GRACEFUL SUN-MOTH

Information Kit & Survey Methods

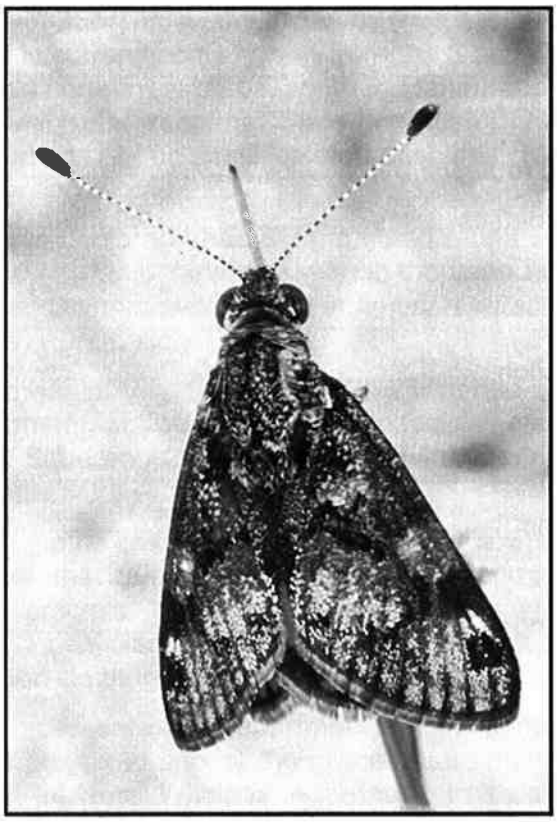

Photo: David Pike, City of Joondalup

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Contents

Summary 2
1. Introduction 2
2. Biology and ecology of the graceful sun-moth 3
Sun-moths 3
Graceful sun-moth 4
Best time of year to survey 5
Places favoured by the GSM 5
Suitable weather conditions 6
Survey replication 6
3. How to conduct a GSM survey 6
Transect length and route 6
Recording transect details 7
4. How to conduct a *Lomandra* density survey 8
The species 8
Quadrat data collection 9
Collecting Lomandra samples 11
5. Licences 11
6. Specialist equipment 11
Appendix One - GSM transect data sheet 12
Appendix Two - Lomandra density data sheet 14

Summary

This document is an information kit on the endangered graceful sun-moth *Synemon gratiosa*. It documents the currently-known distribution of the species, how to identify it, and how to conduct surveys of bushland to determine if it is present.

It is intended that DEC staff, bushland Friends groups, Local Government officers, land developers and their environmental consultants will use this kit to assist them to determine if the graceful sun-moth is present at a particular site.

1. Introduction

The graceful sun moth (GSM) is a small day-flying moth endemic to south-west Western Australia, and is currently only known from the Swan Coastal Plain between Quinns Rocks, in Perth's northern suburbs, south to Mandurah. There are few known populations, none of which are in formal State-managed conservation estate, and almost all known populations are on small isolated bushland remnants and subject to a high risk of local extinction.

The graceful sun moth is declared specially protected fauna under the WA *Wildlife Conservation Act 1950*, as it is rare or likely to become extinct. It is listed as Endangered under the *Commonwealth Environment Protection and Biodiversity Conservation Act (1999)* (EPBC Act).

In addition, extensive areas of vegetation within this widened possible habitat range is proposed for development, and the presence of possible graceful sun moth habitat will be a component of State and Commonwealth environmental impact assessment of development proposals.

Because the adult sun moths are only detectable during a limited period each year (March), it is important that survey for this species is carried out early in the development planning process. Leaving surveys too late will lead to substantial delays to statutory land use planning, environmental impact assessment, and the assessment of vegetation clearing applications.

Over the next one to three years the Department of Environment and Conservation (DEC) is conducting a project to survey the graceful sun moth and its habitat. The survey will extend from (at least) Wilbinga in the north to Yalgorup in the south and will include existing and proposed conservation reserves. The project will seek to clarify the factors that determine the habitat and distribution of the graceful sun moth, will provide a regional context for environmental impact assessment processes, and will provide information to better determine the status of the species.

