



Hamilton Environmental Services
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GOLDEN SUN MOTH SURVEY NOVEMBER 2014 – GLENHOPE



Golden Sun Moth Survey November 2014 - Glenhope

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Cover Photo: A male Golden Sun Moth at the Watchbox Valley property at Glenhope.

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1. INTRODUCTION

Kinrara Pty. Ltd. purchased a 467 ha grazing property that borders the Barfold Gorge in Glenhope in 2013 in order to establish conservation covenants on significant areas of riparian vegetation, and establish a conservation and sustainable agricultural production community.

In the process of establishing infrastructure on the site, in early November 2014, Paul Dettmann opportunistically observed male Golden Sun Moths in flight on the property; further investigation revealed that the species was found across most areas of the property.

Bryan Haywood from NGT Consulting was engaged to undertake a targeted survey for the species, which occurred on the 13th and 14th November 2014.

Hamilton Environmental Services (HES) were engaged to undertake collaborative supporting targeted surveys for the species, which were undertaken by Dr. Steve Hamilton on the 19th November 2014.

This Report details the combined survey findings of all investigations undertaken.

2. BACKGROUND

2.1 Site Location and Description

The property of approximately 467 ha is found within the Mitchell Shire, and is located approximately 6 km W of Glenhope, at the northern end of Sievers Road, off Watchbox (the Baynton-Kyneton) Road (Fig. 2-1; VicRoads 60 A3).

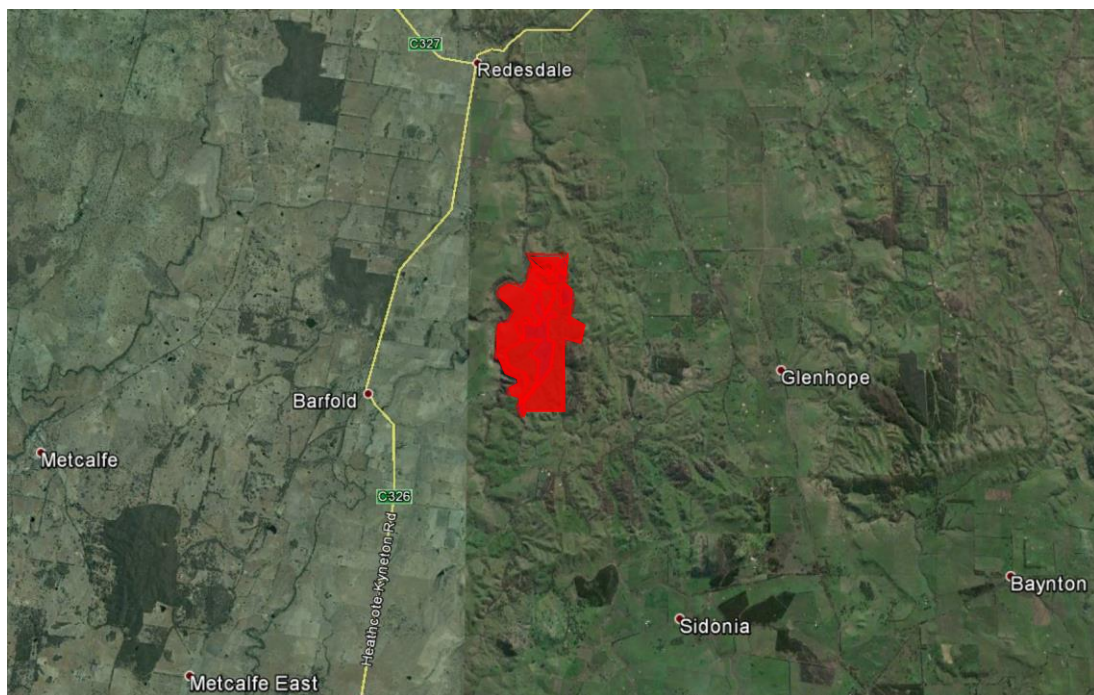


Figure 2-1 Aerial image of the general location of the Watchbox Valley property, shown in red (Image from Google Earth 2014).

The property is bordered by the spectacular Barfold Gorge to the west, and is highly variable in landform, ranging from creek lines in relatively deeply dissected valleys, to steep slopes and plateaus

at the top of escarpments. The geology of much of the property is igneous (volcanic), resulting in derived soils being basaltic in origin (Paul Dettmann pers. comm. 2014).

