Survey guidelines for the Graceful sun-moth (*Synemon gratiosa*) & site habitat assessments

August 2010
Version 1.1

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Cover photos: Coastal heathland habitat of the graceful sun-moth (*Synemon gratiosa)*, taken by Carly Bishop. Graceful sun-moth (inset, x3 magnification) taken by David Pike.

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Please check the DEC website for the most current version of these survey guidelines. www.dec.wa.gov.au.

Department of
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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 the presence of graceful sun-moth at a particular site and the associated habitat characteristics.

1. What's new in version 1.1?

***Lomandra* survey design**

- Quadrat placement to be determined by grid overlay instead of radiating out from the corner of the study area
- In coastal heathland habitat, dunes must be incorporated into the *Lomandra* survey in addition to the standard grid overlay.
- The formula for calculating the number of *Lomandra* quadrats required has changed and details are described in Section 6.2 Habitat assessment survey method.

Data provided to DEC Science Division

- Both *Lomandra* and graceful sun-moth data to be sent through to the DEC Science Division in the file format specified. This is additional to the standard reg. 17 return required by the DEC Wildlife Licensing Division. All data will remain confidential and will be incorporated into future habitat suitability modeling. The accepted file format will be sent out with the reg. 17 license.

2. Introduction

The graceful sun-moth (GSM) is a small day-flying moth endemic to south-west Western Australia, known from Leeman in the north to Preston Beach in the south (Yalgorup NP).

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).

Extensive areas of vegetation within the 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 (late February through early April), 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 Kalbarri 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;
- provide a regional context for environmental impact assessment processes; and
- 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.

3. Biology and ecology

3.1. 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 (Figures 1 and 2).

Figure 1: A typical sun-moth. The forewings are dark, whereas the hind-wings are brightly coloured with orange or red markings

Figure 2: 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 (i.e. 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.

3.2. 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 3). 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.

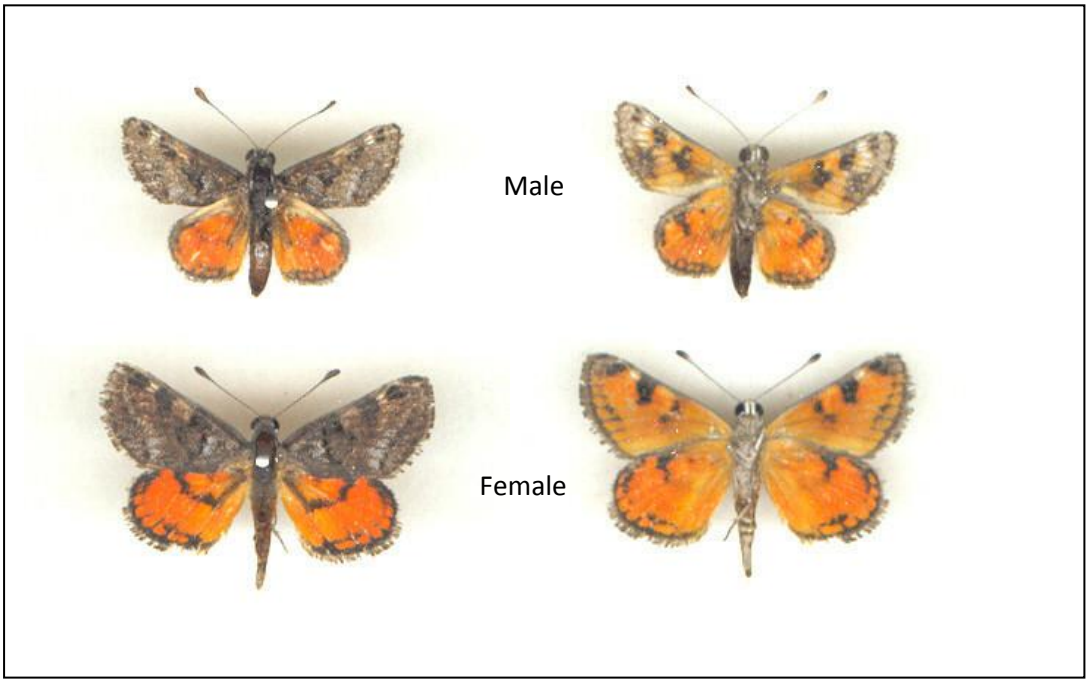


Figure 3: Male and female specimens of the graceful sun-moth. Showing the upper (left) and undersides of the wings. The wingspan of the male is 25 mm, the female 30 mm.

