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Hornsdale Wind Farm SEB Offset Area

Monitoring 2023

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Prepared by EBS Ecology for NEOEN

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GLOSSARY AND ABBREVIATION OF TERMS

ANOVA	Analysis of Variance – statistical method used to test differences between two or more means by analysing the variance of the sampling distribution of the mean.
BOM	Bureau of Meteorology
Burrow	Any hole or burrow suitable for a PBTL
cm	Centimetre(s)
Cryptogam	Biological soil crust most often composed of fungi, lichens, cyanobacteria, bryophytes and algae in varying proportions
DP	Declared Plant
DSE	Dry Sheep Equivalent – standard measure of feed demand which represents a 50 kilogram (kg) wether which consumes 1.0 kg dry matter per day. A pregnant or lactating ewe has a greater energy requirement, and the amount varies according to the advancing pregnancy and the size of the lamb once it is born and feeding.
EBS	Environmental and Biodiversity Services – trading as EBS Ecology
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GPS	Global Positioning System
ha	Hectare(s)
HWF	Hornsdale Wind Farm
HWF1	Hornsdale Wind Farm Stage 1
HWF2	Hornsdale Wind Farm Stage 2
HWF3	Hornsdale Wind Farm Stage 3
ID	Identification (e.g., of species)
JPH	Juveniles Per Hectare - the mean of the total number of juvenile perennial native grass tussocks (i.e. multiplied by 10,000).
km	Kilometre(s)
LMR	Landscape Management Region
mm	Millimetre(s)
m	Metre(s)
MW	Mega Watt(s)
NPW Act	*National Parks and Wildlife Act 1972*
R	Rare – under the *National Parks and Wildlife Act 1972*

NV Act	*Native Vegetation Act 1991*
Project	Hornsdale Wind Farm: A 315 MW renewable electricity project consisting of 99 wind turbine generators.
PBTL	Pygmy Blue-tongue Lizard (*Tiliqua adelaidensis*)
PCQM	Point Centre Quarter Method
pers. comm.	Personal communication
p-value	The level of marginal significance within a statistical hypothesis test representing the probability of the occurrence of a given event. The p-value is used as an alternative to rejection points to provide the smallest level of significance at which the null hypothesis would be rejected.
Quadrat/Q	1 ha monitoring quadrat (Quadrats 1–12)
R^2	The coefficient of determination – the proportion of the variance in the dependent variable that is predictable from the independent variable(s).
SA	South Australia(n)
SEB	Significant Environmental Benefit
SEB Offset Area	Area of land set aside for conservation, to offset for native vegetation clearance during construction of the Project – incorporates the required 3.1 ha PBTL offset.
sp.	Species
ssp.	Subspecies
TPH	Tussocks Per Hectare
WoNS	Weed of National Significance
$\bar{x}$	Sample mean

EXECUTIVE SUMMARY

Background

Hornsdale Wind Farm (HWF) is a 315 Megawatt (MW) renewable electricity project consisting of 99 wind turbine generators and battery storage (the Project) located north of Jamestown in the Mid North region of South Australia (SA). The Project Area extends approximately 15 kilometres (km) in a north-south direction, and approximately 8 km in an east-west direction, with a footprint covering 75 hectares (ha).

The Project was constructed in three stages (Stages 1–3), also known as HWF1, HWF2 and HWF3. The HWF Project was granted approval 10 May 2013, subject to conditions under sections 130(1) and 133 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (see EPBC Act referral 2012/6573). As part of the EPBC Act approval process an offset was calculated to offset the potential impacts to the EPBC Act listed Pygmy Blue-tongue Lizard (PTBL) (*Tiliqua adelaidensis*) (see EPBC Act referral 2012/6573).

To meet the requirements under the *Native Vegetation Act 1991* (NV Act) figures for a Significant Environmental Benefit (SEB) were calculated to determine the required offset for clearance of native vegetation associated with the construction of the Project (see *Hornsdale Wind Farm Native Vegetation Clearance Report* (EBS Ecology 2013)).

The required SEB and PBTL offsets for HWF1, HWF2 and HWF3 were achieved by offsetting a 142.54 ha parcel of land located on private property within the HWF (the SEB Offset Area). The SEB Offset Area was known to support a significant population of PBTLs and, therefore, the PBTL offset of 3.1 ha was incorporated into the SEB Offset Area, which is protected under the NV Act and is listed on the property title.

Annual PBTL and vegetation surveys within the SEB Offset Area are part of a long-term annual monitoring program, which is an EPBC Act approval condition (approval 3d) of the Project (see *Hornsdale Wind Farm Annual Compliance Report under the EPBC Act September 2018* (EBS 2018a)). The program involves annual surveys that will run until 2027, as per the approval conditions.

EBS Ecology (EBS) were engaged by NEOEN to conduct the annual PBTL and vegetation monitoring within the SEB Offset Area for HWF1, HWF2 and HWF3. The baseline survey, the first year of PBTL monitoring surveys was undertaken in 2018 (EBS 2018d) This report provides the results of the 2022 (year 5) monitoring surveys for PBTL and vegetation.

The key results of the 2023 PBTL survey include:

- A total of 386 burrows across the 11 quadrats were checked for PBTL occupancy in 2023, of which 29 burrows (8.20%) contained one or more PBTLs. This compares to 993 burrows in 2022, 774 burrows in 2021 and 1919 in 2020, of which 8.70%, 5.20% and 5.68% contained one or more PBTLs, respectively.
- A total of 32 PBTLs were recorded in 29 burrows including 18 adults and 14 juveniles. This compares to a total of 96 PBTLs in 2022, 41 in 2021 and 113 in 2020.
- The proportion of juvenile PBTLs observed in 2023 (43.75%) was the highest of all monitoring years.

- PBTLs were found in seven of the 11 quadrats, quadrats 3, 4, 5, 6, 8, 9 and 10. The highest number of PBTLs (9) were recorded in quadrats 4 and 6.
- The mean number of PBTLs per quadrat observed in in 2023 ($\bar{x}$ = 2.91 individuals) was less than the baseline ($\bar{x}$ = 17.40 individuals), 2018 ($\bar{x}$ = 16.60 individuals), 2019 ($\bar{x}$ = 19.10 individuals) and 2020 ($\bar{x}$ = 10.30 individuals), 2021 ($\bar{x}$ = 3.70 individuals) and 2022 ($\bar{x}$ = 8.73 individuals) surveys. There was a significant difference in the mean number of PBTLs between the five sampling years (p-value = 0.00789).
- The mean number of burrows per quadrat observed in 2023 ($\bar{x}$ = 35.1) was less than all previously conducted surveys: 2022: $\bar{x}$ = 90.30, 2021: $\bar{x}$ = 70.00, 2020: $\bar{x}$ = 171.10, 2019: $\bar{x}$ = 202.10, 2018: $\bar{x}$ = 115.10 and baseline: $\bar{x}$ = 126.38.
- The mean number of PBTLs per quadrat across the five surveys was significantly greater on eastern than western slopes (p-value = 0.024).
- There was a moderate negative correlation between total rainfall between September and January and the number of PBTLs (r = -0.74). There was also a strong negative correlation between that period's rainfall and the number of spider holes detected (r = -0.83). That is, as rainfall increases, there is a correlating decrease in the number of PBTLs and spider holes detected.

The key results of the 2023 vegetation survey include:

- A total of 86 flora species were observed across the twelve one ha quadrats in 2023. This included 44 native flora species, three of which are State Rare, and 42 weed species, seven of which are Declared under the *Landscapes South Australia Act 2019*.
- Based on the data to date native and weed species diversity has significantly increased since 2018. However, it is unlikely that the observed increase in species diversity reflects the conditions in the SEB Offset Area, given variations in survey effort and climatic conditions (e.g., annual rainfall variability).
- Comparisons between baseline data and the second, third, fourth, fifth and sixth year of monitoring indicate that the native grass tussocks are closer together, smaller in basal width and greater in height than in 2018. Relative to the 2022 results, there has been an increase in tussock spacing and decrease in tussock height.
- Weed cover was higher in 2023 (14.3%) than in 2022 (2.46%) with the majority of weeds within the SEB Offset Area being exotic annual grasses or small herbaceous weeds.
- The mean percentage of litter in 2023 was 70.42%, compared to 73.00% in 2022, when this variable was measured for the first time. Previously, litter was included as a part of weed cover percentage.
- The mean percentage of cryptogram cover decreased to 2.95% from 6.00% in 2022 and 3.00% in 2021 (p-value = 0.8808).

- The mean percentage of bare ground cover (1.58%) was lower than in all previous years (p value = 0.000). This is significant for 2020 compared to all years (2023 p-value = 0.001; 2022 p-value = 0.003; 2021 p-value = 0.001).
- There was a large increase in litter and decrease in bare ground throughout the SEB Offset Area. This is evident in the site photographs. The high amount of ground cover severely impacted the ability of observes to detect spider burrows and detect and measure perennial grass tussocks and juvenile tussocks.
- There was a negative correlation between total rainfall between September and January and the mean bare ground + cryptogram cover (r = -0.91) and the tussock basal width (r = -0.84). There was positive correlation between that period's rainfall and the mean tussock height (r = 0.64).

Recommendations

The following recommendations relating to both vegetation and PBTL monitoring and the overall management of the SEB Offset Area are made:

- Management continues to follow actions that are described in the SEB Management Plan (EBS Ecology 2013, 2017a), including the following:
  - Complete and submit the *Paddock Monitoring Sheet* to HWF to assist the management of the grazing program.
  - Submit the *Activity Record Datasheet* to HWF at the end of each financial year until 2028.
- Quadrats should continue to be monitored annually by a suitably qualified Ecologist in February for PBTL presence, and surveyors should be kept constant, where possible, to ensure a robust dataset is compiled. Results from the PBTL monitoring program should then be used to make management decisions that will improve the quality of PBTL habitat in the SEB Offset Area.
- Additional data on spider burrows (e.g., hole depth) should continue to be collected and analysed in future years to provide insight into the availability of burrows suitable for PBTLs.
- Vegetation condition and rainfall data should continue to be incorporated into future analyses of PBTL survey data to help explain any annual variability in results. Analyses will become more robust as more data is collected throughout the monitoring program.
- Monitor quadrats for threatened flora as observed across the SEB Offset Area in 2021, 2022 and 2023.
- Continue winter grazing to reduce annual exotic grass and retain patchiness for PBTL, adjusting DSE to reflect climatic conditions. A review of the grazing regime would be beneficial and consider the following:
  - Extend the grazing period into spring during years of high rainfall to reduce weed biomass, particularly spring germinates, increase bare ground and break up litter mats.
  - Lower DSE, shorten graze periods or increase rest periods on rocky ridges where widespread deterioration of grassland condition has been observed.

- Prioritise the control of Declared woody weeds that have potential to alter the structure of grassland vegetation. This includes the following species:
  - Dog Rose (*Rosa canina*).
  - Horehound (*Marrubium vulgare*).
- The Land Manager and NEOEN determine ongoing management actions in consultation with a suitably qualified Ecologist, based on the recommendation in this report.

Priority Actions

The following actions should be undertaken in 2023 and leading into the 2024 monitoring period with urgency:

- In cooperation with the landowner, review the grazing regime within the SEB Offset Area. Given the high tussock height, decreased tussock spacing, low bare ground with high litter cover apparent from monitoring photographs, the area would benefit from increased grazing pressure. This should be done with the aim of achieving vegetation characteristics approaching those recorded in 2019 and 2020.
- Discuss the feasibility of more reactive grazing management that can respond more easily and quickly to unpredictable climatic conditions.
- Ensure the Land Manager is familiar with the *Paddock Monitoring Sheet* and *Activity Record Datasheet,* that they are completed for 2022/2023 and that they are submitted by the landowner to HWF.

Following the monitoring survey undertaken in 2023 and considering results and the actions identified above, the following has been implemented;

- Discussion between NEOEN and the landowner regarding the requirement for additional grazing;
- Additional grazing period – sheep were introduced to the SEB area in April 2023, a month earlier than in previous years, to break up litter cover prior to the winter growth period.
- Sheep will remain in the SEB area throughout winter as per the management plan.
- The landowner and NEOEN have committed to meeting Ecologists from EBS Ecology on site at the end of September.
- The above meeting occurred on 20 September 2023. The landowner committed to graze the SEB area from 22 September until 9 October 2023, following any recommendations made by EBS Ecology at that time. The landowner also agreed to provide details of annual management activities through sharing of information currently collected using an app.

Responsibilities

Hornsdale Asset Co previously negotiated an agreement with the Land Manager to manage the SEB Offset Area. Whilst it will be the responsibility of the landholders to implement the SEB Management Plan, HWF will still be responsible for ensuring the plan is implemented to a suitable standard. If the implementation of the plan does not occur or is not implement to the required standard, HWF, in consultation with the landholder, can undertake corrective action to ensure the plan is implemented suitably. This may involve providing further direction to the landholder or utilising the resources of an external contractor to implement specific tasks.

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1 INTRODUCTION

Hornsdale Wind Farm (HWF) is a 315 Megawatt (MW) renewable electricity project consisting of 99 wind turbine generators and battery storage (the Project) located north of Jamestown in the Mid-North region of South Australia (SA). The Project Area extends approximately 15 kilometres (km) in a north-south direction, and approximately 8 km in an east-west direction (Figure 1). The Project was constructed in three stages (Stage 1–3), known as HWF1, HWF2 and HWF3, or Stage 1, 2 and 3.

A Significant Environmental Benefit (SEB) offset was required under the *Native Vegetation Act 1991* (NV Act) to offset the clearance of native vegetation associated with the construction of HWF1, HWF2 and HWF3.

A Pygmy Blue-tongue Lizard (PBTL) (*Tiliqua adelaidensis*) offset was also required as part of an approval condition under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), to compensate for the potential impact to PBTLs resulting from the wind farm development. The PBTL is listed as nationally endangered under the EPBC Act and State endangered under the *National Parks and Wildlife Act 1972* (NPW Act).

The SEB offset for native vegetation has been delivered for all three stages of the Project in a parcel of land 142.54 hectares (ha) in size, located immediately north of XXXX Road (SEB Offset Area) (Figure 1). A significant population of PBTLs is present within the SEB Offset Area. Therefore, the PBTL offset of 3.1 ha has been incorporated into the SEB Offset Area, which is protected under the NV Act and is listed on the property title.

1.1 Objectives

The long-term objectives of the monitoring program are to:

- Undertake long-term (10 years) monitoring of native vegetation and the PBTL population to ensure that suitable conditions are provided within the SEB Offset Area to maintain or increase existing population numbers of PBTLs (including their habitat);
- Identify any threats that may be occurring within SEB Offset Area; for example, weed incursions, feral animals, or changes in vegetation structure, which may negatively affect the PBTL population; and
- Identify any actions that are required to maintain native grasslands with a rich diversity of species, and little disturbance from exotic weeds.

The objectives of this report are to:

- Provide the results of the 2023 vegetation and PBTL annual monitoring surveys within the SEB Offset Area;
- Compare survey results between the current and previous surveys to identify if any obvious changes in vegetation condition and/or the PBTL population are occurring within the SEB Offset Area, and if so, examine how these factors influence one another; and

- Provide management recommendations to improve the vegetation condition in the SEB Offset Area and benefit the PBTL population.

1.2 Approvals

A summary of EPBC Act and previous NV Act approvals for the Project is provided in Table 1.

Table 1. Summary of the relevant approvals associated with the Hornsdale Wind Farm.

Stage	Relevant legislation	Approval reference
HWF1	NV Act	2013/3012/764
HWF2	NV Act	2013/3012/764
HWF3	NV Act	2016/3101/764
All	EPBC Act	EPBC 2012/6573

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Figure 1. Location of the Hornsdale Wind Farm and the SEB Offset Area.

2 BACKGROUND

2.1 Previous surveys and reports

Numerous flora and fauna assessments have been undertaken by EBS Ecology at HWF. An overview of reports prepared between 2010 and 2021 is provided below for reference:

- EBS Ecology (2021) *Hornsdale Wind Farm SEB Offset Area Monitoring 2021.* Report to NEOEN. EBS Ecology, Adelaide.
- EBS Ecology (2020) *Hornsdale Wind Farm Vegetation and PBTL Offset Annual Monitoring 2020.* Report to NEOEN. EBS Ecology, Adelaide;
- EBS Ecology (2019) *Hornsdale Wind Farm Vegetation and PBTL Offset Annual Monitoring 2019.* Report to NEOEN. EBS Ecology, Adelaide;
- EBS Ecology (2018a) *Hornsdale Wind Farm Annual Compliance Report under the EPBC Act September 2018*. EBS Ecology, Adelaide.
- EBS Ecology (2018b) *Hornsdale Wind Farm Stage 2 Native Vegetation Clearance Update August 2018.* Report to NEOEN. EBS Ecology, Adelaide;
- EBS Ecology (2018c) *Hornsdale Wind Farm Stage 3 Native Vegetation Clearance Update August 2018.* Report to NEOEN. EBS Ecology, Adelaide;
- EBS Ecology (2018d) *Vegetation and PBTL Offset Monitoring – Hornsdale Annual Report 2018.* Report to NEOEN. EBS Ecology, Adelaide;
- EBS Ecology (2017a) *Hornsdale Wind Farm SEB Offset Management Plan*. Report to NEOEN. EBS Ecology, Adelaide.
- EBS Ecology (2017b) *Hornsdale Wind Farm Stage 1 Native Vegetation Clearance Update October 2017*. Report to NEOEN. EBS Ecology, Adelaide.
- EBS Ecology (2017c) *Hornsdale Wind Farm Stage 3 Management Plan*. Report to Hornsdale Wind Farm Pty Ltd, EBS Ecology Adelaide.
- EBS Ecology (2016a) *Hornsdale Wind Farm – Annual Compliance Report under the EPBC Act*. Report to NEOEN, EBS Ecology, Adelaide.
- EBS Ecology (2016b) *Hornsdale Wind Farm SEB – Pygmy Blue-tongue Lizard Survey*. Report to NEOEN, EBS Ecology, Adelaide.
- EBS Ecology (2016c) *Pygmy Blue-tongue Lizard Scientific Monitoring and Research Plan - Progress Report for 2015 and 2016*. Report to Hornsdale Wind Farm Pty Ltd. EBS Ecology, Adelaide.
- EBS Ecology (2015a) *Hornsdale Wind Farm Pre-construction Pygmy Blue-tongue Lizard Management Plan*. Report to NEOEN. EBS Ecology, Adelaide;

- EBS Ecology (2015b) *Hornsdale Wind Farm SEB – Native Vegetation and Pygmy Blue-tongue Lizard Management Plan (28 May 2015 - Version 3.1)*. Report to NEOEN. EBS Ecology, Adelaide;
- EBS Ecology (2013) *Hornsdale Wind Farm SEB – Native Vegetation and Pygmy Blue-tongue Lizard Management Plan*. Report to Investec Bank (Australia) Ltd. EBS Ecology, Adelaide;
- EBS Ecology (2012) *Hornsdale Pygmy Blue-tongue Survey 2012*. Report to IBAL on behalf of Aurecon. EBS Ecology, Adelaide;
- EBS Ecology (2011a) *Hornsdale Flora and Fauna Assessment*. Report to Aurecon. EBS Ecology, Adelaide; and
- EBS Ecology (2011b) *Mount Lock Flora and Fauna Assessment*. Report to Aurecon. EBS Ecology, Adelaide.

2.2 SEB Offset Area

The SEB Offset Area within the HWF was selected based on the following key considerations:

- The occurrence of a poor to moderate quality native grassland that could be improved over time with active management;
- The occurrence of a significant population (>30 individuals) of PBTLs; and
- The location within the HWF Project Area and the Northern and Yorke Landscape Management Region (LMR).

A management plan has been prepared for the SEB Offset Area by EBS Ecology (EBS Ecology 2017a), as listed above. The SEB Offset Area Management Plan devised long-term management measures that will improve vegetation condition and protect PBTLs.

2.3 Current management and land ownership

The SEB Offset Area has been owned by the Clark Brothers Shorts Trust since 2008 (Table 2). The land was grazed heavily prior to its sale. However, the land was historically owned by a large pastoral company that stocked it lightly. Since the land's purchase in 2008, it has been lightly grazed by sheep, and mainly by lambing ewes. Generally, little to no grazing occurs prior to 1 May each year, to facilitate the growth of fodder. Four-hundred Pregnant or lactating ewes are typically stocked from the start of May to late August each year at a rate of 2.8 ewes per hectare. This is not equivalent to the Dry Sheep Equivalent (DSE), which is standard for stocking rate measure, since pregnant ewes can increase the DSE by 1.4–2.8 times (EBS Ecology 2017a).

Uneven grazing pressure by sheep within the SEB Offset Area, due to preferential grazing of eastern facing slopes has resulted in 'thatching' of the native grass tussocks on the western slopes of the ridge (A. Brown *pers. comm.* 2013) and increased grazing on the eastern slopes. Many grass tussocks on the western slope accumulate high levels of dead material at their centre, which impairs growth and causes radial dieback. Tussocks then become fragmented and comparable to numerous small grasses in a circular formation, when in fact they are one old, large tussock.

Comments from the landowner indicate that the previous three spring/summer periods, including 2020, 2021 and 2022 have been exceptional seasons. The area has received well-above average rainfall (see Section 2.4.2) with vegetative growth occurring at a level not experienced since the establishment of the Hornsdale SEB. As these conditions were abnormal and not expected, sheep numbers were not increased above the levels discussed above.

Table 2. Hornsdale Wind Farm SEB Offset Area details.

Owner	Clark Brothers Shorts Trust
Manager	Martin Clark
Address	PO Box 233, Jamestown SA 5491
Local Government Area	Northern Areas Council
LMR Region	Northern and Yorke
Hundred	Belalie
Parcel details	(redacted)
Titles	(redacted)
Location	(redacted) Road, Jamestown

2.3.1 Responsibilities

Hornsdale Asset Co previously negotiated an agreement with the landholders to manage the SEB Offset Area. Whilst it will be the responsibility of the landholders to implement the management plan, HWF will still be responsible for ensuring the plan is implemented to a suitable standard. If the implementation of the plan does not occur or is not implemented to the required standard, HWF, in consultation with the landholder, can undertake corrective action to ensure the plan is implemented suitably. This may involve providing further direction to the landholder or utilising the resources of an external contractor to implement specific tasks.

2.4 Rainfall

2.4.1 Annual rainfall

Rainfall data is important as it impacts heavily on vegetation growth. Monthly rainfall data was sourced from the closest weather station to HWF, which is located at Yongala (Station: 019062, BOM 2023). The recorded monthly rainfall at Yongala has been highly variable since 2015, the year preceding the commencement of monitoring (Figure 2).

Table 3 provides a summary of mean monthly rainfall and annual rainfall in millimetres (mm) from 2015 to 2022. Rainfall in 2015 was close to the long-term annual mean, with significant rainfall in January and April, and above average rainfall in November. Above average rainfall occurred in seven months in 2016, with significant rainfall occurring in January, March, September and December. However, the mean monthly rainfall and the annual rainfall both progressively declined each year from 2016 until 2019, with the annual rainfall for 2019 less than half the long-term annual mean (BOM 2023).

In 2020, rainfall returned to above average, with the total of 444.3 mm being 80.5 mm above the long-term mean. In 2020, October was the wettest month, with 81.0 mm, providing exceptional growing conditions for vegetation, while the winter months from May till August all recorded below average monthly rainfall (Figure 2). Rainfall was below average in 2021, although higher than the 2016-2019 period. There was high rainfall in the winter months (53.4 mm in June and 72.8 in July) as well as in November (88.2 mm), again providing exceptional growing conditions for vegetation.

Rainfall returned to above average in 2022, with 418.1 mm recorded at Yongala. Dry late summer (January to February) and autumn conditions were followed by a wet winter and spring. Rainfall was well above average from August to December, providing ideal conditions for growth of winter and spring annual grasses.

Table 3. Summary of mean monthly and annual rainfall (Yongala Station, 2015–2022).

Year	Mean monthly rainfall (mm)	Annual rainfall (mm)
Long-term mean	30.3	363.8
2015	27.5	329.6
2016	41.9	502.4
2017	25.0	300.5
2018	17.8	213.2
2019	14.5	174.2
2020	37.0	444.3
2021	24.7	296.4
2022	34.8	418.1

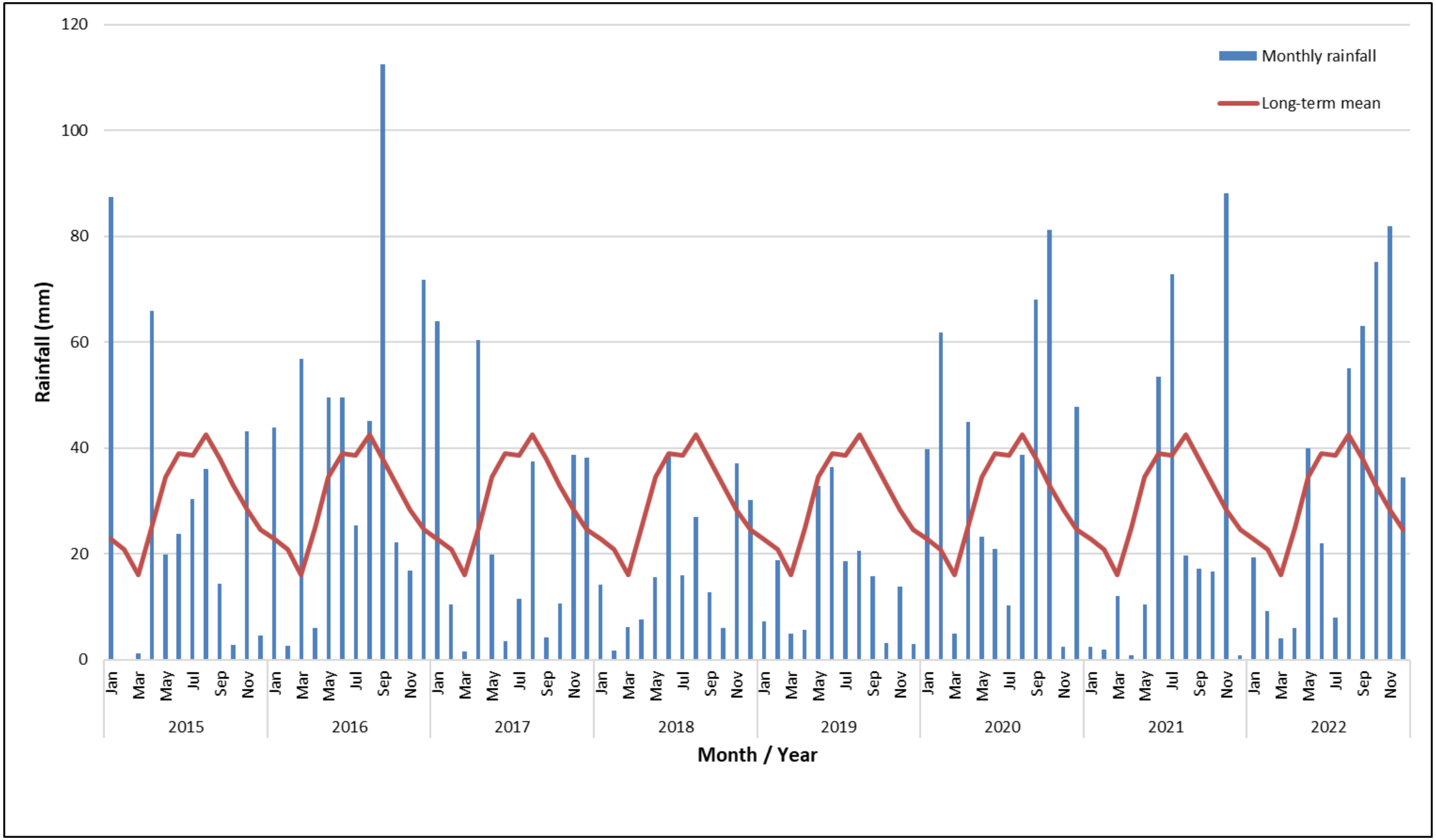

Figure 2. Monthly rainfall (mm) from 2015 to 2022 (Yongala Station: 019062) (BOM 2023). Long-term mean monthly rainfall for each month represented by red line.