The vegetation communities of the property wholly contained within the Goldfield Bioregion were, prior to European settlement, likely to be a mixture of Plains Grassy Woodland Ecological Vegetation Class (EVC) on the escarpments and upper slopes, Valley Grassy Forest EVC on the mid and lower slopes, and Alluvial Herb-rich Woodland/Creekline Grassy Woodland Mosaic EVC along the drainage lines and creek lines (Department of Primary Industries and Environment [DEPI] 2014a and 2014b).

The property has been grazed by stock over a long period (Paul Dettmann pers. comm. 2014), and has been largely cleared of indigenous woody vegetation, with only scattered trees of Grey Box (*Eucalyptus microcarpa*), Long-leaved Box (*E. goniocalyx*), Yellow Box (*E. melliodora*), River Red Gum (*E. camaldulensis*) and Red Box (*E. polyanthemus*) remaining. While there are some small areas where introduced pasture species have been obviously been sown and have established, the majority of the property would appear to have been unimproved, uncultivated and unfertilised pasture. The ground layer generally is typical of such a land use history, and is predominantly composed of opportunistic introduced pasture species such as Toowoomba Canary Grass (*Phalaris aquatica*), Squirrel's-tail Fescue (*Vulpia bromoides*), Wild Oat (*Avena fatua*), Annual Ryegrass (*Lolium rigidum*), Burr Medic (*Medicago polymorpha*), Cat's Ear (*Hypochaeris radicata*) and Great Brome (*Bromus diandrus*), with only occasional patches where a low diversity of indigenous graminoids, such as Brown-backed Wallaby-grass (*Austrodanthonia duttoniana*), Bristly Wallaby-grass (*Austrodanthonia setacea*) and Red-anthered Wallaby-grass (*Joycea pallida*), are found.

2.2 Golden Sun Moth

2.2.1 Conservation Status

The Golden Sun Moth (*Synemon plana*) is listed as critically endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and as a threatened taxon under the *Victorian Flora and Fauna Guarantee Act 1988* (Gilmore *et al.* 2008; Department of the Environment, Water, Heritage and Arts [DEHWA] 2009).

2.2.2 Distribution

Golden Sun Moths were known to occur throughout south-eastern Australia in temperate grasslands (and grassy woodlands) including New South Wales, Australian Capital Territory, Victoria and South Australia (DEHWA 2009). However, the original extent of Golden Sun Moth habitat and continuity of populations has been significantly reduced to only 125 known sites, most of which are < 5 ha in area, resulting in the species becoming fragmented and highly modified by urban and agricultural development.

The Golden Sun Moth is now considered extinct in South Australia (DEHWA 2009).

2.2.3 Habitat

Potential habitat for the species includes all areas which have, or once maintained, native grasslands or grassy woodlands (including derived grasslands) across the historical range of the species. The Golden Sun Moth is also known to inhabit degraded grasslands, including those dominated by the exotic Chilean Needlegrass (*Nassella neesiana*), a weed of national significance (DEHWA 2009).

The 'typical' plant assemblage present is extremely difficult to define, especially in light of the recent discovery of the species at many sites previously considered 'unsuitable'. The species has shown a preference for *Austrodanthonia* species, such as Short Wallaby-grass (*A. carphoides*), Bristly Wallaby-grass (*A. setacea*), Hill Wallaby-grass (*A. eriantha*), Lobed Wallaby-grass (*A. auriculata*) and Clustered Wallaby-grass (*A. racemosa*). However, previous definitions of 40 % *Austrodanthonia* cover (O'Dwyer

and Attiwill 1999) are no longer considered accurate (Braby and Dunford 2006, Gilmore *et al.* 2008). The species has been found flying and presumably breeding in grasslands dominated by other indigenous species such as Redleg Grass (*Bothriochloa macra*), Spear-grasses (*Austrostipa* spp.), Weeping Grass (*Microlaena stipoides*), Kangaroo Grass (*Themeda triandra*), and in degraded and weed infested patches dominated by the exotic Chilean Needlegrass (DEHWA 2009).

