

Yarralumla Equestrian Park Offset

Golden Sun Moth Monitoring 2017

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Executive Summary

SMEC Australia Pty Ltd prepared this monitoring report on behalf of the ACT Government Suburban Land Agency to meet the 2017 annual reporting requirements of the *Yarralumla Equestrian Park Offset Management Plan* (RJPL 2014a, the OMP). This report fulfils the reporting requirements for golden sun moth (*Synemon plana*, GSM) monitoring at the YEP for year 4 as specified in the OMP.

The key observations during the 2017 survey are:

- GSM remain widespread throughout YEP at low-moderate numbers
- Since 2016, perennial exotic tussock grasses, particularly African love grass, have significantly invaded the site. This represents a major threat to the extent and condition of native grassland and GSM habitat at the YEP.
- No GSM pupa cases were observed at the YEP during 2017
- 15 female GSM were observed at the YEP during the 2017 surveys.

The key results of analysis of change over the five-year monitoring period indicates that:

- The spatial extent of NTG has not increased or declined. The extent of native pasture at the site has declined due to perennial exotic tussock grass invasion.
- While the total extent of GSM habitat has increased since 2013, the extent of moderate quality habitat has decreased with a corresponding increase in the extent of low quality habitat and Chilean needle grass dominated habitat. This is correlated with exotic perennial tussock grasses invading the site, and is indicative of a general decline in GSM habitat quality at the YEP.
- Floristic value scores have not shown a statistically significant increase or decline at the site over the five-year monitoring period.
- Grassland ranking scores have not increased, instead have shown a qualitative decline, since 2015.
- GSM habitat ranking scores have not increased, instead have shown a qualitative decline, over five years.
- GSM flying moth numbers have not shown a statistically significant increase or decline over five years.

This monitoring report provides evidence that existing management actions are not effectively conserving or improving NTG or GSM habitat at the YEP. A review of management actions at the YEP is triggered due to the lack of the required improvements, as measured against the impact thresholds specified in the OMP.

Recommendations

Future mapping of NTG extent should be revised to account for the revised EPBC Act-listing for critically endangered Natural Temperate Grassland of the South-Eastern Highlands, and associated updated condition thresholds (Australian Government 2016).

A review of the management programme at YEP has been triggered due to an assessment of performance compared with impact thresholds. To be compliant with Approval conditions 1(g) and 3, the ACT Government must review the offset management programme performance in consultation with the Commonwealth, PCS and the ACTEA. The following recommendations should be considered during the management planning process review:

- Ongoing management actions should be revised and an active management response developed and implemented in consultation with the Commonwealth and PCS. Specifically, the following management activities, which may be non-compliant or only partially compliant with the requirements of the OMP, were identified and require urgent review:

- Weed control
- Tree and shrub removal
- Vehicle movement
- Establishment of new jumps, infrastructure
- New track formation.
- Future management actions should be targeted to address both maintenance and restoration requirements for Offset management. This could be facilitated by reviewing the over-arching objective of improving the condition and extent of NTG and GSM habitat at the site in consultation with the Commonwealth and PCS, and, if retained a restoration plan, in contrast to a maintenance plan, would need to be developed to enable delivery of the specified improvement targets.

Of critical priority, and requiring action independent of the management plan review process, is control of perennial exotic tussock grasses, specifically African lovegrass, Chilean needle grass and serrated tussock. Invasion by these species is threatening the extent, integrity and condition of NTG and GSM habitat at the YEP and hence.

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Appendix D	Summarised Meteorological Data 2013-2017
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1. Introduction

SMEC Australia Pty Ltd prepared this monitoring report on behalf of the ACT Government Suburban Land Agency (SLA, formerly the Land Development Agency) to meet the 2017 annual reporting requirements of the *Yarralumla Equestrian Park Offset Management Plan* (RJPL 2014a, the OMP). The OMP was prepared to meet specific offset requirements of the Commonwealth Department of Environment and Energy (DoEE) *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval decision (*EPBC 2012/2692*) for mixed-use development proposed for Campbell Section 5, Constitution Avenue, ACT.

The OMP details the requirement for ongoing monitoring of EPBC Act listed endangered Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory, and the EPBC Act listed critically endangered golden sun moth (*Synemon plana*, GSM) populations at the Yarralumla Equestrian Park (YEP) offset area (RJPL 2014a). Subsequent to the approval, the listing of endangered Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory has been revised under the EPBC Act, and areas within the ACT formerly within this community are now classified as the EPBC Act listed critically endangered Natural Temperate Grassland of the South-Eastern Highlands (Australian Government 2016). In this report, the former endangered ecological community and the revised critically endangered ecological community are collectively referred to as natural temperate grassland (NTG) except where a specific reference to the listed ecological community is required.

This report presents the results of year 4 monitoring surveys undertaken in November and December 2017 in the YEP offset area. As this report presents the fifth year of data collected according to the monitoring protocol specified in the OMP, assessment and analysis of trends at the site can be undertaken. The results are briefly examined in relation to existing site information and the baseline year (i.e. year 0), year 1, year 2 and year 3 monitoring data collected during spring and summer from 2013 to 2016 (RJPL 2014b; RJPL 2015; SMEC 2016, SMEC 2017). The implications of results are considered in relation to impact thresholds identified in the OMP.

2. Methods

2.1. Regional GSM Information

ACT researchers and consultants shared information regarding the timing and location of GSM sightings, particularly 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 Planning and Research, ACT Government (CPR).

2.2. Survey Area

The survey area comprised the YEP offset area defined in the OMP (RJPL 2014a) (Figure 1). Traverse routes were located, as defined in the OMP (RJPL 2014a) (Figure 1). Corrected locations for vegetation quadrats and point-count assessment reported in the year 0 baseline assessment report (RJPL 2014b) were used.

2.3. Revised Vegetation and GSM Habitat Assessment

Mapping of vegetation and potential GSM habitat areas presented in the OMP (RJPL 2014a) and the year 0 (i.e. 2013), year 1 (i.e. 2014), year 2 (i.e. 2015) and year 3 (i.e. 2016) monitoring reports (RJPL 2014b; SMEC 2016, SMEC 2017) was reviewed by conducting a meandering traverse throughout the site, with close inspection of native pasture and NTG areas. Changes in vegetation mapping were reviewed in a subsequent site visit.

2.4. Native Pasture and Natural Temperate Grassland Monitoring

The condition of native pasture and NTG was assessed in twelve 4 m² quadrats located throughout the YEP offset area, as described in the year 0 (i.e. 2013) monitoring report (RJPL 2014b). Quadrats were qualitatively assessed using the NTG quality scale of Nash and Hogg (2013, Appendix E to the OMP (RJPL 2014a)). Nash and Hogg's (2013) criteria for the quality scale are based on criteria used for identifying NTG, as specified in the former Commonwealth listing advice for endangered Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory (Australian Government 2011).

As specified in the OMP (RJPL 2014a), a modified version of Rehwinkel (2007) was used to quantitatively determine relative floristic value scores for native pasture and NTG within each quadrat (Appendices C and D of the OMP (RJPL 2014a)), consistent with ACT Government guidelines for assessing NTG (ACT Government 2010b). To ensure consistency and allow comparison with previous years, quadrats were assessed using the floristic value scores based on Rehwinkel (2007).

NTG condition was reviewed against criteria for the revised NTG community listing (Australian Government 2016). Threshold values for determining the classification of NTG were determined from Australian Government (2016). Floristic value scores referenced in these thresholds relate to the updated method of Rehwinkel (2015) and are not comparable to those based on Rehwinkel (2007).

To meet criteria for classification as NTG, the patch must be >0.1 ha (e.g. 20 m x 50 m), within the defined region and altitude, and apparently naturally treeless or sparsely treed, and it must meet criterion A or B:

- Criterion A: contains a foliage cover of more than 50% *Themeda triandra* (Kangaroo Grass) or *Poa labillardierei* (River Tussock) – or *Carex bichenoviana* (Plains Sedge) if the patch is an ephemeral wetland
- Criterion B: contains a greater percentage cover of native plants (including annual and perennial species but not cryptogams) than of perennial exotic species (including weeds), AND in

favourable sampling times (generally spring and early summer, and in non-drought affected seasons) it has:

- at least 8 non-grass native species, or
- at least 2 indicator species, or
- a floristic value score of at least 5

OR at other sampling times it has:

- at least 4 non-grass native species, or
- at least 1 indicator species, or
- a floristic value score of at least 3.

Thresholds for favourable sampling times were applied.

Due to the modified sampling method applied to the detailed vegetation assessment (i.e. the use of 4 m x 4 m quadrats rather than 20 m x 20 m quadrats), failure of sites to meet one of the three floristic diversity thresholds does not indicate that the site does not meet thresholds for inclusion in the critically endangered NTG community.

Due to the absence of a minimum size criteria for the former EPBC Act listed endangered Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory, the minimum size restriction was not considered as part of the thresholds when monitoring the extent of NTG at this site. Application of this threshold would result in artificial changes in the extent of NTG present.

2.5. GSM Flying Surveys

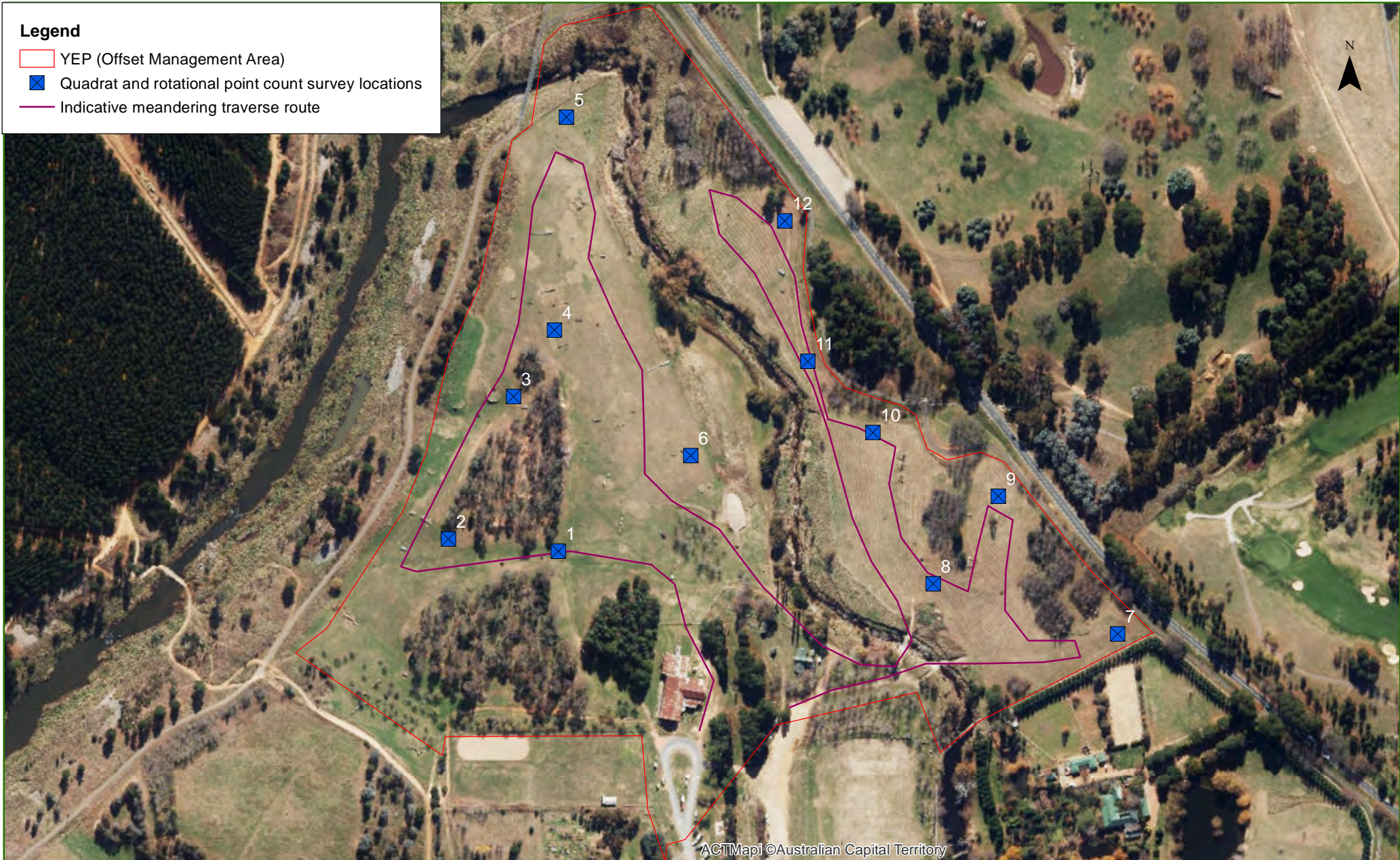
Flying GSM surveys were conducted in a manner consistent with the ACT Government (2010a) GSM survey guidelines and specifically according to the protocol outlined in the OMP (RJPL 2014a Appendix F). As specified in the OMP (RJPL 2014a), rotational point counts were conducted at the monitoring quadrats located throughout the YEP offset area according to the following protocol:

- Locate each of the quadrats used for the vegetation and habitat assessments using GPS
- While standing in the middle of each quadrat, count all GSM observed in and beyond the quadrat to approximately 20 m while rotating through 360°
- Record GSM numbers on the Flying GSM survey data sheet (RJPL 2014a Appendix G)
- Wait 30 seconds
- Repeat Steps 2-4, nine more times
- Average the GSM count at each site and enter result on the flying GSM survey data sheet (RJPL 2014a Appendix G).

The timed traverse was undertaken, as specified in the OMP (RJPL 2014a Appendix F). During the 2013 baseline survey, the transect route indicated in Figure 5 of the OMP (RJPL 2014a) was confirmed as an appropriate route for the timed traverse survey. As specified in the OMP (RJPL 2014a), the following protocol was followed:

- Follow the mapped traverse identified in the OMP as closely as practicable
- Note the time when starting to walk the traverse
- Count all GSM observed while walking slowly and steadily along the traverse
- Note the time once the traverse is completed
- Record GSM numbers and times on the Flying GSM survey data sheet (RJPL 2014a Appendix G)
- Calculate the number of GSM observed per minute.

On-site weather data was recorded during all flying GSM field surveys. Incidental GSM observations were also recorded during other site visits and between surveys.



Legend

- YEP (Offset Management Area)
- X Quadrat and rotational point count survey locations
- Indicative meandering traverse route

FIG NO.1 **FIGURE TITLE** Yarralumla Equestrian Park offset area and survey details (2017)

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Location: X:\Projects\3002461 LDA YEP Monitoring\Variation 2017\GIS\MXD\Figure 1 Yarralumla Equestrian Park offset area and survey details (2017).mxd

2.6. GSM Habitat Monitoring

As specified in the OMP (RJPL 2014a), a qualitative GSM habitat assessment was undertaken in each of the twelve monitoring quadrats using the GSM habitat quality scoring system of Hogg (2012, Appendix H of the OMP), which takes into consideration both grassland condition and GSM activity.

2.7. Meteorological Data

Meteorological data for Canberra Airport from 1 January 2013 to 31 December 2017 was obtained from the Bureau of Meteorology.

2.8. Analysis of Monitoring Data

GSM population trends and grassland condition trends were analysed for change over time.

All analyses were conducted in program R 3.4.3 (R Development Core Team 2017), under the assumption of independence and equal variance. Normality was tested using a Shapiro Wilk test and review of Quantile – Quantile Plots. Pearson correlation matrixes were generated for key potential explanatory variables to identify those with high explanatory power. A limit of 0.7 was used to assess for highly correlated variables.

GSM population trends, as measured using the annual averaged data from point count and traverse surveys for 2013-2017, were examined through linear and multiple regression analysis. We tested whether there was evidence of a correlation between average GSM numbers and time, flying season rainfall and flying season soil temperature. Data was assessed for normality and tested for autocorrelation.

Grassland condition trends, as measured using the annual average floristic value scores for 2013-2017, were examined through linear multiple regression analysis. We tested whether there was evidence of a correlation between average GSM numbers and time, flying season rainfall and flying season soil temperature. Data was assessed for normality and tested for autocorrelation.

Trends in the extent of NTG and GSM habitat were reviewed by plotting changes in extent over time. Statistical analysis was not conducted on the extent of NTG and GSM habitat.

3. Results

3.1. Regional GSM Information

The first report of flying GSM during the 2017/18 season was of 100 males at Jerrabomberra East Grasslands on 2 November. By the second week of November (i.e. 6–12), GSM were flying at several sites in the ACT. The start date of the 2017/18 flying season is approximately a fortnight earlier than the 2015/16 and 2016/17 seasons but comparable to the four flying seasons prior to 2015.

3.2. Vegetation and GSM Habitat Mapping

Vegetation mapping and GSM habitat mapping was conducted on 7 November 2017. Changes to vegetation mapping were reviewed during a second site visit on 12 January 2018. Due to the spring conditions, exotic annual species were present in high proportions across the site, making detection and confirmation of the extent of degraded native pastures challenging. Figure 2 shows the distribution of vegetation communities mapped at YEP in 2017. Summaries of the areas of each vegetation community are shown in Table 1.

The distribution of significant weeds at YEP is shown in Figure 3. Chilean needle grass (*Nassella neesiana*) patches were extensive. African lovegrass (*Eragrostis curvula*), has extensively invaded areas formerly mapped as native pasture, particularly in areas with soil disturbance. Isolated patches of serrated tussock (*Nassella trichotoma*) also occur in eight locations across YEP.

Table 1. 2017 summary of vegetation and land use mapping.

Vegetation type / land use	2017 (ha)
Natural temperate grassland	0.5
Native pasture	0.7
Mixed native and exotic pasture	5.8
Exotic pasture	6.7
(Construction area)	0
(Non-grassland areas (e.g. buildings, riparian margins, woodland))	8.0
Total Project Area	21.6
Chilean needle grass ¹	1.8
African lovegrass	2.1

¹ Chilean needle grass and African lovegrass distribution polygons are mapped as overlays, and hence are exempt from the total project area.

GSM habitat extent within YEP is summarised in Table 2 and shown in Figure 4. Low to moderate quality GSM habitat persists across the majority of the mapped area.

Table 2. 2017 summary of GSM habitat areas.

GSM habitat area	2017 (ha)
Low quality	6.4
Low quality habitat dominated by Chilean needle grass	1.6
Moderate quality	1.1
High quality	0.0
Total	9.1



Legend

- YEP (Offset Management Area)
- Natural Temperate Grassland
- Native Pasture
- Mixed Native and Exotic Pasture
- Exotic Pasture

FIG NO.2	FIGURE TITLE Distribution of vegetation communities at Yarralumla Equestrian Park (2017)	DATE 15/02/2018		PAGE SIZE A4	COORDINATE SYSTEM GDA 94 MGA Zone 55	© SMEC Australia Pty Ltd 2018. All Rights Reserved. Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, this map contains data from a number of sources - no warranty is given that the information contained on this map is free from error or omission. Any reliance placed on such information shall be at the sole risk of the user. Please verify the accuracy of all information prior to using it. This map is not a design document.
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FIG NO.3 **FIGURE TITLE** Distribution of Serrated tussock, African lovegrass and Chilean needle grass at Yarralumla Equestrian Park (2017)

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Legend

- YEP (Offset Management Area)
- Medium Quality GSM Habitat
- Low Quality GSM Habitat
- Low Quality GSM habitat dominated by CNG

FIG NO.4 **FIGURE TITLE** Distribution of Golden Sun Moth habitat in Yarralumla Equestrian Park (2017)

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Location: X:\Projects\3002461 LDA YEP Monitoring\Variation 2017\GIS\MXD\Figure 4 Distribution of Golden Sun Moth habitat in Yarralumla Equestrian Park (2017).mxd

3.3. Native Pasture and Natural Temperate Grassland Monitoring

Grassland monitoring was conducted in favourable spring conditions on 7 November 2017. Plant species, Braun-Blanquet abundance scores and a qualitative assessment of grassland quality based on the scale prepared by Nash and Hogg (2013) were recorded for each quadrat. Table 3 presents a summary of the key vegetation quality indicators, including the quantitative site value score calculation based on Rehwinkel (2007) and qualitative grassland quality and GSM habitat quality scores. In 2017, floristic value scores were also calculated according to Rehwinkel 2015, to facilitate consideration against criteria for inclusion in the revised NTG listing (Table 3). Data is presented in Appendix A.

To assess sites against criteria for inclusion in the EPBC Act-listed critically endangered natural temperate grassland community (Australian Government 2016), the updated floristic value score calculation described in Rehwinkel (2015) was applied, identifying grassland in quadrats 2, 3, 7, 8, 10 and 12 as NTG.

Assessment of the site against the updated criteria for the critically endangered community listings are shown in Table 4. Due to the need to maintain consistency with the OMP, quadrat sizes are smaller than the standard required for calculation of the floristic value scores. Thus, the potential for areas mapped as native pasture and an updated floristic value score of less than five is recorded, to meet the updated criteria for the revised critically endangered NTG ecological community cannot be excluded.

Table 3. Vegetation survey results for 2017.

Quadrat	Number of native species	Number of exotic species	Number of significant weeds	Floristic value score (Rehwinkel 2007)	Floristic value score (Rehwinkel 2015)	Grassland quality score	GSM habitat quality score
1	0	10	0	0	0.00	N/A	2
2	5	12	2	1	5.53	4B	5
3	6	10	2	2	7.15	4A	5
4	3	11	1	0	1.51	3B	4
5	3	15	1	0	0.20	N/A	1
6	1	13	1	0	0.10	4A	3
7	9	15	1	2	7.47	4A	2
8	10	11	2	5	10.00	5B	4
9	1	12	2	0	0.12	N/A	N/A
10	8	16	3	2	6.24	4A	5
11	4	14	1	0	1.52	1	3
12	10	12	1	5	9.77	5B	4

Note: Quadrats that scored less than 1 for grassland quality and GSM habitat quality are denoted 'N/A'.

Table 4. Summarised assessment against Commonwealth criteria for the EPBC Act-listed natural temperate grassland critically endangered ecological community based on floristic data and site characteristics.

Quadrat (Threshold)	Condition	Number of non-grass species (8)	Number of indicator species (2)	Floristic value score (5)	Meets natural temperate grassland criteria / comment
1	Mixed native and exotic	0	0	0.00	No
2	Native grassland	2	1	5.53	Yes
3	Native grassland	4	3	7.15	Yes
4	Native pasture	2	1	1.51	No
5	Exotic pasture	1	0	0.20	No
6	Native pasture	0	0	0.10	No
7	Native grassland	4	3	7.47	Yes
8	Native grassland	3	4	10.00	Yes
9	Mixed native and exotic	0	0	0.12	No
10	Native grassland	5	2	6.24	Yes
11	Mixed native and exotic	3	0	1.52	No
12	Native grassland	5	3	9.77	Yes

Note: Condition thresholds applied relate to those for surveys undertaken in favourable conditions.