DEC would expect that development proponents and their consultants will consider the possibility of GSM being present and will carry out surveys for the graceful sun moth.

2. Biology and ecology of the graceful sun-moth

Sun-moths

Sun-moths are brightly coloured moths that are active during the day, usually in warm to hot weather, and they prefer bright sunshine. They look and behave more like butterflies than typical moths. There are 45 species of sun-moth in Australia, with more than 20 in Western Australia. Although they vary in size, with wingspans between 25 and 80 mm, they are all basically similar in appearance, behaviour and biology.

The upper surfaces of the forewings are usually dull in colour, whereas the upper surfaces of the hind wings are bright red or orange. The undersides of both wings are also bright red or orange. When at rest, the wings are folded so that only the dull fore wings are apparent, providing camouflage for the moth.

A typical sun-moth. The forewings are dark, whereas the hind-wings are brightly coloured with orange or red markings.

When at rest, the sun-moth's dark coloured forewings completely cover the brightly coloured hind wings.

Sun-moths have a life cycle that takes one to three years to complete. The adult moths are only active for a relatively short period each year. Each adult moth lives for only 2 to 10 days, but the adult moths at a particular site will appear over a four-week or longer period. The 'flight-period' of each sun-moth species is at about the same time each year. The vast majority of species fly during spring, i.e. between September and December. However, a few species, including the GSM, appear only during autumn. The exact time at which they appear each year varies by as much as

1-2 weeks, depending on weather conditions. There is also regional variation in flight times based on latitude.

During the adult phase, the moths mate and the females then spend most of their time laying eggs. Males actively seek out females and are usually encountered more frequently, although the sex ratio is usually 1:1.

The larvae (caterpillars) of each species feed on only one or a few closely related species of plants. The spring-flying species all feed on native grasses, sedges and other closely related groups of plants. The autumn-flying species all feed on species of mat-rushes (*Lomandra* **species). The eggs are laid at the base of the 'food-plant'**, and the larvae that hatch from the eggs burrow into the growing tip and down into the underground culms, roots or rhizomes. They live entirely within or alongside the underground parts of the plant, making them very difficult to locate. The larvae look like beetle grubs – they are white or cream in colour, with a small dark brown head. **Most species take one year to complete the life cycle (ie egg → larva → pupa →** adult moth) although some take two or more years. For species that take two years to develop, there may **be two separate 'cohorts' within the population. These may** constitute completely independent populations, although it is thought that some individuals may develop in one or three years and so maintain the genetic link between cohorts

Graceful sun-moth

The GSM flies between mid or late February and late March or early April each year. The flight time seems to vary between years, probably as a result of weather conditions. It also seems to vary with latitude (being somewhat earlier in the south of the species' **range) and with proximity to the coast (being somewhat later close to the** coast). In any case, March seems to be the main flight period and the first half of March is when the species is most abundant, and hence easiest to detect.

The GSM is small, with a wingspan of only 25 – 30 mm (Figure 1). The upper surface of the forewings is dark grey, whereas the upper surface of the hind wings and the entire underside of all the wings is bright orange, with some dark grey markings.

