

Throsby North Offset

Golden Sun Moth population monitoring and habitat mapping 2017

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Executive Summary

SMEC Australia Pty Ltd and Alison Rowell, Biologist and Environmental Consultant, prepared this monitoring report on behalf of 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 Throsby North during summer 2017/18.

The key outcomes of GSM population monitoring were:

- GSM were recorded at low activity levels at Throsby North in 2017.
- GSM activity was clustered in the eastern half of the site.
- No GSM pupae cases were observed.
- Two incidental observations of female GSM were recorded.

The key outcomes of GSM habitat monitoring were:

- The site supports 70.8 ha of GSM habitat, comprising:
 - 58.2 ha of low quality GSM habitat
 - 12.6 ha of medium GSM habitat
- Cattle grazing has improved the GSM habitat structure by reducing the density and cover of phalaris.
- Some areas of exotic-dominated vegetation contained occasional very small patches of native grasses. With continued appropriate grazing and weed control these native patches may expand and connect, in time increasing the area of mapped habitat.

A review of GSM survey results in relation to previous survey data and the habitat mapping 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 in habitat condition may be associated with the following:
 - The criteria for GSM habitat quality assessment differed between 2010 and 2017-2018.
 - Some areas mapped as habitat in 2010, including dams and swales, patches of box-gum woodland or exotic trees, and areas dominated by exotics, were excluded from the 2017-2018 mapping.
 - Some areas mapped as moderate or high quality in 2010 were dominated by phalaris and subterranean clover in 2017-18, which may have been absent in 2010 due to drought, and consequently were not mapped as GSM habitat in 2017.
 - Some areas mapped as moderate quality habitat in 2010 were dominated by dense kangaroo grass in 2017-18, which may have been less dense in 2010, and consequently were mapped as low quality or not GSM habitat.
- Per minute of survey effort, GSM abundances recorded in 2017 were within the range of abundances recorded in previous years, suggesting that the GSM population is stable at this site.
- Transect alignment does not correspond well with the distribution of habitat.

- GSM were recorded at low numbers in most areas identified as GSM habitat.

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

- Cattle grazing has improved the GSM habitat structure and should continue at levels appropriate to seasonal conditions.
- Monitoring transect layout should be reviewed, with reference to monitoring purpose, to determine whether more informative data could be collected if transect layout is adjusted to better reflect the distribution of GSM habitat.
- GSM population monitoring should consider habitat condition from the previous two years, as biomass in the two years preceding a survey may be as important as habitat condition in the year of survey.

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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 Throsby North.

1.2. Survey Site

The Throsby North Offset is a 172 ha extension to the Mulligans Flat Nature Reserve and Gorooyarroo Nature Reserve (Figure 1). Throsby North was established as an Offset under the Gungahlin Strategic Assessment (Umwelt 2013). The site supports exotic, native, and mixed grassland, and areas of open box-gum woodland. The southern part of the site is grazed.

The Extension to the Mulligans Flat and Gorooyarroo Nature Reserves Offset management plan (For the Throsby North, Throsby East, and Kenny Broadacre Offset Areas; ACT Government 2015), established as required under the EPBC Act approvals, specifies measures to conserve the Offset area and details the monitoring program for the Golden Sun Moth and Golden Sun Moth habitat. Specifically, there is a requirement for surveying Golden Sun Moth populations and habitat at Throsby North once every three years from 2017, using the ACT Government Golden Sun Moth survey guidelines (ACT Government 2010).

The Extension to the Mulligans Flat and Gorooyarroo Nature Reserves Offset management plan (ACT Government 2015) requires that PCS and Conservation and Research (CR) re-evaluate strategies used to manage Golden Sun Moth and natural temperate grassland in Throsby North if, as a result of the

monitoring program, it is determined that there is a measured decline in the population of the Golden Sun Moth.

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.
- **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 Throsby North were previously surveyed in 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). In 2015, GSM activity was clustered in the central part of the site, with no GSM recorded in the northern part of the site. The southern part of the site was not surveyed in 2015. In 2016, GSM were recorded across the whole site.

GSM habitat was monitored at Throsby North in 2015 (SMEC 2016) and 2016 (Rowell and O’Sullivan 2017). In 2015, GSM habitat quality was variable, with a high proportion of exotic annual grasses (SMEC 2016). Grasses were generally taller and/or denser in 2016 than 2015 with variable changes in annual exotic grassland across the site (Rowell and O’Sullivan 2017).