The site history of a site is likely to be very important in determining habitat suitability for the species; cultivated, fertilised or pasture improved sites are highly unlikely to support Golden Sun Moth; however, it is likely to occur on sites that have experienced a low intensity grazing history with no or negligible history of site improvement, even if these sites have been grazed for a long period of time. The critical habitat feature seems to be the maintenance of some remnant indigenous grass cover (DEHWA 2009). This view is supported by recent survey efforts that have uncovered many new colonies of the Golden Sun Moth in areas with such a land use history, which most likely indicates that the species has less specific habitat requirements (i.e. in terms of indigenous grass composition and abundance) than previously thought (Gilmore *et al.* 2008).

2.2.4 Biology

Golden Sun Moth larvae spend two to three years under ground feeding on the roots of native perennial grasses including Wallaby-grass (*Austrodanthonia* spp.), Spear-grass (*Austrostipa* spp.), and Redleg Grass (Edwards 1994). The belief that the larvae of the species feed on these grasses is based on the presence of cast pupa shells and tunnels leading up to nearby tussocks. It has recently been discovered that larvae may also feed on introduced grass species, with cast pupa shells found protruding from introduced Chilean Needlegrass tussocks. This discovery suggests that in some circumstances the species may feed on exotic grasses (DEHWA 2009).

Adult moths emerge from underground during the breeding season, between mid-October to early January, depending on the climate and location. They are active only during the hottest part of hot, sunny, and relatively still days. Adult emergence occurs continuously across the breeding season, although the distribution and abundance of emerging adults varies with the microclimate and microhabitat features of the site (Department of Environment and Conservation NSW [DEC] 2007). Adult moths lack functional mouthparts and are unable to feed, and live for only one to four days (O'Dwyer and Attiwill 2000).

Adult males spend their time patrolling the grassy patches in search of displaying females, who flash their brightly coloured hindwings to attract the males. Once mated, the females lay their eggs between the tillers of a tussock or between tillers and the soil (Gibson 2006). Females are estimated to lay between 100 and 150 eggs (Edwards 1994). Females are reluctant to fly, and most likely walk between tussocks during display and egg laying. In contrast, adult males are capable of active and prolonged flights, although it is estimated that they will not travel more than 100 m away from suitable habitat patches (Clarke and O'Dwyer 2000).



Figure 2-2 A male (left) and female (right) Golden Sun Moth (from DEHWA 2009).

3. METHOD

DEHWA (2009) outlines the preferred survey methods for Golden Sun Moth. The two methods commonly employed are the Fixed Point method, which is best suited to small sites or sites with a small population, and a Transect method, which is better suited to large sites with extensive populations.

On such a large property when significant numbers of Golden Sun Moths had been initially observed, it was decided that application of the Transect method was the most appropriate for this property and survey period.

DEHWA (2009) suggest that the observer should walk/traverse in a vehicle for at least a 100 m distance, recording the number of moths per 100 m, taking care not to count the same individual twice. Surveys should be conducted over at least 4 suitable days, and once presence has been established, surveys should focus on the determining the relative distribution of the species. The male Golden Sun Moth flying period is probably only over 4-5 days, and within this period, they are likely to be most active on still, clear or mostly cloudless, warm to hot days (> 20°C at 1000 hours), between 1000 and 1400 hours, at least 2 or more days after rain.

Surveys were conducted to conform to the above methodology and optimal conditions, and to ensure that all habitats found across the property were surveyed.

There were forty two (48) walked or vehicle-based transect surveys undertaken by multiple observers across the property when appropriate conditions prevailed between the 13th and 21st November 2014; all were a minimum length of 100 m (Transects 1 to 35, 39 to 51; Fig. 3-1).

Nine transects were completed outside of the target property: Transects 36 to 38 on an adjacent property to the east, and Transects 15 to 20 on a property to the immediate north of the target property, to ascertain whether the species was found more broadly in the district (Fig. 3-1).

All transects were geo-located at starting and finishing point.

For Transects 1 to 14 and Transect 21, which were conducted by Steve Hamilton, projective foliage cover for every plant species 5 m either side of the transect alignment was estimated, and further to this, the percentage of bare earth and leaf litter also recorded. An image was taken at the start of the transect looking along the traverse alignment.

The NGT Consulting report (NGT Consulting 2014) provides additional detail on the methodology and transects associated with that reporting (Transects 39 to 51), including survey for Common Grass Blue Butterflies and Robber flies.

Transect counts were extrapolated to per ha estimates on the assumption that each transect of 100 m equivalent was observing male Golden Sun Moths to a distance of 10 m on either side of the transect alignment; the transect was considered to be a 20 m belt transect of 100 m length (0.2 ha).

