

Kinlyside Offset Nature Reserve

Golden Sun Moth population monitoring and habitat mapping 2017

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Report for

Golden Sun Moth Population Monitoring and Habitat Mapping 2017 | Kinlyside Offset Nature Reserve - Golden Sun Moth population monitoring and habitat mapping 2017 | ACT Government – Environment and Planning | 3002620

Executive Summary

SMEC Australia Pty Ltd and Alison Rowell, Biologist and Environmental Consultant, have prepared this monitoring report on behalf of the Parks and Conservation Service (PCS), Environment and Planning Directorate, ACT Government. This report presents the findings of a Golden Sun Moth *Synemon plana* (GSM) survey and habitat mapping conducted at Kinlyside during summer 2017/18.

The key outcomes of GSM population monitoring were:

- GSM were recorded at low activity levels across the known habitat areas, except the southernmost transect where no GSM were recorded.
- The highest GSM activity levels were recorded in medium quality habitat in the central-western section of the site.
- No GSM pupae cases were observed.
- No incidental observations of female GSM were recorded.

The key outcomes of GSM habitat monitoring were:

- The site supports 33.6 ha of GSM habitat, comprising:
 - 29.3 ha of low quality GSM habitat
 - 4.3 ha of medium GSM habitat
- Biomass was relatively low in the east of the site, and bare ground had increased since 2016.
- Biomass was high in the low-lying creek flats where grazing has been excluded, which is a necessary erosion control measure, but may reduce the quality of the habitat for GSM.

Review of GSM survey and habitat mapping results in relation to previous data indicated:

- The assessment of condition of GSM habitat appears to have declined substantially from that recorded in 2010 (Eco Logical 2011), with the majority of the site recorded as supporting low quality habitat in 2017, rather than moderate or high quality habitat. This apparent decline may be associated with the following:
 - The criteria for GSM habitat quality assessment differed between 2010 and 2017-2018.
 - A large area in the western side of Kinlyside was mapped as low quality habitat in 2010, but was not considered GSM habitat in the 2017-2018 mapping due to the density of *Themeda australis*, which is not associated with GSM.
 - Small areas that were mapped as habitat in 2010, including erosion gullies, patches of trees, and areas dominated by exotics, were excluded from the 2017-2018 mapping.
 - The habitat may be degraded by excessive grazing in some areas, and with increased density due to grassland recovery following drought in other areas.
- Per hour of survey effort, GSM abundances recorded in 2017 were within the range of abundances recorded in previous years.
- There is no evidence of a decline in GSM activity.
- GSM were not recorded in all areas identified as potential GSM habitat.

The following recommendations should be considered in future management and monitoring of GSM habitat at Kinlyside:

- Reassess grazing levels across the site, in particular:

Report for

Golden Sun Moth Population Monitoring and Habitat Mapping 2017 | Kinlyside Offset Nature Reserve - Golden Sun Moth population monitoring and habitat mapping 2017 | ACT Government – Environment and Planning | 3002620

- Grazing in the eastern lease should be lighter in dry summers.
- Undertake a mid-season meandering transect to record GSM presence-absence in low quality habitat areas not covered by existing transects.

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List of Figures

Figure 1. Kinlyside Offset Nature Reserve boundary and GSM monitoring transects. 1

Figure 2. Total GSM observations at Kinlyside Offset Nature Reserve..... 9

Figure 3. Average GSM observations at Kinlyside Offset Nature Reserve.....10

Figure 4. GSM habitat mapping at Kinlyside Offset Nature Reserve.14

Figure 5. Average GSM observations at 25 m intervals with GSM habitat mapping at Kinlyside Offset Nature Reserve.19

Figure 6. Average GSM observations at 100 m intervals with GSM habitat mapping at Kinlyside Offset Nature Reserve.20

Figure 7. Average GSM observations at 100 m intervals in 2015 (SMEC 2016) with GSM habitat mapping at Kinlyside Offset Nature Reserve.....21

Figure 8. Average GSM observations at 100 m intervals in 2016 (Rowell and O’Sullivan 2017) with GSM habitat mapping at Kinlyside Offset Nature Reserve.....22

List of Tables

Table 1. Survey dates and weather conditions for surveys at Kinlyside Offset Nature Reserve. 7

Table 2. Results summary for flying moth surveys conducted at Kinlyside Offset Nature Reserve. .. 8

Table 3. Mapped GSM habitat area at Kinlyside Offset Nature Reserve.....12

Table 4. Habitat transects at Kinlyside Offset Nature Reserve.13

Table 5. Site-wide summary of GSM observations at Kinlyside Offset Nature Reserve (2015-2017).
16

Table 6. Number of GSM recorded per minute in each transect at Kinlyside Offset Nature Reserve in 2015 (SMEC 2016), 2016 (Rowell and O’Sullivan 2017), and 2017.16

1. Introduction

1.1. Background

SMEC Australia Pty Ltd (SMEC) and Alison Rowell, Biologist and Environmental Consultant, prepared this report on behalf of the Parks and Conservation Service (PCS), Environment and Planning Directorate, ACT Government as one component of the contract '*North Canberra Golden Sun Moth Population Monitoring and Habitat Mapping 2017/1*'. SMEC was engaged to monitor Golden Sun Moth (GSM) populations at six sites and to map GSM habitat at nine sites in and adjacent to the ACT. These sites have been, or are proposed as, offsets for development of GSM habitat.

The GSM is listed as critically endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and listed as endangered under the *ACT Nature Conservation Act 2014* (NC Act). In the ACT region, GSM occur in an area about 100 km long and 30 km wide, extending from the Queanbeyan district in the south-east to the Boorowa area in the north-west (ACT Government 2017). In the ACT, the species is known to occur at approximately 78 lowland grassland and derived grassland sites in and adjacent to the city of Canberra.

GSM population monitoring and habitat mapping was required at the following sites:

- Jarramlee Offset Nature Reserve (Jarramlee)
- Kinlyside Offset Nature Reserve (Kinlyside)
- Throsby North Offset (Throsby North)
- Yass Valley Lot 2 Offset (Yass Valley Lot 2)
- West MacGregor Offset Nature Reserve (West MacGregor)
- Woolshed Creek (Woolshed Creek).

In addition, habitat mapping was required at the following offset sites:

- Jerrabomberra East (Jerrabomberra East)
- Throsby East Offset (Throsby East)
- West Majura (West Majura).

This report relates to GSM population monitoring and habitat mapping conducted at Kinlyside.

1.2. Survey Site

The Kinlyside Offset Nature Reserve (Kinlyside) is a 281 ha nature reserve located between the suburb of Casey, ACT and grazed leasehold land to the north and west (Figure 1). Kinlyside was established as an offset under the Gungahlin Strategic Assessment (Umwelt 2013a). The site consists of EPBC and non-EPBC box-gum woodland, red stringybark/scribbly gum woodland/forest, and exotic, mixed, and native grassland.

The Kinlyside Nature Reserve and Offset Area Offset Management Plan, established as required under the EPBC Act approvals, identifies four habitat management zones for Matters of Environmental Significance, including GSM. The management plan specifies measures to conserve the offset area and details the monitoring program for GSM and GSM habitat within the GSM habitat management Zone (Figure 1; Territory and Municipal Services Directorate 2015). Specifically, there is a requirement to survey GSM populations and habitat at Kinlyside once every three years from 2017, using the ACT Government golden sun moth survey guidelines (ACT Government 2010).

The Kinlyside Nature Reserve and Offset Area Offset Management Plan requires that PCS and Conservation, Planning and Research (CPR) manage GSM habitat to maintain the current extent of

GSM populations within the Offset Area, and improve the quality of GSM habitat within GSM habitat management zones by:

Maintaining or improving the diversity and cover of GSM food,

Providing habitat structure that is suitable for the GSM,

Maintaining a low cover of weeds species,

Controlling the recruitment of trees and shrubs.

PCS and CPR must take corrective actions if, as a result of the monitoring program, it is determined that there is a measured decline in the population of the GSM (Territory and Municipal Services Directorate 2015).

Results were analysed with reference to the following previous surveys:

- **Eco Logical Australia.** 2011. *Golden sun moth surveys at One Tree Hill, Kinlyside and Throsby*, Prepared for Conservation Planning and Research, ACT Government, Department of Territory and Municipal Services, February 2011.
- **Eco Logical Australia.** 2012. *Accelerated Land Development 2011 Golden Sun Moth Conservation Planning and Research Surveys*, Prepared for Conservation Planning and Research, ACT Government, Department of Territory and Municipal Services, January 2012.
- **RJPL.** 2013. *Kinlyside Golden Sun Moth Survey 2012*, Report to the Land Development Agency, February 2013.
- **SMEC.** 2016. *Golden Sun Moth Population and Habitat Monitoring Program. 2015 Report.* Prepared for Parks and Conservation Service. April 2016.
- **Rowell, A and O’Sullivan, T.** 2017. *Golden Sun Moth Population and Habitat Monitoring, 2016.* Bonner, Throsby North and Kinlyside Environmental Offsets, Prepared for Parks and Conservation Service. March 2017.

