



March 2017

MONITORING OF GOLDEN
SUN MOTH SYNEMON
PLANA AND ITS HABITAT AT
RESERVOIR HILL
(LAWSON SOUTH OPEN SPACE)



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MONITORING OF GOLDEN SUN MOTH *SYNEMON PLANA* AND ITS HABITAT AT RESERVOIR HILL (LAWSON SOUTH OPEN SPACE)

1. The Project

Lawson South in Belconnen ACT contains areas of habitat for the Golden Sun Moth *Synemon plana*, which is listed as critically endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. The Land Development Agency received approval from the Department of Sustainability, Environment, Water, Population and Communities to develop the new Lawson South residential estate subject to a number of conditions protecting listed threatened communities and species (EPBC Act referral 2010/5549).

An Environment Management Plan (EMP) was prepared to address Condition 5 of the approval (Rowell 2013), and a Construction Environment Management Plan (CEMP) was prepared based on the EMP (Indesco 2013). The CEMP outlines measures required to maintain or improve the Golden Sun Moth (GSM) habitat on Reservoir Hill, for constructing a movement corridor for the moth, and revegetating areas disturbed by construction. The CEMP includes management recommendations for the pre-construction, construction and post-construction periods, with an emphasis on protecting the Golden Sun Moth habitat from damage and maintaining its condition by implementing appropriate biomass and weed control.

This report covers the construction period, when the row of mature pines had been removed, barrier fencing surrounded all except the north-western portion of the GSM conservation area, and path verge rehabilitation and landscaping were nearing completion. A previous report (Rowell 2016) covers the pre-construction period.

2. Scope of this report

The site conditions and management of the GSM habitat within Reservoir Hill are to be assessed according to the project approval, which includes a requirement for an annual monitoring survey of the moth and its habitat, plus a description of corrective actions to be undertaken if the monitoring indicates a decline in habitat condition (EPBC Act referral 2010/5549, conditions 5(d) and 5(e)).

A fact sheet with a summary of information and photographs of GSM was prepared for RAM Constructions for use in training staff members and contractors at Lawson South. It is attached as Appendix A.

3. Methods

3.1 Monitoring of Golden Sun Moth and its habitat

3.1.1 Golden Sun Moth

The site was surveyed on days of suitable weather (as far as possible) during the local flight period of the moth, as determined by GSM activity at reference sites. Good weather conditions for GSM emergence are generally between 1000 and 1400 hours in warm sunny weather with little wind, and more than two days since significant rainfall or an unusually cold night.

Transect counts were carried out as prescribed in the EMP, which involved walking (approximately) north-south transects 50 metres apart across the whole site and recording the number of flying male moths seen in each 50-metre segment of the transects. Concurrent searches were made for female moths and pupal cases. Results were compared with the 2012 baseline monitoring and the 2015 monitoring (Rowell 2016).

The GSM monitoring transects are shown in Figure 1. The monitoring track crossed constructed paths in several places, and the northern half of the central transect was partially covered by mulch associated with landscaping.

3.1.2 Habitat monitoring

The vegetation was monitored as prescribed in the EMP. This involved measurement of vegetation and other habitat parameters on the three permanent 100 metre step-point transects at the end of the moth flying season. The ground was searched for pupal cases during the vegetation transect survey. Transect results were compared with previous monitoring and the desirable range of habitat parameters in the EMP. The locations of the vegetation monitoring transects are shown in Figure 1.

A photographic record of the transects was made as described in *Golden Sun Moth Survey at Offsets Nature Reserves* (ACT Government, undated), with a close-up plan view at the zero point, and a landscape view of the transect from the zero point with a measuring stick at the three-metre mark.