Informal surveys were conducted to located female individuals and larval casings, but these survey results have not been included in this report.

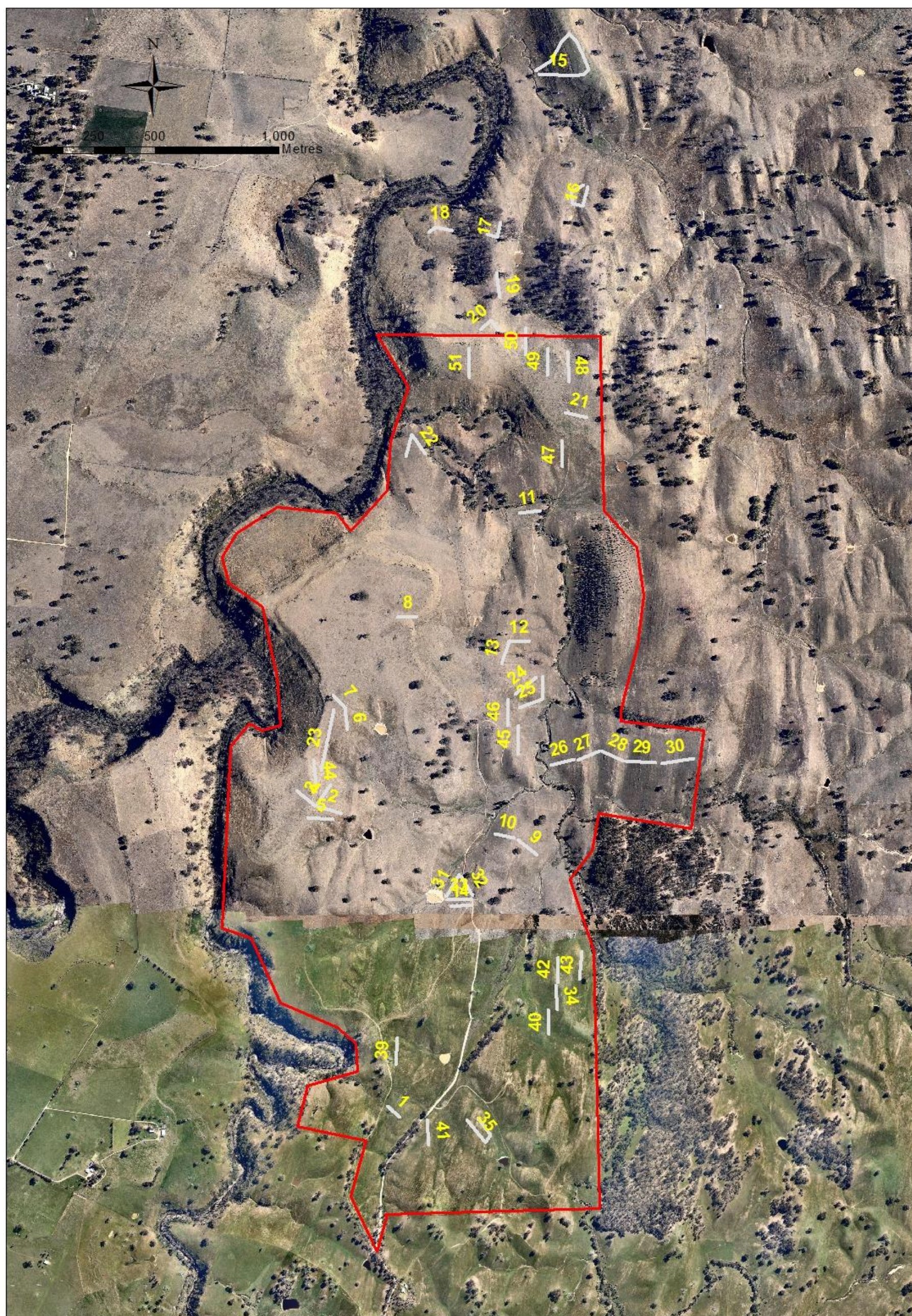


Figure 3-1 The location of the forty two Golden Sun Moth survey transects conducted on the Watchbox Valley property, and the six conducted on the property to the immediate north. Image from NearMap (2014).

