 'granularity' or spatial heterogeneity of the vegetation that is being monitored. Point-intercept methods can also be used to measure diversity, but they frequently do not detect less abundant species in the plot, meaning that visual assessments of diversity often provide higher (better) estimates; but they suffer from high levels of variation caused by differences between observers (Godínez-Alvarez *et al.* 2009b). Recent experience in monitoring grassy ecosystems in Victoria are able to guide the choice of plot scale and layout (Rumpff *et al*. 2009; DELWP unpublished data). Relative to many other systems, grasslands are fairly heterogeneous on very small scales (~1 m and less) but evenly structured over moderate spatial scales (>5 m).

The actual location of monitoring plots can be determined in several ways, but generally some form of randomisation is preferred (Vos *et al*. 2000). Most monitoring schemes use randomly positioned permanent plots to track changes at sample locations over time ('re-sampling' e.g. Green 1989; Lindenmayer *et al*. 2012). While intuitive and statistically efficient, this approach can provide an incentive to manage the plots at a higher standard than the surrounding area, invalidating the conclusions. The alternative is to employ re-allocated plots which are randomly positioned from survey to survey, which removes the incentive to 'manage the plot', but makes it difficult to distinguish the temporal change of interest from spatial variation between sample locations (Vos *et al*. 2000). Lindenmayer *et al*. (2012) kept yearly monitoring costs low by only sampling a subset of permanent plots annually, but still ensuring that enough plots were monitored annually to report on trends, and that all plots were adequately sampled over time.

Detectability studies in grasslands show that the time taken to detect the presence of a plant species with a known level of certainty varies between species, and depends on the density of grass at the site (Garrard 2009a). Detectability models may be used to design targeted surveys for species of interest; however this requires data that are not currently available for most species.

Important conservation documents and resources

- One ABC Bayesian Network model, for McCorkell Road Reserve
- Nationally Threatened Ecological Communities of the Victorian Volcanic Plain: Natural Temperate Grassland & Grassy Eucalypt Woodland. A guide to the identification, assessment and management of nationally threatened ecological communities (DSEWPAC 2011).

The composition, structure and function of Grassy Eucalypt Woodland of the Victorian Volcanic Plain improves

Introduction

The outcome

The Victorian Government has committed to improving the composition, structure and function of GEW of the Victorian Volcanic Plain (here after GEW) within the program area. This will be achieved through a range of outputs, particularly the establishment and management of a 1,200 hectare woodland reserve and network of Conservation Areas within the Urban Growth Boundary (UGB).

This outcome will be measured in the following Conservation Areas:

- Grassy Eucalypt Woodland Reserve (Figure 4)
- Conservation areas[2]: 16,17, 18p (NC), 19 (Figure 5) 22B and 22C (NC), 25, 26, 27, 29, 31, 33A (NC), 34B (NC) (Figure 6).

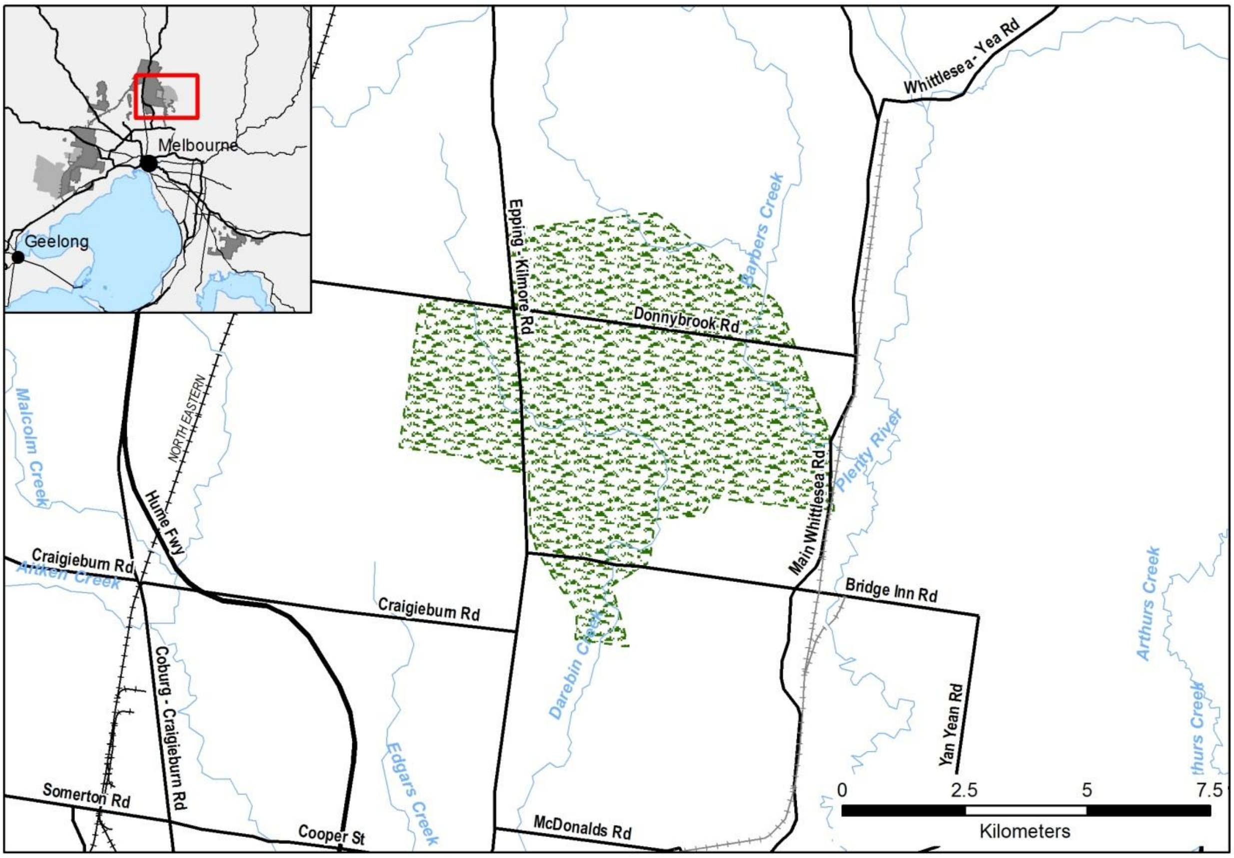

Figure 4: GEW- Grassy Eucalypt Woodland Reserve (indicative boundary)

[2] Brackets refers to the part of the Conservation Area that the outcome monitoring will apply if the Conservation Area is split into multiple categories under the BCS. (NC) – Nature Conservation, (PL) – Existing Public Land

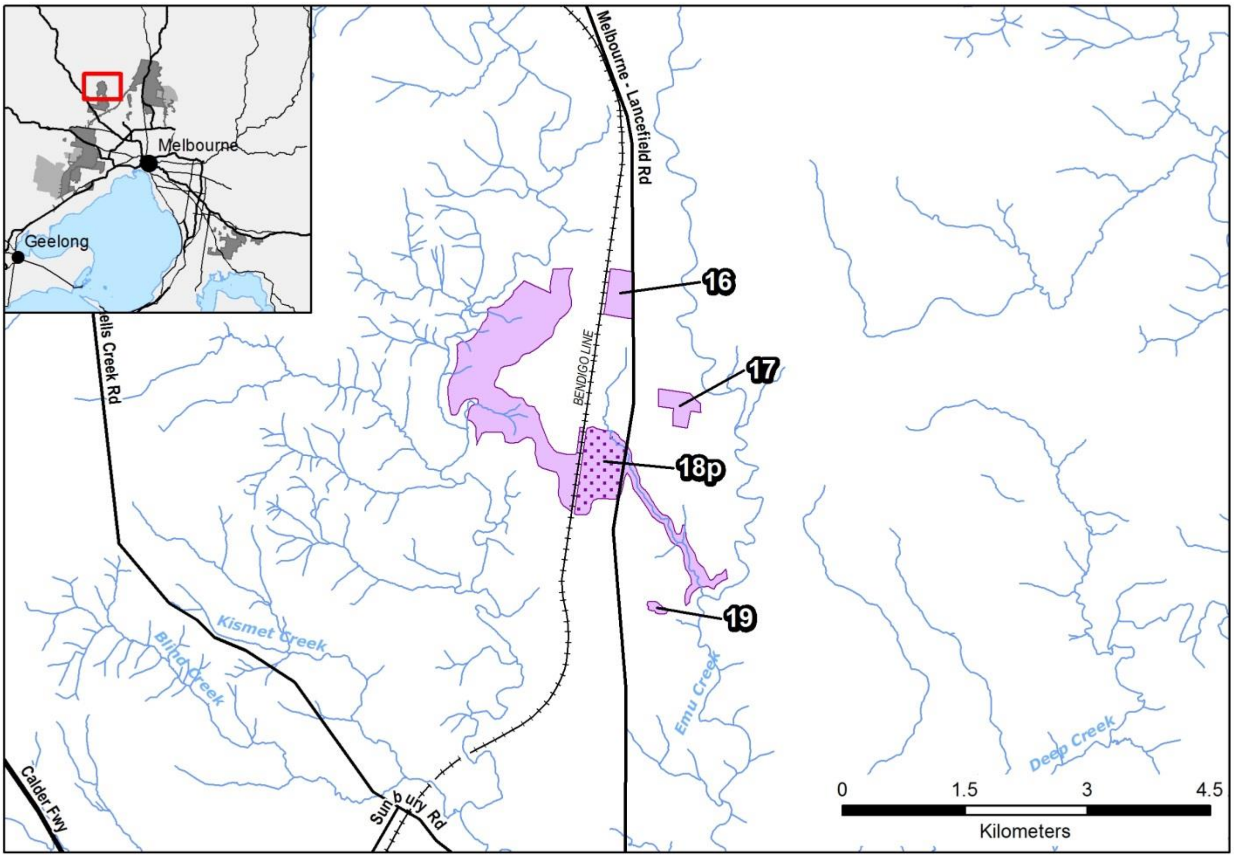

Figure 5: GEW- Conservation Areas, North-Western Growth Corridor.

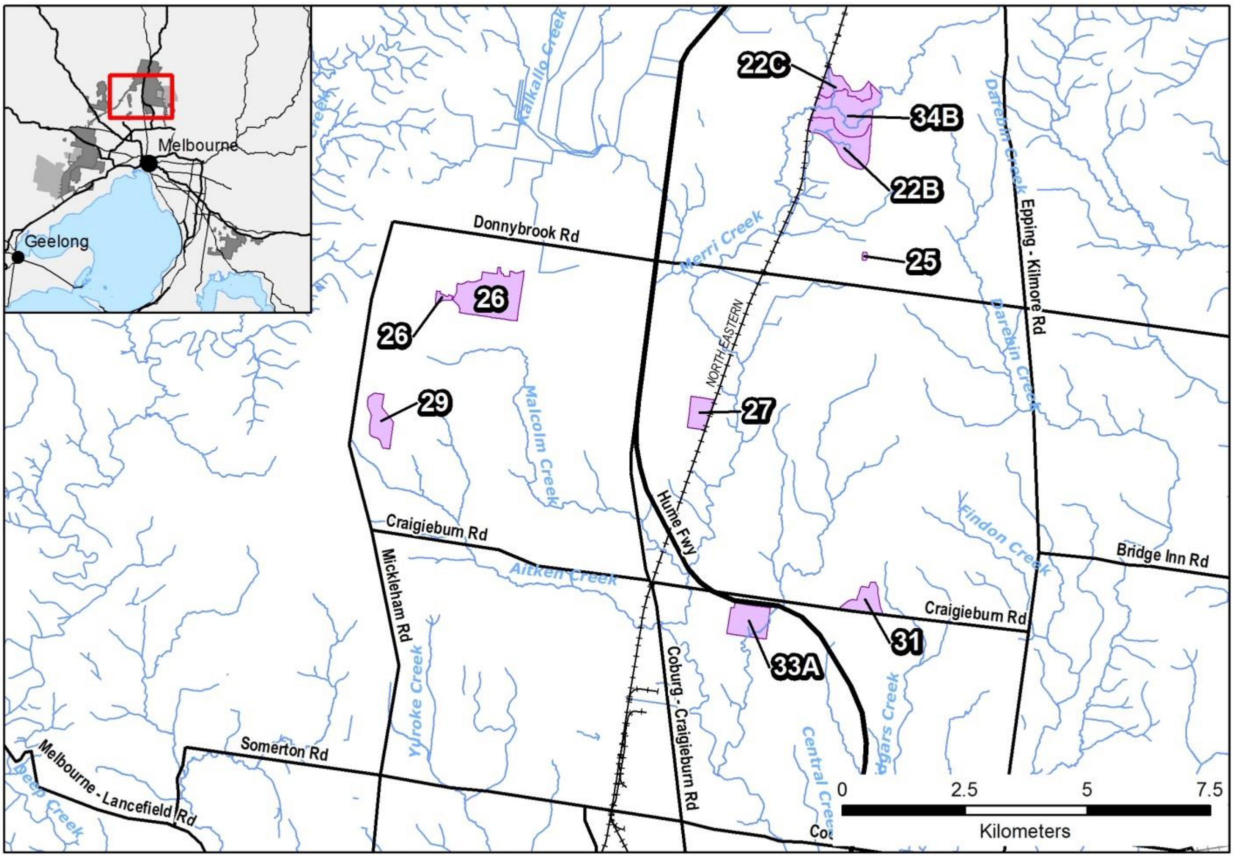

Figure 6: GEW- Conservation Areas, Northern Growth Corridor

Description of the community

GEW occurs exclusively on basalt landscapes, on terrain ranging from heavy soil plains to rocky rises. It is wooded with eucalypts (mostly River Red Gum *Eucalyptus camaldulensis* in the MSA area), and may also support a mid-storey of small trees and shrubs. The understorey is dominated by one or more native tussock-forming grasses, along with a variety of herbs (DSEWPAC 2011).

Distribution of the community

GEW is by definition restricted to the landscape formed by lava flows in the Quaternary periods (TSSC 2008), which extends from north of Melbourne past Portland in Victoria's west. GEW is mainly located in pockets just north of Melbourne, between the Dunkeld and Beaufort areas, and in scattered places elsewhere.

Conservation status of the community

GEW is listed as Critically Endangered under the EBPC Act (Department of the Environment 2009b). It corresponds to the Western Basalt Plains (River Red Gum) Grassy Woodland Floristic Community 55-04, listed as threatened under the FFG Act (DSE 2012). This FFG-listed community is restricted to the north and west of Melbourne (i.e. within the MSA area), the eastern most portion of the broader EPBC-listed community.

Key performance indicators

Table 6 KPIs to demonstrate an improvement in the composition, structure and function of GEW.

KPI:	**Hectares making transition between states**	
Measure	Baseline	0 ha
	Data collection	Mapping undertaken between August and December undertaken every five years compared to previous reporting period
	Data management	Native Vegetation Information Management System (NVIM)
	Target	0 hectares make undesirable transitions between states
	Frequency	Every five years
Reporting	Forum	Five yearly Report
	Start Date	Five years after securing land
	Responsibility	Department of Environment, Land, Water and Planning
KPI:	**Cover of native perennial herbs**	
Measure	Baseline	Mean cover of native perennial herbs in all 20 x 20m plots in GEW states over the first five after the land is secured
	Data collection	Estimated cover of native perennial herbs in all 20 x 20 m plots in GEW states monitored in spring annually
	Data management	Native Vegetation Information Management System (NVIM)
	Target	The mean cover of native perennial herbs in each GEW state remains above the baseline
	Confidence Interval	The upper 95% confidence interval of the mean cover of native perennial herbs remains above the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Ten years after securing land
	Responsibility	Department of Environment, Land, Water and Planning

KPI:	**Diversity of native perennial herbs**	
Measure	Baseline	Mean diversity of native perennial herbs in all 20 x 20m plots in GEW states over the first five years after land is secured
	Data collection	Estimated diversity of native perennial herbs in all 20 x 20 m plots in GEW states monitored in spring annually
	Data management	Native Vegetation Information Management System (NVIM)
	Target	The mean diversity of native perennial herbs in each GEW state remains above the baseline
		The upper 95% confidence interval of the diversity of native perennial herbs remains above the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Ten years after securing land
	Responsibility	Department of Environment, Land, Water and Planning
KPI:	**Cover of target grass species (*Themeda triandra*, *Poa* spp., *Austrostipa mollis*)**	
Measure	Baseline	Mean cover of target grass species in all 20 x 20m plots in GEW states over the first five years after land is secured
	Data collection	Mean cover of target grass species in all 20 x 20m plots in GEW states monitored in spring annually
	Data management	Native Vegetation Information Management System (NVIM)
	Target	The mean cover of target grass species in each GEW states remains above the baseline
	Confidence Intervals	The upper 95% confidence interval of the cover of target grass species remains above the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Ten years after securing land
	Responsibility	Department of Environment, Land, Water and Planning
KPI:	**Relative abundance of woodland structural types**	
Measure	Baseline	Not applicable
	Data collection	Per cent of 50 x 50 m plots in the target cover range for each woodland structure category, monitored in spring annually
	Data management	Native Vegetation Information Management System (NVIM)
	Target	The percentages of plots in each woodland structure category are within the target range for each category (Table 9)
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	As soon as the number of plots available for calculating percentages exceeds 20
	Responsibility	Department of Environment, Land, Water and Planning
KPI:	**Per cent of plots with Eucalypt recruits**	
Measure	Baseline	Not applicable
	Data collection	Per cent of 50 x 50 m plots with Eucalypt recruits monitored in spring annually
	Data management	Native Vegetation Information Management System (NVIM)
	Target	25 – 75% of plots have some Eucalypt recruits
	Frequency	Annually
Reporting	Forum	Five yearly Report

KPI:	Per cent of plots with Eucalypt recruits	
	Start Date	Five years after securing land
	Responsibility	Department of Environment, Land, Water and Planning

KPI:	Per cent of all perennial vegetation composed of perennial weeds	
Measure	Baseline	0%
	Data collection	Per cent of perennial vegetation which is weeds in permanent 20 x 20 m plots collected in spring annually compared to the original per cent cover in that plot in the year land is secured
	Data management	Native Vegetation Information Management System (NVIM)
	Target	Mean change in per cent cover of perennial vegetation that is composed of weeds across all permanent plots in each GEW state remains below the baseline
	Confidence Interval	The lower 95% confidence interval of the mean change in cover in each GEW state remains below the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Five years after securing land
	Responsibility	Department of Environment, Land, Water and Planning

Other data collection

Table 7 Other data collection to support analysis of cause of change in GEW

Data	Cover of annual weeds
Frequency	Annually, in Spring
Data management	Native Vegetation Information Management System (NVIM)
Data	Cover of annual herbs
Frequency	Annually, in Spring
Data management	Native Vegetation Information Management System (NVIM)
Data	Level of soil nitrate
Frequency	Every 5 years
Data management	Native Vegetation Information Management System (NVIM)
Data	Level of soil Phosphorus (measure in parts per million Colwell extraction)
Frequency	Every 5 years
Data management	Native Vegetation Information Management System (NVIM)
Data	Shrub abundance
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM)
Data	Proportion of C3 and C4 grasses
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM)
Data	Cover of organic litter, moss and rock
Frequency	Annually

Data management	Native Vegetation Information Management System (NVIM)
Data	Fauna inventory
Frequency	Every five years
Data management	Victorian Biodiversity Atlas (VBA)
Data	Kangaroo abundance (in areas where relevant to management)
Frequency	Annually (subject to review, as required)
Data management	Victorian Biodiversity Atlas (VBA)
Data	Pest animal abundance (in areas where relevant to management; including foxes, cats and rabbits)
Frequency	Annually (subject to review, as required)
Data management	Victorian Biodiversity Atlas (VBA)
Data	Flora inventory
Frequency	Every five years (in areas identified in the initial inventory reports for a property)
Data management	Victorian Biodiversity Atlas (VBA)
Data	'Quality' of the woodland in each plot, using the GEW quality metric.
Frequency	Annually, calculated from plot data.
Data management	Native Vegetation Information Management System (NVIM)

Monitoring protocol

Background

The plot design for GEW is similar to that for NTG, but takes into account the tree layer, which is patterned at a relatively large scale (the average mature *Eucalyptus camaldulensis* canopy is ~20 m wide locally). A mixture of permanently marked and annually re-allocated plots will be employed (to manage the trade-off noted below, under 'Supporting Information'). It is expected that 75% of the plots in each state will be permanent, and 25% will be re-allocated annually; however this allocation may be altered if required. Several scales of plot are used.

Intensive point-intercept plots (20 x 20 m)

This sampling method addresses the following KPIs:

- Cover of native perennial herbs in GEW states
- Diversity of native perennial herbs in GEW states
- Cover of target grass species in GEW states
- Cover of perennial weeds in GEW states.

Sampling will be repeated every year in spring (1 September – 30 November).

Each plot will be a square 400 m2 in area (20 x 20 m). The plots will be aligned with the points of the compass (North, South, East, West), and those plots which are permanently marked with a short metal peg at the north-west corner.

Five 20 m lines will be laid out across the plot (meeting the sides at 2, 6, 10, 14, 18 m). These lines will each define a set of 50 sampling points, located 40 cm apart. In total, the plot will contain 250 sampling points.

At each point, a narrow metal pin will be held vertically, and any vascular plant species, exposed rock, detached plant litter, bare ground or moss intersecting the pin recorded. Multiple items may be recorded

at a single point (including multiple plant species, rock and plants), meaning that when the values for all plants are summed, the total cover may exceed 100%. Every data point for plant species will be recorded as 'basal area' (a point where the plant contacts the ground; a stem or tiller), or 'cover' (a point where any plant part touches the pin, including leaves held away from the base of the plant). Every 'basal' point also contributes to 'cover' (i.e. basal area is a subset of cover).

After the point intercept measurements are complete, an unstructured 3 minute search of the plot will be undertaken, to record all native herb and shrub species. Native herbs and shrubs are defined as any native species not in the families Poaceae, Juncaceae or Cyperaceae. Species of ambiguous native or exotic status will be ignored.

Intensive plots will be allocated randomly (some permanent, some re-allocated), and stratified according to state. The stratification will also require that one or more plots fall within populations of Matted Flax-lily, see below. We do not yet know the spatial distribution of the states, so the stratification cannot be tabulated (cf grassland).

Conservation Areas outside the major GEW Reserve will be sampled by at least 2 plots, with an extra plot added for every 50 ha of woodland vegetation (50-100 ha: 3 plots, 100-150 ha: 4 plots, etc.). Half will be annually re-allocated (at least one of each kind in each relevant area).

Larger vegetation structure plots (50 x 50 m)

Large 50 x 50 m plots will be employed for woodland structure measurements, addressing the following KPIs:

- Percentage of plots in different woodland structure categories
- Percentage of plots with Eucalypt recruits.

The larger plots will each be centred on a 20 x 20 m plot (described above); extending 15 m out each side, and marked with a short, permanent peg at each corner.

All trees >1.3 m tall (breast height) within the plot will be counted, and assigned to size classes based on their diameter at breast height (dbh) (<5 cm (saplings), 5-60 cm (small trunks), >60 cm (large trunks)). *Eucalyptus* stems will be distinguished from stems of other groups (wattles, woody weeds).

The presence or absence of *Eucalyptus* seedlings < 1.3 m high will be recorded.

Canopy photographs will be taken vertically at breast height to allow automated measurement of canopy cover (the mean of four photographs per plot, each taken from a 1 m high tripod located on the corners of the smaller plot). Canopy thus does not include cover below breast height.

Each plot will be assigned to one of three landscape positions, on the basis of subjective field observations:

- Undulating Plains
- Gilgai Plains
- Stony Rises.

Each plot will be assigned to one of four woodland structural types, as shown in Table 8: Plots which do not conform to any listed structural type are physically possible, but are known to be exceedingly rare. Any such plots should be ignored when assessing the structural KPI (i.e. atypical plots are considered neither desirable nor undesirable in the structural mix).

Table 8 Definitions of woodland structural types.

Structural type	Saplings / shrubs per plot	Trunks per plot	Canopy cover
Multi-layered vegetation	10 - 200	>0	>1
Open vegetation	<10	0	<1
Park-like vegetation	<10	>0	>1
Vigorous regeneration	>200	any number	any number

In order to determine whether the percentages of plots in each woodland structure category is within the target range for each category, Table 9 will be consulted. It lists the target ranges for each structural type, according to three different landscape units.

Table 9 Target ranges for structural types, in different landscape units.

GEW vegetation type	Target Range on 'Undulating plains'	Target range on 'Gilgai plains'	Target range on 'Stony rises'
Multi-layered vegetation	10 – 70	0 – 15	70 - 100
Open vegetation	0 – 15	5 – 30	0 - 15
Park-like vegetation	20 – 80	50 – 95	0 - 10
Vigorous regeneration	0 - 5	0 - 5	0 - 5

Rapid plots

Sampling will be repeated every year in spring (1 September – 30 November). All rapid assessment plots will be re-allocated each year.

Each plot will be a square 1 m^2 in area (1 x 1 m).

Within each plot, rapid visual estimates will be made of the cover of the following important elements. Some of these measures do not relate to the KPIs, but refer to the additional measures that are useful for describing GEW dynamics. All of these measures can also be derived from the point intercept data in the intensive point-intercept plots:

- *Themeda triandra*
- *Poa* spp.
- *Austrostipa mollis*
- Native herbs
- C4 native grasses
- C3 native grasses
- Exotic perennial weeds (with Romulea assessed separately, given its highly-seasonal growth pattern)
- Exotic annual weeds
- Bare ground and exposed rock
- Litter
- Eucalypt seedlings
- Eucalypt canopy (yes or no).

State mapping

This monitoring approach addresses the following KPI:

- Hectares making transition between states.

Every five years, in line with the reporting, woodland states will be re-mapped, and compared to the map from the previous period. The area of sites that remain in the same state, or make a transition to a more or less valuable state will be recorded according to table 10 below. Any transition not listed as a feasible positive transition is considered a negative transition or not possible for the purposes of this reporting framework.

It is noted that the states cannot be reliably mapped using remote sensing, and mapping large areas manually can be labour-intensive and is not precisely repeatable. To control the intensity and consistency of mapping, the following procedure will be followed:

- The state-transition model will guide the identification of states
- Up-to-date aerial photographs will be used first to distinguish cropped and non-cropped land
- The previous polygon boundaries will be used and re-annotated in all cases, except where the observer notices an obvious change in state within the polygon; subsequently that polygon will be divided or re-assigned
- The minimum polygon size will be 0.25 ha (equivalent to 50 x 50 m).