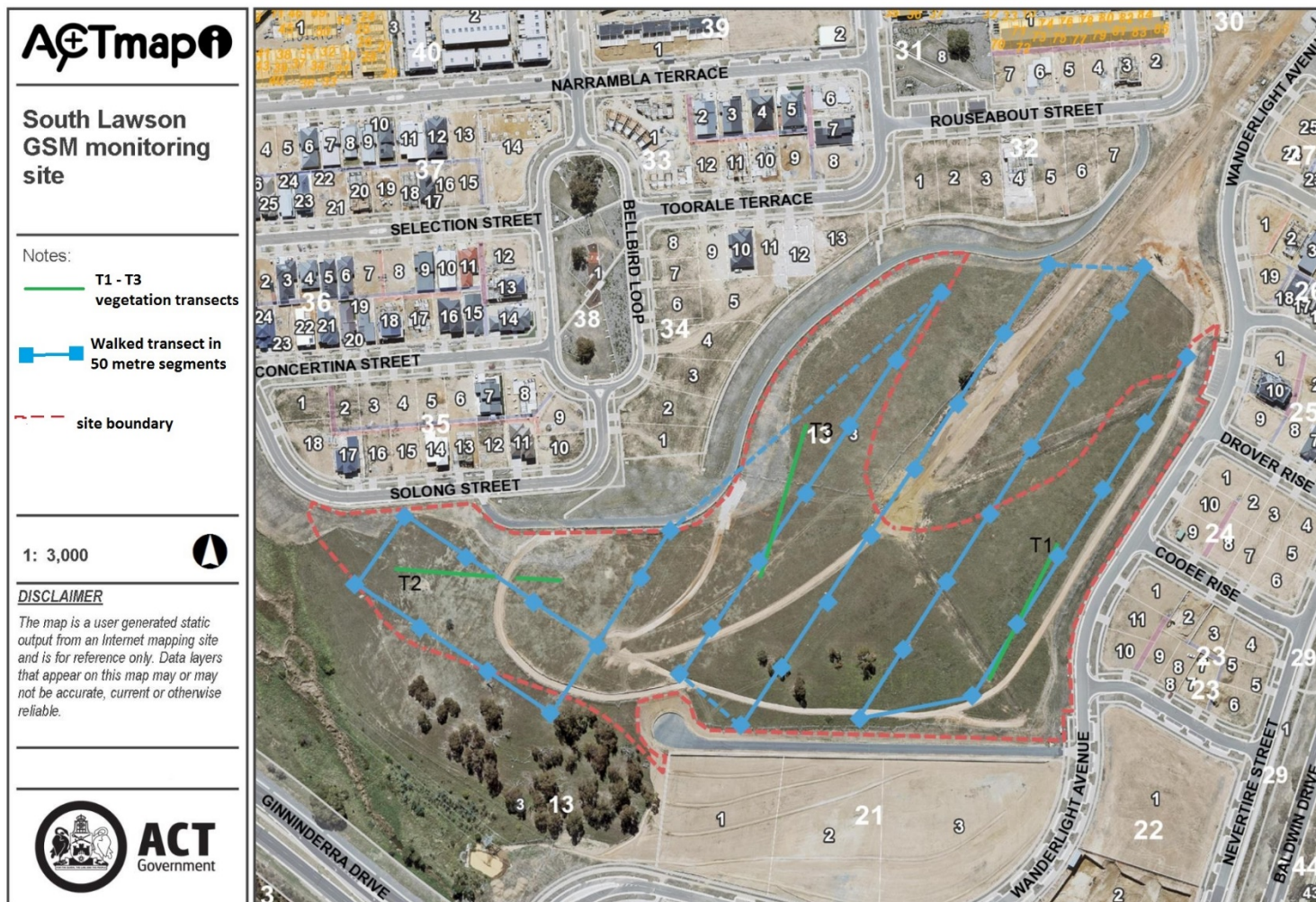


Figure 1. Location of vegetation and GSM monitoring transects, Lawson South 2016.

GSM Monitoring at Lawson South. A. Rowell, 2017.

4. Results

4.1 Golden Sun Moth monitoring

The first record of flying male GSM in the northern ACT in 2016 was on 16 November, and the last was on 31 December.

Weather conditions during the four transect GSM surveys are summarised in Table 4.1. All four surveys were conducted on warm days in December 2016. There was 20 mm of rain in the week before the first survey, and 22 mm fell between the second and third surveys.

The time period between each survey was four days. Due to the very short life span of adult GSM, this ensured that different cohorts of moths were counted in each survey. Only one GSM was seen during the final survey, suggesting that the flying season was finishing.

The length of transects surveyed was 1.77 km, slightly shorter than the 1.85 km surveyed in 2012 and similar to the 1.75 km covered in 2015. The transects are 50 metres wide, so the area surveyed was about 8.85 ha. Note that parts of the surveyed area were not GSM habitat at the time of the surveys, due to path construction and landscaping.

The survey transects and GSM observations are shown in Figure 2. This shows that the distribution of GSM in 2016 was broader than in 2015, with flying males scattered across most of the site. In the first 2016 survey, most of the moths were seen on the western slope, and in the third survey all the sightings were on the eastern side of the hill. This is a common feature of GSM behaviour, where emergence occurs earlier in the season in warmer locations.

Table 4.1. Golden Sun Moth monitoring at Lawson South, December 2016

Date	Time (AEDT)	Daily T range °C	T range during survey T °C	Conditions during survey
19 Dec	1115-1330	11-27	18-21	Mild, sunny, light wind.
23 Dec	1135-1310	15-32	23-27	Warm, sunny, light wind.
27 Dec	1135-1250	18-32	25-29	Warm, partial light haze, light wind.
31 Dec	1125-1245	19-32	29-30	Warm, sunny. Wind light on east slope, moderate on west slope.