2.4.2 Spring and summer rainfall

Discussions with the landowner following the 2021 and 2022 monitoring periods indicated that high spring and summer rainfall may be an important factor influencing vegetation and litter cover. It may also have an influence on the detectability of spider burrows.

Since 2014, rainfall between September and the following January has been characterised by falls below the long-term average of 99.3 mm for the period, with one above average year in 2016. A total of 151.6 mm was recorded between September of that year and January 2017.

In contrast, the previous three years (2020, 2021 and 2022) have each recorded well above the average spring and summer rainfall. This peaked with 220.1 mm in the 2022 period (Figure 3).

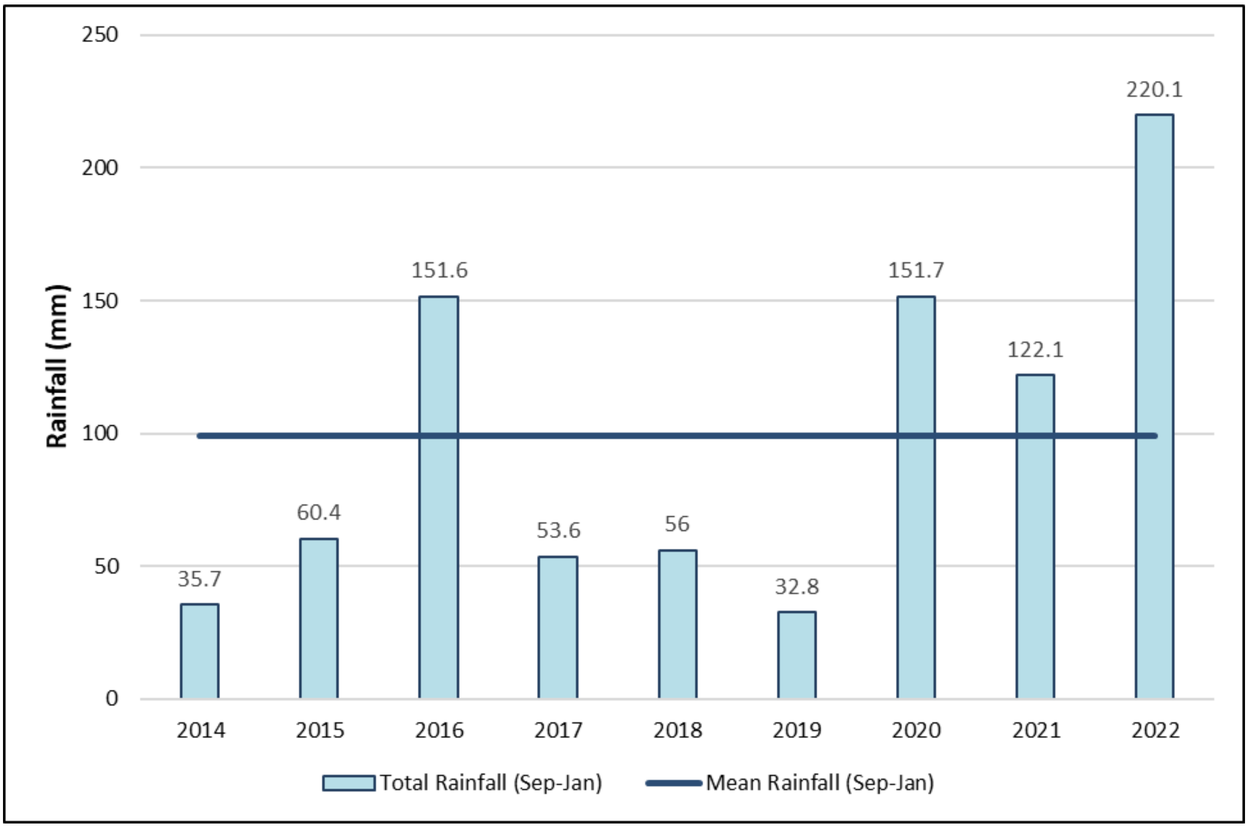

Figure 3. Spring and summer (September to January) rainfall recorded since 2014 (Yongala Station: 019062) (BOM 2023).

2.5 Weather conditions during the survey

The weather conditions during the field surveys (6 – 10 March 2023) were generally fine and mild and conducive to good detection rates of burrows on all three days of the survey (Table 4). With an average maximum temperature of 22.1°C, this was the coolest survey period since monitoring began in 2015. This is also approximately 5°C below the long-term mean maximum temperature for March (BOM 2023).

No minimum temperature data was available for 9 March or maximum temperature for 10 March. Future monitoring surveys will collect temperature data on site to reduce any limitations associated with incomplete data sets.

Table 4. Weather observations for the duration of the 2023 PBTL and Vegetation surveys (Yongala Station: 019062) (BOM 2023).

Date	Temp (°C)		Rain (mm)
	Min	Max	
06/03/2023	10	23	0
07/03/2023	10.1	22.1	0.2
08/03/2023	10.1	19.5	0
09/03/2023	No data	23.9	0
10/03/2023	10.9	No data	1
Mean	10.3	22.1	0.2

3 METHODS

3.1 Field survey dates

The 2023 annual PBTL and vegetation monitoring was undertaken by Ecologists from EBS Ecology in two separate trips. The PBTL and vegetation monitoring were undertaken concurrently from 6 to 10 March 2023.

3.2 Monitoring quadrats

Monitoring was conducted within 12 quadrats (Figure 4). Eight quadrats (Quadrat 1 to 8) were established in 2015 and four (Quadrat 9 to 12) were established in 2018. Of the 12 quadrats, 11 are located within open grassland, while one (Quadrat 12) is located within a small area of *Allocasuarina verticillata* (Drooping Sheoak) Woodland. Drooping Sheoak Woodland is considered unsuitable habitat for PBTLs and, therefore, Quadrat 12 is not monitored for PBTL presence and abundance.

Each quadrat is 100 x 100 metre (m) (1 ha) in size and oriented in a north-south direction. A steel dropper is located in each corner of the quadrat to permanently mark the quadrats. The GPS Coordinates of the corner posts for each quadrat are provided in Appendix 1. A photo of each quadrat is taken from the north-eastern corner looking to the south-western corner during each annual monitoring survey. These photos are provided in Appendix 2 – Vegetation monitoring quadrat photographs.

3.3 Monitoring history

3.3.1 PBTL monitoring (11 quadrats)

Eight PBTL monitoring quadrats were established in 2016 as part of HWF Stages 1 and 2, which were subsequently surveyed during the baseline survey (EBS Ecology 2016b). Quadrats 9–11 were established and monitored, along with Quadrats 1–8, in 2018. Quadrats 1–11 have been surveyed and data analysed in subsequent years.

3.3.2 Vegetation monitoring (12 quadrats)

Baseline data was collected across the 12 monitoring quadrats in 2018, with year 1 and year 2 monitoring conducted in 2019 and 2020 respectively. Additional vegetation monitoring attributes were collected as baseline data in 2020 (described in Section 3.5.3) and in 2022 (described in Section 3.5.4) to assist in determining vegetation condition trends.

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Figure 4. Location of monitoring Quadrats 1–12 within the SEB Offset Area. Pygmy Blue-tongue Lizards are not monitored in Quadrat 12.

3.4 Pygmy Blue-tongue Lizard monitoring methods

Quadrats 1–11 were systematically traversed on foot by two surveyors at 4 m intervals. Each burrow suitable for PBTLs was marked with a GPS and an individual survey pin. All marked burrows were subsequently examined using an optic fibre 'videoscope' (Yateks M Series) to determine whether burrows were occupied by PBTLs. The videoscope is an illuminated articulating insertion probe approximately 8 mm in diameter, with a digital video display screen. The probe can be easily directed into the burrow and bent around corners with the use of a joystick.

The optic fibre was slowly fed into each burrow, until a PBTL, spider or other fauna was observed, or until the bottom of the burrow was reached. The survey method was consistent with the *Survey guidelines for Australia's threatened reptiles: Guidelines for detecting reptiles listed as threatened under the Environment Protection and Biodiversity Conservation Act 1999* (DSEWPC 2011).

The presence or absence of PBTLs, spiders and other fauna, and burrow depth (<10 centimetres (cm), 10-20 cm, 20-30 cm, >30 cm) were recorded for each burrow. For each burrow occupied by PBTLs, the number of individuals was recorded and their age class (juvenile or adult) was estimated. Previous surveys estimated three age classes (juvenile, sub-adult and adult). However, the 2021, 2022 and 2023 survey (and future surveys) did not classify individuals into the sub-adult age class due to the difficulty in distinguishing this age class. All survey pins were removed at the completion of each survey.

Refer to the following reports for more detailed information on the Project, previous ecological investigations and general information on PBTL ecology and behaviour.

- EBS Ecology (2018d) *Vegetation and PBTL Offset Monitoring – Hornsdale Annual Report 2018.* Report to NEOEN. EBS Ecology, Adelaide; and
- EBS Ecology (2016b) *Hornsdale Wind Farm SEB – Pygmy Blue-tongue Lizard Survey*. Report to NEOEN, EBS Ecology, Adelaide.

3.5 Vegetation monitoring methods

3.5.1 Transects (adapted PCQM method)

Vegetation condition within the SEB Offset Area was measured by monitoring attributes along 100 m transects within each of the 12 monitoring quadrats. The 100 m transect sampling method used for the SEB Offset Area is based partly on an adaption of the Point Centre Quarter Method (PCQM) (Tongway & Hindley 2005), whereby attributes for 32 perennial plants are measured along the 100 m transect.

The PCQM method was initially developed to measure vegetation cover, vegetative volume, percentage dead material and number of plants per hectare. However, the method was adapted for the Hornsdale SEB Offset Area monitoring program to measure grass tussock health (height, basal width and canopy width, percentage dead material), spacing (distance between tussocks), density (tussocks per hectare) and recruitment (juvenile tussocks per hectare).

The transects were positioned such that the northernmost end of the tape was tied to a wooden peg installed at the halfway point between the northeast and northwest droppers of the monitoring quadrat and ran in a southerly direction to a wooden peg installed at the southern edge. The wooden pegs were installed in 2020 to allow for more accurate monitoring repetition each year.

Along the transect eight monitoring pins were positioned in the ground at every 10 m, starting at 10 m and ending at the 80 m mark as indicated in

Figure 5.

A 1 m x 1 m vegetation survey quadrat was positioned at each monitoring pin and further divided into four quarters (quarters 1-4), as indicated in

Figure 5, with attributes collected for the nearest plant to the centre point of each 1m x 1m quadrat. Figure 6 provides an image of the 1 x 1 m survey quadrat set up in the field.

Terminology used

Plant – means perennial tussock grass, hummock grass, sedge and long-lived perennial shrubs and trees. Annual species and short-lived and/or herbaceous perennial species were not included in the vegetation survey.

Grass – means perennial native grass of the genus *Austrostipa*, *Rytidosperma*, *Enneapogon*, *Aristida*, *Walwhalleya* and *Themeda*.

Per plant data

The following data was collected for each plant:

- The species of the plant;
- The vegetative height of the plant (in cm) (i.e. not including the flowering head);
- The basal width and canopy width of each plant (in cm) (n.b. canopy width was not collected prior to 2020); and
- The spacing of plants: the distance (in cm) to the nearest plant in the direction of each of the four quarters.

The species of plants recorded per quarter were included in the species diversity for each of the 12 monitoring quadrats, which was supplemented by a rambling survey of each 1 ha quadrat (see Section 3.5.2 below). The plant attributes and spacing data per survey quarter were averaged for each of the 12 monitoring quadrats.

Per quadrat data

In addition to per plant data, the following information was collected:

- Tussocks per hectare: the mean of the total number of native perennial grass tussocks within each 1 x 1 m quadrat, extrapolated to 1 ha (i.e. multiplied by 10,000);
- Juvenile tussocks per hectare: the mean of the total number of juvenile perennial native grass tussocks within each 1 x 1 m quadrat, extrapolated to 1 ha (i.e. multiplied by 10,000);

- Percentage (%) of dead material: the mean percentage (%) of dead material on native perennial grass tussocks in each 1 x 1 m quadrat, then the mean of the eight 1 x 1 m monitoring quadrats; and
- Percentage (%) cover of weed species: the mean percentage (%) cover of weed species in each 1 x 1 m quadrat, then the mean of the eight 1 x 1 m monitoring quadrats.

A photo was taken at the northeast star dropper of each 1 ha quadrat, facing the southwest star dropper.

3.5.2 Ramble survey

In addition to the transect survey, a ramble survey was conducted at each of the 1 ha monitoring quadrats (i.e. randomly walking through each quadrat), with the following data was recorded:

- General observations: a description of vegetation association condition and any notable changes since the previous year's survey;
- Native species diversity: a list of all native flora species present, including rare flora species, supplementary to the species recorded during the transect survey;
- Weed species diversity: a list of all exotic flora species present, supplementary to the species recorded during the transect survey; and
- Weed species cover: approximate cover of weed species (%) in the 1-hectare monitoring quadrat.

3.5.3 Additional data collected from 2020

Additional data was collected in 2020 to assist in determining other grassland condition trends. The additional baseline data was collected at each of the eight 1m x 1m quadrats positioned along each 100 m transect and included:

- The canopy width (in cm) of the nearest plant to the centre point in each quarter of the 1m x 1m quadrat;
- The cover (%) of cryptogams (mosses, algae and lichen); and
- The cover (%) of bare ground (e.g. surface free of vegetation, rock, wood, cryptogams and litter).

3.5.4 Additional data collected from 2022

Additional data was collected from 2022 to assist in determining other grassland condition trends. The additional data was collected at each of the eight 1 m x 1 m quadrats positioned along each 100 m transect and included:

- The cover (%) of litter material (i.e. dead plant matter and thatch no longer attached and standing).

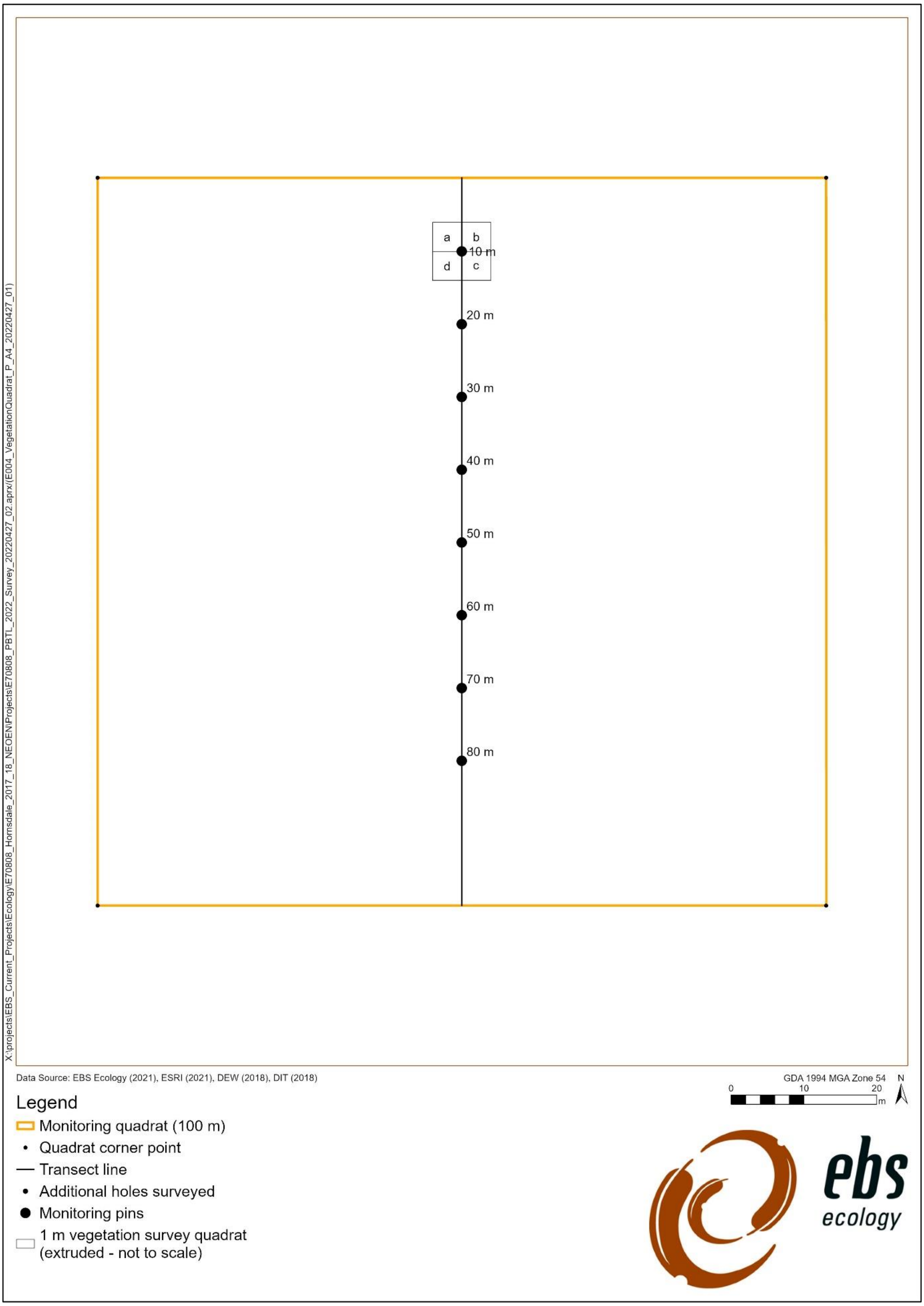

Figure 5. An example of a 1 ha vegetation monitoring quadrat with the layout of (1) a vegetation monitoring transect with monitoring pins and (2) the location of a 1 x 1 m vegetation survey quadrat.

Figure 6. Set-up of a 1 x 1 m vegetation survey quadrat.

3.6 Survey limitations

3.6.1 PBTL monitoring

The ground cover of vegetation was at an optimal stage (reasonably dry and lacked growth) for conducting searches for PBTLs, as the lack of vegetative growth aids in detecting spider burrows. Despite the high search effort (see Section 3.4) and favourable weather conditions, high litter and vegetation cover was not conducive to the easy detection of spider burrows. It is likely that burrows were not detected and therefore not surveyed for PBTLs.

The PBTL demography data collected should be treated with caution, as it is difficult to distinguish age-associated features with a burrow/video scope, particularly when views of PBTLs are restricted to within the burrow only.

3.6.2 Vegetation monitoring

At the time of the monitoring surveys, not all plants (particularly grasses) could be identified to species level due to lack of seed or other diagnostic features, caused by seasonal variation. Most plants were identified to genus or species level. However, some native and exotic species were completely dried off and could not be identified. Nonetheless, the data collected is considered to provide an adequate representation of the diversity at the SEB Offset Area.

High cover of litter and ground vegetation meant that juvenile grasses were difficult to detect, being largely obscured by rank grasses.

3.7 Statistical analyses

The PBTL and vegetation data analyses were conducted using the R software environment for statistical and graphical computing (R Core Team 2020).

3.7.1 PBTL monitoring

Type II one-way ANOVAs were used for statistical analyses to detect differences in the number of burrows, spiders and PBTLs recorded in the Baseline, 2018, 2019, 2020, 2021 and 2022 surveys. Type II ANOVAs are used to test for effects in an unbalanced design when there is no interaction observed between the explanatory variables, which is appropriate here given the different number of quadrats sampled during the baseline survey and since no interactions between the explanatory variables were detected. A p-value of 0.05 was used to infer a significant difference in PBTL numbers in response to the explanatory variables.

Type II two-way ANOVAs were used for statistical analyses to detect differences in the number of PBTLs in response to year and the number of burrows and spiders, respectively, as well as any differences in the number of PBTLs in response the various rainfall variables (i.e., the total rainfall 12 months, three months, one month and three winter months preceding each survey – data from BOM 2020).

A subset of the PBTL data (i.e., 2018–2022data) was also analysed using ANOVA to test for the influence of vegetation condition variables (collected during the 2018–2022 vegetation surveys) on the number of PBTLs.

3.7.2 Vegetation monitoring

One-way ANOVAs were used for statistical analyses to detect differences in the vegetation attributes recorded in the 2018, 2019, 2021 and 2022 surveys. A p-value of 0.05 was used to infer a significant difference.

3.7.3 Influence of rainfall on vegetation condition variables and PBTLs

Given anecdotal comments from the landowner regarding spring – summer rainfall, the total rainfall recorded for the spring – summer period (September to January) prior to each monitoring survey was analysed. Previous years data analysis has concentrated only on rainfall totals for the three months prior to the monitoring survey, that is December, January and February.

The September to January rainfall (see Section 2.4.2) was compared to the total number of PBTLs recorded and variables that might influence the habitat suitability and detectability of PBTL:

- Total number of spider holes surveyed across all quadrats.
- Cover (%) of bare ground + cover (%) of cryptogram, using the mean of the 1m x 1m quadrat measure calculated across all 12 monitoring sites.

- Basal width, tussock height and per-cent dead material, using the mean of the 1m x 1m quadrat measure calculated across all 12 monitoring sites.

While weed cover and litter cover may also influence habitat suitability, these variables were not compared to rainfall as those datasets have only been recorded since 2020.

The Pearson Correlation Coefficient of each dataset was calculated to determine if any relationships exist with increasing spring – summer rainfall.

4 PYGMY BLUE-TONGUE LIZARD MONITORING RESULTS

4.1 2023 results

4.1.1 Pygmy Blue-tongue Lizards

A total of 386 burrows across the 11 quadrats were checked for PBTL occupancy, of which 29 burrows (8.2%) contained one or more PBTLs (Figure 7; Table 5). Overall, 32 PBTLs were recorded in the 29 burrows (18 adults; 14 juveniles).

PBTL were found in seven of the 11 quadrats. The highest number of PBTLs were recorded within Quadrats 4 and 6 (9 individuals in each from 41 and 48 burrows checked respectively). No PBTLs were recorded in Quadrats 1,2, 7 and 11 (from 15, 60, 18 and 9 burrows checked respectively) (Figure 7; Table 5).

A positive correlation was found between the number of burrows and the number of PBTLs present within a quadrat (p-value = 0.3061; R^2 = 0.01742 (Figure 8A), however it was not significant: more burrows surveyed did not necessarily have the highest number of PBTL (i.e., no PBTL were recorded at Quadrat 2 where the highest number of holes was surveyed (60), however, the majority of holes surveyed in Quadrat 2 were cracks (rather than spider holes) (Table 5).

There was no significant difference in the number of PBTLs in response to aspect in 2023 (p-value = 0.584) (Figure 8B).

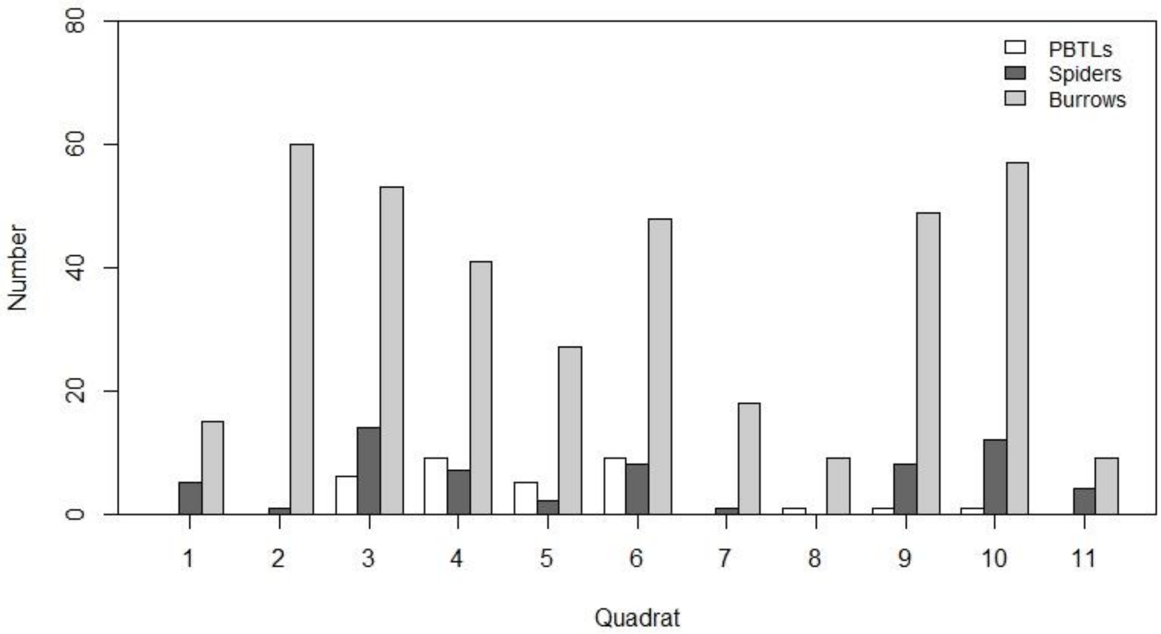

Figure 7. The number of burrows, spiders and PBTLs observed within Quadrat 1–11 in 2023.