GSM populations at Kinlyside were previously surveyed in 2010 (Eco Logical Australia 2011), 2012 (RJPL 2013), 2015 (SMEC 2016) and 2016 (Rowell and O’Sullivan 2017). Previous surveys have found low GSM activity, in accordance with activity levels described by Hogg (2010). During the 2010 and 2015 surveys observations of GSM were restricted to the central-western part of the site whilst in 2012 and 2016 GSM were recorded across a larger area of the central and north-eastern parts of the site.

GSM habitat extent at Kinlyside was mapped in 2010 (Eco Logical Australia 2011) and 2012 (RJPL 2013). Habitat condition within known GSM habitat in the central part of the site was assessed in 2015 (SMEC 2016) and 2016 (Rowell and O’Sullivan 2017). During 2015 the site had little vegetation, low biomass and large bare patches. During 2016 the grasses were mostly low and sparse, bare earth cover was low to moderate, and there was moderate cover of exotic species, mainly clovers and annual grasses. Native perennial grass cover was moderate-high.

1.3. Objectives

This report presents the findings of GSM surveys and habitat mapping conducted during summer 2017/18 at Kinlyside. The purpose of this monitoring is to meet the monitoring requirements specified in the Kinlyside Nature Reserve and Offset Area Offset Management Plan (Territory and Municipal Services Directorate 2015), to inform management of potential management requirements and to provide the ACT Government with information to determine whether corrective actions are triggered.

The GSM population survey objective was to determine GSM distribution and abundance in Kinlyside in 2017. Specifically, the data collated would enable PCS and CPR to assess whether the GSM

population is significantly lower than other populations surveyed in the ACT in the same year relative to previous GSM survey results at Kinlyside.

The objective of habitat mapping conducted at Kinlyside was to determine the extent and condition of GSM habitat in Kinlyside in 2017. The data collated would assist long term monitoring and inform future management decisions by determining a baseline level of the extent and/or quality of the GSM habitat.

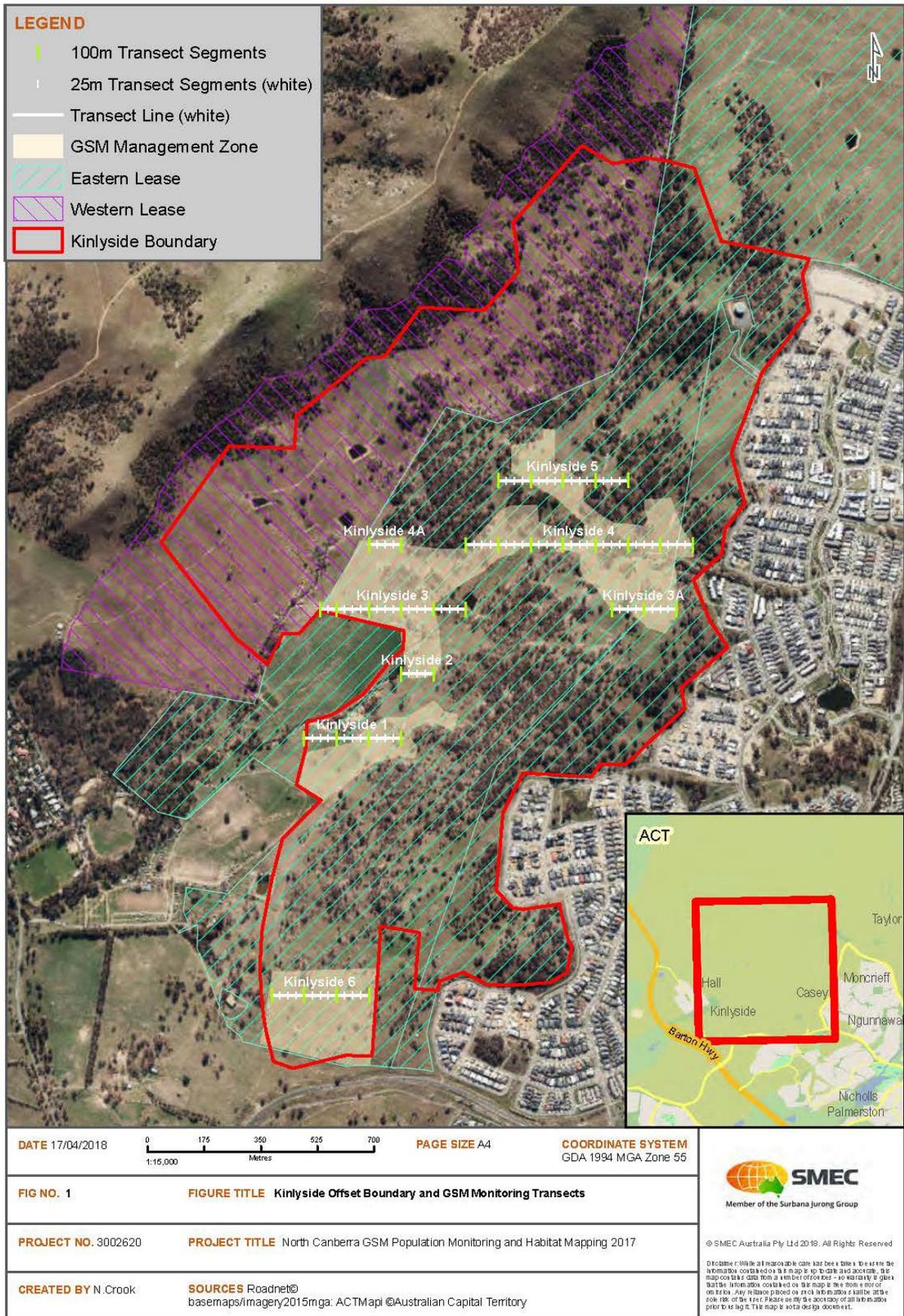


Figure 1. Kinlyside Offset Nature Reserve boundary and GSM monitoring transects.

2. Methods

2.1. GSM Surveys

2.1.1. Regional GSM Information

ACT researchers and consultants shared information regarding the timing and location of GSM sightings, particularly at the start of the flying season, via email on a weekly basis during the GSM flying season. The start of the GSM flying season was confirmed using known reference sites in the ACT and based on information from other consultants in the ACT, and Conservation Research, ACT Government (CR).

2.1.2. Survey conditions

GSM surveys were conducted in accordance with the ACT Golden Sun Moth Survey Guidelines (ACT Government 2016), modified to record summaries of the number of male moths at 25 m intervals as specified in the brief. Three surveys were undertaken at least one week apart on days with suitable weather conditions, specifically:

warm to hot days (above 20°C by 10am)

warmest part of the day (between 10am – 2pm)

clear, mostly cloudless sky

still or relatively still wind conditions

no less than two days since rain (>1 mm) or an unusually cold night.

During the second survey, transects were walked in reverse order to counter time-of-day effects.

2.1.3. Flying moth surveys

The existing transects and transect segments at Kinlyside were walked by ecologists experienced in GSM surveys. A moderately slow walking pace of approximately 2 minutes per 100 m (i.e. 30 s per 25 m) was employed for consistent recording along the transects and between sites. All male GSM flying within 25 m of the transect were recorded.

The following transect survey data was recorded in the Population Transect datasheet (Appendix H to the RFQ):

- Reserve name
- Date
- Number of days since rain
- Survey number
- Transect
- Transect segment
- Transect Start GPS coordinates
- Each 25 m Transect segment start time
- Each 25 m Transect segment end time
- Each 100 m Transect segment start time
- Each 100 m Transect segment end time
- Temperature at start of each 100 m transect segment

- Cloud cover at start of each 100 m transect segment (i.e. none, low (scattered <30% cloud), moderate (patchy 40-70% cloud), high (>70% cloud cover))
- Wind speed at start of each 100 m transect segment (i.e. none, low (slight breeze), moderate (light wind), high (strong gusts or constant high wind))
- Number of male GSM observed along each 25 m transect segment
- Number of male GSM observed along each 100 m transect segment (this would be compiled following surveys based on the 25 segment transects).

Data was recorded in Excel in the format specified in the survey brief.

2.1.4. Incidental observations

Incidental observations on the site were recorded along with the details specified in the Incidental Observations datasheet (Attachment I to the RFQ).

Incidental observations include:

- Pupae cases observed during or independently of transect surveys
- Female moths observed during or independently of transect surveys
- Significant observations of male moths observed independently of transect surveys. Note that incidental observations of male flying moths were not recorded during transect surveys, due to time constraints.

Incidental observations were recorded with the following data (where recorded) in the format specified in the survey brief:

- Reserve name
- Date
- Survey number
- Observation GPS coordinates
- Closest transect to the observation
- Closest transect segment to the observation
- Time of observation
- Temperature at time of observation
- Cloud cover at time of observation (i.e. none, low (scattered <30% cloud), moderate (patchy 40-70% cloud), high (>70% cloud cover))
- Wind speed at time of observation (i.e. none, low (slight breeze), moderate (light wind), high (strong gusts or constant high wind))
- Number of GSM observed
- Type of GSM observation (i.e. males, females, pupae).

2.2. GSM Habitat Monitoring and Mapping

The habitat assessment scope comprised two components:

- Mapping habitat condition classes
- Habitat monitoring transects.