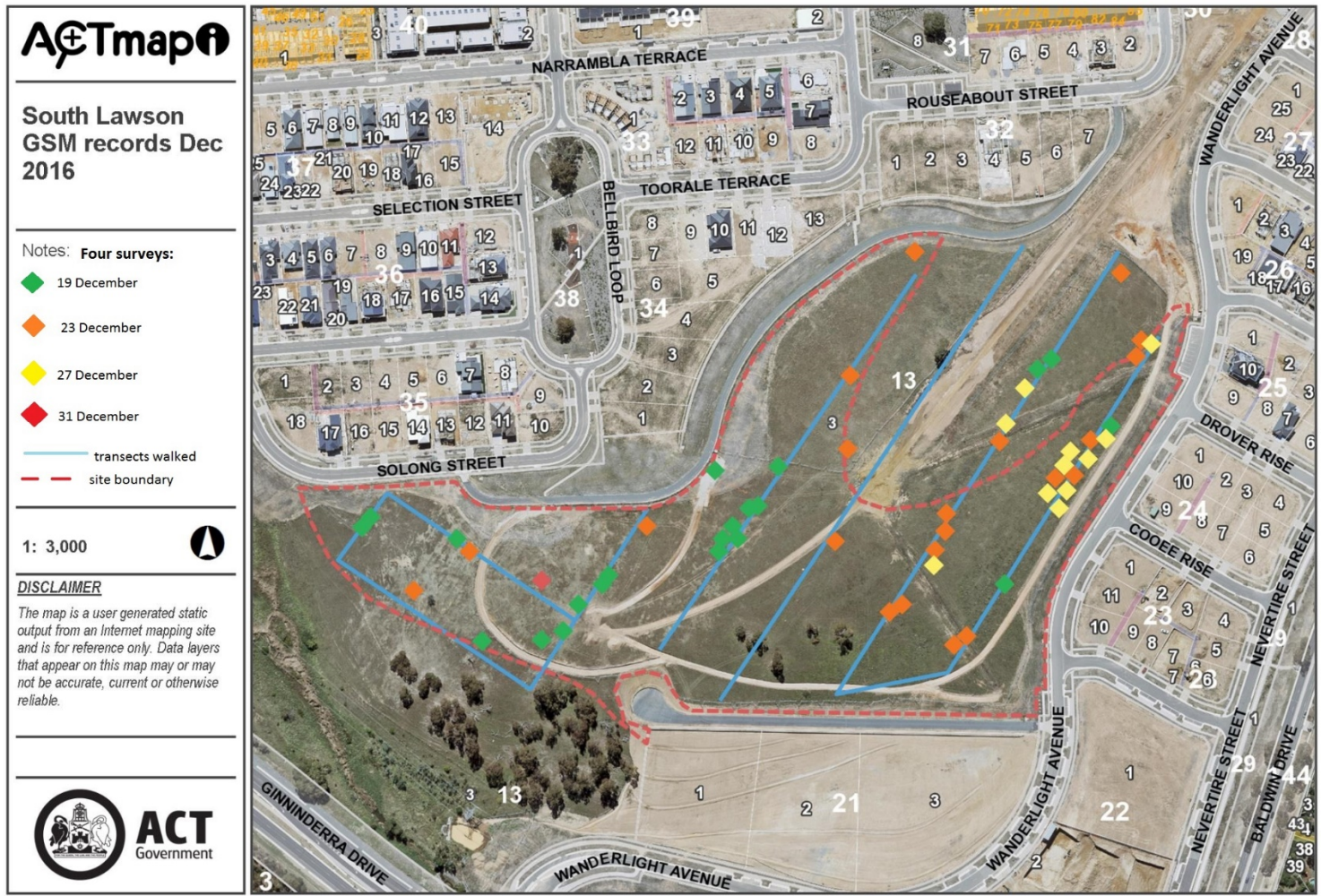


Figure 2. Golden Sun Moth observations, Lawson South December 2016

GSM Monitoring at Lawson South. A. Rowell, 2017.

As in 2015, no female GSM or pupal cases were found during the 2016 survey. This is not unusual for sparse GSM populations, as the transect survey method is not designed to detect females or pupal cases.

A summary of GSM monitoring results is shown in Table 4.2. As in previous years, the number of flying male GSM recorded in all surveys was relatively low, and the overall results were very similar to 2012 and 2015. The average number of GSM recorded per survey hour in 2016 was 8.3 (8 in 2012, 7 in 2015). The highest daily count in a survey in 2016 represented an average of 2.4 flying males per hectare surveyed, compared to 2.6 per hectare in 2012 and 2015.

The average 2016 GSM density within the habitat would be slightly greater than calculated above, as parts of the transect did not contain GSM habitat at the time of survey. Some of the northern part of the central transect was covered in mulch associated with the new landscaping, and smaller areas had been disturbed or destroyed by path construction.

Table 4.2. Golden Sun Moth survey results, South Lawson, December 2016

Date	Total GSM/survey	GSM/hour	Average GSM/100m of transect	GSM/hectare of transect
19 Dec	21	9.3	1.2	2.4
23 Dec	21	13.3	1.2	2.4
27 Dec	12	9.6	0.7	1.1
31 Dec	1	0.8	0.1	0.1
Mean	13.8	8.3	0.8	1.5

4.2 Golden Sun Moth habitat monitoring

The condition of the grassland in December 2016 suggested that most of the site had been mown as prescribed in the EMP, with the exception of the north-eastern area which was outside the barrier fencing and had not been mown for some time. The grasses in this area were tall and dense, and the barrier passed through the middle of Transect 3. Very few GSM were recorded in the dense grasses.

Some variations were necessary when placing the vegetation transects, due path construction since 2015. Transect 1 was moved about 10 metres uphill to the west, and Transect 2 was extended to the west to replace a 16-metre break where a path and wall crossed the transect. The revised co-ordinates for the vegetation transects are in Table 4.3.