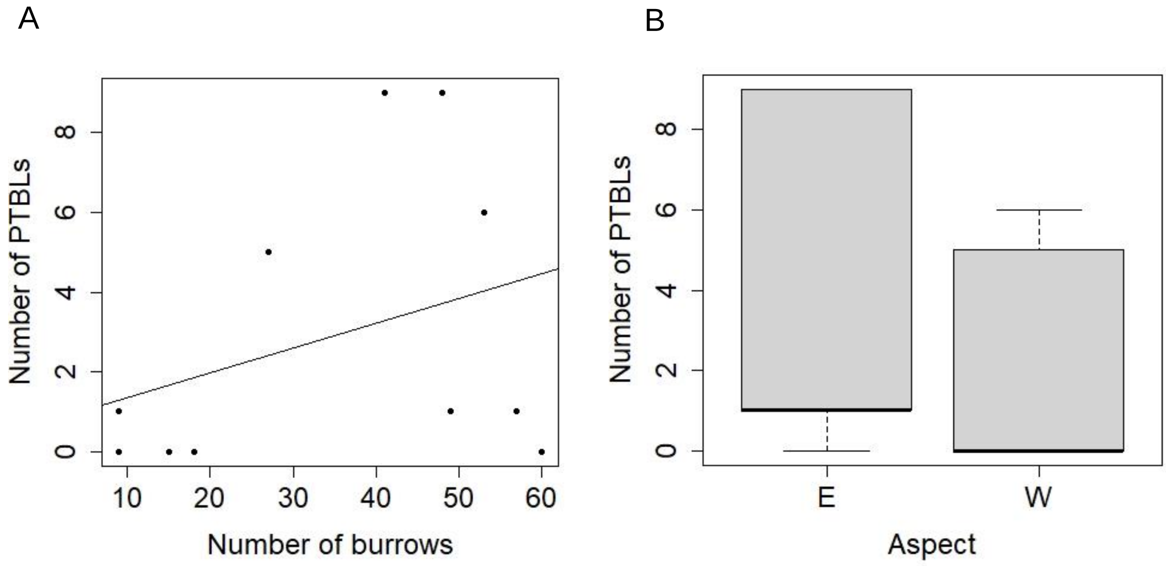

Figure 8. (A) The positive correlation between the number of burrows and number of PBTLs observed within each quadrat in 2023 (R^2 = 0.01742). (B) The distribution (minimum, maximum, median, 25th and 75th percentiles, outliers) of the numbers of PBTLs observed in quadrats on eastern (E) and western (W) orientated slopes in 2023.

4.1.2 Spiders

A total of 62 spiders were observed, with the most recorded in Quadrat 3 (14 individuals) and the least in Quadrats 8 (0 individuals) (Figure 7; Table 5).

4.1.3 Burrows

Density

A total of 386 burrows across the 11 quadrats were checked for PBTL occupancy. The density of burrows was highly variable over the SEB Offset Area, ranging from 9 burrows in Quadrat 8 and 11 to 60 in Quadrat 2 (Figure 7; Table 5). A higher density of burrows occurred on eastern facing slopes (264 burrows) than western facing slopes (122 burrows). However, there is one more quadrat on eastern facing slopes than western facing slopes (Figure 4; Table 5).

Quadrats 2, 10 and 3 had the highest number of burrows surveyed, while Quadrats 8, 11 and 1 had the fewest burrows.

Depth

The majority of burrows surveyed were <10 cm (184 burrows; 48.29%) and 10–20 cm (126 burrows; 33.07%) in depth, with 53 burrows 20–30 cm in depth (13.91%) and 18 burrows >30 cm in depth (4.72%) (Figure 9). The majority of PBTLs occurred in burrows 10-20 cm in depth (17 burrows; 54.84%), followed by burrows 10-20 cm in depth (11 burrows; 35.48%), >10 cm in depth (2 burrows; 6.45%) (Figure 9). No PTBL were observed in burrows <30 cm in depth. Quadrat 2 contained the most burrows 10–20 cm in depth (Figure 10), while quadrats 4 and 6 recorded the highest numbers of PBTLs (Figure 7).

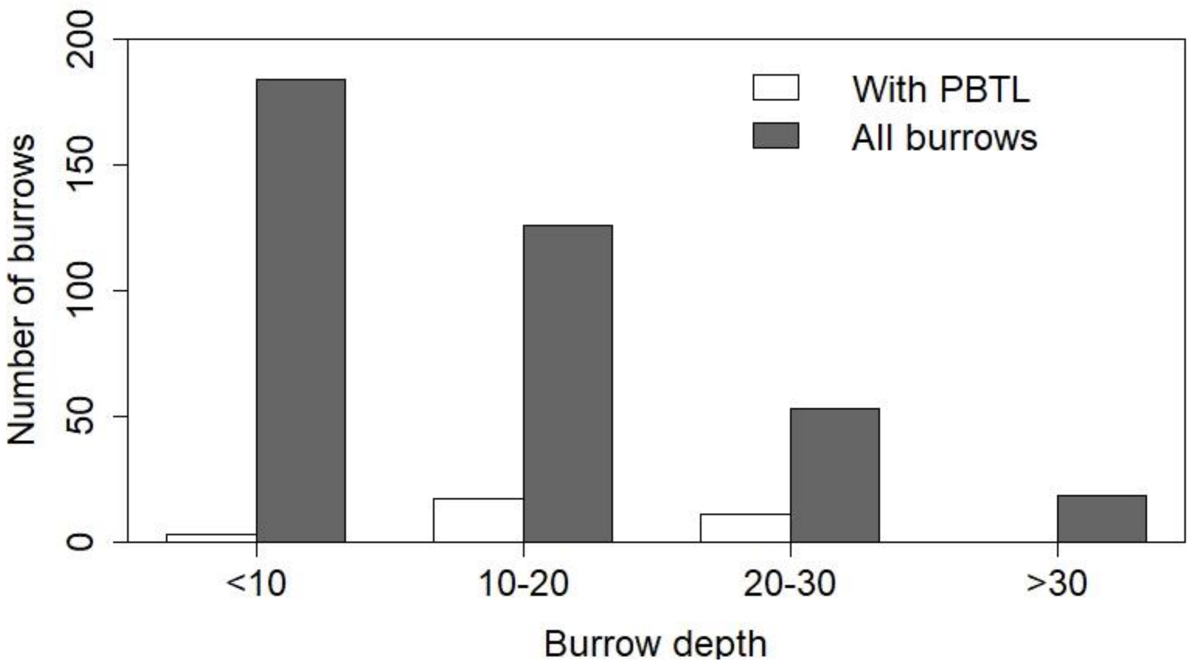

Figure 9. The number of burrows containing PBTLs and the total number of burrows in each depth class in all quadrats in 2023.

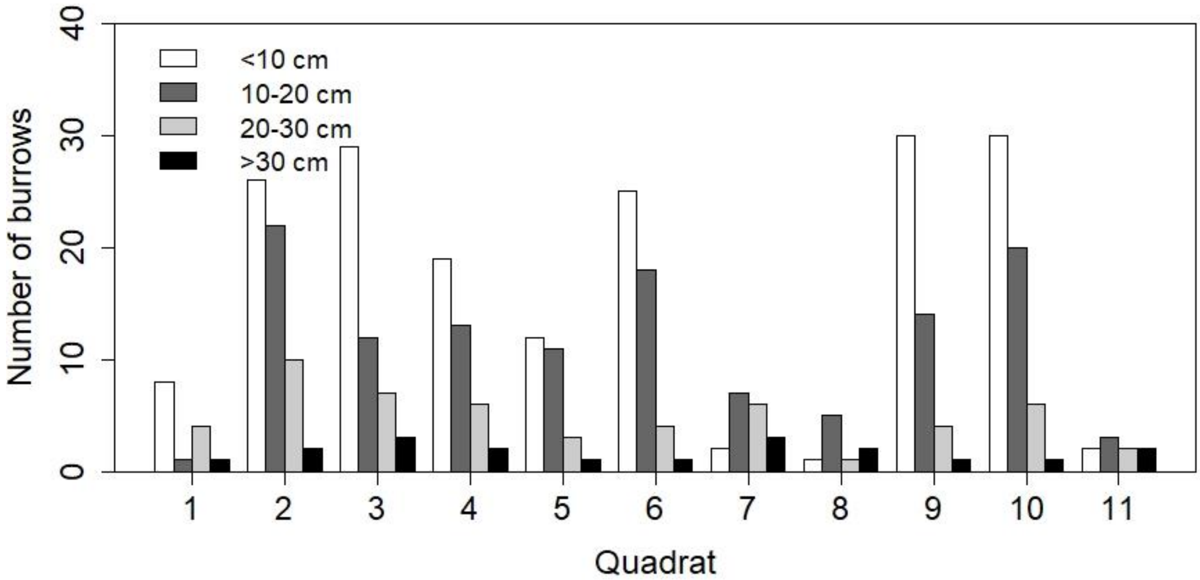

Figure 10. The total number of burrows in each depth class in Quadrats 1–11 in 2023.

4.1.4 Other burrow contents

Invertebrates observed within burrows across all quadrats included ants (14), beetles (12), centipedes (5), snails (3) and weevils (5) (Table 5).

A total of 6 burrows were empty, while 239 contained debris and 4 were too small to feed the videoscope optic fiber into (Table 5). These small burrows are likely too small to contain PBTLs. PBTLs were recorded in burrows that were the size of the scope.

Table 5. Summary of the results from the 2023 PBTL monitoring quadrats.

Quadrat	Aspect	Burrows with PBTLs	Juvenile PBTLs	Adult PBTLs	Total PBTLs	% Burrows with PBTLs	Ant	Beetle	Centipede	Debris	Empty burrow	Mouse hole	Snail	Snake	Spider	Burrow too small	Weevil	Total burrows
1	W	0	0	0	0	0	1			7					5	1	1	**15**
2	E	0	0	0	0	0		2		57					1			**60**
3	W	6	0	6	6	11.3	1		1	26			3		13	2	1	**53**
4	E	8	4	5	9	22.0	2		1	22		1			7			**41**
5	W	5	2	3	5	18.5			1	18			1		2			**27**
6	E	7	6	3	9	18.5		1		28					8	1	3	**48**
7	W	0	0	0	0	0		1		12		1			1		3	**18**
8	E	1	1	0	1	11.1				7				1				**9**
9	E	1	1	0	1	2.04	2	4	3	30					8		1	**49**
10	E	1	0	1	1	1.75	8	5		28	1	2			12			**57**
11	W	0	0	0	0	0		1		3					4		1	**9**
Total/ Mean		**29**	**14**	**18**	**32**	**8.29**	**14**	**12**	**5**	**239**	**6**	**2**	**3**	**1**	**62**	**4**	**5**	**386**

4.1.5 Quadrat 1

A total of 15 burrows were checked within Quadrat 1 in 2023, none of which contained a PBTL (0%) (Figure 11). Spiders were present in five burrows, while one contained a weevil and one ants (Table 5).

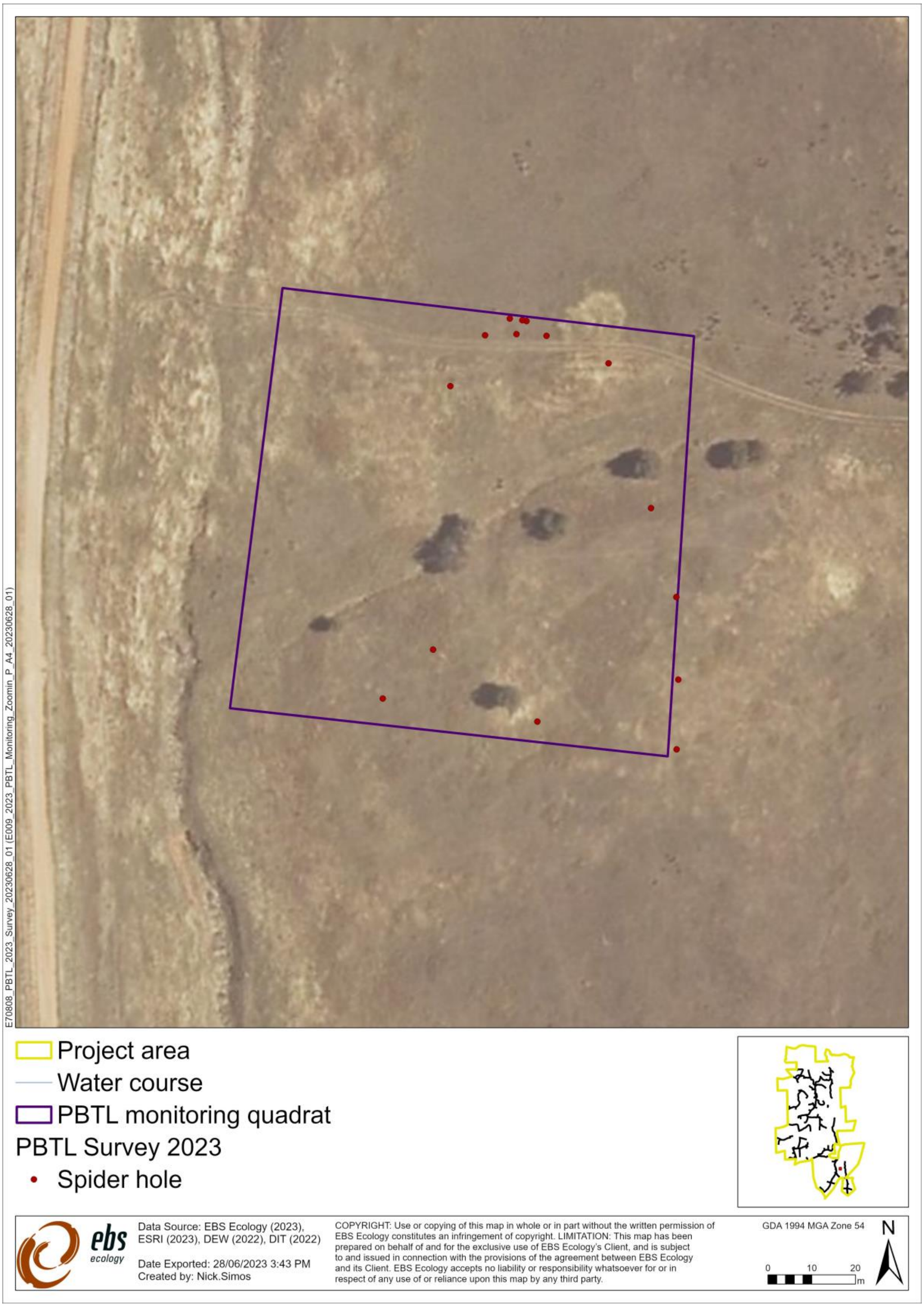

Figure 11. Location of burrows surveyed and PBTLs observed within Quadrat 1 during the 2023 survey.

4.1.6 Quadrat 2

Sixty burrows were checked within Quadrat 2 in 2023. None of which contained PBTLs (0%) (Figure 12). Only one spider was recorded, two beetles and the remainder of burrows recorded as filled with debris (Table 5).

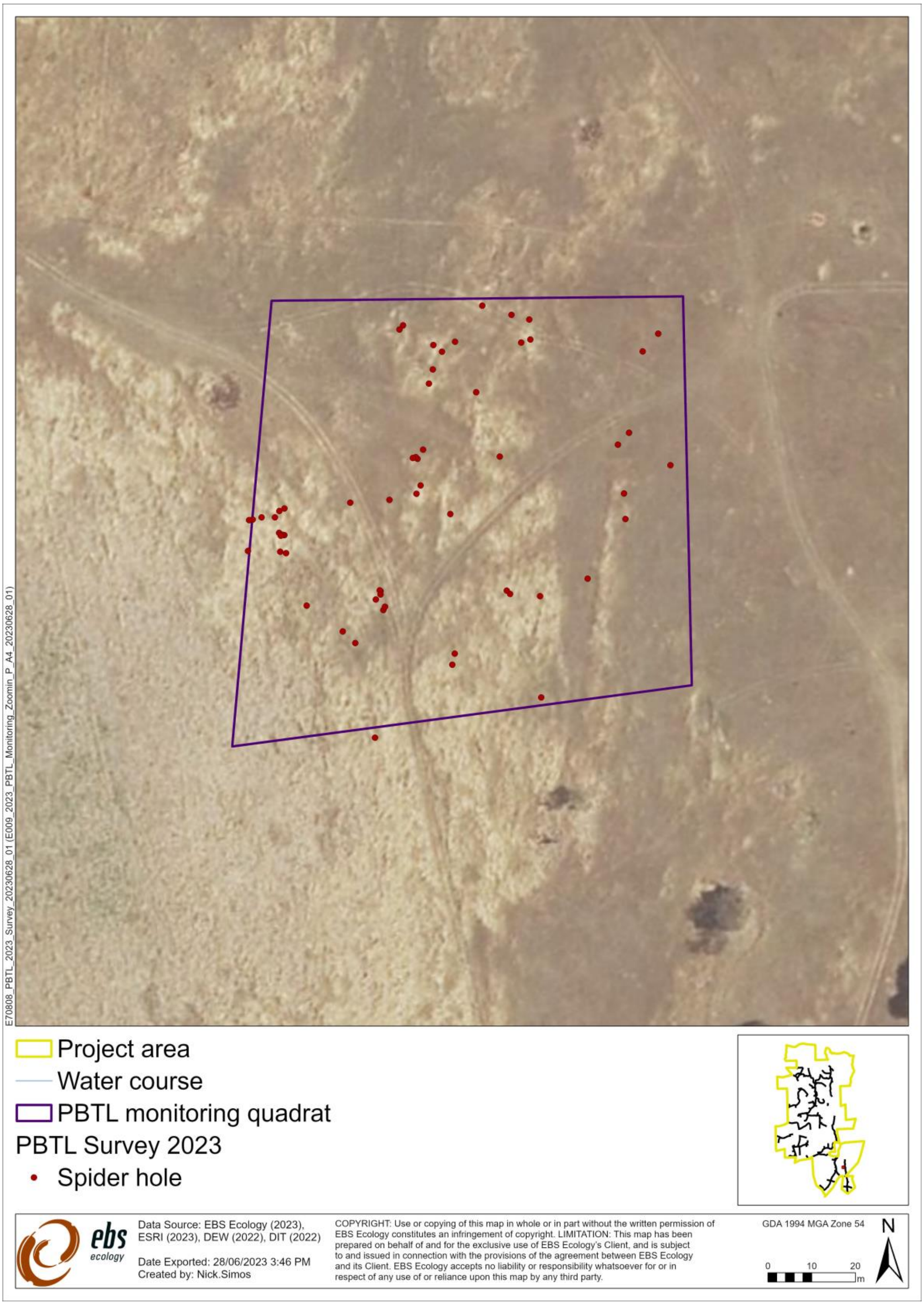

Figure 12. Location of burrows surveyed and PBTLs observed within Quadrat 2 during the 2023 survey.

4.1.7 Quadrat 3

A total of 53 burrows were checked within Quadrat 3 in 2023. Six contained PBTLs (11.3%) (Figure 13). A total of 6 PBTLs were recorded, all adults. Thirteen burrows contained spiders and 26 debris, with contents of the remaining burrows including snails (3), ants (1), centipedes (1) and weevils (1). Two burrows were assessed as too small to be used by PBTLs (Table 5).

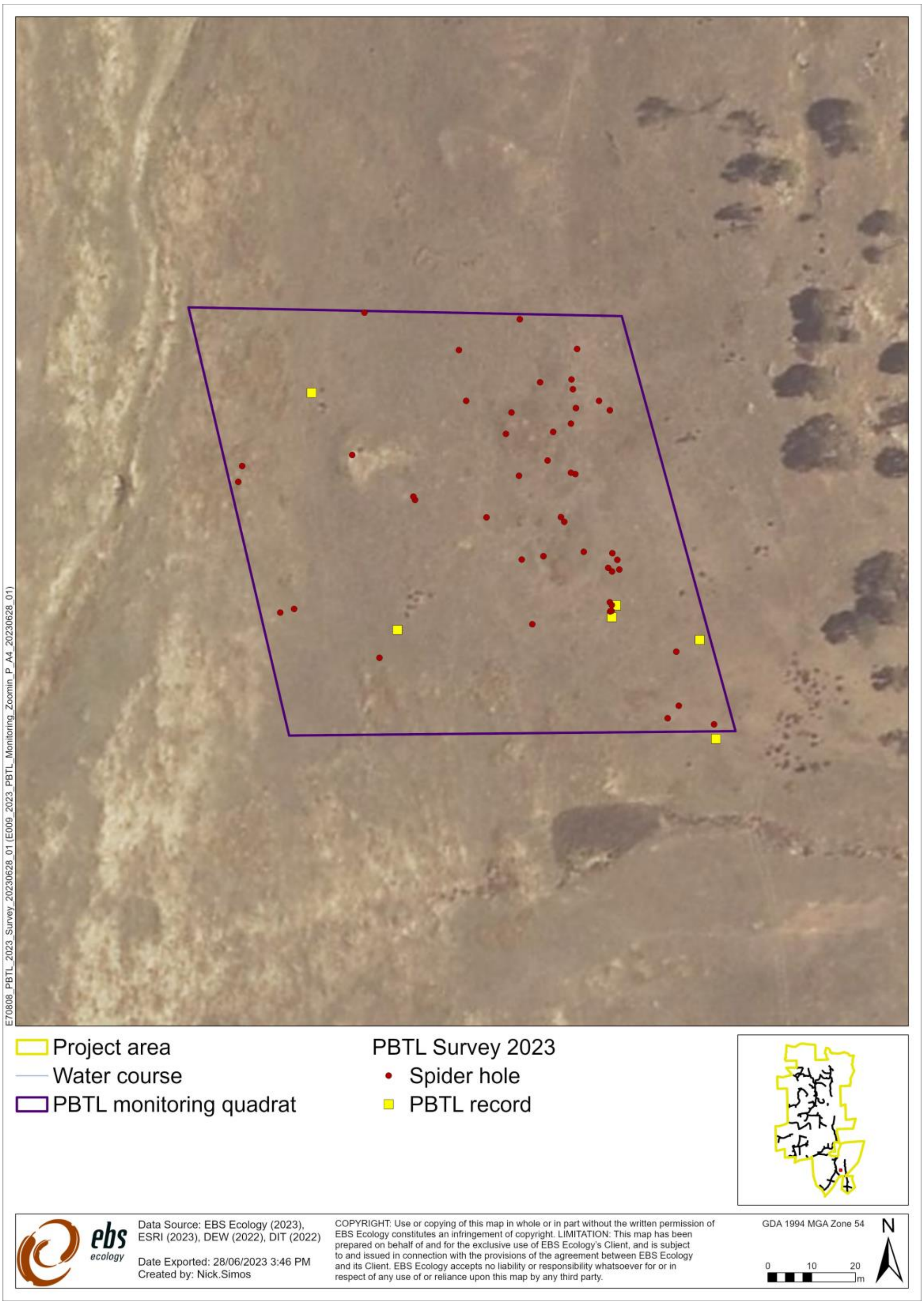

Figure 13. Location of burrows surveyed and PBTLs observed within Quadrat 3 during the 2023 survey.

4.1.8 Quadrat 4

A total of 41 burrows were checked within Quadrat 4 in 2023, 8 of which contained PBTLs (22.0%) (Figure 14). A total of 9 PBTLs were recorded (five adults; four juveniles). Remaining burrows contained debris (22), spiders (7), ants (2), centipedes (1) and a House Mouse (*Mus musculus*) (1) (Table 5).

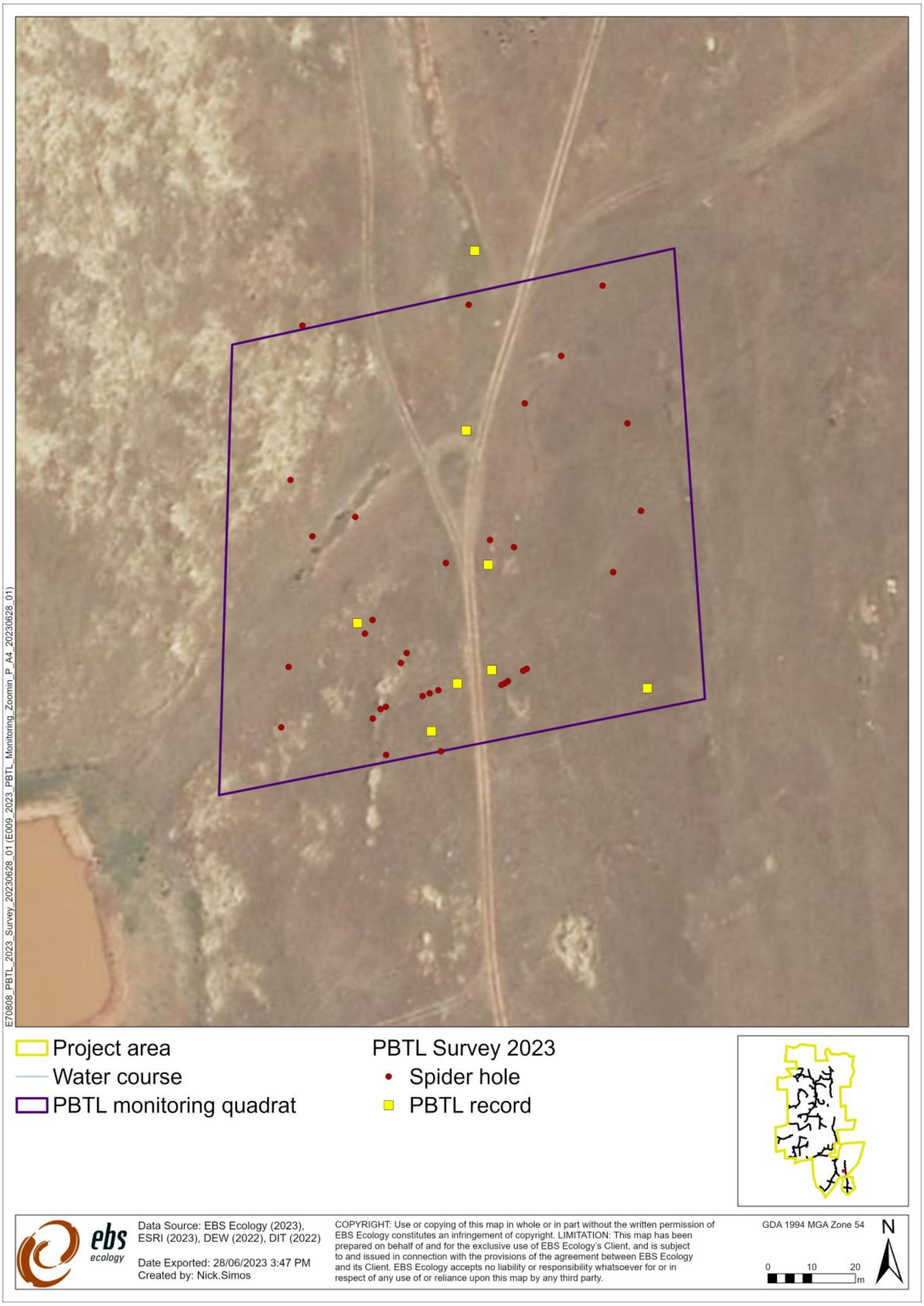

Figure 14. Location of burrows surveyed and PBTLs observed within Quadrat 4 during the 2023 survey.

4.1.9 Quadrat 5

Twenty-seven burrows were located and checked in Quadrat 5 in 2023. Five burrows contained PBTLs (18.5%) (Figure 15). A total of three adult and 2 juvenile PBTLs were recorded, with remaining burrows containing debris (27), spiders (2), snails (1) and centipedes (1) (Table 5).