Table 10. GEW states and positive transitions

State	'GEW state' for monitoring purposes	Feasible positive transitions
Themeda Woodland (TW)	Yes	n/a
C3 Woodland (C3W)	Yes	TW
Nutrient-enriched Woodland (NW)	Yes	C3W, TW
Derived C3 Grassland (DC3G)	Yes	C3W, TW
Cleared and Nutrient-enriched Pasture (CNP)	No	DC3W, NW
Regeneration Thicket (RT)	No	NW, C3W, TW
Derocked Derived Grassland (DDG)	No	n/a
Derocked and Nutrient-enriched Pasture (DNP)	No	DDG

Vegetation and plant inventory

Soon after securing a property, a complete survey will be made of all vascular plant species. Surveys will be done mostly between September and January, by a qualified and experienced botanist.

The aim of the surveyor is to compile a list of species for the property that is as exhaustive as possible. Each parcel to be surveyed will be walked so that no sizable area remains unsurveyed. For large parcels, this will be done by dividing the site arbitrarily into ~50-100 ha units before survey commences, and treating each unit as an individual patch. For woodland patches where total grass cover is >30%, an effort of 1.5 hours per hectare will be spent searching for plants; until no new plant taxon for the property has been detected for over 30 mins within the patch. For woodland patches where total grass cover is <30%, 1 hour per hectare will be spent searching for plants; until no new plant taxon for the property has been detected for over 30 mins within the patch (preliminary surveys suggest most patches are 'completed' after a 30 minute break in species detection, long before 1.5 hours per hectare is expended). Every discrete patch of un-cultivated woodland (i.e. states TW, C3W, NW, DC3G, RT, and CNP) on a property will be visited. Cultivated sites have a much lower diversity of species and are thus a lower priority for flora inventory. Every wetland or drainage line visible on the aerial imagery will be visited and surveyed with intensity similar to that for grasslands. For non-native vegetation 5 min per hectare should be spent searching.

Occurrences of any ‘significant’ native species will be mapped, including any EPBC or FFG listed species, species considered rare or threatened by either the DELWP advisory list (DEPI 2014d) or by Walsh and Stajsic (2007), or any species considered by the botanists to be locally significant.

Occurrences of any ‘significant’ exotic species will also be mapped, (unless they are so widespread as to make mapping unhelpful), including all species listed under the *Catchment and Land Protection Act 1994*, all species identified as emerging weeds, or any species considered by the botanists to pose a significant threat.

The initial inventory reports will be published for each property. They will identify any areas that warrant repeat surveys for future reporting. Repeat surveys are appropriate in the following circumstances:

- Populations of serious weeds, or suspected emerging weeds
- Populations of significant species
- Mapped ‘hot spots’ which contain concentrations of biological values which are considered important in aggregate.

Fauna inventory

Soon after the acquisition of a property, surveys will be conducted for a sub-set of fauna groups. These groups have been chosen to represent the major vertebrate groups, the major groups of pest animals (e.g. Foxes and Rabbits), important elements of ecosystem function (e.g. Spiders) or notable elements of ecosystem composition or diversity (e.g. Plains-wanderer). As a range of survey techniques will be required, detailed inventory approaches will be developed for each property and will depend on the size of the property and the occurrence and distribution of micro-habitats (e.g. rocky rises, drainage lines). Some taxa require multiple techniques (e.g. reptiles) and some techniques can be deployed to concurrently survey different groups (e.g. camera traps). Table 11 details the suite of fauna groups for inventory in the GEW community. Surveys will be conducted at the appropriate time of year for the particular taxon and by experienced taxon experts.

Table 11: Fauna groups for inventory in GEW properties

Group	Potential survey techniques	Reason for survey
Reptiles	Pitfall traps Funnel traps Active searches Camera traps	Significant component of vertebrate fauna, may contain significant species
Amphibians	Acoustic detectors Spotlighting Pitfall traps	Significant component of vertebrate fauna, may contain significant species
Ground-dwelling mammals	Camera traps	Significant component of vertebrate fauna, may contain significant species
Kangaroos and wallabies	Incidental observations Camera traps	Significant component of vertebrate fauna, may present management issues
Spiders	Pitfall traps Sweep nets	Feeding guild structure likely independent indicator of grassland state and condition
Diurnal birds	Timed area searches	Significant component of vertebrate fauna, may contain significant species
Nocturnal birds	Spotlighting	Significant component of vertebrate fauna, may contain significant species

Group	Potential survey techniques	Reason for survey
Foxes	Spotlighting Incidental observations Camera traps	Significant threat to native vertebrate fauna
Rabbits	Identification of active burrows Incidental observations Camera traps	Cause damage to habitat, threat to native plants
Insectivorous bats	Acoustic detectors	Significant component of vertebrate fauna, may contain significant species
Arboreal mammals	Spotlighting Camera traps	Significant component of vertebrate fauna, may contain significant species

Occurrences of any 'significant' fauna species will be mapped, including any EPBC or FFG listed species or any species considered by subject experts to be locally significant.

The initial inventory reports will be published for each property. They will identify any areas that warrant repeat surveys for future reporting. Repeat surveys are appropriate in the following circumstances:

- Populations of invasive or overabundant species that require management
- Populations of significant species
- Mapped 'hot spots' which contain concentrations of biological values which are considered important in aggregate.

GEW Quality

The KPIs all provide good indications of GEW change under management, but they address separate aspects of the community, and no single KPI is a direct and all-encompassing measure of "composition, structure and function" for the community (see the Program Outcome). Management may, however, cause changes in multiple variables simultaneously and it is not always obvious how one set of changes (relevant to one KPI) compares with another (relevant to a different KPI). To address this issue, an overall 'quality' metric for GEW will be developed, that addresses "composition, structure and function". It will be developed using the approach described for NTG by Sinclair *et al*. (2015). The GEW quality metric will be created specifically for GEW in contrast to similar existing metrics like Habitat Hectares (Parkes *et al.* 2003) that aims to compare condition across ecosystems.

Supporting information

General ecology

In contrast to NTG, GEW has been the subject of very little research, and much of what is known is gleaned from anecdotal observation and inference from related ecosystems, rather than experimental studies on the community.

The community occurs on much the same basalt terrain as the NTG. All of the basic factors which control that system (above) apply to the woodland: high fertility, clay soils, poorly-developed drainage systems, and rocky soils. The one overriding difference is that the factors excluding trees are relaxed, allowing woodland to develop. This may occur in several ways (which may interact):

- Higher rainfall
- Local topographic wetness

- Local rockiness (providing a matrix to hold water, presumably some degree of 'mulching', physical barriers to soil cracking, providing germination niches, etc.)
- Inclusion of larger particles in the soil profile (from multiple origins, including deposition by wind and water or local processes).

In the MSA area, GEW occurs in three terrain contexts, which represent three informal 'types' of the community. These are important, as their ecology, species composition, current condition, and management options differ. Goals for these areas may also differ:

- Undulating plains. On undulating basalt plains, with some rocks at or near the surface, *Themeda triandra* is (in intact examples) the dominant grass, and *Eucalyptus camaldulensis* is by far the dominant tree (Yellow Box *Eucalyptus melliodora* dominates in places in the north-west growth corridor). These areas are topographically similar to many areas of NTG, but receive enough rainfall to support trees. This vegetation probably once supported a middle layer of small trees (e.g. *Acacia melanoxylon*, *Acacia mearnsii*, Drooping She-oak *Allocasuarina verticillata* and Honeysuckle *Banksia marginata* (Hoddle 1839, Kearney 1853)). This stratum is now essentially absent. It was probably lost to timber-gathering, inappropriate fire regimes and browsing by livestock (Beardsell 1997; Hateley 2010; Howitt 1855)
- Gilgai Plains. On gilgai plains, which are flat, with very heavy clay soil and without many rocks at the surface, *Poa labillardierei* dominates the ground layer (in intact examples). The overstorey is dominated by *E. camaldulensis* and Swamp Gum *E. ovata*. It is likely that these gilgai areas never supported many smaller trees or shrubs
- On stony rises or lava barriers, where the ground surface is very rocky and well-drained, the ground layer is (in intact examples) dominated by Soft Spear-grass *Austrostipa mollis*, along with *Themeda triandra*, Weeping Grass *Microlaena stipodies* and a range of wallaby grasses *Rytidosperma* spp. A well-developed shrub layer remains in some places (*Acacia*, *Bursaria*, *Melicytus*, *Allocasuarina*, previously *Banksia*). The tree canopy includes *Eucalyptus camaldulensis*, *E. melliodora* and Manna Gum *E. viminalis*.

Early accounts indicate that tree densities varied greatly, with some areas of 'forest' and other very open woodlands with low tree densities. This was presumably caused in part by topography and local patterns of wetness. However, we know from recent observations that woodland eucalypts may germinate and grow very densely, leading to thick stands of narrow trees. The mechanisms which naturally prevented the formation of dense stands of Eucalypts in most places are unknown, but probably included the following elements:

- Regular burning, which may kill or suppress Eucalypt seedlings, leaving only occasional plants to reach the canopy
- Browsing and grazing by native marsupials, which may have regulated seedling survival
- Competition for water during drought, when individual trees may require root access to areas beyond their crowns, leading to low tree densities
- Competition from grass, which presumably suppresses tree seedling growth
- Periodic drought or flooding, which may have killed cohorts of seedlings.

The large, long lived canopy of River Red Gum trees produces many hollows. These are of great value to mammals and birds (indeed the place name Wollert in the centre of the growth corridor apparently derives from the local aboriginal name for possums - 'Walert'). The detailed surveys of Beardsell (1997) confirmed that the growth corridor supports numerous hollow-dependent animals, with "ten species of parrot…recorded breeding in River red Gum hollows… during the bird census of 25-29th October 1988. These included the Musk Lorikeet, Purple-crowned Lorikeet, Little Lorikeet, Blue-winged Parrot, Little Corella, Long-billed Corella and Red-rumped Parrot" along with more common parrot species. The bark of River Red Gums also forms crevices, under which invertebrates and small reptiles may live (Beardsell 1997).

The stony rises with exposed surfaces, clefts and crevices offer good opportunities for animal thermoregulation, and provide habitat for a number of reptile species, including Bluetongue Lizards and

Cunningham's Skink (Beardsell 1997). Other species of mammal, reptile and invertebrate inhabit the heavy cracking soils, living under ground or under litter.

It is notable that the now-extinct mid-storey once produced edible seed-bearing cones (*Banksia*, *Allocasuarina*), edible exudates (*Acacia*) and nectar (*Banksia*). The nature of the faunal assemblage that once used these resources is undocumented.

Land use legacies and threats

Agricultural settlement brought about significant changes in the management of this community.

- Fire regimes changed. Intense and extensive fires may have been used to 'clear out' country by early settlers, but a regime of fire suppression has dominated for over a century
- Grazing by livestock has altered the biological composition of the ecosystem, and the properties of the soil (Dorrough *et al*. 2004b; Lunt *et al*. 2007). The changes involve soil compaction, shifts in soil nutrients, loss of grazing-sensitive species (such as tall native herbs), reduced eucalypt recruitment, reduced fire frequency and altered competitive interactions which favour some groups of exotics (notably annuals)
- Mature trees and shrubs are often removed for firewood (Howitt 1855)
- Some areas are used for cropping which involves turning the soil, removing rocks, and usually adding fertilisers (increasing, particularly, phosphate levels). Rocks were also removed from the plains and used to build dry stone walls
- Introduced animals have displaced or preyed on native animals, leading to massive local (and absolute) extinctions
- Introduced plants have displaced native species, particularly *Nassella* species from South America, and many other species which compete well in nutrient-enriched places.

Land use continues to change, and all of the factors above remain threats. In addition to these factors, ecological 'debts' incurred by past land uses continue to threaten this community. These may result in the extinction of native species as a result of small population sizes and insufficient habitat area or quality.

DELWP has produced a 'state-transition' model which describes the shifts in structure and composition that occur to the woodland community when it is perturbed by human intervention (or lack of intervention). The states can be recognised and mapped in the field, and can be used to summarise the series of ecological changes that have occurred in the past, and the constraints that this legacy puts on management and restoration for the future. Some states are considered desirable, others merely tolerable, and others undesirable. In addition to the state model, this monitoring framework recognises a series of 'structural types'. It is important to note how these differ from the state model:

- The state-transition model records step changes in the function of the community, and is structured to show departures from a reference state, and hence changes in ecological condition or value
- Structural types record gradual cycles of change to the woody layer over time. These changes (like weed invasion) may play out within a state. None of the structural types are inherently desirable or undesirable, but the relative abundance of them is considered important, hence the KPI related to structural heterogeneity is distinct from that related to states.

The target ranges for the structural types are derived from expert responses (9 respondents with some missing values where experts declined to comment on a given scenario). The experts were asked to imagine segments of land (100 x 100 m) conforming to each structural type, and to select how many of each type they would use to construct their optimally structured landscape. Aggregation or dispersion was not considered. Note that larger ranges reveal low expert consensus, and hence a broad target that may rarely require active pursuit

Monitoring techniques

The quantification of woodland structure is part of the science of 'forest mensuration', a well-developed field with a large literature dealing with measurement techniques and statistics for describing all aspects of tree size, shape, density, arrangement and temporal change. The techniques employed here (e.g. diameter classes and stem density) are standard and have been widely employed for many decades (Van Laar and Akça 2007).

Beneath the tree and shrub layer, GEW closely resembles NTG; the methods for monitoring the ground layer are shared between these communities.

The composition, structure and function of Seasonal Herbaceous Wetlands (freshwater) of the Temperate Lowland Plains improves

Introduction

The outcome

The Victorian Government has committed to improving the composition, structure and function of Seasonal Herbaceous Wetland (freshwater) of the Temperate Lowland Plains (SHW) within the program area(here after SHW). This will be achieved through a range of outputs, particularly the establishment and management of a 15,000 hectare grassland reserve and network of Conservation Areas within the Urban Growth Boundary (UGB).

This outcome will be measured in the following Conservation Areas for SHW greater than three hectares in size:

- Western Grassland Reserve (Figure 7)
- Conservation areas 2, 15 (Figure 8).

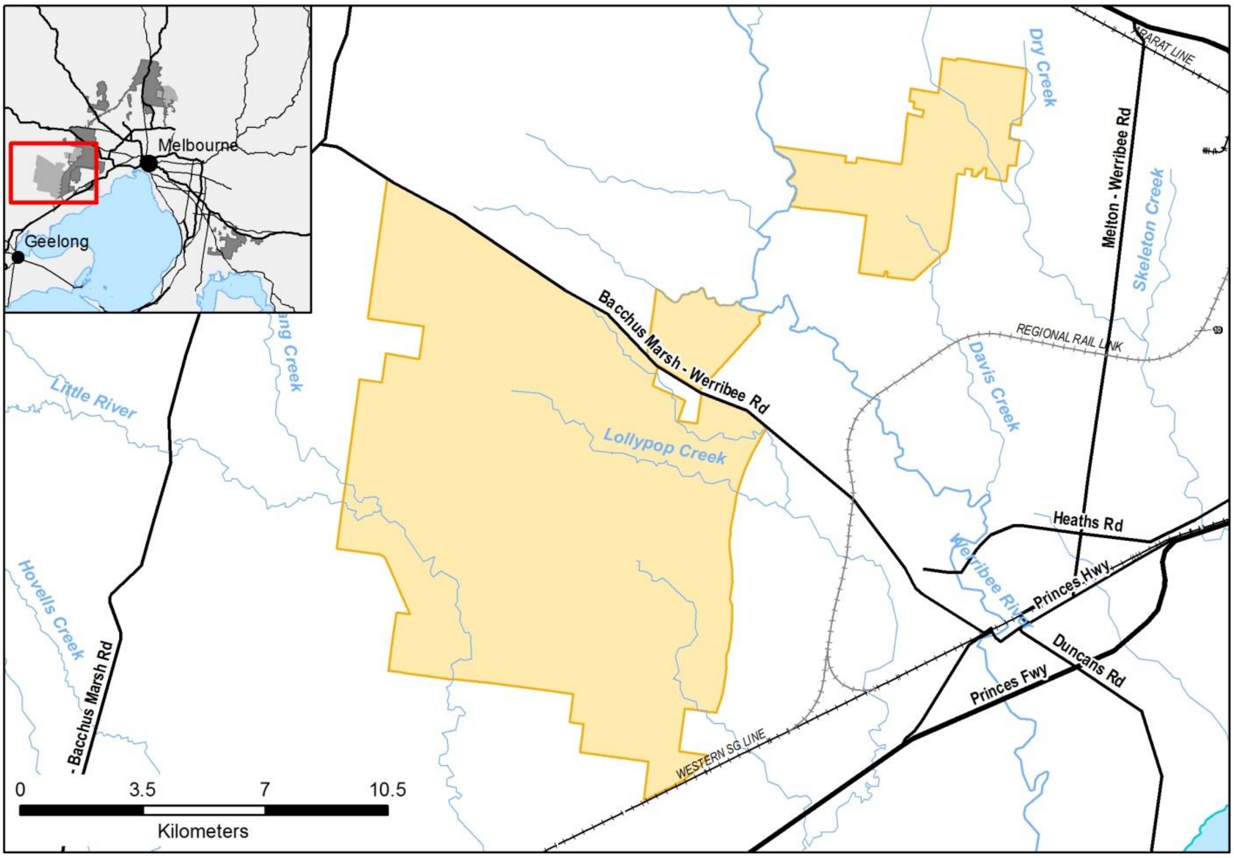

Figure 7: SHW (freshwater) - Western Grassland Reserve

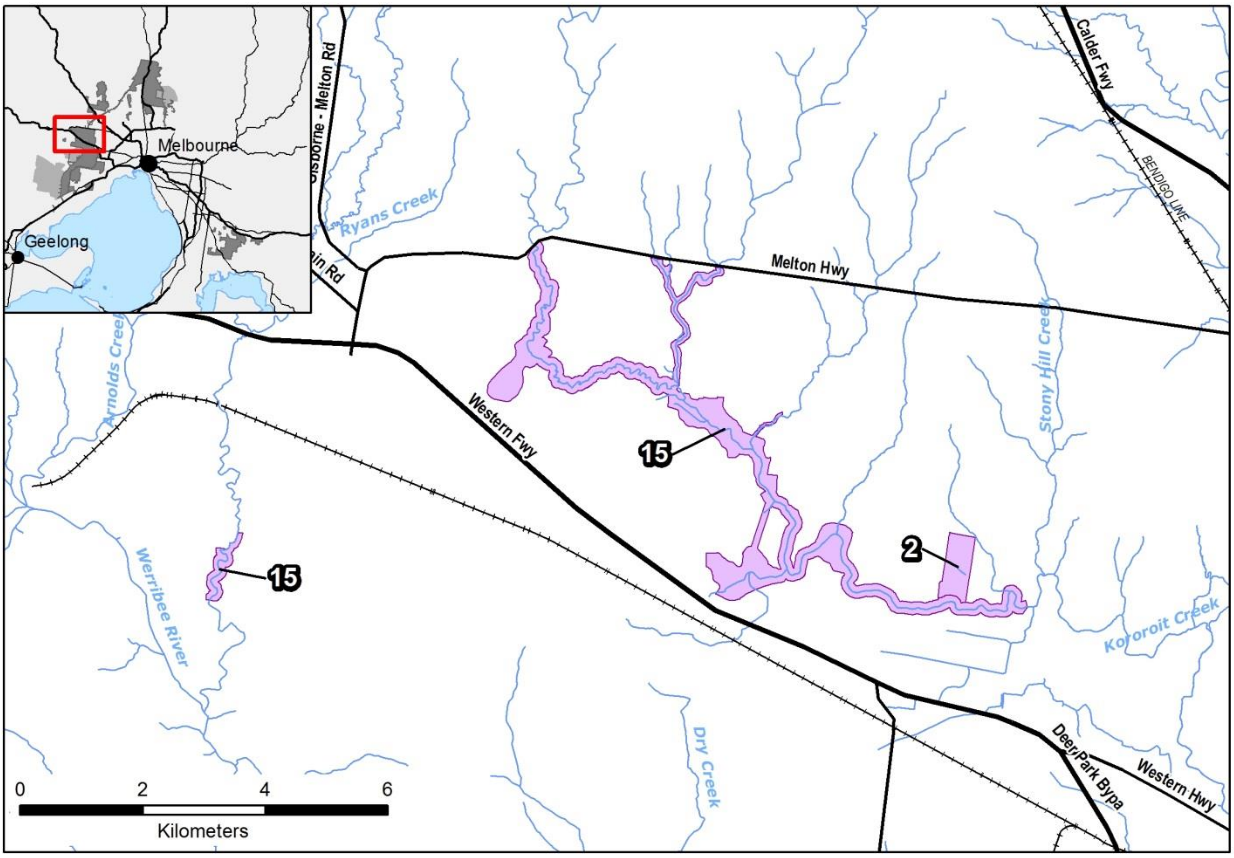

Figure 8: SHW (freshwater) - Conservation Areas, Western Growth Corridor

Description of the community

SHW are wetlands that occur on fertile clay soils. They are inundated after rains, but may remain dry for long periods. Their vegetation is low and open, composed mostly of grasses, sedges, broad-leaved herbs and ferns. In the MSA area, they most often occur in association with NTG, on volcanic soils. The community is described in detail in the Commonwealth listing advice (TSSC 2012).

Distribution of the community

This community was formerly scattered in large and small patches across the lowland plains of south-eastern Australia, including in the MSA region the Victorian Volcanic Plain and the Gippsland Plain. It is now restricted to small, scattered remnants throughout its former range (TSSC 2012).

Conservation status of the community

SHW are listed as Critically Endangered under the EBPC Act (Department of the Environment 2009b). The community overlaps with 'Herb-rich Plains Grassy Wetland (West Gippsland) Community' listed as threatened under the FFG Act.

Key performance indicators

Table 4 KPIs to demonstrate an improvement in the composition, structure and function of SHW.

KPI:	Diversity of native perennial herbs during spring-summer	
Measure	Baseline	0
	Data collection	Estimated diversity of native perennial herbs collected in spring- summer annually in each wetland >three ha compared to the mean diversity for that wetland five years after land is secured

KPI:	Diversity of native perennial herbs during spring-summer	
	Data management	Native Vegetation Information Management System (NVIM)
	Target	The five year mean change in diversity of native perennial herbs remains above the baseline
	Confidence Interval	The upper 95% confidence interval of the five year mean of the diversity of native perennial herbs remains above the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Ten years after land is secured.
	Responsibility	Department of Environment, Land, Water and Planning
KPI:	**Diversity of all native herbs during drawdown**	
Measure	Baseline	0
	Data collection	Estimated diversity of all native herbs collected one month after observed peak water level in each wetland >three ha compared to the mean diversity for that wetland for drawdown events within the first five years of land being secured
	Data management	Native Vegetation Information Management System (NVIM)
	Target	The five year mean change in diversity of all native herbs remains above the baseline
	Confidence Interval	The upper 95% confidence interval of the 5 year mean of the diversity of all native herbs remains above the baseline
	Frequency	Opportunistic, dependent on rainfall (no more than once a year)
Reporting	Forum	Five yearly Report
	Start Date	Ten years after land is secured
	Responsibility	Department of Environment, Land, Water and Planning
KPI:	**Per cent of all perennial vegetation during Spring-Summer composed of weeds**	
Measure	Baseline	0%
	Data collection	Per cent of vegetation which is perennial weeds in each wetland >three ha in extent monitored in spring-summer annually compared to the original per cent in that wetland in the year land is secured
	Data management	Native Vegetation Information Management System (NVIM)
	Target	Mean change in per cent cover of perennial vegetation that is perennial weeds remains below the baseline
	Confidence Interval	The lower 95% confidence interval of the mean change in per cent cover remains below the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Five years after land is secured
	Responsibility	Department of Environment, Land, Water and Planning
KPI:	**Per cent of all perennial vegetation during drawdown composed of weeds**	
Measure	Baseline	0%
	Data collection	Per cent of vegetation which is perennial weeds in each wetland >three ha in extent monitored one month after observed peak water level compared to the original per cent in that wetland in the first drawdown event after the land is secured
	Data management	Native Vegetation Information Management System (NVIM)
	Target	Mean change in per cent cover of perennial vegetation that is weeds remains below the baseline

KPI:	Per cent of all perennial vegetation during drawdown composed of weeds	
	Confidence Interval	The lower 95% confidence interval of the mean change in per cent cover remains below the baseline
	Frequency	Opportunistic, dependent on rainfall (no more than once a year)
Reporting	Forum	Five yearly Report
	Start Date	Five years after land is secured
	Responsibility	Department of Environment, Land, Water and Planning

Other data collection

Table 5 Other data collection to support analysis of cause of change in SHW.

Data	Annual weeds
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM)
Data	Soil phosphorous and nitrate
Frequency	Every five years
Data management	Native Vegetation Information Management System (NVIM)
Data	Dates of filling and draining
Frequency	As observed
Data management	Native Vegetation Information Management System (NVIM)
Data	Diversity of 'High quality' indicator species as recorded in the monitoring plots
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM)
Data	Cover and diversity of woody shrubs, as recorded in the monitoring plots
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM)
Data	'Quality' of the wetland in each plot, using the SHW quality metric
Frequency	Annually, calculated from plot data.
Data management	Native Vegetation Information Management System (NVIM)

Monitoring protocol

Whole-wetland grid sampling

The following sampling procedure addresses the following KPIs:

- Per cent of all perennial vegetation composed of weeds (in spring-summer)
- Per cent of all perennial vegetation composed of weeds (at drawdown)
- Diversity of native perennial herb species (in spring-summer)
- Diversity of all native herb species (during drawdown).

All SHWs within the Western Grassland Reserve and Conservation Areas that are over three ha in size will be monitored. Each wetland provides a single estimate of the relevant measures, which are combined for reporting purposes.

The subject wetlands will be visited and monitored annually in Spring-Summer (defined here as 1September-23 December). At this time, the proportion of perennial vegetation that is exotic will be measured and target species searches will be conducted.

The wetlands will also be visited ~one month after they have reached maximum filling and are drawing down (up to once per year). At this time, the proportion of perennial vegetation that is exotic will be measured and target species searches will be conducted. Maximum filling will be judged based on monthly 'drive-by' observations of selected wetlands in the north and west of Melbourne that are readily observable.

At these times, each wetland will be crossed by a series of parallel line transects 25 m apart (oriented in any convenient direction to cover the wetland). The locations of these transects will be recorded using a hand-held GPS, so that each monitoring round will use a similar sampling layout. An observer will walk each transect, and place a 1 x 1 m frame on the ground every 10m. Within this quadrat, point-intercept measures will be taken at 9 points, distinguishing the following plant species groups:

- Native perennial herbs and ferns
- Native perennial grasses
- Native perennial sedges and rushes
- Exotic perennials.