2.2.1. Habitat mapping

The following criteria for classifying GSM habitat were followed in this survey. Alison Rowell developed this approach to provide a repeatable approach, which can be used across multiple sites in the ACT by different users. Four condition classes of GSM habitat were defined based on relatively stable habitat features such as density of larval food plants, weed cover and physical characteristics such as soil type, slope and aspect.

- HIGH quality GSM habitat
 - Primary NTG or native pasture dominated by native larval food plants (i.e. *Rytidosperma* sp. and/or *Austrostipa* sp.), with low weed cover and some bare ground.
 - MEDIUM quality GSM habitat
 - Primary or secondary grassland, with a moderate component of *Rytidosperma* sp. and/or *Austrostipa* sp., and/or moderate weed cover.
- or
- Native-dominated grassland with a high component of *Rytidosperma* sp. and/or *Austrostipa* sp., but less than High quality habitat because of one or more of the following conditions:
 - On a steep slope or hill top
 - On a south or east-facing slope
 - Soil very shallow and/or stony, rock outcrops present
 - Secondary grassland or contains scattered trees.
- LOW quality GSM habitat
 - Larval food plants (*Rytidosperma* sp., *Austrostipa* sp. and/or Chilean needle grass) are a minor component of the ground layer, growing sparsely or in patches among unsuitable vegetation such as:
 - Exotic species (excluding Chilean needle grass)
 - Native C₄ grasses (such as *Themeda triandra*.)
 - Other unsuitable native ground cover (e.g. *Poa labillardieri*, rushes / sedges)
 - Trees, shrubs, regeneration, plantings.
 - CNG (Chilean needle grass) dominated GSM habitat
 - Grassland dominated by Chilean needle grass.

Across the sites surveyed, several different types of grassland were put into the medium and low habitat classes, with the differences often resulting from past land uses. Areas classified as high quality habitat were generally less disturbed grasslands, and often the critically endangered Natural Temperate Grassland community. Grasslands which have not been ploughed, heavily grazed or pasture-improved tend to retain cryptogams, bare ground and native forbs, contain fewer exotic species, and have lower and more stable biomass. They also retain the shorter species of *Rytidosperma* (*R. carphoides*, *R. auriculatum*, *R. laeve*), while more disturbed grasslands contain more robust 'native pasture' species such as *R. caespitosum* and *Austrostipa bigeniculata*. Where relevant to management, differences were recorded.

Biomass was not included as a component of GSM habitat measurement due to the high variability in response to short term management measures or seasonal conditions. While an important feature of GSM habitat condition, this makes it unsuitable for monitoring long-term change. Biomass was mapped as a separate overlay independent of the underlying habitat quality.

General characteristics of biomass classes were:

- Low biomass: tussocks up to 10 cm high, bare ground common between tussocks, litter layer sparse.
- Medium biomass: tussocks up to 20 cm high, little bare ground between tussocks, litter common but not continuous.
- High biomass: tussocks greater than 20 cm high and closely spaced, little or no bare ground, litter layer continuous and thatchy, often including subterranean clover.

For all condition classes, the ideal biomass condition for each site would be low to medium, i.e. most areas without dense thatch or tall dense tussock grasses over 10 cm high.

This approach provides information on the habitat quality and current management needs on the same map, without giving undue importance to what may be temporary changes in apparent quality. It should also avoid having greatly differing habitat quality maps for a site from year to year, which could be confusing viewed together, or misleading about underlying habitat quality if only one year's mapping was viewed.

Habitat mapping was undertaken through review of aerial photographs, followed by a detailed site walk-over to identify habitat zone boundaries.

2.2.2. Habitat monitoring

One, 100-point habitat transect was established in each identified habitat zone, i.e. a maximum of three (4 when Chilean needle grass was present) transects at each site. Transects were 100 metres, except where a habitat zone was less than 100 m across, in which case 100 points were sampled on a 50 m transect. Data was collected according to the GSM Habitat Transect datasheet (Attachment L to the RFQ), specifically recording the presence of GSM larvae food plants at each point on the transect. The following data was collected for each transect:

- Reserve name
- Date
- Habitat Zone
- Transect
- Transect co-ordinates (start and end point)
- Dominant feature present at each point:
- Cryptogams
- Bare Earth
- Rock
- Litter / Dead Vegetation
- Chilean Needle Grass
- Serrated Tussock
- Annual Exotic Grass
- Perennial Exotic Grass
- Exotic Broadleaf
- Rytidosperma sp.
- Austrostipa sp.
- Other Perennial Native Grass

- Other native plants.

Notes were made of other relevant habitat characteristics, including soil types, grazing type and pressure, fire, slashing, erosion, site damage, pupal case locations, presence of trees / shrubs, etc.

Reference photographs were taken of each transect using the method in the Draft ACT Golden Sun Moth Monitoring Plan (Attachment D to the RFQ).

3. Results

3.1. GSM Surveys

3.1.1. Regional GSM Information

The first report of GSM during the 2017/18 season was of 100 males at Jerrabomberra East Grasslands on the 2 November. By the second week of November (i.e. 6 – 12) GSM were flying at several sites in the ACT.

3.1.2. Survey conditions

Surveys were conducted on 21 November, 1 December and 11 December during warm, sunny or partly cloudy conditions (Table 1).

Table 1. Survey dates and weather conditions for surveys at Kinlyside Offset Nature Reserve.

Survey No.	Date	Survey Time	Temperature during surveys (°C)	Weather conditions	Min and max temperature (°C)	Cloud cover	Last rain
1	21 Nov 2017	1027-1157	19.0 – 22.0	Sunny, light wind (0-10 km/hr)	7.4 - 26.1	0-20%	19 Nov (0.4 mm)
2	1 Dec 2017	1015-1157	25.0 – 27.0	Partly cloudy, moderate wind (15-25 km/hr)	15.0 – 30.6	15-75%	29 Nov (0.2 mm)
3	11 Dec 2017	1200-1344	23.0 – 27.0	Sunny, light/moderate wind (5-20 km/hr)	12.0 – 29.7	10-25%	8 Dec (6.2 mm)

3.1.3. Flying moth surveys

Low overall levels of GSM activity were recorded at Kinlyside during the 2017 survey period (Total GSM = 91, Average GSM = 30.3; Table 2). GSM abundance was consistent in the first two surveys, but no GSM were recorded during the third survey. A total of 57 GSM were recorded on 21 November, 34 GSM were recorded on 1 December, and no GSM were recorded on 11 December (Table 2). Weather conditions were similar between surveys. The survey in which no GSM were observed was conducted three days after 6.2 mm rainfall (Table 1). GSM were recorded in all areas surveyed except the southernmost transect (transect 6; Figure 2). Average GSM abundances were low as no GSM were recorded in the third survey (Figure 3; Table 2). A complete list of GSM flying moth records is presented in Appendix A.

3.1.4. Incidental Observations

No incidental observations were made at Kinlyside during 2017.

Table 2. Results summary for flying moth surveys conducted at Kinlyside Offset Nature Reserve.

Transect	S1 Time (mins)	S1 GSM	S1 GSM/mins	S2 Time (mins)	S2 GSM	S2 GSM/mins	S3 Time (mins)	S3 GSM	S3 GSM/mins	Total GSM	Average GSM	Average GSM/min
1	10	3	0.30	10	4	0.40	16	0	0	7	2.3	0.23
2	1	3	3.00	2	1	0.50	5	0	0	4	1.3	1.17
4	16	0	0	24	2	0.08	30	0	0	2	0.7	0.03
4A	1	3	3.00	3	1	0.33	4	0	0	4	1.3	1.11
5	16	11	0.69	24	6	0.25	10	0	0	17	5.7	0.31
3	22	18	0.82	22	19	0.87	23	0	0	37	12.3	0.56
3A	9	19	2.11	9	1	0.11	8	0	0	20	6.7	0.74
6	6	0	0	10	0	0	11	0	0	0	0	0
WHOLE SITE	81	57	1.24	104	34	0.32	107	0	0	91	30.3	0.52