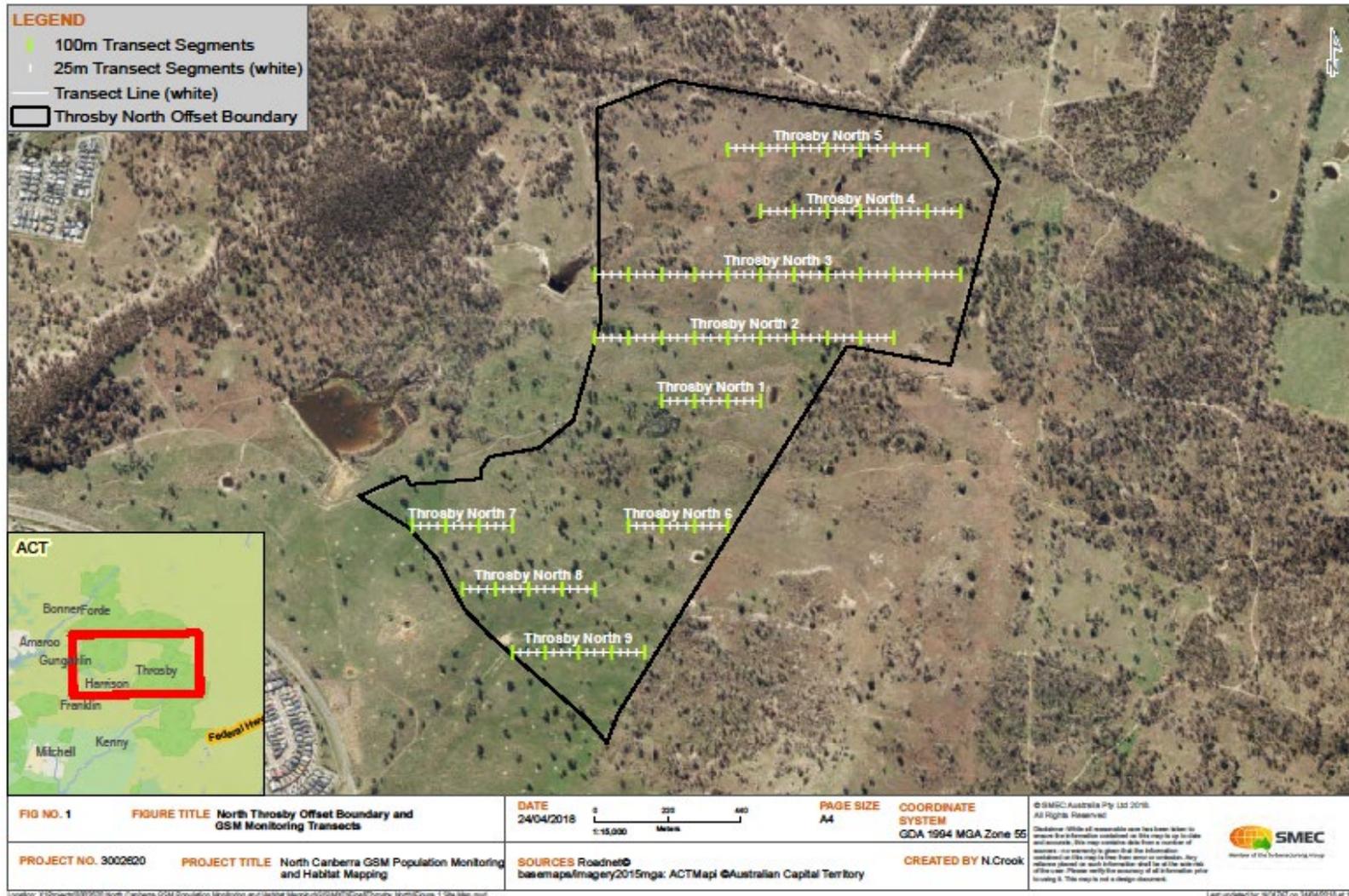
1.3. Objectives

This report presents the findings of GSM surveys and habitat mapping conducted during summer 2017/18 at Throsby North. The purpose of this monitoring is to meet the monitoring requirements specified in the Extension to the Mulligans Flat and Gorooyarroo Nature Reserves Offset management plan (ACT Government 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 Throsby North in 2017. Specifically, the data collated will enable PCS and CR to assess whether the GSM population has declined relative to previous GSM survey results at Throsby North.

The objective of habitat mapping conducted at Throsby North was to determine the extent and condition of GSM habitat within Throsby North in 2017 to assist long term monitoring and inform future management decisions. Specifically, the data collated will enable PCS and CR to assess whether the extent and /or quality of the GSM habitat (including natural temperate grassland) has declined from baseline level.

Figure 1.1 Throsby North Offset boundary and GSM monitoring transects



Report for

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 2010), 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 Throsby North 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 of 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 method, 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 15 November, 20 December and 12 December during warm, sunny conditions (Table 1).

Table 1. Survey dates and weather conditions for surveys at Throsby North Offset.

Survey No.	Date	Survey Time	Temperature during surveys (°C)	Weather conditions	Min and max temperature (°C)	Cloud cover	Last rain
1	15 Nov 2017	1316-1511	25.0 – 29.0	Mostly sunny, light wind (0-10 km/hr)	8.2 – 28.2	5-25%	12 Nov (0.2 mm)
2	20 Nov 2017	1101-1315	20.0 – 23.0	Sunny, light wind (0-15km/hr)	8.4 – 25.5	0-5%	19 Nov (0.4 mm)
3	12 Dec 2017	1040-1220	22.0 – 26.0	Sunny, light wind (5-15 km/hr)	16.4 – 30.6	0-5%	8 Dec (6.2 mm)

3.1.3. Flying moth surveys

Low overall levels of GSM activity (Hogg 2010) were recorded at Throsby North during the 2017 survey period (Total GSM = 138, Average GSM = 46; Table 2). A total of 45 GSM were recorded on 15 November, 92 GSM were recorded on 20 November, and one GSM was recorded on 12 December (Table 2; Figure 2). The number of GSM recorded per minute of survey effort was highest during the 20 November survey at all sites except transect 5 where more GSM were recorded on 15 November. The survey in which only one GSM was observed across the whole site was conducted four days after 6.2 mm rainfall (Table 1).

GSM were recorded in all transects throughout the site, though very few GSM were recorded on four of eight transects (transects 1, 4, 7 and 8; Table 2; Figure 2). GSM records were clustered towards the east of the site, with almost no records at the western ends of any transect, excepting transect 6 (Figure 3). A complete list of GSM flying moth records is presented in Appendix A.

3.1.4. Incidental observations

Incidental observations of female GSM were not recorded during flying moth transects. Two female GSM were recorded during 2017 surveys (Figure 4). A full list of incidental observations is presented in Appendix B.

Table 2. Results summary for flying moth surveys conducted at Throsby North Offset.

Transect #	S1 Time (mins)	S1 GSM	S1 GSM/min	S2 Time (mins)	S2 GSM	S2 GSM/min	S3 Time (mins)	S3 GSM	S3 GSM/min	Total GSM	Average GSM	Average GSM/min
1	8	3	0.38	7	7	1	5	0	0	10	3.30	0.46
2	28	6	0.21	37	28	0.89	17	0	0	34	13.00	0.37
3	36	2	0.06	39	13	0.33	24	0	0	15	5.00	0.13
4	27	2	0.07	29	8	0.28	13	0	0	10	3.30	0.12
5	30	27	0.90	21	9	0.43	15	0	0	36	12.00	0.44
6	7	5	0.71	7	18	2.57	6	1	0.17	24	8.00	1.15
7	7	0	0	9	1	0.11	5	0	0	1	0.30	0.04
8	13	0	0	13	8	0.62	7	0	0	8	2.70	0.21
WHOLE SITE	156	45	0.29	162	92	0.78	92	1	0.02	138	46	0.36