Reference photographs for the vegetation transects are at the end of this report (Appendix B). These show native-dominated grassland of mainly low to moderate height and density, except for the taller grasses in the northern half of Transect 3. The native grasses appear to be slightly denser than in the 2015 photographs.

Comparison with the 2015 photographs show that the asbestos-pipe rehabilitation areas were still weedy, but more native grasses had become established (landscape photograph Transect 1), and the formerly bare vehicle track in the Transect 3 landscape photograph has naturally revegetated with Wallaby Grass.

By December 2016, the verges of the footpaths had been sown with sterile Ryecorn and native grasses, though establishment of the native grasses appeared to be poor.

There was little evidence of native grasses in the area to the west of the tree plantation, where a GSM corridor was to be constructed to facilitate movement of GSM males from Lawson South to the former Belconnen Naval Station site to reduce the risks of genetic isolation. This corridor is not a specific requirement of the project approval, but was included as an objective in the EMP/CEMP as partial fulfilment of approval condition 5 which requires the EMP 'to maintain or improve the Golden Sun Moth habitat within Reservoir Hill'.

The results of the vegetation transect surveys are shown in Table 4.4, with comparisons to the January 2013 and December 2015 results.

Table 4.3. Vegetation transect co-ordinates (GDA 94), January 2017

	Transect 1	Transect 2	Transect 3
Start	690243 E 6099246 N	689978 E 6099308 N (break from 35 to 51 metres)	690100 E 6099310 N
Finish	690286 E 6099331 N	689874 E 6099315 N	690130 E 6099404 N

Table 4.4. Vegetation transect results at South Lawson, January 2017.

Category	Desirable range (% hits) (EMP, Rowell 2013)	Transect 1 % hits			Transect 2 % hits			Transect 3 % hits		
		Jan-13	Dec-15	Jan-17	Jan-13	Dec-15	Jan-17	Jan-13	Dec-15	Jan-17
Cryptogams		0	0	0	14	18	14	0	6	3
Bare ground	5-15	1	1	7	6	10	7	11	13	11
Rock		0	0	0	3	6	2	1	3	1
Litter/dead vegetation	5-15	25	17	20	5	12	6	16	24	16
Non-vegetation hits		26	18	27	28	46	29	28	46	31
Annual exotic grass		4	30	8	4	1	3	4	7	7
Perennial exotic grass		4	7	7	0	0	0	0	0	0
Exotic broadleaf		5	15	10	2	3	1	3	4	3
Total exotic hits	<5	13	52	25	6	4	4	7	11	10
All perennial native grasses		59	29	47	65	50	64	65	43	59
Other native species		2	1	1	1	0	3	0	0	0
Total native hits		61	30	48	66	50	67	65	43	59
TOTAL HITS		100	100	100	100	100	100	100	100	100
GSM larval food plants	Desirable range	Jan-13	Dec-15	Jan-17	Jan-13	Dec-15	Jan-17	Jan-13	Dec-15	Jan-17
Austrostipa+Rytidosperma (Wallaby+Spear Grasses)	55-65	35	14	17	49	32	41	62	32	56

Due to the small changes in the locations of Transects 1 and 2 and the unmown portion of Transect 3, quantitative comparisons with previous monitoring are not completely reliable. The overall result was a movement back towards the 2012 condition, after the disturbance of the initial mowing event in 2013. Perennial native grass cover and the cover of GSM larval food plants was higher on all transects compared to 2015. In Transect 1 this was mainly due to a reduction in exotic annual grass cover, and in Transects 2 and 3 was associated with a reduction in plant litter. The regeneration of native grasses on the disused vehicle track in Transect 3 also contributed to the increase. The relatively low cover of known larval food grasses on Transect 1 is due in part to the dominance of other native grasses (especially Weeping Rice-grass *Microlaena stipoides*).

It is notable that GSM density variation at Lawson South does not appear to be related to the density of the larval food plants as might be expected. One of the commoner Wallaby Grasses on the western part of the site is Short Wallaby Grass *Rytidosperma carphoides*. In the northern ACT this species is common on knolls, on shallow or well-drained soils and around rock outcrops where other grasses find it difficult to survive. The tussocks are often very small, and as the larvae are root-feeders, dominance of this species may not always be an indicator of good GSM habitat. Surveys at Canberra Airport found higher GSM numbers were supported by areas containing food plant species other than Short Wallaby Grass, when compared with areas containing the same mean cover of Short Wallaby Grass (Rowell 2010). Tussocks with a larger root volume may allow a larva to complete its cycle on a single tussock without the risk and energy cost potentially involved in tunnelling through the soil to another tussock.

Other surveys have found a strong association between GSM density and the large tussocks of the introduced Chilean Needlegrass *Nassella neesiana*, which often occurs as a near-monoculture in flatter areas and on more productive soils (Braby and Dunford 2006, Richter *et al.* 2009), which also suggests that soil type affects the quality of GSM larval habitat.

Exotic broadleaf cover was slightly down on all transects from the 2015 figures, suggesting some success in weed control, either directly or due to mowing. As before, exotic cover was higher on the eastern slope, probably due to the less extreme conditions there. Some other parameters such as bare ground and perennial exotic grasses remained low in all transects, but the transects do not sample enough of the site to provide good information for weed management.