These data will result in a simple cover estimate for natives and exotics at each sampling location, at a density of approximately 40 observations per hectare, although this will vary for wetlands with irregular shapes. It is estimated that this sampling intensity will provide approximately 70 observations for the smallest wetland, 1080 for the largest.

All the plot estimates from a given wetland will be combined to form a total cover estimate for that wetland. The data from multiple wetlands can be combined for reporting purposes using an area-weighted average.

To determine the diversity of native annual and perennial herb species, two appropriately experienced observers must search each wetland, spending at least 10 min/ha and record all herb species.

Vegetation and plant inventory

Soon after the acquisition of any relevant wetland, a complete survey of all vascular plant species in the wetland will be conducted in spring. Surveys will be done by a qualified and experienced botanist.

The aim is to compile a list of species for the property that is as exhaustive as possible. Each wetland will be walked so that no sizable area remains unsurveyed. An effort of 1.5 hours per hectare will be spent searching for plants; until no new plant taxon has been detected for over 30 mins.

Occurrences of any 'significant' native species will be mapped, including any EPBC or FFG listed species, species considered rare or threatened by either the DELWP advisory list (DEPI 2014d) or by Walsh and Stajsic (2007), or any species considered by the botanists to be locally significant.

Occurrences of any 'significant' exotic species will also be mapped, (unless they are so widespread as to make mapping unhelpful), including all species listed under the *Catchment and Land Protection Act 1994*, all species identified as emerging weeds, or any species considered by the botanists to pose a significant threat.

The initial inventory reports will be published for each property. They will identify any areas that warrant repeat surveys for future reporting. Repeat surveys are appropriate in the following circumstances:

- Populations of serious weeds, or suspected emerging weeds

- Populations of significant species.

Fauna inventory

Soon after the acquisition of a property, surveys will be conducted for amphibians, using acoustic call detectors and/or spotlighting. The intensity of survey effort will depend on the number, size and spatial configuration of the community on the property. Surveys will be conducted by experienced herpetologists and ornithologists. Occurrences of any 'significant' species will be mapped, including any EPBC or FFG listed species or any species considered by subject experts to be locally significant.

The initial inventory reports will be published for each property. They will identify any areas that warrant repeat surveys for future reporting. Repeat surveys are appropriate in the following circumstances:

- Populations of invasive or overabundant species that require management
- Populations of significant species.

SHW quality

The KPIs all provide good indications of SHW change under management, but they address separate aspects of the community, and no single KPI is a direct and all-encompassing measure of "composition, structure and function" for the community (see the Program Outcome). Management may, however, cause changes in multiple variables simultaneously and it is not always obvious how one set of changes (relevant to one KPI) compares with another (relevant to a different KPI). To address this issue, an overall 'quality' metric for SHW will be developed, that addresses "composition, structure and function". It will be developed using the approach described for NTG by *Sinclair et al*. (2015). This SHW quality metric will be created specifically for SHW in contrast to similar existing metrics like Habitat Hectares (Parkes *et al.* 2003) that aims to compare condition across ecosystems.

Supporting information

General ecology

SHWs are not well studied, and research on other similar wetlands must be used to interpret their ecology, along with local natural history observations.

SHW are inherently dynamic. Most SHWs have relatively small catchments and fill in response to local rainfall which varies in quantity and timing from year to year (often in the cooler months, sometimes after heavy summer storms). Depending on when rains fill the wetlands, the rate of evaporation and the temperature of the water produce quite different conditions for plants and animals.

The species that inhabit SHW have developed ways of tolerating this changeable environment. Many species grow prolifically and reproduce when conditions suit, then retreat to a bank of seeds (e.g. *Centipeda*), buried buds (e.g. *Eleocharis* and *Marselia*) or eggs (e.g. Shield shrimp) during hostile periods (discussed for semi-arid wetlands by Brock *et al.* 2003; James *et al.* 2007). Different plant species grow and reproduce at different times of the wet-dry cycle, and in different seasons. Some grow when the wetland is full (e.g. *Myriophyllum*), others on the exposed mud when the wetland is drawing down (e.g. *Pilularia*, *Isoetes*), still others on the dry bed (e.g. chenopods, *Euchiton*, *Senecio*). Many animals (notably wading birds) vacate the wetlands entirely when conditions do not suit. These life-history strategies are common and well-known in seasonal wetlands worldwide (Deil 2005).

The physical and chemical characteristics of SHW are also dynamic. In periods of prolonged drought, the wetland floor may form deep cracks, providing sheltered microhabitats for frogs and other animals. These cracks close when the wetland is wet or muddy. Nutrients also cycle rapidly, being resident in sediments when dry, and entering the water column when inundated. Studies in Australian floodplain wetlands show that phosphorous loads may shift substantially from substrate to water column over periods of weeks

(Knowles *et al.* 2012). While the effects of phosphorous are relatively stable and well known in grasslands and woodlands, the effects of nutrient accumulation in SHW are not well known.

Despite this natural dynamism, different wetlands do maintain distinctive characteristics driven by long-term climatic or hydrological trends. Marginal differences in long term 'wet-dry' cycles can produce a range of vegetation types, from SHW dominated by *Rytidospermum duttonianum* and *Marselia* at sites that experience relatively low rainfall (typical west of Melbourne), to SHW dominated by *Poa labillardierei* (typical north of Melbourne) or *Glyceria* in places that are more often wet.

One defining feature of all SHW sites is their occurrence on fertile clays. Like NTG and GEW, this encourages the growth of some plant families (grasses, daisies, etc.) at the expense of others (heaths, etc.), making SHW universally dominated by grasses or forbs.

The inherent dynamism of the community makes SHW resilient to some human disturbances. For example, while continual ploughing will remove SHW (TSSC 2012) the community certainly survives occasional cropping. Some SHW species survive cropping better than others, and may increase in cover after cropping (e.g. *Eleocharis acuta* and *Marselia* species seem particularly resilient, while *Poa labillardierei* and many herbs seem to be very sensitive). Invasion by dryland weeds (e.g. Thistles) during dry phases is often reversed once the wetland fills, with native wetland species re-occupying the site.

Within the circumscription of the SHW community, marked changes in species composition may occur from place to place and from time to time. These changes are difficult to evaluate in simple terms, since many observed changes in species abundance may represent a natural temporal shift, or a response to degradation. For these reasons, no state-and-transition model has been devised to assist management of SHW (unlike grassland and woodland). Similarly, the KPIs are not framed using the abundance of any particular species, nor are they organised by 'state'.

When SHW was circumscribed under the EPBC Act, a list of plants was defined which indicate a site that remains relatively intact. These species tend to be lost from SHW that is heavily grazed, ploughed, or subject to inappropriate hydrological regimes. The continuing presence of these species is consistent with adequate management, their loss indicates degradation. These species range from conspicuous, widely-spreading species (e.g. *Marselia*) to very cryptic and seasonal species (e.g. *Isoetes*). While this list of species includes many of the most sensitive there are other sensitive species found in eth Melbourne region which also apparently indicate an intact wetland (e.g. *Goodenia heteromera*), and any monitoring protocol should consider a wide range of species.

Land use legacies and threats

SHWs occur in fertile lowland areas which are attractive for agriculture and development, making the community vulnerable to impacts from human land uses:

- Inappropriate grazing by livestock alters the species composition in SHW, with grazing sensitive species being depleted or removed. While this impact may be severe, the circumscription of the community to include dominance by some grazing tolerant species (e.g. *Rytidospermum duttonianum*) means that the community usually persists under grazing, albeit in a degraded form. Grazing by cattle also causes physical damage to SHW soils ('pugging'), and may contribute to increased nutrient loads from animal waste
- Many SHW patches are ploughed, particularly small patches within arable drylands, or patches that fill relatively infrequently. Repeated ploughing combined with cropping may completely degrade or remove SHW; however SHW may survive single or infrequent ploughing, particularly in the absence of weeds and in favourable climatic conditions. Some examples of SHW have probably been shifted from dominance by sensitive species to less sensitive species due to past ploughing, and thus some native species may indicate a more degraded system. There is not enough research to determine whether this has occurred in any particular case, or whether the patterns are natural

- All SHWs have some degree of weed invasion. SHW may, however, be relatively resilient to weeds because the dynamics of wetland filling and drying means that many weeds do not get an opportunity to drive native species out of the site. A few species of wetland weed, however, can compete directly with native species in wet phases (e.g. *Paspalum distichum*)
- Most SHWs have experienced hydrological modification; however the type and degree of impact vary greatly. Modifications include the following:
    - Dams within patches of SHW may deprive the remainder of the wetland of some water causing subtle changes in wet-dry cycles. The earth removed to make the dam is often left on site and can develop permanent weed cover
    - Dams which hold water in former SHW may fill more often than they once did leading to vegetation changes that reflect the new hydrological regime (which may no longer be SHW)
    - Many larger swamps have been drained so they can be cropped or grazed using channels that divert water away from the wetland, removing SHW
    - Groundwater harvesting may deprive SHW of water however the magnitude of this problem is likely small in the Melbourne area
    - Stormwater inputs to SHW may increase the length and depth of inundation and may bring excess nutrients into SHWs
- Most SHWs have received nutrient inputs from fertiliser application in or around the wetland. Most studies of eutrophication are in permanent lakes, estuaries and wetlands, and the effects of eutrophication in SHW are poorly known. Given the close ecological relationships between SHW and other grassy ecosystems on fertile clays (NTG and GEW), it is likely that increased nutrient loads cause shifts in species composition
- Most SHWs have had the surrounding native vegetation removed or degraded. The impacts of this are subtle, but are likely to include elevated levels of weed invasion, altered animal communities, and altered nutrient inputs
- Introduced animals including domestic cats and dogs may disturb native animals within SHW
- SHW are vulnerable to being shaped by earth moving machinery to control water flows (retarding basins, etc.).

Monitoring techniques

There is no generally-accepted concept of SHW ‘condition’, nor any accepted set of measurable indicators which relate to improvement or degradation. Unlike NTG and GEW, there is no conceptual model of SHW to structure goals or monitoring.

There is, however, a large literature on wetland ecology and condition in general, and many relevant examples of monitoring programs in other non-permanent wetlands. This global literature was reviewed and summarised by DELWP (DSE 2005c; 2006) for the creation of the Index of Wetland Condition (DSE 2009a).

Most wetland assessment methods assume that ‘condition’ relates to the retention or loss of those ecological attributes that characterise an ecosystem in its ‘desired natural’ reference condition. There are a relatively small suite of indicators (measurement variables) which are usually used to determine condition in wetlands. They may be summarised as follows (modified from DSE 2005c and subsequent publications, Fennessy *et al.* 2007; The Nature Conservancy 2012):

- Wetland catchment and context (e.g. buffer type and width)
- Wetland size and form (size, shape)
- Hydrological regime (period, season, depth)

- Water properties (salinity, turbidity, nutrient loads, temperature)
- Vegetation composition (native or exotic cover, species diversity, presence or abundance of target species, community heterogeneity)
- Physical structure (Bare ground cover, open water, woody debris)
- Soil conditions (structure, texture, profile)
- Faunal community composition (abundance or diversity of selected taxa, often waterbirds or invertebrates).

These indicators may be measured directly, or assessed indirectly via the degree of threat acting upon them. For some of these variables, remote sensing is increasingly being used to measure changes (Adam *et al.* 2010; Rebelo *et al.* 2009).

Point intercept methods (Godínez-Alvarez *et al.* 2009a) generally provide sound quantitative measures of plant abundance (See grassland and woodland monitoring protocols, above). The dominant species in SHW, however, spread clonally to form extensive mats covering large areas (often tens and occasionally hundreds of square metres). This means that data points within a 20 x 20 m quadrat are highly likely to be non-independent records of the same individual (e.g. the natives *Eleocharis acuta*, *Marselia drummondii*, the exotic *Paspalum distichum*), making the sampling method proposed for grasslands and woodlands inappropriate for SHW. A more spatially dispersed sampling approach is required.

The dynamism of SHW means that the cover of any given species may change radically from year to year, and these changes may not relate to any long term changes of concern. The proportion of weeds is likely to fluctuate substantially, making monitoring and reporting difficult. This can be countered in several ways. The first is to ignore annual species, which are particularly subject to fluctuations. The second is to simplify the measure so that all perennial weeds are considered equivalent. permitting species to come and go; but presuming that highly intact wetlands will generally have low weed cover, and highly degraded wetlands will suffer from continual weed invasions. The third is to measure weed cover not only at regular time intervals (appropriate generally for reporting), but also opportunistically in response to filling and drying events, controlling somewhat for temporal variation.

Similarly, the cover of native species will fluctuate markedly between years and these changes may not relate to any long term changes of concern. One way to counter this fluctuation is to monitor native species only at the phase of wetland filling and drying that they would be expected to be encountered. In the case of SHW, most native species of plants including annuals can be detected when the wetland is drawing down. Many perennials are easily detected every spring and summer.

Important conservation documents and resources

- Advice to the Minister for Sustainability, Environment, Water, Population and Communities from the Threatened Species Scientific Committee (the Committee) on an Amendment to the List of Threatened Ecological Communities under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act): Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains (TSSC 2012)
- The impact of Melbourne’s growth on ‘seasonal herbaceous wetlands (freshwater) of the temperate lowland plains’, Melbourne Strategic Assessment (DEPI 2013e).

No substantial negative change to the population of Button Wrinklewort (*Rutidosis leptorrhynchoides*)

Introduction

The outcome

The Victorian Government has committed to ensuring there is no substantial negative change to the population of Button Wrinklewort within the program area. This will be achieved through a range of outputs, particularly the management of Conservation Area 10 – Truganina Cemetery which is part of the network of Conservation Areas within the Urban Growth Boundary (UGB).

This outcome will be measured in the following Conservation Areas:

- Conservation Area[3]: 10 (NC & PL) (Figure 9).

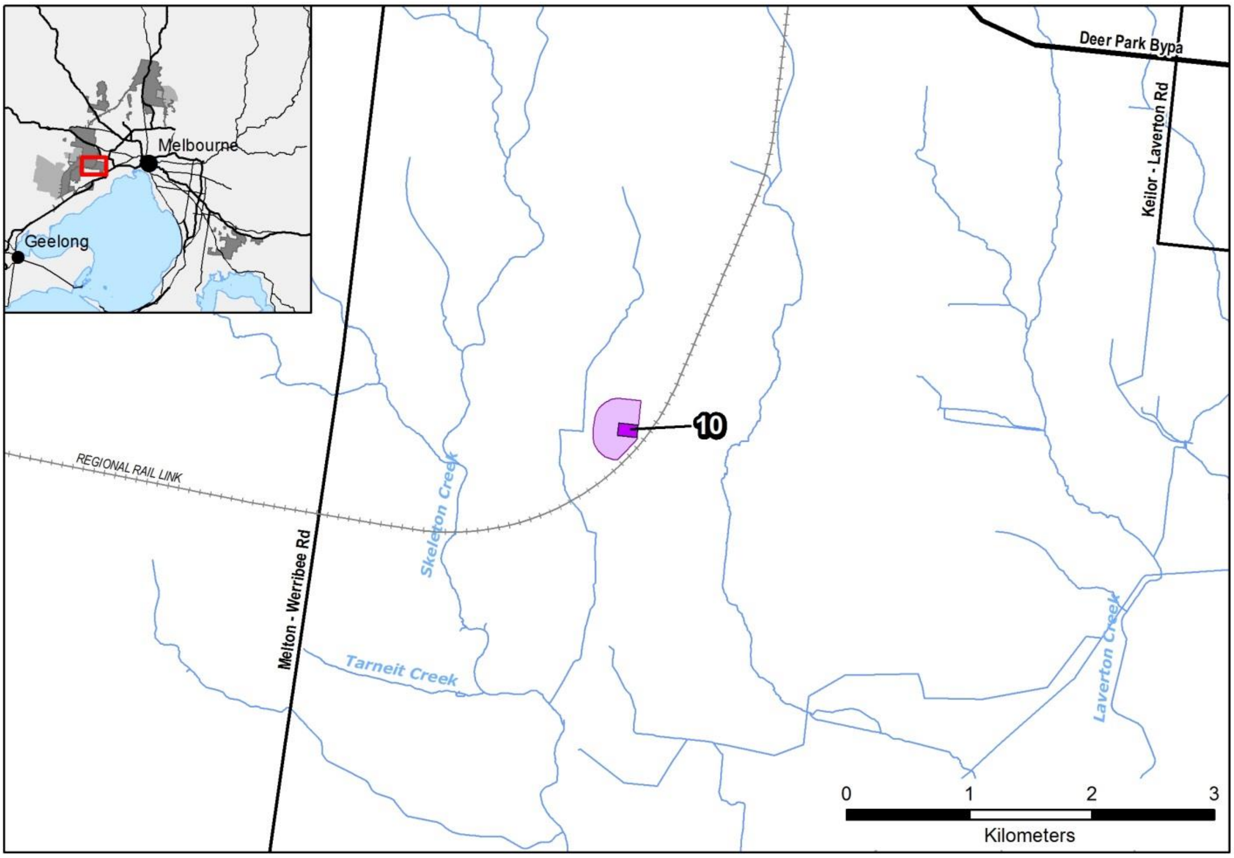

Figure 9: Button Wrinklewort- Conservation Area 10 Truganina Cemetery.

The darker pink section is the Public Land component of the conservation area

Description of the species

Button Wrinklewort *Rutidosis leptorhynchoides* F. Muell. (Asteraceae) is a perennial forb growing 25-35 cm tall. Its leaves are dark green, narrow and up to 3.5 cm long and 1.5 cm wide with rolled edges concealing the undersides. The yellow tubular flowers are held in a compound head 2.5 cm wide (Australian Government 1998).

[3] Brackets refers to the part of the Conservation Area that the outcome monitoring will apply if the Conservation Area is split into multiple categories under the BCS. (NC) – Nature Conservation, (PL) – Existing Public Land

Distribution of the species

This species is known from nine populations in the ACT, seven populations in southern NSW and 11 populations in Victoria (ACT Government 1998; DSE 2009b). In Victoria populations occur in Rokewood, Wickliffe, the western suburbs of Melbourne and between Beaufort and Ararat (Department of the Environment 2012d; N. Scarlett, pers. comm.).

It is known to occur on roadsides and in rail reserves and cemeteries in the Melbourne area and is unlikely to occur on private land in Victoria (J. Morgan, pers. comm.).

Conservation status of the species

Button Wrinklewort is listed as Endangered (EN) under the EPBC Act (Department of the Environment 2009c). It is listed Threatened under the FFG Act and Endangered (e) in the DELWP advisory list (DEPI 2014d).

Key performance indicators

Table 6 KPI to demonstrate no substantial negative change in the population of Button Wrinklewort.

KPI:	Average annual population count over last five years	
Measure	Baseline	Mean population count over the first five years after securing the land
	Data collection	Calculated from annual population counts using transects monitored between November and December
	Data management	Victorian Biodiversity Atlas (VBA)
	Target	Five yearly mean population count remains above the baseline
	Confidence Interval	The upper 95% confidence interval of the five yearly mean population count remains above the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Ten years after land is secured
	Responsibility	Department of Environment, Land, Water and Planning

Other data collection

Table 7 Other data collection to support analysis of cause of change in the population of Button Wrinklewort.

Data	Cover of bare ground
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part monitoring for NTG outcome
Data	Cover of weeds
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part monitoring for NTG outcome
Data	Number of flowering plants
Frequency	Annually
Data management	Victorian Biodiversity Atlas (VBA)

Data	Number of recruits
Frequency	Annually
Data management	Victorian Biodiversity Atlas (VBA)

Monitoring protocol

Monitoring of this species will be conducted annually when it is likely to be flowering (November and December).

Permanently marked transects 3 m apart will be established, covering the known spatial distribution of all plants recorded to date.

Each transect will be examined once annually, between 1 November - 31 December (single experienced observer each transect) and all plants within 1.5 m either side of the transect will be recorded. The positions of plants will be recorded using their co-ordinates on the transect grid.

Any plants which appear to be recruits will be identified (i.e. small plants not encountered previously).

All plants that are reproductive for that year will be identified (i.e. in bud, flower or seed).

Supporting information

General ecology

Button Wrinklewort occurs in grasslands or grassy woodlands, most commonly on sites with relatively low competition, including sites which have been scalped and low rises with shallow soil and low moisture (ACT Government 1998). This species flowers between December and April, with its stems dying back in Autumn, and new basal leaves emerging in winter (ACT Government 1998). Flowering does not occur in the first year (Morgan 1995b). Pollination is by insects such as scarab beetles, flies and moths.

Most of its seeds fall close to the parent plants (most within ~40 cm), where they germinate as soon as the autumn rains come (within 8-12 days of first major autumn falls, (Morgan 1995a; Wells and Young 2002). Morgan (1995a) found that there was little or no capacity for seed storage in soil from year to year, concluding that they either rotted or were eaten by insects. Scarlett and Parsons (1990), however, stated that stored seeds may remain viable for up to 12 years. Seeds germinate in light or shade, but survival of seedlings is higher in open gaps between grass tussocks (Morgan 1997). Transplanted juveniles can survive in smaller gaps, suggesting that they are more tolerant to competition than seedlings (Morgan 1997). Adult plants are very drought tolerant and probably survive for 10-15 years (Morgan 1995b). Regenerative buds grow at the soil surface and regeneration is not possible from underground structures (Morgan 1999). This combination of factors means that the species is largely dependent on the standing adult plants to reproduce; and that substantial recruitment will only occur every few years when rainfall is sufficient and gaps are available.

The gaps necessary for recruitment may be created by management burning every few years, depending on biomass accumulation. The optimal season is presumably when the plant is dormant (March-June). Gap creation using grazing is inappropriate, as Button Wrinklewort is very palatable and sensitive to removal by grazing.

The population genetics of Button Wrinklewort has been relatively well studied, and more is known about its demographics than most species. Button Wrinklewort is self-incompatible, meaning that pollen is unable to cause fruit set within an individual plant or on a plant with an equivalent genotype (Morgan 1995a; Young and Murray 2000). This mechanism is controlled by a single multi-allelic locus, where incompatible pollen is rejected by the receiving stigma (Young and Murray 2000). Self-incompatibility is advantageous in large genetically diverse populations, such as that of Button Wrinklewort before its habitat

was fragmented. It may be a severe disadvantage when small populations become isolated (Pickup and Young 2008).

Small populations of Button Wrinklewort are demonstrably less 'fit' than larger populations. Morgan (1999) showed that seed set varied greatly from year to year in large populations with notably 'good' and 'bad' years. In contrast, plants in smaller populations were only capable of producing low seed yields; making 'every year a bad year' for smaller populations. Similarly, Pickup and Young (2008) showed that the probability of successful fertilisation of flowers declined in smaller populations. These effects are explained by self-incompatibility. In small populations the probability of incompatible pollen meeting a stigma is elevated. Smaller populations are known to have higher genetic identity in general, supporting this contention (Young and Brown 1999). Importantly, the effects of small populations can be reversed by introducing new self-incompatibility alleles by crossing with other populations (Pickup and Young 2008). Morgan (1999) also suggested that smaller populations may produce less seed because they are less able to attract pollinators. Population density also affects seeding rates. Densely packed populations produce more seed, presumably because pollinator visitation rates or efficiency decrease in sparse stands (Morgan and Scacco 2006).

There is no clear definition of what size defines a "small" population, but the effects noted here are observable in populations of ~500 plants. The Truganina population has fluctuated between ~400-1000 plants since 1994 (J. Morgan, unpublished data). Genetic structure has been closely investigated in Button Wrinklewort. Notably, great variations in chromosome number have been revealed (Brown and Young 2000; Leeton and Fripp 1991; Murray and Young 2001; Young and Murray 2000). All studies agree that the Truganina cemetery population is entirely diploid (i.e. plants have two chromosome sets), making it the largest population of diploid plants in Victoria. Other populations immediately west of Melbourne are diploid (e.g. St Albans), but not those further west (e.g. Bannockburn, Rokewood and Wickliffe) (Murray and Young 2001). Both diploid and tetraploid populations are necessary to preserve the full genetic heritage and evolutionary potential of the species, making Truganina Cemetery an important population. Populations show clear spatio-genetic structure, with positive genetic associations evident from plants growing near each other (within ~1m), presumably due to short distance seed dispersal (Wells and Young 2002).

Button Wrinklewort is easy to propagate and grow and populations can be re-established successfully in the wild. Small populations established by planting survive for many years (Morgan 2000) and produce at least as much viable seed as natural populations, which lead to vigorous and fertile plants. Direct seeding trials have established populations in excess of 1000 plants (Gibson-Roy 2010).

Land use legacy and threats

The main threats to this species are:

- Habitat loss due to urbanisation and industrialisation
- Grazing or an increase in grazing activity as Button Wrinklewort is palatable to stock, recruitment has occurred where grazing has ceased (Department of the Environment 2012d)
- Herbivory by introduced molluscs. This threat is highest closer to urban areas but can be lowered by frequent burning (Holland *et al*. 2007)
- Introduced grasses, which can reduce inter-tussock space and therefore negatively impact recruitment
- Infrastructure works, for populations on road verges or in rail reserves
- Infrequent fire can reduce recruitment due to biomass accumulation (Department of the Environment 2012d);(Morgan 1997) suggests that fire is required at least every three years to maintain sufficient inter-tussock space
- Small population sizes, increasing the risk of local extinction due to stochastic events, inbreeding depression (Young and Brown 1999) and low seed production. Furthermore, the species is

dependent on the standing population for recruitment and therefore vulnerable to things that negatively impact on flowering and seed production (Morgan 1995a).

Monitoring techniques

Button Wrinklewort is visible at all times of year. However, it is more detectable during flowering (November to December) (J. Morgan, pers. com.). In the grassland sites in the Melbourne area, however, it may be lower than the dominant grass (*Themeda triandra*), making it difficult to see unless the observer is close by. There are no studies quantifying the detectability of Button Wrinklewort, but the effect of grass cover on detection rates of many small-statured grassland plants has been shown to be strong (Garrard 2009b).

Actual counts are preferred because (if performed competently) they provide the most accurate record of the population. They are not often employed in ecology because they require intensive effort at each site. Here, however, the single, small (1.6 ha) site makes the use of direct counts feasible. This population has been regularly surveyed using complete counts since 1994, numbers fluctuate from survey to survey but the trend is a population decline (J. Morgan, unpublished data).

Important conservation documents and resources

- FFG Act Action Statement (DSE 2003c)
- National Recovery Plan (OEH 2012)
- Two ABC Bayesian Network models, for St Albans Rail Reserve and Truganina Cemetery.

No substantial negative change to the population of Large-fruit Groundsel (*Senecio macrocarpus*)

Introduction

The outcome

The Victorian Government has committed to ensuring there is no substantial negative change to the population of Large-fruit Groundsel within the program area. This will be achieved through a range of outputs, particularly the management of Conservation Area 5 which is part of the network of Conservation Areas within the Urban Growth Boundary (UGB).