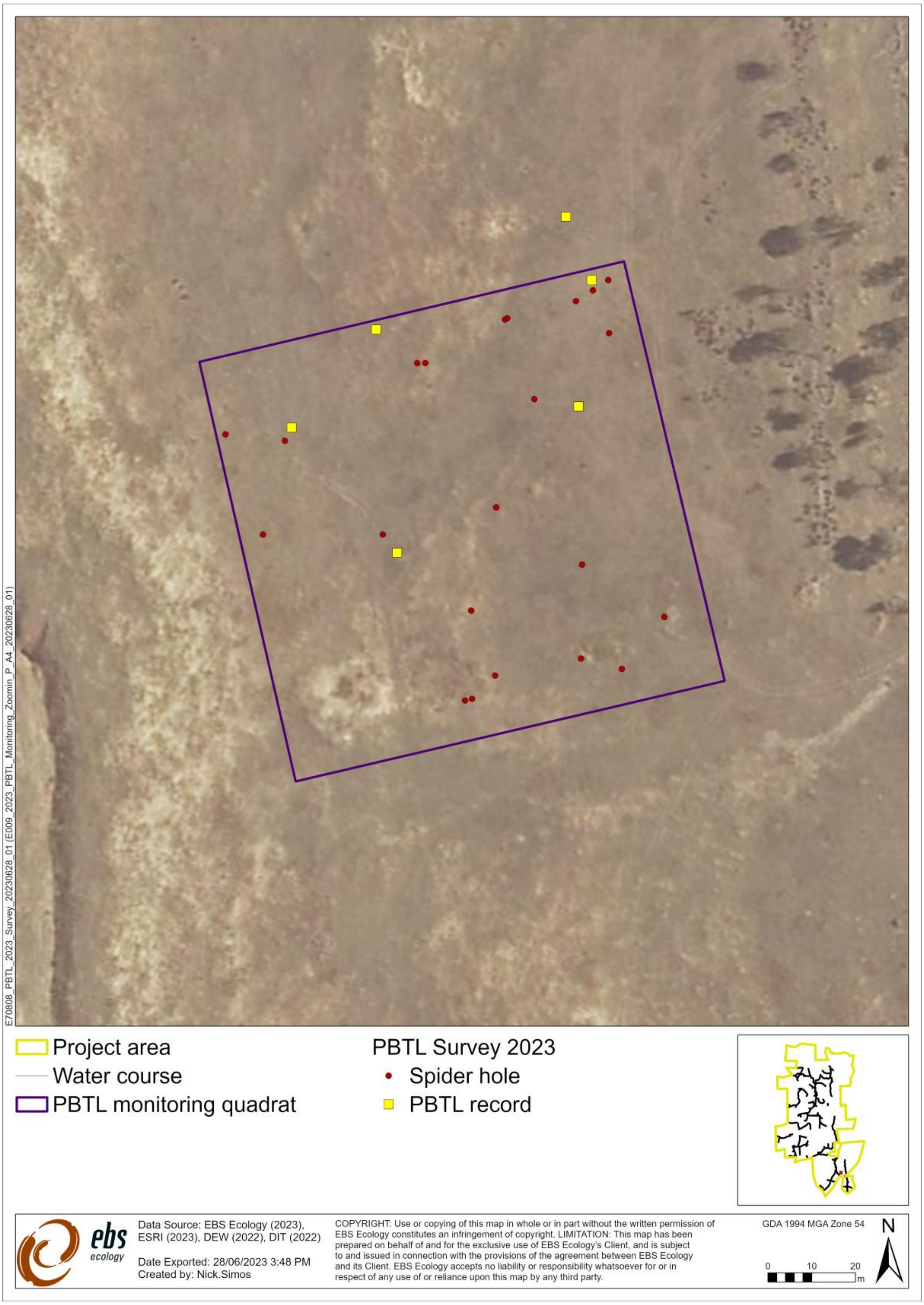

Figure 15. Location of burrows surveyed and PBTLs observed within Quadrat 5 during the 2023 survey.

4.1.10 Quadrat 6

A total of 48 burrows were checked within Quadrat 6 in 2023, seven of which contained PBTLs (18.5%) (Figure 16). A total of nine PBTLs were recorded (three adults; six juveniles). Spiders, weevils and debris were observed in eight, three and 28 burrows respectively. A beetle was found in one burrow, while one burrow was assessed as too small to be used by a PBTL (Table 5).

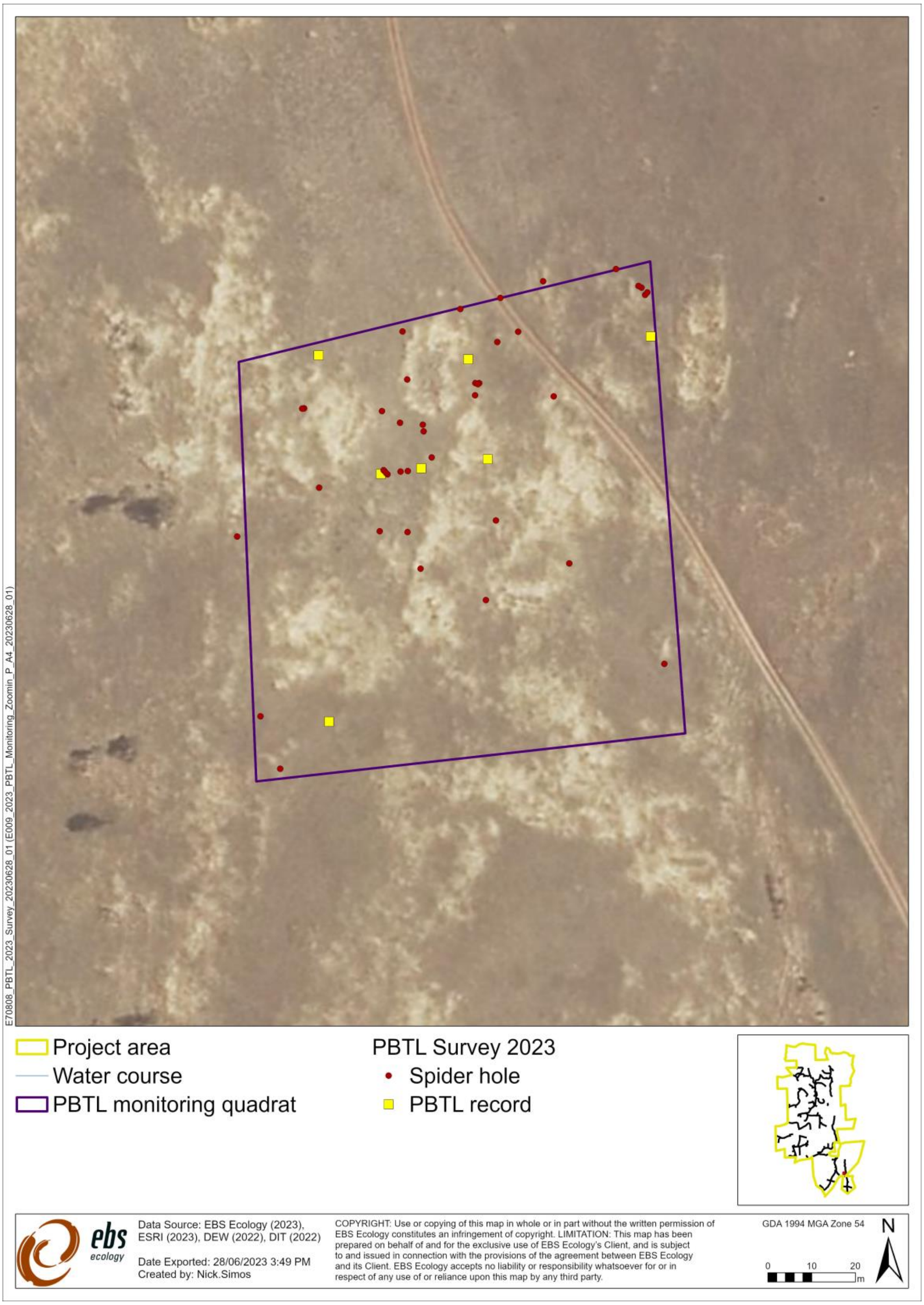

Figure 16. Location of burrows surveyed and PBTLs observed within Quadrat 6 during the 2023 survey.

4.1.11 Quadrat 7

Only 18 burrows were located and checked within Quadrat 7 in 2023. None contained PBTLs (0%) (Figure 17). The majority of burrows contained only debris (12), beetles, spiders and House Mice were each observed in a single burrow each, while weevils were found in three burrows (Table 5).

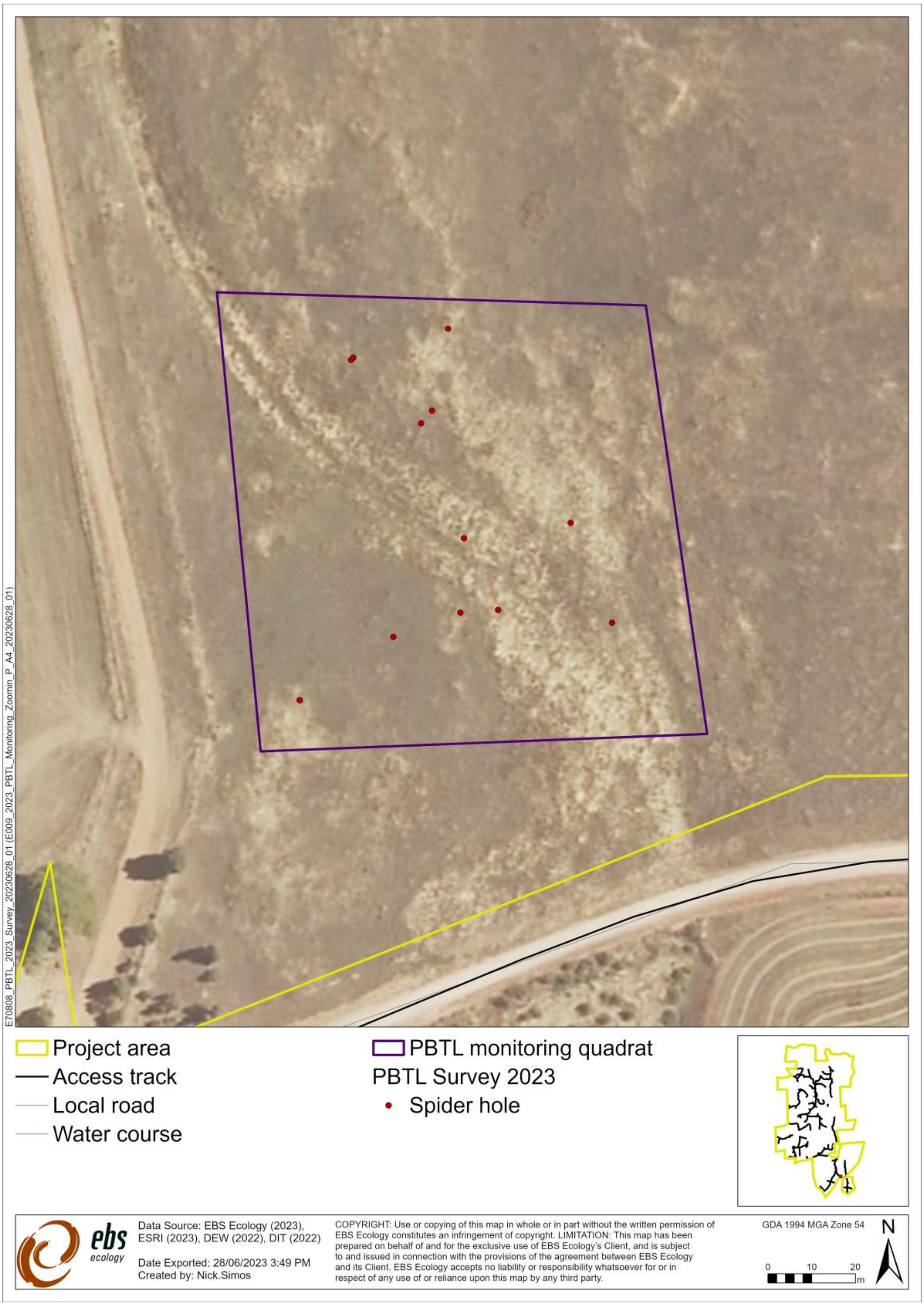

Figure 17. Location of burrows surveyed and PBTLs observed within Quadrat 7 during the 2023 survey.

4.1.12 Quadrat 8

Nine burrows only were located and checked within Quadrat 8 in 2023. One contained a juvenile PBTL (11.1%). No adult lizards were recorded (Figure 18). Seven burrows contained debris, while one was occupied by a small snake, probably a juvenile *Pseudonaja textilis* (Eastern Brown Snake) (Table 5).

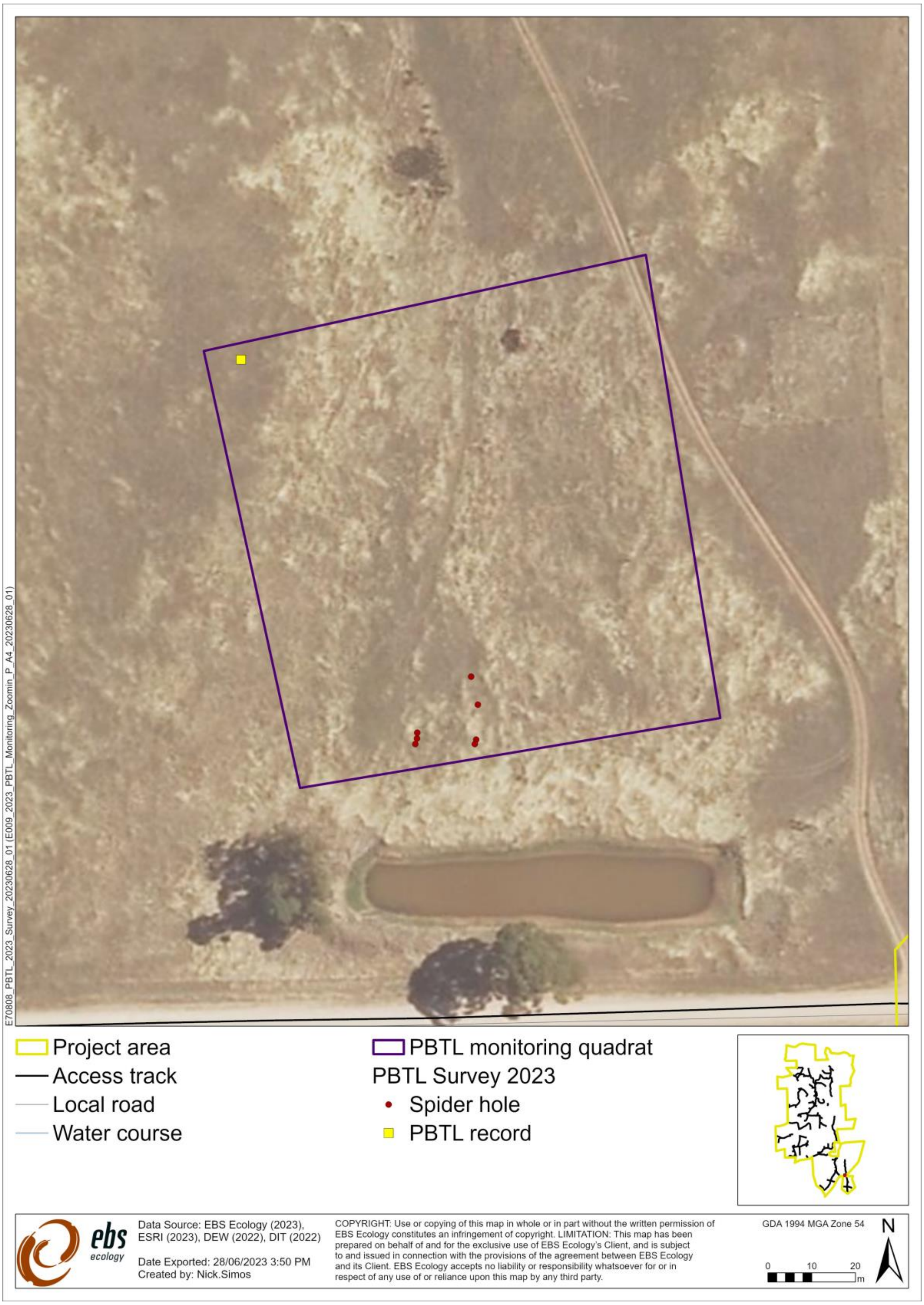

Figure 18. Location of burrows surveyed and PBTLs observed within Quadrat 8 during the 2023 survey.

4.1.13 Quadrat 9

A total of 49 burrows were checked within Quadrat 9 in 2023, one of which contained a PBTL (2.04%) (Figure 19). The single PBTL recorded was a juvenile. Thirty burrows contained debris, while spiders (8), beetles (4), centipedes (3) and ants (2) occupied the remining burrows (Table 5).

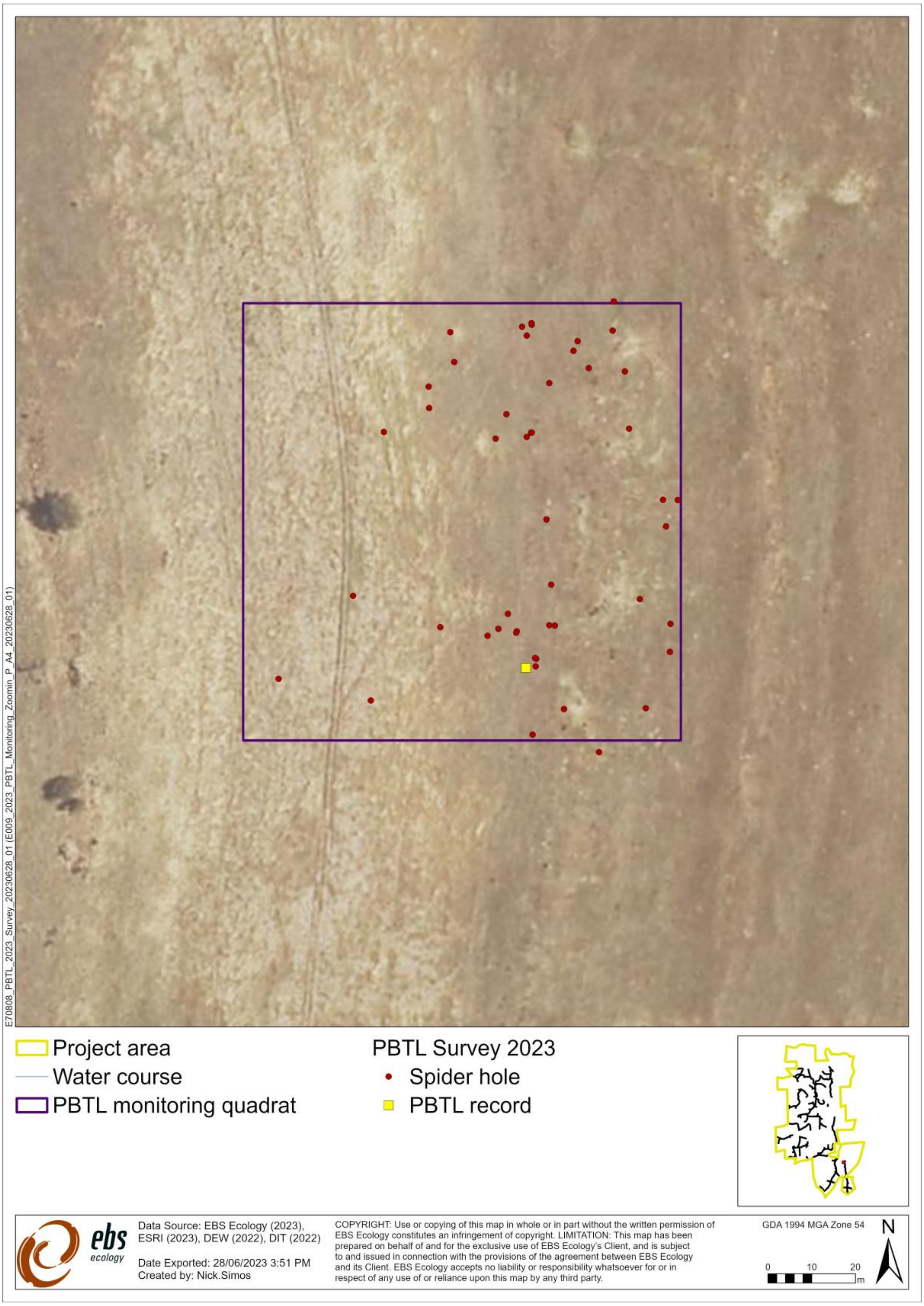

Figure 19. Location of burrows surveyed and PBTLs observed within Quadrat 9 during the 2023 survey.

4.1.14 Quadrat 10

A total of 57 burrows were checked within Quadrat 10 in 2023, one of which contained an adult PBTL (1.75%) (Figure 20). Spiders, weevils, beetles and debris were observed in four, one, one and three burrows, respectively (Table 5).

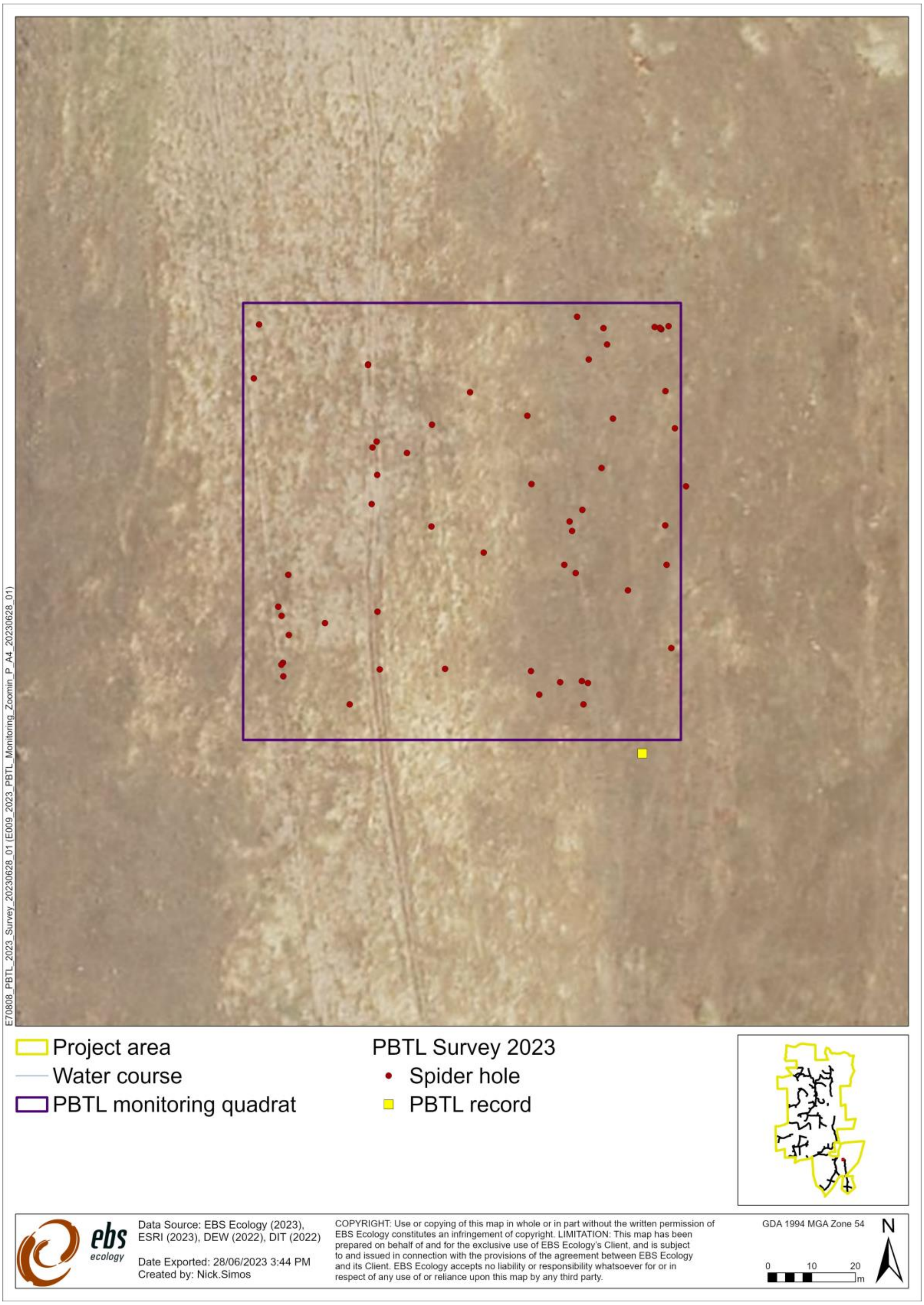

Figure 20. Location of burrows surveyed and PBTLs observed within Quadrat 10 during the 2023 survey.

4.1.15 Quadrat 11

A total of nine burrows were checked within Quadrat 11 in 2023, none of which contained PBTLs (0%) (Figure 21). Most burrows contained either spiders or debris (four and three respectively). Weevils and beetles were also recorded (Table 5).

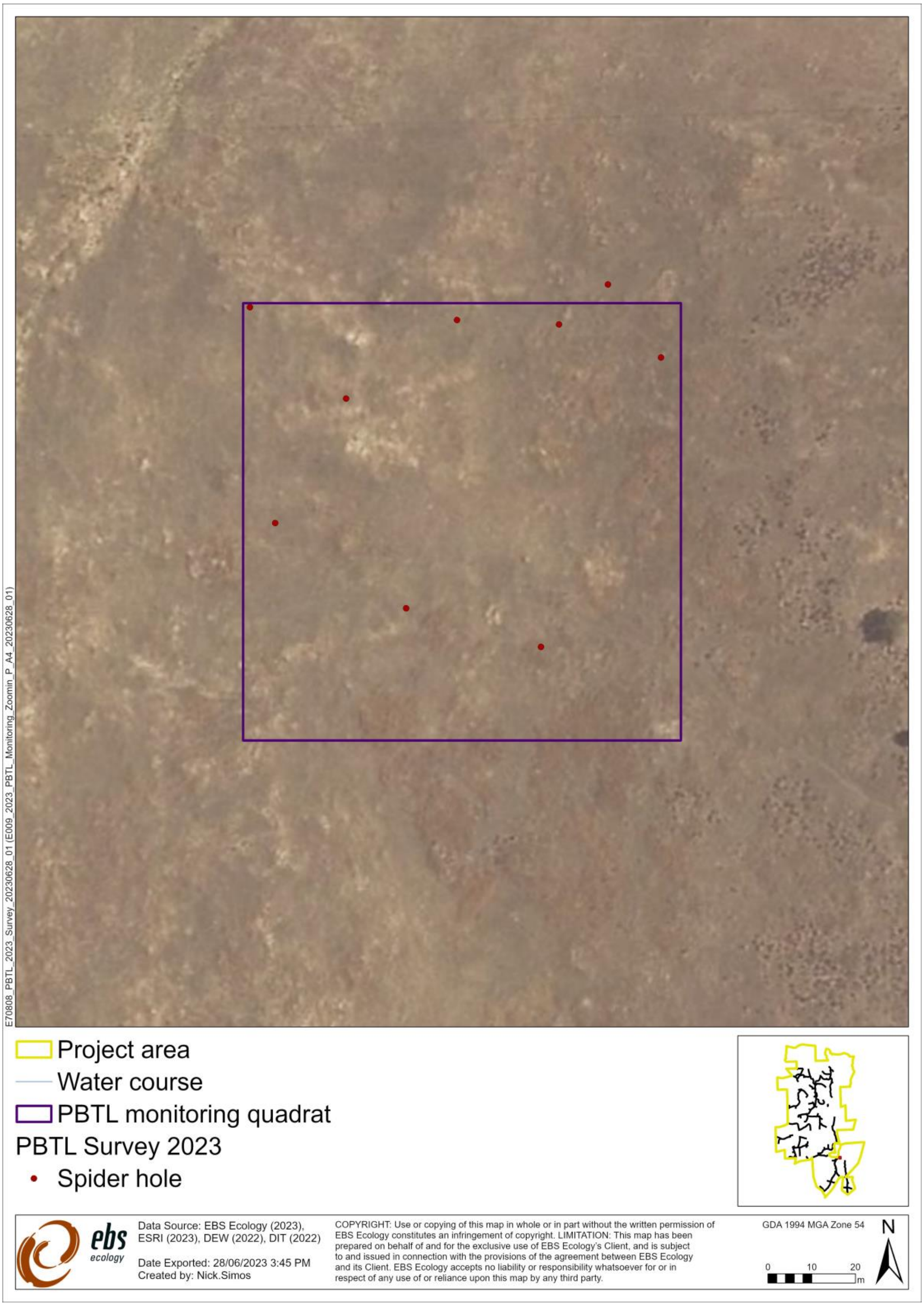

Figure 21. Location of burrows surveyed and PBTLs observed within Quadrat 11 during the 2023 survey.