5. Discussion

5.1 GSM population and habitat condition

The GSM population is stable, with flying male GSM numbers and distribution in 2016 very similar to 2012 and 2015. The larval period is thought to be two to three years, so more than one generation has come to maturity during this period and the GSM population does not so far appear to have been adversely affected by the changes in site management.

There has been limited progress towards the desired GSM habitat parameters as measured in the vegetation transect monitoring. These parameters were derived using the best available information from measurements on a well-studied flat site and may not be achievable on the Lawson South site, which includes east, west and south-facing slopes, some quite steep. It is likely that GSM numbers and larval food plant cover are naturally lower at Lawson South than at lowland sites containing more typical GSM habitat.

5.2 Impact of construction

There was minimal damage to the conservation area outside the footprint of the construction and landscaping areas, with secure fencing and vehicle movement controls in place. There were some minor variations from the original path designs during construction, to take account of the hill slopes. This involved extending the verge batters in places, instead of constructing rock walls and benching. In the long-term, this solution is likely to result in the restoration of GSM habitat on the gently sloping batter, depending on the success of revegetation with native grasses. By January 2017 the revegetation of track verges appeared to be at an early stage, with few native grasses established.

Revegetation of the asbestos pipeline scars has had limited success. Some native grasses have established, including some GSM larval food plants. However, broad-leaved weeds are common on the scars and will continue to be a source of weed invasion if not controlled. Of particular concern are St John's Wort *Hypericum perforatum*, Paterson's Curse *Echium plantagineum* and Saffron Thistle *Carthamus lanatus*.

Broad-leaved weeds in these disturbed areas could be sprayed with a selective herbicide before oversowing with native grass seed between autumn and early spring, following the Greening Australia protocol. This should allow the native grass plants to survive, but would cause the loss of some native forbs. This is an acceptable risk as the current cover of native forbs is very low, and they are more likely to reinvade later from the surrounding native-dominated grassland if the weeds are better controlled.

By January 2017, the area proposed in the EMP and CEMP for rehabilitation of a potential GSM movement corridor along the western side of the tree plantation was still bare and compacted after nearby works. To complete the rehabilitation, the Greening Australia revegetation protocol should be implemented in this strip.

5.3 General weed management

Weed management is prescribed in the CEMP: 'Weed control should be by regular spot-spraying, outside the GSM flying period. The most suitable months will be February to April and September. Priority species are Serrated Tussock, African Lovegrass, Chilean Needlegrass, Phalaris, St John's Wort and Saffron Thistle.' These species are scattered across the site, and spot-spraying of them is an ongoing requirement.

There is a weed-dominated patch about 20 x 30 metres on the eastern side of Reservoir Hill, below the summit (GDA 94 690231 E, 6099358 N), and another directly north of the summit. These are probably former stock camps, and contain dense Phalaris, Ryegrass, Serrated Tussock and Saffron Thistle. These areas should be mown short in the short-term, but rehabilitation is desirable in the longer-term, or they will continue to be a source of weed seeds and high fuel loads. Following cut-and-remove, they could be treated with a broad-spectrum herbicide and resown with native grasses at an appropriate time of the year, following the Greening Australia protocol. Speargrasses, Wallaby Grasses and Redleg Grass would be appropriate species for revegetating these patches.

5.4 Biomass management

Many GSM sites in the ACT are successfully managed by mowing at the beginning of spring and/or in early autumn, depending on grass height and density. Mowing reduces the vigour of some weeds and is also compatible with urban open space uses.

The north-eastern area of the site which has not been mown for some time requires attention. It should be treated as prescribed in the CEMP for areas where the grasses have become too tall and dense: 'the grassland should be cut to a height of about 8-10 cm, and the slashed material should be immediately raked, baled and removed from the site. Rake height should be set above ground to avoid soil disturbance. This should occur between February and September, i.e. outside the GSM flying period, and not when soil moisture is very high.'

The vegetation west of the ridge is naturally sparser, and where the slope allows it should be managed by flail mowing as prescribed in the CEMP: 'Mowing with a flail mower should take place about twice per year depending on seasonal conditions, and should aim to maintain the height of tussocks (excluding seed heads) between 5 and 15 cm. Mowing should take place between late January and late September, to avoid the GSM flying season and to allow spring and summer flowering native plants to set seed.' The steepest part of the west-facing slope also has the sparsest vegetation and most shallow soil, and this could be left mostly unmown to limit disturbance.

The above management should continue to be applied to the eastern slope, where mowing of the area south of the playground has reduced some weeds such as Wild Oats and has maintained relatively high numbers of GSM. The grass around the Peppermint Gums on the southern slope of Reservoir Hill is moderately dense, but is less likely to support GSM. Where the slope allows safe access, parts of this area could be mown with a flail mower as required.