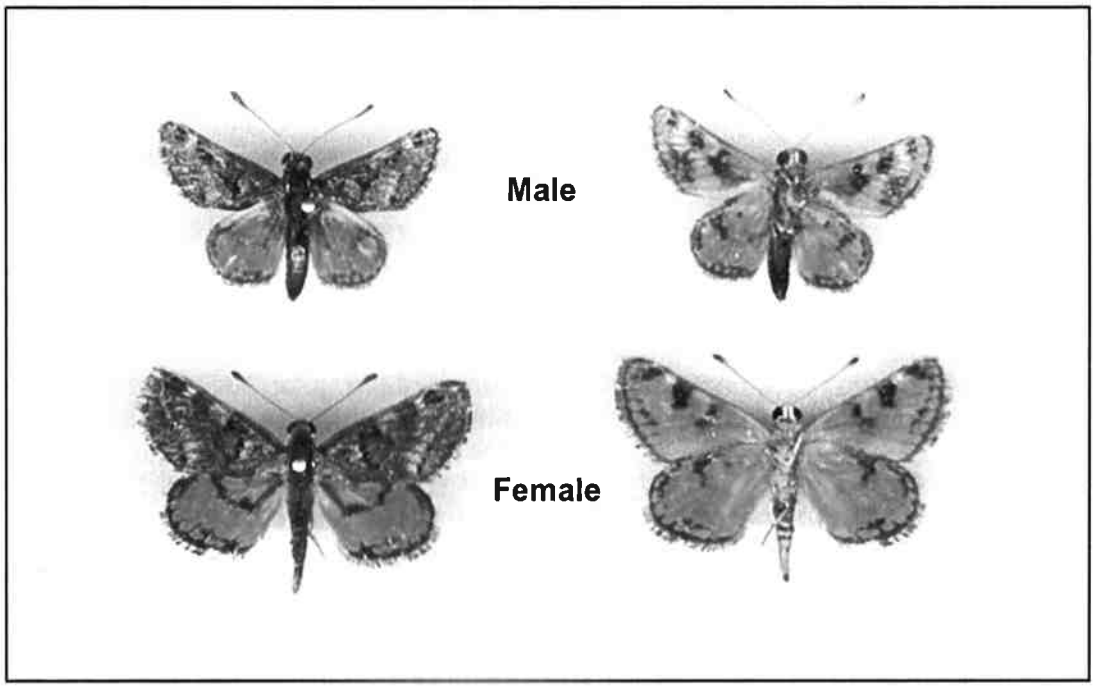

Figure 1: Male and female specimens of the graceful sun-moth. Showing the upper (left) and undersides of the wings. The wingspan of the male is 25 mm, the female 30 mm.

The larvae are only known to feed on two closely related and similar-looking species of *Lomandra* mat-rushes – *Lomandra maritima* and *Lomandra hermaphrodita*. Several new populations of the graceful sun moth were located in 2009 on coastal sand and limestone heaths and shrublands. These populations were using a different species of food plant (*Lomandra maritima*) from the food plant that graceful sun moth had previously been known to use (*Lomandra hermaphrodita*).

The graceful sun moth is currently only known from two general vegetation types:

- Banksia woodland/woolly bush on deep sands, in the northern suburbs of Perth on the Swan Coastal Plain. In these sites the GSM breeds on *Lomandra hermaphrodita*, which often occurs in low numbers.
- Open areas of herbland, heathland and shrubland on Quindalup soils (sand and limestone) close to the coast where it breeds on *Lomandra maritima*, which is often present in reasonable numbers and may even be a dominant understorey herb.

Lomandra maritima is abundant in the near coastal vegetation north and south of Perth and the discovery of these new populations means it is possible that additional habitat and populations may be found. It is also possible that the larvae may feed on other species of *Lomandra*, although at present this is thought to be unlikely.

The larvae feed inside the bulb-like leaf bases, growing tip and rhizome beneath the ground. The larvae are thought to take either one or two years to reach maturity but this is presently unknown.

Populations of the GSM are typically small, and the species is naturally rare. Even in sites where it occurs, it can be difficult to detect the presence of the GSM simply because few adults are present. For example, in Koondoola bushalnd in Perth's northern suburbs, a two hour survey may record anywhere between none and 3 adult moths. For this reason, it is necessary for surveys:

- to target the best time of year (when adults are most abundant);
- to target places within each site that are favoured by the moths; and
- to be conducted in weather conditions when the moths are most active; and
- to be repeated sufficient times to ensure that the GSM is not overlooked

Each of these issues is discussed below.

Best time of year to survey

In all sites presently known the first half of March has been found to be the peak flight period. However, surveys conducted in late February (i.e. after 20 Feb) or early April (before 10 April) may also detect moths. However, only March surveys can provide sufficient information to determine that the GSM is NOT present at a particular site.

Places favoured by the GSM

GSM will always be found fairly close to their breeding areas. Because of their dependence on Lomandra food plants, areas within and around places that have high densities of these plants should be examined.