4.2 Comparison between years

4.2.1 PBTLs

The mean number of PBTLs per quadrat observed in 2023 ($\bar{x}$ = 2.91 individuals) was less than the baseline ($\bar{x}$ = 17.40 individuals), 2018 ($\bar{x}$ = 16.60 individuals), 2019 ($\bar{x}$ = 19.10 individuals) and 2020 ($\bar{x}$ = 10.30 individuals), 2021 ($\bar{x}$ = 3.70 individuals) and 2022 ($\bar{x}$ = 8.73 individuals) surveys (Figure 22). There was a significant difference in the mean number of PBTLs between the five sampling years (p-value = 0.00789) with the significant difference occurring between years 2023 and 2019 (the years with the highest and lowest PBTLs recorded).

Relative to 2022, the number of PBTLs decreased in all quadrats except Quadrats 8 (where it was the same). All Quadrats had lower numbers of individuals recorded than the 2018-2020 period. For the last three years for Quadrats 2, 3 and 8 and four years for 1 and 9 these Quadrats recorded much lower PBTL numbers than the preceding years (2018-2020) (Figure 23). Similar to past years, Quadrat 4 and 6 continued to have the highest numbers of PBTLs of the 11 Quadrats, however four sites recorded no PBTL when all other years except 2021 recorded at least 1 PBTL at each site.

The proportion of adult PBTLs observed in 2023 (56.25%) was lower than all previous surveys: 2022 (88.30%), 2021 (95.10%), 2019 survey (91.90%), 2020 (84.07%), the Baseline (71.94%) and 2018 (83.53%). As such, the proportion of juvenile PBTLs observed in 2023 was the highest surveyed (43.75%) compared to 2022 (11.70%), 2021 (4.98%), 2020 (15.93%), 2019 (8.10%), 2018 (16.47%), and Baseline (28.06%).

A significant positive correlation was detected between the number of PBTLs and spiders (p-value = 0.00024) (R^2 = 0.326) across the six surveys. A significant positive correlation was also detected between the number of PBTLs and burrows (p-value = 0.0001) (R^2 = 0. 5824) across the six surveys (Figure 24A; Figure 24B).

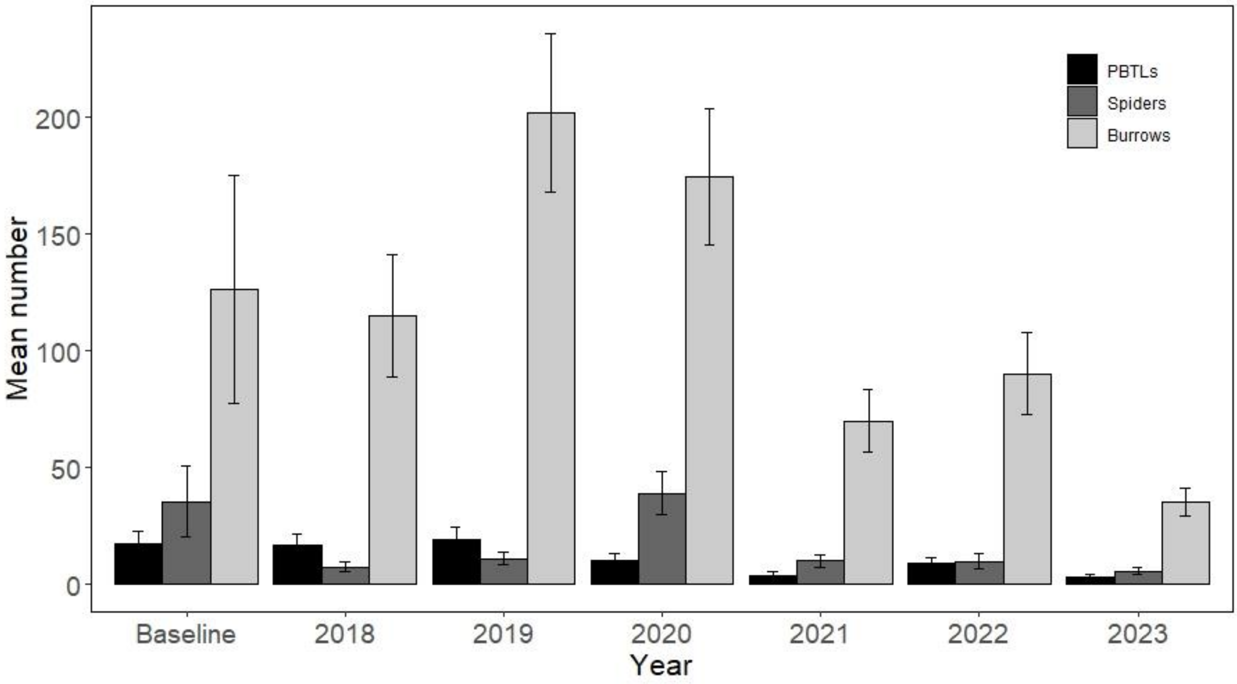

Figure 22. The mean number (± S.E.) of PBTLs, spiders and burrows across the 11 quadrats during the baseline, 2018, 2019, 2020, 2021, 2022 and 2023 surveys (n.b. the Baseline survey only surveyed Quadrat 1–8).

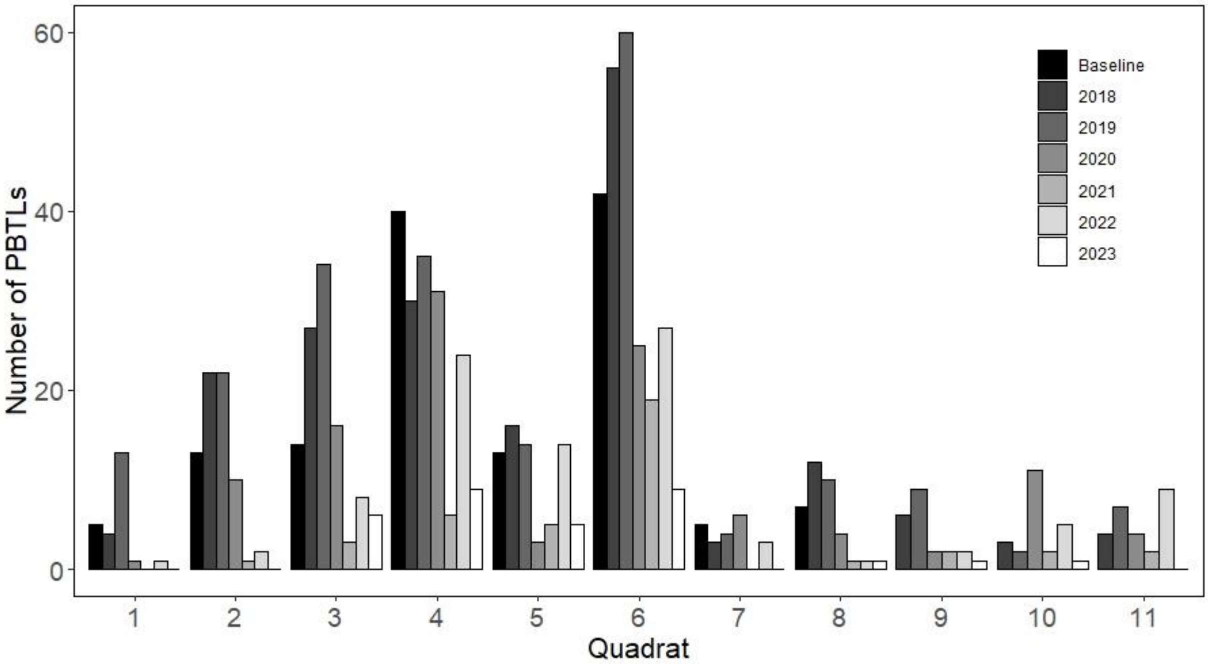

Figure 23. The number of PBTLs observed within each quadrat during the baseline, 2018, 2019, 2020, 2021, 2022 and 2023 surveys (n.b. the Baseline survey only surveyed Quadrat 1–8).

Table 6. The total number of PBTLs within each age class recorded during the Baseline, 2018, 2019, 2020, 2021, 2022 and 2023 surveys (n.b. the Baseline survey only surveyed Quadrat 1–8; the 2020, 2021 and 2022 surveys classified PBTLs as Adult or Juvenile).

Age class	Baseline	2018	2019	2020	2021	2022	2023
Adult	100	142	193	95	39	84	18
Sub-adult	10	8	15				
Juvenile	29	20	2	18	2	12	14
Total	**139**	**170**	**210**	**113**	**41**	**96**	**32**

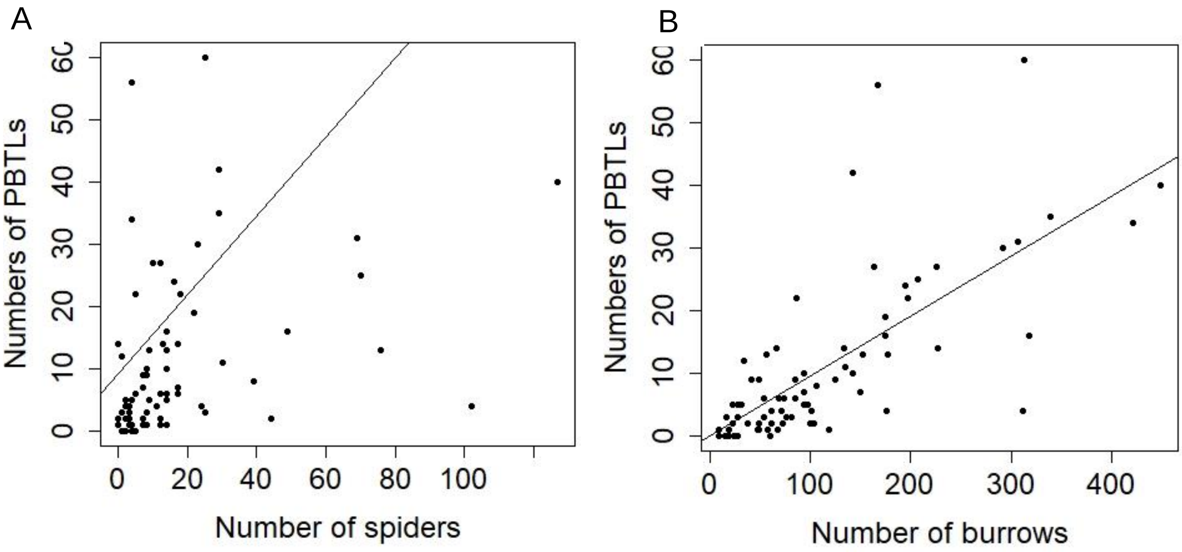

Figure 24. The positive correlation between the numbers of PBTLs and spiders (A) and burrows (B).

4.2.2 Spiders

The mean number of spiders per quadrat observed in 2023 (x̄ = 5.64 individuals) was lower than 2022 (x̄ = 9.90 individuals) 2021 (x̄ = 10 individuals), 2020 (x̄ = 38.72 individuals), 2019 (x̄ = 11.00 individuals) and the baseline (x̄ = 35.50 individuals), but similar to the 2018 (x̄ = 7.27 individuals) survey (Figure 22).

This difference was statistically significant (p-value = 0.00026), with the Tukey post hoc test revealing a significant difference between the 2020 and 2018 surveys (p-value = 0.0067), 2020 and 2019 surveys (p-value = 0.025), 2021 and 2020 survey (p-value = 0.018), the 2022 and 2020 survey (p-value = 0.017), the 2023 and 2016 survey (p-value = 0.030) and the 2020 and 2023 survey (p-value = 0.0037).

Relative to 2022, the number of spiders decreased in Quadrats 1, 3, 4, 5, 6 and 11, remained the same in Quadrats 7 and 8 and increased in Quadrats 2, 9 and 10 (Figure 25).

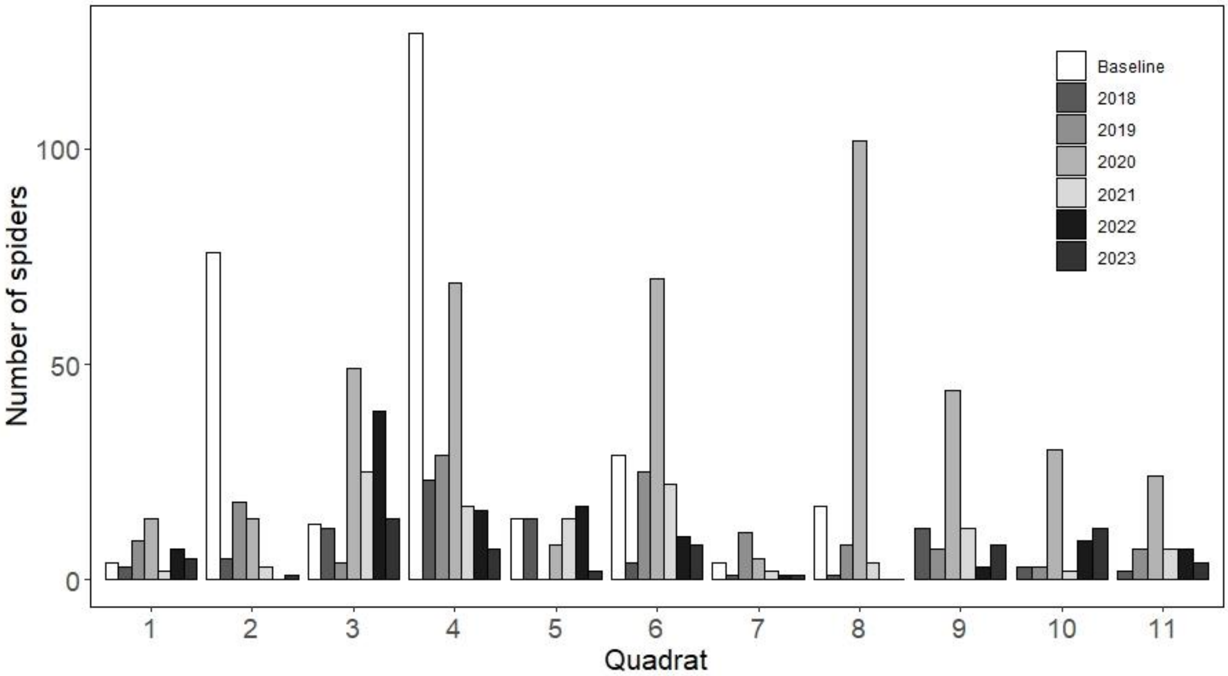

Figure 25. The number of spiders observed within each quadrat during the baseline, 2018, 2019, 2020, 2021 2022 and 2023 surveys (n.b. the baseline survey only surveyed Quadrat 1–8).

4.2.3 Burrows

The mean number of burrows per quadrat observed in 2023 (x̄ = 35.1) was less than all previously conducted surveys: 2022: x̄ = 90.30, 2021: x̄ = 70.00, 2020: x̄ = 171.10, 2019: x̄ = 202.10, 2018: x̄ = 115.10 and baseline: x̄ = 126.38 (Figure 22).

This difference was statistically significant (p-value = 0.00249), with the Tukey post hoc test revealing a significant difference between the 2021 and 2019 surveys (p-value = 0.098), between 2019 and 2020 (p-value = 0.047), 2019 and 2023 (p-value = 0.0004) and 2020 and 2023 (p-value = 0.005), all others are not significant.

Relative to 2022, the number of burrows decreased in Quadrats 1, 3, 4, 5, 6, 7, 8, 10 and 11, with all quadrats except 10 recording their lowest number of burrows. The number of burrows increased in Quadrat 2 and 9 from 2022 to 2023 (Figure 26).

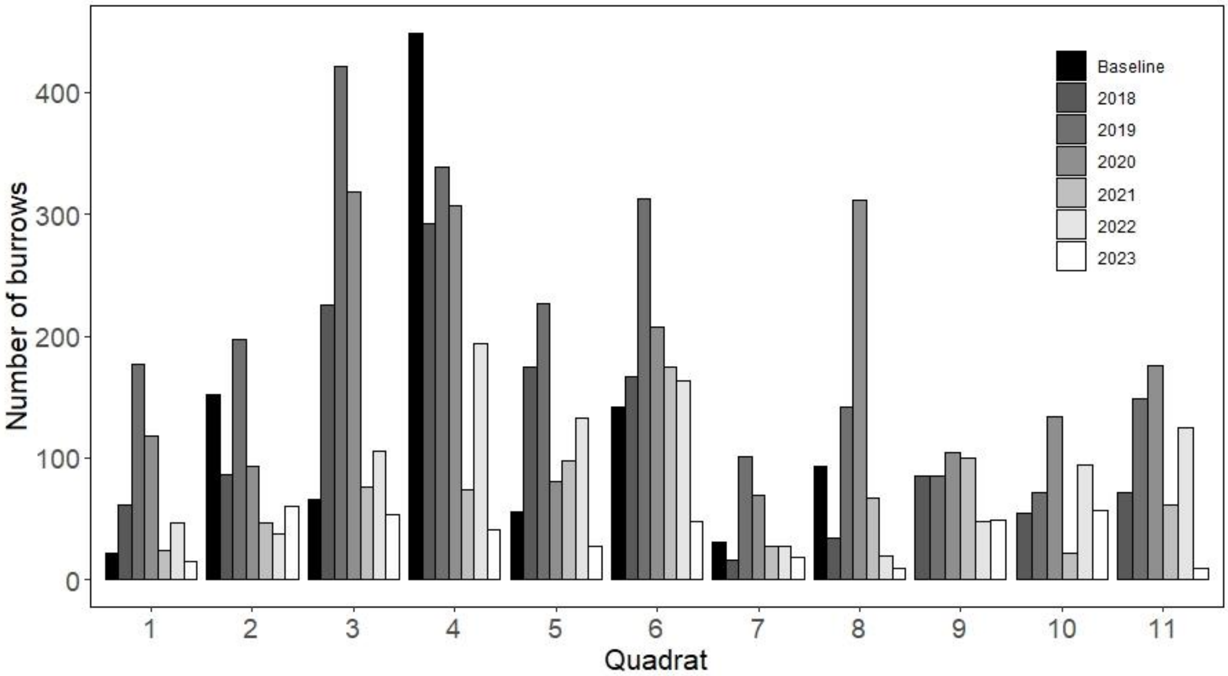

Figure 26. The number of burrows checked within each quadrat during the baseline (2016), 2018, 2019, 2020, 2021, 2022 and 2023 surveys (n.b. the baseline survey only surveyed Quadrat 1–8).

4.3 Influence of aspect, rainfall and vegetation condition variables on PBTLs

4.3.1 Aspect

The mean number of PBTLs per quadrat across the six surveys was significantly greater on eastern than on western slopes (p-value = 0.024) (Figure 32A).

4.3.2 Rainfall

As for previous years, the number of PBTLs were compared against rainfall 3 months prior to survey, total rainfall for the year prior to survey, rainfall 1 month prior to survey and rainfall in the winter prior to survey. There was no correlation detected for any of these rainfall timeframes. However, when compared to the spring-summer rainfall recorded prior to the monitoring (i.e. total rainfall for September to January), some relationships were detected.

There is a moderate to strong negative correlation between spring-summer rainfall and the total number of PBTLs (r = -0.74) and the total number of spider holes (r = -0.83) observed during the monitoring. That is, as spring-summer rainfall increases, the number of PRBLs and the number of spider holes detected decreases. That is, as rainfall increases, there is a correlating decrease in the number of PBTLs and spider holes detected. This is shown by the graphs in Figure 27 and Figure 28.

When spring-summer rainfall was compared to vegetation monitoring data, there was a strong negative correlation with mean bare ground % + cryptogram % (r = -0.91) (Figure 29) and tussock basal width (r = -0.84) (Figure 30). There was a moderate positive correlation with tussock height (r = 0.64), with height increasing during periods of higher rainfall (Figure 31).

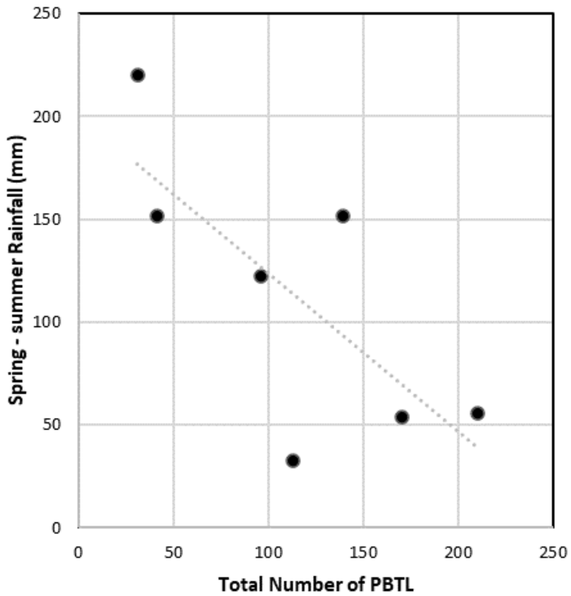

Figure 27. The total number of PBTLs detected during each monitoring year plotted against spring-summer rainfall. There is a moderate negative correlation between the datasets (r = -0.74).

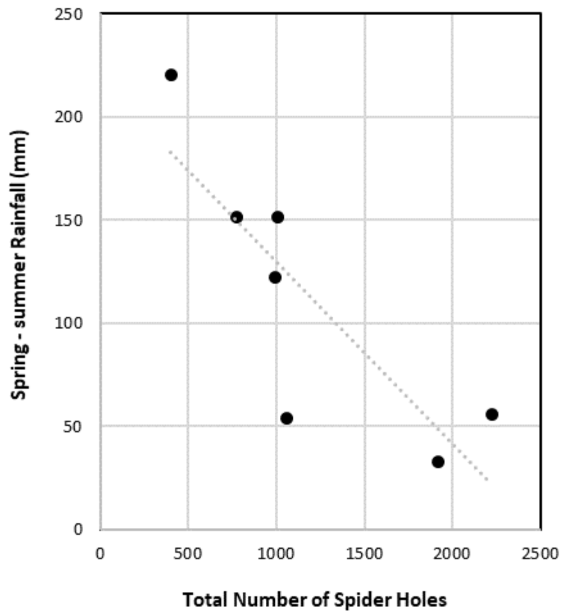

Figure 28. The total number of spider holes detected during each monitoring year plotted against spring-summer rainfall. There is a moderate negative correlation between the datasets (r = -0.83).

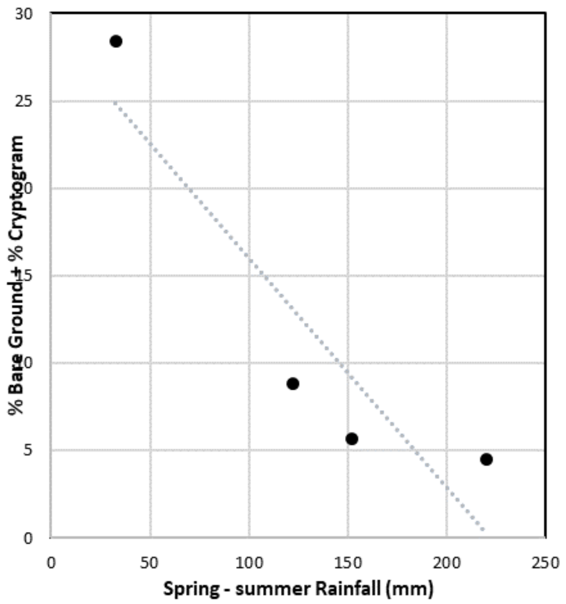

Figure 29. The mean bare ground + cryptogram cover measured during each monitoring year plotted against spring-summer rainfall. There is a strong negative correlation between the datasets (r = -0.91).

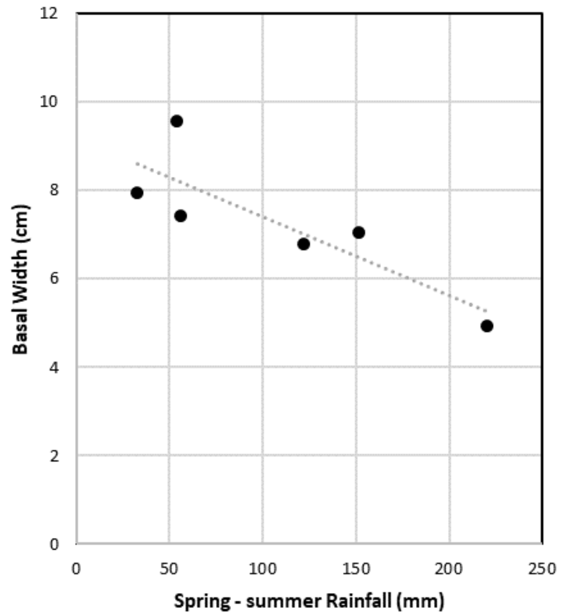

Figure 30. The mean tussock basal width measured during each monitoring year plotted against spring-summer rainfall. There is a moderate negative correlation between the datasets (r = -0.84).

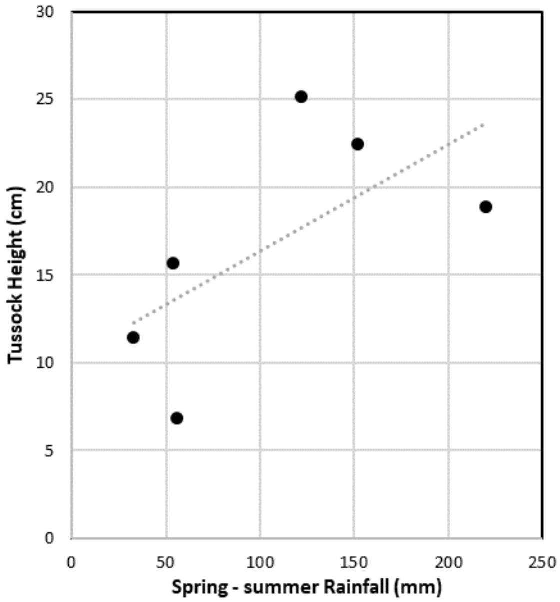

Figure 31. The mean tussock height measured during each monitoring year plotted against spring-summer rainfall. There is a moderate positive correlation between the datasets (r = 0.64).