Figure 3.1 Total GSM observations at Throsby North Offset

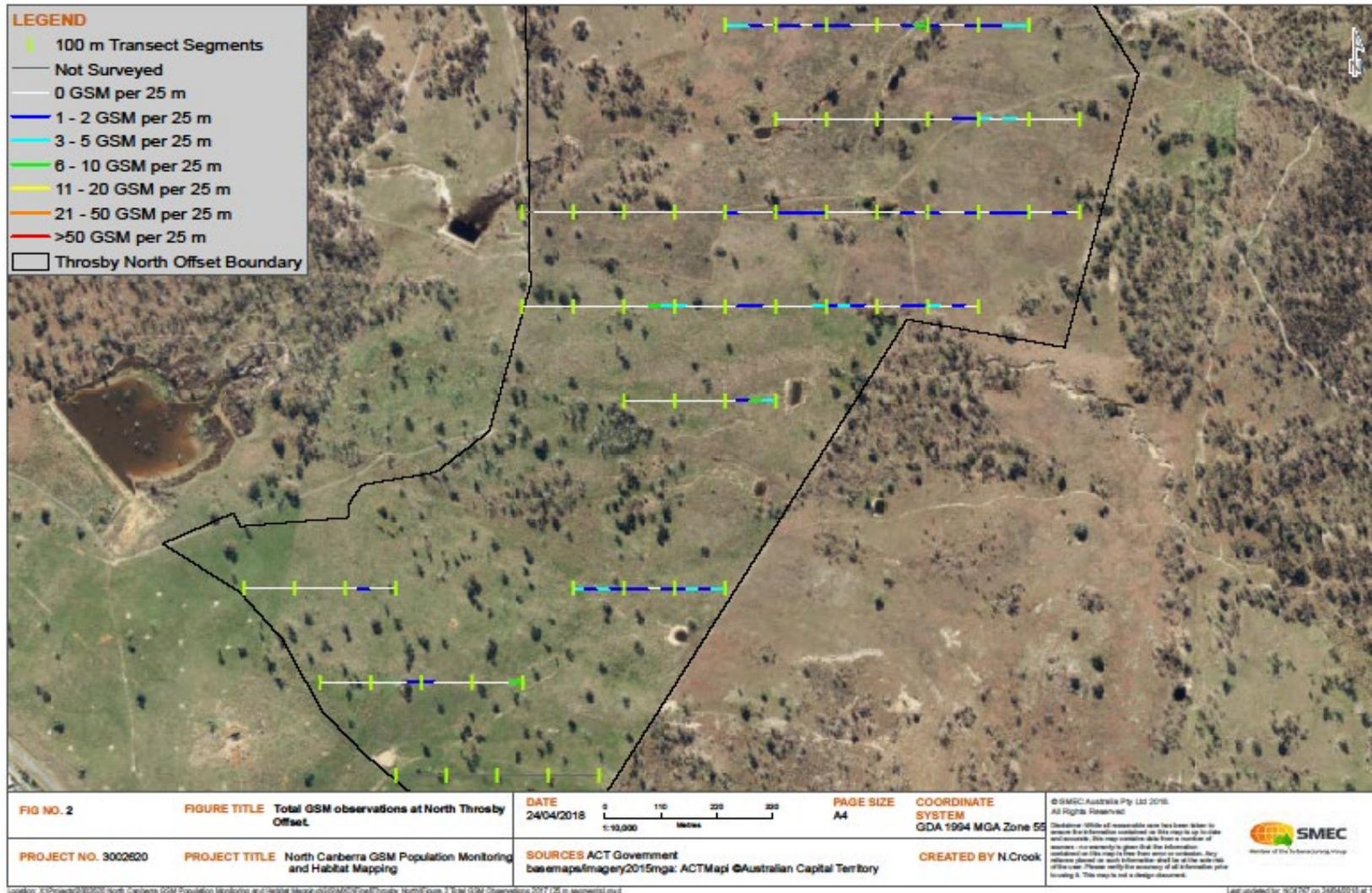


Figure 3.2 Average GSM observations at Throsby North Offset

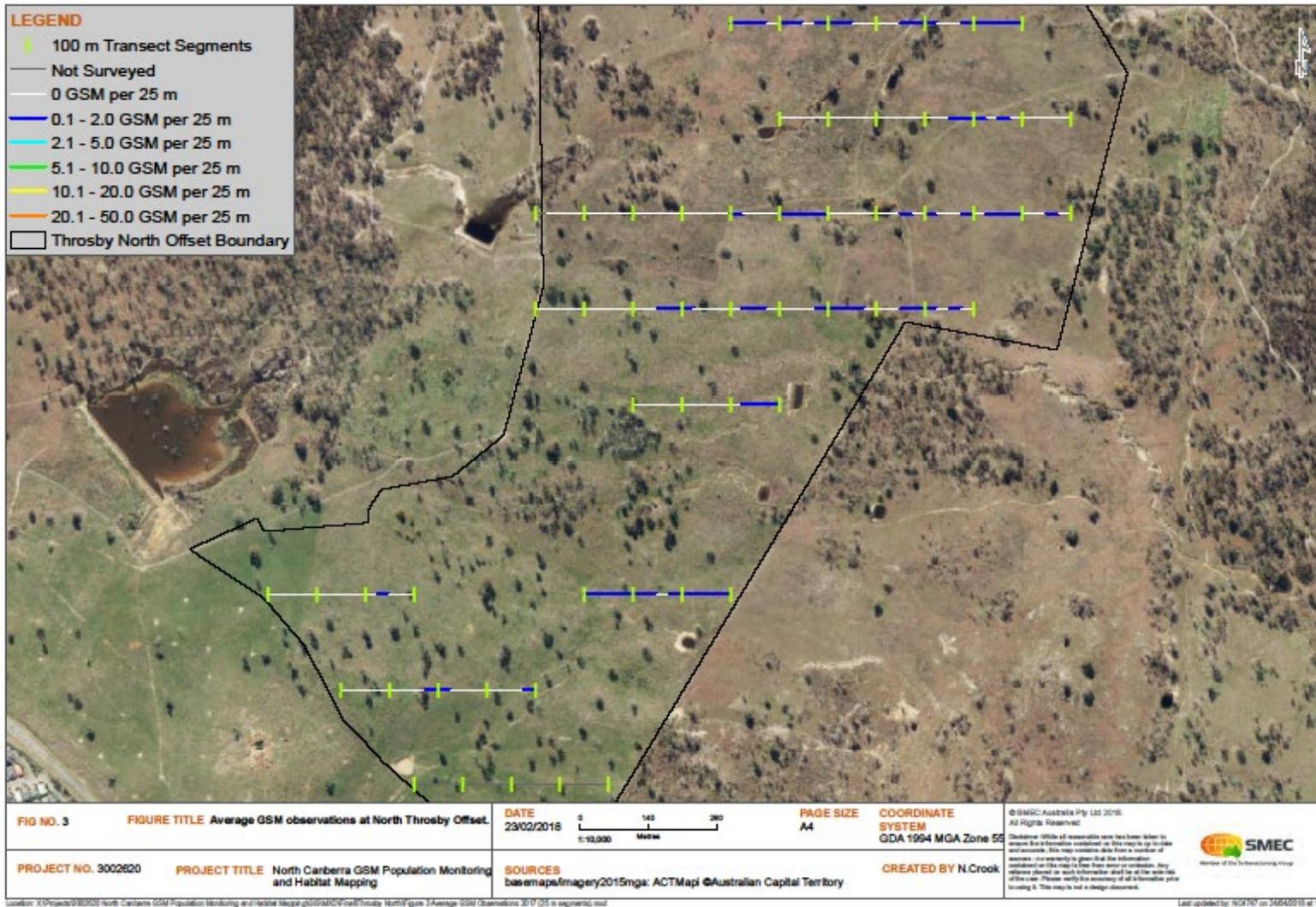
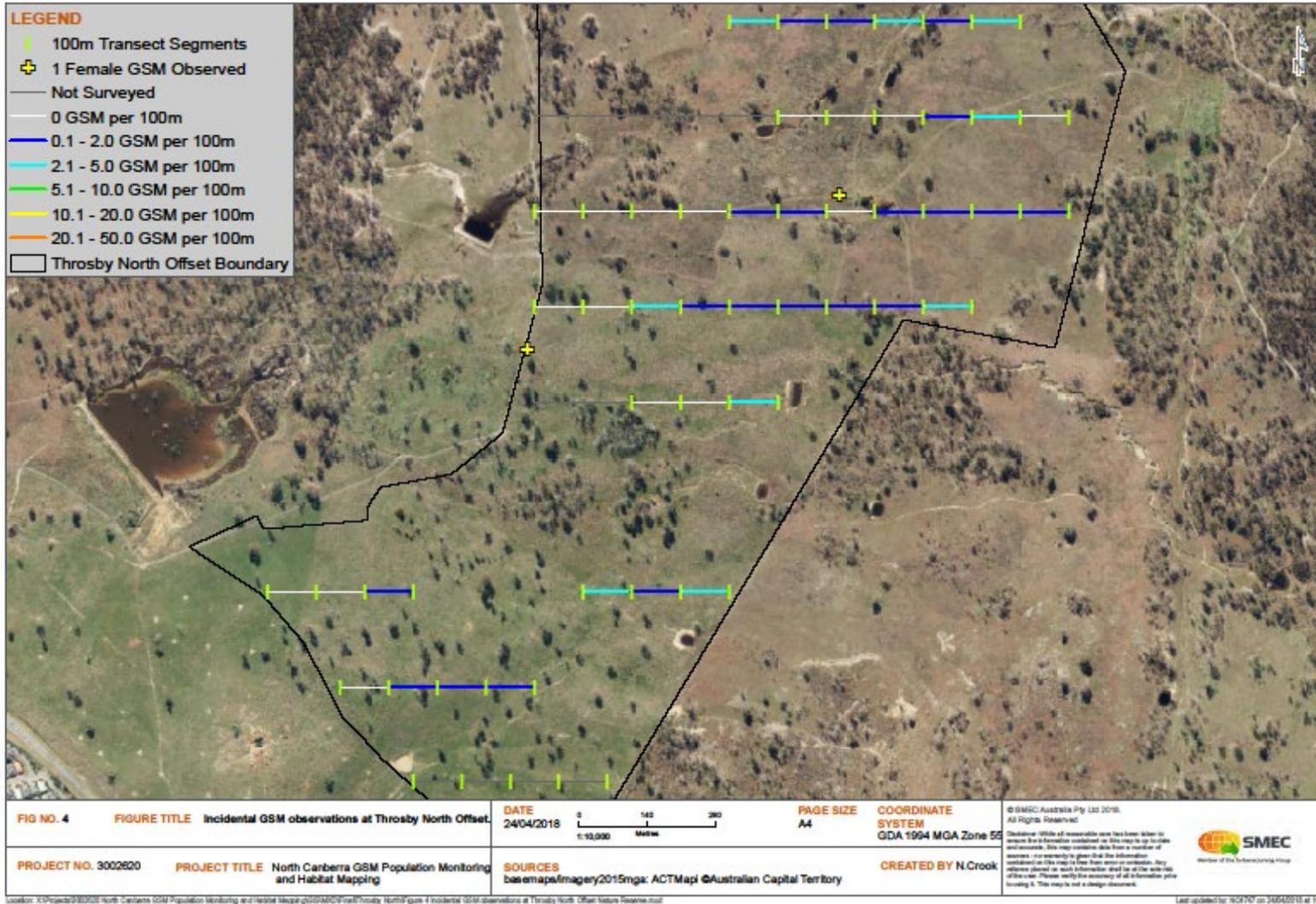