This outcome will be measured in the following Conservation Area:

- Conservation Area: 5.

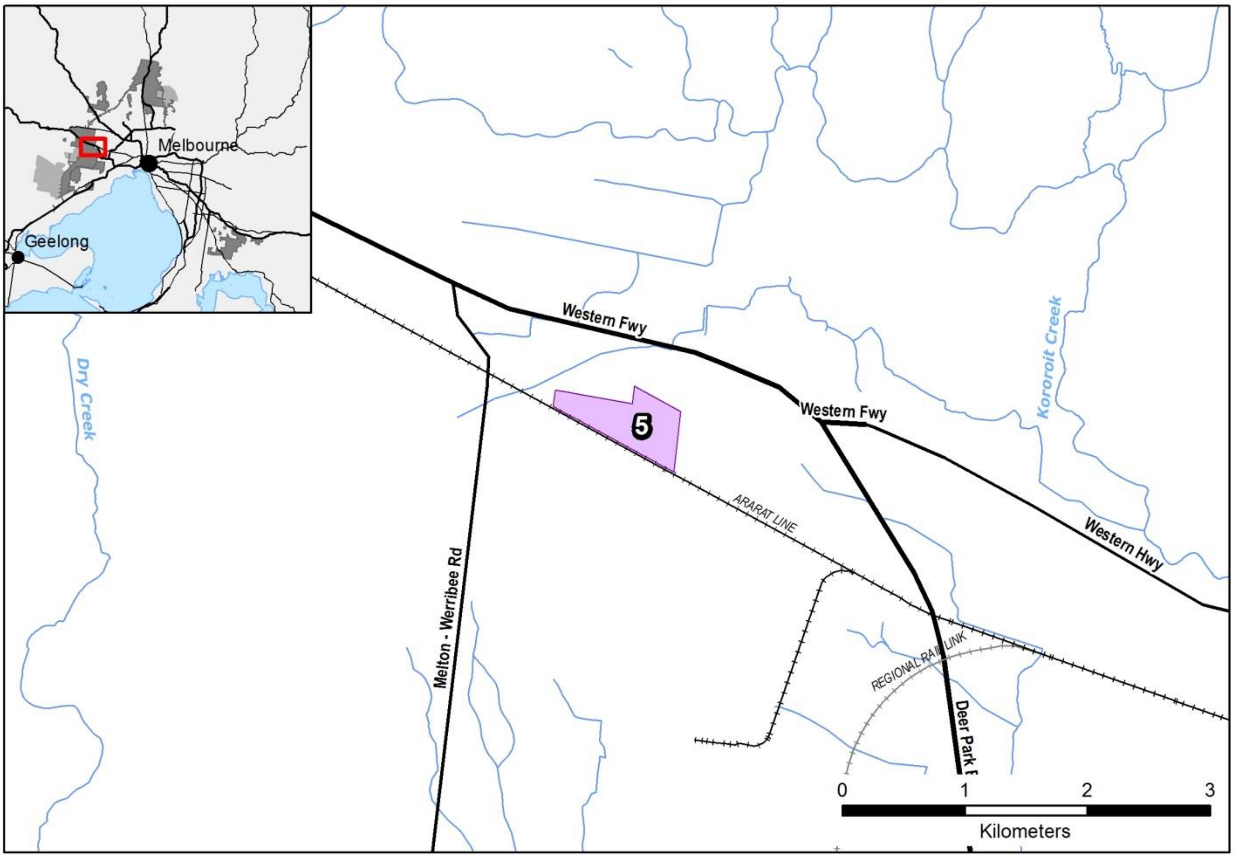

Figure 10: Large-fruit Groundsel- Conservation Area 5

Description of the species

Large-fruit Groundsel, *Senecio macrocarpus* F. Muell. ex Belcher (Asteraceae; also known as Large-headed Groundsel, Large-fruit Fireweed and Fluffy Groundsel), is a perennial daisy usually growing to about 40cm high (Belcher 1983; Hills and Boekel 1996; Walsh 1999). Its foliage is coarse and grey, made up of alternate linear leaves covered with cobwebby hairs. The short inflorescence bears 2-10 heads, each supporting up to 150 tiny yellow florets. These are surrounded by a series of stiff, linear bracts (phyllaries) which remain conspicuous after the flowers and seeds have gone. The flower heads are relatively large compared to other *Senecio* species, hence the common name.

Distribution of the species

Large-fruit Groundsel occurs in Victoria and South Australia and formerly occurred in Tasmania.

In Victoria, Large-fruit Groundsel has been collected extensively from the plains of the west, and in a few other widely dispersed locations. Its easterly limit is now probably Castle Flat at Yan Yean. In the west, Large-fruit Groundsel is known from a rail side at Dobie near Ararat, Yalla-Y-Poora Recreation Reserve, and Deep Lead Flora Reserve. It was once distributed more widely in the west of the state, from Horsham to Nhill (Sinclair 2010).

The core of the species range is the Werribee Plain (between Geelong, Bannockburn, Bacchus Marsh, Sunbury and Melbourne), where numerous collections have been made over many years, and many small populations persist (Sinclair 2010), N. Scarlett, pers. comm., 2012).

Conservation status of the species

Large-fruit Groundsel is listed as Vulnerable (VU) under the EPBC Act (Department of the Environment 2009c). It is listed Threatened under the FFG Act and Endangered (e) in the DELWP advisory list (DEPI 2014d).

Key performance indicators

Table 8 KPI to demonstrate no substantial negative change in the population of Large-fruit Groundsel.

KPI:	Average annual population count over last five years	
Measure	Baseline	Mean population count over the first five years after securing the land
	Data collection	Calculated from annual population counts using transects monitored between September 1st and November 30th
	Data management	Victorian Biodiversity Atlas (VBA)
	Target	Five year mean population count remains above the baseline
	Confidence Interval	The upper 95% confidence interval of the five year mean population count remains above the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Upon securing the land
	Responsibility	Department of Environment, Land, Water and Planning

Other data collection

Table 9 Other data collection to support analysis of cause of change in the population of Large-fruit Groundsel.

Data	Cover of bare ground
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part monitoring for NTG outcome
Data	Cover of weeds
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part monitoring for NTG outcome
Data	Number of new plants

Frequency	Every five years
Data management	Victorian Biodiversity Atlas (VBA)

Monitoring protocol

Monitoring for this species will include an annual intensive count of known plants in the Conservation Area, and a five-yearly broad area survey of the Conservation Area to locate any new or previously undetected plants. All surveys will be undertaken by trained botanists, familiar with identification of this species.

Broad area survey

A broad search of the Conservation Area will be undertaken to locate previously undetected plants, conducted every five years between 1 September - 30 November.

Transects 50 m apart will be established, running north-south across all of Conservation Area 5 (total transect length ~9 km).

Each transect will be examined once (single experienced observer each transect) and any plants visible from the transect will be recorded, in order to detect concentrations of plants in the Conservation Area.

Intensive count

Permanently marked transects 4m apart will be established, running north-south from the railway line fence, covering all known plants (total transect length for current known plants is ~5 km). If any new plants are found outside the existing 4m grid established for counts (above), the 4m grid will be extended or a new 4m grid positioned to cover the newly detected area of occurrence.

Each transect will be examined once (single experienced observer each transect) and all plants within 2m either side of the transect will be recorded and their position noted by marking them with pins, or by recording their co-ordinates on the transect grid;

Plants which appear to be recruits will be noted (i.e. small plants not encountered previously).

Supporting information

General ecology

Published observations of Large-fruit Groundsel across its range (Cutten and Squire 2002; 2003; Davies 1995; 2000; 2003; Morgan 1998c; a; Mueck 2000) allow a picture of its life history and ecological niche to be pieced together. This information was summarised in the National Recovery Plan (Sinclair 2010).

Large-fruit Groundsel is a perennial species which lives for many years, possibly decades. It may remain grey-green all year round, or it may die back during drought and re-sprout from a sturdy rootstock. It flowers in spring, and also over summer in suitable conditions. Most reproduction in this species is likely to derive from apomixis (asexual clonal seed production) or self-fertilisation (Lawrence 1985, Aherns and James 2015). The seeds are relatively large among *Senecio* species, and are probably not dispersed as readily over long distances. Seeds do not remain viable for years when stored in envelopes (D. Tonkinson pers. comm.), and the species probably does not form a significant long-lived seed bank, but this assertion has not been tested. The seeds are able to secrete a mucilaginous (thick, gluey) material when moistened, which presumably acts to glue them onto the soil surface (N. Scarlett, pers. comm.). These basic life-history traits (relatively large seeds, relatively long lifespan) set Large-fruit Groundsel apart from some other local *Senecio* species, which are shorter-lived opportunists.

Most populations of Large-fruit Groundsel are very small (<500 individuals), except for one very extensive population in South Australia (>35,000 individuals). The species displays relatively low genetic diversity across its range, and most small populations have markedly low diversity (Ahern and James, 2015).

Large-fruit Groundsel occurs throughout its range on relatively heavy soils, although these may vary from clays to clay loams. It is tolerant of seasonal waterlogging, some salinity and extreme summer drought.

Morgan (1998a) demonstrated that Large-fruit Groundsel seeds germinate readily without treatment in light or darkness, including under dense swards of grass. Seedlings, however, survive best and grow fastest in large gaps. Thus, like many native grassland herbs, Large-fruit Groundsel benefits from regular biomass removal by fire, or inherently unproductive sites which do not accumulate biomass.

Large-fruit Groundsel plants usually re-sprout after fire (Cutten and Squire 2003), however adult plants may be killed if burnt when the first shoots are emerging from the rootstock (A. Arnold, J. Morgan, pers. comm.). At Laverton, the population seems to have survived a long period of regular mowing (S. Hadden, pers. comm.). Sheep, however, are known to find the species highly desirable, and will consume it in preference to most other vegetation (N. Scarlett, pers. comm.) Sheep grazing was probably responsible for the rapid decline of this species soon after settlement.

Land use legacies and threats

The Recovery Plan for Large-fruit Groundsel (Sinclair 2010) listed the following threats to the persistence of this species:

- Grazing causing the preferential removal of plants
- Inappropriate disturbance regimes permitting biomass to accumulate and restrict recruitment
- Competition from weeds
- Outright Clearing / Removal
- Alterations in hydrology.

Monitoring techniques

Large-fruit Groundsel is visible at all times of year in all but the most extreme drought. In the grassland sites in the Melbourne area, however, it may be lower than the dominant grass (*Themeda triandra*), making it difficult to see unless the observer is close by. There are no studies quantifying the detectability of Large-fruit Groundsel, but the effect of grass cover on detection rates of many small-statured grassland plants has been shown to be strong (Garrard 2009b).

The only known previous systematic surveys for Large-fruit Groundsel were carried out in South Australia at Messent Conservation Reserve, with the aim of precisely delineating the spatial extent of a large population, without estimating its numerical size. That study used a series of widely-spaced transects (total length 60 km), walked by observers who recorded plants within 2m of the transect. This was considered a reasonable distance to easily detect the species in sedgeland (Cutten and Squire 2002; 2003).

Large-fruit Groundsel is very easily confused with *Senecio squarrosus*, which has a similar form, but less-coarse foliage, smaller heads and differently shaped and coloured seeds. The two species may occur together (e.g. Mt Derrimut NCR; S. Sinclair, pers. obs. 2012; in South Australia, Aherns and James, 2015), and Senecio squarrosus is known to occur very close to conservation Area 5. Thus, it is essential that any surveys of Large-fruit Groundsel are conducted by a botanist with experience distinguishing these taxa.

Important conservation documents and resources

- FFG Act Action Statement (DSE 2009b)
- National Recovery Plan (Sinclair 2010).

No substantial negative change to the population of Maroon Leek-orchid (*Prasophyllum frenchii*)

Introduction

The outcome

The Victorian Government has committed to ensuring there is no substantial negative change to the population of Maroon Leek-orchid within the program area. This will be achieved through a range of outputs, particularly the management of Conservation Area 35, which is part of the network of Conservation Areas within the Urban Growth Boundary (UGB).

This outcome will be measured in the following Conservation Area:

- Conservation area: 35 (Figure 11).

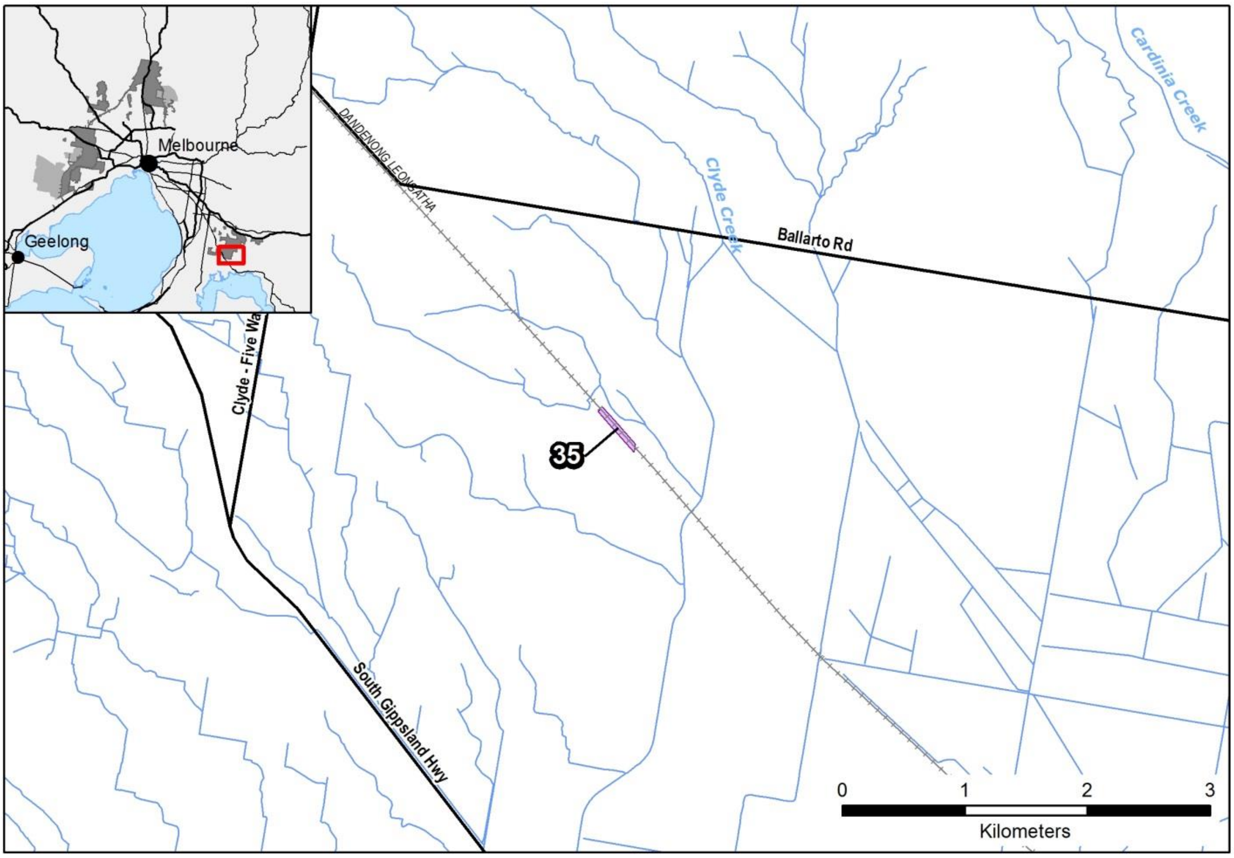

Figure 11: Maroon Leek-orchid- Conservation Area 35

Description of the species

The Maroon Leek-orchid *Prasophyllum frenchii* F. Muell. (Orchidaceae) grows up to 60 cm tall. The stem is green to reddish green. It supports 20-60 maroon or green and maroon flowers, which are subsessile and spreading. The leaf blade is equal to or longer than the inflorescence. The lateral sepals (10 mm long) are elliptic with acuminate tips and the dorsal sepal is broad (8 mm long), erect and slightly curved at the apex. The petals are elliptic and have straight tips. This species has a unique labellum that has a short claw and is ovate in shape. It has a raised, dark and prominent callus plate (Jeanes and Backhouse 1995; Woolcock and Woolcock 1984).

Distribution of the species

This species is endemic to south-eastern Australia with its range extending from south-eastern South Australia to eastern Victoria. It is currently known from seven populations of approximately 1000 plants, six of which are in Victoria (Duncan 2010), and several smaller populations.

Conservation status of the species

Maroon Leek-orchid is listed as Endangered (EN) under the EBPC Act (Department of the Environment 2009c). It is listed Threatened under the FFG Act and Endangered (e) in the DELWP advisory list (DEPI 2014d).

Key performance indicators

Table 10 KPI to demonstrate no substantial negative change in the population of Maroon Leek-orchid.

KPI:	Count of individuals emergent at least once over a five year period	
Measure	Baseline	Count of individuals emergent at least once over the first five years after securing the land
	Data collection	Calculated from annual population counts to locate emergent individuals monitored between September 1st and October 31st
	Data management	Victorian Biodiversity Atlas (VBA)
	Target	Count of individuals emergent at least once over a five year period remains above 90% of the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Ten years after securing the land
	Responsibility	Department of Environment, Land, Water and Planning

Other data collection

Table 11 Other data collection to support analysis of cause of change in the population of Maroon Leek-orchid.

Data	Cover of bare ground
Frequency	Annually - Annual survey in permanent and re-allocated plots
Data management	Native Vegetation Information Management System (NVIM)
Data	Cover of weeds
Frequency	Annually - Annual survey in permanent and re-allocated plots
Data management	Native Vegetation Information Management System (NVIM)

Monitoring protocol

As this species is confined to one small area it is feasible to monitor the entire population in the Conservation Area by an annual ‘count’, aided by permanent marker pins to delineate the distribution of known plants. Monitoring will take place between 1 September - 31 October.

To find previously marked plants and establish the location of new plants, the Conservation Area will be walked four times (twice each for two people), along marked transects parallel to the railway line (~2 km in total), avoiding the railway line, railway ballast and dense blackberry thickets.

All plants will be marked with a numbered pin and by recording the co-ordinates with reference to the transect. The numbered pin will be located at the north corner of a (hypothetical) 10 x 10 cm square centred on the plant, with one side oriented parallel with the railway line (NW-SE).

The status of any previously marked plants (with marker pins) will be noted as either emergent or not. Plants are considered to be the same individual if they emerge within the 10 x 10 cm square aligned as described above. A metal detector may be used to locate marker pins.

At each count, each 10 X 10 cm square is recorded as occupied or not. The final count of emergent individuals for each year is given by the number of occupied squares.

Weed and bare ground surveys

At the first survey, four plots consisting of two 20 m transects, 5 m apart parallel to the railway line, will be randomly positioned. Half of the plots (2) will be randomly re-located at each subsequent survey and the other two will be permanently marked and re-visited at each survey.

These lines will each define a set of 100 sampling points, located 20 cm apart. In total, the plot will contain 200 sampling points.

At each point, a narrow metal pin will be held vertically, and any perennial monocot and dicot weeds and any bare ground, intersecting the pin recorded. Multiple items may be recorded at a single point (including multiple plant species, rock and plants), meaning that when the values for all plants are summed, the total cover may exceed 100%. Every data point for plant species will be recorded as "basal area" (a point where the plant contacts the ground; a stem or tiller), or "cover" (a point where any plant part touches the pin, including leaves held away from the base of the plant). Every "basal" point also contributes to "cover" (i.e. basal area is a subset of cover).

Supporting information

General ecology

Maroon leek-orchid is poorly represented in the academic literature and thus there is very little information about its biology. It inhabits grassland and grassy woodland on sandy to black clay loams. Sites are damp, and range from well-drained to seasonally waterlogged. Some sites have had periodic fire or grazing. The specific habitat requirements of this species are not well known (Duncan 2010).

A single leaf emerges in late autumn after the onset of seasonal rains. In the southern part of its range, including around Melbourne, flowering starts in late October and is finished by late November. The leaf shrivels about four weeks after the end of flowering and if the plant has been pollinated the seed capsule begins to ripen. The plant survives through the summer as a dormant tuber, which is replaced annually.

The pollinator of this species is not known, but other species in the genus *Prasophyllum* are visited by a range of insects including bees, wasps, ants and beetles. There may not be a specific insect pollinator and it is also possible that self-pollination occurs as this is known from some *Prasophyllum* species (Duncan 2010). Dormancy is common in this species and seems to fluctuate widely with no discernible pattern or relationship to environmental conditions (M. Duncan pers. comm.).

Land use legacies and threats

Despite the relative lack of knowledge about this species, some threats to its persistence are clear.

- The loss or degradation of habitat due to agriculture and urban development

- Populations on road or rail lines are at risk from maintenance activities
- Small, isolated populations make the species vulnerable to local extinction due to stochastic events (the role of genetic factors is unknown)
- Grazing by stock, kangaroos, rabbits, molluscs and caterpillars
- Weeds, especially perennial grasses, *Watsonia meriana* and *Rubus fructicosus* (at the Clyde population)
- Altered fire regimes, particularly the prolonged absence of fire, which can lead to a build-up of grass biomass, inhibiting growth and flowering. This is a problem at Clyde
- Alteration of the hydrological regime can lead to habitat being unsuitable. Draining of shallow freshwater marshes or dam construction has the potential to unfavourably alter the hydrology of a site
- Climate change leading to drying in south-eastern Australia is a potential long-term threat to this species (Duncan 2010).

Monitoring techniques

This species is notoriously difficult to monitor as it is near impossible to determine if previously unknown plants are new recruits, previously dormant plants or previously vegetative plants (K. Lester, pers. comm.). It can be difficult to determine whether the leaves of this species belong to a single plant that has multiple growth points or has formed clonal tubers, or to genetically distinct plants growing close together. The species also displays an erratic emergence and dormancy pattern, such that the number of leaves emerging in any season may not represent the full complement of living plants in any area. This species can undergo long periods of dormancy and emergence is unpredictable making demographic monitoring difficult (M. Duncan, pers. comm.). There is no specific quantitative information about detection rates.

Important conservation documents and resources

- FFG Act Action Statement (DSE 2003a)
- National Recovery Plan (Duncan 2010)
- The Victorian Threatened Orchid Recovery Team.

No substantial change to the population of Matted Flax-lily (*Dianella amoena*)

Introduction

The outcome

The Victorian Government has committed to ensuring there is no substantial negative change to the population of Matted Flax-lily within the program area. This will be achieved through a range of outputs particularly the establishment and management of a network of Conservation Areas outside the Urban Growth Boundary (UGB).

The outcome will be measured in the following conservation areas:

- Grassy Eucalypt Woodland Reserve (Figure 12)
- Conservation Areas[4]: 22B and 22C (NC), 23 (NC), 24, 26, 33A (NC), 34B and 34C (NC) (Figure 13).