3.3. Graceful sun-moth habitat

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. Sites on limestone may have both *Lomandra* species present.

Prior to 2009, the graceful sun-moth had only been recorded in *Banksia* woodland containing the monocotyledon *Lomandra hermaphrodita* (Asparagaceae). In early 2009 new populations of the graceful sun-moth were located in coastal heathland associated with *Lomandra maritima,* a species closely related to the original host plant *L. hermaphrodita. Lomandra maritima* is abundant in coastal vegetation between Binningup and Shark Bay, so the discovery of this new host plant meant it was possible that additional habitat and populations of graceful sun-moth may be found.

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. It is also possible that the larvae may feed on other species of *Lomandra*, although at present this is thought to be unlikely.

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

4. 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.

5. Survey guidelines for the graceful sun-moth

5.1. 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.

5.2. 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.

5.3. Sites favoured by the graceful sun-moth

GSM will always be found 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 are a priority for survey.

Male GSM are territorial and they establish small territories (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.

5.4. Survey effort

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%.

The survey effort prescribed reflects the substantial differences in graceful sun-moth counts in the 2 different habitat types. At least 4 repeat surveys are needed in coastal heathland habitat to ensure that the GSM is not present at a particular site as based on the golden sun-moth survey prescription (DEWHA 2009a, 2009b).

Survey effort in *Banksia* woodland will be increased (possibly up to 6-8 repeat surveys) due to the poor detectability at these sites. Confirmation of *Banksia* woodland survey effort will be clarified and confirmed before the 2011 survey season once detailed analysis is complete.

Repeat surveys during suitable weather conditions need to be carried out at approximately weekly intervals to maximise detection across the flying season.

Once graceful sun-moths have been detected on a site the remaining surveys should focus on determining the relative distribution across the site for use in future decision making.

5.5. 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.

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

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.

5.6. 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 (% cover)
- Start time of transect & end time of transect which will be used to calculate number of moths seen per hour

For each GSM capture or sighting, record:

- Whether it is sunny (S) or cloudy (C) if cloudy % cloud cover to be estimated
- Easting and Northing coordinates
- Time of capture/sighting.
- Wind speed in km/hr at time of capture/sighting
- Location (on track / in vegetation)

See appendix 1 for an example of a standard GSM transect recording sheet. These can also be obtained electronically from DEC.

5.7. Collecting specimens

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

Decisions on GSM vouchering will be made by DEC Science Division and decided on a case-by-case basis dependent on location. Please contact either Carly Bishop (9334 0310) or

Matthew Williams (9334 0399) for advice and specimens can be dropped at either Kensington or Woodvale Science Division.

Captured GSMs should be kept in a cool dark place to prevent wing damage.

6. Survey guidelines for site based habitat assessments

6.1. Background to the larval food plant species

Lomandra hermaphrodita and *Lomandra maritima* are 2 closely related species upon which GSM larvae feed. The species are quite similar in appearance but can be distinguished using locality, colour of the leaf base and colour of old leaves (Table 2). *Lomandra maritima* is restricted to coastal sites while *Lomandra hermphrodita* is more widespread and found across the Swan Coastal Plain and into the Darling Range (Figure 4). Although *L. maritima* is restricted to coastal sites, it is much more prominent than *L. hermphrodita* due to its larger biomass and clumping habitat (Figure 5). *L. hermaphrodita* is extremely widespread but will never be a dominant component of the community. It is generally found constantly in a range of vegetation communities (*Banksia woodland, Jarrah woodland, Tuart woodland* etc.) but in low numbers and biomass comparative to *L. maritima.*

Table 2: Characteristics used for identification 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 basal leaves spiraled?	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