4.3.3 Vegetation condition variables

The mean number of PBTLs per quadrat in 2018–2022 decreased with increasing grass tussock basal width, but with the addition of the 2023 data, there is no association (p-value = 0.5401) (Figure 32B).

No correlations were detected between the number of PBTLs and the remaining vegetation condition variables tested.

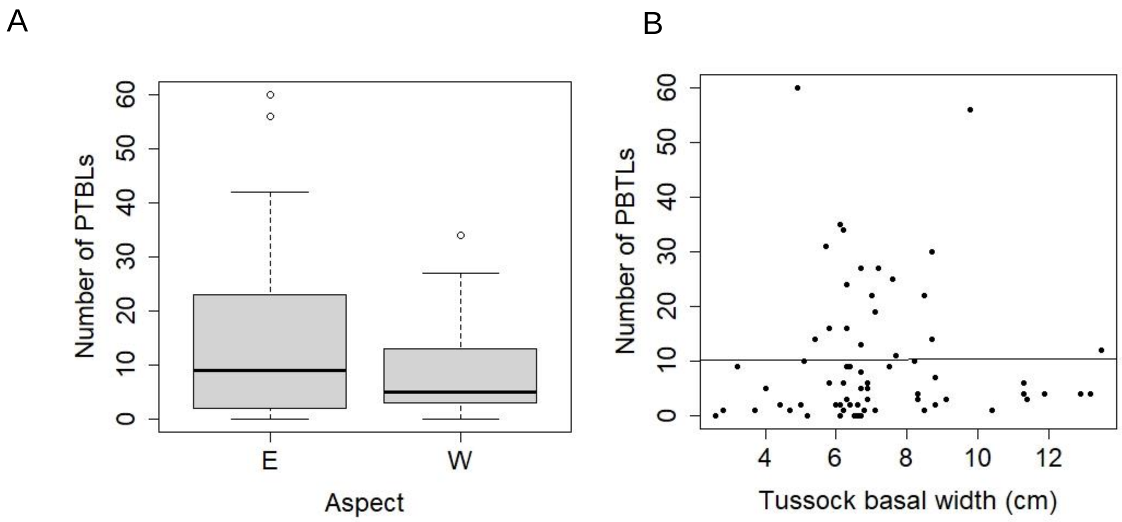

Figure 32. (A) The distribution (minimum, maximum, median, 25th and 75th percentiles, outliers) of the number of PBTLs observed in quadrats on eastern (E) and western (W) orientated slopes across all five surveys. (B) The negative correlation between the tussock basal width (cm) and number of PBTLs observed within each quadrat in 2023.

5 VEGETATION MONITORING RESULTS

5.1 2023 results

The results of the 2023 vegetation monitoring surveys are presented below. A comparison of the data recorded of all five survey years (2018–2023) is provided in Section 5.2.

5.1.1 Vegetation associations per quadrat

A summary of descriptions and condition notes of each of the vegetation associations per quadrat is provided in Table 7 below.

Table 7. Summary of vegetation associations and vegetation condition notes in 2023 within each monitoring quadrat.

Quadrat	Broad Vegetation Group	Description
1	Tussock Grassland on Low Footslopes and Drainage Areas	Dense *Themeda triandra* (Kangaroo Grass)/*Austrostipa* sp. (Spear-grass) Grassland in moderate to good condition with some juvenile recruitment. The grassland had good structural diversity with an abundance of dense tussocks, with evidence of only light grazing. Regeneration of *Allocasuarina verticillata* (Drooping Sheoak) was recorded. There was a high cover of litter throughout the quadrat, with very little bare ground or space in the vegetation. The landowner has been feeding out stock in the monitoring quadrat. There was a high cover of weeds in the area where feed has been placed.
2	Tussock Grassland on Eastern Slopes	Highly degraded mixed Grassland of *Aristida behriana* (Brush-wire Grass) +/- *Austrostipa/Rytidosperma* sp. (Wallaby Grass), but with areas free of native species. Few juvenile tussocks were recorded. Weeds and litter are dominant, particularly *Avena barbata* and *Trifolium angustifolium.* Declared Weed *Marrubium vulgare* (Horehound) and *Echium plantagineum* (Salvation Jane) were also present. The quadrat was characterised cracking clay soils, with a many large soil cracks present.
3	Tussock Grassland on Western Slopes	Dense sward with lower-growing tussocks in fair condition, dominated by *Aristida behriana* (Brush Wire-grass), *Austrostipa* sp. (Spear-grass) and *Avena barbata* (Wild Oats). Grasses have become increasingly rank, particularly on the lower slope, with an increasing dominance of *Themeda triandra.* The site is rocky and occurs on a west facing hill slope with weeds (Wild Oats) increasing downslope and vegetation cover becoming more sparse up slope. Some recruitment of juvenile tussocks was recorded.
4	Tussock Grassland on Eastern Slopes	*Aristida behriana* and *Austrostipa* sp. Grassland in poor condition with occasional patches of *T. triandra.* Condition improves upslope but historical impact remains evident likely due to position near the old dam. *Avena barbata* (Wild Oats) and *Trifolium angustifolium* were abundant.
5	Tussock Grassland on Western Slopes	Low growing *Austrostipa scabra* (Spear-grass)/*A. behriana* Grassland in poor to moderate condition on west facing hill slope improving upslope. Abundant Wild Oats.
6	Tussock Grassland on Eastern Slopes	Mixed age *Austrostipa* sp. Grassland in moderate condition. Good spacing of native grass tussocks, but a high weed and litter cover and little bare ground.
7	Tussock Grassland on Low Footslopes and Drainage Areas	Dense low *T. triandra/Austrostipa* Grassland in poor to moderate condition with a high cover of weeds including Wild Oats and *Trifolium angustifolium*. Some juvenile tussock recruitment.

8	Tussock Grassland on Low Footslopes and Drainage Areas	Grassland in poor to moderate condition with native *Austrostipa* sp., *R. caespitosum*, *A. behriana* and *Walwhalleya proluta* (Panic Grass) tussocks. Spacing between tussocks and recruitment observed. Weeds/exotic species (particularly *Trifolium angustifolium*) were abundant throughout and Declared Plants Horehound and Salvation Jane were observed. The quadrat was dominated by large soil cracks, probably the result of saturation or inundation during a period of high rainfall.
9	Tussock Grasslands on Rocky Ridges	Degraded site on ridge dominated by Wild Oats comprising over 90.00%. No bare ground, with dense thatch covering spaces between plants. There was a higher diversity of native species in rocky area on the cliff edge. Scattered *Enneapogon nigricans* (Black-head Grass), *Austrostipa* and *A. behriana*. Wild Sage was frequent and a few individual Horehound (Declared weed) plants were recorded.
10	Tussock Grasslands on Rocky Ridges	Located in an area of poor-quality grassland dominated by Wild Oats. No bare ground, with dense thatch covering spaces between plants. *Austrostipa* tussocks very widely spaced with no recruitment observed.
11	Tussock Grassland on Western Slopes	Mixed grassland in moderate condition with *Triodia irritans* complex (Spinifex) scattered throughout and good cover of *A. behriana* and other native grasses with only light grazing impact. Mid-dense cover of Wild Oats was present.
12	Woodlands on Rocky Slopes	This quadrat is located in a patch of *Allocasuarina verticillata* (Drooping Sheoak) woodland on a west facing slope in moderate to good condition. Good diversity and dominated by State Rare *Cryptandra campanulata* (Long-flower Cryptandra) and native tussock grasses. Low diversity and cover of weeds.

5.1.2 Summary of 2023 results

A total of 87 flora species were observed across the twelve 1 ha quadrats in 2023. This included 45 native flora species and 42 weed species (Appendix 3). Three flora species listed as Rare under the *National Parks and Wildlife Act 1972* (NPW Act) were observed within the SEB Offset Area:

- *Cryptandra campanulata* (Long-flower Cryptandra) (Quadrats 1, 3, 5, 11 and 12);
- *Maireana rohrlachii* (Rohrlach's Bluebush) (Quadrat 6); and
- *Rumex dumosus* (Wiry Dock) (Quadrats 1, 7 and 9).

Seven weed species declared under the *Landscapes South Australia Act 2019* were observed within the SEB Offset Area:

- *Chondrilla juncea* (Skeleton Weed) (Quadrats 6, 7 and 8);
- *Echium plantagineum* (Salvation Jane) (Quadrats 1–12);
- *Marrubium vulgare* (Horehound) (Quadrats 1, 2 and 4–12);
- *Reseda lutea* (Cut-leaf mignonette) (Quadrats 1 – 3 and 11);
- *Rosa canina* (Dog Rose) (Quadrats 1 – 5, 7 and 9-12); and
- *Xanthium spinosum* (Bathurst Burr) (Quadrat 1).

The mean number of tussocks per hectare was 90,000, and the mean number of juvenile tussocks per hectare was 5,167 (Table 8). The mean percentage of dead material in grass tussocks was 54.67%. Mean weed cover was 14.42%, which was similar to, but slightly less than, the 1 ha estimate of weed cover (20.42%). Mean cryptogam cover (2.92%) and mean cover of bare ground (6.00%) were both very low.

Mean litter cover (70.42%) was recorded for the second time this survey year and accounts for lower weed cover percentages, since all dead plant material laying on the ground was counted as litter.

The mean plant spacing was 26.92 cm, and the mean plant basal width and height were 4.94 cm and 18.75 cm, respectively.

A summary of the 2023 per quadrat and per plant results for each of the twelve 1 ha quadrats is provided in Table 8. Complete lists of all the native and weed species observed within in each quadrat are provided in Appendix 3.

Table 8. Summary of 2021 vegetation monitoring per quadrat and per plant results.

Quadrat	Per Quadrat											Per Plant	
	Native species diversity	Weed species diversity	Tussocks (per ha)	Juvenile tussocks (per ha)	Dead material (%)	Weed cover (%)	Weed cover 1 ha estimate (%)	Cryptogam cover (%)	Bare ground cover (%)	Litter cover (%)	Plant spacing (cm)	Plant basal width (cm)	Plant height (cm)
1	23	21	140,000	8,000	55	30	25	1	54	54	17.7	6.50	29.99
2	10	19	20,000	1,000	24	4	15	0	0	99	33.6	2.60	14.69
3	19	16	110,000	14,000	66	18	25	2	2	63	26.9	5.80	18.22
4	12	16	130,000	4,000	52	43	50	3	1	44	21.0	3.20	14.29
5	18	18	50,000	2,000	67	12	20	3	1	81	35.9	4.00	13.28
6	14	16	50,000	0	81	15	20	2	0	83	31.7	6.40	12.04
7	15	19	120,000	11,000	46	17	25	1	1	48	24.3	6.70	28.93
8	11	22	60,000	3,000	46	1	10	1	2	91	33.9	6.20	28.42
9	12	21	20,000	1,000	55	2	10	5	0	96	31.1	3.70	8.46
10	7	21	20,000	4,000	36	2	10	1	0	100	27.8	2.80	10.38
11	16	15	150,000	7,000	58	19	25	9	2	66	18.8	6.10	17.76
12	29	17	210,000	7,000	70	10	10	7	9	20	18.6	5.30	30.44
Total/ Mean	**15.50**	**18.42**	**90,000**	**5,167**	**54.67**	**14.42**	**20.42**	**2.92**	**6.00**	**70.42**	**26.74**	**4.94**	**18.91**

5.2 Comparison between 2018 - 2023 results

5.2.1 Native species diversity

Mean native species diversity within the SEB Offset Area was the second highest since surveys began with 15.50 species in 2023 compared to 18.30 species in 2022, 13.20 species in 2021, 14.91 in 2020, 7.42 in 2019 and 5.75 in 2018 (Figure 33).

Mean native species diversity was significantly different between 2018 and 2020 (p-value = 0.00004), 2018 and 2021 (p-value = 0.0015), 2018 and 2022 (p-value = 0.000), 2019 and 2020 (p-value = 0.0012), 2019 and 2021 (p-value = 0.02), 2019 and 2022 (p-value = 0.000), 2018 and 2023 (p-value = 0.000), and 2019 and 2023 (p-value = 0.0004).

Native species diversity at each quadrat for 2018 to 2023 is provided in Appendix 3 – Table 12.

In 2023 a total of 44 native species were observed within the SEB Offset Area, compared to 45 in 2022, 39 in 2021, 41 in 2020, 24 in 2019, and 20 in 2018. This included 3 native species that were detected for the first time in the SEB Offset Area (Appendix 3 – Table 13).

All native species recorded in the SEB Offset Area for 2018 to 2023 are listed in (Appendix 3 – Table 10).

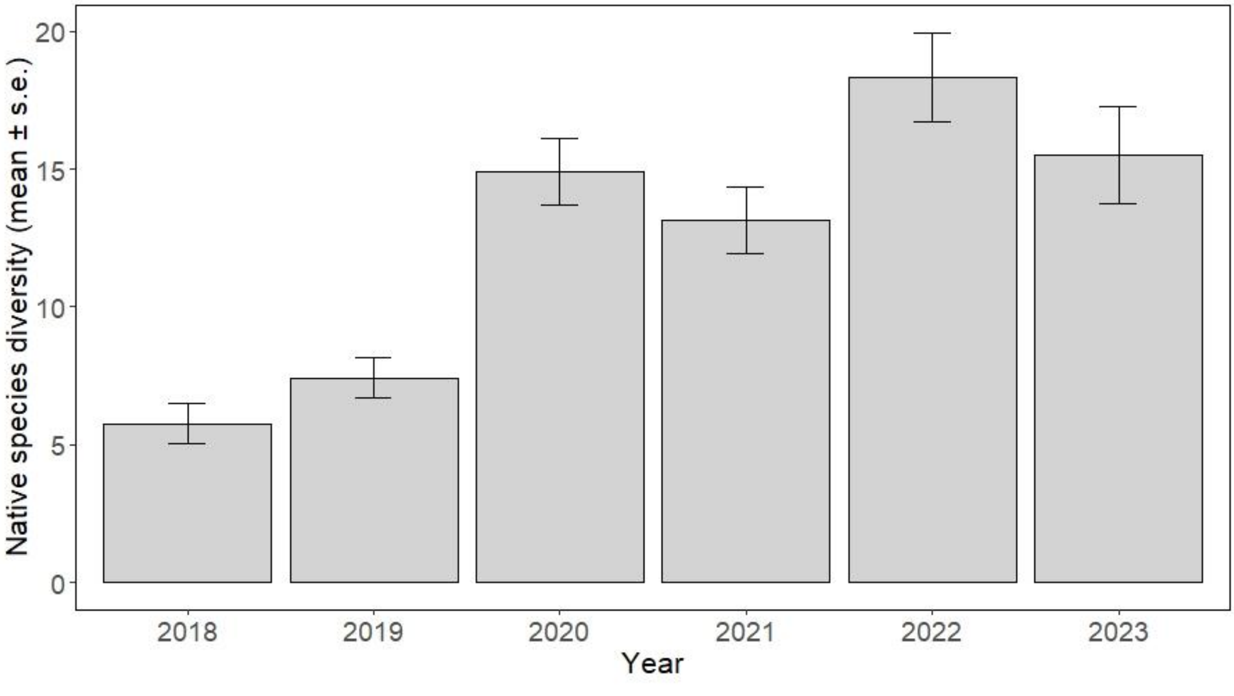

Figure 33. Mean native species diversity from 2018 - 2023.

5.2.2 Weed species diversity

Mean weed species diversity within the SEB Offset Area increased to 18.4 species in 2023 compared to 15.2 in 2022, 12.25 species in 2021, 10.58 species in 2020, 6.17 in 2019 and 3.50 species in 2018 (Figure 34). Mean weed species diversity overall was significantly different between all years (p-value = 0.000) except 2018-2019 and 2020-2021.

Weed species diversity at each quadrat for 2018 to 2023 is provided in Appendix 3 – Table 12.

In 2023 a total of 42 weed species were observed within the SEB Offset Area, compared to 34 in 2022, 30 in 2021, 22 in 2020, 14 in 2019, and 13 in 2018. This included 9 weed species that were detected for the first time in the SEB Offset Area (Appendix 3 – Table 11).

All weed species recorded in the SEB Offset Area for 2018 to 2023 are listed in (Appendix 3 – Table 11).

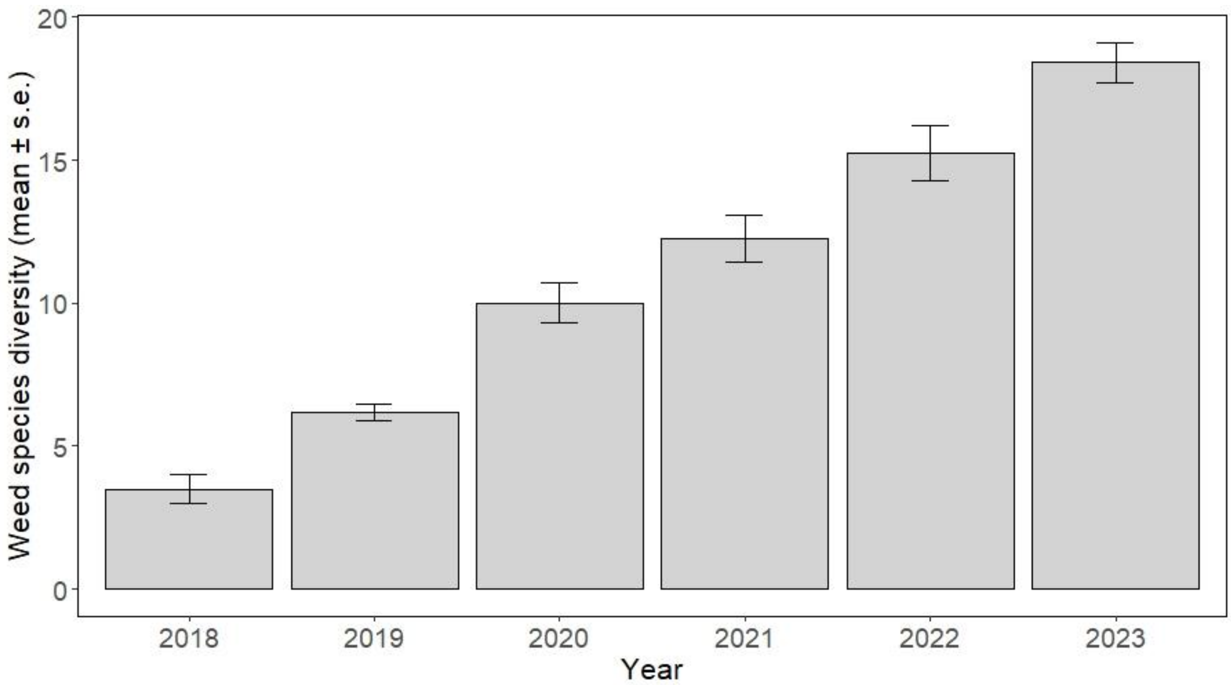

Figure 34. Mean weed species diversity in 2018 to 2023.

5.2.3 Perennial plant spacing

The mean spacing of perennial plants increased to 26.7 cm compared to 2022 (20.9 cm) and 2021 (26.0 cm), but remained lower than 2020 (56.9 cm), 2019 (41.6 cm) and 2018 (29.7 cm) (Figure 35). These differences were significant between 2020 and 2021 (p-value = 0.040), 2020 and 2022 (p-value = 0.010), and 2020 and 2023 (p-value = 0.05).

Mean spacing of perennial plants at each quadrat for 2018 to 2023 is provided in Appendix 3 – Table 14. Mean plant spacing increased in all quadrats since 2022, except in Quadrat 11 and 12 where plant spacing had decreased. Four of the twelve quadrats had a mean spacing that was further than the 2018 spacings.

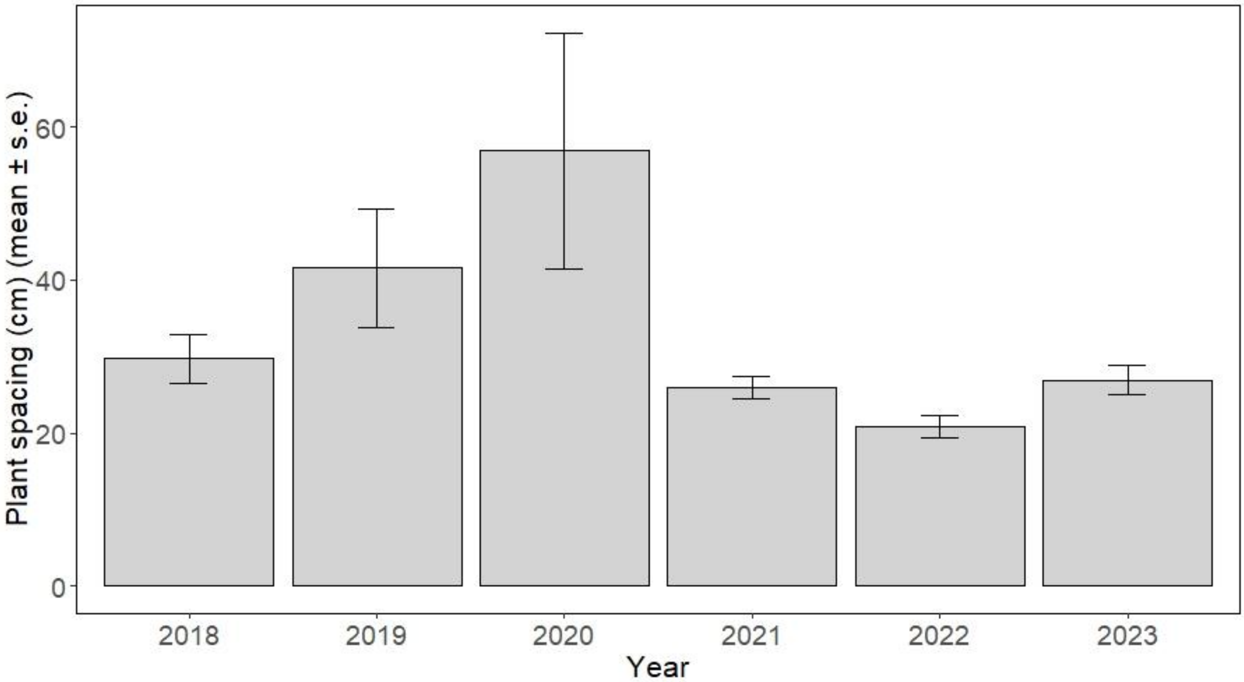

Figure 35. Mean plant spacing in 2018 to 2023.

5.2.4 Perennial plant density (tussocks per hectare)

The increase in perennial plant spacing is reflective of the decrease in the mean number of perennial grass tussocks per hectare (TPH) in 2023 of 90000 from 164,583 in 2022, 94,815 in 2021, 121,583 in 2020 and 114,167 in 2019 (Figure 36). This difference was not significant (p-value = 0.09). The mean number of TPH in 2018 was 95,000. However, this was calculated from Quadrats 9–12 only and therefore not included in Figure 36 and the statistical analysis.

Mean TPH at each quadrat in 2018 (Quadrats 9–12 only), 2019, 2020, 2021, 2022 and 2023 is provided in Appendix 3 – Table 15. From 2022 to 2023, mean TPH decreased at all quadrats while from 2021 to 2022, mean TPH increased at all quadrats (Appendix 3 – Table 15).

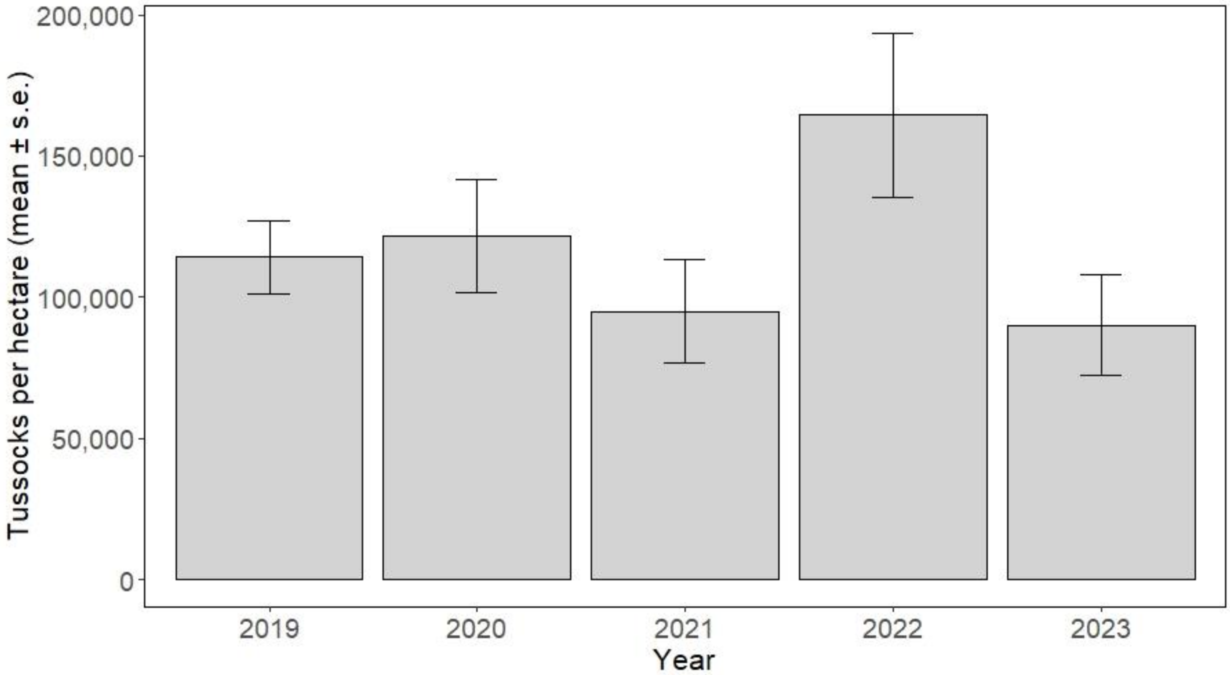

Figure 36. Mean tussocks per hectare from 2019 to 2023. 2018 data is not plotted as data is only available for Quadrats 9–12.

5.2.5 Juvenile recruitment (juveniles tussocks per hectare)

The mean number of juvenile perennial grass tussocks per hectare in 2023 (5,167 juveniles per hectare (JPH)) was higher than 2021 (4,417 JPH, p-value = 0.999) but remained lower than 2022 (9,167 JPH, p-value = 0.999), 2020 (76,167 JPH, p-value = 0.000) and 2019 (15,667 JPH, p-value = 0.95) (Figure 37). The mean number of JPH in 2018 was 9,550, however, this was calculated from Quadrats 9–12 only and therefore not included in Figure 37 and the statistical analysis.