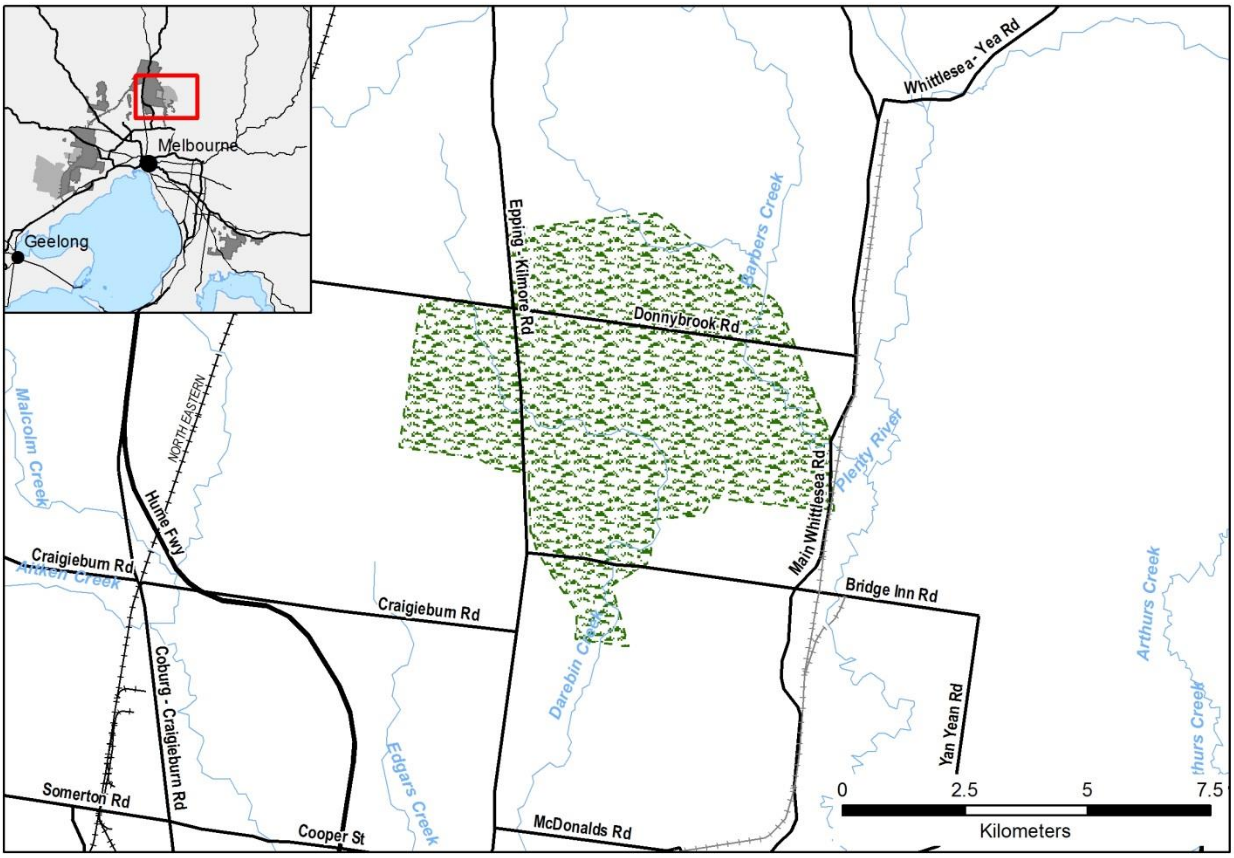

Figure 12: Matted Flax-lily- Grassy Eucalypt Woodland Reserve (indicative boundary)

[4] Brackets refers to the part of the Conservation Area that the outcome monitoring will apply if the Conservation Area is split into multiple categories under the BCS. (NC) – Nature Conservation, (PL) – Existing Public Land

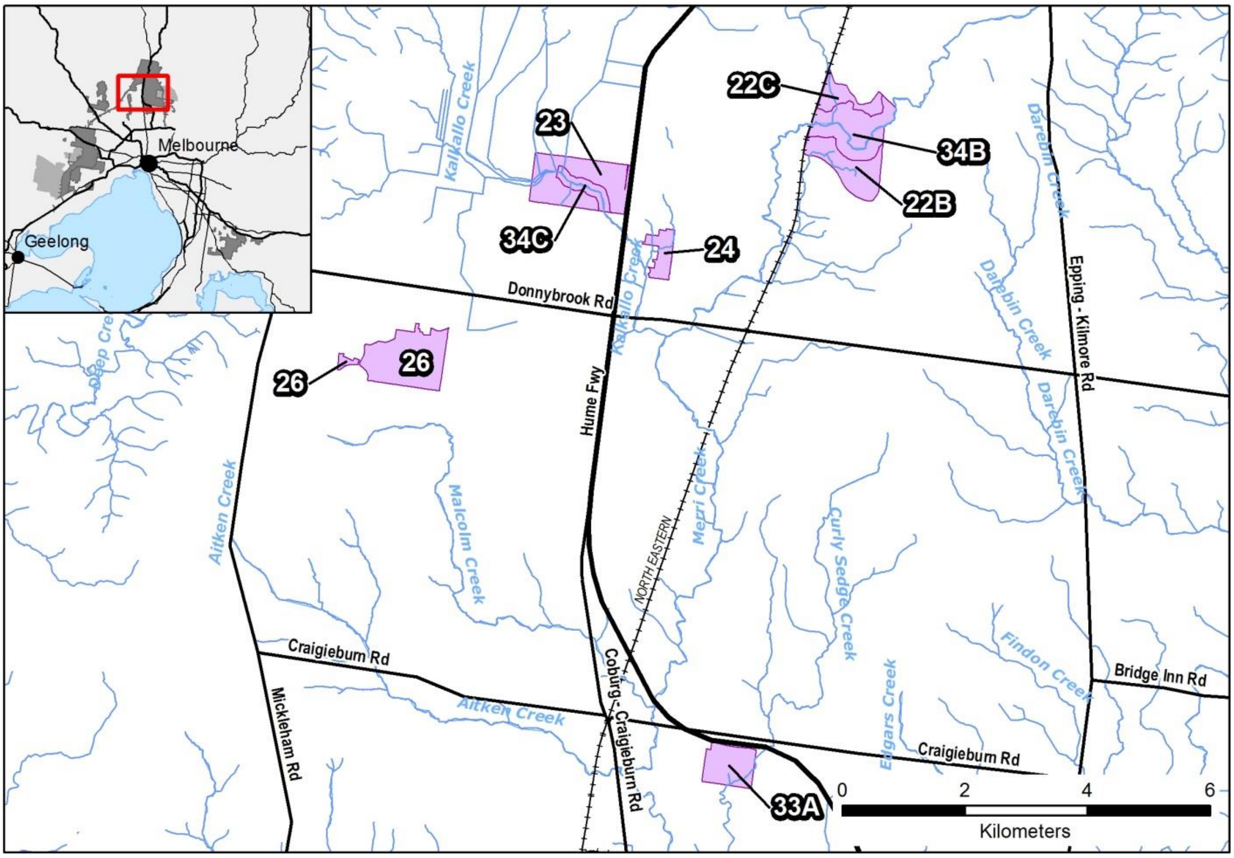

Figure 13: Matted Flax-lily- Conservation Areas, Northern Growth Corridor

Description of the species

Matted Flax-lily *Dianella amoena* G.W. Carr & P.F. Horsfall (Liliaceae s.l.) is a perennial lily that forms mats up to 5 m wide. It has linear grey-green leaves up to 43 cm long and 4-12 mm wide. There are small, irregularly spaced teeth on the leaf blades, sheaths and midribs. There is a distinct red colouration on the base of many plants. It produces large star-shaped flowers with pale to deep blue-violet petals on 20-90 cm arching stems. There are six prominent stamens on each flower with bright orange strumae before the lime-yellow anther. Pollinated plants produce round purple berries 7 mm in diameter (Carr and Horsfall 1995; DSE 2005a).

Distribution of the species

Matted Flax-lily is currently thought to be endemic to Victoria; there are old records from Tasmania, but it is now presumed extinct in that state. In Victoria it had a wide but patchy distribution ranging from the south-west to the east of the state. There are unconfirmed observations from between Stawell and Horsham. Matted Flax-lily is now known from about 120 sites forming about 50 reproductively isolated populations. Most of these populations are small and highly fragmented; there are thought to be about 2,500 plants in total (Carter 2010), although this may be an under-estimate due to limited survey effort.

Conservation status of the species

Matted Flax-lily is listed as Endangered (EN) under the EBPC Act (Department of the Environment 2009c). It is listed Threatened under the FFG Act and Endangered (e) in the DELWP advisory list (DEPI 2014d).

Key performance indicators

Table 12 KPI to demonstrate no substantial negative change in the population of Matted Flax-lily.

KPI:	Average annual population count over last five years	
Measure	Baseline	Mean population count for the first five years after securing the land
	Data collection	Annual population counts using transects monitored between October and January
	Data management	Victorian Biodiversity Atlas (VBA)
	Target	Five year mean population count remains above the baseline
	Confidence Interval	The upper 95% confidence interval of the five year mean remains above the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Ten years after land is secured
	Responsibility	Department of Environment, Land, Water and Planning

Other data collection

Table 13 Other data collection to support analysis of cause of change in the population of Matted Flax-lily.

Data	Cover of bare ground
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part monitoring for the GEW outcome
Data	Cover of weeds
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part monitoring for the GEW outcome

Monitoring protocol

Monitoring for this species will include an annual census of known plants, and a five-yearly broad area survey to locate any new or previously undetected plants. All surveys will be undertaken by trained botanists, familiar with identification of this species.

Broad area surveys

Every five years, searches will be conducted of suitable habitat within the conservation areas. This is to detect individuals that have not been formerly detected.

Searches will be structured, with each Conservation Area divided into portions of ~50 ha, each searched for ~2.5 hours if they are predominantly native vegetation or stony rises, and otherwise for 1 hour. According to (Garrard 2009a) this additional survey effort offers a detection probability substantially less than 0.2 (20% chance of finding the species if present) even under ideal conditions, however it is likely to add significantly to the effort expended to date on locating this species (which is unknown).

Annual sampling

Every year, all known plants will be visited and recorded as alive, dead, absent. Previously unrecorded plants observed in the broad area surveys are to be added to the annual population count and re-visited during subsequent annual population counts. Plants locations will be recorded using GPS co-ordinates.

Supporting information

General ecology

Matted Flax-lily occurs on grassland and grassy woodland. It occurs on a variety of soils, including well drained to seasonally wet, fertile and sandy loams to cracking clays. Many sites have been substantially altered by agriculture and urbanisation and therefore contain numerous introduced species (Carter 2010).

Pollination in this species is largely carried out by native bees (Blue-banded Bee, *Amegilla cingulate* and *Lasioglossum* spp.) (Department of the Environment 2012e); G. Carr and K. Just, pers. com.) with seed dispersal mostly by fruit-eating birds and possibly reptiles (DSE 2009b). Vegetative reproduction via rhizomes is also possible (Department of the Environment 2012e). Flowering is from October to April. When pollinated the ripe seeds are black and shiny (DSE 2005a). Plants can form small clumps (up to 20 m^2). Most populations are only a few plants (Carter 2010). Twenty one sites have been identified as significant for the survival of this species, more information can be found in Carter (2010).

In the short-term, Matted Flax-lily appears to be relatively resilient to habitat degradation, being able to persist in heavily weed dominated areas and in areas subject to heavy stock grazing. This is due to its rhizomatous habit, as the plant forms dense clusters that once established can re-sprout. However, the processes of weed invasion and stock grazing could have a detrimental effect on the species over the long-term. This is because the plants currently observable are most likely old colonies that established when the habitat was in better condition. Recruitment is less likely in degraded habitat so over the years there may be an overall decline if the older plants die and are not replaced (K. Just, pers. comm.). The medium-term prognosis for this species is unknown, but presumably negative due to its high degree of depletion and fragmentation. Given its long-life span any changes due to demographic or genetic effects may be slow to become apparent.

Land use legacies and threats

The main threats to this species are:

- Weed invasion causing biomass accumulation, which can smother plants, reduce the available area for rhizome shooting and prevent seedling recruitment. Most sites are affected by weeds
- Remnant populations along roads and railway lines are susceptible to herbicides (although *Dianellas* in general are rather resistant to herbicides) and vehicle damage
- Agricultural practices such as fertilizer application and grazing may have a deleterious effect
- Little is known about the effect of fire, it is thought to be detrimental in the absence of post-fire weed control but may be beneficial in reducing competition from native grasses
- Pollinator replacement is considered a threat to this species. Competition with the Honey Bee (*Apis mellifera*) can negatively affect the Blue-banded Bee. *A. mellifera* is not a pollinator of Matted Flax-lily (Carter 2010; Department of the Environment 2012e)
- Reproductive isolation as a resulted of habitat fragmentation has probably rendered many small populations susceptible to local extinction (Carter 2010).

Monitoring techniques

Matted Flax-lily has some distinctive features that distinguish it from similar species such as shorter leaves, ‘leaf-teeth’ (epidermal projections) and larger flowers. However, summer defoliation caused by water

stress can make identification difficult. Another problem is the formation of large mats making the identification of individual plants difficult. Care should be taken to distinguish isolated shoots from individual plants (Department of the Environment 2012e). Matted Flax-lily can be very difficult to detect when the habitat is subject to heavy grazing. Removal of grazing animals for three months may be necessary to detect all populations (K. Just, pers. comm.). To obtain a detection probability of 0.8, a search of 66 minutes per hectare is required under favourable conditions (10% *Themeda triandra* cover and an experienced observer); detection probability is negatively influenced by *Themeda* cover and positively influenced by observer experience (Garrard 2009a).

Important conservation documents and resources

- National Recovery Plan (Carter 2010).

No substantial negative change to the population of Small Golden Moths Orchid (*Diuris basaltica*)

Introduction

The outcome

The Victorian Government has committed to ensuring there is no substantial negative change to the population of Small Golden Moths Orchid within the program area. This will be achieved through a range of outputs particularly the establishment and management of Conservation Area 3, which is part of the network of Conservation Areas inside the Urban Growth Boundary (UGB).

The outcome will be measured in the following conservation area:

- Conservation Area: 3 (Figure 14).

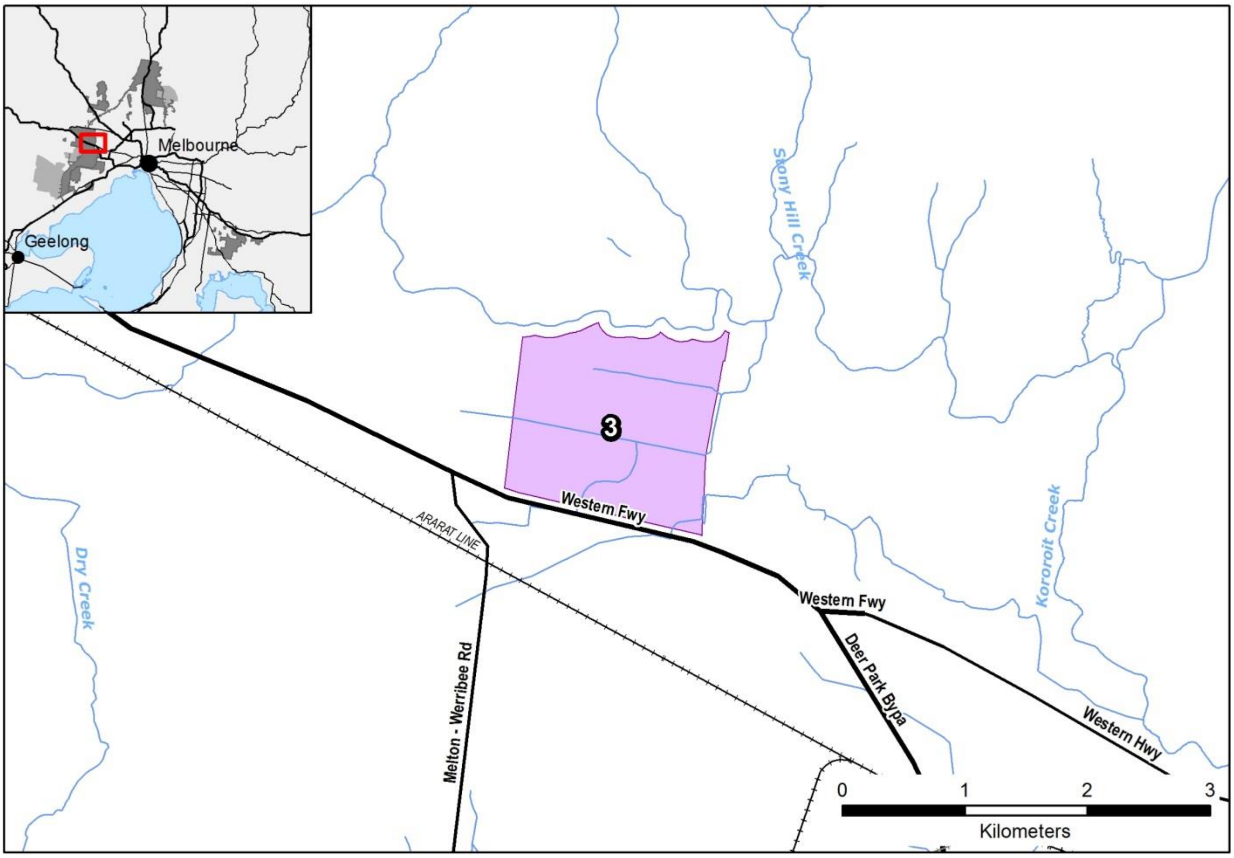

Figure 14: Small Golden Moths Orchid, Conservation Area 3

Description of the species

Small Golden Moths Orchid *Diuris basaltica* D.L. Jones (Orchidaceae) is a deciduous, perennial orchid. It emerges from an underground tuber and has an erect green stem up to 15 cm tall with 3-7 leaves in a basal tuft. The small (~20mm), narrowly-opening golden-yellow flowers appear in spring, singly or in pairs (Backhouse and Lester 2010).

Distribution of the species

This species is endemic to a small area to the west of Melbourne on the Keilor and Werribee plains. It is probably restricted to four locations at Laverton, Derrimut, Rockbank and Melton South. One of these populations, on private land near Clarke's Road (within proposed Conservation Area 3) contains about 400 plants (Backhouse and Lester 2010; DSE 2009b). The other populations all contain under ten plants (Backhouse and Lester 2010).

Conservation status of the species

Small Golden Moths Orchid is listed as Endangered (EN) under the EBPC Act (Department of the Environment 2009c). It is listed Threatened under the FFG Act and Endangered (e) in the DELWP advisory list (DEPI 2014d).

Key Performance Indicators

Table 14 KPI to demonstrate no substantial negative change in the population of Small Golden Moths Orchid.

KPI:	Count of individuals emergent at least once over a five year period	
Measure	Baseline	Count of individuals emergent at least once over a 5 year period calculated five years after securing the land
	Data collection	Calculated from annual population counts using transects to locate emergent monitored between September 1st and October 31st
	Data management	Victorian Biodiversity Atlas (VBA)
	Target	Count of individuals emergent at least once over a 5 year period remains above 90% of the baseline
	Frequency	Every 5 years
Reporting	Forum	Five yearly Report
	Start Date	Ten years after securing the land
	Responsibility	Department of Environment, Land, Water and Planning

Other data collection

Table 15 Other data collection to support analysis of cause of change in the population of Small Golden Moths Orchid.

Data	Cover of bare ground
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part monitoring for the NTG outcome
Data	Cover of weeds
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part monitoring for the NTG outcome

Monitoring protocol

Monitoring for this species will include an annual intensive count of known plants, and a five-yearly broad area survey to locate any new or previously undetected plants. All surveys will be undertaken by trained botanists, familiar with identification of this species.

Broad area survey

Transects 50 m apart will be established, running north-south across the area of high quality native vegetation in the south-east corner of the Conservation Area (~30 ha, transect length ~6 km).

Each transect will be examined once (single experienced observer each transect) and any plants visible from the transect will be recorded, in order to detect the spatial distribution of clusters of plants in the Conservation Area. New plants will be marked so that they can be included in the intensive surveys.

Intensive count

At the first survey, a permanent transect grid will be established, aligned north-south, with transects 4 m apart. It will cover the whole known population in the conservation area (total estimated transect length ~10 km).

Plants will be located by systematically walking the transects. Plants will be marked with a numbered pin, representing the north-east corner of a 10 x 10 cm square centred on the plant, aligned so that one edge is parallel to the transects (north-south). The positions of all plants will be recorded using their co-ordinates on the transect grid;

The status of any previously marked plants (with marker pins) will be noted as either emergent or not. Plants are considered to be the same individual if they emerge within the 10 x 10 cm square aligned as described above. A metal detector may be used to re-locate marker pins;

The final count of emergent individuals for each year is the number of occupied squares.

Supporting information

General ecology

Small Golden Moths Orchid has been given very little attention in the literature and there is scarce information about its ecology. It grows in herb-rich native grasslands on heavy basalt soils. The dominant species is Kangaroo Grass (*Themeda triandra*). Other species include wallaby grasses (*Rytidosperma* spp.), spear grasses (*Austrostipa* spp.) and tussock grasses (*Poa* spp.). There are also a wide variety of wildflowers and herbs (Backhouse and Lester 2010).

The leaves of Small Golden Moths Orchid emerge in late autumn after the onset of seasonal rains. Flowering is from September to October and by late spring the leaves have shrivelled and fertilised capsules are maturing. The plant survives as a dormant tuber through summer and early autumn, which is replaced annually. The pollinator of this species is probably the native bee *Lasioglossum* (*Chilactus*) *lanarium* (Walker 1997). The orchid probably mimics nearby yellow pollen or nectar producing flowers (e.g. *Velleia paradoxa*, *Goodenia pinnatidfida*). Natural pollination seems to be occurring at the Rockbank site. The species can occur in densely crowded tufts, possibly made up of up to 30 individuals, although this is not typical (Backhouse and Lester 2010).

Transect counts (a sub-set of the population) at Conservation Area 3 remained relatively stable (100-162 emergent individuals) between 2004 and 2010 (DELWP, unpublished data).

Land use legacies and threats

The major threat to this species is habitat loss due to agriculture and urban and industrial development. The risk of extinction is high due to the small number of individuals and populations. Other threats include:

- accidental destruction of plants, for example from uncontrolled four wheel drive access
- Grazing by rabbits, hares and invertebrates
- Weed invasion
- The accumulation of grasses which may reduce growth or prevent flowering
- Fire during severe or prolonged drought may negatively affect post-fire regeneration (Backhouse and Lester 2010).

Monitoring techniques

Small Golden Moths Orchid can be surveyed by establishing transects, or through counts of the total population or a combination of the two. Individuals should be marked allowing for them to be tracked over successive counts (M. Duncan, pers. com.). It can be difficult to determine whether the leaves of this species belong to a single plant that has multiple growth points or has formed clonal tubers, or to genetically distinct plants growing close together. The species also displays an erratic emergence and dormancy pattern, such that the number of leaves emerging in any season may not represent the full complement of living plants in any area. Small Golden Moths Orchid can be difficult to detect when dense swards of *Themeda triandra* are present at a site (K. Lester, pers. comm.). There are no studies quantifying the detectability of this species, but the effect of *Themeda* cover on detection rates of many small-statured grassland plants has been shown to be strong (Garrard 2009a; b).

Important conservation documents and resources

- National Recovery Plan (Backhouse and Lester 2010)
- The Victorian Threatened Orchid Recovery Team.

No substantial negative change to the population of Spiny Rice-flower (*Pimelea spinescens* subsp. *spinescens*) and the population is self-sustaining

Introduction

The outcome

The Victorian Government has committed to ensuring there is no substantial negative change to the population of Spiny Rice-flower within the program area and the population is self-sustaining. This will be achieved through a range of outputs particularly the establishment and management of a network of Conservation Areas outside the Urban Growth Boundary (UGB).

The outcome will be measured in the following conservation areas:

- Western Grassland Reserve (Figure 15)
- Conservation Areas[5]: 1, 2, 3p (NC), 4, 5, 10p (NC & PL), 11 and 12 (Figure 16).

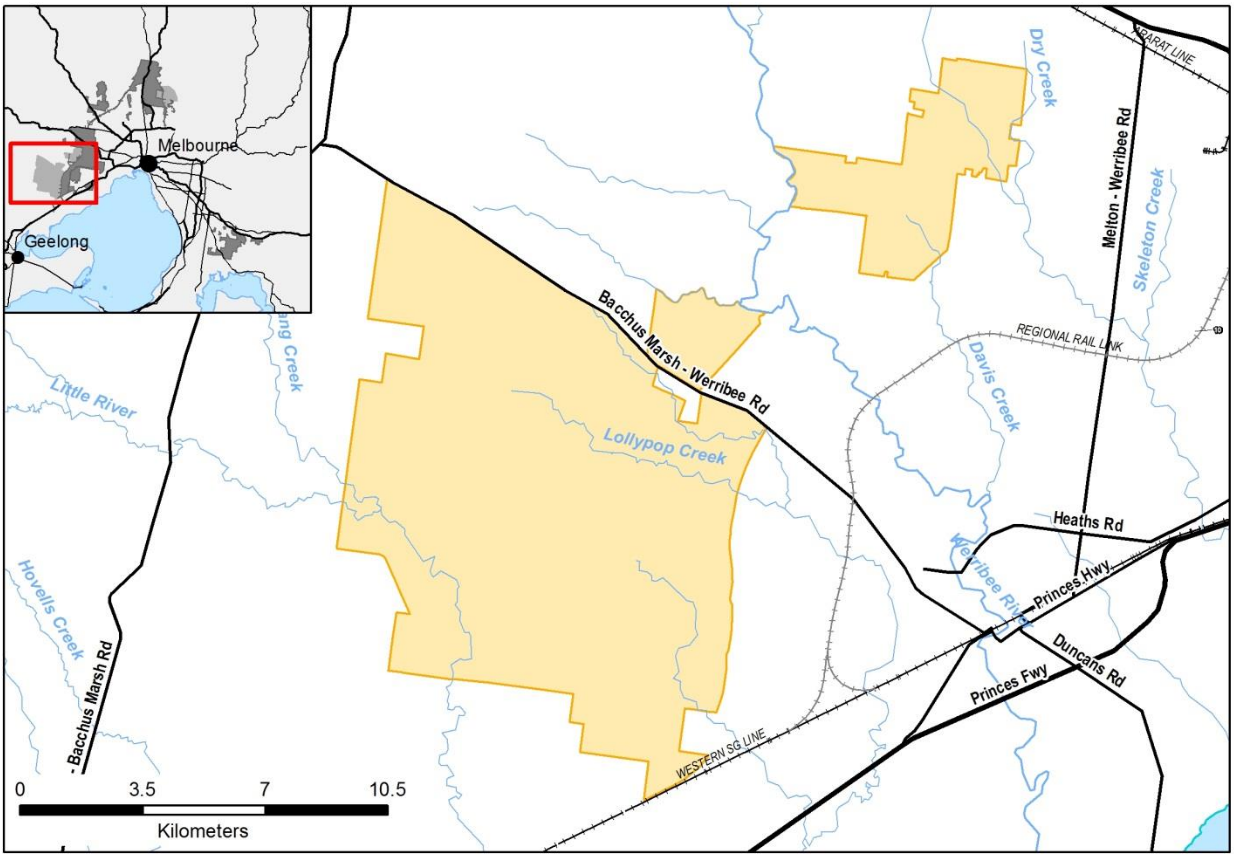

Figure 15: Spiny Rice-flower- Western Grassland Reserve

[5] Brackets refers to the part of the Conservation Area that the outcome monitoring will apply if the Conservation Area is split into multiple categories under the BCS. (NC) – Nature Conservation, (PL) – Existing Public Land

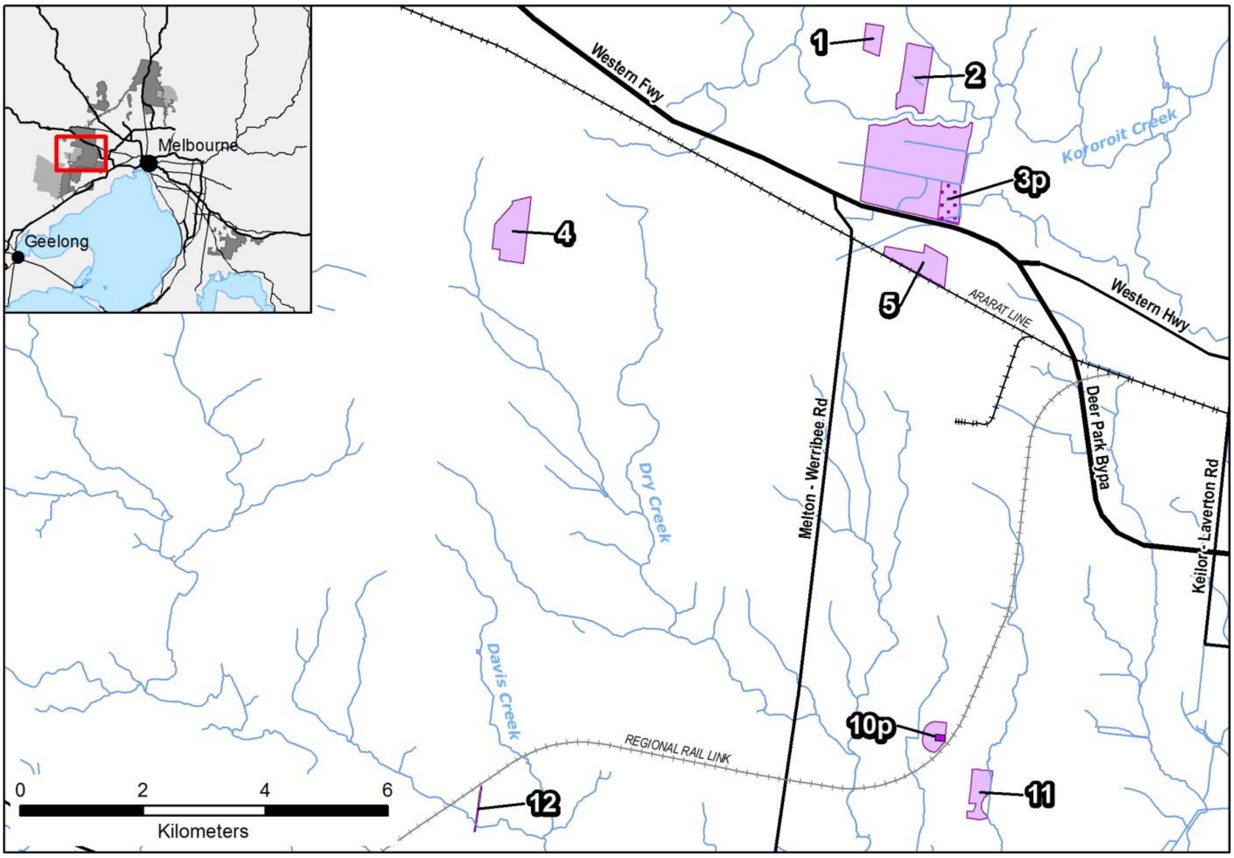

Figure 16: Spiny Rice-flower- Conservation Areas, Western Growth Corridor.