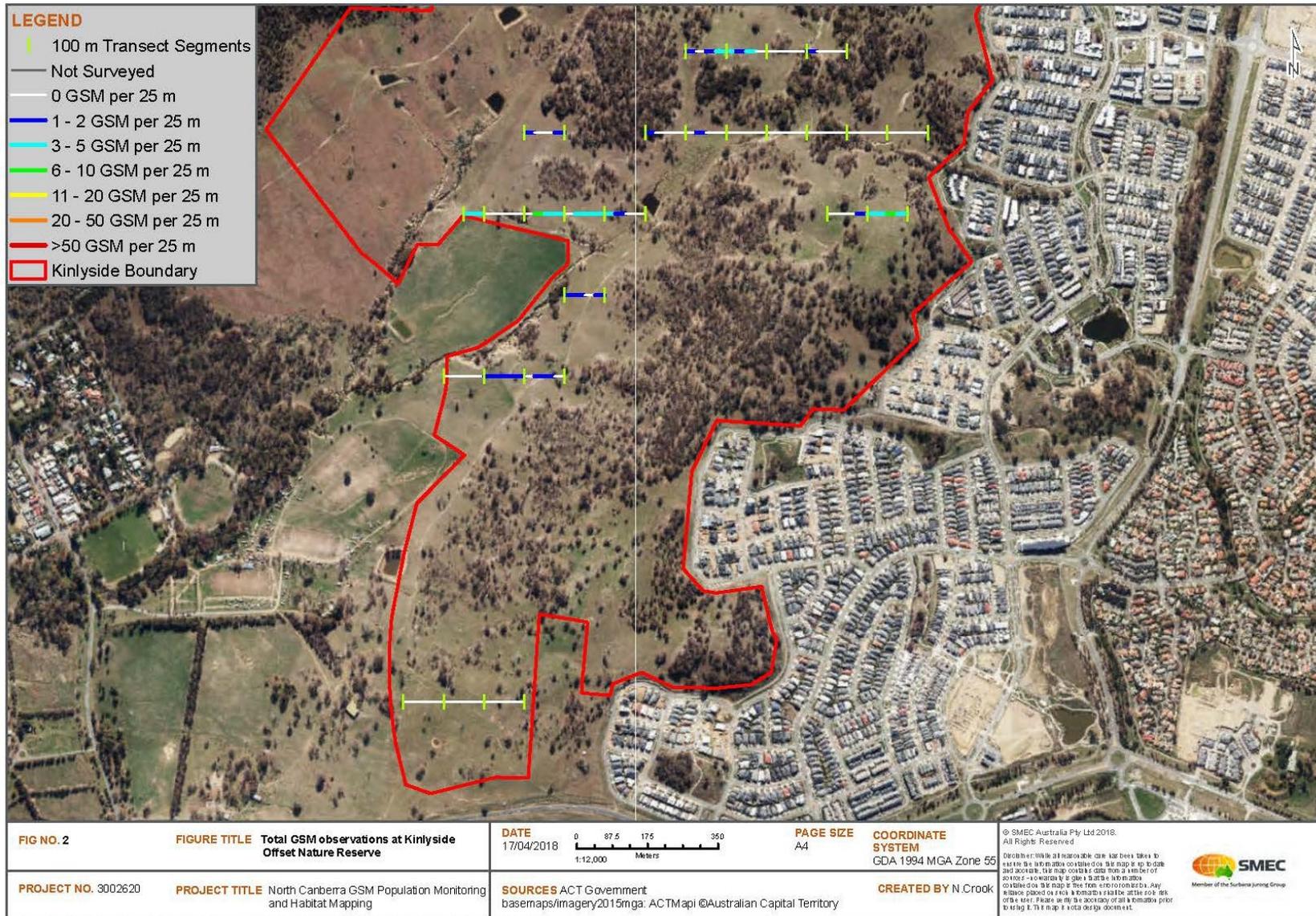


Figure 2. Total GSM observations at Kinlyside Offset Nature Reserve.

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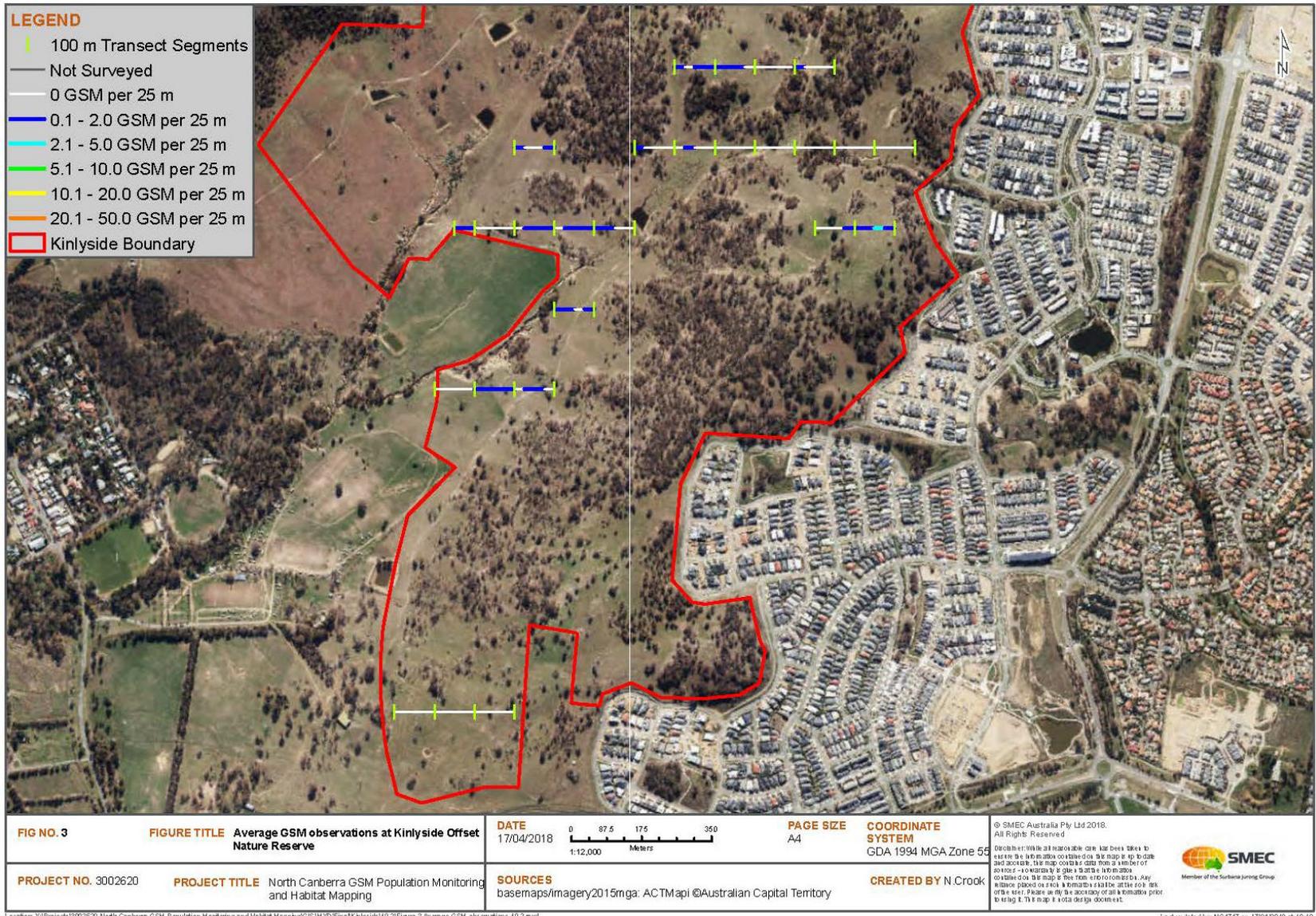


Figure 3. Average GSM observations at Kinlyside Offset Nature Reserve.

3.2. GSM Habitat Monitoring and Mapping

The distribution of habitat condition classes is shown in Figure 4, and the extent of each habitat class is shown in Table 3. Habitat transect data for each habitat class is presented in Table 4. Habitat transect data are presented in Appendix B. Transect photographs are presented in Appendix C.

The habitat mapping on the eastern lease was carried out in December 2017 and March 2018, and the western lease was mapped in April 2018.

The ground layer in the cleared areas was dominated by native grasses. The site contains low hills on the eastern boundary and a high hill beyond the western boundary, and two creeks in the valley meet near the southern end of the site. The western lease has been grazed by cattle since about 2000 (by sheep before 2000), the eastern lease is grazed by sheep (Territory and Municipal Services Directorate 2015), and low numbers of kangaroos are present across the site. Kangaroo grass provided nearly 100% of the ground cover in most areas west of the western creek, where biomass was mostly moderate. Wallaby, spear, and redleg grasses were more common on the eastern side of the valley, where biomass was generally low. Stock had been fenced out of strips of land along the deeply eroded lower sections of the creeks as part of recent rehabilitation works.

The occasional presence of Subterranean Clover suggests some pasture improvement in the past, but there are now few introduced perennial pasture grasses on the site and weeds such as thistles and serrated tussock are well-controlled. Eucalypt regeneration is low in the golden sun moth habitat management zone, as required by the Kinlyside Nature Reserve and Offset Area Offset Management Plan (Territory and Municipal Services Directorate 2015).

Most of the habitat has been described as low quality, with cover of wallaby grasses mostly low. On the eastern side of the valley it occurs as patches of moderately weedy secondary grassland scattered among woodland, and on the western side it is scattered patches of shorter grassland where the kangaroo grass is sparser due to shallow soil (knolls and ridges) or heavier grazing (fenced strip east of the western creek).

The areas designated as medium quality habitat are mostly on flats and gentle slopes beside the eastern creek, but two included a slope and a hilltop, and all contained short species of wallaby grass (*Rytidosperma carphoides* and *R. auriculatum*). The creekside habitat was native pasture with moderate bare ground and low to moderate cover of wallaby, spear and redleg grasses. The eastern hilltop and slope habitat was rocky, but had high cover of wallaby and other native grasses, some bare ground and native forbs and cryptogams.