3.4. GSM Flying Surveys

All surveys were conducted on warm, sunny days with light winds (Table 5). Point count survey data is presented in Appendix B and a complete list of GSM records is presented in Appendix C.

Table 5. Weather conditions during GSM flying moth surveys.

Date	Temperature (°C)	Last rainfall (mm)	Wind speed (km/h)	Cloud cover
9/11/2017	25	18.6 (Nov 7)	<5 km/hr	<5%
30/11/2017	28 - 29	0.2 (Nov 29)	<5 km/hr	-
12/12/2017	25 - 28	6.2 (Dec 8)	<5 km/hr	<5%

All flying moth surveys were undertaken during the peak period of GSM activity in the ACT and are consequently valid representations of GSM activity levels at the YEP offset site. GSM activity observed during the traverse surveys was low (i.e. 0-2 moths per minute) during all three surveys based on the semi-quantitative GSM site assessment method developed by David Hogg Pty Ltd (2010). The relatively continuous distribution of records along the traverse route demonstrate that GSM were flying across the majority of open areas in YEP during the 2017/18 flying season.

A total of 46 GSM was recorded during the traverse survey on 7 November, 87 on 30 November and 128 on 8 December (Table 6). The locations of GSM records are shown in Figure 5. The maximum GSM number observed at one point during the transect surveys was 12 on 12 December at 55 U, 688422, 60900686. GSM were recorded at all rotational survey points except survey point 7 (Table 7). The highest

GSM number observed during the rotational point surveys was at survey point 1. The 14 incidental records included five late flying males observed on 12 January at four locations east of Yarralumla Creek.

Surveys were generally conducted later in the day (Table 6), with the second survey, on 30 November 2017 conducted particularly late during the GSM flying period. This has the potential to have reduced the GSM numbers detected, particularly during rotational point counts when moths were unlikely to be flushed.

The distribution of GSM records is shown with reference to mapped habitat in Figure 6.

Table 6. Summary of traverse survey results.

Date	Survey	Start	Finish	Total Time (min)	Number of observations	Total GSM	Max GSM	GSM/min
9/11/17	1	14:00	14:58	58	24	46	3	0.8
30/11/17	2	14:35	15:50	75	21	87	10	1.2
12/12/17	3	11:00	12:20	80	40	128	12	1.6

Table 7. Rotational survey point results.

Point	Survey 1 Average	Survey 1 Max	Survey 2 Average	Survey 2 Max	Survey 3 Average	Survey 3 Max	Combined Average	Combined Max
1	0.2	1	0	0	14.9	24	5.0	24
2	0.8	3	0.4	2	2.4	4	1.2	4
3	0	0	0.3	2	1.7	3	0.7	3
4	0.1	1	0	0	4.3	12	1.5	12
5	0	0	0.1	1	0	0	0	1
6	1.0	3	0	0	0.4	2	0.5	3
7	0	0	0	0	0	0	0	0
8	0.6	1	0	0	0.1	1	0.2	1
9	0.1	1	0	0	0	0	0	1
10	0	0	0	0	0.3	1	0.1	1
11	0.1	1	0.6	2	0	0	0.2	2
12	0	0	0.5	2	0	0	0.2	2



Legend

- YEP (Offset Management Area)
- Transect: 1-5 individuals
- Transect: 6-10 individuals
- Transect: 11-15 individuals
- Rotational point: 0 moths
- Rotational point: 0.1 - 5 average # moths per survey

FIG NO.5 **FIGURE TITLE** Distribution of Golden Sun Moth records (traverse and rotational point surveys) at Yarralumla Equestrian Park in 2017

DATE 24/01/2018
 0 40 80 160
 1:4,250 Metres

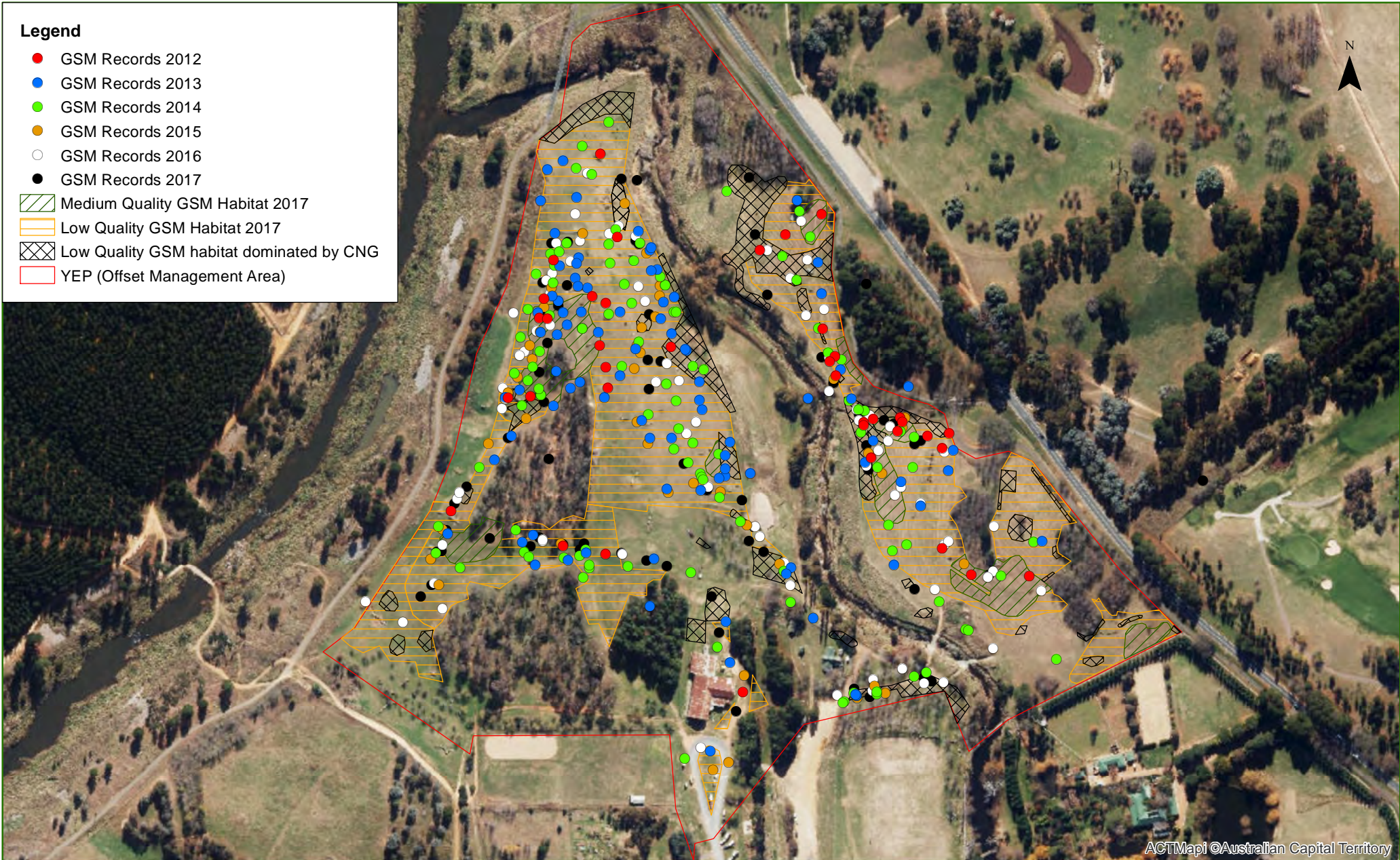
PAGE SIZE A4
COORDINATE SYSTEM GDA 94 MGA Zone 55


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CREATED BY M. Allen **SOURCES** Imagery © Base/imagery2015mga



<p>FIG NO.6 FIGURE TITLE Golden Sun Moth distribution in relation to GSM habitat at Yarralumla Equestrian Park (2017)</p>	<p>DATE 15/02/2018</p> <p>0 40 80 160 1:4,250 Metres</p>	<p>PAGE SIZE A4</p> <p>COORDINATE SYSTEM GDA 94 MGA Zone 55</p>	<p>© SMEC Australia Pty Ltd 2018. All Rights Reserved</p> <p>Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, this map contains data from a number of sources - no warranty is given that the information contained on this map is free from error or omission. Any reliance placed on such information shall be at the sole risk of the user. Please verify the accuracy of all information prior to using it. This map is not a design document.</p>  <p>Member of the Stantec Group</p>
<p>PROJECT NO. 3002461 PROJECT TITLE Yarralumla Equestrian Park Offset 2017 Monitoring Report</p>	<p>CREATED BY M. Allen SOURCES Imagery © Base/imagery2015mga</p>		

3.5. Incidental Observations

Incidental observations of GSM are shown in Figure 7. Four female GSM were observed during the rotational count surveys (i.e. one at Point 2, and three at point 6) while four female GSM were observed during the traverse surveys. Five incidental sightings of single female GSM and one observation of two female GSM were also recorded. Five of these sightings were recorded on 9 November while the last observation was from 12 December. No pupae cases were recorded at YEP during 2017.

3.6. GSM Habitat Monitoring

GSM habitat ranking scores (Nash and Hogg 2012) for each quadrat are presented in Table 8. Quadrat 9 did not meet thresholds for classification as GSM habitat.

Table 8. GSM habitat ranking score 2017.

Quadrat	GSM Habitat Ranking Score
1	2
2	5
3	5
4	4
5	1
6	3
7	2
8	4
9	N/A
10	5
11	3
12	4

3.7. Meteorological Data

Monthly rainfall and average daily maximum and minimum air temperatures (2014-2017) are presented in Figure 8 and Figure 9. Total rainfall during the months leading up to the GSM 2017 flying season (i.e. June to October: 140.4 mm) was lower than the 10-year average (i.e. 229.6 mm) and far lower than during the same period in 2016 (i.e. 454.2 mm). Rainfall during the 2017 flying season (i.e. November / December: 165.5 mm) was slightly higher than the 10-year average (i.e. 149.6 mm) and higher than during the same period in 2016 (i.e. 121.4 mm).

Monthly average daily maximum and minimum soil temperatures recorded at 10 cm depth for 2014-2017 is presented in Figure 10. Figure 11 shows daily maximum soil temperature and Figure 12 shows daily precipitation leading up to and during the past four GSM flying seasons (i.e. October to December). All relevant meteorological data from 2014 to 2017 are presented in Appendix D and Appendix E. All meteorological data presented in this report was recorded at the Canberra Airport (i.e. site 070351).

3.8. Cross Country Infrastructure Development

A new horse jump complex was built during the last year adjacent to sampling point 8 at E 688735, N 6090658. The jump comprises three wooden fences, each with three vertical posts and two horizontal rails. The fences are approximately 2 m long and 1 m high (Figure 13).

The jump was established in an area formerly occupied by NTG, which is described as moderate quality potential GSM habitat (Figure 2, Figure 4). Approximately 0.9 m² of NTG has been lost to the direct placement of the nine posts. A further 25 m² of NTG appears to have been disturbed inside the jump between the fences during the works and has now recovered as African lovegrass-dominated mixed native and exotic grassland (Figure 14).

African lovegrass appears to have invaded the NTG on the entry and exit to the jump. NTG vegetation remains either side of the jump (Figure 15).



FIG NO.7 **FIGURE TITLE** Distribution of incidental Golden Sun Moth records in Yarralumla Equestrian Park during the 2017/18 flying season

DATE 15/02/2018
 0 40 80 160
 1:4,250 Metres

PAGE SIZE A4
COORDINATE SYSTEM GDA 94 MGA Zone 55

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CREATED BY M. Allen **SOURCES** Imagery © Base/imagery2015mga

Location: X:\Projects\3002461 LDA YEP Monitoring\Variation 2017\GIS\MXD\Figure 6 Distribution of incidental Golden Sun Moth records in Yarralumla Equestrian Park during the 2017.18 flying season.mxd

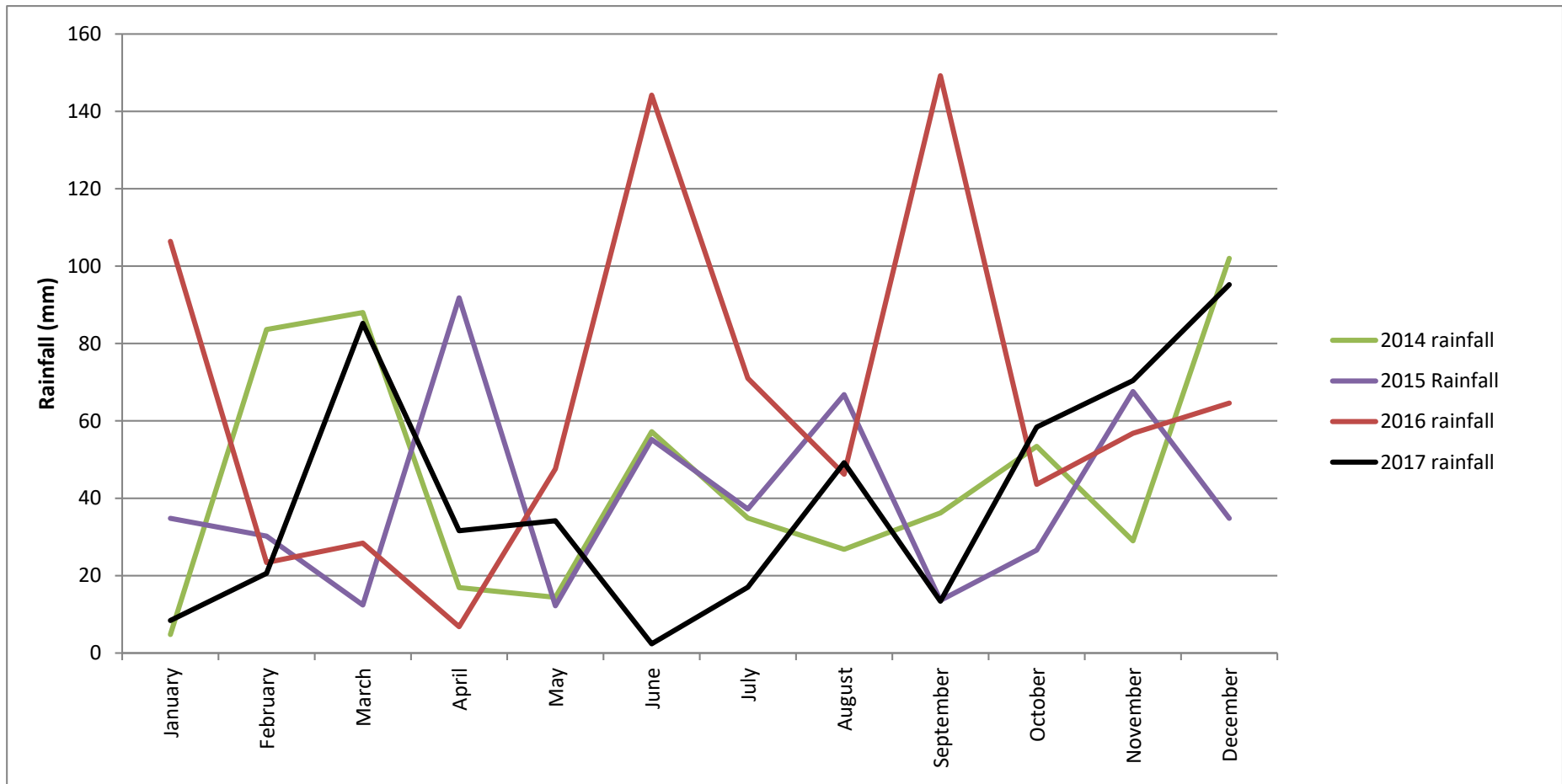


Figure 8. Monthly rainfall at Canberra Airport (2014-2017).

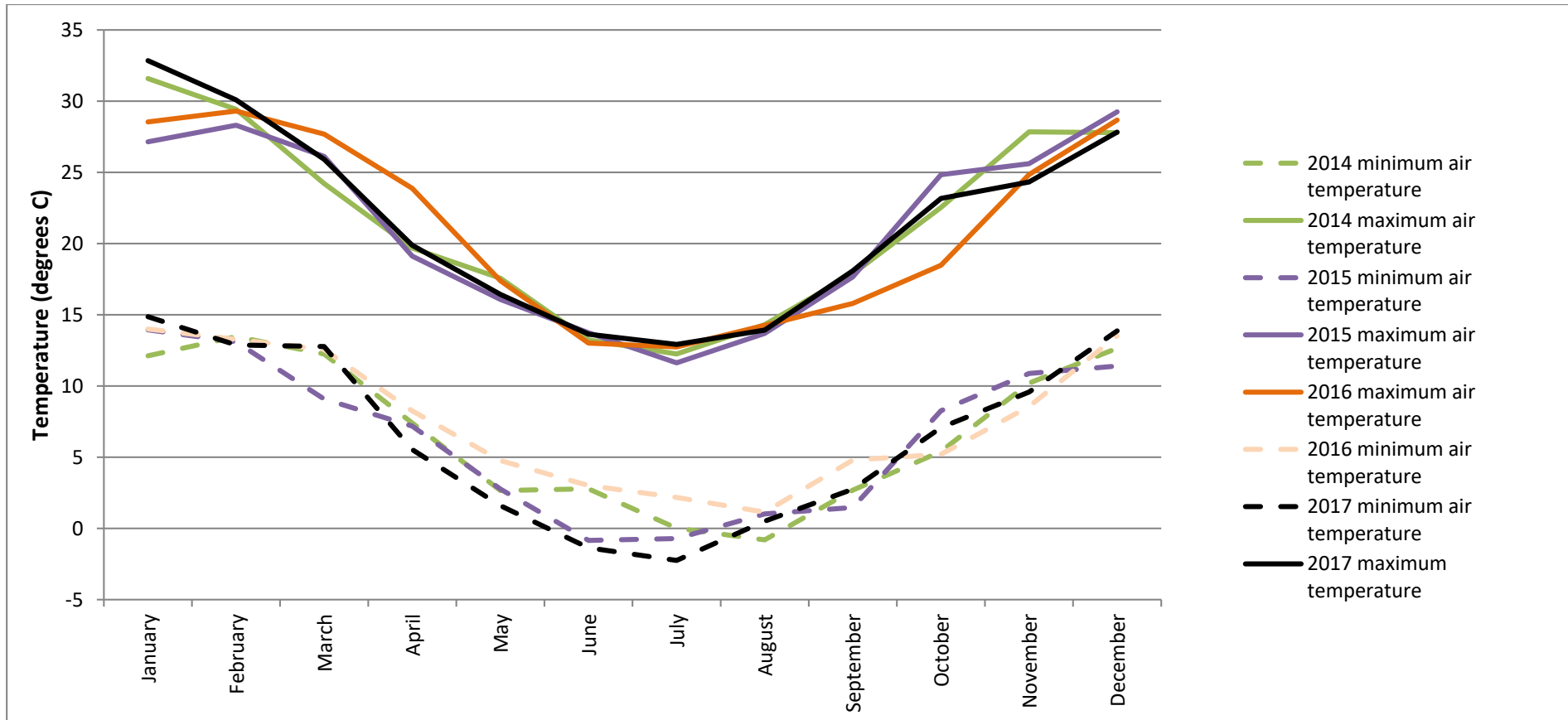


Figure 9. Monthly average daily maximum and minimum air temperature at Canberra Airport (2014-2017).

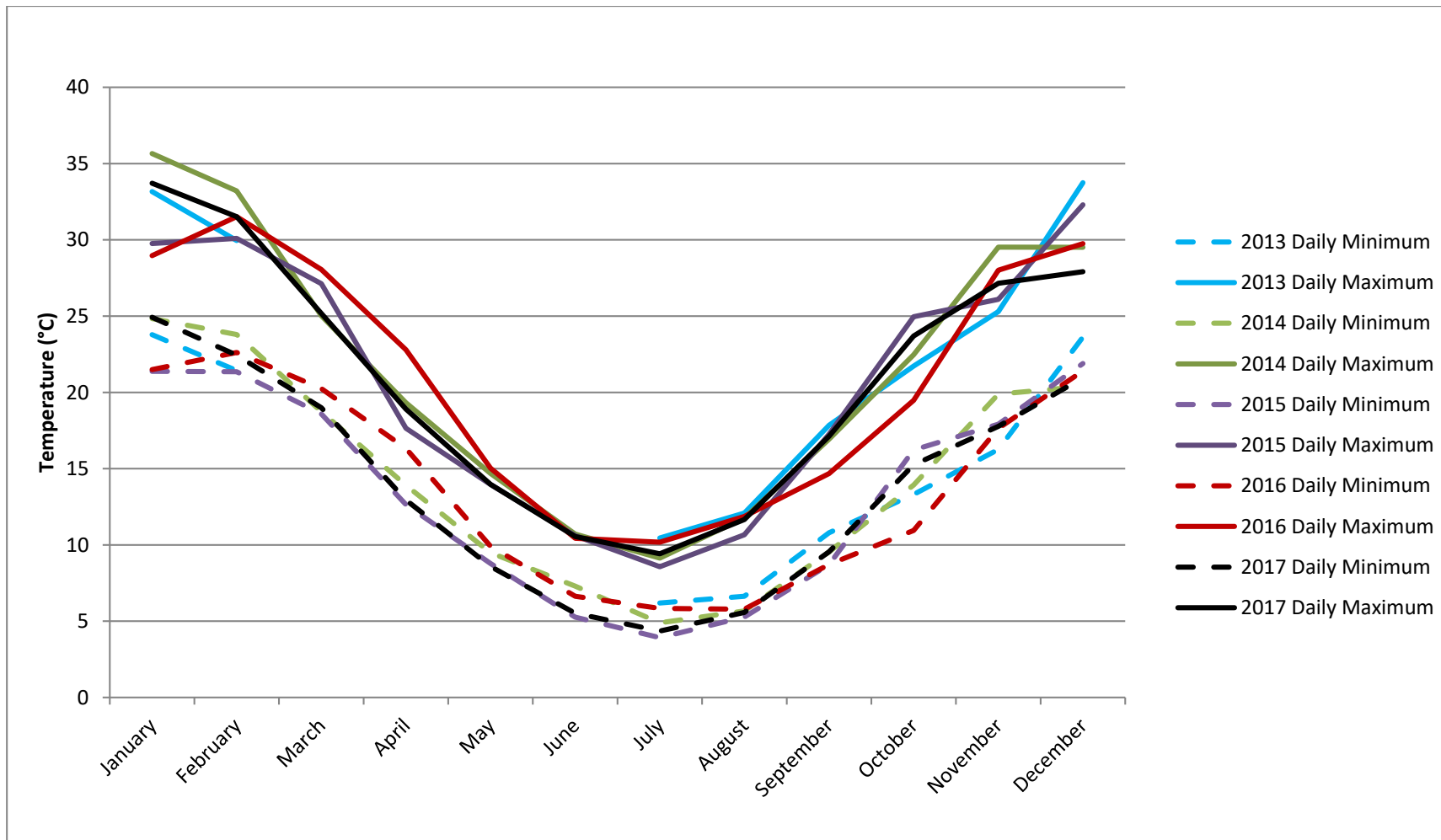


Figure 10. Monthly average daily maximum and minimum soil temperature (10 cm) depth at Canberra Airport.