Description of the species

Spiny Rice-flower *Pimelea spinescens* subsp. *spinescens* Rye (Thymelaeaceae) is a small, spreading shrub, growing up to 30 cm high. It has partly herbaceous stems and narrow, green, oval shaped leaves 2-10 mm long and 1-3 mm wide. The flowers are hairless, pale yellow and unisexual. They have four oval-shaped petal-like lobes and four stalkless green bracts growing at the base. Female flowers have a shorter style than ovary. There are up to 12 flowers per inflorescence (Carter and Walsh 2006). Mature plants possess a thick, straight taproot of ~1 m long (Mueck 2000).

Distribution of the species

Spiny Rice-flower is endemic to Victoria. It occurs in the central west and in the Victorian Volcanic Plain, Victorian Midlands and Riverina IBRA bioregions. There are about 20 populations containing approximately 12,000 plants (Carter and Walsh 2006).

Conservation status of the species

Spiny Rice-flower is listed as Critically Endangered (CR) under the EBPC Act (Department of the Environment 2009c). It is listed Threatened under the FFG Act and Vulnerable (v) in the DELWP advisory list (DEPI 2014d).

Key performance indicators

Table 16 KPI to demonstrate no substantial negative change in the population of Spiny Rice-flower and population of Spiny Rice-flower is self-sustaining.

KPI:	Number of years that recruits form over 10% of the populations over a ten year period	
Measure	Baseline	Not applicable
	Data collection	Calculated from annual population counts for each conservation area using plots monitored between May to August
	Data management	Victorian Biodiversity Atlas (VBA)
	Target	Recruits form more than 10% of the population in each conservation area at least once in previous ten years
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Ten years after securing the land
	Responsibility	Department of Environment, Land, Water and Planning
KPI:	**Five year mean population density**	
Measure	Baseline	Mean population density (plants per plot) in each Conservation Area for the first five years after securing each area of land
	Data collection	Calculated from annual population counts using transects monitored between May to August
	Data management	Victorian Biodiversity Atlas (VBA)
	Target	Five year mean population density remains above the baseline
	Confidence Interval	The upper 95% confidence interval for the five year mean remains above the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Ten years after securing the land
	Responsibility	Department of Environment, Land, Water and Planning

Other data collection

Table 17 Other data collection to support analysis of cause of change in the population of Spiny Rice-flower.

Data	Cover of bare ground
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part of the monitoring for the NTG outcome
Data	Cover of weeds
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part of the monitoring for the NTG outcome
Data	Identity of dominant species (top 5 ranked by cover)
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part of the monitoring for the NTG outcome
Data	Height of biomass

Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part of the monitoring for the NTG outcome

Monitoring protocol

Annual survey

Annual surveys will take place between 1 May - 31 August. Every known population of Spiny Rice-flower will be sampled by at least two permanent 5 x 5 m plots. The numbers of plots in each conservation area are shown in Table 26. Plots will be randomly located, with the constraint that every plot must contain at least one individual Spiny Rice-flower.

Table 18 Distribution of monitoring plots among Conservation Areas for Spiny Rice-flower.

Conservation Area	Number of plots
1	5
2	5
3 (NC)	5
4	5
5	8
10 (NC & PL)	2
11	2
12	3
Western Grassland Reserve	TBC (<20)
TOTAL	35+

Within each plots the number of individual plants will be counted, distinguishing the gender of the plant (male, femail, unknown) and life-stage (recruit, mature), along with the percentage of mature plants flowering.

The cover of vegetation (by species) within each plot will be measured using a point-intercept method. Four lines will be established to cover the plot (running W-E, set 50, 150, 250, 350, 450 cm from the northern edge). Along each line, the species (or rock, bare ground, litter) touching the tape at each 40 cm interval will be recorded, meaning each plot is sampled by 60 points. This data will provide the list of the five most abundant species in each plot, the cover of weeds and the cover of bare ground (bareground +litter+ rock). Biomass height will be estimated on a simple 3-point ordinal scale (Low-0-20cm, Moderate-20-40cm, High-40+cm), with reference to the maximum expected height of the grass sward in this ecosystem (tussock height ~60 cm), ignoring inflorescences.

Supporting information

General ecology

Spiny Rice-flower inhabits grassland or open shrubland on heavy soils, which are generally red clays in the north and heavy grey-black clays in the south. The vegetation is often dominated by *Themeda triandra*. This species usually occurs on flat ground but can be found on slight rises or in wettish depressions (Carter and Walsh 2006).

Spiny Rice-flower flowers in mid-winter, which is unusual for a grassland species. In mid to late spring the rice-shaped fruit appears. Plants are slow growing and long lived (possibly over 100 years) (DSE 2005b; Mueck 2000). Furthermore, low numbers of seeds are produced and the longevity of these is unknown. Germination and seedling survival seems to be irregular and there is little evidence of recruitment in most populations. This species is fire tolerant and readily resprouts after a burn (Mueck 2000).

Genetic diversity within populations is high in this species, but this is probably a legacy of greater connectivity in the past, and its erosion may be slow due to the longevity of plants and possible soil seed

banks retaining genetic information from previous generations (James and Jordan 2014). This diversity could be maintained by sourcing seed from different areas, particularly from drier areas, as this might help protect against the effects of climate change (S. Mueck, D. Reynolds, V. Cragie & N. Walsh, pers. comm.).

Land use legacies and threats

The main threats to this species are detailed in (Carter and Walsh 2006) and can be summarised as follows:

- A lack of fire may lead to plants being crowded out by native grasses and weeds
- Heavy grazing by stock may remove the species
- Many populations occur on rail or roadside reserves and thus are threatened by maintenance activities such as slashing, grading, road-widening and soil compaction
- Changing land use from grazing to cropping or from farming to industrial or residential use can lead to population decline or local extinction
- Weeds may compete with the species and reduce germination niches.

Monitoring techniques

Garrard (2009a; b) has conducted extensive research into the survey requirements for detecting this species. Detection is positively influenced by a lower cover of Kangaroo Grass (*Themeda triandra*) and the experience of the observer. When surveys are conducted by an experienced botanist, the average time to detection was 37 minutes per hectare at sites with 10% *Themeda* cover. This increases to 67 minutes at sites with 30% *Themeda* cover and 152 minutes at sites with 70% cover (Garrard, pers. comm.). Under the most favourable conditions, almost 2 hours per hectare (110 minutes) is required to achieve a probability of detection of 0.95, given Spiny Rice-flower is present. The effort required to achieve the same certainty is much higher under sub-optimal conditions (i.e. less experienced observer, high *Themeda* cover).

Important conservation documents and resources

- FFG Act Action Statement
- National Recovery Plan (Carter and Walsh 2006)
- EPBC Act Significant Impact Guidelines (DEWHA 2009a)
- The *Pimelea spinescens* recovery team.

Golden Sun Moth (*Synemon plana*) persists

Introduction

The outcome

The Victorian Government has committed to ensuring that the Golden Sun Moth persists within the program area. This will be achieved through a range of outputs particularly the establishment and management of a network of Conservation Areas outside the Urban Growth Boundary (UGB).

The outcome will be measured in the following conservation areas:

- Western Grassland Reserve (Figure 17)
- Conservation Areas[6]: 4, 13 (Figure 18), 23 (NC), 26, 27, 33A (NC) and 34C (NC) (Figure 19).

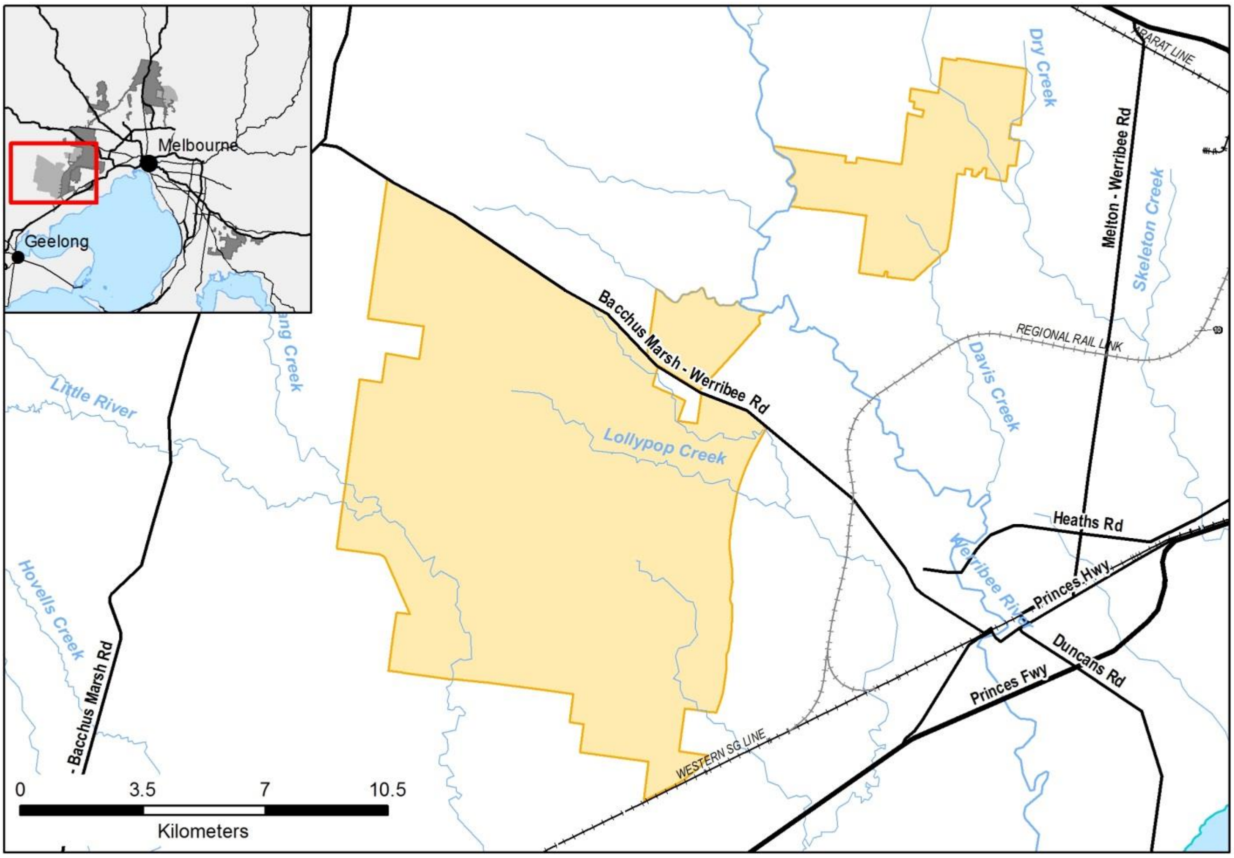

Figure 17: Golden Sun Moth- Western Grassland Reserve

[6] Brackets refers to the part of the Conservation Area that the outcome monitoring will apply if the Conservation Area is split into multiple categories under the BCS. (NC) – Nature Conservation, (PL) – Existing Public Land

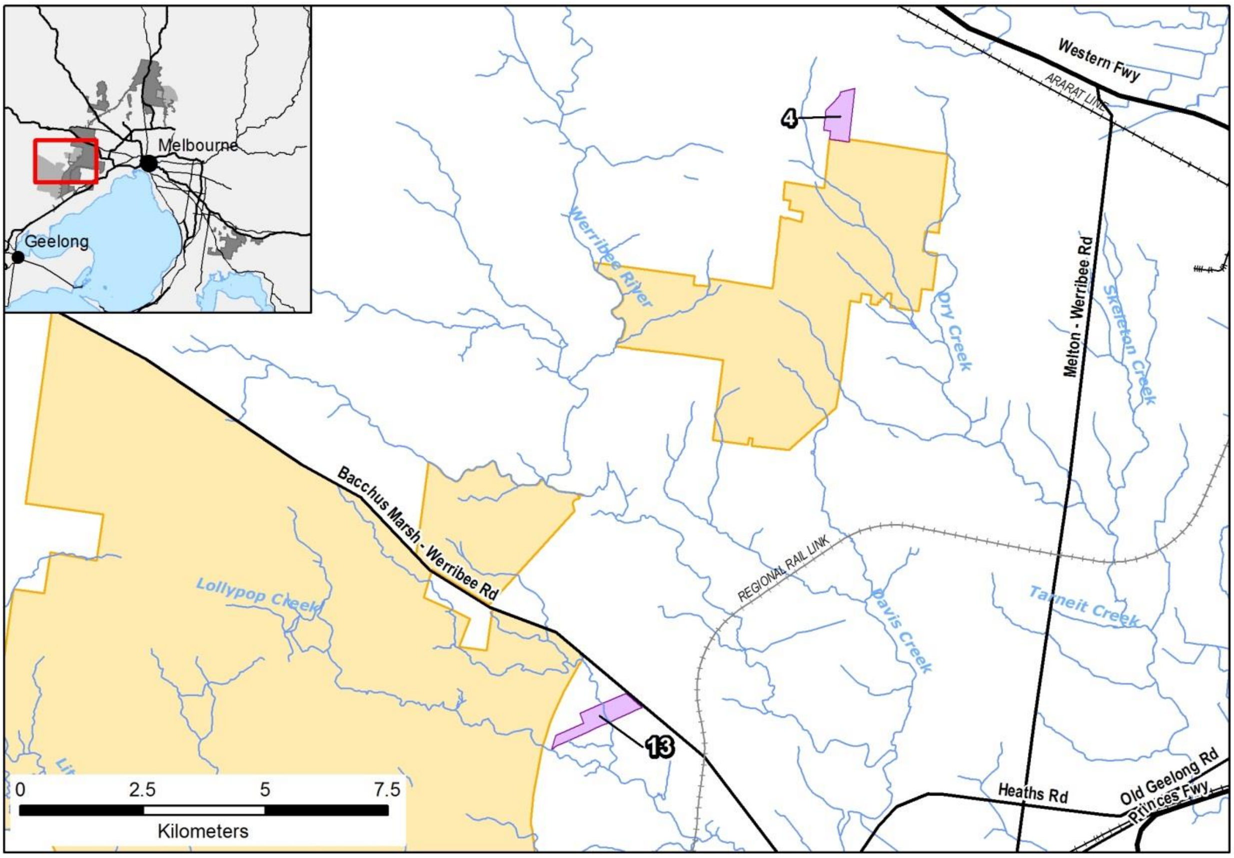

Figure 18: Golden Sun Moth- Conservation Areas, Western Growth Corridor

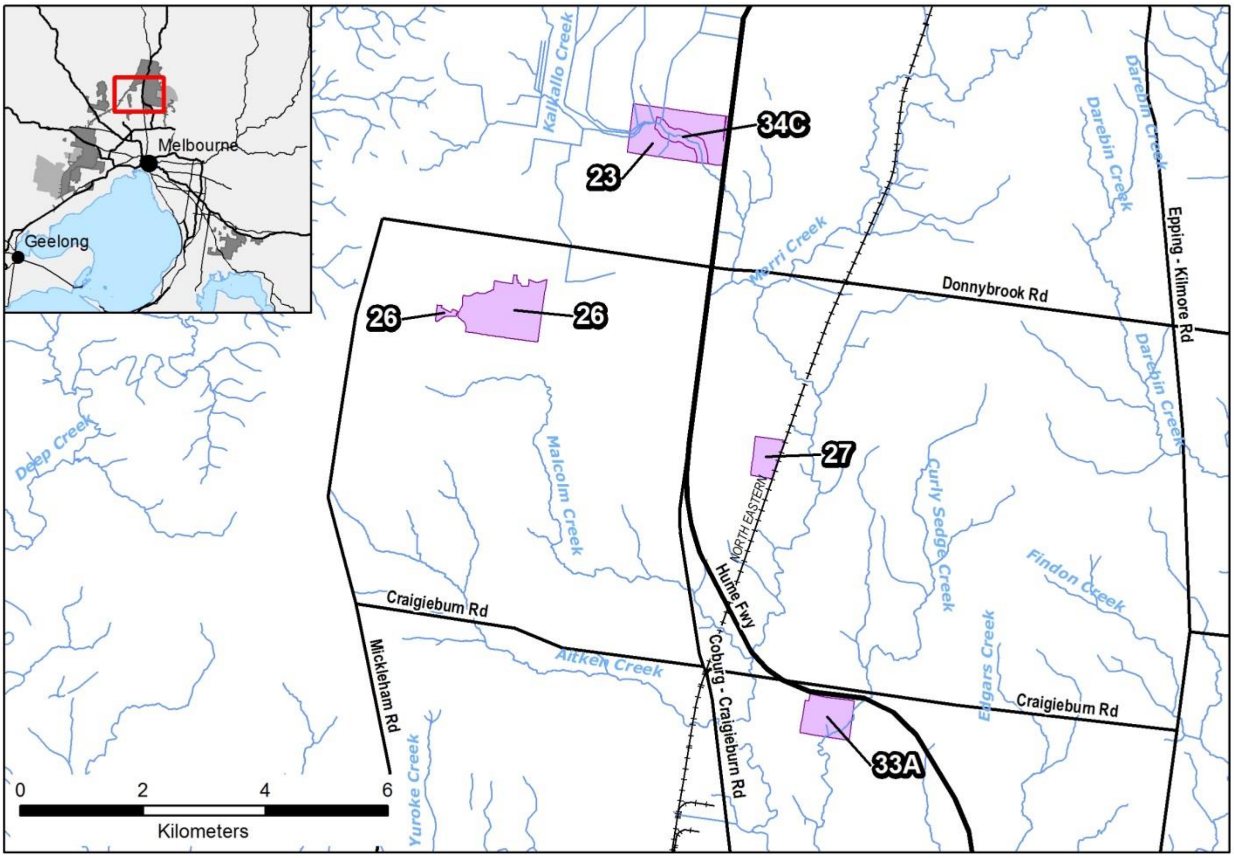

Figure 19: Golden Sun Moth- Conservation Areas, Northern Growth Corridor

Description of the species

Golden Sun Moth *Synemon plana* (Lepidoptera: Castaneda) is a medium-sized day-flying moth with a wingspan of approximately 3 cm. Adults lack functional mouthparts and cannot feed. Females have an extensible ovipositor and reduced hindwings, both sexes have clubbed antennae. Colouration varies between the sexes with males having pale grey underwings with brown spots and the females white with black spots on the edge. The upper forewings are dark brown with grey scales in males and dark grey with pale grey scales in females. The hindwings are bronze/brown with dark brown patches in the male and bright orange with black spots on the edge in females. The colouration along with reduced female hindwings is unique within the genus and can be used to distinguish *S. plana* from other members of the genus *Synemon* (Department of the Environment 2012c).

Distribution of the species

Golden Sun Moth is found in south-eastern NSW, the ACT and Victoria. In Victoria populations have been found across the Victorian Volcanic Plain including in the west and north of Melbourne (Brown and Tolsma 2010; Brown *et al.* 2011; DSE 2011). Distribution on private land is poorly understood despite extensive attempts to survey due to the difficulty of getting access to conduct surveys (Brown *et al.* 2011).

Conservation status of the species

Golden Sun Moth is listed as Critically Endangered (CR) under the EPBC Act (Department of the Environment 2009a). It is listed Threatened under the FFG Act and Critically Endangered (CR) in the DSE advisory list (DSE 2013).

Key performance indicators

Table 19 KPI to demonstrate the persistence of the Golden Sun Moth.

KPI:	**Proportion of monitored sites that are occupied**	
Measure	Baseline	Five year mean proportion of sites occupied established after the first five years since securing the land
	Data collection	Calculated from transects to identify occupied sites, conducted between November and January annually
	Data management	Victorian Biodiversity Atlas (VBA)
	Target	Five year mean proportion of sites occupied remains above the baseline
	Confidence interval	The upper 95% confidence interval for the five year mean proportion of sites occupied remains above the baseline
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Ten years after securing the land
	Responsibility	Department of Environment, Land, Water and Planning

Other data collection

Table 20 Other data collection to support analysis of cause of change in the Golden Sun Moth.

Data	Cover of bare ground
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part monitoring for the NTG outcome
Data	Cover of weeds
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part monitoring for the NTG outcome
Data	Weather conditions during survey (temperature, cloud cover, wind speed and direction).
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM)
Data	The dominant grass at each plot
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM)

Monitoring protocol

Surveys for this species will be conducted annually, during the male flight season (November – January) Optimal survey conditions are between 11am and 3pm, with temperatures 20-35°C, cloud cover < 25% and light winds.

Surveys will be undertaken in permanent 400 x 400m (8 ha) plots, distributed among the Conservation Areas such that each area is sampled by 2 – 5 plots:

- Conservation Area 4 – 2 plots
- Conservation Area 13 – 2 plots
- Conservation Area 23 – 3 plots
- Conservation Area 26 – 5 plots
- Conservation Area 27 – 2 plots
- Conservation Area 33 – 3 plots.

The Western Grassland Reserve will be divided into 250 ha grids, and a single 8 ha plot allocated within each grid (random, excluding states 'De-rocked Grassland', 'De-rocked nutrient-enriched pasture' and 'Crop').

In each plot, transects will be established 20 m apart and searched for moths. Searching will continue until one individual has been detected or the whole plot searched.

An initial study is required to determine detection probability for this species. In each plot transects 20 m apart will be established and searched for moths. Searching will continue until one individual has been detected or the whole plot searched. The time to first detection or the total time taken to survey the plot (in the absence of detection) will be recorded. This information will allow for the determination of detection probability (see Garrard *et al.* 2008 for an explanation).

At subsequent surveys the plot will be searched until one individual is detected (with time to detection recorded) or search time is sufficient to achieve a 95% probability of detection as calculated from the initial survey.

The KPI and methodology is based on an assumption that the Golden Sun Moth occurs across much of the Western Grassland Reserve and that it is therefore valid to measure occupancy. Should results of initial surveys across the Western Grassland Reserve indicate that the moth population is more restricted in area suggesting that occupancy is not a useful measure, this KPI and methodology will be reviewed.

Supporting information

General ecology

In Victoria the Golden Sun Moth is associated with native grasslands, grassy woodlands and areas of non-native pasture (Brown *et al*. 2012) and may be found in paddocks and roadsides. Some studies have noted a positive relationship between the cover of Wallaby Grasses (*Rytidosperma* spp.) and the abundance of Golden Sun Moth, e.g. (O'Dwyer and Attiwill 1999). However, the species has also been found at sites where Wallaby Grasses are absent and the site is dominated by other species including *Themeda triandra* and *Austrosipa* spp. or introduced grasses (Brown *et al*. 2011). Nevertheless, the presence of Wallaby Grasses probably indicates good habitat (Brown *et al*. 2012). Open tussock structure and bare ground are also presumed to be important (Brown and Tolsma 2010). Caterpillars of this species are thought to feed on roots of Wallaby Grasses (Douglas 2004), however, they may also feed on Chilean Needle Grass (*Nassella neesiana*) (Braby and Dunford 2006). Soils are variable (sands, clays and loams) with a pH slightly acidic to basic and available Phosphorus below 14 µg/g (O'Dwyer and Attiwill 1999).

There is a considerable degree of genetic difference between populations, which should be considered distinct conservation units. This is not surprising in a short-lived species with limited dispersal. It is not clear what the population structure is in the Melbourne area as it has not been sampled (Clarke and O'Dwyer 2000), although Victorian populations are distinct from NSW and ACT populations and are classified in group 1 (of 5) (Clarke and Whyte 2003; Department of the Environment 2012c). This southern population may be distinct enough to merit classification as a separate race or subspecies (Clarke and O'Dwyer 2000).

There is little information about population fluctuations over time, but dispersal ability is limited (males can fly about 100 m away from suitable habitat) and therefore populations >200 m apart are considered isolated and the probability of re-colonisation of isolated patches is low (Clarke and O'Dwyer 2000). A limited dispersal ability means that areas where the species has become extinct are unlikely to be recolonised (Department of the Environment 2012c).

Monitoring techniques

Climatic conditions most suitable for male flight (females are semi-flightless) are relatively still, clear, sunny days, >20°C (>30°C is better), between 10 am and 3 pm. Previous surveys have used transects 20 m apart in paddocks or roadside transects on either side of the road. Most animals are detected in light winds, with temperatures between 20-35°C and cloud cover of 0-25% (Brown *et al*. 2012). The male flight period is November– January (Douglas 2004). Males only make short flights (generally a few tens of metres) of short durations. Direct counts (on one occasion) reflect only the number of males flying at the time as of the count as most individuals will not be flying. The moths live for 2-3 years but not all animals will be active in each annual cohort (Gibson and New 2007). Both spot counts and transects are effective survey techniques (Gibson and New 2007). However, for sites to be compared counts must be made under the same conditions, using the same technique.

Land use legacies and threats

The main threats to this species are:

- Habitat loss and degradation and soil disturbance
- Management regimes that result in the loss of Wallaby Grasses and bare ground, such as too much or too little grazing, the application of fertilizers, the introduction of exotic species and mowing and slashing (Department of the Environment 2012c)
- Soil disturbance (e.g. cultivation, ripping rabbit burrows) can kill moth larvae and remove Wallaby Grasses (Department of the Environment 2012c)
- Fire, although the nature of this threat is not well understood. The species may be fire tolerant outside the male flight period (Douglas 2004). Indeed, controlled burning (outside the male flight period) my help to maintain suitable habitat (Department of the Environment 2012c)
- The invasion of weeds including exotic annual grasses (Department of the Environment 2012c).

Important conservation documents and resources

- FFG Act Action Statement (DSE 2004)
- EPBC Act Significant Impact Guidelines (DEWHA 2009c)
- Sub-regional Species Strategy for the Golden Sun Moth (DEPI 2013d).

Growling Grass Frog (*Litoria raniformis*) persists

Introduction

The outcome

The Victorian Government has committed to ensuring that the Growling Grass Frog persists within the program area. This will be achieved through a range of management actions, including the establishment and management of a network of Conservation Areas inside the Urban Growth Boundary (UGB).