4. RESULTS

Golden Sun Moths were observed in 39 of the 42 transects on the Watchbox Valley property (Table 4-1).

The average density of Golden Sun Moths on the property was 10.9 male individuals per 100 m transect across all transects, or 45 male individuals ha⁻¹ across all 42 transects.

The nine transects on the adjacent properties (Transects 15 to 20, and 36 to 38) found some evidence of the species, at a density of 7 male individuals ha⁻¹ (Table 4-1).

Vegetation data was collected in only 15 of the transects (Transects 1 to 4 and Transect 21), and this data can be viewed in Appendix A. The vegetation composition and cover has not been extrapolated to the other 35 transects.

A total of 31 vascular plant species were recorded across the fifteen transects, with 17 of these being introduced species, and 14 indigenous (Appendix A).

The mean indigenous species projective foliage cover across the 15 transects was only 19 %, while the mean introduced species projective foliage cover was 78 %; given the high cover of both indigenous and introduced species cover resulted in a relatively low estimate of bare earth across most transects (an average of 7 % across all 15 transects), and the dominance of introduced herbaceous species and no woody indigenous species has resulted in a low estimated cover of leaf litter (8 %)(Appendix A).

There was no clear correlation between the indigenous species projective foliage cover and the number of male Golden Sun Moths observed; the highest count in a transect (41 in Transect 8) did equate to the highest indigenous species projective foliage cover observed (37 % cover)(Appendix A).

Table 4-1 Golden Sun Moth survey data and prevailing weather conditions for the fifty one transects completed. Transect locations are shown in Fig. 3-1.

Transect	Date	Time	Observer ¹	Transect length (m)	Transect type	Transect direction	Temperature (°C) ²	Wind speed (km/h) ³	Cloud cover ⁴	Sunshine ⁵	Golden Sun Moth (males/transect)	Golden Sun Moths (males/ha) ⁶	Total Indigenous species cover (%) ⁷	Total introduced species cover (%) ⁷
1	19-11-14	1050	SH	106	Walk	SE	20	F1	0/8	Y	3	14	16	82
2	19-11-14	1115	SH	107	Walk	E	20	F1	0/8	Y	16	75	15	89
3	19-11-14	1130	SH	105	Walk	NE	20	F1	0/8	Y	40	190	15	82
4	19-11-14	1135	SH	100	Walk	NW	21	F1	0/8	Y	17	85	10	85
5	19-11-14	1140	SH	105	Walk	W	21	F2	0/8	Y	12	57	7	77
6	19-11-14	1208	SH	100	Walk	S	21	F1	0/8	Y	4	20	16	66
7	19-11-14	1215	SH	100	Walk	NW	21	F1-2	0/8	Y	12	60	27	71
8	19-11-14	1222	SH	101	Walk	E	22	F2-3	0/8	Y	41	203	37	77
9	19-11-14	1244	SH	100	Walk	SW	22	F2-3	0/8	Y	3	15	22	75
10	19-11-14	1250	SH	102	Walk	W	22	F2-3	0/8	Y	2	10	5	81
11	19-11-14	1317	SH	107	Walk	W	22	F2-3	0/8	Y	3	14	25	72
12	19-11-14	1418	SH	104	Walk	E	23	F2-3	0/8	Y	4	19	15	91
13	19-11-14	1425	SH	103	Walk	S	23	F2-3	0/8	Y	2	10	16	81
14	19-11-14	1440	SH	105	Walk	W	23	F4	0/8	Y	5	24	26	81
15			PD	590		NE/S/W					3	3		
16			PD	240		N/S					0	0		
17			PD	104	Walk	E/N					2	10		
18			PD	104	Walk	E					2	10		
19			PD	100	Walk	S					2	10		
20			PD	106	Walk	NE					6	28		
21	19-11-14	1400	SH	103	Walk	W	22	F2-3	0/8	Y	4	19	36	56
22			PD	190	Walk	NW/SE					35	92		
23			PD	254	Walk	S					25	49		
24			PD	108	Walk	NE					7	32		
25			PD	188	Walk	NE					0	0		
26			PD	101	Walk	E					12	59		
27			PD	100	Walk	E					17	85		
28			PD	100	Walk	SE					20	100		
29			PD	121	Walk	E					10	41		
30			PD	135	Walk	E					5	19		
31			PD	105	Walk	NE					16	76		
32			PD	100	Walk	SE					17	85		
33			PD	104	Walk	W					14	67		
34			PD	118	Walk	SE					3	13		
35			PD	244		SE/NW					11	23		
36			PD	375		W/S/E					0	0		
37			PD	548		NE					0	0		
38			PD	715		SE/NW					2	1		
39	14-11-14	940	BH	180	Walk	S	27	F1-2	8/8	N	5	14		
40	14-11-14	950	BH	100	Walk	S	27	F1-2	8/8	N	2	10		
41	14-11-14	1000	PD	180	Walk	S	27	F1-2	8/8	N	3	8		
42	14-11-14	1005	PD	180	Walk	S	28	F1-2	8/8	1/2	11	31		
43	14-11-14	1018	PD	150	Walk	S	29	F3	8/8	N	0	0		
44	14-11-14	1023	PD	150	Walk	S	30	F3	8/8	N	1	3		
45	14-11-14	1035	BH	150	Walk	S	30	F1-2	8/8	N	3	10		
46	14-11-14	1040	BH	100	Walk	S	29	F1-2	8/8	N	0	0		
47	13-11-14	1230	BH	150	Walk	N	30	F0-1	4/8	N	37	123		
48	14-11-14	1055	PD	150	Walk	S	28	F1-2	8/8	N	11	37		
49	13-11-14	1240	BH	150	Walk	N	30	F1	4/8	N	2	7		
50	13-11-14	1300	BH	100	Walk	N	30	F1	6/8	Y	12	60		
51	13-11-14	1310	BH	100	Walk	N	31	F1	6/8	Y	9	45		