Male GSM are territorial. They establish small territories, called leks, that are about 20 square metres in extent. The territories are always in open areas – in remnant

bushland the leks are almost always along tracks and fire breaks. Like many butterflies, the males may also seek out hilltops or the ridges of dunes. Thus surveys for the GSM should always include examination of these features if they are present within a site. When disturbed, males will fly away but rarely leave the lek. If a male GSM is encountered and flies away, it is best to take a few steps backwards and allow it to return.

After mating, female GSM generally avoid tracks. They will usually be found in the breeding areas where their Lomandra food plants occur. Females are less active and far less noticeable than males – usually sightings of males outnumber those of females by at least 5 to 1.

Suitable weather conditions

GSM are only active in warm sunny weather and prefer bright sunshine. The optimal time of day to observe them is between 10 am and 3 pm. Based on limited data, it seems that they will become inactive if the wind is too strong (above about 18 km/h). In March, when the sea breeze occurs regularly each afternoon, surveys should be conducted prior to the sea breeze arriving.

Survey replication

Because the GSM can be difficult to detect, multiple surveys must be conducted during the flight period. Previous work has shown that in sites where the GSM occurs, the probability of detecting the GSM on any given day is only slightly greater than 50%. Because of this delectability problem, the current standard is that at least 4 surveys are needed to ensure that the GSM is NOT present at a particular site. This standard will be reviewed once better data on GSM detectability is available.

3. How to conduct a GSM survey

Transect length and route

Surveys to detect the GSM must follow a standard protocol. This is based on the standard butterfly walk transect method, which includes day-flying moths. This method is used at more than a thousand butterfly monitoring sites throughout Europe and North America (see Pollard & Yates 1993, or visit the UK butterfly monitoring website at http://www.ukbms.org)

At a given site, an aerial photograph and/or vegetation map is used to determine the location of tracks and firebreaks, major vegetation types, landforms and fire history. Using this information, a transect route is determined in advance that includes as many of these features as possible. Both recently and long-unburnt areas should be examined. If the location and density of *Lomandra maritima* or *L. hermaphrodita* is known, this should also be considered in devising the transect route.

Once the route of the transect is determined, it is walked at a steady pace by one or more observers, and any GSMs seen within 5m to each side and ahead of the observers are recorded. Any GSM seen outside of this corridor, or detected at the **site during other activities, is recorded as an 'incidental' observation.**

To facilitate recording, the transect is divided into 'sectors' each approximately 100 m long. The boundaries of the sectors should correspond to local features, such as

track intersections, or prominent landmarks such as tall trees, etc. Recording the transect route on a GPS is the most convenient method of ensuring transect repeatability.

The transect should be long enough that it samples a fair proportion of the site. A very rough guide to the sampling fractions needed are listed in Table 1. To determine the appropriate transect length, use the formula:

Transect length in km = 0.7 x square root (Area in hectares).

Table 1: Sampling fractions required per site area

Site area	Sampling fraction	Transect length
5ha or less	30 – 70%	0.7 – 1.6 km
6 – 10 ha	20 – 30%	1.7 – 2.2 km
11 – 20 ha	15 – 20%	2.3 – 3.1 km
21 – 50 ha	10 – 15%	3.2 – 5.0 km
51 – 100 ha	7 – 10%	5.0 – 7.0 km
101 – 200 ha	5 – 7%	7.0 – 10.0 km
201 ha or more	5%	10 km

In large sites the transect should consist of several smaller transects scattered across the entire extent of the site.

Recording transect details

Each time a transect is surveyed, standard details are recorded. Before commencing the transect, record:

- Date
- Number and identity of observers
- Weather conditions – air temperature, wind speed & direction, estimate of cloudiness
- Start time of transect
- Once the walk transect starts, record:
- As you enter each sector, note whether it is sunny (S) or cloudy (C).
- The number of GSM detected in each sector is recorded.
- At the completion of the survey, note the finish time.

See appendix 1 for an example of a standard GSM transect recording sheet.

Collecting specimens

Digital photos of captured GSMs should be taken for identification by DEC Science Division. Photos can be emailed to Carly.Bishop@dec.wa.gov.au for processing.