Two transects were surveyed in medium quality habitat in 2018, to sample the variation in the category at Kinlyside. Transect 3D was in low diversity native pasture on the creek flat, and was also surveyed in December 2016. The cover of non GSM larval food plants was similar in 2018, but cover of food plants and bare ground was higher, and litter cover was lower. Transect 3aB was in diverse secondary grassland on a rocky hill on the eastern boundary of the site, with high cover of short wallaby grasses. This habitat is similar to that covered by transect 5B in 2016, which was also in a rocky area.

The low quality habitat sampled in transect 1 was on a gentle west-facing slope, in an area where incidental observations of GSM were made in 2016. The vegetation was dominated by kangaroo and redleg grasses, with isolated patches of shorter wallaby grasses (few of which were recorded on the transect). This area was similar to the patches of low quality habitat on the western side of the offset, with moderate biomass and little bare ground in the sections dominated by kangaroo grass.

Table 3. Mapped GSM habitat area at Kinlyside Offset Nature Reserve.

GSM Habitat Classification	2017 Surveyed Area (ha)
Low Quality GSM Habitat	29.3
Medium Quality GSM Habitat	4.3
High Quality GSM Habitat	0.0
CNG dominated GSM Habitat	0.0
Not GSM Habitat	247.6
Total	281.2

Table 4. Habitat transects at Kinlyside Offset Nature Reserve.

Transect/ QUALITY	Crypt	Bare	Rock	Litter	CNG	Serrated Tussock	Annual Exotic Grass	Perennial Exotic Grass	Exotic Broadleaf	Wallaby	Stipa	Perennial Native Grass	Other Native	NOTES
T3D/Medium	5	21	0	8	0	0	2	0	2	4	12	45	1	Short low-diversity native grassland on flat ground near creek.
T3aB/Medium	13	4	9	10	0	0	0	0	6	22	4	23	9	Short diverse native grassland on rocky hilltop
T1/Low	0	5	0	9	0	0	0	0	7	1	0	76	2	Gentle west-facing footslope, medium height Themeda common.

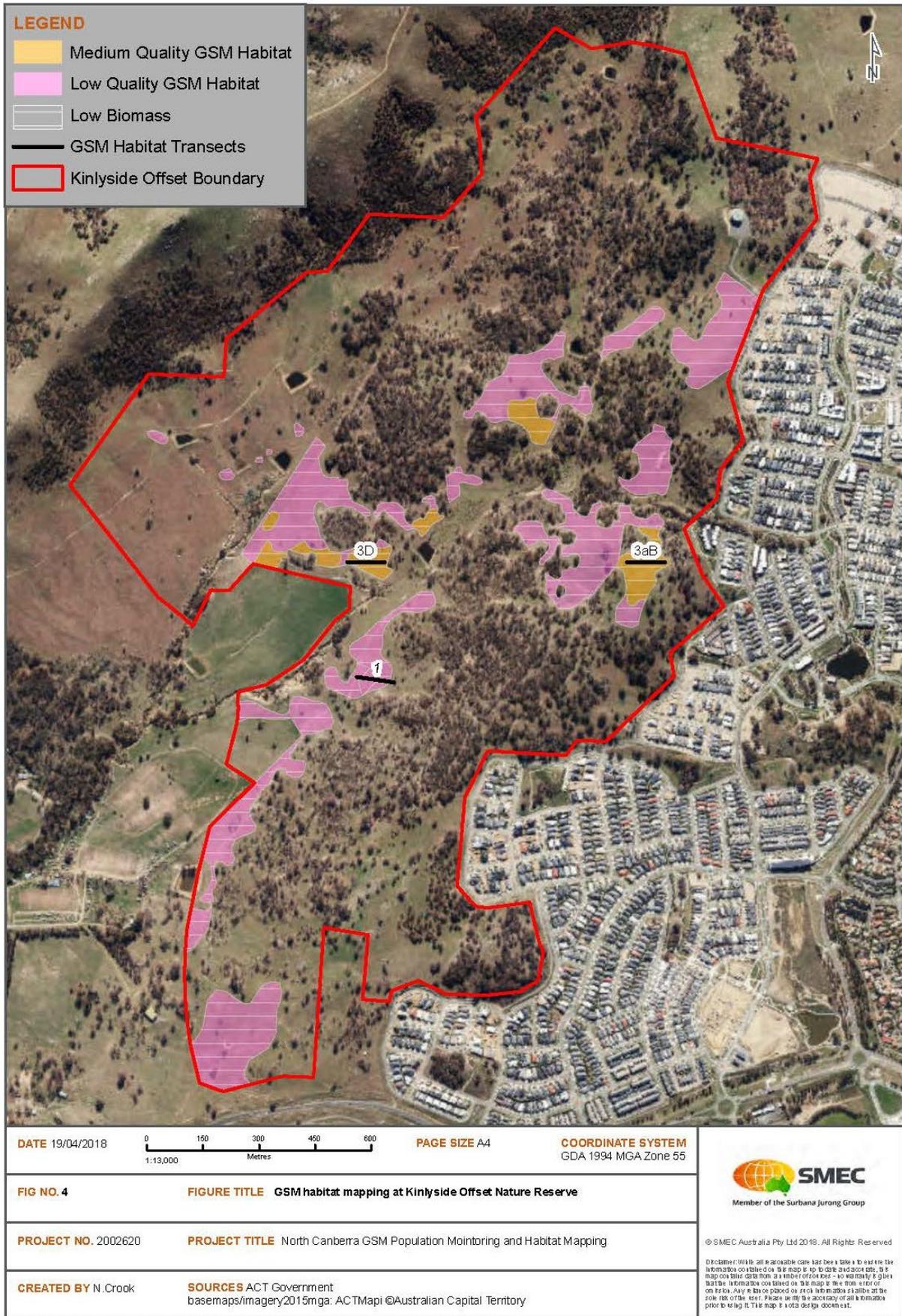


Figure 4. GSM habitat mapping at Kinlside Offset Nature Reserve.

4. Discussion

4.1. Habitat mapping

The extent of GSM habitat cannot be directly compared between the 2017 mapping and that conducted in previous years, as different criteria were used to define habitat and habitat quality, and site boundaries differed. In 2010, Eco Logical (2011) identified five quality categories, but no transects were measured in that study, and the estimated percentage cover of 'suitable native species' in all categories greatly exceeded those recorded in any habitat transects during the 2017-18 surveys across all sites, where 'suitable native species' were taken to be wallaby and spear grasses. 'Suitable native species' may have included all native grasses in the Eco Logical (2011) assessment, and could therefore have included non GSM food plant species.

Eco Logical (2011) identified extensive areas of high, moderate-high, and moderate habitat throughout the central part of Kinlyside, and RJPL (2013) identified extensive potential habitat, without assessment of habitat quality, within the low-lying parts of central Kinlyside. In contrast, habitat assessments conducted in 2015, and subsequently, indicated that much of the site was low quality, likely as a result of grazing pressure (SMEC 2016). More recent assessments suggested that the habitat may have improved marginally between 2015 and 2016 (Rowell and O'Sullivan 2017), however in 2017 only a small proportion of the site was mapped as GSM habitat, and most of this was low quality GSM habitat.

The habitat quality definition used in the current report does not classify habitat as high quality if it occurs as patches among woodland, as such areas generally support lower densities of GSM than areas of primary native grassland. This follows the Gungahlin Strategic Assessment Report (Umwelt 2013b) which stated 'populations within the Plan area in Gungahlin are characterised by low to moderate population sizes and habitat type 'D' – secondary grassland. These populations are considered less significant than those within natural temperate grassland... and have a likelihood of reverting back into woodland following the cessation of grazing'. According to the criteria used to define GSM habitat quality levels in the current report, there is no evidence that areas of high quality GSM habitat occur at Kinlyside.

Eco Logical (2011) recorded a large area of low quality habitat on the western side of Kinlyside (One Tree Hill area), described as 'Large portions of the site at the eastern base of the ridge line were dominated by dense *Themeda australis* (>90%)'. In 2017 the *Themeda* cover had increased to >95% (estimated) in almost all of this area, and it was not classified as GSM habitat as GSM are not associated with *Themeda* dominated grassland. This area identified by Eco Logical (2011) as low quality habitat would not be considered GSM habitat if classified according to the criteria used in the current report. Other smaller areas included as habitat in the Eco Logical (2011) mapping were excluded from the 2017-18 mapping. These included erosion gullies, patches of trees, and some areas found to be dominated by exotics, especially phalaris. The 2010 assessment (Eco Logical 2011) was conducted at the end of the millennium drought, when most native grasslands had the low and sparse structure of good GSM habitat. In 2009, phalaris and subterranean clover had virtually disappeared from many native pastures, only to reappear after the drought broke. As the grasslands recovered following drought their structure has become less suitable for GSM, which may have contributed to the consistent trend of reduced extent and declining quality of GSM habitat across sites in the ACT.

4.2. GSM observations in relation to habitat mapping

GSM activity was low to very low across the whole site on all surveys, and presence appears associated with mapped GSM habitat. However, no GSM were recorded in several areas identified as low quality GSM habitat. Highest average GSM observations recorded at 25 m and 100 m intervals

was associated with areas of medium quality GSM habitat along transects 3 and 3A (Figure 5, Figure 6). No transects were located on low quality habitat in the western lease as these patches were mostly very small.