1. SH is Steve Hamilton, BH is Bryan Haywood, and PD is Paul Dettmann;
2. Temperature estimate from Redesdale Weather Station (Bureau of Meteorology 2014);
3. Wind speed estimate using Beaufort Scale class from Redesdale Weather Station (Bureau of Meteorology 2014);
4. Cloud cover estimate using the Okta Scale (Bureau of Meteorology 2014);
5. Sunshine (Y/N) = Yes or No;
6. Estimated number of Golden Sun Moths per ha based on the assumption that each transect of 100 m equivalent was observing male Golden Sun moths to a distance of 10 m on either side of the transect alignment; the transect was considered to be a 20 m belt transect of 100 m length (0.2 ha);
7. Calculated by the summing of all estimates of individual species projective foliage cover in each category (see Appendix A).

5. DISCUSSION

The Watchbox Valley property was found to have Golden Sun Moth spread across most of its extent, with only 3 of the 42 transects surveyed with no flying male individuals observed. The mean number of individuals observed was 10.9 male individuals per 100 m transect across all 42 transects, or 45 male individuals ha^{-1} across all 42 transects.

Given the wide distribution of the species across the majority of the property, the total population of male individuals across the 467 ha property when extrapolating from the estimated mean density of 45 males ha^{-1} , would be over 20,000.

There was a very high mean cover of introduced plant species across assessed sites (78 %), and a commensurate low average cover of indigenous plants in assessed sites (19 %). While all sites observed to have flying male Golden Sun Moths maintained some indigenous ground layer cover, in some instances, the estimated indigenous cover was only 5 % (Transect 10). Further to this, there was no clear correlation between the indigenous species projective foliage cover and the number of male Golden Sun Moths observed.

There were twenty six individual male Golden Sun Moth observed in nine transects conducted on adjacent properties. While this indicates that the species may be far more widespread locally than known, the results of the survey do certainly indicate that the Watchbox Valley property has a significant and viable Golden Sun Moth population. Field surveys indicate that the total numbers of Golden Sun Moth on this property is very high, and may represent one of the larger known single site populations.

Based on the field surveys, Fig. 5-1 has been developed to show the indicative densities of Golden Sun Moth across the Watchbox Valley property; the property extent has been divided into low, medium and high density population zones. This zoning is based on the transect surveys and estimation of the vegetation assemblage based on the 15 transects where vegetation had been assessed, and therefore are broad estimates only. High density sites do broadly equate to the 'plateau' areas of the property on basaltic soils, and medium and low density areas are on the slopes and valleys across the site (Fig. 5-1).

Further and more detailed investigations in future years on this and adjacent properties are warranted and strongly recommended.