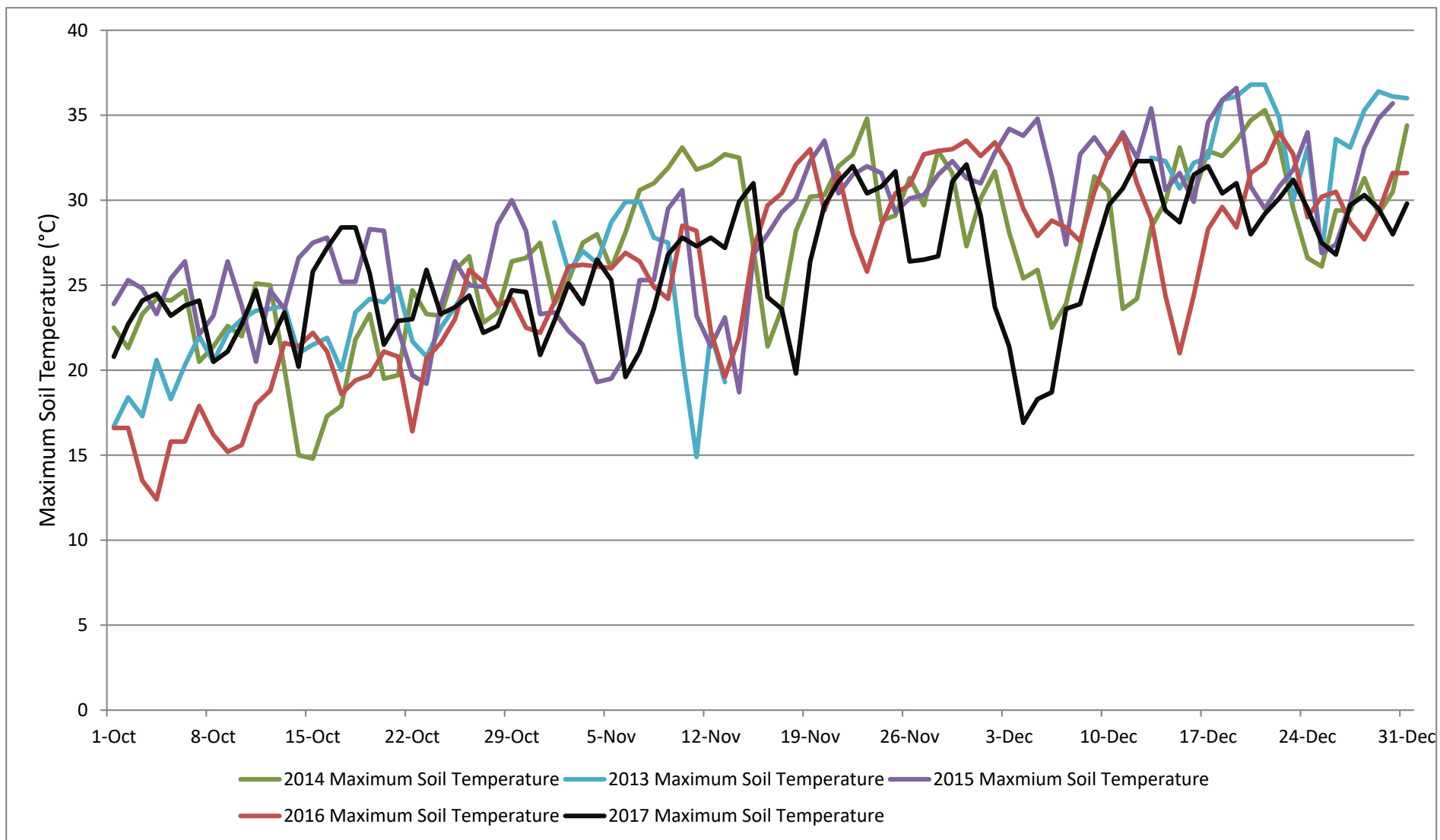


Figure 11. Maximum daily soil temperature at Canberra Airport during the GSM flying period.

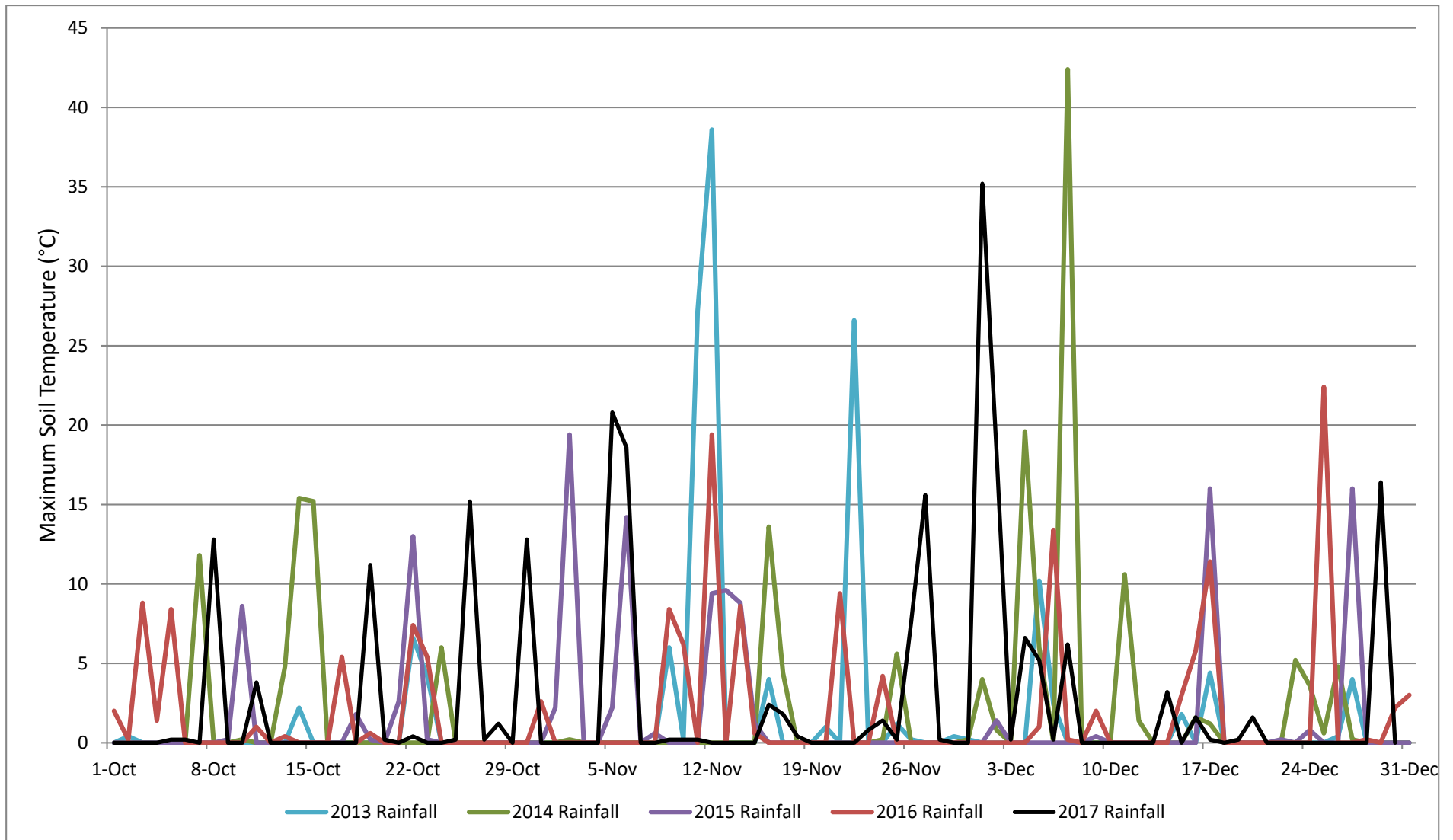


Figure 12. Daily rainfall at Canberra Airport during the GSM flying period.



Figure 13. New horse jump in natural temperate grassland near sampling point 8.



Figure 14. African lovegrass-dominated vegetation around posts and in the new jump.



Figure 15. Natural Temperate Grassland 2 m to the north of posts and outside of the jump.

3.9. Multiple Year Analyses

3.9.1. Vegetation and GSM Habitat Extent

Vegetation Type Extent

Changes in the distribution and extent of vegetation types and land uses reported in the OMP (RJPL 2014a), and year 0 (RJPL 2014b), year 1, year 2 and year 3 monitoring reports (RJPL 2015; SMEC 2016) to 2017 are summarised in Table 9. Trends in the extent of NTG and other grassland types within YEP are shown in Figure 16.

While the extent of NTG has remained constant since 2013, the extent of native dominated pasture has declined substantially (i.e. more than halved) between 2016 and 2017 after remaining constant in the previous four years. The decline in native pasture area was attributable to the invasion of native pasture areas with perennial exotic tussock grasses, particularly African lovegrass, resulting in the reclassification of substantial areas as mixed native and exotic pasture. Trends in the extent of significant perennial grassy weeds (i.e. Chilean needle grass and African lovegrass), mapped as an overlay to other vegetation types, are shown in Figure 17.

In 2016, five relatively small patches of African lovegrass were mapped at YEP; two in the northern section adjacent to Yarralumla Creek and three in the eastern section near Lady Denham Drive. The 2017 survey recorded an 86% increase in the coverage of African lovegrass at YEP between November 2016 (i.e. 0.3 ha) and November 2017 (i.e. 2.1 ha) (Table 9). Large tracts of African lovegrass are now dominant across much of the central and eastern parts of YEP (Figure 3). This invasive weed is now scattered throughout the entire site, with well-established patches present. The three previously identified patches east of the Yarralumla Creek doubled in size from late 2016 to November 2017.

Notably, this species has already invaded seven of the NTG patches at YEP and is present immediately adjacent to the remaining two patches.

The spatial extent of Chilean needle grass has increased by 33% and 22% since 2013 and 2016 respectively (Table 9). Chilean needle grass patches supporting GSM are located in the north and east of the YEP, and along the edge of the access track to the west of Yarralumla Creek in the south of the YEP (Figure 3).

Table 9. Revised vegetation and land use mapping compared with 2013 and 2016.

Vegetation type / land use	2013 (ha)	2014 (ha)	2015 (ha)	2016 (ha)	2017 (ha)	Change since 2013 (ha) (%)	Change since 2016 (ha) (%)
Natural temperate grassland	0.5	0.5	0.5	0.5	0.5	0	0
Native pasture	1.7	1.7	1.6	1.6	0.7	-1.0 (-58%)	-0.9 (-56%)
Mixed native and exotic pasture	5.0	5.0	4.9	4.9	5.8	+0.8 (+16%)	+0.9 (+24%)
Exotic pasture	5.4	5.4	6.5	6.5	6.7	NA ¹	+0.2 (+3%)
(Construction area)	0.8	0.8	0	0	0	NA	NA
(Non-grassland areas (e.g. buildings, riparian margins, woodland))	8.0	8.0	8.0	8.0	8.0	NA	NA
Total Project Area	21.6	21.6	21.6	21.6	21.6	NA	NA
Chilean needle grass ²	1.2	1.2	1.1	1.4	1.8	+0.6 (+50%)	+0.4 (+22%)
African lovegrass	0	0	0	0.3	2.1	+2.1 (N/A)	+1.8 (+600%)

¹ Construction area (0.8 ha) reclassified as exotic pasture in 2014, hence difference in extent between 2013 and 2017 extent not applicable. ² Chilean needle grass and African lovegrass distribution polygons are both overlays, and hence are exempt from the total project area.

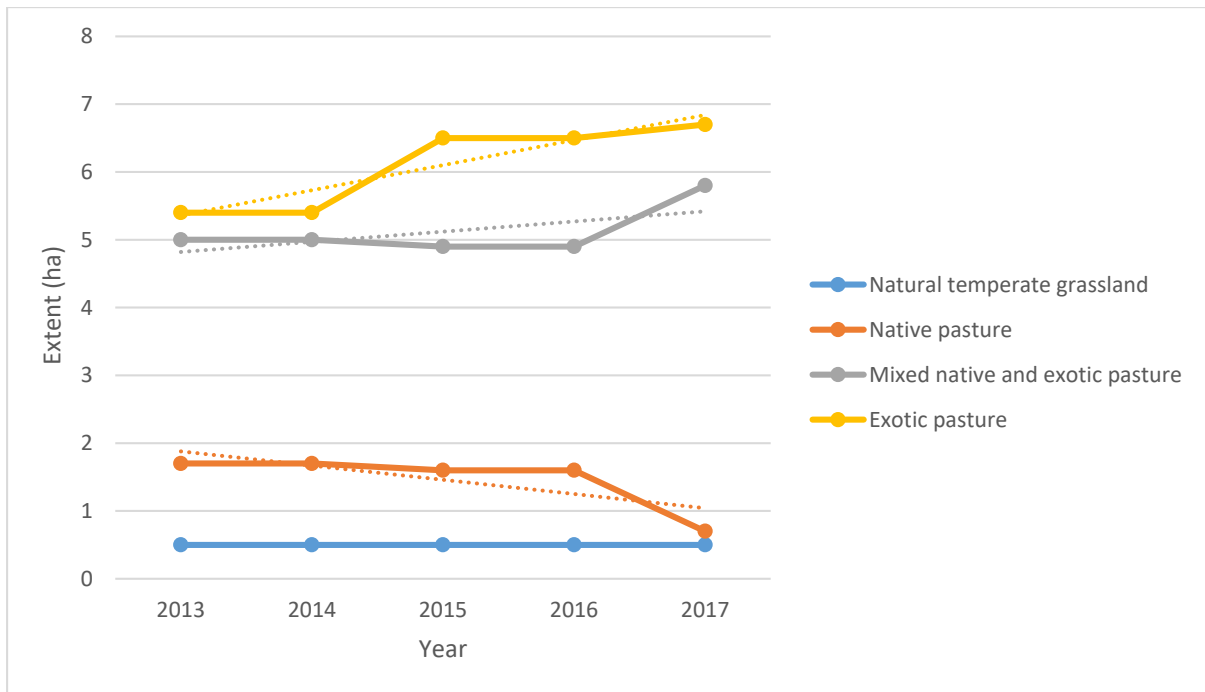
GSM Habitat Extent

GSM habitat extent reported in the OMP (RJPL 2014a) and the year 0 (i.e. 2013) (RJPL 2014b), year 1 (RJPL 2015), year 2 (SMEC 2016) and year 3 (SMEC 2017) monitoring reports are compared in Table 10 and Figure 18.

Trends in the extent of GSM habitat quality in the period 2013 to 2017 are shown in Figure 18. Overall, the extent of GSM habitat has increased since 2013, although this is primarily due to an increase in the extent of low quality habitat dominated by Chilean needle grass between 2014 and 2015, and an increase in the mapped extent of low quality GSM habitat in the same year (Table 10). It is likely that the increase in the mapped extent of low quality GSM habitat between 2014 and 2015 is due to improving site knowledge rather than any biological change.

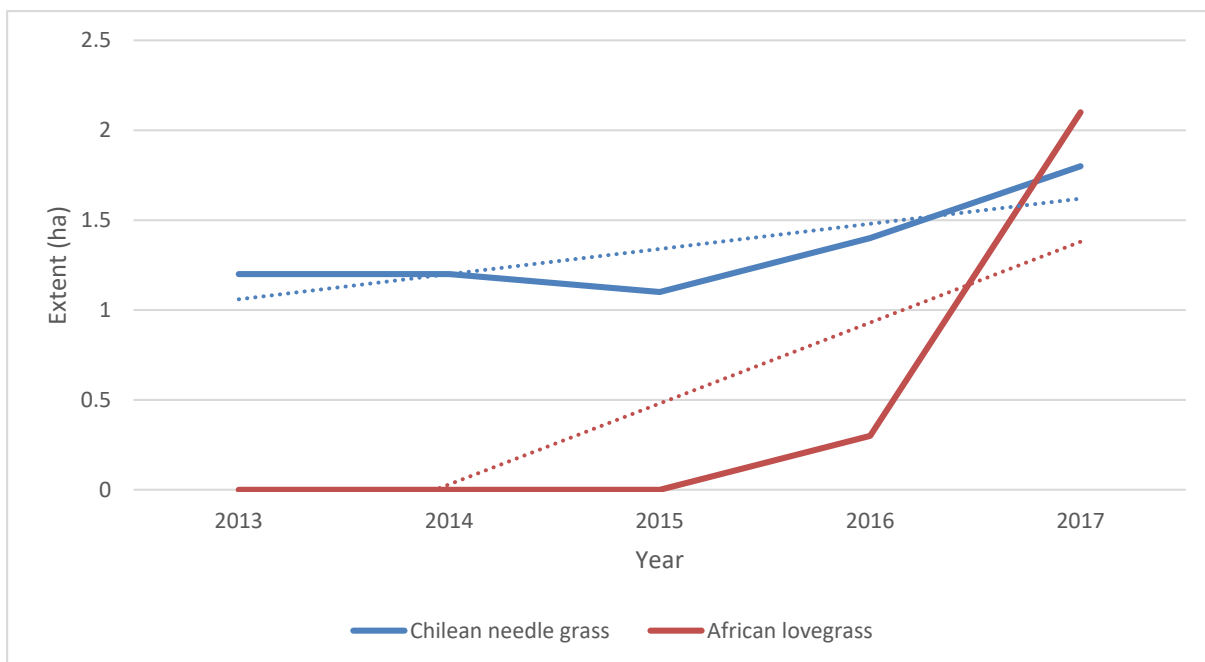
Although the total extent of GSM habitat at YEP in 2017 (i.e. 9.1 ha) was very similar to the total mapped extent during 2016 (i.e. 9.2 ha), considerable changes to the mapped distribution of the different habitat categories were made following the 2017 vegetation survey (Table 10, Figure 18).

The increase in perennial exotic grass cover associated with increased invasion by Chilean needle grass and African lovegrass (Table 9, Figure 3) has halved the extent of medium quality potential GSM habitat (i.e. the highest quality habitat at YEP) since 2013 with the most severe reduction occurring between 2016 and 2017 (Table 10, Figure 18). Correspondingly, the extent of low quality GSM habitat and low quality GSM habitat containing Chilean needle grass both increased.



Note: Dotted lines indicate linear trends.

Figure 16. Grassland extent at Yarralumla Equestrian Park (2013-2017).

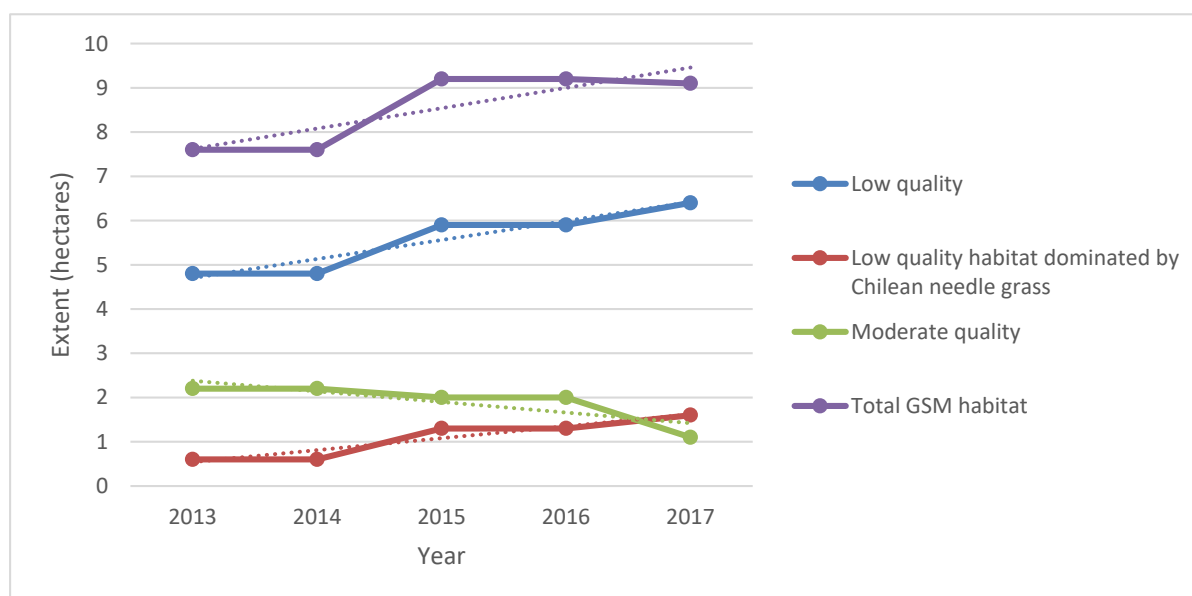


Note: Dotted lines indicate linear trends.

Figure 17. Extent of African lovegrass and Chilean needle grass at Yarralumla Equestrian Park (2013-2017).

Table 10. Revised 2017 GSM habitat areas compared with 2013 and 2016.

GSM habitat area	2013 (ha)	2014 (ha)	2015 (ha)	2016 (ha)	2017 (ha)	Change since 2013 (ha)
Low quality	4.8	4.8	5.9	5.9	6.4	+1.6
Low quality habitat dominated by Chilean needle grass	0.6	0.6	1.3	1.3	1.6	+1.0
Moderate quality	2.2	2.2	2.0	2.0	1.1	-1.1
High quality	0.0	0.0	0.0	0.0	0.0	0.0
Total	7.6	7.6	9.2	9.2	9.1	+1.5



Note: Dotted lines indicate linear trend.

Figure 18. GSM habitat extent Yarralumla Equestrian Park (2013-2017).

3.9.2. Native Pasture and Natural Temperate Grassland Condition

Floristic scores and grassland ranking scores for each survey season are shown in Table 11 and Table 12 respectively. Three quadrats, i.e. quadrats 1, 5 and 9 were not located within predominantly native vegetation, consistent with previous years. A high level of inter-annual variability in floristic value scores is present within each monitoring quadrat (Figure 19 and Table 11), which is the result of variable seasonal conditions and survey timing.

Table 11. Summary of floristic value scores (2013 to 2017).

Quadrat	Site floristic value score				
	2013	2014	2015	2016	2017
1	0	0	0	0	0
2	4	7	1	4	1
3	7	4	2	1	2
4	2	2	1	5	0
5	1	0	0	1	0
6	4	8	1	5	0
7	1	5	1	0	2

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Quadrat	Site floristic value score				
	2013	2014	2015	2016	2017
8	2	2	0	11	5
9	0	0	0	0	0
10	2	5	1	5	2
11	4	4	1	5	0
12	6	14	1	9	5
Average	2.75	4.25	0.75	3.83	1.42

Note: During data review, 2016 data for quadrat 4 and quadrat 5 appeared to have been switched. This table has been updated to reflect the correct data.