6. References

- ACT Government, undated. *Golden Sun Moth Survey at Offsets Nature Reserves*. Conservation Planning and Research, unpublished document.
- Braby, M. and Dunford, M. 2006. *Field observations on the ecology of the golden sun moth, Synemon plana* Walker (Lepidoptera: Castiniidae). *Australasian Entomologist*, **33** (2): 103-110.
- Indesco, 2013. *Construction Environment Management Plan for Golden Sun Moth habitat on Reservoir Hill, Lawson South*. Prepared by Indesco using information and recommendations from Rowell (2013).
- Richter, A., Osborne, W., Robertson, G. and Hnatiuk, S. 2009. *Community Monitoring of Golden Sun Moths in the Australian Capital Territory Region, 2008-2009*. University of Canberra.
- Rowell, A. 2010. *Canberra Airport – Input to Golden Sun Moth community monitoring project, 2008-2009*. Report to Capital Airport Group.
- Rowell, A. M. 2013. *EMP for Golden Sun Moth habitat on Reservoir Hill, Lawson South*. Prepared for INDESCO and LDA, February 2013.
- Rowell, A. M. 2016. *Monitoring of Golden Sun Moth Synemon plana and its habitat at Reservoir Hill (Lawson South Open Space)*. Report prepared for RAM Constructions and LDA.

Appendix A. Golden Sun Moth (*Synemon plana*) fact sheet

The Golden Sun Moth is protected under Commonwealth legislation as a critically endangered species. It is a medium-sized moth that is active during the day. Its wing span is about 35 mm, and in flight the males appear dark brown or blackish, with a rapid wing beat. At rest the wings of the male appear dark bronzy brown with silvery lines. The female has forewings similar to the male, and also has bright orange-yellow hindwings that can be hidden or revealed by moving the forewings.

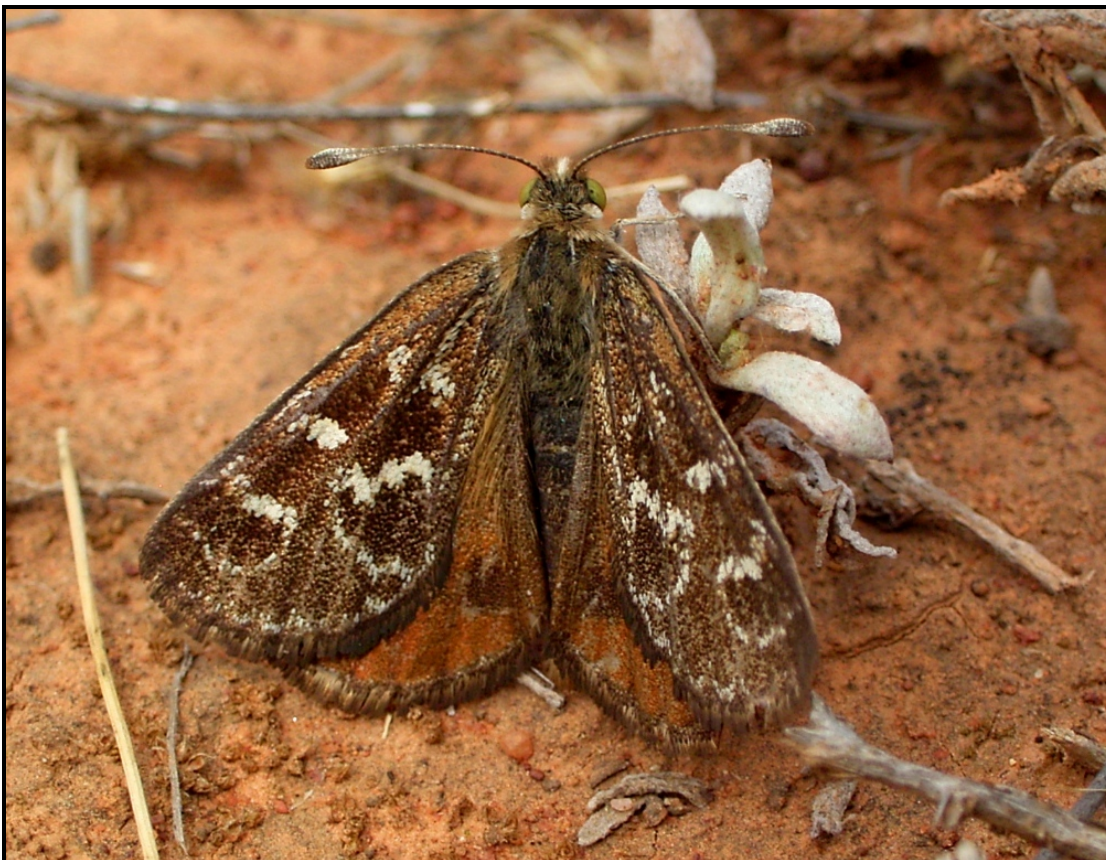
The larvae are present in the soil at all times, living underground for two or more years and feeding on the roots of particular grasses. Adults are only seen under suitable weather conditions during a few weeks in spring and early summer, when they emerge from the soil to mate and lay eggs. The reddish brown pupal case is left protruding from the soil after the adult emerges. During periods of warm sunny weather, the males fly low and rapidly over the grassland searching for the females, which sit in areas of short grass displaying their golden hind wings to attract the males. The females are not as easily seen as the males, as they tend to remain on the ground. Males usually turn back if they fly out of their habitat, but both males and females may rest on bare ground such as paths to bask in the sun.