Figure 3.3 Incidental GSM observations at throsby North Offset



3.2. GSM habitat monitoring and mapping

Habitat mapping was undertaken in January and April 2018, and vegetation transects were surveyed in April. The distribution of habitat condition classes, including the biomass overlay, is shown in Figure 5, and the extent of each habitat class is shown in Table 3. Mapped GSM habitat area for each habitat zone is presented in Table 4. Habitat transect data are provided in Appendix C. Transect photographs are provided in Appendix D.

All parts of the site had been grazed by cattle in 2017-18. The northern paddock has been partly cleared from box-gum woodland, with the eastern half managed as GSM habitat (ACT Government 2015). Biomass was mostly medium in this paddock and the ground layer was native-dominated, with less evidence of pasture improvement than other parts of the site. The areas mapped as low quality GSM habitat contained mixed native grassland, often including a moderate amount of kangaroo grass *Themeda triandra* but also perennial exotic forbs like Catsear *Hypochaeris radicata*. The areas mapped as medium quality GSM habitat had higher cover of spear grasses *Austrostipa spp.* and wallaby grasses *Rytidosperma spp.*, including patches of shorter species (*Rytidosperma carphoides* and *R. auriculatum*). The medium quality habitat also contained native forbs, including lemon beautyheads *Calocephalus citreus*, and moderate amounts of bare ground.

The southern two-thirds of the site contained weedy native pasture dominated by spear, wallaby and redleg grasses *Bothriochloa macra* with phalaris *Phalaris aquatica* and subterranean clover *Trifolium subterraneum*. Phalaris occurred scattered through the native pasture and as dense stands in drainage lines, low-lying areas and around some trees. Biomass was mostly low in the areas mapped as GSM habitat and higher in the western woodland areas. Areas mapped as medium quality GSM habitat contained moderate to high cover of wallaby grasses with some bare ground.

Table 3. Mapped GSM habitat area at Throsby North Offset.

GSM Habitat Classification	2017 Surveyed Area (ha)
Low Quality GSM Habitat	58.2
Medium Quality GSM Habitat	12.6
High Quality GSM Habitat	0.0
CNG dominated GSM Habitat	0.0
Not GSM Habitat	101.8
Total	172.6

Table 4. Habitat transects at Throsby North Offset.

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
1/Medium	5	13	0	16	0	0	0	0	11	12	3	30	10	Native grassland, some native forbs, biomass low
2/Low	3	10	0	34	0	0	1	21	12	6	0	13	0	Weedy native pasture, some phalaris and sub clover, biomass low