Decisions on GSM vouchering will be made by DEC Science Division and decided on a case-by-case basis dependent on location. If a GSM is captured, please contact either Carly Bishop (9334 0310) or Matthew Williams (9334 0399) and advise location of capture.

Captured GSMs should be kept in a cool dark place.

4. How to conduct a *Lomandra* density survey

The species

Lomandra hermaphrodita and *Lomandra maritima* are 2 closely related species upon which GSM larvae feed. The species are quite similar but can be distinguished using a combination of locality, colour of the leaf base and colour of old leaves (Table 2).

Lomandra hermaphrodita

Lomandra maritima

Table 2: Characteristics of Lomandra hermaphrodita and L. maritima

Characteristic	*Lomandra hermaphrodita*	*Lomandra maritima*
Habit	Plants consist of several plantlets forming small tufts – generally uniform in size	Spreading clumps of variable size
Old leaves spiralled	Yes – red-brown in colour	Yes – straw coloured
Leaf length	150 - 450 mm	300 - 600 mm
Leaf width	1 - 2 mm	1 - 2 mm
Leaf base margin	Pale brown, pink or purple, splitting into fibres	White or pale grey, splitting into fibres
Location	Sandy soil on coastal plain and lateritic soil on the Darling Range, growing throughout the Perth region	Sandy soils near the coast. Geraldton to Bunbury
Flowers	April - June	August - October

Quadrat data collection

The aim of the *Lomandra* surveys are to determine fine-scale *Lomandra* presence and density and dominant plant species at each site. Additional site characteristics should also be collected and will be used to determine *Lomandra* site preference (and hence GSM habitat) across the Swan Coastal Plain.

As with the GSM transect method, the *Lomandra* density surveys must follow the standardised method outlined below. This will ensure consistent collection of high-quality data for analysis and use in GSM habitat preference modelling. A standard data sheet can be found in Appendix 2.

Equipment

- 2m x 2m PVC-pipe quadrat
- Handheld GPS
- Compass
- Trowel
- Data sheets

Method

The site should be sampled using a replicate number of 2 x 2 m quadrats dependent on site size. Table 3 provides a rough guide to quadrat number. Quadrats should be spaced at 50 m intervals along a minium of 3 transects. Each transect should begin in a corner of the project area and radiate out across the site at equal angles based on compass or GPS bearings (Figure 2). On larger or irregular shaped sites, transect bearings may radiate from 2 or more corners to ensure site coverage.