4.3. Comparison of GSM observations with previous surveys

It is likely that the GSM population at Kinlyside has always been sparse, as is usually the case in areas formerly covered by woodland. In the 2017 monitoring period, GSM activity levels were similar to those reported from the 2016 monitoring (Rowell and O’Sullivan 2017) or the 2015 monitoring (SMEC 2016). The lower number of GSM recorded in 2015 is, in part, due to differences in survey effort and location, where four transects surveyed in 2016 and 2017 were not surveyed in 2015. Detection rates were also substantially higher than recorded during non-structured surveys conducted in previous years (RJPL 2013; Ecological 2011) which is expected as transect surveys target known population areas.

Even within the reduced transect length, GSM records were much less widely distributed in 2015 (Figure 7) than in 2016 (Figure 8) and 2017 (Figure 6). Increased activity of GSM between 2015 and 2016 is consistent with findings elsewhere in northern ACT, with lower GSM activity generally across the region in 2015. In both 2016 and 2017, GSM were distributed throughout most surveyed areas, excluding the southernmost transect. GSM activity levels along each transect varied slightly between years, but higher activity levels were largely recorded in the same transects (Table 6).

Overall, there is no evidence of any reduction in GSM activity at Kinlyside over time.

Table 5. Site-wide summary of GSM observations at Kinlyside Offset Nature Reserve (2015-2017).

Year (reference)	Total # GSM	# GSM/min	# GSM/km
2011 (Eco Logical 2011)	3	-	-
2012 (RJPL 2013)	56	0.05	-
2015 (SMEC 2016)	11	0.07	2.6
2016 (Rowell and O’Sullivan 2017)	100	0.67	19.2
2017	91	0.52	11.9

Table 6. Number of GSM recorded per minute in each transect at Kinlyside Offset Nature Reserve in 2015 (SMEC 2016), 2016 (Rowell and O’Sullivan 2017), and 2017.

Transect #	2016 GSM/minute	2017 GSM/minute
1	0.13	0.23
2	0.64	1.17
3	2.25	0.56
3a	0.06	0.74
4	0.40	0.03

Transect #	2016 GSM/minute	2017 GSM/minute
4a	1.08	1.11
5	0.78	0.31
6	0.00	0.00
Whole site average	0.67	0.52

4.4. Management observations

The condition of the GSM habitat is mostly satisfactory with perennial weeds well-controlled, but biomass was generally lower than in 2016. Concerns were raised about grazing intensity at Kinlyside following surveys in late 2015 in which large areas of bare ground were observed in potential GSM habitat zones (SMEC 2016), and this assessment is supported by the current monitoring. Biomass was slightly higher in 2016 relative to 2015 (Rowell and O’Sullivan 2017), but was low again in summer and autumn 2017-18.

The grass on some ridges and flat areas in the eastern part of the site is cropped very low, and although there does not appear to have been loss of native tussocks or plant diversity, lighter grazing would be desirable during dry summers. In contrast, grasses in areas along the lower sections of the creeks where stock have been fenced out are likely to become too tall and dense to support GSM, but this measure is necessary for erosion control. The slope and hilltop areas mapped as medium quality GSM habitat contain more intact grassland and are likely to be less prone to seasonal fluctuations in biomass and grassland quality than the creek flat habitat. It may be necessary to reassess current grazing levels in these areas in order to meet the GSM habitat improvement objectives of the Kinlyside management plan (Territory and Municipal Services Directorate 2015).

The change from sheep to cattle grazing of the western lease around the year 2000 has probably reduced the amount of potential GSM habitat in that area as the kangaroo grass has recovered and become dominant, but this area is not primarily managed for GSM. Kangaroo grass is present but not dominant in the GSM habitat management zone in the eastern lease, and it is likely that the historical and current levels of sheep grazing have helped to produce and maintain this situation to the benefit of GSM.

4.5. Evaluation of survey methods

The existing transects do not survey some GSM occupied habitat at Kinlyside, as shown by the many incidental observations along the central access track in the eastern lease and in the far north of the site in 2016 (Rowell and O’Sullivan 2017). Incidental observations are valuable in indicating the extent and connectivity of a fragmented population. These could be enhanced by undertaking at least one mid-season meandering transect covering potential habitat in the western lease and areas in the eastern lease not covered by transects, including potential habitat outside the GSM habitat management zone and areas in the north-east and south-east where GSM have not been recorded. Such presence-absence surveys can also be carried out over a longer period on suitable days by relying on flushing adults after the usual flying period, and this can make detection of laying females more likely.

In 2017, GSM flying moth surveys were conducted using a more detailed transect method, where flying moth numbers were recorded every 25 m rather than every 100 m, as had been done in previous GSM surveys at other sites. This method increases the amount of time required to complete

surveys due to substantial additional recording time. The 25 m method appears to provide greater resolution of where GSM flying activity is focussed, and provides some additional resolution regarding areas where no GSM habitat is present (Figure 5 and Figure 6). It is unclear how informative this resolution really is, given the mobility of flying male moths and their tendency to fly over shorter vegetation rather than areas where females are necessarily present. The potential risk of double counting is also increased, due to the need to stop and record data more regularly rather than moving at a more consistent pace. Using 100 m transects appears to provide similar levels of information.

To evaluate the effectiveness of any increases in resolution, this method would need to be trialled in conjunction with a detailed survey for pupae cases or female GSM. In the absence of this data; however, the additional resolution provided by using 25 m transect segments may be of limited informative value and has the potential to be misleading if used to assess likely breeding hot-spots.

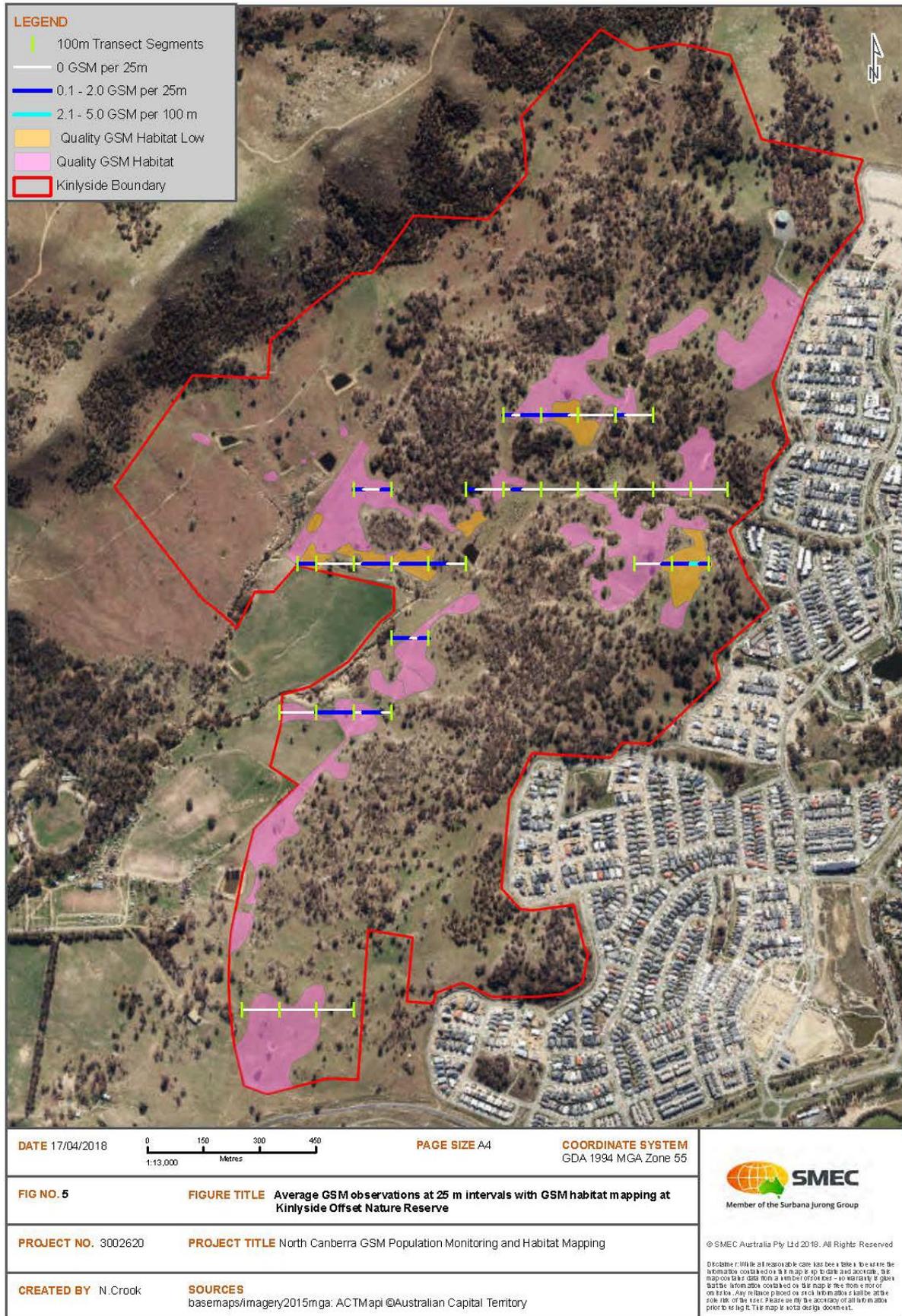


Figure 5. Average GSM observations at 25 m intervals with GSM habitat mapping at Kinlyside Offset Nature Reserve.