The outcome will be measured in the following conservation areas:

- Conservation Areas[7]: 14 (GGF) (Figure 20), 15 (GGF) (Figure 21), 21, 34, 33A, 33B, 33C (Figure 22) and 36 (GGF) (Figure 23).

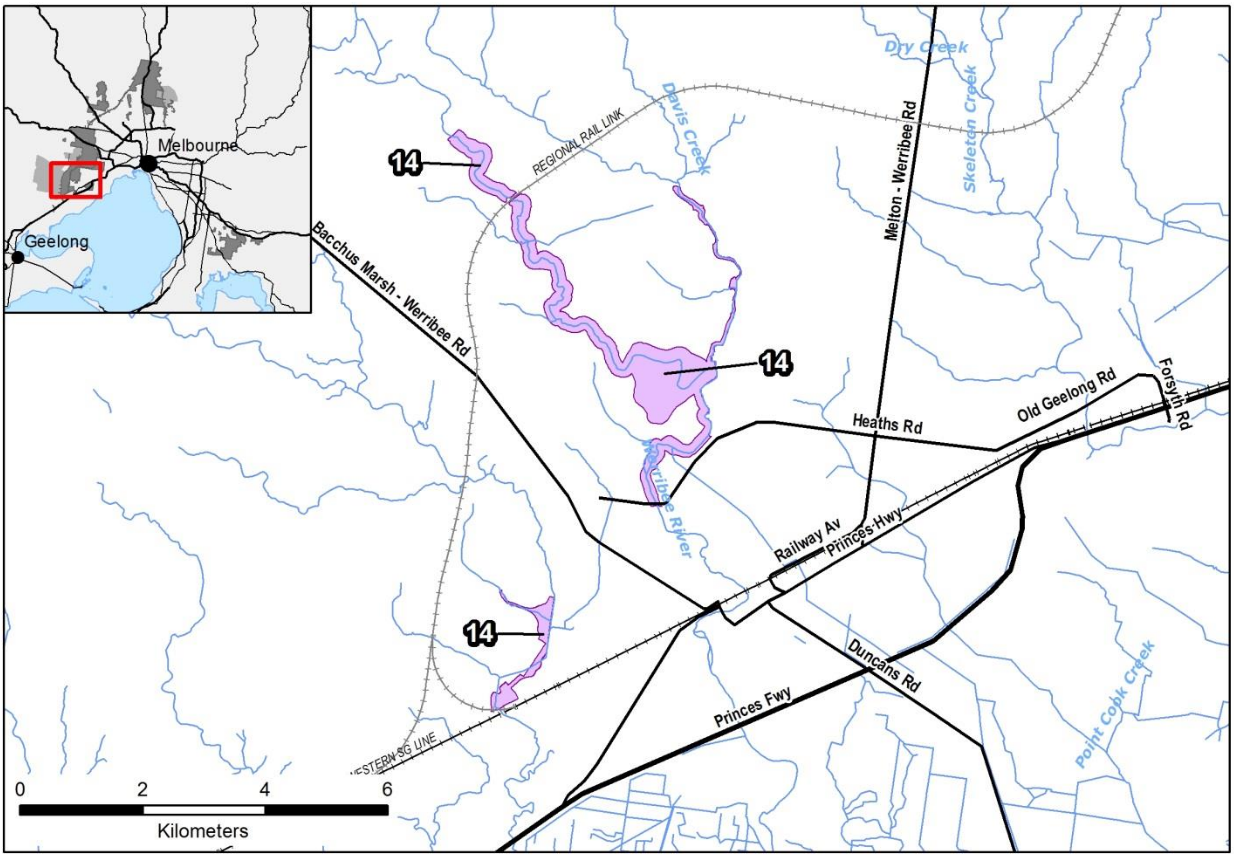

Figure 20: Growling Grass Frog: Conservation Areas, Western Growth Corridor

[7] Brackets refers to the part of the Conservation Area that the outcome monitoring will apply if the Conservation Area is split into multiple categories under the BCS. (GGF) Growling Grass Frog Conservation, floodplain and open space.

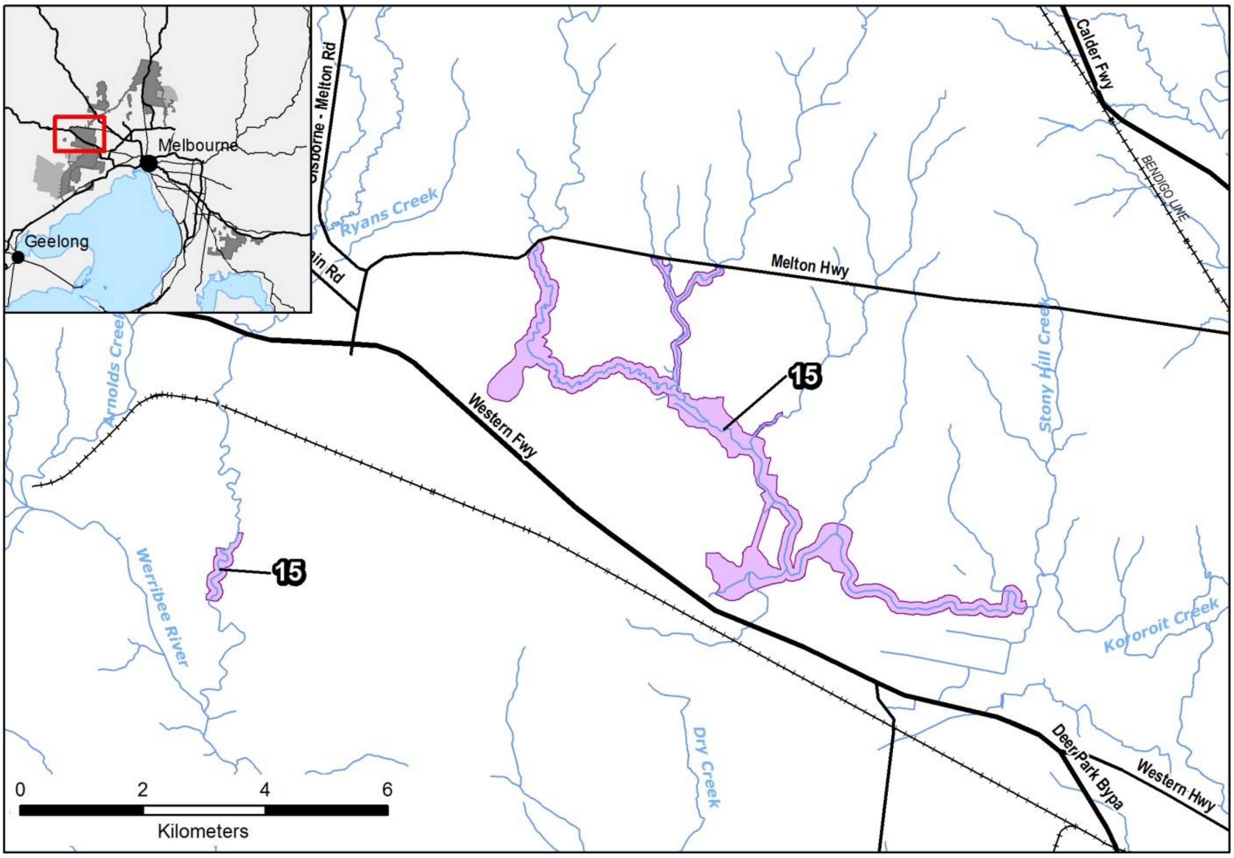

Figure 21: Growling Grass Frog- Conservation Areas- Western Growth Corridor

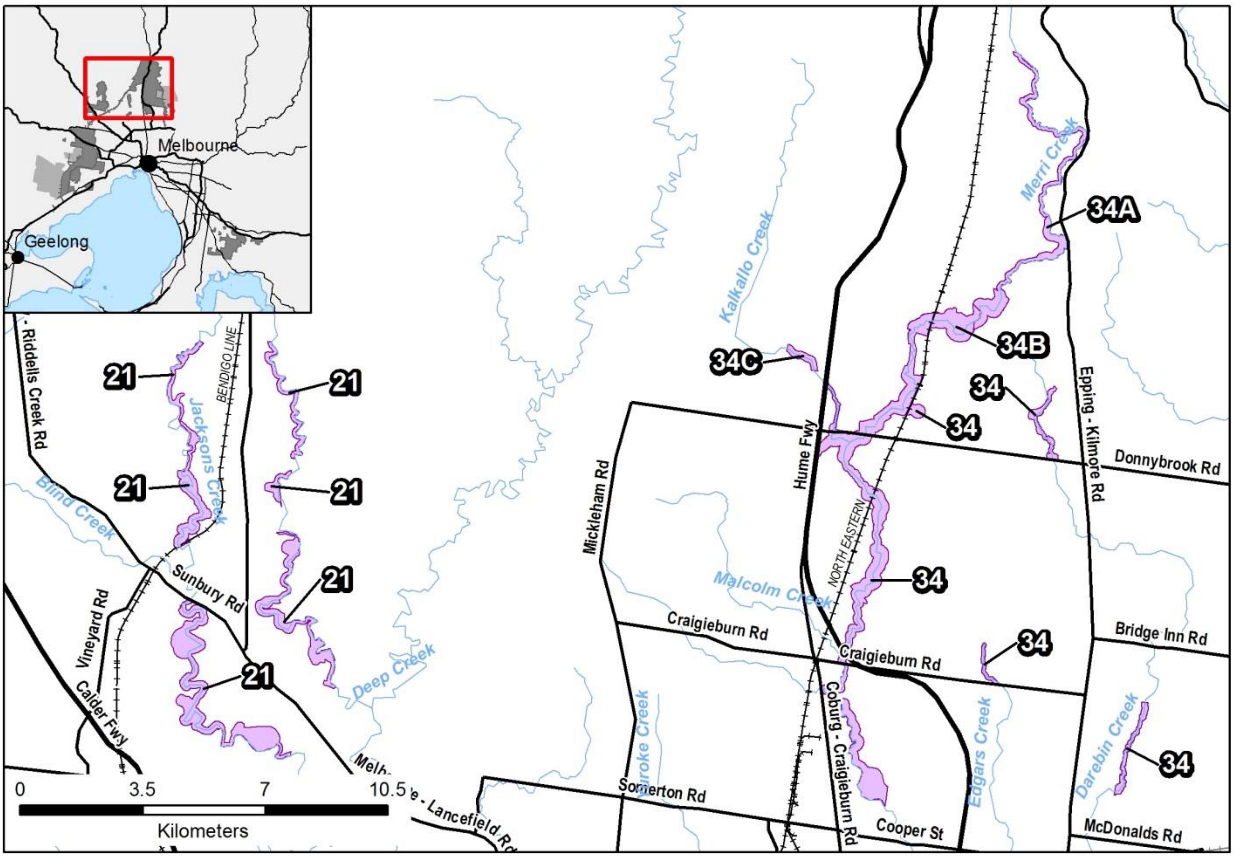

Figure 22: Growling Grass Frog- Conservation Areas- North-Western and Northern Growth Corridor

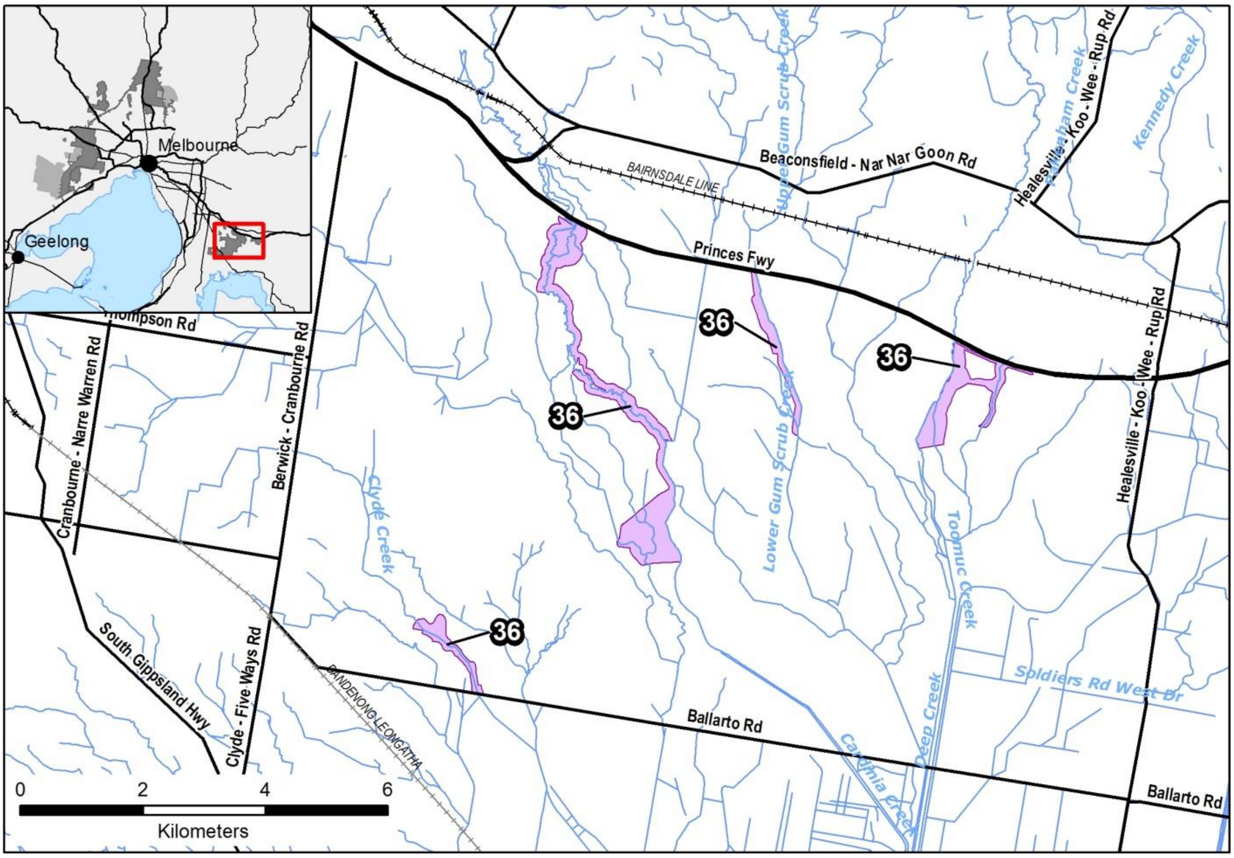

Figure 23: Growling Grass Frog- Conservation Areas, South-Eastern Growth Corridor

Description of the species

The Growling Grass Frog *Litoria raniformis* (Anura: Hylidae) is a large semi-aquatic member of the 'bell frog' complex, a group of species with similar morphology and ecology (Heard *et al*. 2010). It is the largest species in this complex with males 55-65 mm and females 60-104 mm snout-vent length (Barker *et al*. 1995). The dorsum is olive to emerald green in colour with gold, brown, bronze or black mottling, and is typically warty. The ventral surface is white (Tyler and Knight 2009).

Distribution of the species

The Growling Grass Frog is widely distributed across lowland south eastern Australia.(Barker *et al*. 1995). In Victoria it has been found in most regions with the exception of the Mallee and alpine areas. It is declining in many parts of its geographic range (Clemann and Gillespie 2013).

Conservation status of the species

The Growling Grass Frog is listed as Vulnerable (VU) under the EBPC Act (DSE 2013). It is listed as Threatened under the Flora Fauna Guarantee Act and Endangered (EN) in the DELWP advisory list (DSE 2013).

Key performance indicators

Table 21 KPI to demonstrate the persistence of the Growling Grass Frog.

KPI:	**Projected risk of extinction for each Conservation Area, estimated using a stochastic patch-occupancy model for Growling Grass Frog metapopulations.**	
Measure	Baseline	The projected risk of extinction over 50 years under the scenario of completed urban development in the approved areas surrounding the Conservation Area
	Data collection	Predictions of extinction risk from the stochastic patch occupancy model, incorporating all available occupancy and habitat data for each Conservation Area
	Data management	Stochastic patch-occupancy model for Growling Grass Frog metapopulations
	Target	A reduction in extinction risk over time, relative to the baseline level of risk
	Frequency	Every five years
Reporting	Forum	Five yearly Report
	Start Date	Five years after commencement of the Program
	Responsibility	Department of Environment, Land, Water and Planning

Other data collection

Table 22 Other data collection to support analysis of cause of change in the Growling Grass Frog.

Data	Wetland occupancy (%)
Frequency	Annually
Data management	Victorian Biodiversity Atlas (VBA)
Data	Water salinity
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM)
Data	Water temperature
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM)
Data	Vegetation composition / structure
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM)

Monitoring protocol

Predicted risk of extinction using a stochastic patch occupancy model)

The predicted risk of extinction will be determined using a stochastic patch occupancy model (SPOM) which simulates the stochastic changes in the occupancy of each patch though time. Changes in occupancy is a function of the per time-step probabilities of extinction and colonisation. From this process the predicted risk of metapopulation extinction over 50 year period will be derived by calculating the proportion of simulations in each time-step where the number of extant populations is zero. The predicted risk of extinction will initially be determined assuming that all development of category 2 Growling Grass Frog habitat has occurred. Program interventions will then be updated in the model to determine the predicted

risk of extinction resulting from those interventions. Full details of the derivation of these parameters are given in Heard *et al*. (2013).

It is important to note here that the probability of occupancy for each time step is calculated according to the probability of occupancy at the previous time-step. For this reason empirical data derived from regular surveys can improve model performance. The baseline may also be adjusted as a result of the new data.

Surveys

At least 40 wetlands per metapopulation will be sampled in a given year and where possible sampling will be balanced between on-stream and off-stream habitat within conservation areas.

Frog surveys will be undertaken by experienced observers. Surveys will be conducted at night, between October and March, with at least two repeat surveys requires per wetland wherever possible. The number of surveys required to achieve a detection probability of 0.95 is two from October to December and three from January to February. Each repeat survey will consist of the following (from Heard *et al.* 2010):

1. Ten minute quiet observation from the waterline, listening for males calling.
2. Systematic search of the site with spotlights looking for active frogs.
3. Where appropriate, within 20m of the waterline, an active search by lifting rocks, logs or other surface debris (e.g. sheets of tin).
4. The detection or non-detection of frogs during the call and visual surveys should be recorded separately.
5. Other information to be recorded at each wetland:
    a. Site location (co-ordinates) and unique site code
    b. Date of survey and survey number (e.g. 1 of 3)
    c. Start and finish times
    d. Air temperature, wind strength, relative humidity and rain intensity
    e. Water temperature
    f. Salinity (measured via electrical conductivity)
    g. Names of personnel
    h. Vegetation structure should be visually assessed, using the protocols used by Heard *et al*. (2012, 2013).

Repeat surveys at most monitoring sites in each year are necessary to provide a basis for assessing the likely rate of false-negatives (i.e. failure to detect at occupied sites) in the data.

Supporting information

General ecology

Growling Grass Frog produces large clutches of eggs and rapidly-growing tadpoles typically reaching metamorphosis in 2-3 months (although over-wintering may occur). Sexual maturity in males can occur within four months of metamorphosis (Heard *et al.* 2012b). Typical maximum lifespan is thought to be two to three years (Heard *et al.* 2012b) , but individuals have been found to live for up to five years (Mann *et al*. 2010). In southern Victoria, this species is mainly active during spring and summer. Reproductive activity (calling males, courtship and egg-laying) begins in September and ends in January or February.

Growling Grass Frog inhabits permanent and ephemeral wetlands including lakes, billabongs, slow-flowing sections of rivers and streams, swamps and ponds. It is also found in artificial wetlands including farm dams

(Pyke 2002). Terrestrial microhabitat preferences are for bare soil and bank-side rocks but leaf litter and emergent fringing vegetation are also used for shelter. This species seems to avoid dense ground vegetation. In the aquatic zone it is typically found on dense mats of floating and submerged vegetation, amongst rooted vegetation and sometimes on emergent rocks or fringing vegetation (Heard *et al*. 2008). It adopts a sit-and-wait strategy and seems to be a generalist carnivore, eating a wide variety of invertebrates and small vertebrates, including conspecific tadpoles and metamorphlings (Pyke 2002).

Recent evidence strongly supports a metapopulation structure for this species (but see papers by Wassens *et al*. 2010, Wassens *et al*. 2007, Wassens *et al*. 2008), suggesting a "patchy" population structure on the Murrumbidgee flood plain). Within the Melbourne area populations of *L. raniformis* inhabit networks of habitat patches (wetlands) with high site fidelity, relatively low dispersal and susceptibility to local extinction due to environmental and demographic factors. Regional persistence relies on a balance between local extinction and colonisation (Heard *et al.* 2012c). Current evidence from northern Melbourne suggests wetlands close to neighbouring populations are more likely to be occupied. Individuals show high wetland fidelity, but occupancy of wetlands is temporally dynamic. Local extinction risk is related to hydroperiod (lower in permanent waterbodies) and vegetation type (lower for high cover of emergent, submergent and floating vegetation) but only weakly related to proximity of neighbouring populations. The probability of colonisation is strongly positively influenced by proximity of neighbouring populations (Heard *et al.* 2012c).

Chytrid fungus (*Batrachochytrium dendrobatidis*) causes the disease chytridiomycosis and has been linked to the decline of amphibian species worldwide (Heard *et al.* 2012a; Heard *et al.* 2014; Skerratt *et al.* 2007). Recent research has shown that chytrid is ubiquitous in Growling Grass Frog habitats in the Melbourne area. The impact of this fungus varies spatially with some habitats being partial refugia: warm and saline wetlands in particular lead to lower risk or infection, and lower mortality amongst infected frogs. The most important environmental factor limiting the impacts of chytrid on populations is water temperature. Higher water temperatures reduce the probability and intensity of chytrid infections. Salinity has a weaker but still important effect, with more saline conditions reducing the probability and intensity of chytrid infections. These findings have important management implications for the conservation of this species: managing wetland conditions so that they are unfavourable for chytrid and ensuring the retention of warm, slightly salty wetlands such as quarry holes and spring-fed farm dams will minimise the impacts of chytrid on Growling Grass Frog metapopulations.

Urbanisation is already having a negative impact on this species in the Melbourne region. For this reason further declines should be expected after the commencement of reporting under the Program and breaches of the target baseline. As a catchment becomes more urbanised, patches are lost, resulting in an initial decline. Other effects of urbanisation such as eutrophication of wetlands, or changes in stream hydrology have time-lags in their effects, such that the impacts of urbanisation and may take some years to fully manifest themselves in decline and local extinction, as habitat is progressively degraded. In absence of effective management intervention, a slow, ongoing decline in rates of wetlands occupancy that continues after urbanisation is completed is to be expected. Whether this decline can be arrested it or reversed will depend on how effective habitat management, restoration and creation is at mitigating the initial gross loss of habitat, as well as the "slow burn" of habitat degradation that will inevitably follows the urbanisation of catchments occupied by *L. raniformis*.

Land use legacies and threats

The major threats to this species within the Melbourne Strategic Assessment area are:

- Habitat loss from urban development
- Fragmentation and isolation of remaining habitats due to removal of wetlands, and the construction of partial or full barriers to dispersal within metapopulations such as transport infrastructure and urbanised landscapes
- Habitat degradation caused by direct interference, eutrophication, inappropriate hydrological regimes, and changes in water quality

- Impacts of infection by chytrid fungus (*B. dendrobatidis*) – see ecology section above
- Removal of aquatic vegetation and terrestrial vegetation and debris
- Alteration to hydrological regimes, particularly an increase in the frequency and intensity of high flow events, due to reduced catchment permeability. These high flow events lead to stream habitats being gouged out and channelized, and the loss of deep, still pools that are the preferred in-stream habitat for *L. raniformis*
- Invasive predatory fish (e.g. Mosquito Fish, *Gambusia holbrooki*) have been implicated in Growling Grass Frog decline (Pyke 2002)., although further research is required in this area as current evidence for their impacts in the MSA area is largely circumstantial (Clemann and Gillespie 2013).

Monitoring techniques

Adults can be surveyed using transects along streams and around off-stream waterbodies incorporating the whole water surface and 20m beyond the water line on both sides or the circumference of standing water bodies. Nocturnal surveys using spotlights, to scan the water surface and aquatic vegetation is the preferred means of detecting the presence of *L. raniformis*. Members of the species can be identified directly or from their eye shine. Vocal imitation can be used to stimulate calling, however the efficacy of this technique is dubious, especially outside breeding season, and reliance on detection of calls alone will often result in failure to detect the species. Surveys should be conducted between October and March. Nocturnal surveys produce higher detection probabilities. Tadpoles can be surveyed using funnel-trapping, conducted at night with a light lure, or dip-netting, conducted during the day and used when funnel-trapping is not possible. Detection probability for tadpoles is low (about 0.35 per 24 hour survey) using these techniques (Heard *et al*. 2006). Furthermore, tadpole surveys are expensive and laborious.

Previous studies of Growling Grass Frog metapopulations have demonstrated the utility of occupancy rates (proportion of a specified set of wetlands occupied by Growling Grass Frogs) as a measure of population status and trend (Heard *et al*. 2010; 2012; 2013). Wetland occupancy rates have two key strengths as a measurement variable for monitoring and reporting:

- Rates of wetland occupancy are an ecologically meaningful measure of status for frog populations that occur as classical metapopulations. Declines are expected to manifest chiefly as reductions in the proportion of occupied wetlands. Monitoring this state-variable also provides a measure of system status that directly reflect the ecologically relevant processes of patch colonisation and extinction that define the dynamics of the metapopulation
- Surveys using appropriate methods (see below) can determine the occupancy status of any wetland to a high and known degree of reliability. Assessing presence-absence is significantly less expensive than alternative approaches, such as measuring abundance using mark-recapture methods. The survey methodology is well established, reliable, non-invasive and comparatively cheap to implement (Heard *et al.* 2008; Heard *et al.* 2010), see also box below.

Important conservation documents and resources

- National Recovery Plan (Clemann and Gillespie 2013)
- EPBC Act Significant Impact Guidelines (DEWHA 2009b)
- Sub-regional Species Strategy (DEPI 2013a)
- National recovery team (Clemann and Gillespie 2013)
- Guidelines for managing the endangered Growling Grass Frog in urbanising landscapes (Heard *et al.* 2010).

Southern Brown Bandicoot (eastern) (*Isoodon obesulus obesulus*) persists

Introduction

The outcome

The Victorian Government has committed to ensuring that the Southern Brown Bandicoot persists within the Southern Brown Bandicoot management area. This will be achieved through a range of outputs.

The outcome will be measured in the Southern Brown Bandicoot management and connectivity areas (Figure 24), defined in (DEPI 2014c).