Mean JPH at each quadrat in 2018 (Quadrats 9–12 only), 2019, 2020, 2021, 2022 and 2023 is provided in Appendix 3 –Table 16. From 2022 to 2023, mean JPH was lower at seven of the twelve quadrats (in Appendix 3 – Table 16).

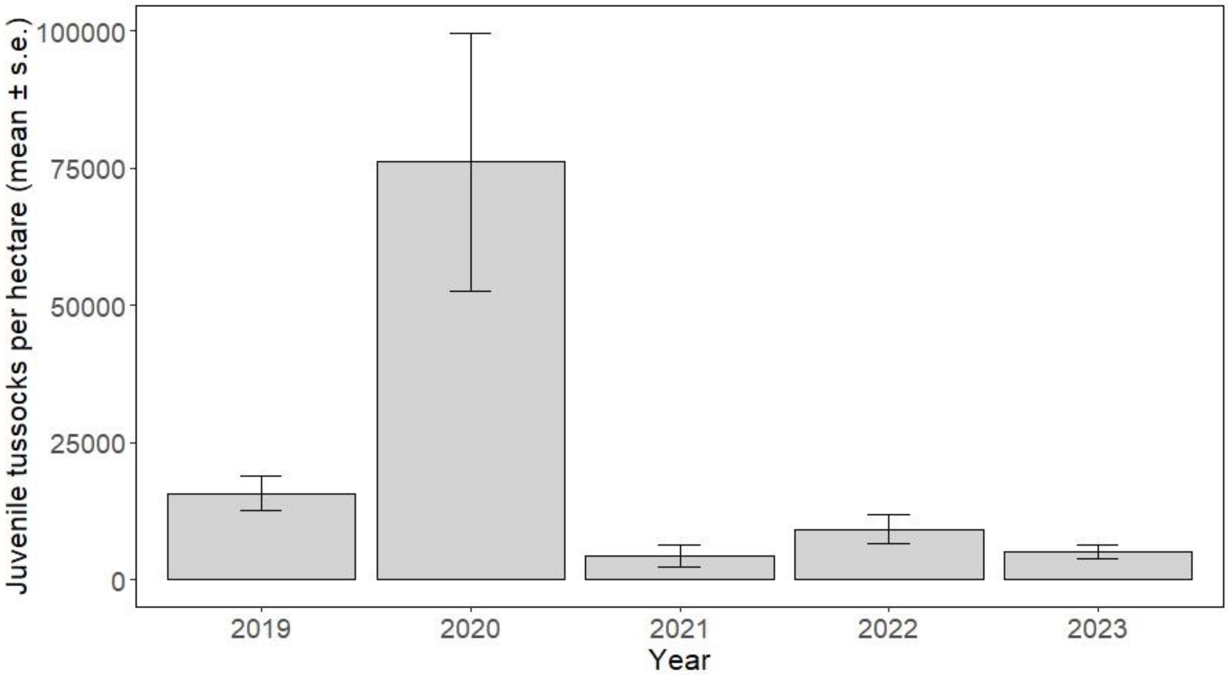

Figure 37. Mean juvenile tussocks per hectare from 2019 to 2023. 2018 data is not plotted as data is only available from Quadrats 9–12.

5.2.6 Perennial plant size and health attributes

Perennial plant basal width

The mean basal width of perennial plants decreased again to 4.94 from 6.80 cm in 2022, 7.06 cm in 2021, 7.95 cm in 2020, 7.43 cm in 2019, and 9.58 cm in 2018 (Figure 38). This difference is significant between 2018 and 2021 (p-value = 0.047), 2018 and 2022 (p-value = 0.022), 2018 and 2023 (p-value = 0.000), and 2020 and 2023 (p-value = 0.010). Mean perennial plant basal width at each quadrat in 2018, 2019, 2020, 2021, 2022 and 2023 is provided in Appendix 3 – Table 17. From 2022 to 2023 mean perennial plant basal width decreased at eleven quadrats and increased at one quadrat and all quadrats have a small perennial plant basal width than the baseline 2018 (Appendix 3 – Table 17).

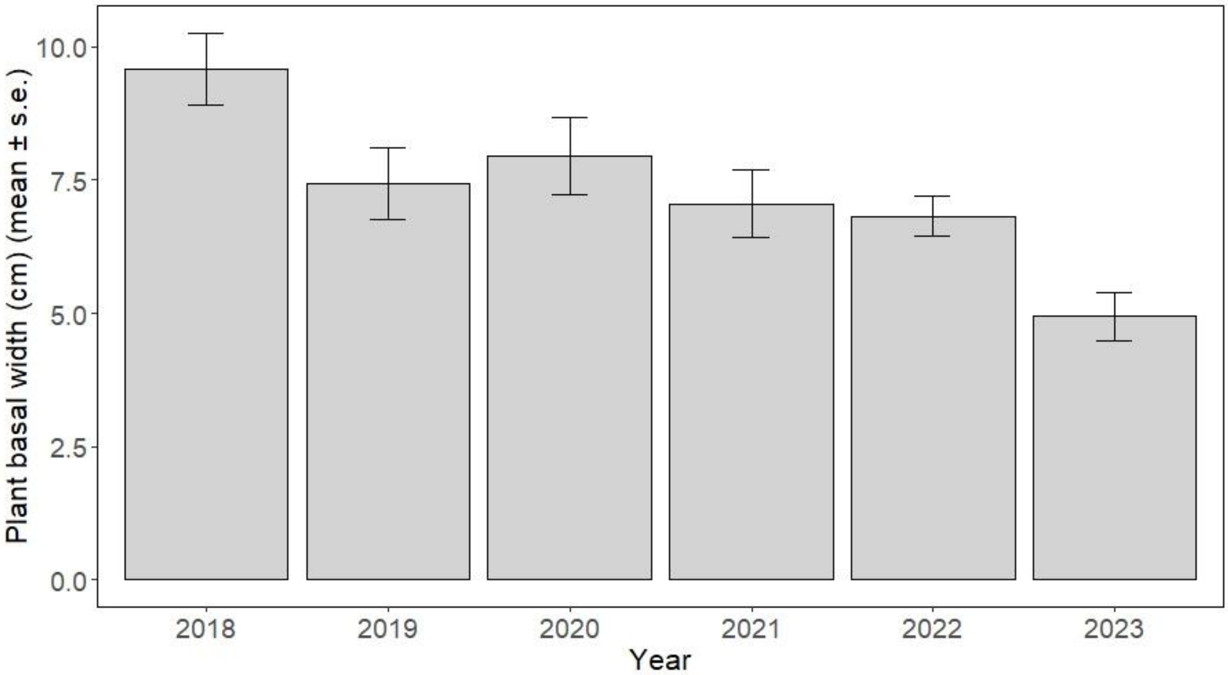

Figure 38. Mean basal width of perennial plants from 2018 to 2023.

Perennial plant height

The mean height of perennial plants decreased to 18.9 cm from 25.19 cm in 2022 and 22.43 cm in 2021 but remained higher than 11.40 cm in 2020, 6.90 cm in 2019, and 15.70 cm in 2018 (Figure 39).

Mean perennial plant height was significantly different between 2018 and 2019 (p-value = 0.019), 2018 and 2022 (p-value = 0.001), 2019 and 2021 (p-value = 0.000), 2019 and 2022 (p-value = 0.000), 2019 and 2023 (p-value = 0.000), 2020 and 2021 (p-value = 0.002) and 2020 and 2022 (p-value = 0.000). Perennial plant height was not significant for the remaining years (2018 and 2020; 2018 and 2021; 2019 and 2020; 2021 and 2022; 2022 and 2023; 2021 and 2023; 2020 and 2023).

Mean perennial plant height at each quadrat in 2018 to 2023 is provided in Appendix 3 – Table 18. From 2022 to 2023, mean perennial plant height decreased at 8 quadrats and increased at 4 quadrats (Appendix 3 – Table 18).

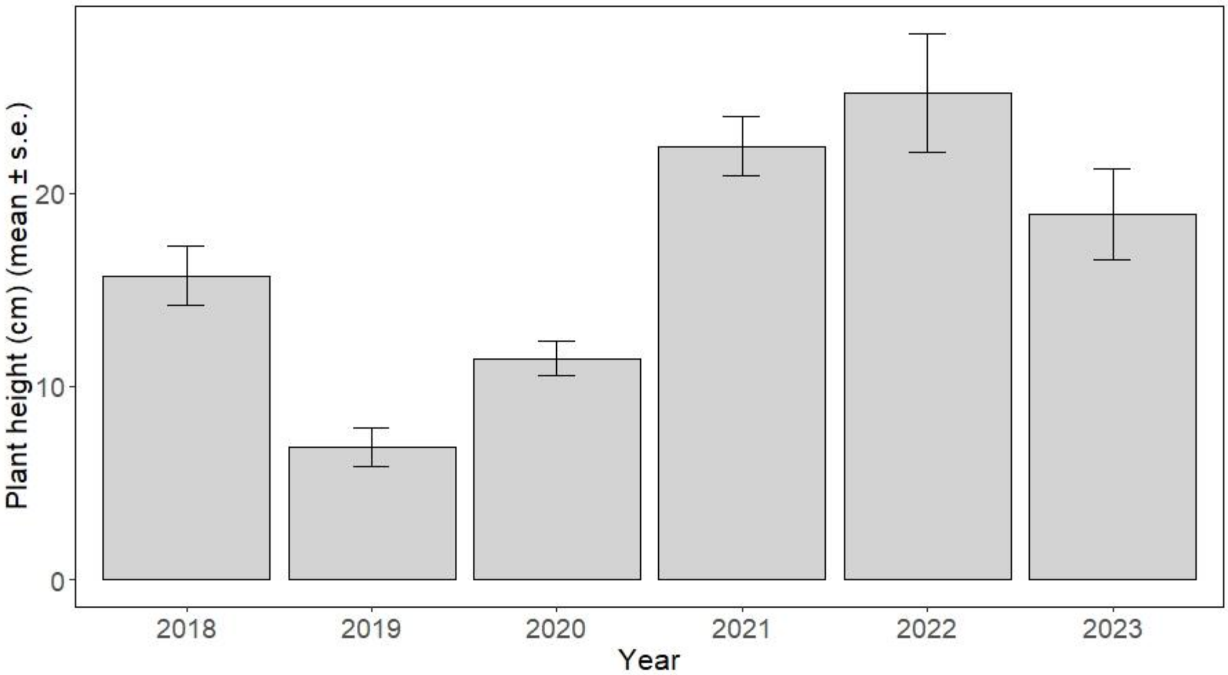

Figure 39. Mean height of perennial plants from 2018 to 2023.

Dead material on perennial grass tussocks

The mean percentage of dead material on perennial grass tussocks significantly increased from 16.7% in 2022 to 54.7% in 2023 (p-value = 0.000) (Figure 40). The mean percentage of dead material was higher than 2020 (39.9%, p-value = 0.02) but less than 2019 at 84.80% (p-value = 0.000) and 2021 (80.7%, p-value = 0.000). The mean percentage of dead material was 92.25% in 2018, however, this was calculated from Quadrats 9–12 only and therefore not included in Figure 40 and the statistical analysis.

Mean percentage of dead material on perennial grass tussocks at each quadrat in 2018 to 2023 is provided in Appendix 3 – Table 19. From 2022 to 2023, mean percentage of dead material increased at all 12 quadrats, but all quadrats were lower than 2021. Between 2020 and 2023, mean percentage of dead material increased at eight quadrats and decreased at 4 quadrats. Between 2019 and 2023, mean percentage of dead material decreased at eleven of the twelve quadrats (Appendix 3 – Table 19).

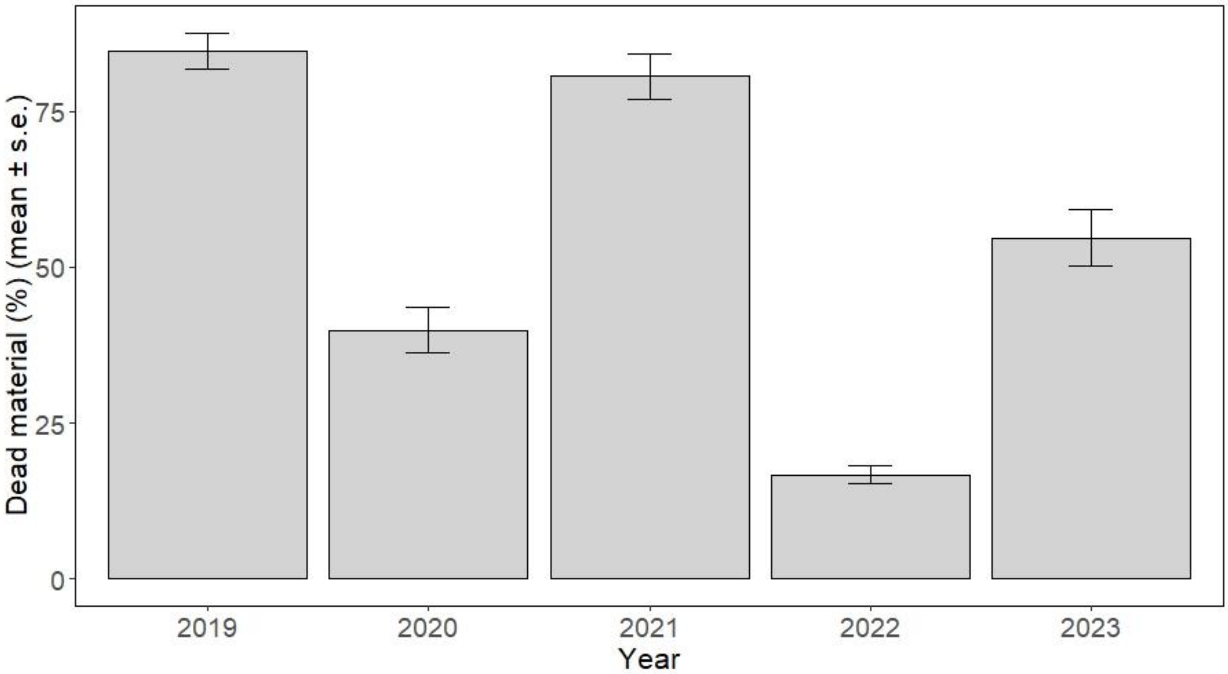

Figure 40. Mean percentage of dead material on perennial grass tussocks from 2019 to 2023. 2018 data is not plotted as data is only available from Quadrats 9–12.

5.2.7 Percentage weed cover

The mean weed cover based on 1x1 m surveys is higher in 2023 (14.3%) compared to 2022 (2.46%, p-value = 0.735), but lower than all previous years surveyed; 2021 at 58.50% (p-value = 0.000), 2020 at 59.73% (p-value = 0.000) and 2019 at 32.00% (p-value = 0.370) (Figure 41). Weed cover based on 1x1 m surveys was 39.50% in 2018. However, this was calculated from Quadrats 9–12 only and therefore not included in the statistical analysis.

Mean weed cover based on 1 ha estimates indicated slightly higher weed cover than the 1 x 1 m surveys (20.4%). Although this value represented a decrease from all previous years at 57.9 in 2021, 48.33 in 2020 and 35.50% in 2019, except 2022 (3.75%). These differences were significant (p-value = 0.000) (Figure 42). Mean weed cover based on 1 ha estimates was 40.50% in 2018. However, this was calculated from Quadrats 9–12 only and therefore not included in the statistical analysis.

Mean weed cover based on 1 x1 m surveys and 1 ha estimates at each quadrat from 2018 to 2023 is provided in Appendix 3 – Table 20 and Table 21. Based on 1 x 1 m sampling from 2022 to 2023, 10 quadrats increased in weed cover. In 2021 to 2023 and from 2020 compared to 2023 the majority of the 12 quadrats decreased in weed cover (eleven and ten respectively). Between 2019 and 2023, mean weed cover decreased at 6 of 12 sites. Based on 1 ha estimates from 2022 to 2023 and increase in weed cover occurred in eleven of the twelve quadrats and was equal at one quadrat. From 2021 to 2023 and 2020 to 2023 decreases in weed cover were observed the majority of quadrats (10 and 9 quadrats respectively). Between 2019 and 2022, mean weed cover decreased at 7 of 12 sites and increased at 4 quadrats. (Appendix 3 – Table 21).

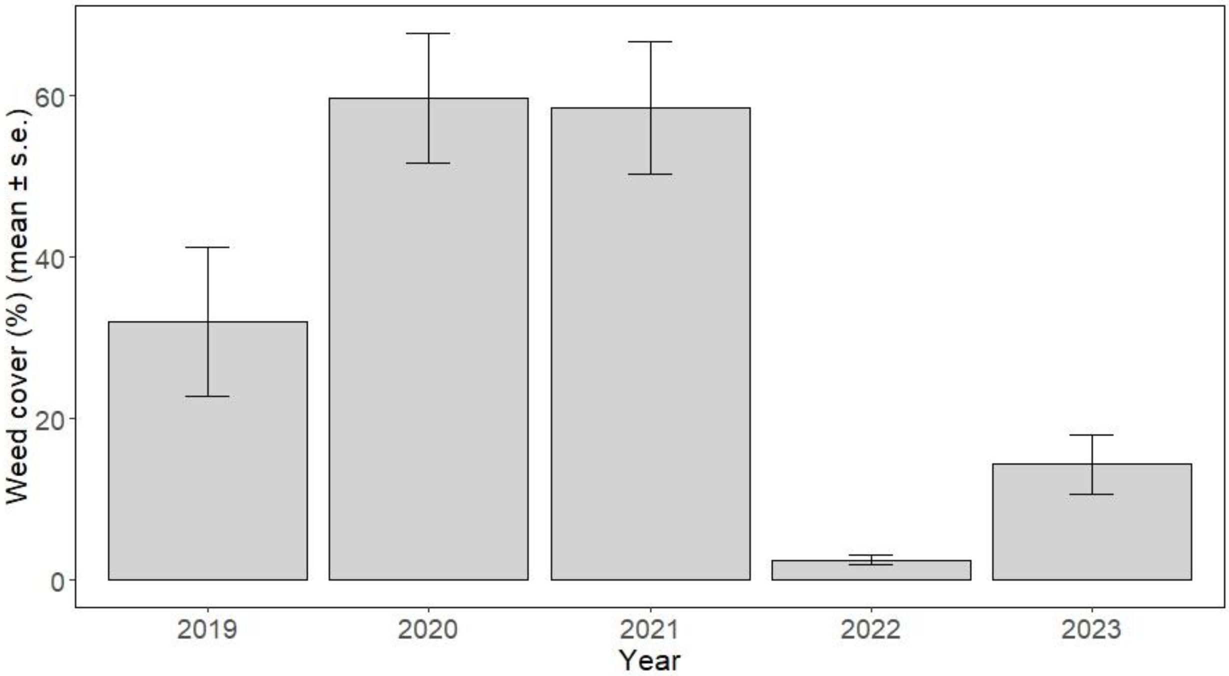

Figure 41. Mean percentage weed cover based on 1 x 1 m surveys from 2019 to 2023. 2018 data is not plotted as data is only available from Quadrats 9–12.

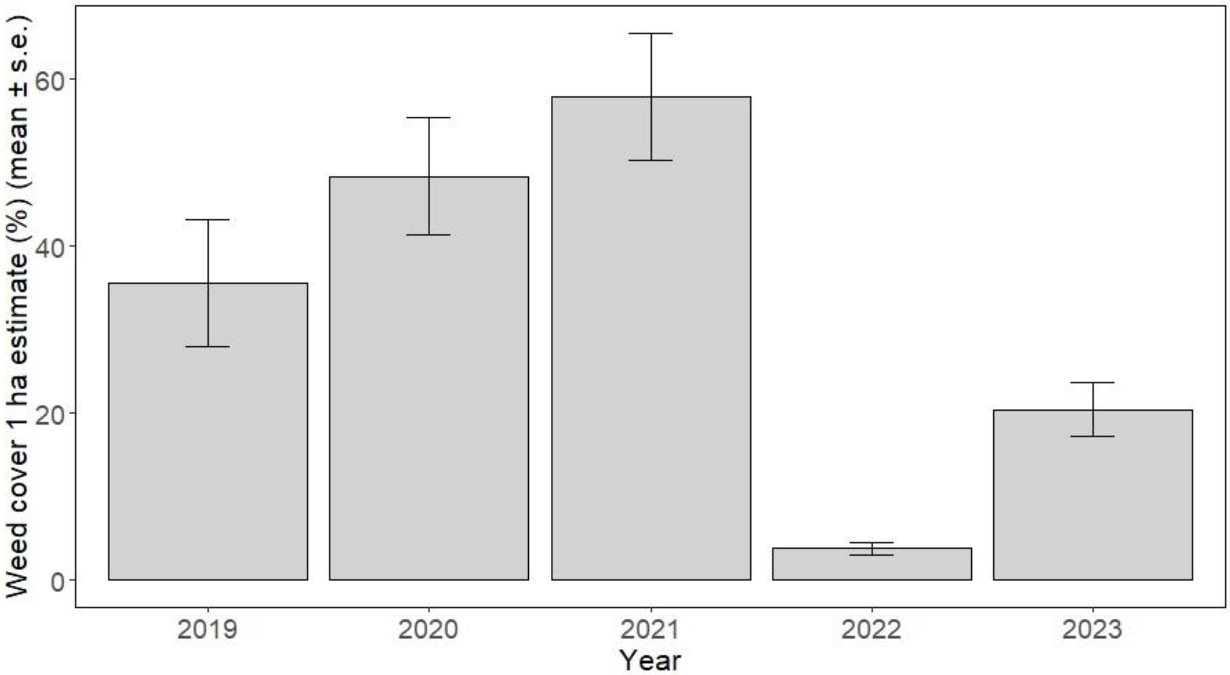

Figure 42. Mean percentage weed cover based on 1 ha estimate from 2019 to 2023. 2018 data is not plotted as data is only available from Quadrats 9–12.

5.2.8 Percentage cryptogram cover

The mean percentage of cryptogram cover decreased to 2.95 in 2023 compared to 6.00% in 2022, 3.00% in 2021 (p-value = 0.8808), and 20.00% in 2020 (p-value = 0.001) (Figure 43).

Mean percentage of cryptogram cover at each quadrat in 2020, 2021, 2022 and 2023 is provided in Appendix 3 – Table 22. From 2022 to 2023 and 2021 to 2023, mean percentage of cryptogram cover increased at five quadrats and decreased at seven quadrats. Between 2020 and 2023, mean percentage of cryptogram cover increased at one quadrats and decreased at eleven quadrats (Appendix 3 – Table 22). The difference in cryptogram cover was significant between 2020 and all other years (2021 p-value = 0.002; 2022 p-value = 0.01; 2023 p-value = 0.002).

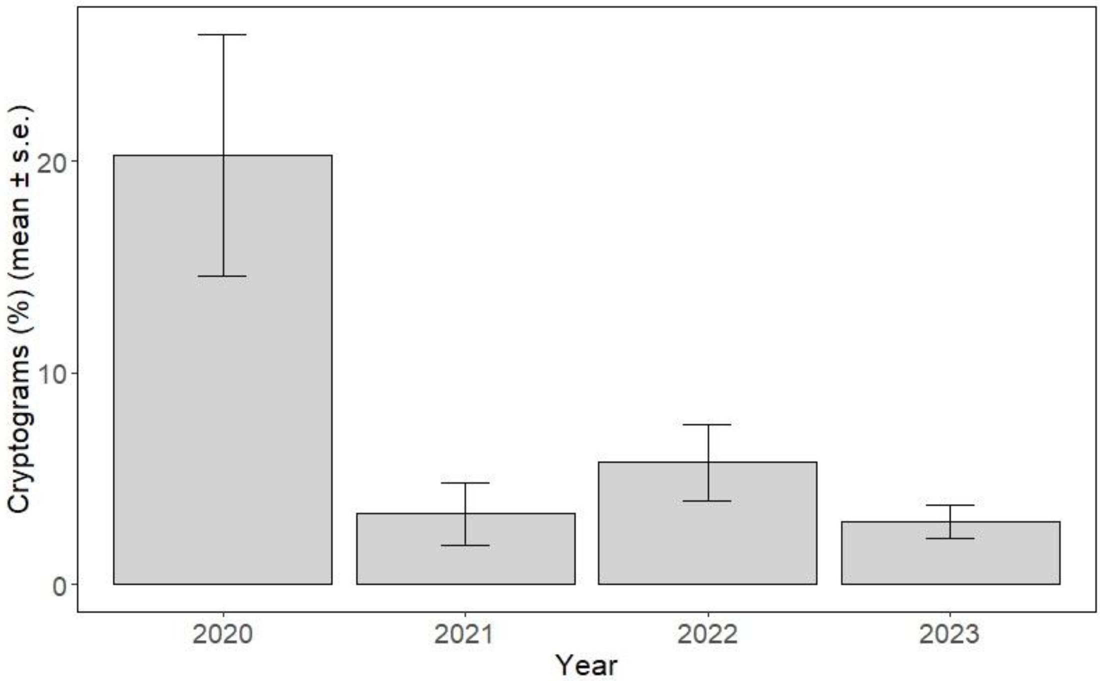

Figure 43. Mean percentage of cryptogram cover from 2020 to 2023. Data from 2018 and 2019 is not plotted as data is only available from 2020 to 2023.

5.2.9 Percentage bare ground

The mean percentage of bare ground cover was lower than all previous years (1.58% in 2023) compared to 3.00% in 2022 and 2.33% in 2021 and 8.06% in 2020 (p-value = 0.000). This is significant for 2020 compared to all years (2023 p-value = 0.001; 2022 p-value = 0.003; 2021 p-value = 0.001).

Mean percentage of bare ground cover at each quadrat in 2020, 2021, 2022 and 2023 is provided in Appendix 3 – Table 23. From 2022 to 2023, mean percentage of bare ground cover increased at three quadrats, decreased at eight quadrats and remained the same at one quadrats. Between 2021 and 2023, mean percentage of bare ground cover increased at four quadrats, decreased at 7 quadrats and remained the same at one quadrat. Between 2020 and 2023, mean percentage of bare ground cover decreased at all sites (Appendix 3 – Table 23).