Table 12. Summary of grassland ranking scores assessment (2013 to 2017).

Quadrat	Grassland ranking score				
	2013	2014	2015	2016	2017
1	N/A	N/A	N/A	N/A	N/A
2	4C	5A	3A	3A	4B
3	5C	4A	4C	1	4A
4	4C	3A	1	4C	3B
5	N/A	N/A	N/A	1	N/A
6	4C	4A	3B	4B	4A
7	4C	3A	3B	N/A	4A
8	5C	3A	N/A	4B	5B
9	N/A	N/A	N/A	N/A	N/A
10	4C	4A	1	3A	4A
11	4C	4A	2	3A	1
12	5C	5A	1	4A	5B

Note: During data review, 2016 data for quadrat 4 and quadrat 5 appeared to have been switched. This table has been updated to reflect the correct data.

Note: In application of the Grassland Quality Score, there has been inconsistency in the consideration of the presence of threatened species. In this case, it has been assumed that the grassland quality score refers to threatened flora species and the presence of GSM is consequently not considered in the application of the scale. This contrasts with the approach applied in 2013, but is consistent with that applied in 2014. Application of the scale in 2015 and 2016 appears inconsistent in the treatment of the presence of GSM.

In 2017, only quadrats 8 and 12 had a floristic value score of four or greater, down from seven quadrats in 2016 and 2014, and five quadrats in 2013. In contrast, in 2015, no quadrats exceeded this threshold. Six quadrats recorded a floristic value score of 0 in 2017 compared with three quadrats in 2016, four in 2015, three in 2014 and two in 2013. Floristic value scores were lower than the 2013 – 2016 average at eight quadrats, equal to the average at two quadrats and higher than average at the remaining two quadrats. The quality of grassland at quadrats 2, 4 and 6 is reduced relative to 2013; however, to some extent this may be the impact of micro-siting of monitoring quadrats.

The lower native and exotic species diversity and floristic value scores recorded in 2017 relative to 2016 is likely due to a marked difference in rainfall prior to the vegetation surveys. Total rainfall during the months leading up to the 2017/18 flying moth season (i.e. June to October: 140.4 mm) was lower than the 10-year average (i.e. 229.6 mm) and far lower than during the same period in 2016 (i.e. 454.2 mm) (Australian Government 2017, 2018). Climate variability, particularly rainfall, and seasonal variability, are important factors in grassland composition and cover (Williams *et al.* 2015). This is supported by the high yearly variance in native diversity and floristic value scores recorded since monitoring commenced in 2013.

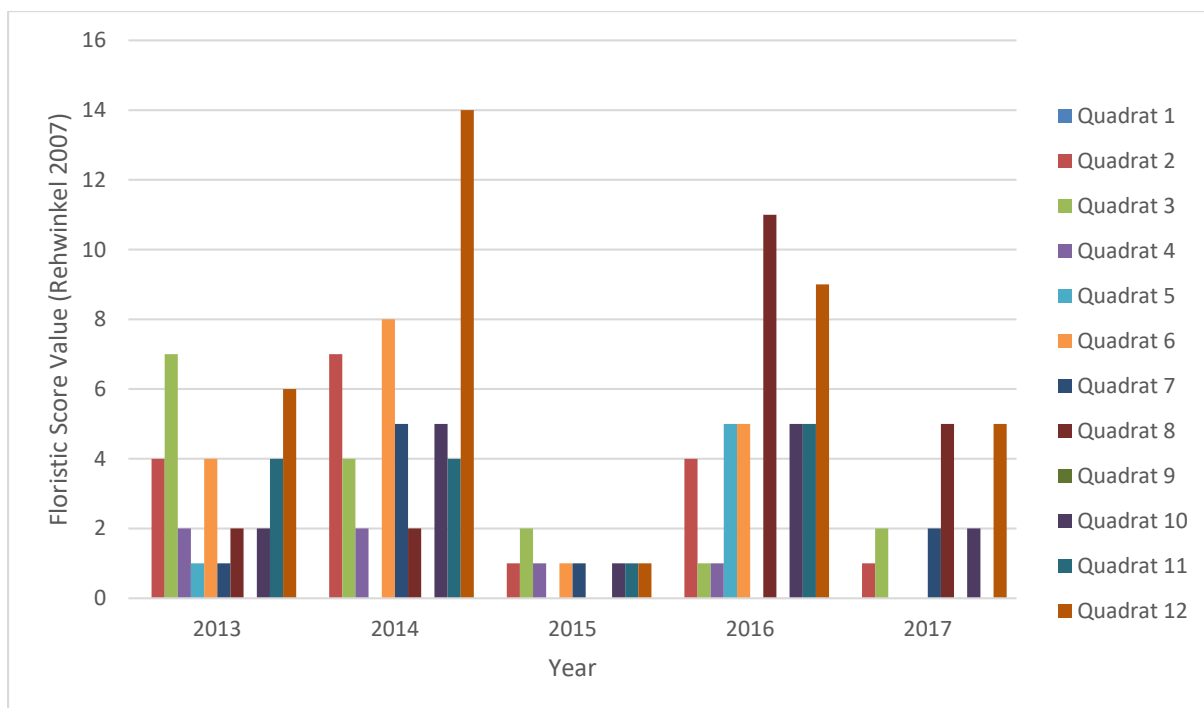


Figure 19. Floristic value score for each quadrat (2013 to 2017).

Exotic species richness was greater than native species richness in each of the twelve monitoring quadrats. At least one significant weed species was recorded in all but one of the quadrats. The increase in perennial weeds, particularly African lovegrass, Chilean needle grass and serrated tussock, has the potential to be a driver of long term reduction in the quality of vegetation condition at YEP.

The inter-annual variation in grassland quality since surveys commenced at YEP in 2013 is likely partly due to the discussed seasonal conditions, survey timing (i.e. early November vs December surveys). Inter-annual variation in grassland composition and structure at YEP can be strongly influenced by rainfall during the months leading up to the vegetation surveys conducted each November / December. Rainfall during winter and spring 2016, for example, was well above average in Canberra (i.e. 511 mm cf. 296 mm), which led to favourable conditions for exotic grassland species that spring / summer (Australian Government 2016). The winter and spring of 2017 experienced lower than average rainfall in Canberra (i.e. 211 mm cf. 296 mm) and could therefore be expected to cause less favourable growing conditions for exotic annual species (Australian Government 2017).

Statistical analysis was conducted to identify any significant changes on native pasture and natural temperate grassland condition over time that could not be explained by biological or meteorological conditions.

The Shapiro Wilks test of normality supports the null hypothesis of normal distribution ($W = 0.93$, $p = 0.61$); however, the review of the Quantile-Quantile Plots suggests non-normality, as expected due to the small sample size. As transformation of the data was not meaningful given the sample size, analyses proceeded despite the breach of this assumption.

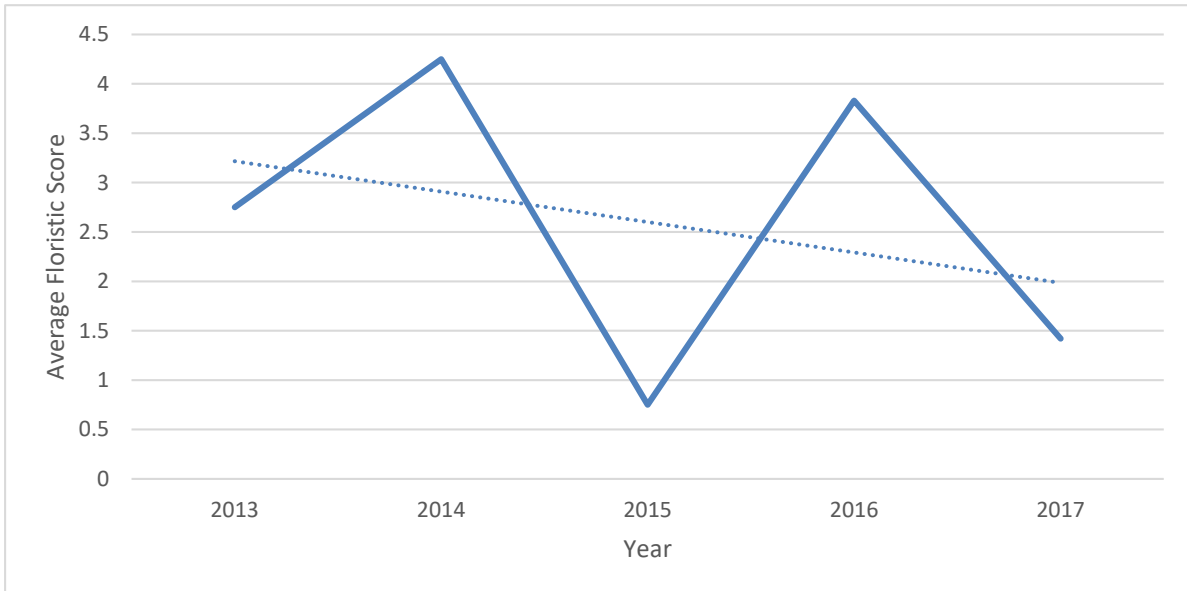
Two separate regression analyses were used to test if the floristic values scores are influenced by the time since observations commenced and the average rainfall from August to October.

The results of the regression analysis indicated that:

- there is no significant relationship between the floristic value score recorded at the rotational points from the year when observations commenced ($R^2 = -0.20$, $F(1,3) = 0.35$, $p = 0.56$). Figure 20 shows that there is a possible negative trend in average floristic value score over time, but that this is small relative to the inter-annual variation.

- there no significant relationship between the floristic value score and the average rainfall ($R^2 = 0.006$, $F(1,3) = 1.02$, $p = 0.37$).

Multiple regression was used to assess whether there is any interaction in the effect of the average rainfall from August to October and the time since observations commenced. There was no relationship between the floristic value score, the time since observations commenced and average rainfall from August to October ($R^2 = -0.002$, $F(2,2) = 0.99$, $p = 0.50$). The interaction with the average rainfall from August to October did not improve the time since observations commenced. There is no evidence of autocorrelation for the multiple regression analysis.



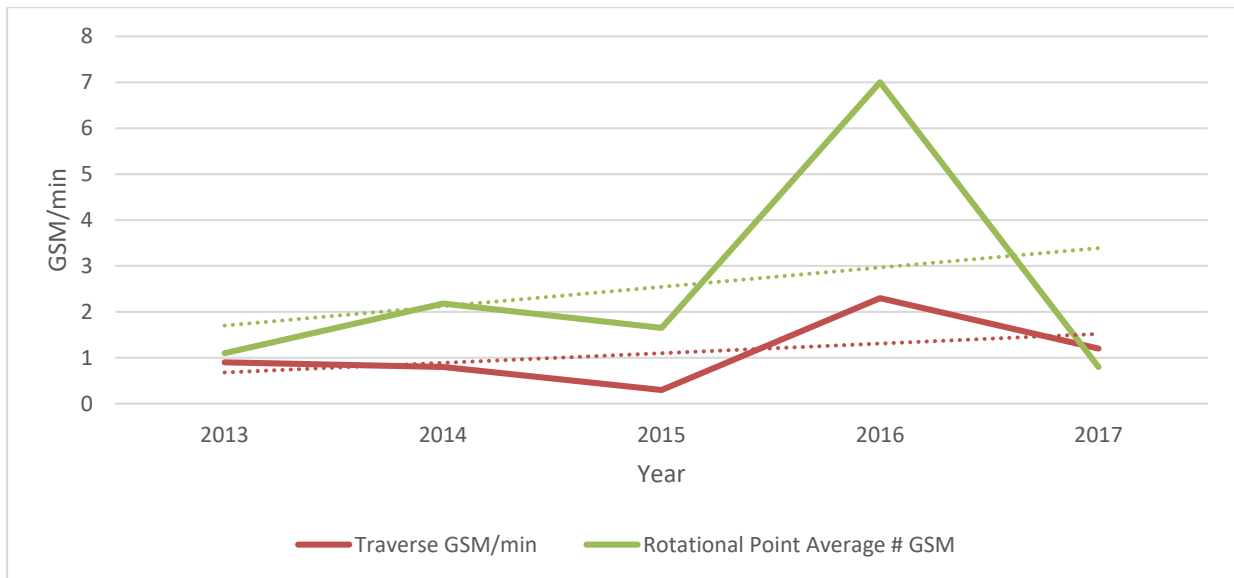
Note: Dotted lines indicate linear trend.

Figure 20. Annual trends in the average floristic value score (2013-2017).

3.9.3. Flying Moth Numbers

Statistical analysis was conducted to identify any significant changes of flying GSM numbers over time that could not be explained by biological or meteorological conditions.

Trends in GSM numbers over the period 2013-2017, as measured by timed traverse surveys and rotational point counts, are shown in Figure 21. Qualitative review indicates that there is a high level of inter-annual variation, and that there is a slight positive trend over time.



Note: Dotted lines indicate linear trend.

Figure 21. Trends in GSM flying numbers (2013-2017).

While there are likely to be many factors which determine seasonal levels of GSM activity, past research indicates that rainfall and soil temperature leading up to and during the GSM flying season are potentially key variables, although there is limited empirical evidence to support this (Australian Government 2009, Hogg 2010).

Recent notable differences in inter-annual conditions in Canberra include much higher rainfall during spring 2016 than during the same period in 2017 and during earlier survey years (i.e. 2013, 2014, 2015). The four months from July to September 2016 were the wettest such period on record in Canberra (Australian Government 2017) causing a delay in the GSM flying season and may have partly contributed to the very high numbers of GSM recorded at YEP in November and December 2016 (Australian Government 2017) (Figure 12 and Figure 21). Rainfall during winter 2017 was well below average in Canberra; however, this was followed by above average rainfall during the GSM flying season (i.e. October to December). A wet period during late November / early December likely suppressed flying activity for a short period. Soil temperatures in 2017 at Canberra Airport leading up to the GSM flying season were similar to the previous surveys (i.e. 2013 to 2016) (Figure 11). Time of day may have partly influenced the number of GSM recorded during 2017; the first two surveys were conducted after 02:00 pm in suitable weather conditions.

Timed Traverse Surveys

The numbers of GSM observed during the timed traverse surveys were considerably lower in 2017 than in 2016 but slightly higher than observed during 2013, 2014 and far higher than during 2015 (Table 13, Figure 22). The average number of GSM observed per minute during 2017 (i.e. 1.2) is similar to the 2013 - 2017 average of 1.1 GSM/minute. The average maximum and minimum number of GSM per minute during the traverse surveys in 2017 were lower than recorded in 2016 and equal or higher than recorded from 2013 to 2015.

Table 13. GSM traverse survey results (2013-2017).

Year	Average GSM numbers				
	Total GSM	Max number GSM	Average GSM / min	Max GSM / min	Min GSM / min
2013	64.0	8.3	0.9	1.4	0.4
2014	74.3	9.7	0.8	1.6	0.1
2015	25.7	3.7	0.3	0.6	0.1
2016	277.0	92.0	2.3	3.1	1.8
2017	87.0	8.3	1.2	1.6	0.8

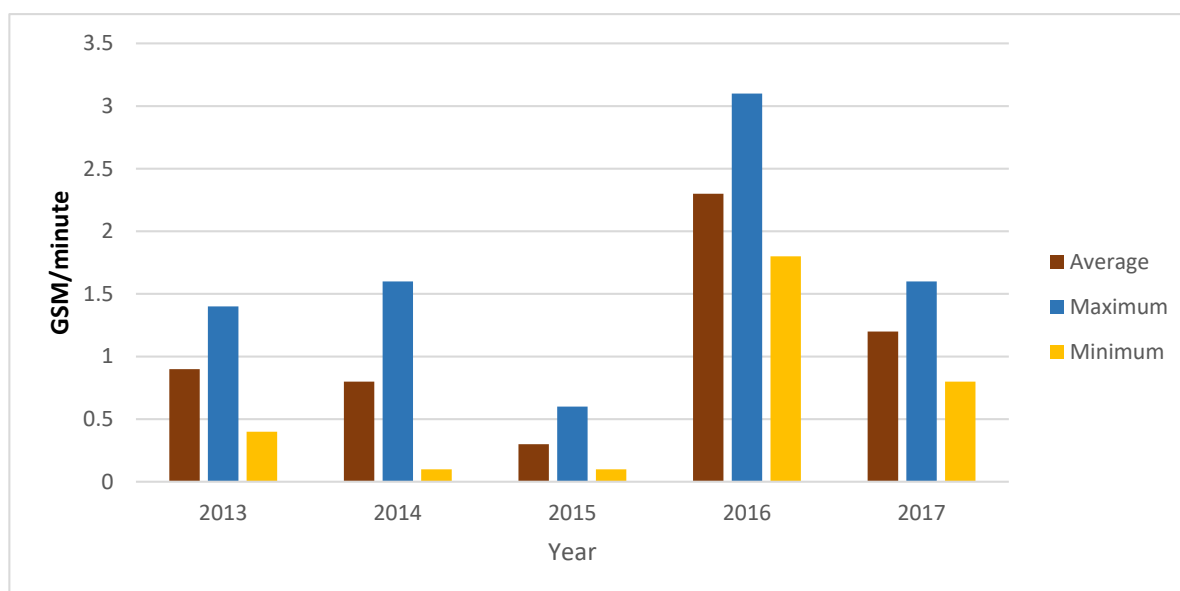


Figure 22. Comparison of yearly GSM traverse survey results (2013-2017).

A Pearson correlation matrix was generated for key potential explanatory variables (Table 14). Based on the standard threshold value of 0.7, only average rainfall for the period August to October had a strong linear relationship with the number of moths detected per minute during timed traverse surveys, or the average numbers of moths detected at point counts. No strong linear correlation was present between time since observations commenced.

Table 14. Co-efficient of correlation matrix for flying moth numbers and key potential explanatory variables.

Data	Time since observations commenced (Years)	Rainfall (Aug - Oct)	Rainfall (Nov - Dec)	Average Max Temperature (Nov - Dec)	Average Min Temperature (Nov - Dec)
Traverse	0.45	0.94	0.22	-0.31	0.08
Point Count	0.26	0.95	-0.33	0.17	0.12

The Shapiro Wilks test of normality rejected the null hypothesis of normal distribution ($W = 0.91$, $p = 0.05$); however, the review of the Quantile-Quantile Plots suggests non-normality for both the meandering traverse and the point count datasets, as expected due to the small sample size. Analyses proceeded despite the breach of this assumption.

Two separate regression analyses were used to test if the number of GSM per minute recorded on the traverse is influenced by the time since observations commenced and the average rainfall from August to October. The results of the regression analysis indicated that:

- there no significant relationship between the number of GSM per minute recorded along the traverse line from the year when observations commenced ($R^2 = -0.06$, $F(1,3) = 0.74$, $p = 0.45$). This is consistent with Figure 21.
- there was a significant positive effect between the number of GSM per minute recorded and the average rainfall ($R^2 = 0.81$, $F(1,3) = 22.12$, $p = 0.01$).

Multiple regression was used to assess whether there is any interaction in the effect of the average rainfall from August to October and the time since observations commenced. No autocorrelation between rainfall and year was detected. There was no relationship between the number of GSM/per minute, the time since observations commenced and average rainfall from August to October ($R^2 = 0.82$, $F(2,2) = 10.34$, $p = 0.08$). Including the average rainfall from August to October did improve the time since observations commenced.

Rotational Point Count Surveys

GSM presence / absence at each survey point has been the same since the 2015 survey. The average number of GSM recorded during the rotational point surveys in 2017 was equal to or lower than the 2013-2017 average at all survey points except site 1 (Table 15, Figure 23, Figure 24). Far lower numbers of moths were recorded at points 4, 8, and 10 in 2017 than during 2016. As noted in past surveys, point 4 consistently supports higher numbers of GSM than elsewhere; however, a record low average of 1.5 was recorded in 2017 compared with 3.9 (2013), 8.9 (2014), 5.6 (2015) and 43.2 (2016). The highest number of GSM observed during 2017 was at point 1 where far higher numbers were recorded in 2017 than in the previous two years.

Table 15. Summary of average rotational point counts (2013-2017).

Point	Average (1DP)					'13-'17 Av.	Maximum				
	2013	2014	2015	2016	2017		2013	2014	2015	2016	2017
1	2.1	3.4	1.7	2.2	5.0	2.9	6	14	3	8	24
2	2.3	2.3	2.4	0.5	1.2	1.7	7	7	5	2	4
3	3.0	6.3	2.3	3.6	0.7	3.2	8	20	5	14	3
4	3.9	8.9	5.6	43.2	1.5	12.6	14	26	9	129	12
5	0.4	0.6	0.4	1.7	0	0.6	5	2	1	7	1
6	0.8	1.9	3.8	4.4	0.5	2.3	4	5	6	13	3
7	0.1	0.0	0.0	0	0	0.0	1	1	0	0	0
8	0.2	0.0	0.0	12.1	0.2	2.5	3	0	0	51	1
9	0.0	0.8	1.3	1.4	0	0.7	0	2	3	4	1
10	0.1	0.7	1.2	11.8	0.1	2.8	1	2	3	46	1
11	0.2	0.7	1.1	2.1	0.2	0.9	2	1	1	7	2
12	0.0	0.5	0.0	0.5	0.2	0.2	1	1	0	6	2

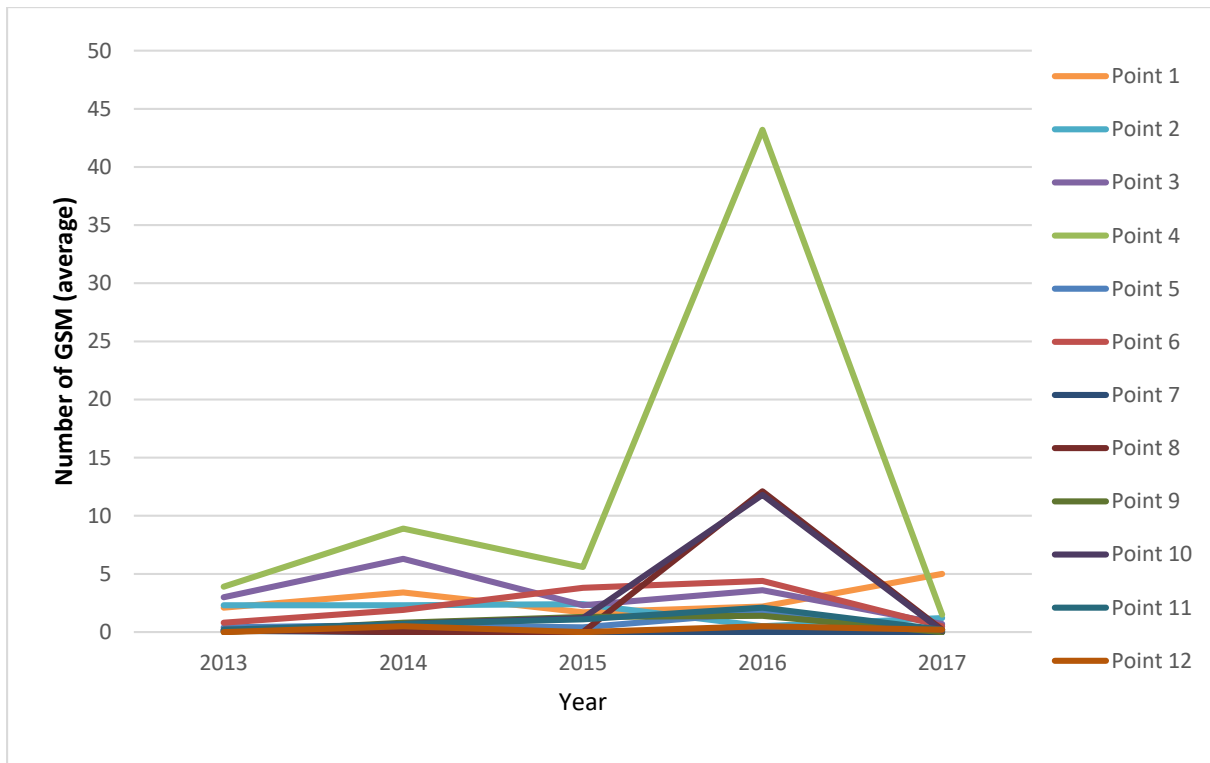


Figure 23. Average rotational point count observations (2013-2017).