Figure 3.4 GSM habitat mapping at Throsby North Offset

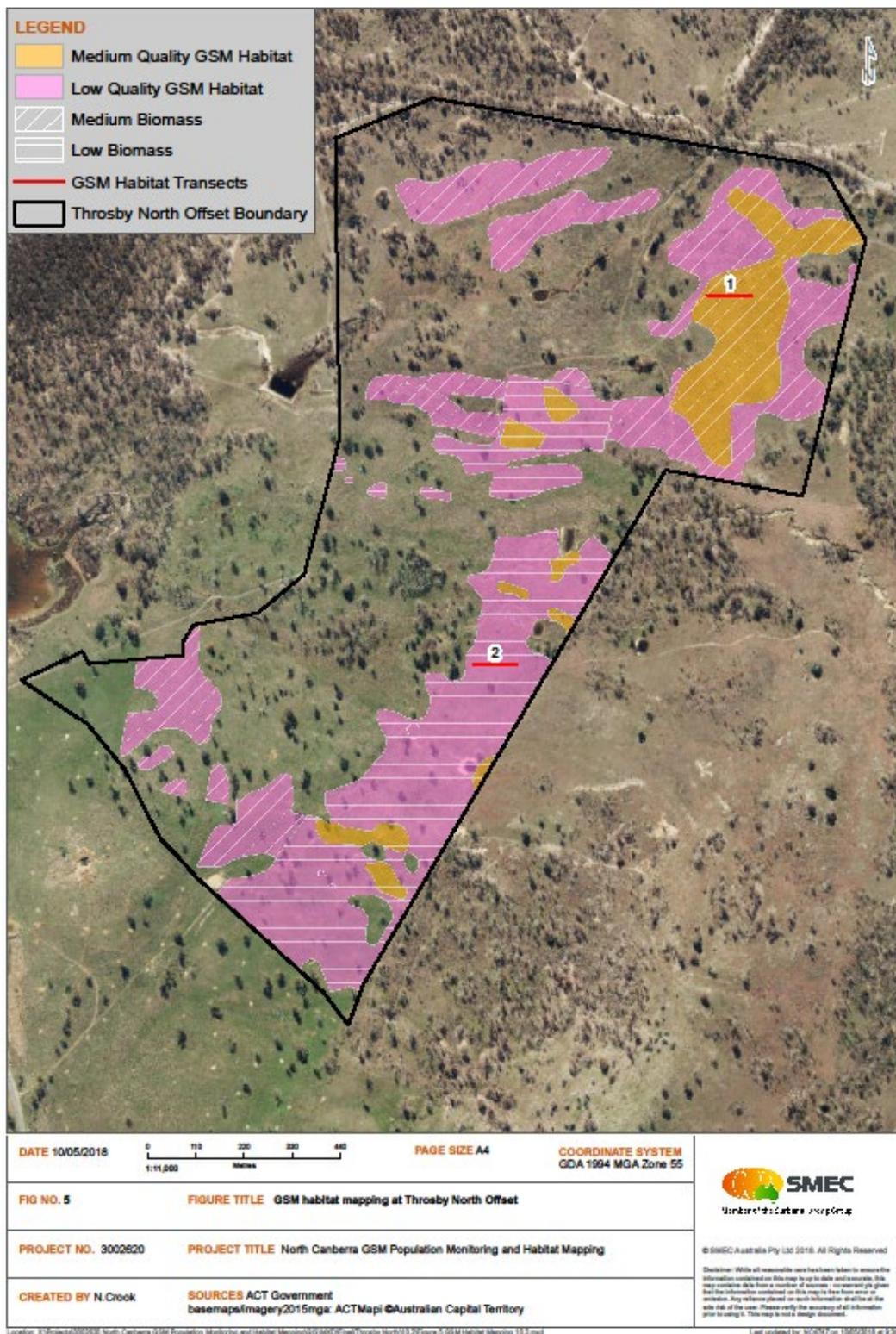
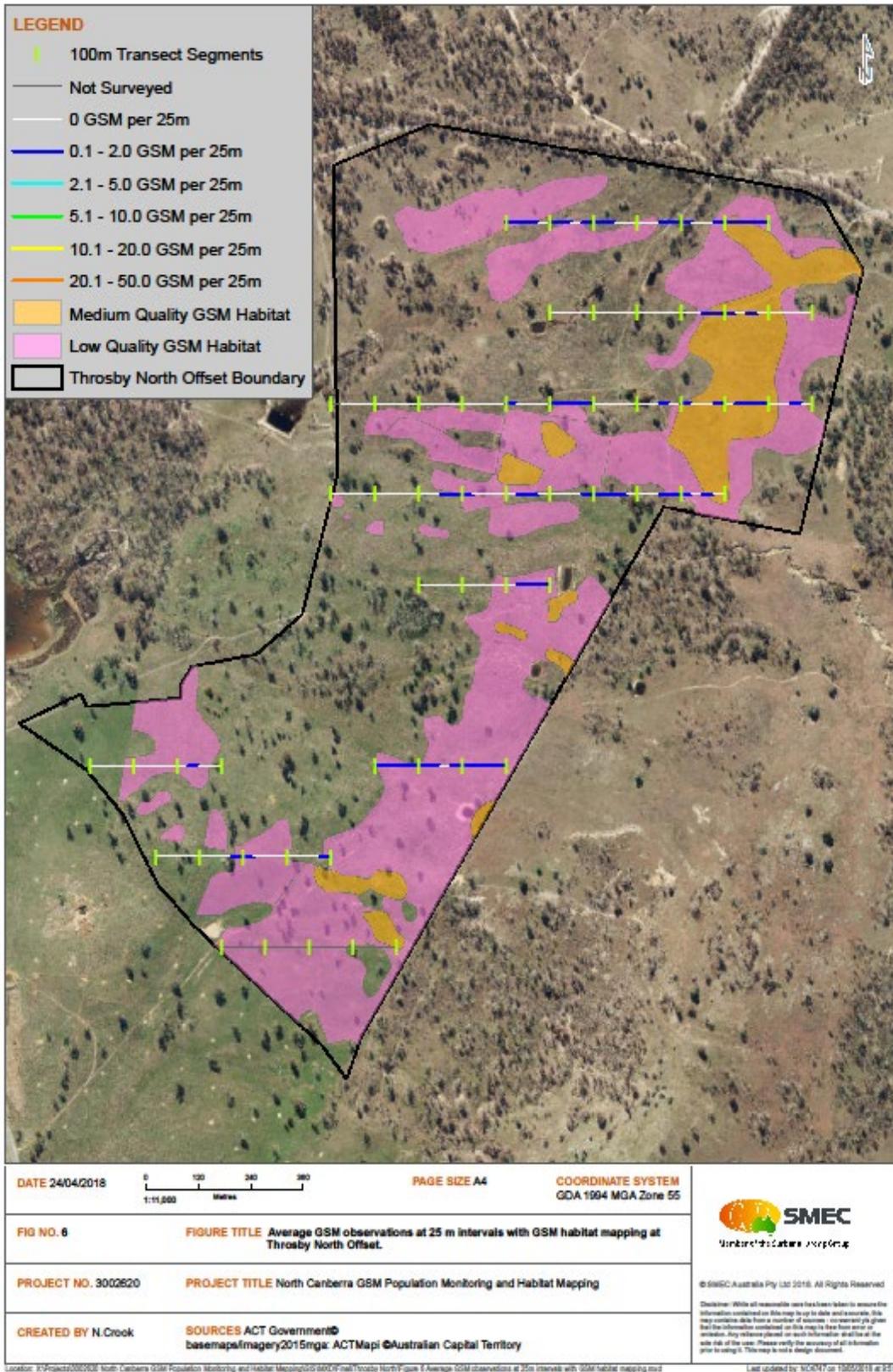


Figure 3.5 Average GSM observations at 25 metre intervals with GSM habitat mapping at Throsby North Offset



4. Discussion

4.1. Habitat mapping

The extent of GSM habitat cannot be directly compared between the 2017 mapping and habitat assessments conducted in previous years (Eco Logical 2011, SMEC 2016, Rowell and O’Sullivan 2017), as different criteria were used to define habitat and habitat quality types and habitat extent was not mapped in two of the three previous habitat assessments (SMEC 2016, Rowell and O’Sullivan 2017), but all previous surveys identified varied habitat quality, with a high proportion of exotic grasses.

Eco Logical (2011) identified five quality categories based mainly on the estimated cover of ‘suitable native species’, but habitat transects were not measured. Most of Throsby North was assessed as containing moderate to high quality GSM habitat in 2010 (Eco Logical 2011), but no high quality GSM habitat was identified at Throsby North in 2017-2018. 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 2013) which stated that ‘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’.

Some of the areas mapped as moderate or high quality in 2010 lie in broad swales which were dominated by phalaris and subterranean clover in 2017-18. After several years of drought phalaris and subterranean clover had virtually disappeared from many native pastures in the ACT by 2009, reappearing after the drought broke in 2010. The central and southern parts of Throsby North were heavily grazed by sheep in 2009 (A. Rowell, pers. obs.); phalaris was not common on the site at that time and may not have recovered by the time mapping took place in 2010. Similarly, some northern areas mapped as moderate quality habitat in 2010 were dominated by dense kangaroo grass in 2017-18 and consequently were mapped as low quality or not GSM habitat, while kangaroo grass may not have been common in 2010 after several years of drought. Some other areas included as habitat in the Eco Logical (2011) mapping were excluded from the 2017-18 mapping. These included dams and swales, patches of box-gum woodland or exotic trees and areas dominated by exotics, especially phalaris.

The biomass across the site in 2017-18 was lower than in 2016 (Rowell and O’Sullivan 2017), due to a drier summer and grazing by cattle. The phalaris in particular was reduced in the southern GSM habitat areas, improving the habitat structure for GSM. Habitat transect 7B was dominated by tall phalaris, annual exotic grasses and subterranean clover in 2016, and was surrounded by similar vegetation. In 2017-18, this area was found to be on the southern edge of a large patch of low quality habitat, containing native grasses and exotic forbs and much less phalaris, with biomass much lower than in 2016. Grazing in the northern paddock was at a level that retained native forbs and moderate cover of kangaroo grass in some areas. Less ryegrass *Lolium sp.* was noted in 2017-18 than in 2016, but this may be due to drier conditions as much as to increased grazing. Annual grasses were not visible as a major component of the vegetation in 2017-18 as they had died back and become part the litter layer or had been grazed off.