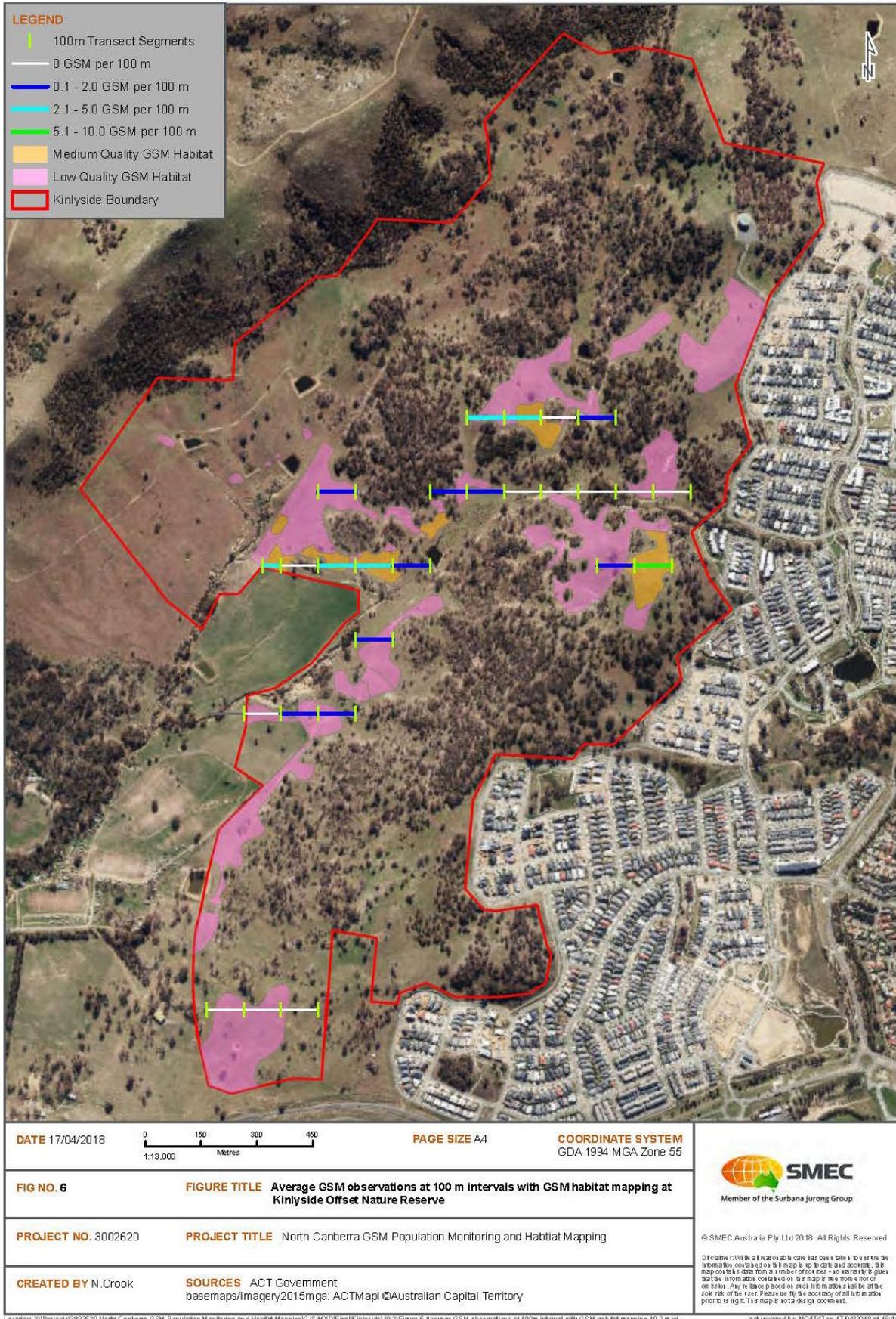


Figure 6. Average GSM observations at 100 m intervals with GSM habitat mapping at Kinlyside Offset Nature Reserve.

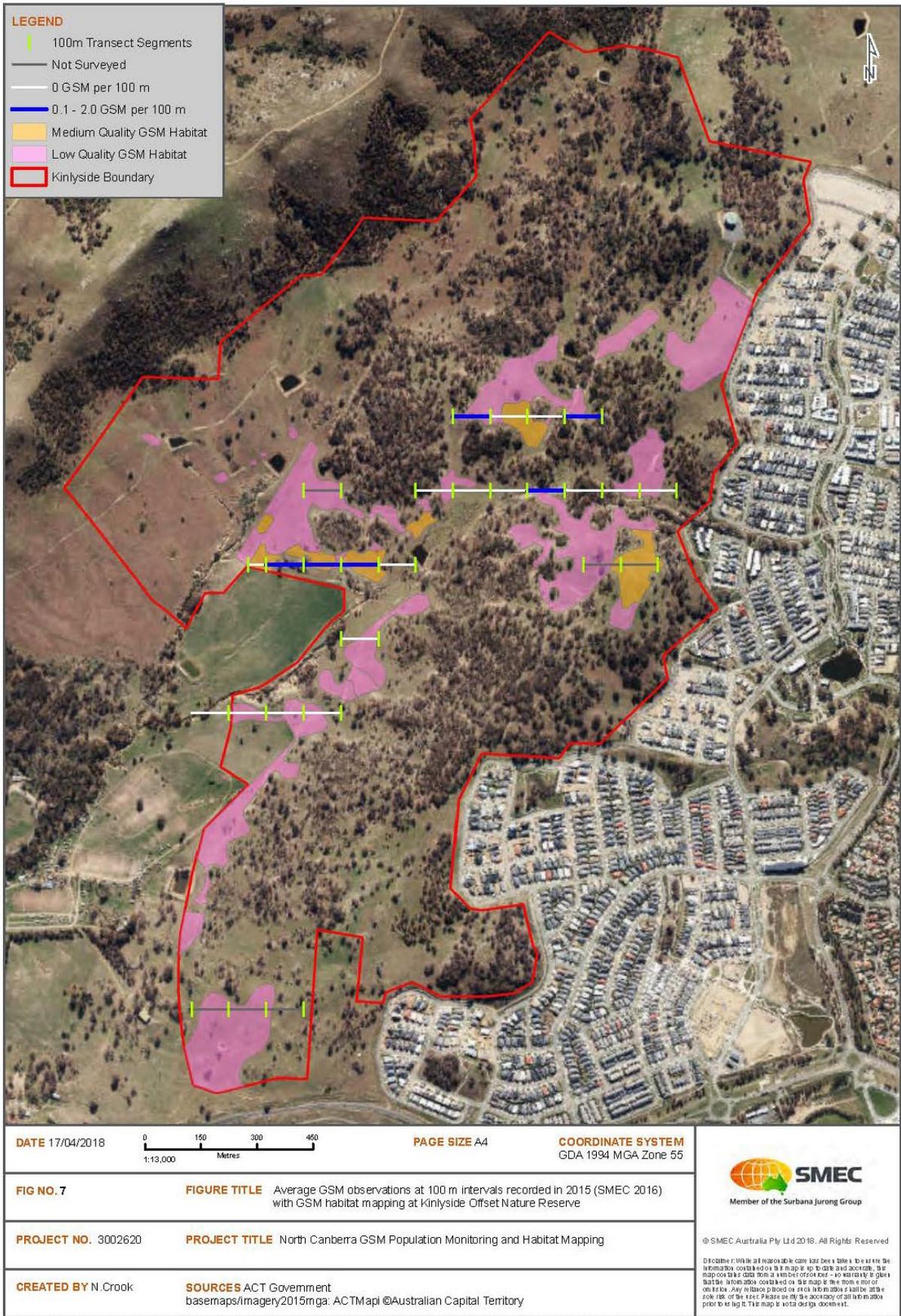


Figure 7. Average GSM observations at 100 m intervals in 2015 (SMEC 2016) with GSM habitat mapping at Kinlyside Offset Nature Reserve.