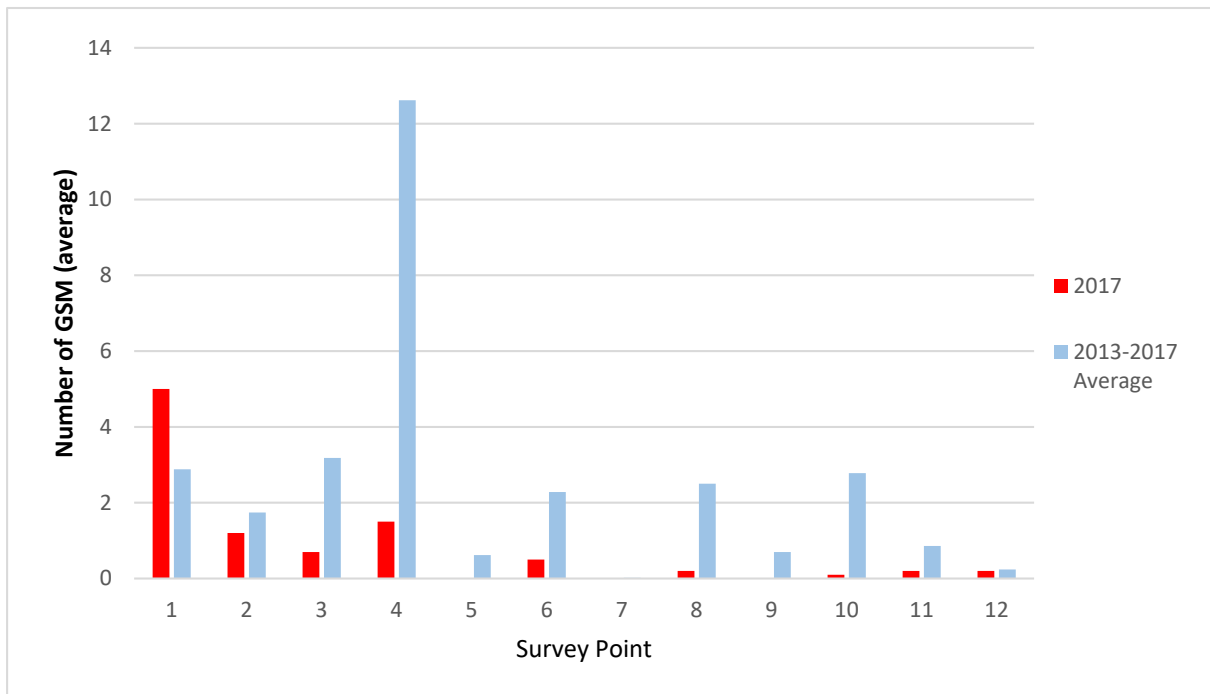


Figure 24. Average rotational point counts (2017 vs 2013-2017 average).

Two separate regression analyses were used to test if the average number of GSM recorded on the rotational points is influenced by the time since observations commenced and the average rainfall from August to October.

The results of the regression analysis indicated that:

- there no significant relationship between the average number of GSM recorded at the rotational points from the year when observations commenced ($R^2 = -0.24$, $F(1,3) = 0.22$, $p = 0.67$). This is consistent with Figure 21.
- there was a significant positive effect between average number of GSM recorded at point counts and the average rainfall ($R^2 = 0.01$, $F(1,3) = 26.27$, $p = 0.01$).

Multiple regression was used to assess whether there is any interaction in the effect of the average rainfall from August to October and the time since observations commenced. There was no relationship between the number of GSM/per minute, the time since observations commenced and average rainfall from August to October ($R^2 = 0.79$, $F(2,2) = 8.79$, $p = 0.10$). The interaction with average rainfall from August to October did not improve explanatory power of the time since observations commenced. There is no evidence of autocorrelation for the multiple regression analysis.

3.9.4. GSM Habitat Monitoring

GSM habitat value scores recorded in 2017 ranged between N/A (i.e. *no GSM habitat*) and 4 (*Moderate quality NTG habitat with very low numbers of GSM*) (Table 16). Eleven of the monitoring quadrats were determined to have some GSM habitat value, due to the presence of potential host species and GSM activity.

Trends in the average GSM habitat ranking scores are shown in Figure 25. While a slight negative trend was indicated due to declines between 2014 and 2016, the average GSM habitat ranking score was slightly higher in 2017 relative to 2013. Due to the qualitative nature of GSM habitat ranking scores, further statistical analysis of these scores is not valid.

The average 2017 GSM habitat quality score of 2.4 is lower than the 2013-2016 average (i.e. 3.3). The variation in GSM habitat scores between the years is likely attributable to variation in seasonal conditions and GSM density. Reductions in GSM habitat scores were also potentially influenced by African lovegrass invading native pasture areas since 2016.

Table 16. GSM habitat quality scores (2013 - 2017).

Quadrat	GSM habitat quality score				
	2013	2014	2015	2016	2017
1	2	2	1	1	2
2	5	5	4	4	5
3	6	6	6	4	5
4	4	4	3	4	4
5	1	1	1	1	1
6	3	5	4	3	3
7	2	4	2	1	2
8	4	2	2	3	4
9	0	N/A	N/A	N/A	N/A
10	3	5	4	3	5
11	4	5	5	3	3
12	4	5	4	3	4

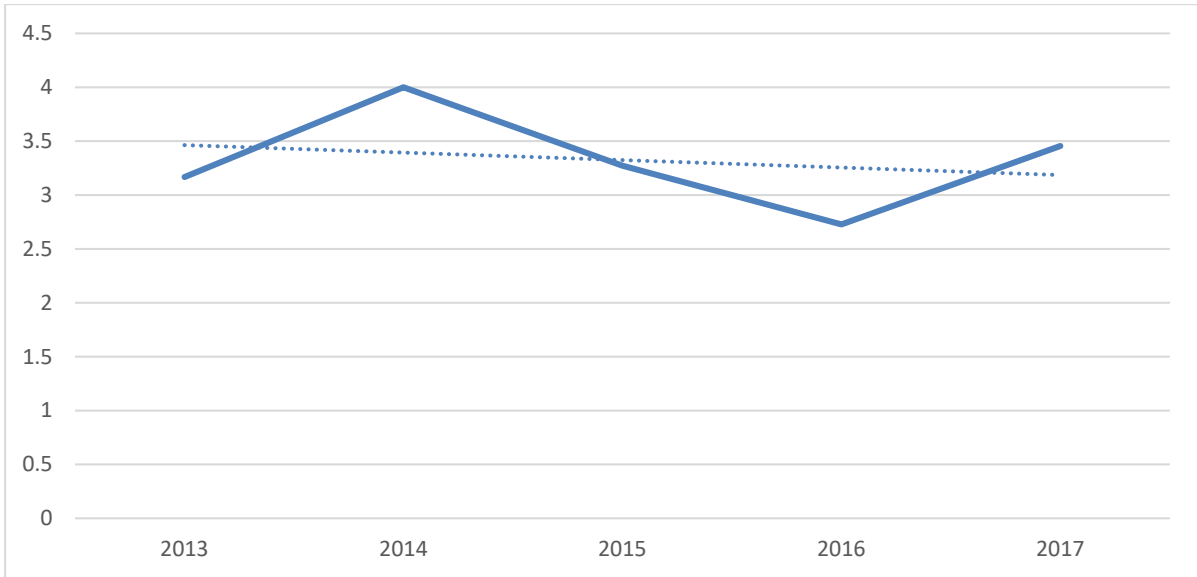


Figure 25. Trends in GSM habitat ranking scores (2013-2017).

4. Discussion

4.1. Vegetation and GSM Habitat

Due to the revision of the former EPBC Act-listed endangered Natural Temperate Grassland of the Southern Tablelands of NSW and the Australian Capital Territory to EPBC Act-listed critically endangered Natural Temperate Grassland of the South-Eastern Highlands, and associated updated condition thresholds, future mapping should be revised to take into account the revised thresholds (Australian Government 2016). While mapping conducted under the former listing may not be directly comparable to the existing listing, site management would be appropriately informed as to how to best manage the EPBC Act-listed critically endangered Natural Temperate Grassland of the South-Eastern Highlands.

Between 2016 and 2017, the extent of native grassland and moderate quality GSM habitat has been reduced by the substantial expansion of significant weeds, i.e. the perennial tussock grasses Chilean needle grass and African lovegrass (Table 9, Figure 3). These species have high potential to invade and degrade NTG, potentially causing the loss of the native ecological communities.

Further expansion of African lovegrass is likely to reduce the extent of the small patches of NTG present at YEP, and to cause the degradation and possible loss of GSM habitat. Chilean needle grass poses a serious threat to the native pasture and NTG at YEP but is considered less of a threat to GSM than African lovegrass. Small patches of serrated tussock (*Nassella trichotoma*) were recorded in eight locations across YEP in 2017. Scattered plants had previously been recorded (SMEC 2017); and this species has the potential to spread rapidly across the site, degrading NTG and GSM habitat if not appropriately controlled.

The increase in the distribution of these invasive species, and the corresponding degradation of native pasture and GSM habitat, highlights the need for targeted weed management at YEP. Without such intervention, further degradation of native pasture and NTG areas at YEP is expected.

Key results relevant to impact response thresholds (Section 5.4) are:

- The spatial extent of NTG has not increased or declined. The extent of native pasture at the site has declined due to perennial exotic tussock grass invasion, and we recommend weed management protocols are revised to avert future reduction in GSM habitat.
- The overall extent of GSM habitat has increased since 2013; however, this is most likely due to the increased knowledge of the GSM distribution at the site. While the overall extent of GSM habitat has increased, the extent of moderate quality habitat at the site has decreased with a corresponding increase in the extent of low quality habitat and Chilean needle grass dominated habitat. This is correlated with exotic perennial tussock grasses invading the site, and is indicative of a general decline in GSM habitat quality at the site.

4.2. Native Pasture and Natural Temperate Grassland Monitoring

Floristic value scores show a high level of inter-annual variation, and, on average, exhibit a marginal and non-significant decline across the site since 2013 (Table 11, Figure 20). The high level of inter-annual variation is likely attributable to variation in seasonal conditions.

Linear and multiple regression analysis, taking into account late winter and early spring rainfall, did not identify any biologically or statistically significant relationship between floristic value scores and time. Also, no significant relationship was detected between floristic value score and rainfall in the three months prior to surveys.

Similarly, grassland ranking scores also indicate a slight decline in grassland condition at the monitoring points. NTG ranking scores have not increased on average or at any site since 2013, and a decrease was noted at some sites. Whether this is indicative of declining trend in grassland condition is unclear

due to the high level of variability from year to year. Some inter-annual variation in habitat ranking scores is likely due to the subjective nature of this ranking and varying seasonal conditions are also likely to influence scores.

Declines in vegetation condition at the site are associated with the invasion of perennial exotic tussock grasses, as discussed in Section 4.1.

Key results relevant to impact response thresholds (Section 5.4) are:

- floristic value scores have not shown a statistically significant increase or decline at the site over the five-year monitoring period from 2013-2017.
- grassland ranking scores have not increased but have instead shown a qualitative decline since 2015.

4.3. GSM Habitat Monitoring

Average GSM habitat ranking scores have demonstrated a slight decline over three years between 2014 and 2016 and no sites have increased. Whether this is indicative of a declining trend in grassland condition is unclear due to the high level of inter-annual variation. Some inter-annual variation in habitat ranking scores is likely due to the subjective nature of this ranking. Varying seasonal conditions may also influence scores. Declines in GSM habitat ranking scores, independent of seasonal variation and the subjectivity of assessment, are likely to be due to perennial exotic grasses invading native grassland areas.

Key results relevant to impact response thresholds (Section 5.4) are:

- GSM habitat ranking scores have not increased but have instead shown a qualitative decline over five years from 2013-2017.

4.4. GSM Flying Surveys

The combined data from the five years confirms that GSM activity has remained widespread throughout open areas of the YEP; although, GSM have not been recorded in the far south-east section of the survey area (i.e. point 7) since a single moth was recorded in 2014.

The difference between the GSM activity levels between years, in particular, the huge spike in numbers in 2016, at the YEP is probably due to the high variability in GSM flying levels between days, and the inability to obtain a representative sample of GSM flying levels over three survey days. Climatic variation between years may cause additional inter-annual variation. In particular, regression analysis indicates a statistically significant correlation between pre-flying season rainfall and GSM flying activity.

Key results relevant to impact response thresholds (Section 5.4) are:

- GSM flying moth numbers have not shown a statistically significant increase or decline over five years from 2013-2017.

4.5. Summary

Overall, the evidence shows that the extent or condition of native grassland or GSM habitat has not improved since monitoring began in 2013.

Evidence also shows that the flying GSM population has not increased.

Measures of grassland and GSM habitat condition indicate a possible non-significant negative trend over time. This observation may be correlated with degradation due to weed invasion that has occurred since 2016. The seven-fold increase in African lovegrass distribution since 2016 represents a major threat to the YEP's grassland and GSM habitat condition.

5. Compliance with the Offset Management Plan

5.1. Survey Requirements

All NTG and GSM monitoring surveys were conducted according to the methods specified in the OMP (RJPL 2014a). Quadrats were located at co-ordinates specified in the 2013 monitoring report (RJPL 2014b), which are consistent with Figure 5 of the OMP (RJPL 2014a), rather than at the incorrect co-ordinates reported in Appendix B of the OMP.

5.2. Reporting Requirements

The OMP (RJPL 2014a) requires that annual monitoring reports:

- provide and assess the monitoring data for the previous twelve months against the previous monitoring results
- conclude whether or not there has been a lack of increase or a decline in GSM population numbers in the YEP due to equestrian activities, taking into account regional population trends and local ecological conditions
- conclude whether or not there has been no improvement or a decline in GSM habitat, and NTG quality and extent in the YEP due to equestrian activities, taking into account local ecological conditions.

The current report represents the year 4 monitoring report. The requirements for analysis against the baseline conditions are addressed against the impact thresholds in Section 5.4.

The preparation of this report fulfils the reporting requirements for year 4, as specified in the OMP (RJPL 2014a).

5.3. Management Response Responsibility

The ACT Government, i.e. the SLA, as the successor to the LDA, to whom the Approval is granted, is ultimately responsible for meeting the OMP's three primary requirements:

- Compliance with the YEP 'Ongoing Management Actions'
- Annual monitoring of the condition of the YEP offset (e.g. NTG and GSM status) with respect to management performance and the active management triggers.
- If, after five years or anytime thereafter, ongoing management actions and any subsequent changes to such actions fail to conserve, manage and improve habitat in the YEP, as demonstrated through the annual monitoring program, the DoEE may determine that an Additional Offset Management Plan (AOS) be prepared in accordance with Condition 3 of the Approval.

The SLA would determine whether a management response is warranted, in consultation with the Commonwealth, on the basis of the magnitude of the relative change and interpretation of contextual information including meteorological data and regional GSM activity. A management response may involve a review of ongoing management actions, consideration of an alternative offset or a course of action not yet described.

5.4. Impact Thresholds

The OMP (RJPL 2014a) includes a variety of ongoing management actions derived from the approval conditions. Subsequent active management responses are also identified should specified adverse impact response thresholds be met or exceeded. The key thresholds of potential concern that would trigger ACT Government consultation with the Commonwealth and potentially an active management response is the detection of:

- ‘no increase or a decline in spatial extent of NTG and/or GSM habitat over at least three consecutive seasons, that cannot be attributed to biological influences and seasonal conditions.
- a statistically significant lack of increase or a decline in native grassland and NTG floristic value scores over at least three consecutive seasons that cannot be attributed to biological influences and seasonal conditions.’
- no increase or a decline in NTG ranking scores and GSM habitat ranking scores over at least consecutive three seasons that cannot be attributed to biological influences and seasonal conditions.’
- a statistically significant lack of increase or a decline in flying moth numbers over at least three consecutive seasons that cannot be attributed to biological influences and seasonal conditions.’

Table 17 presents the four response thresholds, as stated in the OMP, and rationale for whether or not they have been triggered. No increases in spatial extent, improvements in ranking scores or statistically significant increases in grassland condition of flying moth numbers were recorded. Consequently, a review of management is triggered on the basis of all threshold measures.

Table 17. Assessment of monitoring results against impact thresholds.

Threshold	Triggered Yes / No	Comment
No increase or a decline in spatial extent of NTG and/or GSM habitat over at least three consecutive seasons, that cannot be attributed to biological influences and seasonal conditions.	Yes	<p>NTG:</p> <ul style="list-style-type: none"> • The spatial extent of NTG has not changed since 2013 (Table 9). • The extent of native grassland has decreased over one season because of perennial exotic tussock grass invasion (Table 9), indicating potential future threats to NTG. • A review of the OMP is triggered, as there has been no increase in the spatial extent of NTG. <p>GSM habitat:</p> <ul style="list-style-type: none"> • The extent of GSM habitat has increased by 1.5 ha since 2013 (Table 10). • Expansion of GSM habitat likely due to the expansion of Chilean needle grass (Table 9), improved mapping and increased knowledge of GSM distribution rather than a real increase in native GSM habitat. • The extent of moderate quality GSM habitat has decreased over one season, but not over three consecutive seasons (Table 10). • A review of the OMP is not triggered, as the spatial extent of GSM habitat has increased since 2013.
A statistically significant lack of increase or decline in native grassland and NTG floristic value scores over at least three consecutive seasons that cannot be attributed to biological influences and seasonal conditions.’	Yes	<p>Native Grassland and NTG Floristic Value Scores</p> <ul style="list-style-type: none"> • Floristic value scores are highly variable but, on average, appear to have declined marginally across the site since 2013 (Table 11, Figure 20). • Linear and multiple regression analysis, accounting for late winter and early spring rainfall, did not identify any biologically or statistically significant relationship between floristic value scores and time. • Floristic value scores have not shown a statistically significant increase at the site.

Threshold	Triggered Yes / No	Comment
No increase or a decline in NTG ranking scores and GSM habitat ranking scores over at least consecutive three seasons that cannot be attributed to biological influences and seasonal conditions.'	Yes	<ul style="list-style-type: none"> A review of the OMP is triggered, as floristic value scores have not shown a statistically significant increase at the site over five years. <p>NTG ranking scores</p> <ul style="list-style-type: none"> NTG ranking scores have not increased on average or at any site since 2013. NTG ranking scores have decreased at some sites, but have a high level of variability from year to year but have decreased at some sites. A review of the OMP is triggered, as NTG ranking scores have not increased, instead have shown a qualitative decline. <p>GSM habitat ranking</p> <ul style="list-style-type: none"> Average GSM habitat ranking scores have demonstrated a slight decline over three years (between 2014 and 2016) and no sites have increased A review of the OMP is triggered, as GSM habitat ranking scores have not increased, instead have shown a qualitative decline.,
A statistically significant lack of increase or a decline in flying moth numbers over at least three consecutive seasons that cannot be attributed to biological influences and seasonal conditions.'	Yes	<p>Flying moth numbers:</p> <ul style="list-style-type: none"> Linear and multiple regression analysis, accounting for late winter and early spring rainfall, did not identify any biologically or statistically significant relationship between flying moth numbers and time. Regression analysis demonstrates a strong correlation to pre-flying season rainfall between August and October. A review of the OMP is triggered, as GSM flying moth numbers have not shown a statistically significant increase over five years.

5.5. Ongoing Management Actions

Ongoing management actions which comprise the various day to day management activities undertaken at the YEP are defined in the OMP (RJPL 2014a). The management actions are designed to permit equestrian activities to continue and develop in parallel with GSM and NTG conservation. These ongoing management actions may be revised if a management response is triggered.

Table 18 presents a preliminary assessment of the current status of the ongoing management actions from the OMP for the past five years. The summary considers biological and seasonal conditions, such as land management changes; exotic weed invasion; climate variability, excessive predation and fire, as they may influence GSM activity and NTG growth in the YEP in addition to equestrian activities.

Table 18 also identifies the following management activities which may be non-compliant or only partially compliant with the requirements of the OMP:

- Weed control
- Tree and shrub removal
- Vehicle movement
- Establishment of new jumps, infrastructure
- New track formation.

5.6. Management Plan Review

This monitoring report provides evidence that existing management actions are not effectively conserving or improving NTG and GSM habitat in the YEP, and that all four impact thresholds have been triggered (Section 5.4). To be compliant with Approval conditions 1(g) and 3, the ACT Government should review the offset management programme performance in consultation with the Commonwealth, PCS and the ACTEA to determine whether an Additional Offset Plan (AOP) is required, whether ongoing monitoring is necessary and whether changes to the OMP are required.

As management thresholds have been triggered, ongoing management actions should be revised and an active management response developed and implemented in consultation with the Commonwealth and PCS. Additional management actions are required to improve weed control and improve supervision of jump installation in NTG areas.

Further, the requirement to improve the condition and extent of NTG and GSM habitat at the site should be reviewed in consultation with the Commonwealth and PCS to determine whether it is appropriate at this site. If this requirement is maintained, a restoration plan would need to be developed to enable delivery of the specified improvement targets.

Table 18. Ongoing management actions - Status summary.