4.2. GSM observations in relation to habitat mapping

GSM activity in 2017 was low, and was loosely associated with mapped GSM habitat. GSM were mostly recorded in areas identified as low and medium quality GSM habitat, with the few GSM records in areas not identified as habitat observed in close proximity to areas of low quality GSM habitat (Figure 7). Some areas of exotic-dominated vegetation contained occasional very small

patches of native grasses (<10 m²), some of which may support very low numbers of GSM and may account for sightings of GSM outside mapped habitat areas. With continued appropriate grazing and weed control these native patches may expand and connect, in time increasing the area of mapped habitat.

Most mapped GSM habitat is in the eastern half of the site, while the western half of the site is woodland. The GSM habitat areas have been cleared from box-gum woodland, and the site has a history of sheep grazing, pasture improvement and cultivation (ACT Government 2015), all of which may contribute to the continuing low GSM numbers. The incidental observations of female moths were both recorded in short vegetation tracks outside the identified habitat area. This would indicate that small fragments of unmapped GSM habitat are present along tracks where localised management has favoured the maintenance of short native grass cover.

The northern paddock contains a broad drainage line and has had a different management history from the rest of the site. It contains more native and exotic forbs than the southern part of the site and has had less recent pasture improvement but may have been cultivated in the past. This paddock was only grazed by kangaroos in 2009 while the southern paddocks were heavily grazed by sheep (Rowell 2010). These differences may also contribute to the continuing low GSM numbers in apparently higher quality habitat in this paddock.

4.3. Comparison of GSM observations with previous surveys

The number of GSM recorded per minute and per kilometre has been consistent between surveys conducted in 2015, 2016 and 2017 (Table 5). GSM activity was widely distributed across the site in both 2017 (Figure 7) and 2016 (Figure 8). Although at low activity levels, the central part of Throsby North has consistently supported the highest numbers of GSM across all years of monitoring, and GSM activity was restricted to the central transects of the site in 2015 (Figure 9). GSM abundance appears to have increased slightly at the two northern transects since 2015. The number of GSM recorded per minute of survey effort was notably higher at transect 5 in 2017 (0.44 GSM/min) than in 2016 (0.17 GSM/min; Table 6). The consistent GSM activity levels and distribution over the past three years suggests that the population of GSM at Throsby North has likely been stable during this period.

It was noted in 2016 that, due to the disturbed nature of the vegetation and the enriched soil at Throsby North, biomass can vary greatly with rainfall from year to year if not well managed (Rowell and O’Sullivan 2017). Flushes of Subterranean Clover add nitrogen to the soil, and phosphate levels are likely to decline slowly, favouring growth of perennial exotic grasses and broad-leaved weeds. The grassland was mostly tall and dense across the site in summer 2016 (Rowell and O’Sullivan 2017) and flying males were common in slashed vegetation along track edges and around the northern site perimeter, while annual grasses were dense and widespread in summer 2015 (SMEC 2016). All of the above conditions could contribute to poor or patchy breeding success in high biomass areas and hence lead to low and variable GSM numbers in those areas in subsequent years, meaning that biomass in the two years preceding a survey may be as important as habitat condition in the year of survey.

Table 5. Site-wide summary of GSM observations (2015-2017).

Year (reference)	Total # GSM	# GSM/min	# GSM/km
2015 (SMEC 2016)	64	0.30	8.0
2016 (Rowell and O’Sullivan 2017)	105	0.22	7.1
2017	138	0.36	10.2

Note: The length of Transects 1 and 4 were reduced by 25m and 125m respectively following the 2015 survey.

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

Transect #	2015 # GSM/minute	2016 # GSM/minute	2017 # GSM/minute
1	NA	0.34	0.46
2	NA	0.34	0.37
3	NA	0.32	0.13
4	NA	0.13	0.12
5	NA	0.17	0.44
6	NA	0.98	1.15
7	NA	0.00	0.04
8	NA	0.06	0.21
9	NA	0.30	NA
10	NA	0.00	NA
11	NA	0.00	NA
12	NA	0.00	NA
Whole site average	0.30	0.22	0.36

4.4. Management observations

The recent cattle grazing has improved the structure of the GSM habitat at Throsby North, which is likely to improve GSM breeding success. Continued grazing at appropriate times and levels should control or reduce the density and cover of phalaris on the site and minimise the biomass fluctuations that are unfavourable to GSM breeding activity and possibly to larval development.

4.5. Other observations

A Superb Parrot *Polytelis swainsonii* (vulnerable under EPBC Act) was observed feeding on the ground on the edge of woodland at the centre of the site in early April 2018 (*Species location removed*).

4.6. Evaluation of survey methods

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 6 and Figure 7). 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.

Transect alignment does not correspond well with the distribution of habitat at Throsby North (Figure 6). It is recommended that the monitoring transect layout be reviewed, with reference to monitoring purpose, to determine whether more informative data could be collected if transect layout is adjusted to better reflect the distribution of GSM habitat at the site.

Figure 4.1 Average GSM observations at 100 metre intervals with GSM habitat mapping at Throsby North Offset