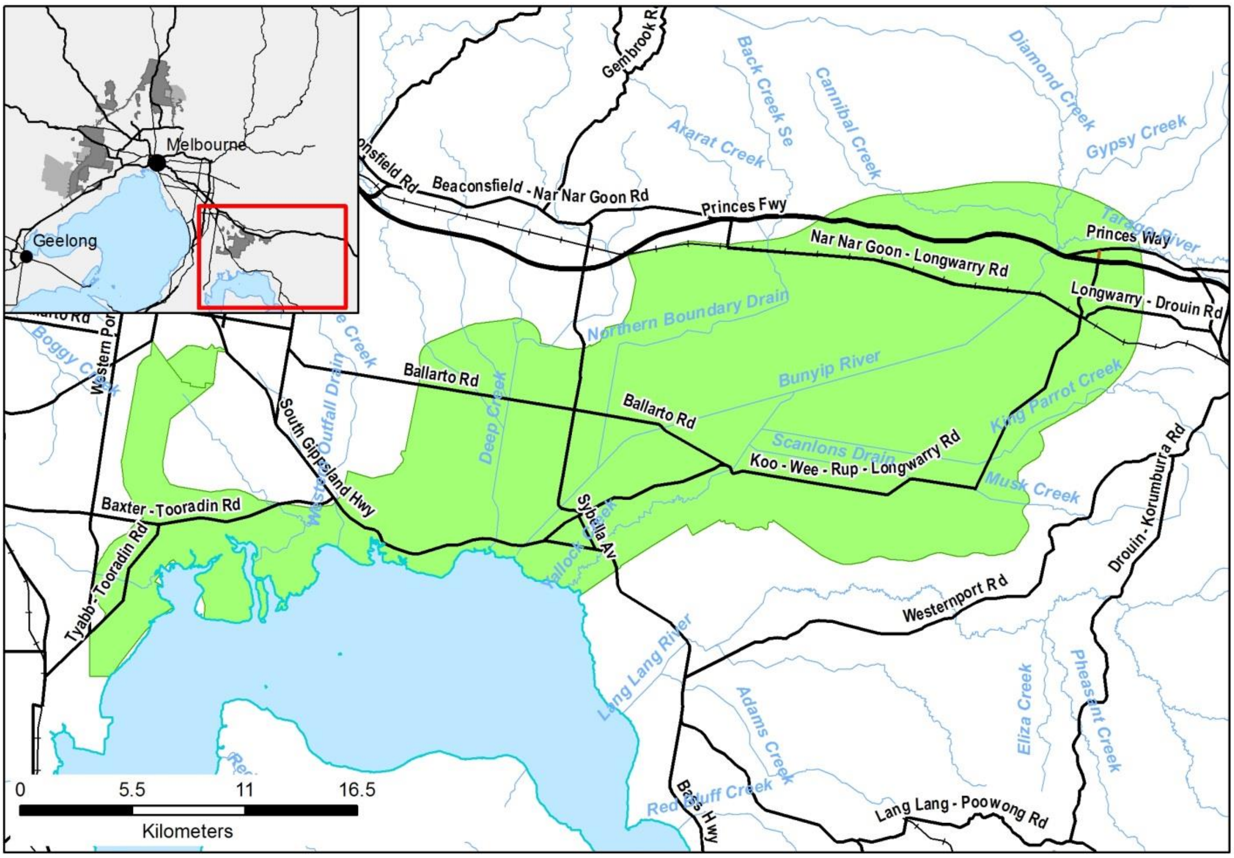

Figure 24: Southern Brown Bandicoot management area

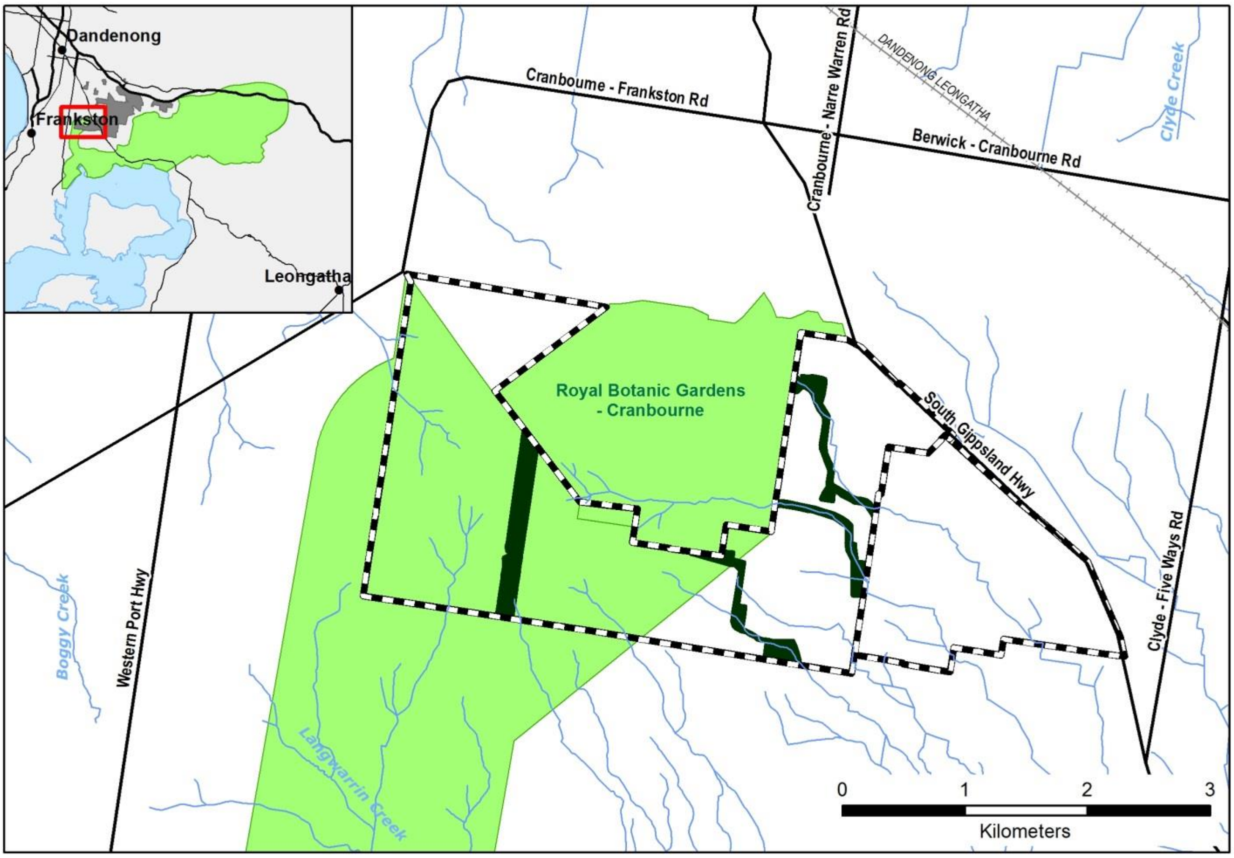

Figure 255: Southern Brown Bandicoot habitat connectivity areas

Description of the species

The Southern Brown Bandicoot *Isoodon obesulus obesulus* (Peramelemorphia: Peramelidae) grows to a head-body length of 280-355 mm with a tail of 80-130 mm. Males (500-1500 g) are generally larger than females (400-1000 g). Their body fur is brown, buff and black above and creamy white underneath. The tail is brown above and creamy yellow below. The forefeet are also creamy white or yellow. The ears are small and rounded and the eyes small and black (Department of the Environment 2012a; Menkhorst and Knight 2011).

Distribution of the species

The eastern sub-species is found in NSW, South Australia and Victoria (Department of the Environment 2012a). In Victoria it is primarily found in coastal and foothill regions, including the south-east Melbourne region (Brown and Main 2010). Isolated populations also found in the Grampians and central western Victoria (Menkhorst 1990). The Southern Brown Bandicoot in Western Australia is considered a separate sub-species (*Isoodon obesulus nauticus*) (Menkhorst and Knight 2011).

Southern Brown Bandicoots are found in the south eastern suburbs of Melbourne but their populations are generally fragmented, and have undergone significant contraction in recent decades. There is a significant population in Cranbourne Botanic Gardens (DSE 2009b).

Conservation status of the species

Southern Brown Bandicoot (eastern) is listed as Endangered (EN) under the EPBC Act (DSE 2013). It is listed Threatened under the FFG Act and Near Threatened (NT) in the DELWP advisory list (DSE 2013).

Key performance indicators

Table 23 KPI to demonstrate the persistence of the Southern Brown Bandicoot.

KPI:	Proportion of monitored sites that are occupied	
Measure	Baseline	Proportion of sites occupied at the first survey
	Data collection	Calculated from camera trap surveys conducted every five years.
	Data management	Victorian Biodiversity Atlas (VBA)
	Target	The proportion of sites occupied remains above the baseline.
	Confidence interval	The upper 95% confidence interval for the proportion of sites occupied remains above the baseline.
	Frequency	Five yearly
Reporting	Forum	Five yearly Report
	Start Date	Five years after commencement of on-ground implementation (2018-19).
	Responsibility	Department of Environment, Land, Water and Planning

Other data collection

Table 24 Other data collection to support analysis of cause of change in the Southern Brown Bandicoot.

Data	Fox occupancy
Frequency	Five yearly
Data management	Victorian Biodiversity Atlas (VBA)
Data	Fox bait take
Frequency	As required by baiting program
Data management	Native Vegetation Information Management System (NVIM)
Data	Extent of native vegetation
Frequency	Five yearly
Data management	Native Vegetation Information Management System (NVIM)
Data	Fire history
Frequency	Five yearly
Data management	DELWP fire database
Data	Infrastructure development within management area
Frequency	Five yearly
Data management	State and local authorities

Monitoring protocol

Monitoring for this species will be undertaken every five years using automated cameras.

Selection of sites

One hundred sites across the Southern Brown Bandicoot management area will be monitored to get a precise estimate of the proportion of sites occupied.

Survey sites will be randomly selected in suitable habitat for the species, as informed by a species distribution model for the Southern Brown Bandicoot. Where possible, stratified random sampling will be used to allocate survey effort to potentially suitable habitat across the study area. The sampling program will be designed to maximise coverage of the available habitat, taking into account site access constraints, and variation in habitat suitability.

Each survey site will consist of two automated cameras, located 50m apart, centred on the randomly chosen survey location, and deployed for approximately 2-3 weeks.

Any factors leading to biasing site selection (e.g. limited access to private land) may mean that inference about the proportion of sites occupied can only be applied to sites with the same characteristics as those sampled. Thus, statistical estimates of occupancy rates may not be able to be validly extrapolated across the entire Southern Brown Bandicoot management area.

Field setup

Camera points will be located using a GPS device. A camera will be attached to the nearest suitable tree (alive, sturdy and not too big for the cable lock) using a cable lock to prevent theft at approximately 0.5 m from the ground.

The camera will be pointed at a bait station, located 1-3 m from the camera (the exact distance and angle is determined by the camera's detection field, dependent on the camera model, and noted in the manufacturer's instructions). To minimise false triggers the camera will be directed south and downslope, where possible.

The area between the camera and bait station, and 1m behind the bait station, will be cleared of all vegetation and debris. The width of clearing should match the field of view of the camera.

Bait will consist of a 5:1:2 mixture of rolled oats, golden syrup and peanut butter with 20 ml/kg of truffle oil, secured in an inaccessible bait holder.

Photo review

The photos will be reviewed by a person experienced in identifying small mammals from automated camera photos.

Supporting information

General ecology

The Southern Brown Bandicoot occupies a variety of habitats including woodland, heathy open forest, sedgeland, shrubland and heathland (Department of the Environment 2012a; Menkhorst 1990). The common factor in these diverse vegetation types is dense low-stature vegetation, with suitable habitat defined as average foliage density of 50-80% (native or exotic) at 0.2 – 1 m from the ground (Department of the Environment 2012a). The species is usually associated with infertile, sandy and well drained soils, but is also found on other soil types (Department of the Environment 2012a). There is a weak positive correlation with the relative abundance of logs, but not other habitat variables (in Naringal East, south-western Victoria (Bennett 1993)).

The Southern Brown Bandicoot uses refuges (temporary nests of grass and leaves) in dense vegetation, as well as more permanent structures under the skirts of grass trees and in rabbit warrens (Broughton and Dickman 1991) and in dense vegetation (Department of the Environment 2012a) for nesting. It uses roadside corridors (Rees and Paull 2000) to move between patches.

Home range estimates suggest a mean home range of between 0.9 and 9 ha (Department of the Environment 2012a). There is some evidence that home range overlap is flexible and probably influenced by invertebrate abundance (overlap range 44 – 72 %). Individuals may expand their home range to

opportunistically exploit high value food sources (with increase in range overlap) (Broughton and Dickman 1991). It is unclear if this species is territorial; in some studies home ranges overlap, whilst others have shown no overlap. It is considered likely that any territoriality is in the form of passive avoidance (Department of the Environment 2012a).

There is little information on long-term population trends in this species, and therefore it is unclear how populations fluctuate over time. They are however, potentially able to re-colonise suitable habitat rapidly due to high reproductive output and high juvenile dispersal (Lobert and Lee 1990; Menkhorst 1990). Juvenile mortality rates may be high (Van Dyck and Strahan 2008).

The diet of this species consists mostly of invertebrates (mainly insects and earthworms), but they also take small vertebrates (Brown and Main 2010), plants and fungus (Broughton and Dickman 1991).

Land use legacies and threats

This species is undergoing large scale and rapid declines across its range, meaning that all extant populations are important for species survival (Brown and Main 2010). Major threats include:

- Predation by foxes, feral cats and dogs. Fox control has had a positive effect on Southern Brown Bandicoot populations (Dexter and Murray 2009; Rees and Paull 2000; Robley *et al.* 2012)
- Inappropriate fire regimes. Some studies have shown that the species prefers early successional communities, with a diversity of regenerating vegetation providing cover and insect food (Paull 1995) and the references therein). However, other studies have shown that they inhabit a larger range of successional habitats (Brown and Main 2010). There is some evidence that a mosaic of successional habitats benefits this species (Brown and Main 2010; Paull 1995). High intensity fires may cause the loss of small isolated populations (Rees and Paull 2000)
- Spatial isolation of habitat remnants, the barrier effects of roads and urban development and habitat loss (due to land clearing and damage from the water mould *Phytophthora cinnamomi*), are also considered to be threats to this species (Brown and Main 2010; Rees and Paull 2000).

Monitoring techniques

Southern Brown Bandicoot can be detected using a variety of techniques including hair tunnels and automated cameras. Other techniques include searching for diggings and scats, soil plots to detect tracks and analysis of material in predator scats. Daily detection probability for camera surveys ranges from 0.1 to 0.5 (De Bondi *et al.* 2010; Smith and Coulson 2012) with some evidence that vertically oriented cameras increase detection probability (Smith and Coulson 2012). If the detection probability is in the lower range (~0.1), more than the recommended 14 days would be required to survey this species with high confidence (Smith and Coulson 2012). At the upper range of detection probability, five days would be sufficient (De Bondi *et al*. 2010). Occupancy methods using automated cameras to detect bandicoots are recommend, as they are cost effective, minimally invasive and easy to implement (Scroggie 2008).

Different lure combinations have been successfully used including mixtures of peanut butter, honey, raw linseed oil, vanilla essence and truffle oil (De Bondi *et al*. 2010) or raw linseed oil, part pistachio and vanilla essence (Smith and Coulson 2012) . A mixture of peanut butter, oats, golden syrup and truffle oil could also be used (Department of the Environment 2012a). It is unknown; however, which lure combinations are most effective.

Important conservation documents and resources

- National Recovery Plan (Brown and Main 2010)
- Sub-regional Species Strategy for the Southern Brown Bandicoot (DEPI 2014)
- Regional Recovery Group for the Western Port Biosphere Reserve (WPB 2011)

- Regional Recovery Plan for Southern Brown Bandicoot (*Isoodon obesulus obesulus*) in the Mornington Peninsula and Western Port Biosphere Reserve (Nicholls and Coates 2011).

Striped Legless Lizard (*Delma impar*) persists

Introduction

The outcome

The Victorian Government has committed to ensuring that the Striped Legless Lizard persists within the program area. This will be achieved through a range of outputs, particularly the establishment and management of a 15,000 hectare grassland reserve and a network of Conservation Areas inside the Urban Growth Boundary (UGB).

The outcome will be measured in the following conservation areas:

- Western Grassland Reserve.

Description of the species

The Striped Legless Lizard *Delma impar* (Squamata: Pygopodidae) is a flap-footed lizard. It lacks forelimbs and the hind limbs are reduced to small flaps on either side of the vent. The species grows to about 30 cm in length with the snout-vent length up to 12 cm. Both sexes have similar colouration, with a large olive/brown vertebral stripe and dark and pale lateral stripes, although this pattern may not always be prominent. The tail has diagonal bands or spots. Males have a small rounded spur under each hind limb flap (Department of the Environment 2012b; Wilson and Swan 2010).

Distribution of the species

Striped Legless Lizard is found in NSW, the ACT, SA and Victoria. The Victorian range has contracted to the south with populations in the outer western and northern suburbs of Melbourne, the western districts and areas around Yea/Alexandra (Department of the Environment 2012b; O'Shea 2005).

Conservation status of the species

Striped Legless Lizard is listed as Vulnerable (VU) under the EPBC Act (DSE 2013). It is listed Threatened under the FFG Act and Endangered (EN) in the DELWP advisory list (DSE 2013).

Key performance indicators

Table 33 KPI to demonstrate the persistence of the Striped Legless Lizard.

KPI:	Proportion of permanent monitoring plots that are occupied	
Measure	Baseline	NA
	Data collection	Calculated from tile grid surveys conducted between November and December annually
	Data management	Victorian Biodiversity Atlas (VBA)
	Target	Evidence of SLL is detected once in every five year period at 100% of permanent monitoring plots
	Frequency	Annually
Reporting	Forum	Five yearly Report
	Start Date	Five years after securing the land
	Responsibility	Department of Environment, Land, Water and Planning

Other data collection

Table 34 Other data collection to support analysis of cause of change in the Striped Legless Lizard.

Data	Cover of bare ground
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part monitoring for the NTG outcome
Data	Cover of weeds
Frequency	Annually
Data management	Native Vegetation Information Management System (NVIM) - Undertaken as part monitoring for the NTG outcome
Data	The ambient air temperature, temperature under one tile per grid, cloud cover, wind direction and strength, survey date, start and finish time
Frequency	At each survey
Data management	Native Vegetation Information Management System (NVIM)

Monitoring protocol

General monitoring guidelines
Monitoring of this species will be undertaken by annually surveying grids of roof tiles. Each grid is a rectangle of 10 x 5 ceramic roof tiles spaced 5 m apart, 50 tiles per grid in total.

The tile grids will be established two months prior to commencing the survey. The location of the corner tiles on each grid will be recorded using GPS. Surveys will take place in spring to early summer. Optimal conditions are between 10am and 4pm, when the tile temperature is 18-40°C and the ambient air temperature is between 15-30°C.

At each tile grid the sheltered area underneath the tiles will be inspected for evidence of lizard presence, including sloughed skins. Six repeat tile checks of each grid will be conducted at least one week apart. Tile checks will not occur at the same time of day on each occasion for any given tile grid during the survey period (i.e. randomly allocate daily site check order). At the end of the survey period each year, tiles from all grids will be collected and stored.

All lizard surveys will be conducted in accordance with these guidelines

Striped Legless Lizard monitoring will consist of three phases:

- Phase 1. Inventory - An intensive search in order to locate populations
- Phase 2. Inventory – Up to 10 year searching to locate previously unknown populations
- Phase 3. Ongoing monitoring of known populations.

<u>Phase 1 - Inventory - An intensive search in order to locate populations</u>
Upon acquisition of a parcel, as part of the fauna inventory, tile grids will be deployed in un-cultivated grassland to determine presence of the Striped Legless Lizard. The number of tile grids to be deployed will be calculated based on a ratio of 1 grid per 50 hectares of land. The location of the grids will be randomly determined across grassland in the parcel, with grids at least 50m apart. Lizard surveys will be conducted according to the general monitoring guidelines detailed above. Any grid found to contain at least one Striped Legless Lizard (alive, dead or a lizard slough) will become a permanent monitoring plot (see phase 3), except where two occupied grids are <100 m apart, in this case the grid where a lizard was first located will become the permanent plot (the location of the other plot will be noted). During this phase, other tile

grids may be located on a property for general fauna inventory. Should Striped Legless Lizard be detected at one of these grids, it will become a permanent location subject to the distance requirements above.

Phase 2 - Inventory – Up to 10 year searching to locate previously unknown populations
The Western Grassland Reserve has been divided up into 250 ha blocks. Any block already containing one or more permanent monitoring plots will be excluded from this phase.

Within each of the remaining blocks, 10 randomly allocated locations at least 50 m from a previous grid location will be identified. One location (one tile grid per location) will be progressively surveyed each year in an effort to detect lizards. Any grid found to contain evidence of Striped Legless Lizard (alive, dead or a lizard slough) will become a permanent monitoring plot (see phase 3), and within each segment Lizard surveys will be conducted according to the general monitoring guidelines detailed above. Phase 2 will cease in a 250 ha block if one or more of the following occurs:

- evidence of SLL is detected during Phase 1 inventory surveys on other parcels within the block
- all of the grassland is exhausted (i.e. no more plots can fit given the distance rules)
- all 10 random locations have been surveyed.

Phase 3 - Ongoing monitoring of known populations
Permanent monitoring plots will be surveyed annually. Each plot will consist of the original tile grid (re-installed in the same location) and four additional grids arranged with the original grid at the centre and the new grids arranged in a cross shape (X) such that the corners of the grids are five metres apart. This grid arrangement may be altered if barriers such as fences prevent it. Lizard surveys will be conducted according to the general monitoring guidelines detailed above.

Supporting information

General ecology

Striped Legless Lizards inhabit tussock grassland and grassy woodlands and probably prefer areas with a dense sward of native grasses (e.g. Kangaroo Grass *Themeda triandra* or Spear Grass *Rytidosperma* spp.) However, lizards are also found in more open habitats and in areas dominated by exotic tussock grasses. There is some evidence that the species depend on particular grassland species or communities (Dorrough and Ash 1999), however this may reflect structural preferences and historic legacies, rather than floristic preferences.

D. impar is rarely recorded at sites dominated by exotic annual grasses (O'Shea 2005). The grassland state-transition model summarises some of the factors that are important for Striped Legless habitat (history of fertiliser use, recent ploughing, fire and grazing history (Dorrough and Ash 1999; O'Shea 2013). As this species utilises cracks in the soil, drainage may be important with low-lying or poorly drained areas being only used in dry periods (Dorrough and Ash 1999).

Striped Legless Lizard is described as a selective feeder specialising in wolf and jumping spiders, crickets and grasshoppers, cockroaches and noctuid moth larvae (Coulson 1995; Kutt *et al*. 1998).

Recent genetic evidence suggests that there are four distinct evolutionarily significant units across the species' range, with the Melbourne region lizards belonging to the south west Victorian population (Maldonado *et al*. 2012).

Nothing is known about how populations fluctuate over time. However long distance dispersal is unlikely with the longest recorded movement distance being 60 m. The ability of this species to colonise (or re-colonise) habitats is limited by a slow rate of population spread (<12 m per year) (Dorrough and Ash 1999) and a likelihood of barriers such as roads preventing movement.

Land use legacies and threats

The major threats to this species are:

- Habitat loss and fragmentation is the key threat to this species. Disturbances such as heavy grazing (leading to soil compaction), pasture improvement and rock removal are also considered detrimental
- Inappropriate fire or grazing regimes, particularly short fire intervals or high intensity grazing that may lead to greater exposure to predators and long intervals or low intensity grazing leading to an accumulation of grassy biomass (O'Shea 2005)
- Other threats include predation, illegal collection, and habitat degradation by weed invasion and disturbances such as ploughing and de-rocking of habitat.

Monitoring techniques

Striped Legless Lizard can be surveyed using roof-tile grids, pitfall traps with drift nets and active searching. Trapping success has not been compared between the three techniques. Active searching (e.g. rock rolling) is discouraged due to low success rates and the possibility of habitat disturbance (Department of the Environment 2012b; O'Shea 2005). Capture success using tile grids is highest in spring and declines in summer with autumn and winter not recommended for surveys. *D. impar* is inactive from March/April until September (O'Shea 2005; Thompson 2006). The best time of day to check grids appears to be between 11am and 3pm (Thompson 2006). Detection is highest when the ambient temperature is between 15 and 30 and the temperature under the tiles is 20 to 30 (Thompson 2006). A typical tile grid contains 50 tiles with five metre spacing arranged in a 10 x 5 grid. When and how often grids are checked depends on the objective of data collection. *D. impar* can also be surveyed using pitfall traps, however roof tiles are considered to be a better survey method as capture rates are similar and roof tiles are less labour intensive and can be left in situ for multiple years. Nevertheless, pit-fall traps are more effective at capturing hatchlings and juveniles (O'Shea 2005).

Important conservation documents and resources

- FFG Act Action Statement (DSE 2003b)
- National Recovery Team, established in 1995 (Robertson and Smith 2010)
- Evaluating the effectiveness of salvage and translocation of Striped Legless Lizards (O'Shea 2013).

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Appendix 1: Wetland Indicator Species

The following species are considered to be native indicator species for Seasonal Herbaceous Wetland. The list is taken directly from TSSC (2012).

Scientific name	Common name
Allittia cardiocarpa	swamp daisy
Asperula conferta s.l.	common woodruff
Asperula subsimplex	a woodruff
Brachyscome basaltica	woodland swamp daisy
Calocephalus lacteus	milky beauty-heads
Calotis spp.	burr daisies
Craspedia paludicola	swamp billy buttons
Diurus spp.	donkey orchids
Eryngium vesiculosum	prickfoot
Helichrysum rutidolepis s.l.	pale everlasting
Hypoxis spp.	golden stars
Isoetes spp.	quillworts
Lobelia concolor	milky lobelia
Lobelia pratioides	poison lobelia
Marsilea spp.	nardoos
Microseris spp.	yam daisies
Microtis spp.	onion orchids
Montia australasica	white purslane
Ornduffia reniformis	running marshflower
Ottelia spp.	swamp lilies
Pilularia novae-hollandiae	austral pillwort
Potamogeton cheesemanii	pondweed
Prasophyllum spp.	leek orchids
Ranunculus inundatus s.l.	river buttercup
Senecio psilocarpus	swamp fireweed
Swainsona spp.	swainson peas
Teucrium spp.	germanders
Thelymitra spp.	sun orchids
Triglochin alcockiae	southern water ribbons
Triglochin striata	streaked arrow-grass
Utricularia spp.	bladderworts; fairies' aprons
Xerochrysum palustre	swamp everlasting

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