Activity	Description	Responsibility	Timeframe	Action summary	Compliance Summary ¹
Offset Management Plan Preparation	The OMP (RJPL 2014a). Prepare an offset management plan to meet the specific requirements of the EPBC Act approval decision (EPBC 2012/2692) that is designed to capture appropriate data to enable detection of any negative trends in GSM numbers and, condition and extent of GSM habitat; and condition and extent of NTG arising from YEP management and recreational activities.	LDA to engage a suitably qualified consultant	Spring 2013 <i>(completed)</i>	OMP prepared (RJPL 2014a)	Fully compliant with approval conditions 1(a-k).
Site Monitoring <ul style="list-style-type: none"> Vegetation survey 	Undertake a vegetation survey of the project area, as specified in the offset management plan to more accurately identify and map the extent and quality of the native pasture, natural temperate grassland and golden sun moth habitat. The survey should be undertaken at a time that minimises conflict with YEP use, e.g. during work hours on week days. Surveyors should check with ACTEA for YEP use prior to surveying.	LDA to engage a suitably qualified consultant	Spring 2013 <i>(completed)</i>	Vegetation Survey complete (RJPL 2014b)	Fully compliant with activity requirement
Site Monitoring <ul style="list-style-type: none"> Golden sun moth numbers Golden sun moth habitat condition and extent Native pasture and Natural Temperate Grassland condition and extent 	Undertake targeted monitoring of golden sun moth and natural temperate grassland, as specified in the offset management plan, to assess golden sun moth numbers, and the condition and extent of vegetation. Monitoring should be undertaken at a time that minimises conflict with YEP use, e.g. during work hours on week days. Surveyors should check with ACTEA for YEP use prior to monitoring.	LDA to engage a suitably qualified consultant	2013 Spring / summer GSM flying season <i>(completed)</i>	5 years of annual monitoring complete (RJPL 2014b, RJPL 2015, SMEC 2016, 2017, 2018 (this document))	Fully compliant with activity requirement

¹ The compliance summary is to the best of SMEC's understanding, given the information available.

Activity	Description	Responsibility	Timeframe	Action summary	Compliance Summary1
Mowing	<p>Sport and Recreation Services to mow annually with a slasher mower during April / May and October / November each year, and for fire reduction on an as-needed basis depending on seasonal weather and grass growth.</p> <p>The ACTEA to continue competition-specific mowing.</p> <p>The October / November mow shall take place as early as possible and preferably not in November or December to avoid the GSM flight season; however, the ACT Government shall liaise annually with the ACTEA and Sport and Recreation Services to determine the most appropriate mowing date subject to seasonal weather and the equestrian timetable.</p>	<p>Sport and Recreation Services</p> <p>(ACTEA)</p>	<p>Annually during April / May and October / November</p>	<p>Mowing has continued as specified. Sport and Recreation Services and ACTEA have communicated on bi-annual mowing requirements.</p> <p>The Oct / Nov mow in 2017 was not undertaken on the request of ACTEA, as the ground was exceptionally hard for equestrian activities. The added grass would cushion horse hoofs.</p>	<p>Fully compliant with activity requirement</p>
Weed Control	<p>ACTEA members to continue weed control practises provided they comply with ACT Government legislation regarding chemical (e.g. herbicide) handling and storage, and weed control proficiencies and practices.</p> <p>ACTEA members to continue weed control in accordance with the weed control calendar (Appendix J). The calendar lists suitable weed control periods for most problem weeds in the YEP that avoid the GSM flying period of October – December.</p> <p>The ACTEA to liaise with the ACT Government for additional weed control in response to, e.g. ongoing weed invasion from the Cotter Plots, weed invasion from seeds in stable waste, weed spread from already established weed populations.</p> <p>Chilean needle grass and African lovegrass control, especially in areas of NTG, is an essential management action to prevent the further degradation of native pasture and NTG, and GSM</p>	<p>ACT Government to co-ordinate with Sport and Recreation Services</p>	<p>Ongoing</p>	<p>Sport and Recreation have undertaken weed control activities; however, they do not appear to have targeted Chilean needle grass or African lovegrass, at least not at an effective level to prevent ongoing invasion.</p> <p>ACTEA has not received any funding to undertake weed control nor is weed control a component or responsibility of their operations at the equestrian park.</p>	<p>Not compliant. Considerable, targeted weed control effort is now required to meet compliance. The weed control implementation component of the OMP needs reviewing.</p>

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Activity	Description	Responsibility	Timeframe	Action summary	Compliance Summary ¹
	habitat. Sport and Recreation to undertake Chilean needle grass and African lovegrass spot control in areas of NTG.				
Tree and Shrub Removal	All regenerating trees and shrubs in native pasture and NTG areas, i.e. GSM habitat areas, as identified on the latest GSM habitat maps, are recommended to be removed. No tree planting is to occur in or within 20 m of GSM habitat or NTG.	ACT Government to co-ordinate with Sport and Recreation Services	Ongoing (undertaken as part of weed control)	SMEC is not aware of removal of trees and shrubs No trees have been planted, as specified.	Partially compliant with activity requirement.
Soil Cultivation	Soil cultivation, e.g. ploughing, rotovating, spike and core aeration in exotic pasture areas, as defined on the latest vegetation map, is permitted without consultation. Soil cultivation, e.g. ploughing, rotovating, spike and core aeration in native pasture or NTG areas, as defined on the latest vegetation map, requires consultation with the ACT Government and may require a site inspection by a suitable qualified environmental professional.	ACTEA in consultation with ACT Government	Ongoing	SMEC is not aware of any soil cultivation outside the specification.	Fully compliant with activity requirement.
Management of Stable Waste and Sand	Stable waste may be spread around jumps and along cross-country galloping routes ² in exotic pasture, mixed pasture and native pasture areas, as defined on the latest vegetation map ³ , without consultation. Stable waste can be spread around jumps and along cross-country galloping routes without consultation. Stable waste is not to be spread in NTG areas except on cross-country galloping routes and only at depths of 1-10 cm with an average depth of 5 cm and a maximum width of 3 m. Sand may be spread on cross-country galloping routes through native pasture and NTG areas at depths of 1-10 cm with an average depth of 5 cm	ACTEA	Ongoing	SMEC is not aware of any stable waste and sand use outside the specification.	Fully compliant with activity requirement.

² Cross-country galloping routes are those routes used for organised competitions.

³ The latest vegetation map shall be published on the ACT Government website.

Activity	Description	Responsibility	Timeframe	Action summary	Compliance Summary ¹
	<p>and a maximum width of 3 m.</p> <p>Sand may be spread over areas of now more than 12 m² on either side of a horse jump at depths of 1-10 cm with an average depth of 5 cm.</p> <p>Sand may be spread on the two concrete crossings over Yarralumla Creek as required for horse and rider safety.</p> <p>Sand may be spread on 'slippery' areas, as an emergency measure during organised equestrian competitions.</p> <p>Additional spreading of sand and stable waste is not to be undertaken without consultation with the ACT Government.</p>				
Grazing	Grazing does not take place in the project area and is not to occur in the future.	ACT Government	Permanent	No grazing has taken place.	Fully compliant with activity requirement.
Burning	Burning is not to be used as a vegetation management tool.	ACT Government	Permanent	Burning has not been used as a vegetation management tool.	Fully compliant with activity requirement.
Vehicle Movement	<p>Vehicles, including jump judge vehicles are to be kept out of NTG areas, as defined on the latest vegetation map, at all times, except:</p> <ul style="list-style-type: none"> during jump maintenance / construction, in which event vehicle movement must be minimised to that absolutely necessary; and where it is not possible to avoid crossing NTG areas, in which event vehicles must do so using the shortest route. <p>Jump maintenance / construction should be undertaken outside of the GSM flying season whenever possible.</p>	ACTEA	Ongoing	<p>ACTEA advises that ACTEA vehicle movement has been kept to a minimum, as specified.</p> <p>Ikon Water contractors and unknown surveyors working on the ACT Healthy Waterways Project (Yarralumla Creek) have repeatedly driven across sensitive NTG areas and created tracks through the grass in some places. The traffic has been uncontrolled and apparently without the</p>	Partially compliant ACT Government contractors should be made aware of the offset requirements. Works associated with the ACT Healthy Waterways Project should be compliant. with the YEP EPBC

Activity	Description	Responsibility	Timeframe	Action summary	Compliance Summary ¹
				knowledge of the offset constraints. The Yarralumla Creek stabilisation works planned for the next 12 months, as part of the ACT Healthy Waterways Project, would potentially increase vehicle traffic across the offset area.	Approval Conditions.
Establishment of new jumps, infrastructure	New jumps and infrastructure in exotic pasture areas, as defined on the latest vegetation map, are permitted without consultation. New jumps and infrastructure in mixed pasture and native pasture areas, as defined on the latest vegetation map*, which require minimal soil disturbance of no more than 3 m ² , i.e. the equivalent of several post-holes, are permitted without consultation. Features with a construction or built disturbance area exceeding 3 m ² , e.g. platform jumps, require consultation with the ACT Government and may require a site inspection by a suitable qualified environmental professional. All new jumps, infrastructure and disturbance in natural temperate grassland areas, as defined on the latest vegetation map, require consultation with the ACT Government and may require a site inspection by a suitable qualified environmental professional.	ACT Government in consultation with a suitably qualified environmental professional.	As needed	One new jump comprising 9 poles was established in NTG adjacent to sampling point 8 (Section 3.8). The area of disturbance, which measures 5 m × 5 m is now dominated by African lovegrass. The ACTEA did not consult with the ACT Government. The disturbance area was small compared with the area lost to weed invasion and the area disturbed by contractor vehicles.	One case of non-compliance. ACTEA volunteer staff need to be reminded of the approval conditions and appropriate actions specifically regarding jump establishment.
New Track Formation	New formed tracks, e.g. fire trails, access tracks, gravel tracks and footpaths, require consultation with the ACT Government before development and may require a site inspection by a suitable qualified environmental professional. This description does not apply to cross-country horse riding courses that develop during competition or general use.	ACT Government	Ongoing	ACTEA has not created any new vehicle tracks, as specified. Ikon Water contractors and unknown surveyors working on the ACT Healthy Waterways Project (Yarralumla Creek) have	Partially compliant ACT Government contractors should be made aware of the offset requirements.

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Activity	Description	Responsibility	Timeframe	Action summary	Compliance Summary ¹
				repeatedly driven across sensitive NTG areas and created tracks through the grass in some places. The traffic has been uncontrolled and apparently without the knowledge of the offset constraints. The Yarralumla Creek stabilisation works planned for the next 12 months, as part of the ACT Healthy Waterways Project, would potentially increase vehicle traffic across the offset area.	Works associated with the ACT Healthy Waterways Project should be compliant with the YEP EPBC Approval Conditions.
Interpretive Signage	GSM interpretive signage (e.g. Appendix I) is to be erected in suitable locations around the YEP. Three signs are proposed. These would be located at the YEP entrance off Cotter Road, at the Woolshed carpark and at the YEP entrance opposite the Molonglo River crossing.	ACT Government in association with ACTEA	2014	Signage has been erected in consultation with ACTEA and the LDA in three appropriate places with consideration given to the more heavily trafficked routes, as specified.	Fully compliant with activity requirement
Document Display	The Offset Management Plan is to be available on the ACT Government website. Monitoring reports and revised vegetation and GSM habitat maps are to be available on the ACT Government website.	ACT Government	Ongoing	ACTEA has the OMP available on its website. The ACT Government, Environment, Planning and Sustainable Development Directorate – Planning website ⁴ lists the Yarralumla Equestrian Park Offset Area and relevant OMP and the 2016 and 2017 monitoring reports.	Partially compliant. The 2014 and 2015 monitoring reports need to be added to the ACT Government website.

⁴ ACT Government, EPSDD website http://www.planning.act.gov.au/topics/design_build/da_assessment/environmental_assessment/offsets_register.

6. Conclusion and Recommendations

Background

This report presents the results of the 2017 monitoring surveys in the Yarralumla Equestrian Park (YEP) offset area conducted in accordance with the Yarralumla Equestrian Park Offset Management Plan (RJPL 2014a, the OMP). This report fulfils the reporting requirements for GSM monitoring at the YEP for year 4 as specified in the OMP (RJPL 2014a).

Results

The 2017 survey indicates that GSM remain widespread throughout YEP at low-moderate numbers; however, introduced grass species have increasingly dominated much of the site in recent years reducing the extent of native pasture and moderate quality GSM habitat. An increase in the distribution of perennial exotic tussock grasses represents a major threat to the extent and condition of native grassland and GSM habitat at the YEP, and hence compliance with the offsetting requirement of the Commonwealth approval conditions.

The key results of the 2017 monitoring program are:

- The spatial extent of NTG has not increased or declined. The extent of native pasture at the site has declined due to perennial exotic tussock grass invasion.
- While the total extent of GSM habitat has increased since 2013, the extent of moderate quality habitat has decreased with a corresponding increase in the extent of low quality habitat and Chilean needle grass dominated habitat. This is correlated with exotic perennial tussock grasses invading the site, and is indicative of a general decline in GSM habitat quality at the YEP.
- Floristic value scores have not shown a statistically significant increase or decline at the site over the five-year monitoring period.
- Grassland ranking scores have not increased, instead have shown a qualitative decline, since 2015.
- GSM habitat ranking scores have not increased, instead have shown a qualitative decline, over five years.
- GSM flying moth numbers have not shown a statistically significant increase or decline over five years.

This monitoring report provides evidence that existing management actions are not effectively conserving or improving NTG or GSM habitat at the YEP. A review of management actions at the YEP is triggered due to the lack of the required improvements, as measured against the impact thresholds specified in the OMP.

Recommendations

Future mapping of NTG extent should be revised to account for the revised EPBC Act-listing for critically endangered Natural Temperate Grassland of the South-Eastern Highlands, and associated updated condition thresholds (Australian Government 2016).

A review of the management programme at YEP has been triggered due to an assessment of performance compared with impact thresholds. To be compliant with Approval conditions 1(g) and 3, the ACT Government must review the offset management programme performance in consultation with the Commonwealth, PCS and the ACTEA. The following recommendations should be considered during the management planning process review:

- Ongoing management actions should be revised and an active management response developed and implemented in consultation with the Commonwealth and PCS. Specifically,

the following management activities, which may be non-compliant or only partially compliant with the requirements of the OMP, were identified and require urgent review:

- Weed control
 - Tree and shrub removal
 - Vehicle movement
 - Establishment of new jumps, infrastructure
 - New track formation.
- Future management actions should be targeted to address both maintenance and restoration requirements for Offset management. This could be facilitated by reviewing the over-arching objective of improving the condition and extent of NTG and GSM habitat at the site in consultation with the Commonwealth and PCS, and, if retained a restoration plan, in contrast to a maintenance plan, would need to be developed to enable delivery of the specified improvement targets.

Of critical priority, and requiring action independent of the management plan review process, is control of perennial exotic tussock grasses, specifically African lovegrass, Chilean needle grass and serrated tussock. Invasion by these species is threatening the extent, integrity and condition of NTG and GSM habitat at the YEP.

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Appendices

Appendix A Vegetation and Habitat Survey 2017

Scientific Name	Common Name	E/N*	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Plant Status
Native Grasses															
<i>Austrostipa bigeniculata</i>	tall spear grass	N		3	4	1	r	r	3	1			2	2	
<i>Austrostipa scabra</i>	rough speargrass	N								1				4	
<i>Bothriochloa macra</i>	redleg grass	N		2					2	2		1	3	1	
<i>Carex</i> sp.	carex sp.	N					+								
<i>Elymus scabra</i>	wheat grass	N												1	
<i>Panicum effusum</i>	hairy panic	N										1			
<i>Rytidosperma caespitosum</i>	tall wallaby grass	N		2											
<i>Rytidosperma carphoides</i>	short wallaby grass	N		2					3	2		2			
<i>Rytidosperma</i> sp.	wallaby grass	N			3				3	3	+		2	1	
<i>Themeda australis</i>	kangaroo grass	N							+	+					

Scientific Name	Common Name	E/N*	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Plant Status
Native forbs															
<i>Acaena ovina</i>	sheep's burr	N							r						
<i>Chrysocephalum apiculatum</i>	yellow buttons	N		2	2	r			2	3		2		2	
<i>Euchiton</i> sp.	cudweed sp.	N								r					
<i>Lomandra bracteata</i>	mat-rush sp.	N			r										
<i>Lomandra filiformis</i> subsp. <i>coriacea</i>	mat-rush sp.	N								1					
<i>Lomandra multiflora</i>	mat-rush sp.	N			r				r	r		r		r	
<i>Rumex brownii</i>	swamp dock	N				r	r					r	r	r	
<i>Wahlenbergia communis</i>	tufted bluebell	N		1								+	+		
<i>Wahlenbergia luteola</i>	bluebell sp.	N			1				+			+		+	
<i>Wurmbea dioica</i>	early Nancy													3	
Exotic grasses															
<i>Aira</i> sp.	hairgrass	E					r		1						

Scientific Name	Common Name	E/N*	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Plant Status
<i>Avena</i> sp.	oats	E	+			3	1	4	2	1	4	1	1	r	
<i>Briza minor</i>	shivery grass	E													
<i>Bromus catharticus</i>	prairie grass	E	2	1				2							
<i>Bromus diandrus</i>	ripgut brome	E									1				
<i>Bromus hordeaceus</i>	soft brome	E				1								1	
<i>Bromus</i> spp.	bromes	E			1	2	1		1	1	2	2	1		
<i>Dactylis glomerata</i>	cocksfoot	E	3	2	2	3	1	3							
<i>Eragrostis curvula</i>	African lovegrass	E		2	1				1	4		3	4	2	ACT C; WoNS
<i>Festuca arundinacea</i>	tall fescue	E		+			2				r			r	
<i>Hordeum</i> sp.	barley sp.	E						1							
<i>Lolium perenne</i>	perennial ryegrass	E	1					2							
<i>Nassella neesiana</i>	Chilean needle grass	E		+	2	2	4	1			1	2			ACT P, C; WoNS
<i>Nassella trichotoma</i>	serrated tussock	E												r	ACT P, C; WoNS

Scientific Name	Common Name	E/N*	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Plant Status
<i>Paspalum dilatatum</i>	paspalum	E				r	+		2		2	1		r	
<i>Phalaris aquatica</i>	tall phalaris	E							r						
<i>Poa annua</i>	annual meadow grass	E					1		1						
<i>Vulpia</i> sp.	rat's tail fescue	E	1	2	1	3	3	2	3	1		3	1	3	
Exotic forbs															
<i>Arctotheca calendula</i>	Cape weed	E			r	+		+							
<i>Cathamus lanatus</i>	saffron thistle	E										r			
<i>Centaurium</i> sp.	centaury sp.	E												+	
<i>Chondrilla juncea</i>	skeleton weed	E							r	r	+				
<i>Echium vulgare</i>	viper's bugloss	E								r	2	+			
<i>Erodium botrys</i>	stork's bill sp.	E	2		1	1									
<i>Erodium cicutarium</i>	common storksbill	E											1		
<i>Hirschfeldia incana</i>	hairy mustard	E	+		r	+	+	2	r		r				

Scientific Name	Common Name	E/N*	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Plant Status
<i>Hypericum perforatum</i>	St John's wort	E								r		+	1		ACT C
<i>Hypochaeris glabra</i>	flatweed	E												2	
<i>Hypochaeris radicata</i>	flatweed	E		2	1	1	1	+	+	1	1	+	1	2	
<i>Malva</i> sp.	mallow sp.	E						1							
<i>Moenchia erecta</i>	erect chickweed	E					r								
<i>Oenothera glazioviana</i>	large-flowered evening-primrose	E											r		
<i>Petrorhagia nanteuilii</i>	proliferous pink	E					r		1	+		1	1		
<i>Plantago lanceolata</i>	narrow leaf plantain	E	1	2			1	1	1			1	1	+	
<i>Spergularia rubra</i>	red sand-spurrey	E											+		
<i>Tolpis barbarta</i>	yellow hawkweed	E									3	r			
<i>Trifolium arvensis</i>	haresfoot clover	E		2			1					2	1	1	
<i>Trifolium campestre</i>	hop trefoil	E							1	1		2	2		

Scientific Name	Common Name	E/N*	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Plant Status
<i>Trifolium</i> sp.	clover	E		r						+					
<i>Trifolium subterraneum</i>	subterranean clover	E	2		1			1	1			1			

* E – Exotic, N - Native

Appendix B Flying GSM Survey 2017 – Point Survey, GSM Per Quadrat

Date	Survey	Quadrat	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4	Quadrat 5	Quadrat 6	Quadrat 7	Quadrat 8	Quadrat 9	Quadrat 10	Total	Average
9/11/2017	1	1	0	1	0	0	1	0	0	0	0	0	2	0.2
9/11/2017	1	2	1	1	3	0	0	2	1	0	0	0	8	0.8
9/11/2017	1	3	0	0	0	0	0	0	0	0	0	0	0	0
9/11/2017	1	4	0	0	0	0	0	0	0	0	0	1	1	0.1
9/11/2017	1	5	0	0	0	0	0	0	0	0	0	0	0	0
9/11/2017	1	6	1	0	1	1	0	2	3	1	0	1	10	1.0
9/11/2017	1	7	0	0	0	0	0	0	0	0	0	0	0	0
9/11/2017	1	8	1	1	0	0	1	1	1	0	0	1	6	0.6
9/11/2017	1	9	0	0	0	0	0	0	0	0	1	0	1	0.1
9/11/2017	1	10	0	0	0	0	0	0	0	0	0	0	0	0
9/11/2017	1	11	0	0	0	0	1	0	0	0	0	0	1	0.1
9/11/2017	1	12	0	0	0	0	0	0	0	0	0	0	0	0
30/11/2017	2	1	0	0	0	0	0	0	0	0	0	0	0	0
30/11/2017	2	2	1	0	0	0	0	0	1	2	0	0	4	0.4
30/11/2017	2	3	2	0	0	1	0	0	0	0	0	0	3	0.3
30/11/2017	2	4	0	0	0	0	0	0	0	0	0	0	0	0