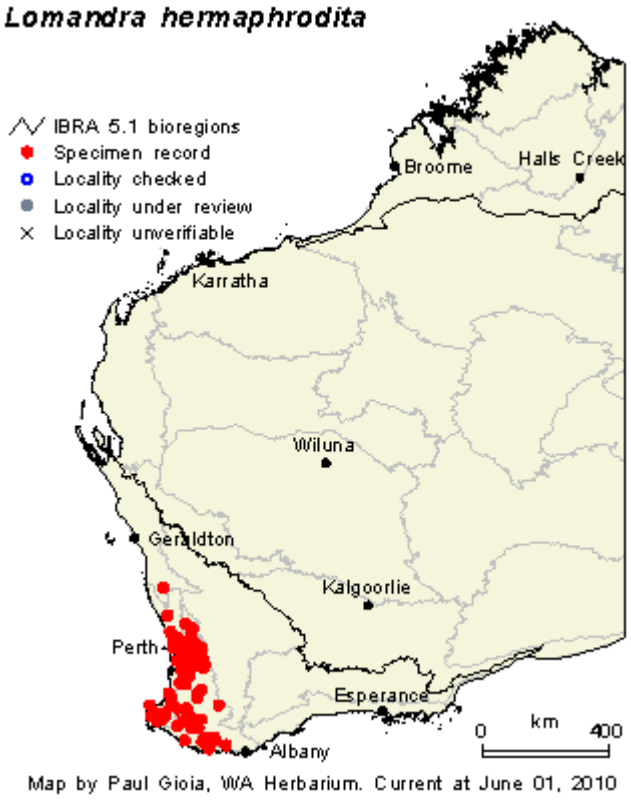


Figure 4: *Lomandra hermaphrodita* specimen and species distribution

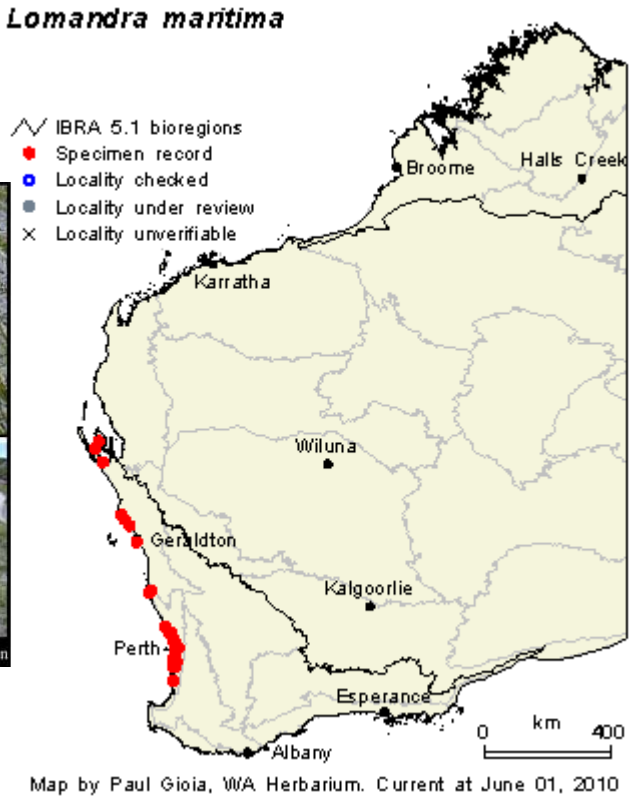


Figure 5: *Lomandra maritima* specimens, site photo and species distribution

6.2. Habitat assessment survey method

The aims 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.

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.

The site should be sampled using a replicate number of 2 x 2 m quadrats dependent on site size being based on the formula below. Table 3 also provides a rough guide to quadrat number per site/study area.