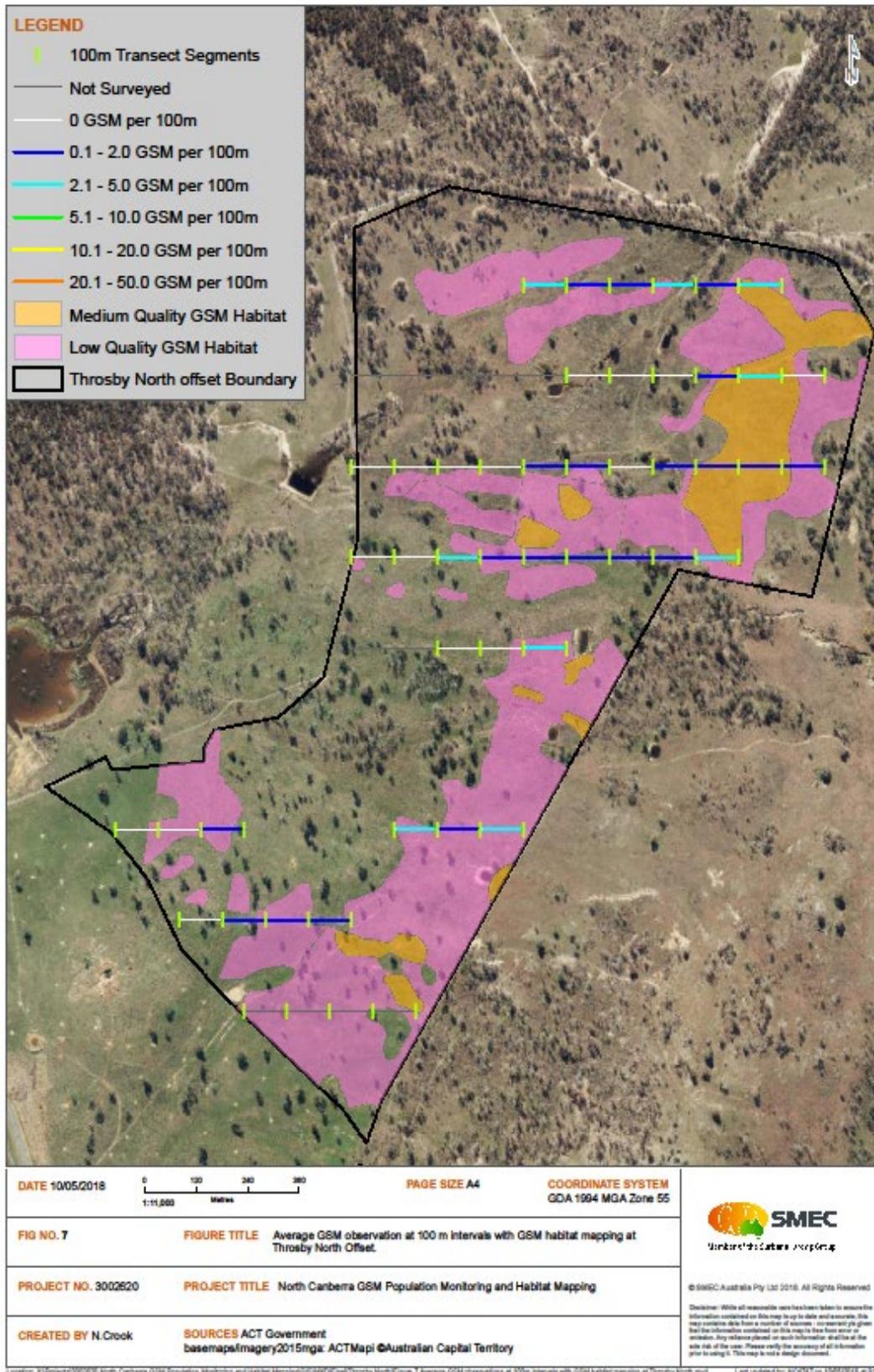


Figure 4.2 Average GSM observations at 100 metre intervals recorded in 2016 with GSM habitat mapping at Throsby North Offset

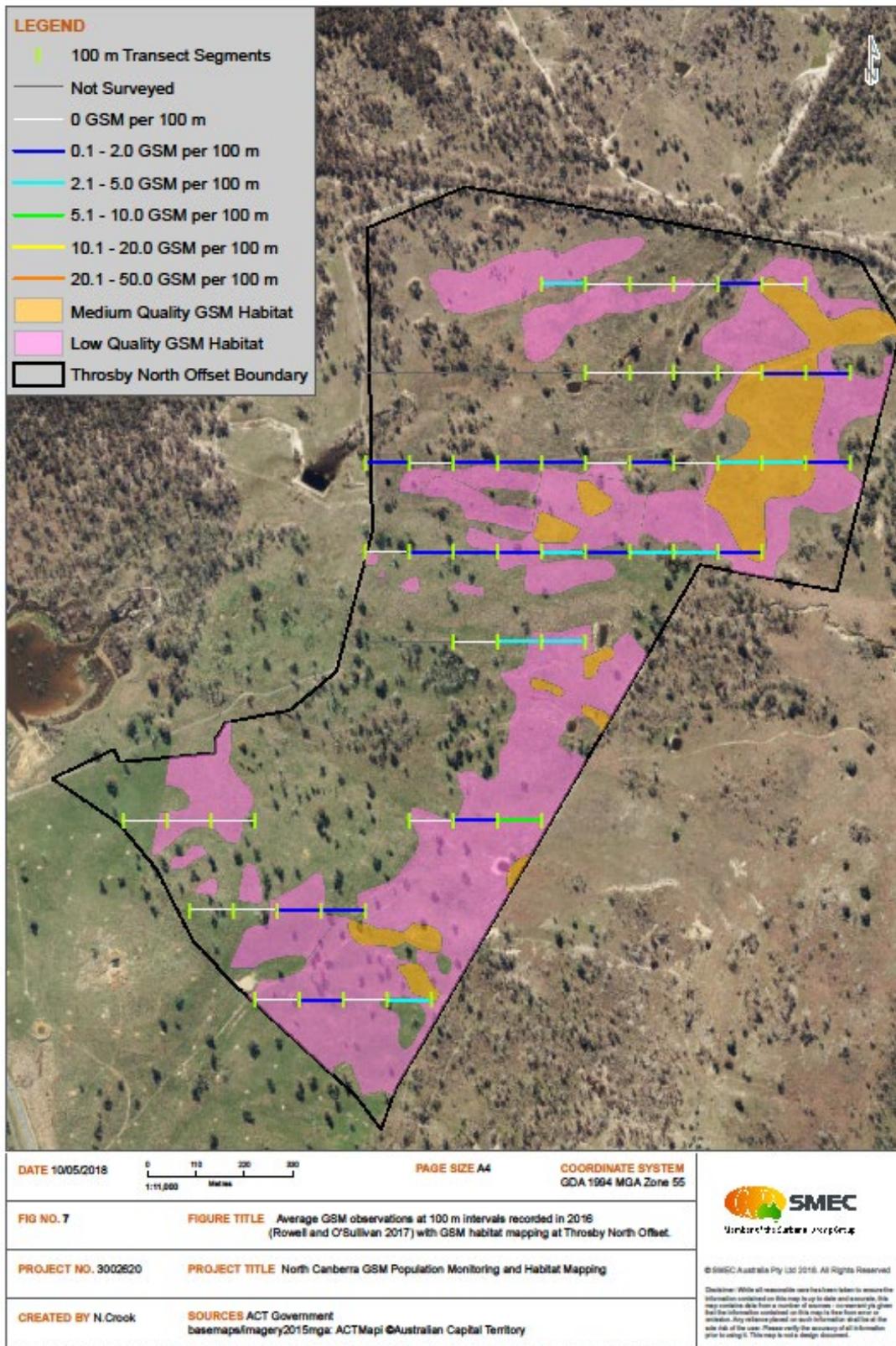
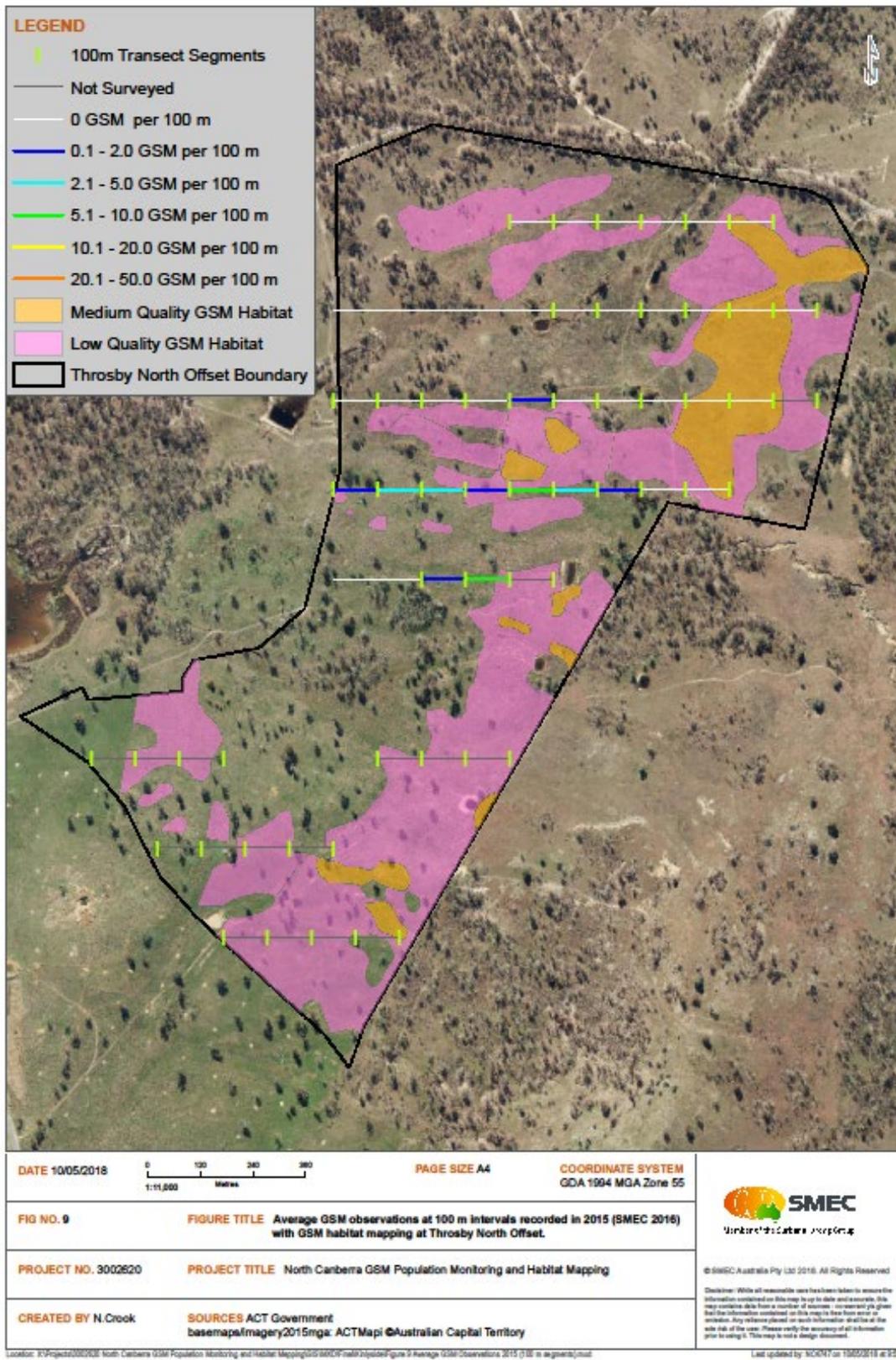