The moth larvae live in the upper layer of the soil, and can be killed by disturbance or compaction of the soil, or any activity that damages the grasses on which they feed. This includes vehicle movements, chemical or fuel spills or changed drainage. Adults can be killed by trampling, vehicles or chemicals.

The fenced habitat should not be accessed except for path construction or vegetation management, and should be protected from damage by trampling, vehicles, fuel, chemicals, dumping, water, storage of materials etc.



Female Golden Sun Moth showing golden hind wings.



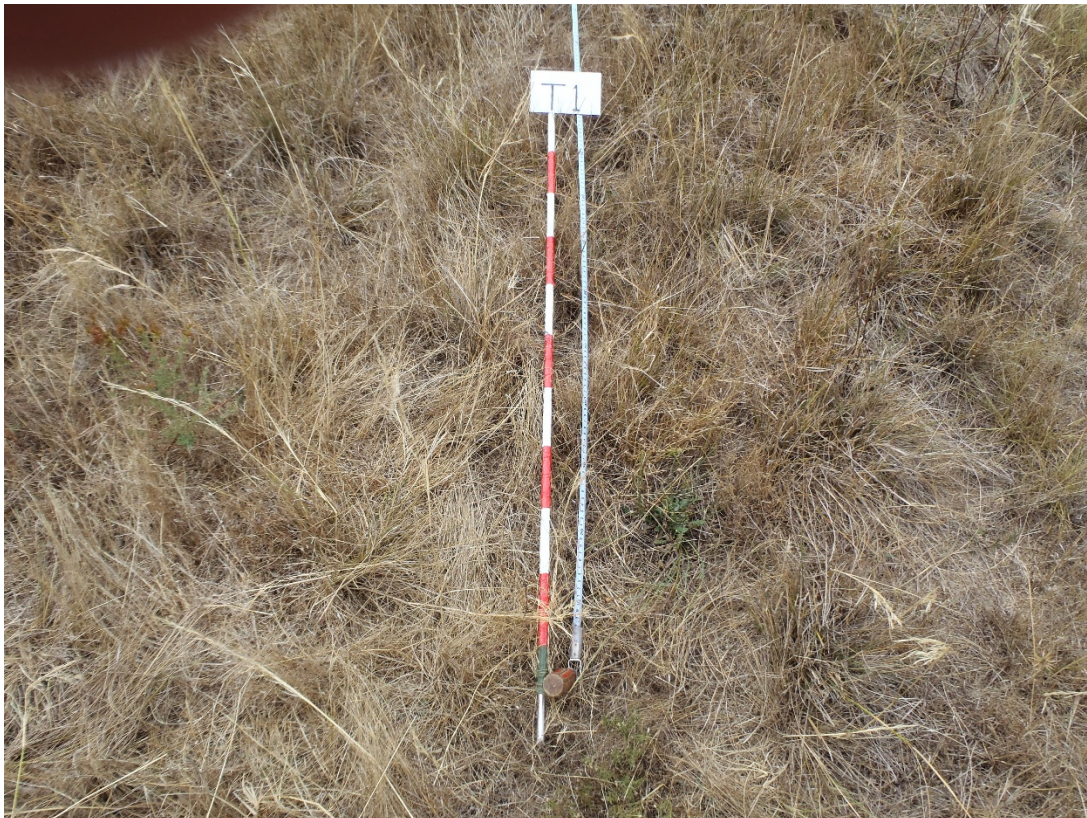
Male Golden Sun Moth.

GSM Monitoring at Lawson South. A. Rowell, 2017.