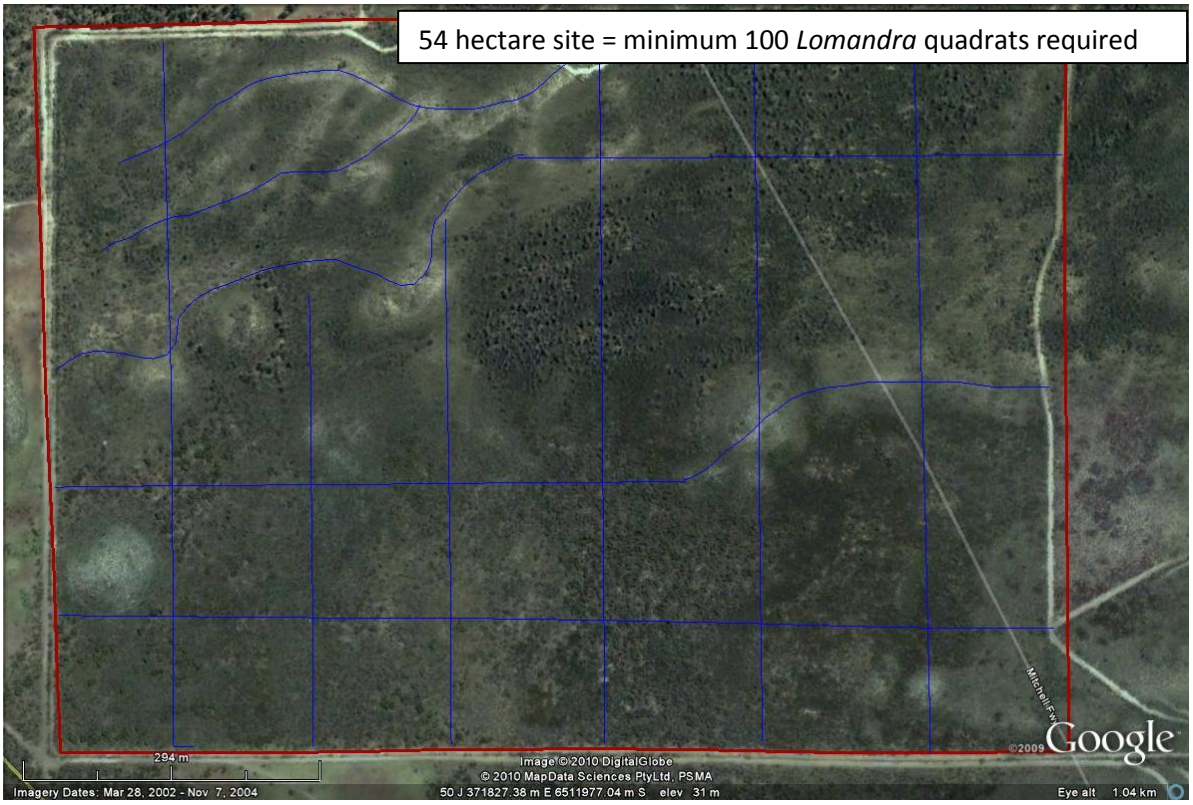
 # *Lomandra* quadrats required = 7 x (area in hectares)$^{0.67}$

Table 3: Number of *Lomandra* quadrats required per site area

Site area (ha)	Minimum no. of quadrats
10	30
20	50
50	100
100	150
200	240
300	320

In coastal heathland habitat, quadrats must follow dune tops, in conjunction to the random grid overlay. Figure 6 is an example of acceptable survey design in coastal heathland habitat with the gridded overlay modified to incorporate key dune elements. In the example below, 80 quadrats would be evenly spaced along the gridded overlay. In *Banksia* woodland habitat, only a random grid overlay is required as key habitat elements are yet to be identified.

Aerial photographs can be used to plan quadrat placement and provided to DEC to ensure acceptable survey design and site coverage.



Data to be collected for **each** quadrat includes (see appendix 2):

- Site name
- Observers
- Survey date
- Easting, Northing, elevation and aspect
- Quadrat number
- Slope
- Bare ground
- Exposed rock
- 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)

Explanation of the site variables listed above and codes to be used are outlined in appendix 3.

When walking between quadrats also score any opportunistic sightings of *Lomandra maritima* & *Lomandra hermaphrodita* using qualitative descriptions (abundant, common, uncommon). Additionally, habitat photos representative of the site should be taken and GPS location recorded.

Table 4: Species specific methods for recording *Lomandra* densities

Lomandra hermaphrodita	***Lomandra maritima***	
	Area covered	**Percentage cover**
Count each individual plant per 2x2m quadrat	0	absent
	negligible	<10%
	0.25m x 0.25m	~10%
	0.5m x 0.5m	25%
	1m x 1m	50%
	1.5m x 1.5m	75%
	2m x 2m	100%

6.3. Collecting Lomandra samples for DNA analysis

One entire *Lomandra maritima* and/or *L. hermaphrodita* specimen, including the intact rhizome, is to be taken from each study area. 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 (Kensington or Woodvale) within 48 hours for processing, complete with GPS coordinates.