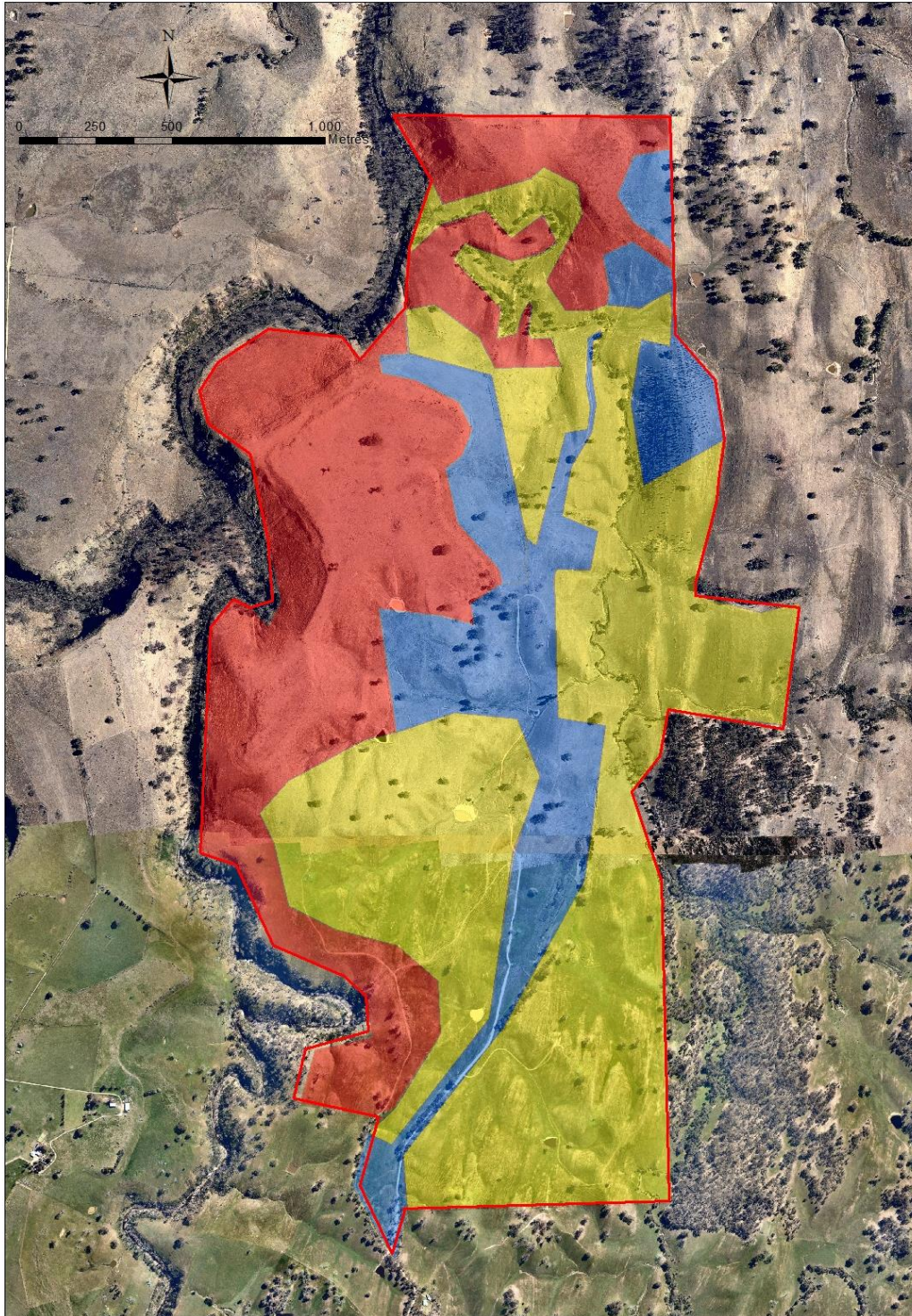


Figure 5-1 Indicative population densities of Golden Sun Moth across the Watchbox Valley property based on the 42 transects completed for the species, and 15 transects where vegetation was assessed. Red shading indicates likely high density of the species, yellow shading indicates likely medium density, and blue shading likely low density of the species. The property boundary is shown as a solid red line. Image from NearMap (2014).

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6.1 Personal Communications

Dettmann, Paul (2014). Director, Cassinia Environmental, Kyneton.