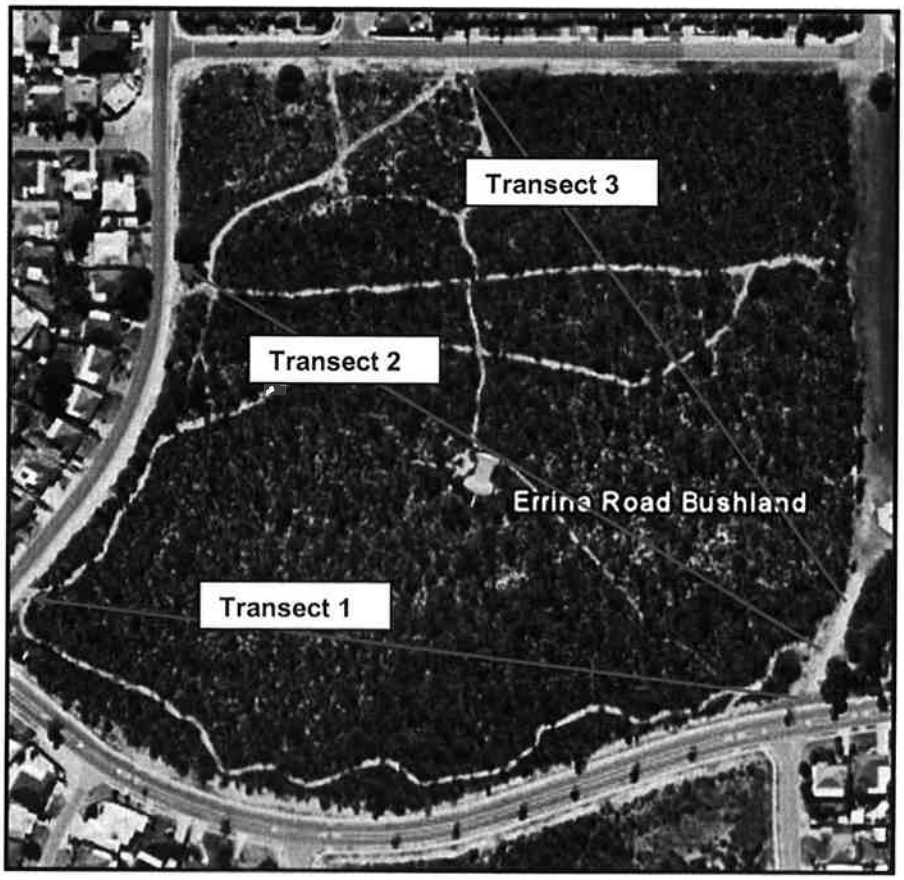

Figure 2: Sample design for Lomandra density/abundance surveys

Table 3: Quadrat number required per site area

Site area	No. of quadrats
< 10 ha	~30
11 to 20 ha	~60
21 to 50 ha	~120
51 to 100 ha	~300

Data to be collected for **each** quadrat includes:

- Site name
- Observers
- Eastings, Northings, elevation and aspect
- Transect and quadrat number
- Slope
- Bare ground
- Position in the landscape
- Vegetation structure
- Vegetation condition
- Surface and sub-surface soil description
- *Lomandra maritima* density using species cover due to its clumping habit (Table 4)
- *Lomandra hermaphrodita* density by counting each individual plant in each quadrat (Table 4)
- Dominant species cover (additional to the *Lomandras*) using the same cover scale as per *Lomandra maritima.*
- When walking between quadrats also score any opportunistic sightings of *Lomandra maritima* & *Lomandra hermaphrodita* using qualitative descriptions (abundant, common, uncommon)

Table 4: Species density scales

Lomandra hermaphrodita	***Lomandra maritima* and dominant species**	
	Area covered	**Percentage cover**
Count each individual plant per 2x2m quadrat	0	absent
	0.25m x 0.25m	~12%
	0.5m x 0.5m	25%
	1m x 1m	50%
	1.5m x 1.5m	75%
	2m x 2m	100%

Data format

Quadrat data should be entered into in an excel file and GPS data provided in shapefiles or csv files.

Additionally, habitat photos representative of the site should be taken and GPS location recorded.

Collecting Lomandra samples

- One entire *Lomandra maritima* and/or *L. hermaphrodita* specimen, including the intact rhizome, is to be taken from each site.
- Additional to this, cut leaf samples of 2 other specimens are to be taken. The sample should be large enough to fill a 10cm x 5cm envelope.
- Each sample should be labelled with the species name, observers name, company name, site name and GPS coordinates.
- Both the entire specimen and leaf samples are to be taken to DEC Science Division within 48 hours for processing, complete with GPS coordinates.

5. Licences & training

GSM surveys

To perform GSM surveys, individuals are required to hold a Regulation 17 Licence to Take Fauna For Scientific Purposes, under the Wildlife Conservation Act 1950. As a condition of the license, the licensee is required to submit a return detailing the species and numbers that were captured or sighted.

If GSM are to be taken from DEC managed lands, a Regulation 4 Authority will need to be obtained in addition to the Regulation 17 Licence.

Only those who have attended a DEC GSM training course can lead GSM field surveys. A trained person **must** have planned the survey and be present in the field for the duration of the survey.

Lomandra samples

Taking flora samples from private land requires the owner or occupier's permission. Collection of *Lomandra* samples on Crown land will require a Scientific or Other Prescribed Purposes License (SOPP) issued by DEC under the Wildlife Conservation Act 1950.

If *Lomandra* samples are to be taken from DEC managed lands, a Regulation 4 Authority application will need to be submitted in addition to the Scientific or Other Prescribed Purposes Licence.

Both fauna and flora permit applications **must** be submitted no later than 31st December 2009 in preparation for the late Feb/March surveys.