7. Providing data to DEC Science Division

All data will remain confidential and will be incorporated into future habitat suitability modeling. Both *Lomandra* habitat assessment data and GSM transect data (including absence sites) should be provided to DEC Science Division in the file format specified. This is additional to the standard reg. 17 return required by the DEC Wildlife Licensing Division.

8. 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 ph: 0266 847 650

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

References

DEWHA 2009a. Background paper to EPBC Act Policy Statement 3.12 - Nationally Threatened Species and Ecological Communities: Significant impact guidelines for the Critically Endangered Golden Sun Moth *Synemon plana)*, by DEWHA, Department of the Environment Water Heritage and the Arts, Canberra, AU.

DEWHA 2009b. Significant impact guidelines for the critically endangered golden sun moth (Synemon plana). Canberra, AU.

Williams, M.R. 2009. Butterflies and day-flying moths in a fragmented urban landscape, south-west Western Australia: patterns of species richness. *Pacific Conservation Biology* 15: 32-46.

Appendix 1: Graceful sun-moth data sheet – one sheet per transect

Site name:	
Date:	Start time:
Observers:	End time:
Transect #:	Wind speed (km/hr):
Temperature C˚:	Wind direction:

Comments

GSM specimen #	**% Cloud**	**Comments (track / vegetation)**	**Easting**	**Northing**	**Time**	**Temp** C˚	**Wind Speed**

Appendix 2: Habitat assessment data sheet – one sheet per quadrat

GSM HABITAT ASSESSMENT – for explanation of variables and codes to be used see over page		
Site name:		
Date:	Aspect:	Surface soil:
Observers:	% bare ground:	Sub-surface soil:
Quadrat number:	Slope:	% exposed rock:
Transect number:	Position in landscape:	Recent burn?
Easting:	Northing:	Veg condition:

Vegetation description/Comments

Species	**Cover/Count**	**Comments**
L. hermaphrodita		
L. maritima		

LIFE FORM/HEIGHT CLASS	**CANOPY COVER**				
	Dense 70-100%	**Mid-Dense 70-30%**	**Sparse 10-30%**	**Very sparse 2-10%**	**Negligible or absent**
Trees over 30m **Trees 10 - 30m** **Trees under 10m**	Tall closed forest Closed forest Low closed forest	Tall open forest Open forest Low open forest	Tall woodland Woodland Low woodland	Tall open woodland Open woodland Low open woodland	No trees
Shrubs over 2m **Shrubs 1 - 2m** **Shrubs under 1m**	Closed tall scrub Closed heath Closed low heath	Tall open scrub Open heath Open low heath	Tall shrubland Shrubland Low shrubland	Tall open shrubland Open shrubland Low open shrubland	Negligible or no shrubs
Mat plants	Dense mat plants	Mat plants	Open mat plants	Very open mat plants	Negligible or no mat plants
Grasses	Closed grassland	Grassland	Open grassland	Very open grassland	Negligible or no grasses
Herbs	Closed herbland	Herbland	Open herbland	Very open herbland	Negligible or no herbs
Sedges	Closed sedgeland	Sedgeland	Open sedgeland	Very open sedgeland	Negligible or no sedges

Appendix 3: Explanation of habitat assessment variables and codes to be used

***Lomandra maritima* scoring**

	Area (m^2)	Cover %
Species cover for *Lomandra maritima* only	0	Negligible or absent
	0.25m x 0.25m	6%
	0.5m x 0.5m	12%
	1m x 1m	25%
	1.3m x 1.3m	50%
	1.5m x 1.5m	75%
	2m x 2m	100%

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.

Quadrat characteristics

CHARACTERISTIC	DESCRIPTION
Slope	Level - 0°
	Very gently inclined - 1°
	Gently inclined - 3°
	Moderately inclined - 10°
	Steep - 23°
	Very steep - 37°
Position in the landscape	crest
	ridge
	upper slope
	mid slope
	lower slope
	flat
	depression
Aspect & Wind Direction	North
	North East
	East
	South East
	South
	South West
	West
	North West
Surface soil colour/texture	colour/texture description (e.g. light grey sand, brown sandy loam etc.)
Sub-surface soil colour/texture	as above
Bare ground	% estimate
Exposed rock	% estimate