Date	Survey	Quadrat	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4	Quadrat 5	Quadrat 6	Quadrat 7	Quadrat 8	Quadrat 9	Quadrat 10	Total	Average
30/11/2017	2	5	0	1	0	0	0	0	0	0	0	0	1	0.1
30/11/2017	2	6	0	0	0	0	0	0	0	0	0	0	0	0
30/11/2017	2	7	0	0	0	0	0	0	0	0	0	0	0	0
30/11/2017	2	8	0	0	0	0	0	0	0	0	0	0	0	0
30/11/2017	2	9	0	0	0	0	0	0	0	0	0	0	0	0
30/11/2017	2	10	0	0	0	0	0	0	0	0	0	0	0	0
30/11/2017	2	11	2	1	0	1	0	1	0	1	0	0	6	0.6
30/11/2017	2	12	0	0	0	0	0	0	0	1	2	2	5	0.5
12/12/2017	3	1	21	4	13	23	18	9	24	13	8	16	149	14.9
12/12/2017	3	2	2	1	0	2	2	4	4	4	4	1	24	2.4
12/12/2017	3	3	2	1	2	0	0	3	1	3	3	2	17	1.7
12/12/2017	3	4	6	12	4	3	3	4	4	5	1	1	43	4.3
12/12/2017	3	5	0	0	0	0	0	0	0	0	0	0	0	0
12/12/2017	3	6	0	1	2	0	0	1	0	0	0	0	4	0.4
12/12/2017	3	7	0	0	0	0	0	0	0	0	0	0	0	0
12/12/2017	3	8	0	0	0	0	0	0	0	0	1	0	1	0.1
12/12/2017	3	9	0	0	0	0	0	0	0	0	0	0	0	0

Date	Survey	Quadrat	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4	Quadrat 5	Quadrat 6	Quadrat 7	Quadrat 8	Quadrat 9	Quadrat 10	Total	Average
12/12/2017	3	10	1	0	0	1	1	0	0	0	0	0	3	0.3
12/12/2017	3	11	0	0	0	0	0	0	0	0	0	0	0	0
12/12/2017	3	12	0	0	0	0	0	0	0	0	0	0	0	0

Appendix C GSM Observations 2017

Date	Survey	x	y	No.	Male / Female	Observation Type
9/11/2017	1	688548	6090547	1	M	TRAVERSE
9/11/2017	1	688474	6090672	2	M	TRAVERSE
9/11/2017	1	688419	6090681	3	M	TRAVERSE
9/11/2017	1	688378	6090684	1	M	TRAVERSE
9/11/2017	1	688296	6090652	1	M	TRAVERSE
9/11/2017	1	688304	6090680	3	M	TRAVERSE
9/11/2017	1	688325	6090733	1	M	TRAVERSE
9/11/2017	1	688386	6090876	3	M	TRAVERSE
9/11/2017	1	688388	6090902	2	M	TRAVERSE
9/11/2017	1	688395	6090935	2	M	TRAVERSE
9/11/2017	1	688465	6090937	3	M	TRAVERSE
9/11/2017	1	688476	6090876	1	M	TRAVERSE
9/11/2017	1	688486	6090837	2	M	TRAVERSE
9/11/2017	1	688505	6090752	3	M	TRAVERSE
9/11/2017	1	688553	6090722	3	M	TRAVERSE
9/11/2017	1	688571	6090679	3	M	TRAVERSE
9/11/2017	1	688656	6090901	1	M	TRAVERSE
9/11/2017	1	688574	6090892	2	1M, 1F	TRAVERSE
9/11/2017	1	688564	6090942	2	M	TRAVERSE
9/11/2017	1	688679	6090785	1	M	TRAVERSE
9/11/2017	1	688701	6090771	1	M	TRAVERSE
9/11/2017	1	688758	6090660	1	M	TRAVERSE
9/11/2017	1	688659	6090559	2	M	TRAVERSE
9/11/2017	1	688710	6090572	2	M	TRAVERSE
9/11/2017	1	688641	6090814	1	F	INCIDENTAL
9/11/2017	1	688658	6090760	3	M	INCIDENTAL
9/11/2017	1	688490	6090736	4	M	INCIDENTAL
9/11/2017	1	688414	6090961	1	F	INCIDENTAL
9/11/2017	1	688414	6090917	2	M	INCIDENTAL

Date	Survey	x	y	No.	Male / Female	Observation Type
9/11/2017	1	688735	6090654	2	F	INCIDENTAL
9/11/2017	1	688685	6090779	1	F	INCIDENTAL
9/11/2017	1	688333	6090691	1	F	INCIDENTAL
9/11/2017	1	688424	6090681	0.2	M	POINT COUNT (AVERAGE)
9/11/2017	1	688333	6090691	0.8	M	POINT COUNT (AVERAGE)
9/11/2017	1	688387	6090809	0	M	POINT COUNT (AVERAGE)
9/11/2017	1	688421	6090864	0.1	M	POINT COUNT (AVERAGE)
9/11/2017	1	688431	6091040	0	M	POINT COUNT (AVERAGE)
9/11/2017	1	688534	6090760	1.0	M	POINT COUNT (AVERAGE)
9/11/2017	1	688888	6090612	0	M	POINT COUNT (AVERAGE)
9/11/2017	1	688735	6090654	0.6	F	POINT COUNT (AVERAGE)
9/11/2017	1	688789	6090726	0.1	M	POINT COUNT (AVERAGE)
9/11/2017	1	688685	6090779	0	M	POINT COUNT (AVERAGE)
9/11/2017	1	688631	6090838	0.1	M	POINT COUNT (AVERAGE)
9/11/2017	1	688612	6090954	0	M	POINT COUNT (AVERAGE)
30/11/2017	2	688529	6090647	3	2M, 1F	TRAVERSE
30/11/2017	2	688466	6090677	3	M	TRAVERSE
30/11/2017	2	688428	6090671	1	M	TRAVERSE
30/11/2017	2	688346	6090676	2	M	TRAVERSE
30/11/2017	2	688313	6090679	2	M	TRAVERSE
30/11/2017	2	688369	6090782	1	M	TRAVERSE
30/11/2017	2	688393	6090869	1	M	TRAVERSE
30/11/2017	2	688403	6090884	2	M	TRAVERSE

Date	Survey	x	y	No.	Male / Female	Observation Type
30/11/2017	2	688414	6090957	3	M	TRAVERSE
30/11/2017	2	688458	6090978	1	M	TRAVERSE
30/11/2017	2	688492	6090844	4	M	TRAVERSE
30/11/2017	2	688500	6090789	3	M	TRAVERSE
30/11/2017	2	688508	6090745	3	M	TRAVERSE
30/11/2017	2	688536	6090728	1	M	TRAVERSE
30/11/2017	2	688567	6090701	3	M	TRAVERSE
30/11/2017	2	688710	6090647	1	M	TRAVERSE
30/11/2017	2	688687	6090677	3	M	TRAVERSE
30/11/2017	2	688670	6090722	3	M	TRAVERSE
30/11/2017	2	688658	6090752	10	M	TRAVERSE
30/11/2017	2	688648	6090787	2	M	TRAVERSE
30/11/2017	2	688641	6090824	2	M	TRAVERSE
30/11/2017	2	688604	6090892	3	M	TRAVERSE
30/11/2017	2	688568	6090923	2	M	TRAVERSE
30/11/2017	2	688567	6090948	2	M	TRAVERSE
30/11/2017	2	688564	6090993	4	M	TRAVERSE
30/11/2017	2	688606	6090927	2	M	TRAVERSE
30/11/2017	2	688632	6090887	2	M	TRAVERSE
30/11/2017	2	688690	6090807	4	M	TRAVERSE
30/11/2017	2	688700	6090784	3	M	TRAVERSE
30/11/2017	2	688721	6090742	1	M	TRAVERSE
30/11/2017	2	688776	6090672	2	M	TRAVERSE
30/11/2017	2	688708	6090579	2	M	TRAVERSE
30/11/2017	2	688652	6090568	6	5M, 1F	TRAVERSE
30/11/2017	2	688666	6090921	6	M	INCIDENTAL
30/11/2017	2	688424	6090681	0	M	POINT COUNT (AVERAGE)
30/11/2017	2	688333	6090691	0.4	M	POINT COUNT (AVERAGE)
30/11/2017	2	688387	6090809	0.3	M	POINT COUNT (AVERAGE)

Date	Survey	x	y	No.	Male / Female	Observation Type
30/11/2017	2	688421	6090864	0	M	POINT COUNT (AVERAGE)
30/11/2017	2	688431	6091040	0.1	M	POINT COUNT (AVERAGE)
30/11/2017	2	688534	6090760	0	M	POINT COUNT (AVERAGE)
30/11/2017	2	688888	6090612	0	M	POINT COUNT (AVERAGE)
30/11/2017	2	688735	6090654	0	M	POINT COUNT (AVERAGE)
30/11/2017	2	688789	6090726	0	M	POINT COUNT (AVERAGE)
30/11/2017	2	688685	6090779	0	M	POINT COUNT (AVERAGE)
30/11/2017	2	688631	6090838	0.6	M	POINT COUNT (AVERAGE)
30/11/2017	2	688612	6090954	0.5	M	POINT COUNT (AVERAGE)
12/12/2017	3	688534	6090612	2	M	TRAVERSE
12/12/2017	3	688528	6090642	3	M	TRAVERSE
12/12/2017	3	688491	6090667	7	M	TRAVERSE
12/12/2017	3	688453	6090678	3	M	TRAVERSE
12/12/2017	3	688422	6090686	12	M	TRAVERSE
12/12/2017	3	688405	6090685	3	M	TRAVERSE
12/12/2017	3	688385	6090691	6	M	TRAVERSE
12/12/2017	3	688344	6090690	3	M	TRAVERSE
12/12/2017	3	688287	6090642	3	M	TRAVERSE
12/12/2017	3	688300	6090679	1	M	TRAVERSE
12/12/2017	3	688308	6090697	4	M	TRAVERSE
12/12/2017	3	688315	6090719	3	M	TRAVERSE
12/12/2017	3	688935	6090738	2	M	TRAVERSE
12/12/2017	3	688359	6090773	1	M	TRAVERSE
12/12/2017	3	688393	6090756	4	M	TRAVERSE
12/12/2017	3	688389	6090803	3	M	TRAVERSE

Date	Survey	x	y	No.	Male / Female	Observation Type
12/12/2017	3	688385	6090828	3	M	TRAVERSE
12/12/2017	3	688392	6090852	4	M	TRAVERSE
12/12/2017	3	688401	6090883	2	M	TRAVERSE
12/12/2017	3	688408	6090900	1	M	TRAVERSE
12/12/2017	3	688409	6090936	1	M	TRAVERSE
12/12/2017	3	688453	6090988	1	M	TRAVERSE
12/12/2017	3	688468	6090934	4	M	TRAVERSE
12/12/2017	3	688466	6090987	2	M	TRAVERSE
12/12/2017	3	688475	6090838	2	M	TRAVERSE
12/12/2017	3	688476	6090814	2	M	TRAVERSE
12/12/2017	3	688503	60900740	4	M	TRAVERSE
12/12/2017	3	688524	6090730	3	M	TRAVERSE
12/12/2017	3	688559	6090688	4	M	TRAVERSE
12/12/2017	3	688696	6090648	2	M	TRAVERSE
12/12/2017	3	688658	6090747	8	M	TRAVERSE
12/12/2017	3	688656	6090767	10	M	TRAVERSE
12/12/2017	3	688650	6090793	3	M	TRAVERSE
12/12/2017	3	688629	6090819	2	M	TRAVERSE
12/12/2017	3	688619	6090840	2	M	TRAVERSE
12/12/2017	3	688559	6090989	2	M	TRAVERSE

Date	Survey	x	y	No.	Male / Female	Observation Type
12/12/2017	3	688671	6090788	1	M	TRAVERSE
12/12/2017	3	688696	6090768	2	M	TRAVERSE
12/12/2017	3	688704	6090575	1	M	TRAVERSE
12/12/2017	3	688646	6090565	2	1M, 1F	TRAVERSE
12/12/2017	3	688650	6090789	1	F	INCIDENTAL
12/12/2017	3	688424	6090681	14.9	M	POINT COUNT (AVERAGE)
12/12/2017	3	688333	6090691	2.4	M	POINT COUNT (AVERAGE)
12/12/2017	3	688387	6090809	1.7	M	POINT COUNT (AVERAGE)
12/12/2017	3	688421	6090864	4.3	M	POINT COUNT (AVERAGE)
12/12/2017	3	688431	6091040	0	M	POINT COUNT (AVERAGE)
12/12/2017	3	688534	6090760	0.4	M	POINT COUNT (AVERAGE)
12/12/2017	3	688888	6090612	0	M	POINT COUNT (AVERAGE)
12/12/2017	3	688735	6090654	0.1	M	POINT COUNT (AVERAGE)
12/12/2017	3	688789	6090726	0	M	POINT COUNT (AVERAGE)
12/12/2017	3	688685	6090779	0.3	M	POINT COUNT (AVERAGE)
12/12/2017	3	688631	6090838	0	M	POINT COUNT (AVERAGE)
12/12/2017	3	688612	6090954	0	M	POINT COUNT (AVERAGE)

Date	Survey	x	y	No.	Male / Female	Observation Type
12/01/2018		688581	6090659	1	M	INCIDENTAL
12/01/2018		688635	6090809	2	M	INCIDENTAL
12/01/2018		688681	6090733	1	M	INCIDENTAL
12/01/2018		688710	6090639	1	M	INCIDENTAL

Appendix D Summarised Meteorological Data 2013-2017

Year	Month	Monthly Precipitation (mm)	Average Maximum Daily Air Temperature (°C)	Average Minimum Daily Air Temperature (°C)	Average Maximum Daily Soil Temperature (°C at 10 cm depth)	Average Minimum Daily Soil Temperature (°C at 10 cm depth)
2013	January	72.6	32.3	13.9	33.2	23.8
2013	February	30.0	27.4	12.8	30.0	21.4
2013	March	197.2	25.7	9.6	Data unavailable	Data unavailable
2013	April	9.8	22.1	5.5	Data unavailable	Data unavailable
2013	May	19.8	17.4	1.3	Data unavailable	Data unavailable
2013	June	85.2	13.9	1.6	Data unavailable	Data unavailable
2013	July	42.8	13.4	1.7	10.5	6.2
2013	August	27.0	14.8	2.4	12.1	6.6
2013	September	91.0	19.9	4.0	17.8	10.8
2013	October	13.4	21.9	3.8	21.7	13.3
2013	November	105.6	23.8	6.7	25.3	16.3
2013	December	23.2	28.5	11.5	33.7	23.6
2014	January	4.8	31.6	12.1	35.7	24.8
2014	February	83.6	29.4	13.5	33.2	23.8
2014	March	88.0	24.2	12.2	25.0	18.7
2014	April	16.9	19.7	7.4	19.3	13.9
2014	May	14.4	17.6	2.7	14.7	9.5
2014	June	57.2	13.2	2.8	10.7	7.3
2014	July	34.9	12.2	0.0	9.1	4.9
2014	August	26.8	14.3	-0.8	11.8	5.7
2014	September	36.2	17.9	2.7	16.9	9.5
2014	October	53.4	22.5	5.4	22.5	13.9
2014	November	29.0	27.9	10.2	29.5	19.9

Year	Month	Monthly Precipitation (mm)	Average Maximum Daily Air Temperature (°C)	Average Minimum Daily Air Temperature (°C)	Average Maximum Daily Soil Temperature (°C at 10 cm depth)	Average Minimum Daily Soil Temperature (°C at 10 cm depth)
2014	December	102	27.7	12.7	29.5	20.4
2015	January	34.8	27.2	13.9	29.6	21.4
2015	February	30.2	28.3	13.0	30.0	21.4
2015	March	12.4	26.1	9.0	27.1	18.6
2015	April	91.8	19.1	7.1	17.7	12.6
2015	May	12.2	16.0	2.8	14.0	8.8
2015	June	55.2	13.7	-0.8	10.6	5.7
2015	July	37.2	11.6	-0.7	8.6	3.9
2015	August	66.8	13.7	1.0	10.7	5.3
2015	September	13.6	17.7	1.5	17.3	8.7
2015	October	26.6	24.8	8.3	24.6	16.2
2015	November	67.6	25.6	10.9	26.1	17.9
2015	December	34.8	29.3	11.4	32.3	21.9
2016	January	106.4	28.5	14.0	29.0	21.5
2016	February	23.4	29.3	13.3	31.5	22.6
2016	March	28.4	27.7	12.6	28.1	20.2
2016	April	6.8	23.8	8.3	22.8	16.3
2016	May	47.6	17.4	4.8	15.0	9.9
2016	June	144.2	13.0	3.0	10.4	6.6
2016	July	71.0	12.7	2.2	10.2	5.8
2016	August	46.2	14.3	1.1	11.9	5.8
2016	September	149.2	15.8	4.8	14.7	8.7
2016	October	43.6	18.5	5.2	19.5	11.0
2016	November	56.8	24.8	8.6	28.0	17.6
2016	December	64.6	28.7	13.5	29.8	21.4
2017	January	8.4	32.8	14.9		

Year	Month	Monthly Precipitation (mm)	Average Maximum Daily Air Temperature (°C)	Average Minimum Daily Air Temperature (°C)	Average Maximum Daily Soil Temperature (°C at 10 cm depth)	Average Minimum Daily Soil Temperature (°C at 10 cm depth)
2017	February	20.6	30.1	12.9		
2017	March	85.2	25.9	12.8		
2017	April	31.6	19.9	5.5		
2017	May	34.2	16.4	1.6		
2017	June	2.4	13.6	-1.4		
2017	July	17.0	12.9	-2.3		
2017	August	49.2	13.9	0.5		
2017	September	13.4	18.1	2.7		
2017	October	58.4	23.2	7.1		
2017	November	70.4	24.3	9.6		
2017	December	95.2	27.8	13.9		

Appendix E Detailed Meteorological Data During the GSM Flying Period

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2013	October	1	0	22.0	8.7	16.7	13.3
2013	October	2	0.4	17.3	4.1	18.4	10.0
2013	October	3	0	16.8	6.2	17.3	12.0
2013	October	4	0	18.5	-1.5	20.6	9.5
2013	October	5	0	20.3	0.5	18.3	10.8
2013	October	6	0	26.1	3.5	20.3	11.8
2013	October	7	0	20.2	2.9	22.0	12.5
2013	October	8	0	19.1	1.7	20.5	13.3
2013	October	9	0	24.8	1.6	22.2	12.5
2013	October	10	0	28.5	6.6	23.0	15.0
2013	October	11	0	20.9	4.7	23.5	15.5
2013	October	12	0	24.0	0.5	23.6	13.7
2013	October	13	0	26.4	2.6	23.8	14.7
2013	October	14	2.2	15.6	1.5	21.0	13.5
2013	October	15	0	19.4	-2.6	21.5	11.6
2013	October	16	0	23.3	1.1	21.9	12.7
2013	October	17	0	21.2	13.7	20.0	15.1
2013	October	18	0	20.5	-3.4	23.4	11.6
2013	October	19	0	24.4	0.9	24.2	13.1
2013	October	20	0	27.2	2.5	24.0	14.3
2013	October	21	0	32.1	5.8	24.9	15.4
2013	October	22	6.6	22.3	13.6	21.7	18.2
2013	October	23	4.2	19.9	15.5	20.8	16.9
2013	October	24	0	16.0	7.9	22.5	14.0
2013	October	25	0	19.0	-2.3	23.7	12.1
2013	October	26	0	22.1	-0.7	25.1	13.0

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2013	October	27	0	21.0	0.9		
2013	October	28	0	23.1	10.1		
2013	October	29	0	20.4	6.0		
2013	October	30	0	22.1	0.6		
2013	October	31	0	24.6	3.3		
2013	November	1	0	25.9	9.2	28.7	19.0
2013	November	2	0	27.0	5.1	25.8	17.8
2013	November	3	0	26.1	5.7	27.0	17.0
2013	November	4	0	18.6	-1.5	26.3	15.6
2013	November	5	0	23.5	-0.3	28.7	15.2
2013	November	6	0	26.8	1.9	29.9	16.7
2013	November	7	0	30.8	5.2	29.9	18.1
2013	November	8	0	32.0	9.9	27.8	20.1
2013	November	9	6.0	22.1	13.0	27.5	18.4
2013	November	10	0.2	11.9	8.9	20.8	14.4
2013	November	11	27.2	14.6	6.4	14.9	12.7
2013	November	12	38.6	23.0	9.5	22.2	12.7
2013	November	13	0	20.0	4.2	19.3	13.7
2013	November	14	0	21.3	5.7		
2013	November	15	0	23.1	4.6		
2013	November	16	4.0	19.0	10.3		
2013	November	17	0	21.4	4.3		
2013	November	18	0	22.5	4.8		
2013	November	19	0	27.9	4.2		
2013	November	20	1.0	29.3	7.4		
2013	November	21	0	27.7	11.5		
2013	November	22	26.6	26.0	12.9		
2013	November	23	0	23.3	6.8		
2013	November	24	0	22.5	5.7		

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2013	November	25	1.2	20.6	7.4		
2013	November	26	0.2	22.9	2.9		
2013	November	27	0	27.3	5.0		
2013	November	28	0	31.6	8.6		
2013	November	29	0.4	21.8	13.7		
2013	November	30	0.2	22.7	6.9		
2013	December	1	0	23.5	7.9		
2013	December	2	0	29.3	7.9		
2013	December	3	0	31.5	10.2		
2013	December	4	0	32.4	14.9		
2013	December	5	10.2	17.4	11.9		
2013	December	6	2.4	19.6	5.2		
2013	December	7	0	24.1	2.7		
2013	December	8	0	28.2	6.6		
2013	December	9	0	32.6	13.0		
2013	December	10	0	22.8	15.6		
2013	December	11	0	23.3	5.6		
2013	December	12	0	26.5	4.9		
2013	December	13	0	28.7	5.7	32.5	20.3
2013	December	14	0	25.0	13.1	32.3	23.0
2013	December	15	1.8	26.5	13.8	30.7	22.1
2013	December	16	0	27.3	14.8	32.2	22.9
2013	December	17	4.4	30.7	12.1	32.5	21.8
2013	December	18	0	31.9	13.8	35.9	23.2
2013	December	19	0	35.1	12.7	36.1	24.4
2013	December	20	0	37.2	14.4	36.8	25.5
2013	December	21	0	31.3	17.2	36.8	26.7
2013	December	22	0	38.1	16.9	34.9	26.8
2013	December	23	0	27.6	19.0	30.0	26.4

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2013	December	24	0	24.9	9.4	33.1	22.2
2013	December	25	0	21.9	15.0	26.9	24.4
2013	December	26	0.4	29.9	8.9	33.6	20.5
2013	December	27	4.0	30.2	10.3	33.1	21.8
2013	December	28	0	33.1	13.3	35.3	23.1
2013	December	29	0	30.4	14.7	36.4	24.0
2013	December	30	0	30.4	13.3	36.1	24.9
2013	December	31	0	31.4	10.6	36.0	24.8
2014	October	1	0	16.9	4.8	22.5	13.1
2014	October	2	0	20.0	-2.0	21.3	11.6
2014	October	3	0	20.9	-0.7	23.3	11.6
2014	October	4	0	22.5	10.1	24.2	15.7
2014	October	5	0	27.5	3.7	24.1	14.1
2014	October	6	0	28.1	6.7	24.7	15.8
2014	October	7	11.8	19.8	11.0	20.5	16.0
2014	October	8	0	19.8	2.0	21.4	12.1
2014	October	9	0	20.2	2.2	22.6	12.9
2014	October	10	0.2	22.1	0.4	22.0	13.0
2014	October	11	0	26.6	3.1	25.1	13.7
2014	October	12	0	27.6	4.5	25.0	14.9
2014	October	13	4.8	21.1	13.7	20.1	16.8
2014	October	14	15.4	8.7	6.2	15.0	11.2
2014	October	15	15.2	15.9	6.3	14.8	9.2
2014	October	16	0	17.1	-0.7	17.3	8.8
2014	October	17	0	17.1	1.1	17.9	9.7
2014	October	18	0	20.4	0.6	21.8	10.2
2014	October	19	0	25.1	2.5	23.3	12.4
2014	October	20	0	17.1	6.9	19.5	15.1
2014	October	21	0	17.6	9.5	19.7	14.1