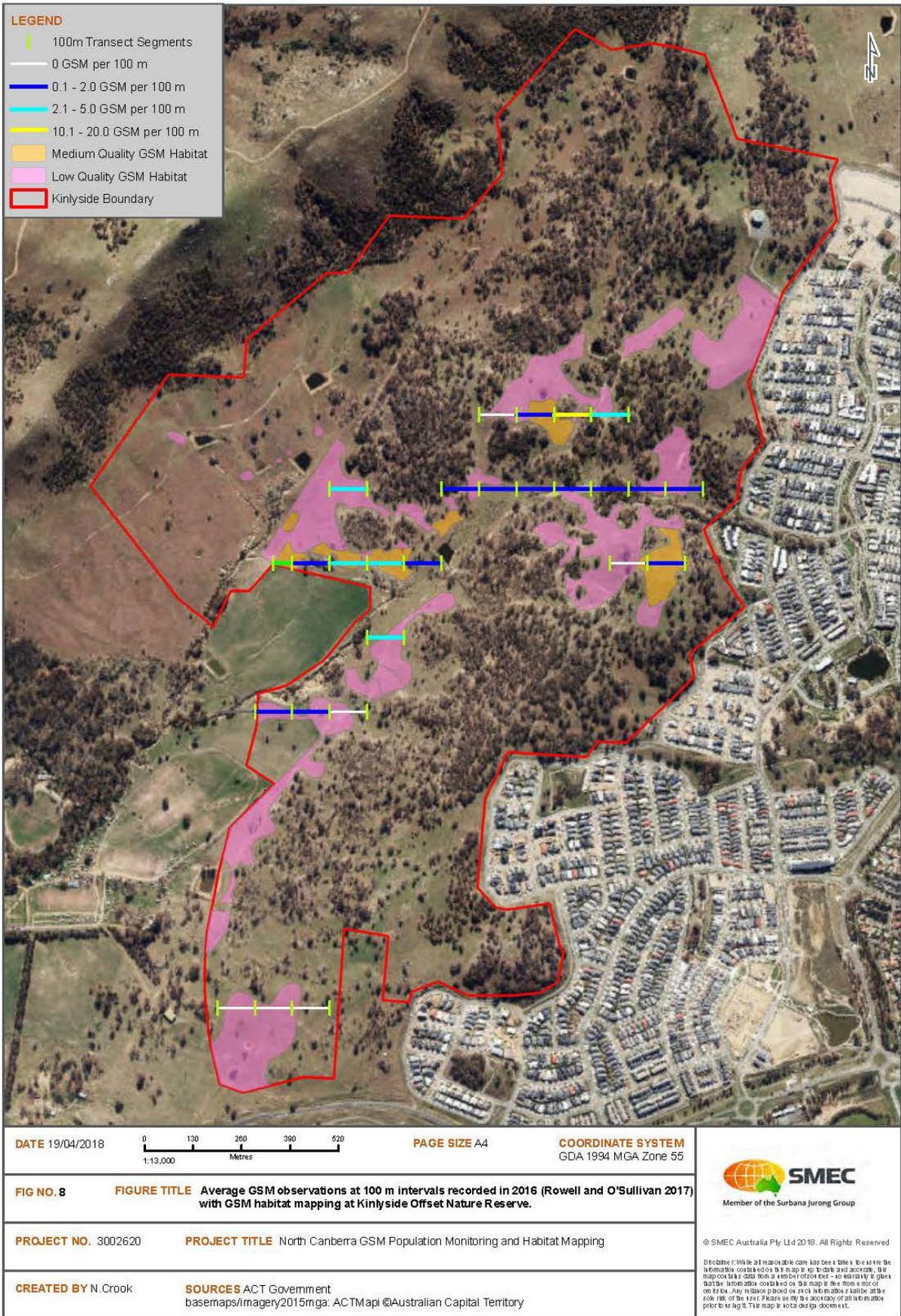


Figure 8. Average GSM observations at 100 m intervals in 2016 (Rowell and O'Sullivan 2017) with GSM habitat mapping at Kinlyside Offset Nature Reserve.

5. Conclusion

The key outcomes of GSM population monitoring were:

- GSM were recorded at low activity levels across the known habitat areas, except the southernmost transect where no GSM were recorded.
- The highest GSM activity levels were recorded in medium quality habitat in the central-western section of the site.
- No GSM pupae cases were observed.
- No incidental observations of female GSM were recorded.

The key outcomes of GSM habitat monitoring were:

- The site supports 33.6 ha of GSM habitat, comprising:
 - 29.3 ha of low quality GSM habitat
 - 4.3 ha of medium GSM habitat
- Biomass was relatively low in the east of the site, and bare ground had increased since 2016.
- Biomass was high in the low-lying creek flats where grazing has been excluded, which is a necessary erosion control measure, but may reduce the quality of the habitat for GSM.

Review of GSM survey and habitat mapping results in relation to previous data indicated:

- The assessment of condition of GSM habitat appears to have declined substantially from that recorded in 2010 (Eco Logical 2011), with the majority of the site recorded as supporting low quality habitat in 2017, rather than moderate or high quality habitat. This apparent decline may be associated with the following:
 - The criteria for GSM habitat quality assessment differed between 2010 and 2017-2018.
 - A large area in the western side of Kinlyside was mapped as low quality habitat in 2010, but was not considered GSM habitat in the 2017-2018 mapping due to the density of *Themeda australis*, which is not associated with GSM.
 - Small areas that were mapped as habitat in 2010, including erosion gullies, patches of trees, and areas dominated by exotics, were excluded from the 2017-2018 mapping.
 - The habitat may be degraded by excessive grazing in some areas, and with increased density due to grassland recovery following drought in other areas.
- Per hour of survey effort, GSM abundances recorded in 2017 were within the range of abundances recorded in previous years.
- There is no evidence of a decline in GSM activity.
- GSM were not recorded in all areas identified as potential GSM habitat.

The following recommendations should be considered in future management and monitoring of GSM habitat at Kinlyside:

- Reassess grazing levels across the site, in particular:
 - Grazing in the eastern lease should be lighter in dry summers.
- Undertake a mid-season meandering transect to record GSM presence-absence in low quality habitat areas not covered by existing transects.

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7. Appendices

Appendix A GSM Transect Data

Refer to "Appendix A - Attachment H - GSM Transect Data - Kinlyside.xlsx"

Appendix B Habitat Transect Data

Refer to “Appendix B - Attachment I - Habitat Transect Data - Kinlyside.xlsx”

Appendix C Habitat Transect Photographs

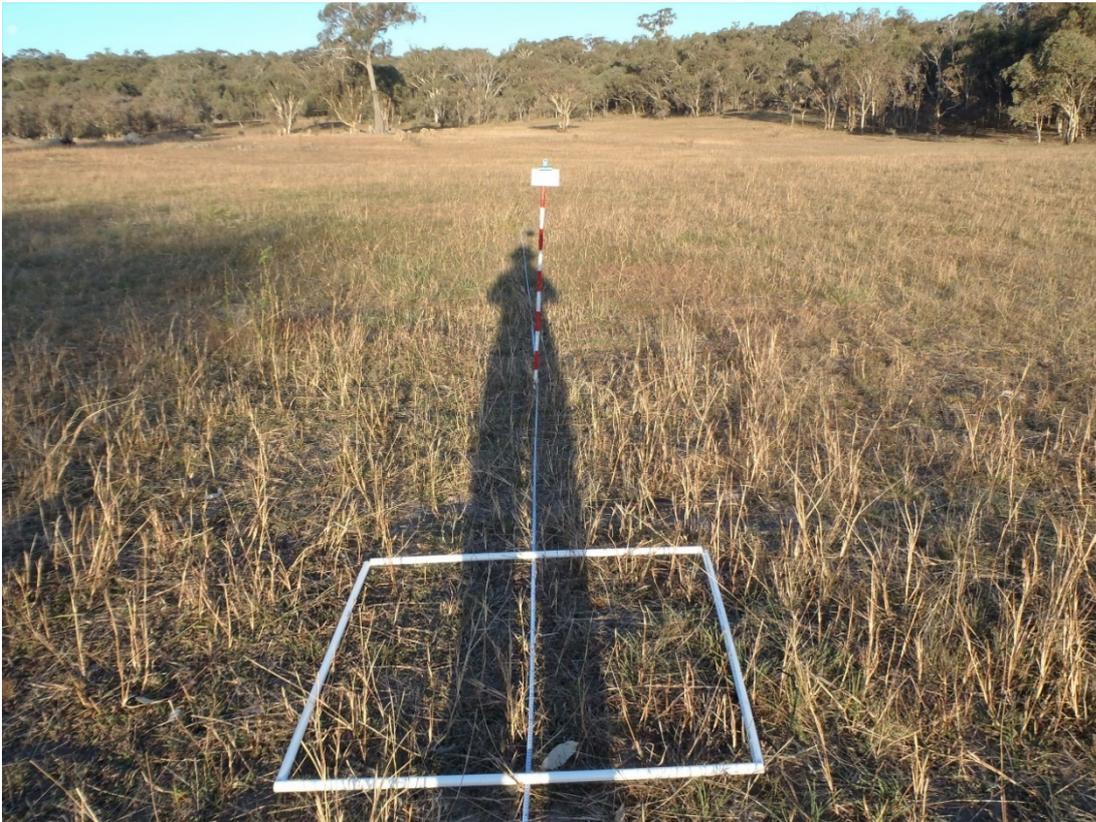


Plate 1. Vegetation transect 1.



Plate 2. Birds-eye view of 0-1 m of vegetation transect 1.



Plate 3. Vegetation transect 3D.



Plate 4. Birds-eye view of 0-1 m of vegetation transect 3D.



Plate 5. Vegetation transect 3ab.



Plate 6. Birds-eye view of 0-1 m of vegetation transect 3ab.



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