Figure 4.3 Average GSM observations at 100 metre intervals recorded in 2015 with GSM habitat mapping at Throsby North Offset



5. Conclusion

The key outcomes of GSM population monitoring were:

- GSM were recorded at low activity levels at Throsby North in 2017.
- GSM activity was clustered in the eastern half of the site.
- No GSM pupae cases were observed.
- Two incidental observations of female GSM were recorded.

The key outcomes of GSM habitat monitoring were:

- The site supports 70.8 ha of GSM habitat, comprising:
 - 58.2 ha of low quality GSM habitat
 - 12.6 ha of medium GSM habitat
- Cattle grazing has improved the GSM habitat structure by reducing the density and cover of phalaris.
- Some areas of exotic-dominated vegetation contained occasional very small patches of native grasses. With continued appropriate grazing and weed control these native patches may expand and connect, in time increasing the area of mapped habitat.

A review of GSM survey results in relation to previous survey data and the habitat mapping 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 in habitat condition may be associated with the following:
 - The criteria for GSM habitat quality assessment differed between 2010 and 2017-2018.
 - Some areas mapped as habitat in 2010, including dams and swales, patches of box-gum woodland or exotic trees, and areas dominated by exotics, were excluded from the 2017-2018 mapping.
 - Some areas mapped as moderate or high quality in 2010 were dominated by phalaris and subterranean clover in 2017-18, which may have been absent in 2010 due to drought, and consequently were not mapped as GSM habitat in 2017.
 - Some areas mapped as moderate quality habitat in 2010 were dominated by dense kangaroo grass in 2017-18, which may have been less dense in 2010, and consequently were mapped as low quality or not GSM habitat.
- Per minute of survey effort, GSM abundances recorded in 2017 were within the range of abundances recorded in previous years, suggesting that the GSM population is stable at this site.
- Transect alignment does not correspond well with the distribution of habitat.
- GSM were recorded at low numbers in most areas identified as GSM habitat.

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

- Cattle grazing has improved the GSM habitat structure and should continue at levels appropriate to seasonal conditions.
- Monitoring transect layout should be reviewed, with reference to monitoring purpose, to determine whether more informative data could be collected if transect layout is adjusted to better reflect the distribution of GSM habitat.
- GSM population monitoring should consider habitat condition from the previous two years, as biomass in the two years preceding a survey may be as important as habitat condition in the year of survey.

References

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Appendices

Appendix A *GSM Transect Data*

Refer to “Appendix A - Attachment H - GSM Transect Data – Throsby North.xlsx”

Appendix B *Incidental GSM Data*

Refer to “Appendix B - Attachment I - Incidental GSM Data - Throsby North.xlsx”

Appendix C *Habitat Transect Data*

Refer to “Appendix C - Attachment L - Habitat Transect Data - Throsby North.xlsx”

Appendix D *Habitat Transect Photographs*

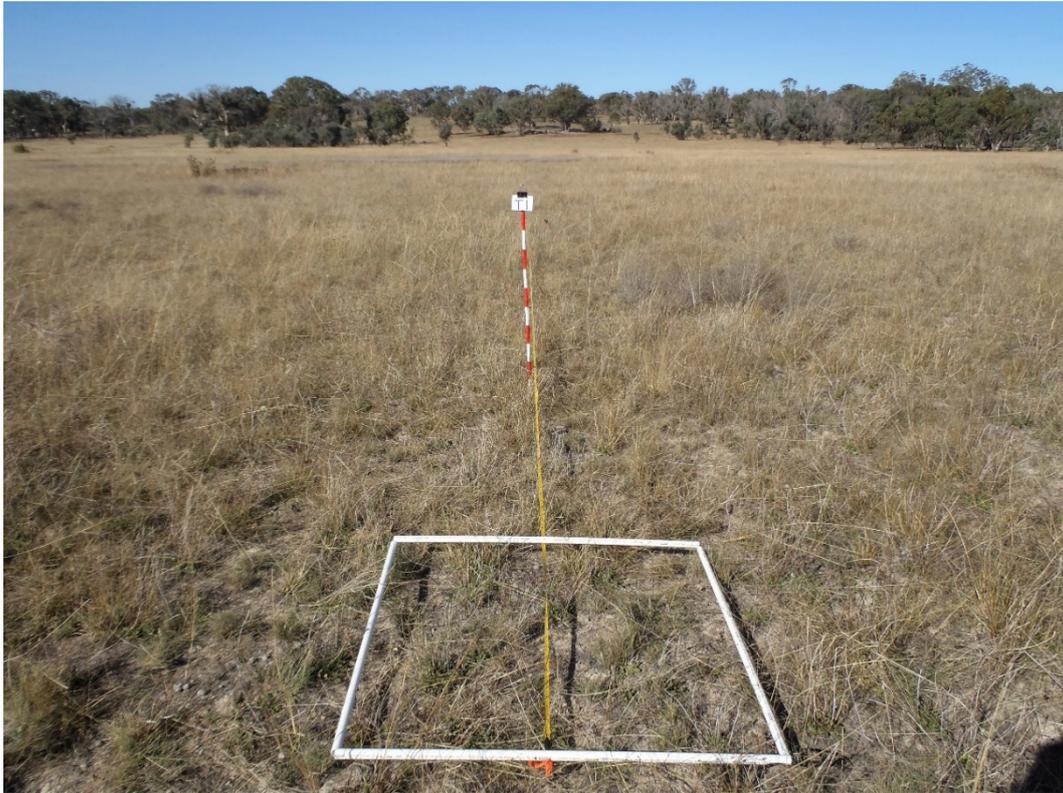


Plate 1. *Vegetation transect 1.*



Plate 2. *Vegetation transect 1, 0-1 m.*



Plate 3. Vegetation transect 2.



Plate 4. Vegetation transect 2, 0-1 m.



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