APPENDIX A TRANSECT VEGETATION DATA

Estimated projective foliage cover for all vascular plant species encountered during completion of Transects 1 to 14 and Transect 21. Bare earth and leaf litter along the transect traverse has also been estimated. Estimated projective foliage cover for each species has been summed to provide an estimate of total indigenous and introduced species cover.

Common name	Scientific name	Lifeform [#]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21
Sheep Sorrel	<i>Acetosella vulgaris</i> *	MH	1											<1			1
Sweet Vernal Grass	<i>Anthoxanthum odoratum</i> *	MNG						5					1				
Capeweed	<i>Arctotheca calendula</i> *	MH														5	
Brown-backed Wallaby-grass	<i>Austrodanthonia duttoniana</i>	MNG	10	10	10	5	5	10	10	15	10	5	5	10	5	15	10
Bristly Wallaby-grass	<i>Austrodanthonia setacea</i>	MNG	5	5	5	<1	<1	5	10	20	10	<1	5	5	10	5	20
Rough Spear-grass	<i>Austrostipa scabra</i>	MNG					<1				1	<1					
Wild Oat	<i>Avena fatua</i> *	LTG	15	15	35	50	20	5	20	40		10	5	10	5	<1	
Great Brome	<i>Bromus diandrus</i> *	LNG	1		1		1		5	5	5	1	1	<1	1		
Soft Brome	<i>Bromus mollis</i> *	LNG															<1
Red Brome	<i>Bromus rubens</i> *	LNG		1	<1	<1	<1	<1								1	
Spear Thistle	<i>Cirsium vulgare</i> *	LH		<1	<1	<1	<1	<1	<1	<1	<1			<1	<1		
Common Wheat Grass	<i>Elymus scaber</i>	MTG	<1				1	1	1	1	1		5	<1	1	5	5
Common Willow-herb	<i>Epilobium billardierinum</i>	MH															<1
Long Storks-bill	<i>Erodium botrys</i> *	MH	<1	1		<1	<1			<1		<1					
Blue Devil	<i>Eryngium ovinum</i>	MH									<1						
Yorkshire Fog-grass	<i>Holcus lanatus</i> *	MNG		<1			<1							1			
Barley Grass	<i>Hordeum leporinum</i> *	MTG							5								
Cat's Ear	<i>Hypochoeris radicata</i> *	MH	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1		<1	<1	<1	<1
Little Star	<i>Hypoxis glabella</i>	SH															
Red-anthered Wallaby-grass	<i>Joycea pallida</i>	LTG	1		<1		<1		1	1	<1						
A Rush	<i>Juncus usitatus</i>	MTG						<1	<1				<1				
Wimmera Ryegrass	<i>Lolium rigidum</i> *	MNG	<1	1	1	<1	1	1	5	1	5	10	5	10	25	10	5
Wattle Mat-rush	<i>Lomandra filiformis</i>	MTG	<1	<1	<1		<1		<1	<1				<1		<1	<1
Burr Medic	<i>Medicago polymorpha</i> *	MH				5	1	<1	<1		<1				<1		
Weeping Grass	<i>Microlaena stipoides</i>	MNG											10			1	1
Water Couch	<i>Paspalum distichum</i> *	MNG											10				

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Common name	Scientific name	Lifeform [#]	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21
Toowoomba Canary Grass	<i>Phalaris aquatica</i> *	LTG	15	10	10	5	5	5	1	1	15	30	10	20	10	15	15
Swamp Dock	<i>Rumex brownii</i>	LH	<1	<1	<1	<1		<1	<1		<1	<1		<1	<1	<1	<1
Narrow-leaf Clover	<i>Trifolium angustifolium</i> *	MH			<1												
Hare's-foot Clover	<i>Trifolium arvense</i> *	MH		1	<1		<1			<1	<1		<1			<1	5
Squirrel-tail Fescue	<i>Vulpia bromoides</i> *	MNG	50	60	35	30	50	50	40	30	50	30	40	50	40	50	30
Bare Earth			1	1	5	5	20	20	5	1	5	15	1	1	5	1	10
Litter			5	5	5	10	10	10	10	10	10	10	10	10	5	5	10
Estimated introduced species cover (%)			82	89	82	85	77	66	71	77	75	81	72	91	81	81	56
Estimated indigenous species cover (%)			16	15	15	10	7	16	27	37	22	5	25	15	16	26	36