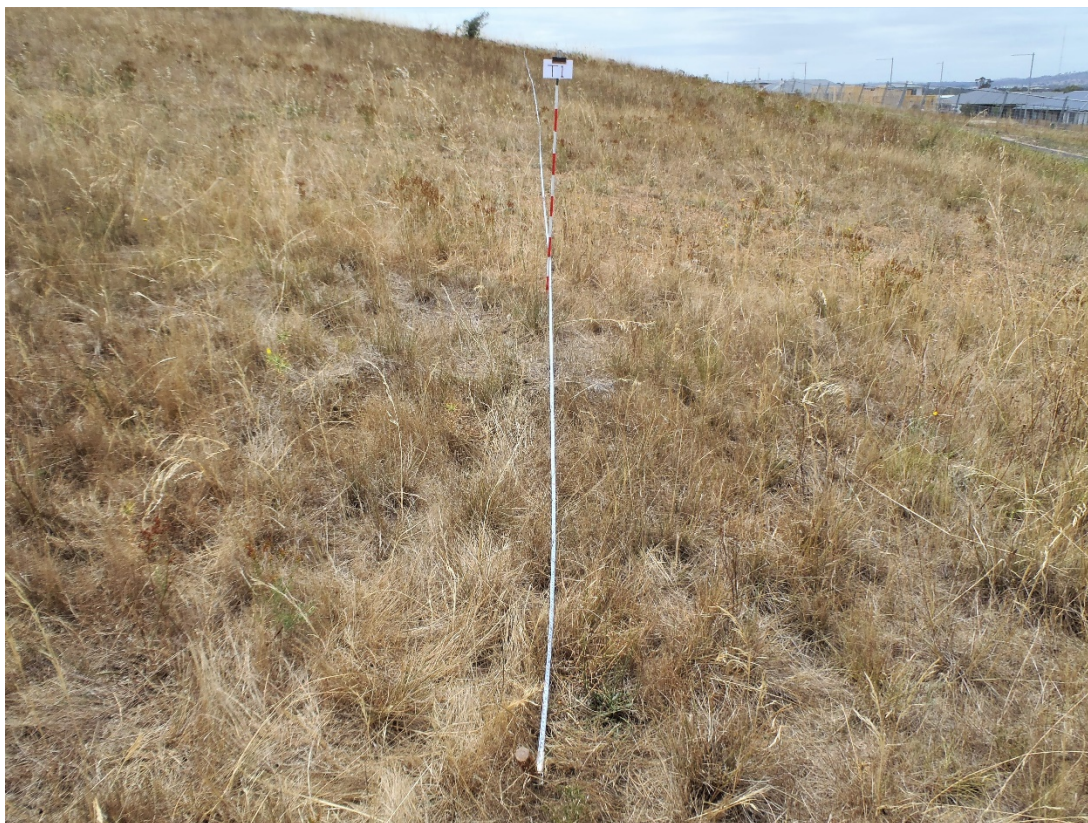
Pupal case protruding from ground after adult moth has emerged.

Appendix B. Vegetation transect reference photographs



GSM Monitoring at Lawson South. A. Rowell, 2017.

Transect 1, plan view at southern end.



Transect 1, landscape view from southern end with asbestos pipeline revegetation area beyond marker stake.



Transect 2, plan view at eastern end.



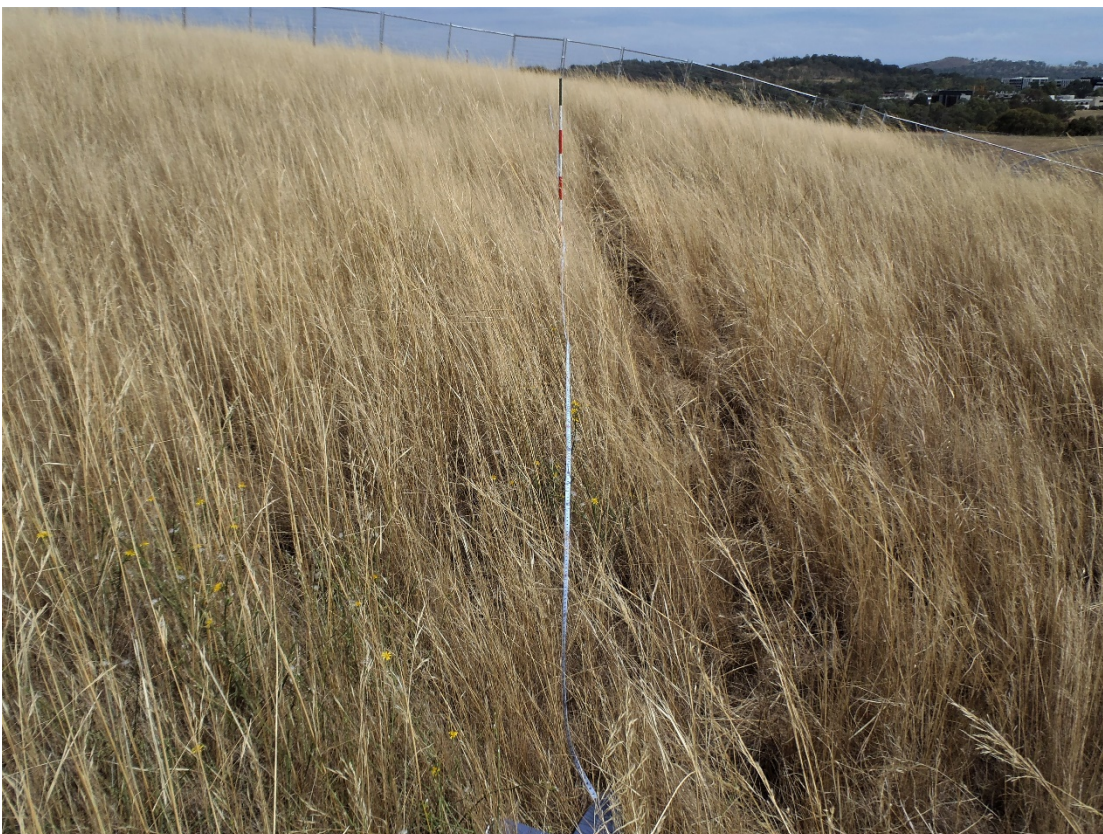
Transect 2, landscape view from eastern end.



Transect 3, plan view at southern end.



Transect 3, landscape view from southern end. Old vehicle track in centre naturally regenerating with Wallaby Grasses.



Transect 3, landscape view from northern end, with unmown native grasses in foreground, barrier fence in background.