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2014	October	22	0	24.9	9.7	24.7	14.5
2014	October	23	0	27.2	8.3	23.3	16.0
2014	October	24	6	28.4	9.7	23.2	15.7
2014	October	25	0	30.0	7.8	25.9	15.6
2014	October	26	0	29.2	8.0	26.7	17.2
2014	October	27	0	24.6	8.5	22.8	18.0
2014	October	28	0	19.8	7.2	23.4	14.7
2014	October	29	0	23.9	7.0	26.4	15.4
2014	October	30	0	26.5	4.4	26.6	16.0
2014	October	31	0	32.0	5.1	27.5	16.6
2014	November	1	0	26.5	14.6	23.9	19.8
2014	November	2	0.2	20.0	4.6	25.3	14.9
2014	November	3	0	22.6	3.3	27.5	15.3
2014	November	4	0	25.2	10.4	28.0	18.8
2014	November	5	0	27.2	9.3	26.0	18.3
2014	November	6	0	24.4	11.8	28.1	18.8
2014	November	7	0	27.4	5.3	30.6	18.2
2014	November	8	0	30.0	5.5	31.0	19.4
2014	November	9	0	33.3	7.7	31.9	19.8
2014	November	10	0	29.3	13.9	33.1	22.3
2014	November	11	0	26.9	8.4	31.8	21.3
2014	November	12	0	27.9	9.6	32.1	21.2
2014	November	13	0	31.2	9.8	32.7	21.9
2014	November	14	0	37.2	9.6	32.5	22.5
2014	November	15	0	29.4	14.5	27.2	22.7
2014	November	16	13.6	18.0	13.9	21.4	17.4
2014	November	17	4.4	23.6	9.3	23.6	13.8
2014	November	18	0	25.7	5.1	28.2	15.1
2014	November	19	0	27.8	13.0	30.2	19.5

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2014	November	20	0	31.4	7.4	30.3	19.0
2014	November	21	0	30.2	12.6	32.0	21.6
2014	November	22	0	31.8	12.5	32.7	22.5
2014	November	23	0	39.0	11.2	34.8	22.6
2014	November	24	0.2	26.4	18.8	28.8	24.6
2014	November	25	5.6	25.4	14.2	29.1	19.2
2014	November	26	0	26.7	6.5	31.3	18.8
2014	November	27	0	25.9	14.2	29.7	22.0
2014	November	28	0	27.5	5.7	32.9	19.9
2014	November	29	0	29.7	9.9	31.6	22.2
2014	November	30	0.2	27.9	13.5	27.3	23.1
2014	December	1	4.0	32.7	11.6	30.1	19.9
2014	December	2	0.8	33.0	13.8	31.7	21.3
2014	December	3	0	31.8	13.5	28.1	22.6
2014	December	4	19.6	28.2	14.5	25.4	20.2
2014	December	5	6.0	28.4	13.4	25.9	19.1
2014	December	6	0	22.6	15.8	22.5	19.5
2014	December	7	42.4	27.5	10.4	23.9	16.8
2014	December	8	0	29.1	11.0	27.3	17.2
2014	December	9	0	29.4	16.0	31.4	19.9
2014	December	10	0	30.8	13.8	30.5	21.6
2014	December	11	10.6	22.6	15.0	23.6	19.8
2014	December	12	1.4	22.2	11.6	24.2	15.6
2014	December	13	0	22.5	12.0	28.4	17.3
2014	December	14	0	28.1	7.2	29.9	17.5
2014	December	15	0	30.8	9.6	33.1	19.3
2014	December	16	1.6	32.6	16.2	30.3	22.1
2014	December	17	1.2	25.9	14.4	32.9	20.9
2014	December	18	0	27.4	9.6	32.6	21.2

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2014	December	19	0	25.3	8.6	33.5	21.1
2014	December	20	0	27.4	10.7	34.7	22.5
2014	December	21	0	30.2	12.4	35.3	24.0
2014	December	22	0	30.8	14.3	33.3	24.6
2014	December	23	5.2	29.0	16.4	29.5	23.0
2014	December	24	3.6	24.9	17.2	26.6	22.3
2014	December	25	0.6	27.0	16.8	26.1	21.0
2014	December	26	4.8	24.6	15.0	29.4	19.8
2014	December	27	0.2	22.7	11.6	29.4	19.7
2014	December	28	0	26.7	9.7	31.3	19.9
2014	December	29	0	29.7	11.2	29.2	21.3
2014	December	30	0	25.0	11.0	30.5	20.7
2014	December	31	0	29.2	7.9	34.4	20.5
2015	October	1	0	24.9	11.1	23.9	15.1
2015	October	2	0	26.5	0.9	25.3	12.5
2015	October	3	0	28.3	2.8	24.8	13.4
2015	October	4	0	31.7	6.7	23.3	14.1
2015	October	5	0	31.8	9.1	25.4	15.4
2015	October	6	0	18.6	6.8	26.4	15.7
2015	October	7	0	20.0	7.4	22.1	16.6
2015	October	8	0	27.1	8.5	23.2	15.5
2015	October	9	0.2	27.4	7.6	26.4	15.5
2015	October	10	8.6	22.1	5.9	23.8	15.0
2015	October	11	0	25.0	6.5	20.5	14.5
2015	October	12	0	21.3	7.7	24.7	14.8
2015	October	13	0	26.1	11.3	23.6	16.8
2015	October	14	0	28.5	11.0	26.6	17.0
2015	October	15	0	30.1	7.7	27.5	16.9
2015	October	16	0	27.8	8.2	27.8	17.5

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2015	October	17	0	21.6	11.1	25.2	19.8
2015	October	18	1.8	27.6	11.5	25.2	17.5
2015	October	19	0.2	29.5	12.1	28.3	17.9
2015	October	20	0	23.8	9.4	28.2	19.0
2015	October	21	2.6	19.0	15.0	22.4	19.7
2015	October	22	13	16.7	12.4	19.7	17.2
2015	October	23	0.2	23.1	9.8	19.2	14.2
2015	October	24	0	26.5	6.8	23.8	13.6
2015	October	25	0	27.0	4.7	26.4	14.2
2015	October	26	0	17.4	7.6	25.0	16.4
2015	October	27	0	22.5	9.6	24.9	16.7
2015	October	28	0	25.3	8.0	28.6	16.6
2015	October	29	0	25.0	5.2	30.0	17.1
2015	October	30	0	22.5	5.0	28.2	18.0
2015	October	31	0	25.3	8.9	23.3	18.9
2015	November	1	2.2	25.4	8.9	23.4	16.2
2015	November	2	19.4	21.3	14.0	22.3	17.4
2015	November	3	0	20.8	13.8	21.5	17.0
2015	November	4	0	22.3	13.9	19.3	16.8
2015	November	5	2.2	23.7	13.5	19.5	16.0
2015	November	6	14.2	23.2	14.7	20.9	17.1
2015	November	7	0	20.7	9.6	25.3	15.7
2015	November	8	0.6	27.8	10.2	25.3	16.5
2015	November	9	0	30.7	9.7	29.5	16.7
2015	November	10	0	18.7	9.7	30.6	18.7
2015	November	11	0	22.7	13.2	23.2	19.9
2015	November	12	9.4	23.6	13.7	21.4	17.3
2015	November	13	9.6	15.3	12.3	23.1	16.8
2015	November	14	8.8	21.1	11.6	18.7	16.8

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2015	November	15	1.2	23.3	10.7	-	-
2015	November	16	0	26.5	4.9	26.8	13.5
2015	November	17	0	30.0	7.0	28.0	16.5
2015	November	18	0	34.8	9.6	29.3	17.9
2015	November	19	0	36.1	10.6	30.1	19.1
2015	November	20	0	26.5	13.1	32.3	20.9
2015	November	21	0	25.3	15.2	33.5	22.6
2015	November	22	0	26.1	13.5	30.4	22.5
2015	November	23	0	27.4	8.0	31.5	20.6
2015	November	24	0	30.3	6.9	32.0	20.4
2015	November	25	0	23.7	5.2	31.6	19.9
2015	November	26	0	22.9	19.5	29.3	23.3
2015	November	27	0	27.4	0.5	30.1	17.8
2015	November	28	0	27.4	9.2	30.3	20.0
2015	November	29	0	28.4	15.9	31.5	22.7
2015	November	30	0	35.0	7.9	32.3	20.9
2015	December	1	0	23.2	10.4	31.3	21.7
2015	December	2	1.4	26.8	12.0	31.0	20.3
2015	December	3	0	29.8	6.6	32.8	19.7
2015	December	4	0	32.0	7.8	34.2	20.6
2015	December	5	0	32.7	8.1	33.8	21.9
2015	December	6	0	28.8	11.2	34.8	23.0
2015	December	7	0	28.2	15.7	31.4	23.9
2015	December	8	0	30.6	16.8	27.4	23.7
2015	December	9	0.4	31.6	17.2	32.7	22.5
2015	December	10	0	27.4	12.2	33.7	22.8
2015	December	11	0	26.1	10.8	32.5	23.5
2015	December	12	0	27.7	3.8	34.0	21.3
2015	December	13	0	32.2	7.3	32.5	21.8

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2015	December	14	0	30.3	6.5	35.4	21.3
2015	December	15	0	27.0	12.4	30.6	23.6
2015	December	16	0	30.2	13.1	31.6	23.0
2015	December	17	16.0	33.6	10.4	29.9	18.5
2015	December	18	0	36.3	13.6	34.6	21.0
2015	December	19	0	37.0	15.4	35.9	23.9
2015	December	20	0	27.9	16.2	36.6	25.5
2015	December	21	0	24.9	19.3	30.8	26.2
2015	December	22	0.2	25.4	14.0	29.5	23.1
2015	December	23	0	26.2	13.6	30.8	22.4
2015	December	24	0.8	28.7	10.9	31.8	20.7
2015	December	25	0	22.0	9.2	34.0	21.6
2015	December	26	0	24.0	11.4	26.9	22.9
2015	December	27	16.0	24.7	11.0	27.4	17.5
2015	December	28	0	30.2	6.4	29.8	16.7
2015	December	29	0	32.4	9.2	33.1	19.8
2015	December	30	0	34.0	9.4	34.8	21.3
2015	December	31	0	34.9	11.4	35.7	22.9
2016	October	1	2.0	14.1	6.5	16.6	8.6
2016	October	2	0.2	19.4	5.3	16.6	11.0
2016	October	3	8.8	14.3	7.3	13.5	8.3
2016	October	4	1.4	14.0	6.5	12.4	6.4
2016	October	5	8.4	14.6	3.6	15.8	8.0
2016	October	6	0	21.2	7.8	15.8	10.5
2016	October	7	0	22.9	7.6	17.9	11.2
2016	October	8	0	18.9	8.5	16.2	8.9
2016	October	9	0	17.4	1.4	15.2	10.8
2016	October	10	0	18.6	6.2	15.6	7.7
2016	October	11	1.0	14.2	5.2	18.0	7.7

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2016	October	12	0	16.0	-0.9	18.8	9.1
2016	October	13	0.4	16.2	1.7	21.6	9.5
2016	October	14	0	18.9	-0.3	21.4	10.7
2016	October	15	0	20.0	1.0	22.2	12.7
2016	October	16	0	23.6	9.0	21.1	14.0
2016	October	17	5.4	16.1	9.7	18.6	9.9
2016	October	18	0	17.5	5.2	19.4	10.1
2016	October	19	0.6	16.0	4.6	19.7	10.5
2016	October	20	0	19.4	1.5	21.1	11.1
2016	October	21	0	21.6	1.4	20.8	14.2
2016	October	22	7.4	13.8	10.4	16.4	8.5
2016	October	23	5.4	16.4	0.7	20.7	8.5
2016	October	24	0	18.2	-1.0	21.6	10.8
2016	October	25	0	20.7	1.2	23.0	13.8
2016	October	26	0	24.1	8.4	25.9	14.9
2016	October	27	0	23.2	7.0	25.2	15.9
2016	October	28	0	18.6	8.9	23.8	16.0
2016	October	29	0	24.0	11.0	24.2	16.7
2016	October	30	0	22.4	10.2	22.5	12.2
2016	October	31	2.6	16.5	5.6	22.2	11.3
2016	November	1	0	18.1	-1.3	24.0	12.7
2016	November	2	0	20.6	4.5	26.1	13.9
2016	November	3	0	23.0	2.5	26.2	14.9
2016	November	4	0	24.5	3.6	26.1	17.4
2016	November	5	0	17.6	11.6	26.0	15.1
2016	November	6	0	19.9	6.6	26.9	16.1
2016	November	7	0	25.3	6.5	26.4	17.3
2016	November	8	0	28.6	7.9	24.9	17.8
2016	November	9	8.4	24.8	11.7	24.2	17.2

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2016	November	10	6.2	24.0	10.6	28.5	16.4
2016	November	11	0	26.1	8.5	28.2	18.9
2016	November	12	19.4	26.5	14.6	22.3	15.0
2016	November	13	0	18.6	10.1	19.6	14.1
2016	November	14	8.6	19.8	7.9	21.9	12.8
2016	November	15	0.6	20.6	4.0	27.1	13.6
2016	November	16	0	25.3	5.2	29.7	17.9
2016	November	17	0	25.5	11	30.4	18.5
2016	November	18	0	30.0	9.1	32.1	20.5
2016	November	19	0	31.1	11.7	33.0	21.9
2016	November	20	0	31.1	13.4	29.4	21.4
2016	November	21	9.4	30.2	14.4	31.6	20.2
2016	November	22	0	31.2	11.9	28.0	21.2
2016	November	23	0	20.4	13.4	25.8	13.8
2016	November	24	4.2	21.2	2.5	28.5	15.6
2016	November	25	0	24.3	4.7	30.4	18.3
2016	November	26	0	24.7	7.9	30.9	19.3
2016	November	27	0	26.5	9.2	32.7	22.0
2016	November	28	0	27.7	14.7	32.9	20.7
2016	November	29	0	28.0	7.9	33.0	22.0
2016	November	30	0	30.1	10.4	33.5	22.7
2016	December	1	0	28.8	12.1	32.6	21.5
2016	December	2	0	30.3	8.5	33.4	22.7
2016	December	3	0	30.9	11.7	32.0	22.8
2016	December	4	0	32.8	10.6	29.5	24.4
2016	December	5	1.0	31.4	17.7	27.9	22.4
2016	December	6	13.4	23.1	16.9	28.8	17.5
2016	December	7	0.2	26.9	8.9	28.4	19.2
2016	December	8	0	31.3	10.1	27.6	17.2

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2016	December	9	2.0	21.6	11.0	30.5	18.1
2016	December	10	0	25.2	7.3	32.7	21.3
2016	December	11	0	28.0	12.8	33.8	23.2
2016	December	12	0	31.2	15.3	31.0	22.8
2016	December	13	0	33.9	10.6	28.9	25.1
2016	December	14	0	28.6	21.6	24.4	20.1
2016	December	15	3.0	14.8	12.8	21.0	17.6
2016	December	16	5.8	20.1	12.3	24.4	18.5
2016	December	17	11.4	27.9	13.5	28.3	17.6
2016	December	18	0	24.9	11.4	29.6	19.5
2016	December	19	0	26.5	11.1	28.4	20.2
2016	December	20	0	30.8	9.7	31.6	20.1
2016	December	21	0	28.7	8.9	32.2	22.6
2016	December	22	0	26.6	14.6	34.0	23.4
2016	December	23	0	31.8	14.6	32.7	24.9
2016	December	24	0	32.5	14.1	29.0	19.9
2016	December	25	22.4	30.9	11.3	30.2	21.3
2016	December	26	0	31.5	14	30.5	23.5
2016	December	27	0	31.9	18.4	28.7	23.3
2016	December	28	0.2	31.9	16.3	27.7	24.5
2016	December	29	0	29.9	21.8	29.3	23.4
2016	December	30	2.2	32.8	20.3	31.6	22.5
2016	December	31	3.0	31.5	18.9	31.6	22.5
2017	October	1	0	19.8	-0.7	22.7	11.7
2017	October	2	0	22.5	1.7	24.1	13.7
2017	October	3	0	25.0	4.5	24.5	13.7
2017	October	4	0	25.4	2.4	23.2	16.5
2017	October	5	0	26.6	8.3	23.8	15.6
2017	October	6	0.2	21.5	11.1	24.1	13.7

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2017	October	7	0.2	21.1	1.3	20.5	15.1
2017	October	8	0	20.1	5.2	21.1	16.2
2017	October	9	12.8	25.4	12.2	22.7	12.5
2017	October	10	0	22.7	4.5	24.7	15.8
2017	October	11	0	25.6	10.8	21.6	16.0
2017	October	12	3.8	20.6	12.3	23.4	13.2
2017	October	13	0	21.3	2.8	20.2	16.1
2017	October	14	0	17.9	10.8	25.8	14.9
2017	October	15	0	24.7	6.7	27.2	16.0
2017	October	16	0	25.2	6.1	28.4	16.4
2017	October	17	0	27.4	3.7	28.4	17.5
2017	October	18	0	27.5	5.5	25.7	18.9
2017	October	19	0	27.3	9.2	21.5	17.6
2017	October	20	11.2	21.1	14.2	22.9	13.0
2017	October	21	0.2	19.9	1.4	23.0	15.6
2017	October	22	0	19.1	9.1	25.9	13.5
2017	October	23	0.4	22.6	3.1	23.3	15.1
2017	October	24	0	24.7	3.6	23.7	17.3
2017	October	25	0	25.8	12.5	24.4	17.6
2017	October	26	0.2	23.8	12.2	22.2	15.7
2017	October	27	15.2	22.7	10.8	22.6	15.6
2017	October	28	0.2	26.4	9.7	24.7	16.7
2017	October	29	1.2	25.4	11.2	24.6	16.3
2017	October	30	0	21.5	9.7	20.9	13.7
2017	October	31	12.8	17.7	3.6	22.9	11.7
2017	November	1	0	21.4	4.8	25.1	13.9
2017	November	2	0	23.1	5.8	23.9	15.1
2017	November	3	0	19.7	4.3	26.5	16.4
2017	November	4	0	21.3	9.5	25.3	16.8

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2017	November	5	0	19.4	8.3	19.6	14.6
2017	November	6	20.8	14.6	10.4	21.1	10.9
2017	November	7	18.6	19.3	2.5	23.6	13.0
2017	November	8	0	20.7	7.0	26.8	13.5
2017	November	9	0	25.5	3.1	27.8	15.2
2017	November	10	0.2	25.6	4.5	27.3	18.0
2017	November	11	0.2	24.1	11.1	27.8	18.1
2017	November	12	0.2	23.5	13.	27.2	18.5
2017	November	13	0	22.8	11.6	29.9	17.8
2017	November	14	0	25.7	7.1	31.0	19.3
2017	November	15	0	28.2	8.2	24.3	20.3
2017	November	16	0	20.1	11.0	23.6	18.0
2017	November	17	2.4	24.3	12.9	19.8	17.5
2017	November	18	1.8	19.0	14.5	26.4	16.1
2017	November	19	0.4	24.4	12.5	29.7	16.9
2017	November	20	0	25.5	8.4	31.1	19.1
2017	November	21	0	26.1	7.4	32.0	20.1
2017	November	22	0	27.2	9.1	30.4	22.4
2017	November	23	0	27.0	12.2	30.8	19.2
2017	November	24	0.8	29.8	8.9	31.7	18.9
2017	November	25	1.4	31.0	10.9	26.4	21.4
2017	November	26	0.2	25.9	11.4	26.5	20.3
2017	November	27	7.6	26.6	16.1	26.7	18.1
2017	November	28	15.6	28.4	11.5	31.1	19.7
2017	November	29	0.2	29.1	16.4	32.1	21.2
2017	November	30	0	30.6	12.8	29.1	22.8
2017	December	1	0	30.6	15.0	23.7	19.9
2017	December	2	35.2	19.6	17.7	21.4	16.8
2017	December	3	18.4	19.9	12.2	16.9	15.8

Year	Month	Day	Precipitation 24 hours before 9am (mm)	Max temp. 24 hours after 9am (°C)	Min. temp. 24 hours before 9am (°C)	Max soil temp. 10 cm depth (°C)	Min soil temp. 10 cm depth (°C)
2017	December	4	0.2	15.7	10.7	18.3	14.6
2017	December	5	6.6	20.0	11.4	18.7	14.9
2017	December	6	5.2	20.2	11.9	23.6	14.0
2017	December	7	0.2	26.7	8.7	23.9	16.8
2017	December	8	6.2	22.5	12.0	26.9	16.1
2017	December	9	0	25.0	7.8	29.7	18.1
2017	December	10	0	28.0	10.9	30.7	20.4
2017	December	11	0	29.7	12.0	32.3	22.8
2017	December	12	0	30.6	16.4	32.3	23.0
2017	December	13	0	32.7	12.5	29.4	23.3
2017	December	14	0	32.9	13.6	28.7	23.4
2017	December	15	3.2	30.5	17.9	31.5	22.5
2017	December	16	0	32.6	14.1	32	23.8
2017	December	17	1.6	31.6	16.3	30.4	24.4
2017	December	18	0.2	32.6	16.4	31.0	24.7
2017	December	19	0	34.3	18.0	28	23.9
2017	December	20	0.2	27.5	22.8	29.2	20.0
2017	December	21	1.6	26.7	9.4	30.1	22.7
2017	December	22	0	29.5	12.5	31.2	23.1
2017	December	23	0	31.8	11.9	29.5	23.6
2017	December	24	0	34.8	13.2	27.5	23.1
2017	December	25	0	23.0	13.4	26.8	21.9
2017	December	26	0	22.4	10.8	29.7	22.6
2017	December	27	0	29.1	15.8	30.3	22.9
2017	December	28	0	32.4	12.9	29.5	24.6
2017	December	29	0	33.4	18.3	28.0	23.3
2017	December	30	16.4	28.3	18.6	29.8	21.6
2017	December	31	0	27.9	14.9	34.4	21.1



Local People. Global Experience.

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