6. Specialist equipment

- Nets and collection jars can be purchased from Australian Entomological **Supplies with a recommended net size of 600mm (24") or similar. The** standard net comprises 3 components: handle (E24), hoop (E34A) and bag (E43AB)

  www.entosupplies.com.au
  0266 847 650

- A thermometer and anemometer is required for site temperature and wind data

Appendix One - GSM transect data sheet

Graceful Sun Moth Transects		
Site name:	Date:	Observers:
Transect #	Sheet of	Start time:
Wind speed & direction: km/hr	Temperature: °C	End time:
Comments/Incidental records:		

Section #	Cloudy?	Species	Section #	Cloudy?	Species

Use additional sheets if required

Section #	Length (m)	From	To

Appendix Two - Lomandra density data sheet

LOMANDRA SURVEY		
Site name:	Observers:	
Date:	Quadrat number:	
Easting:	Aspect:	
Northing:	% bare ground:	Surface soil:
Elevation:	Slope:	Sub-surface soil:
Transect #:	Position:	Veg condition:

Vegetation description:

Species	Cover/Count	Comments

VEGETATION STRUCTURE					
Life Form/ Height Class	**Canopy Cover**				
	Dense 70-100%	**Mid-Dense 70-30%**	**Sparse 10-30%**	**Very sparse 2-10%**	**Absent 0%**
Trees over 30m	Tall closed forest	Tall open forest	Tall woodland	Tall open woodland	No trees
Trees 10 - 30m	Closed forest	Open forest	Woodland	Open woodland	
Trees under 10m	Low closed forest	Low open forest	Low woodland	Low open woodland	
Shrubs over 2m	Closed tall scrub	Tall open scrub	Tall shrubland	Tall open shrubland	No shrubs
Shrubs 1 - 2m	Closed heath	Open heath	Shrubland	Open shrubland	
Shrubs under 1m	Closed low heath	Open low heath	Low shrubland	Low open shrubland	
Mat plants	Dense mat plants	Mat plants	Open mat plants	Very open mat plants	No mat plants
Grasses	Closed grassland	Grassland	Open grassland	Very open grassland	No grasses
Herbs	Closed herbland	Herbland	Open herbland	Very open herbland	No herbs
Sedges	Closed sedgeland	Sedgeland	Open sedgeland	Very open sedgeland	No sedges

CHARACTERISTIC	Area	Cover
***Lomandra maritima* cover** **Other species cover**	0	absent
	0.25m x 0.25m	~12%
	0.5m x 0.5m	25%
	1m x 1m	50%
	1.5m x 1.5m	75%
	2m x 2m	100%
Lomandra hermaphrodita	Count each individual	
Bare ground	as per species cover	

CHARACTERISTIC	DESCRIPTION
Slope	Level - 0°
	Very gently inclined - 1°
	Gently inclined - 3°
	Moderately inclined - 10°
	Steep - 23°
	Very steep - 37°
Position	crest
	ridge
	upper slope
	mid slope
	lower slope
	flat
	depression
Surface soil colour/texture	colour/texture description (e.g. light grey sand, brown sandy loam etc.)
Sub-surface soil colour/texture	as above

Vegetation Condition Ratings

Score	Descriptor	Explanation
1	Excellent	Pristine or nearly so, with no obvious signs of disturbance.
		0% weed cover
2	Very good	Vegetation structure intact, with disturbance affecting individual
		1 – 5% weed cover
3	Good	Vegetation structure altered, with obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, and/or grazing, dieback, logging and/or grazing.
		5 – 25% weed cover
4	Poor	Vegetation structure significantly altered by very obvious signs of multiple disturbances. Retains basic vegetation structure or ability to regenerate it. For example disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and/or grazing.
		25 – 50% weed cover
5	Degraded	Basic vegetation structure severely impacted by for regeneration but not to a state approaching good condition without disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance of vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and/or grazing.
		50 – 75% weed cover
6	Completely degraded	The structure of the vegetation is no longer intact and the area is completely, or almost completely, without native species. These areas are often described as "parkland cleared" with the flora comprising weed or crop species with isolated native trees or shrubs.
		75 – 100% weed cover