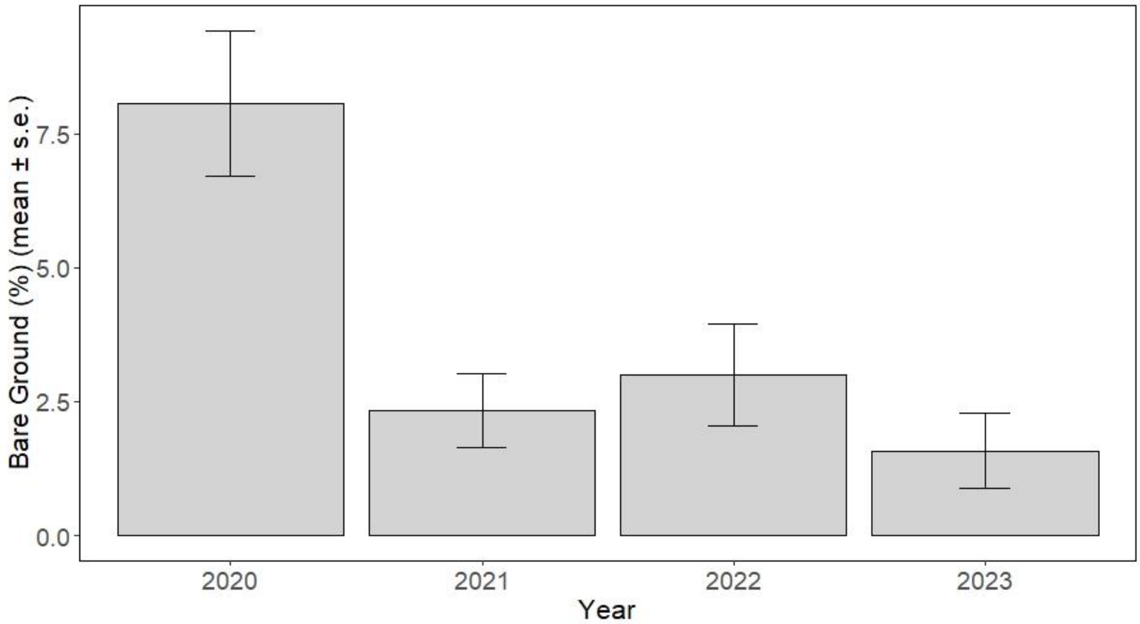

Figure 44. Mean percentage of bare ground cover from 2020 to 2023. Data from 2018 and 2019 is not plotted as data is only available from 2020 to 2023.

6 DISCUSSION

6.1 PBTL monitoring

This report presents Year six (2023) results of the SEB Offset Area PBTL monitoring.

6.1.1 PBTL Abundance

The mean number of PBTLs per quadrat observed in 2023 ($\bar{x}$ = 2.91 individuals) was less than in all other years of monitoring:

- Baseline, $\bar{x}$ = 17.38 individuals.
- 2018, $\bar{x}$ = 16.64 individuals.
- 2019, $\bar{x}$ = 19.09 individuals.
- 2020, $\bar{x}$ = 10.03 individuals.
- 2021 survey, $\bar{x}$ = 3.70 individuals.
- 2022 survey, $\bar{x}$ = 8.73 individuals.

This result follows an increase in PBTLs per quadrat from 2021 to 2022, although is consistent with a general downward trend in numbers. There is a significant difference in the mean number of PBTLs between the six monitoring years (p-value = 0.00789).

Further monitoring will be important to determine the trajectory or stochasticity of the PBTL population within the SEB Offset Area, given the limitation on detecting spider burrows in 2023 and the strong relationship between the number of burrows checked and PBTLs recorded. Future monitoring will also be important in determining any change in trajectory following implementation of recommendations, including changing grazing practices.

6.1.2 Juvenile PBTL

The proportion of juvenile PBTLs observed in 2023 (43.75%) was the highest of all monitoring years. Female PBTLs produce litters of 2-4 live young between late January and mid-March (Hutchinson *et al.* 1994). The higher proportion of juvenile PBTLs observed may be due, at least in part, to the timing of surveys. Most surveys have been undertaken in February, while the 2023 survey occurred in early March, later in the breeding season when more juveniles might be expected.

Greater juvenile numbers may also be the result of rainfall. Although no correlation between high spring – summer rainfall was found in the statistics, evidence from PBTL surveys conducted by EBS Ecology in other areas also indicates a high proportion of juvenile PBTLs following the 2023 breeding season.

The lack of correlation between rainfall and juvenile numbers may relate to the overall small sampling size. Data from future monitoring years at Hornsdale may produce some relationship between rainfall and the proportion of juvenile PBTLs observed.

6.1.3 Slopes and PBTL abundance

The mean number of PBTLs per quadrat across the five surveys was significantly greater on eastern than western slopes (p-value = 0.024) (Figure 32A). This continues the relationship between aspect and PBTLs from all previous years of monitoring.

6.1.4 Rainfall and PBTL

While no correlation was detected in any of the data with rainfall periods tested for previous monitoring years, moderate to strong relationships were found between rainfall between September and January (spring - summer).

This five-month rainfall period was tested for the first time in 2023. Negative correlations were found between the rainfall and the following datasets:

- Total number of PBTLs recorded (r = -0.74).
- Total number of spider holes detected (r = -0.83).
- Mean bare ground cover (%) + mean cryptogram cover (%) (r = -0.91).
- Tussock basal width (-0.84).

Meanwhile, there was a positive correlation between the spring – summer rainfall and tussock height (r = 0.64).

These relationships suggest that total rainfall experienced between September and January is influencing vegetation structure, particularly cover. Negative correlations between some of data and increasing rainfall suggests that vegetation cover is denser during high rainfall in spring and summer. Relationships between PBTLs and spider holes suggest that this may be detrimentally impacting both.

6.1.5 Vegetation and PBTL

The mean number of PBTLs per quadrat in 2018–2022 decreased with increasing grass tussock basal width (p-value = 0.032). However, with the addition of the 2023 data, there is no association (p-value = 0.5401) (Figure 32B). The 2018 – 2022 relationship corresponds with the preferred vegetation cover of the species, which ranges from moderate to sparse (Duffy *et al.* 2012).

No correlations were detected between the number of PBTLs and the remaining vegetation condition variables tested.

The lack of any relationship between number of PBTLs and tussock width following the input of the 2023 data and the lack of any other relationship with other variables suggests that PBTL numbers may be influenced by factors not currently measured by the monitoring. This might include litter cover, a variable that has only been collected since 2022.

Like tussock width, litter cover influences the per-cent of bare ground and is detrimental to the moderate to sparse vegetation cover PBTLs prefer. Future monitoring of litter cover may result in the detection of a relationship between the number of PBTLs and litter cover.

6.1.6 Spiders versus PBTL

A significant positive correlation was detected between the number of PBTLs and spiders (p-value = 0.00024) ($R^2 = 0.326$) across the six surveys. Also, a significant positive correlation was detected between the number of PBTLs and burrows (p-value = 0.0001) ($R^2 = 0.5824$) across the six surveys (Figure 24A; Figure 24B). This is as expected since it is widely accepted that PBTLs occupy single-entrance, vertical burrows made by Lycosid and Mygalomorph spiders (Hutchinson *et al.* 1994; Milne and Bull 2000; Milne *et al.* 2003; Souter *et al.* 2007).

The single-entrance, vertical burrows that PBTLs inhabit are constructed by Lycosid and Mygalomorph spiders (Hutchinson *et al.* 1994; Milne and Bull 2000; Milne *et al.* 2003; Souter *et al.* 2007), and as such, the long-term conservation of PBTLs is reliant upon maintaining viable population of burrowing spiders (Fellows *et al.* 2009).

The mean number of spiders per quadrat observed in 2023 ($\bar{x} = 5.64$ individuals) was similar to the 2018 results ($\bar{x} = 7.27$ individuals), but lower than during all other monitoring periods (Figure 22). This difference was statistically significant (p-value = 0.00026), with the Tukey post hoc test revealing a significant difference between the 2020 and 2018 surveys (p-value = 0.0067), 2020 and 2019 surveys (p-value = 0.025), 2021 and 2020 survey (p-value = 0.018), the 2022 and 2020 survey (p-value = 0.017), the 2023 and 2016 survey (p-value = 0.030) and the 2020 and 2023 survey (p-value = 0.0037).

Relative to 2022, the number of spiders decreased in Quadrats 1, 3, 4, 5, 6 and 11, remained the same in Quadrats 7 and 8 and increased in Quadrats 2, 9 and 10 (Figure 25).

Based on the variability in the number of spiders observed thus far, further monitoring is required to determine the trajectory or stochasticity of spider populations in the SEB Offset Area, which in turn may impact on the PBTL population. The population dynamics of spiders, especially Lycosids and Mygalomorphs, are complex, with factors including prevailing weather, predation, parasitism and competition, all potentially impacting the number of individuals present (Humphreys 1976; Conley 1984; Spiller and Schoener 1995). As such, the cause of variability in spider numbers in the SEB Offset Area cannot be determined at present.

6.1.7 Burrows and PBTLs

The mean number of burrows per quadrat observed in 2023 ($\bar{x} = 35.1$) was less than all previous surveys conducted surveys (Figure 22):

- Baseline $\bar{x} = 126.38$.
- 2018 $\bar{x} = 115.10$.
- 2019 $\bar{x} = 202.10$.
- 2020 $\bar{x} = 171.10$.
- 2021 $\bar{x} = 70.00$.
- 2022 $\bar{x} = 90.30$.

This difference was statistically significant (p-value = 0.00249), with the Tukey post hoc test revealing a significant difference between the 2021 and 2019 surveys (p-value = 0.098), between 2019 and 2020 (p-value = 0.047), 2019 and 2023 (p-value = 0.0004) and 2020 and 2023 (p-value = 0.005), all others are not significant.

Relative to 2022, the number of burrows decreased in Quadrats 1, 3, 4, 5, 6, 7, 8, 10 and 11, with all quadrats except 10 recording their lowest number of burrows (Figure 26).

In general, burrows were difficult to detect due to the high cover of vegetation and litter, with litter cover reaching near 100% in some of the 1m x 1m quadrats. However, even where bare ground was present and burrows should have been easy to detect, few burrows were found. It is not known why this would be the case. Possibly high rainfall that results in saturated soil, particularly in the monitoring quadrats situated in run-on areas, may destroy the integrity of spider burrows.

Monitoring in future years will be required to determine if there has been an actual decrease in spider burrows and whether low numbers in 2023, 2022 and 2021 are due to detection difficulty or other factors.

6.2 Vegetation monitoring

This report presents year six (2023) results of the SEB Offset Area monitoring and provides some early analysis of data to determine trends across the SEB Offset Area. Minimal analysis was undertaken following baseline and Year two monitoring, being too early in the monitoring program to detect any meaningful changes.

6.2.1 Native species diversity

Across all monitoring quadrats, a total of 44 native plant species were recorded. This is the highest number of species recorded for any monitoring period (Appendix 3 - Table 10). Three species were recorded for the first time in 2023:

- *Eutaxia microphylla* (Common Eutaxia).
- *Lagenophora huegelii* (Coarse Bottle-daisy).
- *Thysanotus* sp. (Fringe Lily).

The mean native species diversity was 15.50. This is the second highest mean since surveys began, with the highest being 18.30 species recorded in 2022. Mean native species diversity was significantly different between 2018 and 2020 (p-value = 0.00004), 2018 and 2021 (p-value = 0.0015), 2018 and 2022 (p-value = 0.000), 2019 and 2020 (p-value = 0.0012), 2019 and 2021 (p-value = 0.02), 2019 and 2022 (p-value = 0.000), 2018 and 2023 (p-value = 0.000), and 2019 and 2023 (p-value = 0.0004).

Increases in diversity may be due to winter grazing on weedy annual grass, facilitating opportunities for recruitment of more vulnerable native herbaceous species and an overall decrease in grazing pressure. Decreased grazing pressure may result in palatable native species becoming easier to detect and increase successful recruitment. Common Eutaxia, for example, is a palatable species that suffers from preferential grazing when land is heavily grazed.

Given the land use history of the SEB area, any increase in overall native species diversity may be limited by the seed bank present in the soil and native species that occur in adjacent areas.

Three species listed as Rare under the *National Parks and Wildlife Act 1972* were again observed in 2023:

- *Cryptandra campanulata* (Long-flowered Cryptandra) (Quadrats 1, 3, 5, 11 and 12).
- *Maireana rohrlachii* (Rohrlach's Bluebush) (Quadrat 6).
- *Rumex dumosus* (Wiry Dock) (Quadrats 1, 7 and 9).

Maireana rohrlachii and *Rumex dumosus* were first observed in 2020 while *Cryptandra campanulata* was initially recorded as *Cryptandra amara* (now *Cryptandra campanulata*) in 2018.

Rumex dumosus was recorded in Quadrat 7 for the first time in 2023.

6.2.2 Weed species diversity and cover

Weed diversity has increased since baseline and in the short term since 2022, with 9 new weeds, from a total of 42 species, observed in 2023 (Appendix 3 – Table 11):

- *Bromus hordeaceus* (Soft Brome).
- *Bromus rubens* (Red Brome).
- *Hordeum marinum* (Sea Barley).
- *Lactuca serriola* (Prickly Lettuce).
- *Onopordum acanthium* (Scotch Thistle).
- *Poa bulbosa* (Bulbous Meadow-grass).
- *Trifolium vesiculosum* (Arrow-leaf Clover).
- *Triticum aestivum* (Common Wheat).
- *Verbascum virgatum* (Twiggy Mullein).

Mean weed diversity increased from 15.2 species in 2022 to 18.4 in 2023 and was significantly different between all years (p-value = 0.000) except 2018-2019 and 2020-2021.

While grazing remains a land management tool within the SEB area, there is a continued likelihood that new weed species might be recorded. New species might be introduced by being transported by livestock or in contaminated feed, for example.

The mean weed cover based on 1x1 m surveys is higher in 2023 (14.3%) compared to 2022 (2.46%, p-value = 0.735), but lower than all previous years surveyed; 2021 at 58.50% (p-value = 0.000), 2020 at 59.73% (p-value = 0.000) and 2019 at 32.00% (p-value = 0.370) (Appendix 3 – Table 20). However, this was calculated from Quadrats 9–12 only and therefore not included in the statistical analysis.

Mean weed cover based on 1 ha estimates indicated slightly higher weed cover than the 1 x 1 m surveys (20.4%). This value represented a decrease from all previous years and represented a significant difference (p-value = 0.000).

The statistics do not support expectations that weed cover should be higher following years of high rainfall. This may be due to variations in observers and the way in which data has been collected. In 2022 and

2023, for example, most weed material was annual grasses and forbs that were dead and detached by the late summer monitoring period. This was therefore counted as litter cover and not weed cover. It is unclear what was counted as weed cover in previous years. However, since litter cover was not measured, it is reasonable to assume that dead weed material was counted as weed cover.

So long as future monitoring is consistent with 2022 and 2023 methods, this limitation may become less prevalent.

6.2.3 Bare ground and cryptogram cover

The mean percentage of cryptogram cover decreased to 2.95% in 2023 compared to 6.00% in 2022, 3.00% in 2021 and 20.00% in 2020 (p-value = 0.001) (Appendix 3 - Table 22). This is a significant difference.

The mean percentage of bare ground cover was also the lowest of all years (1.58%). This decreased from 3.00% in 2022, 2.00% in 2021 and 8.06% in 2020 (p-value = 0.000) (Appendix 3 - Table 23.

The cover of bare ground and cryptogram is effectively an indication of the openness of grassland habitat. Greater cover of these two variables may be indicative of more ideal PBTL habitat. It may also be true that a higher amount of bare ground and cryptogram makes detection of spider burrows easier, leading to the detection of more PBTLs.

The mean percentage of litter in 2023 was 70.42%, compared to 73.00% in 2022. (Appendix 3 - Table 24). As this variable was measured for the first time in 2022, it has not been statistically analysed. Previously, litter was included as a part of weed cover percentage and may account for the reduction in weed cover in 2022 and 2023 (Appendix 3 – Table 20). It is important to continue to measure these variables for future data analysis.

The majority of weeds within the SEB Offset Area are exotic annual grasses or small herbaceous weeds that are not feasible to manually control. However, they may be able to be controlled through strategic winter grazing, which is preferred to avoid potential impacts to PBTLs associated with manual weed control (e.g., broad scale herbicide application, heavy machinery impacts, etc.) Weeds recommended for targeted control due to their capacity to suppress native vegetation growth and increasing spread are summarised in Table 9.

Table 9. Location and control methods, suitable for a conservation area, for weed species recommended for targeted control (Robertson 2005; PIRSA 2018).

Species	Common name	Quadrats present	Impacts	Control methods
Echium plantagineum	Salvation Jane	1–12	• Competes with grasslands and pastures • Toxic to livestock	• Multiple biocontrol agents available (contact Natural Resources Northern and Yorke). • Spot spray when actively growing and before seed set. Avoid contact with desirable plants.
Marrubium vulgare	Horehound	2, 4–12	• Competes with grasslands and pastures • Unpalatable • Burrs contaminate wool • Taints meat of livestock if forced to consume	• Horehound Plume Moth (*Wheeleria spilodactylus*) biocontrol. Larva feeds on growing tips and defoliates plants. Collect leaves with larvae present in late spring / early summer and deposit on leaves of new plants. • Manual removal ensuring complete removal of root system from soil. However, ensure spider / PBTL burrows are not destroyed in the process. • Spot spray in autumn and spring, as immature plant before flowering. Avoid contact with desirable plants.
Onopordum acaulon	Horse Thistle	1, 2, 6–11	• Competes with grasslands and pastures • Spine-toothed leaves • Toxic to livestock	• Manual removal ensuring complete removal of root system from soil. However, ensure spider / PBTL burrows are not destroyed in the process. • Spot spray. Avoid contact with desirable plants.
Polygonum aviculare	Wireweed	2, 9	• Competes with grasslands, pastures and crops • Toxic to livestock	• Spot spray. Avoid contact with desirable plants.
Reseda lutea	Cut-leaf Mignonette	2	• Competes with grasslands, pastures and crops	• Manual removal at rosette stage. Suitable for individuals and small infestations. However, ensure spider / PBTL burrows are not destroyed in the process. • Spot spray in winter and spring, before flowering. Avoid contact with desirable plants.
Rosa canina	Dog Rose	1, 5, 7, 9–12	• Forms prickly thickets • Invades grasslands and pastures	• Pull seedling and grub small plants. • Cub and swab in late spring and summer, while plants are actively growing.
Salvia verbenaca	Wild Sage	1–12	• Competes with grasslands and pastures • Unpalatable	• Spot spray in autumn and winter, as immature plant before flowering and seed set. Avoid contact with desirable plants.
Xanthium spinosum	Bathurst Burr	2, 10	• Burrs contaminate wool • Spiny stems • Seedling toxic to livestock	• Spot spray between September and April, as immature plant before burr formation. Avoid contact with desirable plants.

6.2.4 Perennial plant spacing and juvenile tussocks

The mean spacing of perennial plants increased to 26.7 cm compared to 20.90 cm in 2022 and was similar to 2021 results (26.00 cm) (Figure 35). Differences in perennial plant spacing were significant between 2020 and 2021 (p-value = 0.040), 2020 and 2022 (p-value = 0.010) and 2020 and 2023 (p-value = 0.05).

The increase in perennial plant spacing is reflective of the decrease in the mean number of perennial grass tussocks per hectare (TPH) in 2023 of 90,000 from 164,583 in 2022, 94,815 in 2021, 121,583 in 2020 and 114,167 in 2019 (Figure 36). This difference was not significant (p-value = 0.09).

It might be expected that the number of tussocks per hectare would increase following periods of high rainfall, such as has been experienced in 2021 and 2022. This expectation was supported by 2022 monitoring results, however, has not been supported in 2023, where TPH was similar to 2021 results. This may be due to limitations caused by the high amount of litter and weed cover in many of the 1x1 m Quadrats (Figure 45). In such cases, perennial tussocks were only visible following considerable efforts to remove litter cover (Figure 46). Many tussocks may not have been detected as a result.

Decreased TPH may also be due to a low long-term survival rate of juvenile tussocks, with large numbers of juveniles germinating as a result of 2021 spring rains being counted in 2022 but not surviving until the 2023 monitoring. A low long-term survival rate could be caused by a number of factors, but with continued high rainfall and the absence of heavy grazing pressure may be caused by increased competition from weeds and litter cover.

Figure 45. 1x1 m quadrat with 100% litter cover. Any perennial tussocks are not visible.

Figure 46. 1x1 m quadrat after litter has been removed. Some small perennial tussocks are visible.

Although remaining higher than in 2021, the mean number of juvenile perennial grass tussocks per hectare (JPH) in 2023 (5,167 JPH) decreased from 2022 (9,167 JPH) (p-value = 0.999). The decrease in JPH despite continued high rainfall and absence of grazing pressure may be due to high litter and weed cover that has accumulated over several years of high rainfall, as discussed above. It may also be a reflection of survey limitations, since juvenile tussocks were very difficult to detect given the absence of bare ground and lack of space in the vegetation.

6.2.5 Perennial plant size and health attributes

The mean basal width of perennial plants decreased again to 4.94 cm from 6.80 cm in 2022, 7.06 cm in 2021, 7.95 cm in 2020, 7.43 cm in 2019, and 9.58 cm in 2018 (Appendix 3 – Table 17). This difference is significant between 2018 and 2022 (p-value = 0.022), 2018 and 2021 (p-value = 0.047), 2018 and 2023 (p-value = 0.000), and 2020 and 2023 (p-value = 0.010) (Appendix 3 - Table 17).

Tussock height also decreased from 2022 (18.9 cm from 25.19 cm). However, tussock height remains taller than in 2020, 2019 and 2018 (Appendix 3 - Table 18). Tussock height in 2023 was significantly different from 2019 (p-value = 0.000), but was not significantly different from any other year.

There was a significant increase in dead material on perennial grass tussocks from 2022 (54.7% from 16.7%) (p-value = 0.000), however it remained less than in 2021, 2019 and 2018 (Appendix 3 - Table 19).

A decrease in basal width and tussock height is consistent with an increase in the amount of dead material. While all three measures could be reflective of decreasing tussock health, it may also be reflective of climatic conditions. High spring and summer rainfall may have caused a large flush of growth that has begun to die off after a dry late summer period. This is especially so given that tussock height remains higher and dead material remains lower than during the early monitoring years.

The photographs taken at each quadrat (Appendix 2 – Vegetation monitoring quadrat photographs. present visual changes in the grassland over time at Quadrats 1–8 since 2016; and all twelve quadrats since 2018. The photos clearly show a reduction in bare ground and increase in dead litter and thatch since monitoring began.

6.2.6 Grazing impact and ongoing management

Overall, the grassland appeared less grazed in 2023 compared with previous years, with a decrease in tussock spacing and increase in litter and thatch. Given the landowner has maintained grazing patterns in line with the management plan, this is most likely due to increased vegetation growth due to climatic conditions. It is not likely to be due to any real decrease in grazing pressure.

There is evidence to suggest that total rainfall experienced between September and January is influencing vegetation structure, particularly cover. Negative correlations between some of data and increasing rainfall suggests that vegetation cover is denser during high rainfall in spring and summer and that this detrimentally impacts both PBTLs and spider holes.

At the time of preparation of the Hornsdale Wind Farm Vegetation Offset Management Plan (EBS Ecology 2017a), ewes were stocked from the start of May to late August at a rate of 2.5 ewes per ha (M. Clark *pers. Comm.* 2013 in EBS Ecology 2017a). It appears that during spring and summers with high rainfall, the SEB area would potentially benefit from extending grazing periods into mid-late spring (i.e. late September to October). Therefore, an overall review of the grazing regime may be beneficial, with consideration of climatic conditions, retaining tussock spacing for PBTL and supporting ongoing grassland health.

6.2.7 Future monitoring / analysis

Future analyses of plant attributes can continue to explore rainfall variables to determine the influence of seasonal rainfall patterns on plant condition. Trends in litter can also be analysed in the coming years.

Future analyses should also determine if there are any significant changes in any of the plant attributes in response to grazing variables (e.g., stocking rate, grazing period, etc.), which could then be used to inform adaptive management. This may be particularly important if dry conditions persist.

7 RECOMMENDATIONS

The following recommendations relating to both vegetation and PBTL monitoring and the overall management of the SEB Offset Area are made:

- Management continues to follow actions that are described in the SEB Management Plan (EBS Ecology 2013, 2017a), including the following;
  - Complete and submit the *Paddock Monitoring Sheet* to NEON to assist the management of the grazing program.
  - Submit the *Activity Record Datasheet* to NEON at the end of each financial year until 2028.
  - Example of both datasheets are attached as Appendix 4.
- Quadrats should continue to be monitored annually by a suitably qualified Ecologist in February for PBTL presence, and surveyors should be kept constant, where possible, to ensure a robust dataset is compiled. Results from the PBTL monitoring program should then be used to make management decisions that will improve the quality of PBTL habitat in the SEB Offset Area;
- Additional data on spider burrows (e.g., hole depth) should continue to be collected and analysed in future years to provide insight into the availability of burrows suitable for PBTLs;
- Vegetation condition and rainfall data should continue to be incorporated into future analyses of PBTL survey data to help explain any annual variability in results. Analyses will become more robust as more data is collected throughout the monitoring program;
- Monitor quadrats for threatened flora as observed across the SEB Offset Area in 2021, 2022 and 2023;
- Continue winter grazing to reduce annual exotic grass and retain patchiness for PBTL, adjusting DSE to reflect climatic conditions. A review of the grazing regime would be beneficial and consider the following:
  - Extend the grazing period into spring during years of high rainfall to reduce weed biomass, particularly spring germinates, increase bare ground and break up litter mats.
  - Lower DSE, shorten graze periods or increase rest periods on rocky ridges where widespread deterioration of grassland condition has been observed.
- Prioritise the control of Declared woody weeds that have potential to alter the structure of grassland vegetation. This includes the following species:
  - Dog Rose (*Rosa canina*).
  - Horehound (*Marrubium vulgare*).
- The Land Manager and NEOEN determine ongoing management actions in consultation with a suitably qualified Ecologist, based on the recommendation in this report.
- Collect temperature data on site during field survey to reduce limitations due to incomplete climate data sets.

8 2023/2024 PRIORITY ACTIONS

8.1.1 Priority actions

The following actions should be undertaken in 2023 and leading into the 2024 monitoring period with urgency:

- In cooperation with the landowner, review the grazing regime within the SEB Offset Area. Given the high tussock height, decreased tussock spacing, low bare ground with high litter cover apparent from monitoring photographs, the area would benefit from increased grazing pressure. This should be done with the aim of achieving vegetation characteristics approaching those recorded in 2019 and 2020.
- Discuss the feasibility of more reactive grazing management that can respond more easily and quickly to unpredictable climatic conditions.
- Ensure the Land Manager is familiar with the *Paddock Monitoring Sheet* and *Activity Record Datasheet,* that they are completed for 2022/2023 and that they are submitted by the landowner to HWF.

8.1.2 Implementation of priority actions

Following the monitoring survey undertaken in 2023 and considering results and the actions identified above, the following has been implemented;

- Discussion between NEOEN and the landowner regarding the requirement for additional grazing;
- Additional grazing period – sheep were introduced to the SEB area in April 2023, a month earlier than in previous years, to break up litter cover prior to the winter growth period.
- Sheep will remain in the SEB area throughout winter as per the management plan.
- The landowner and NEOEN have committed to meeting Ecologists from EBS Ecology on site in September . At this point, vegetation conditions will be assessed in view of the current and predicted spring weather patterns.
- The landowner has committed to following any recommendations made by EBS Ecology at that time, including the continuation of grazing later into spring in an effort to further reduce weed and litter cover.

NOTE: A meeting occurred on site between the landowner, a NEON representative, and Principal Ecologist from EBS Ecology on 20 September 2023. The current management regime, recent climatic conditions, completion of activity datasheets and future grazing management were discussed.

The outcome of the meeting included an agreement to continue more open communication between the three parties in attendance and an indication from the landowner that greater flexibility in altering grazing regimes in response to changes in climatic conditions was possible. This included extending the 2023 grazing period from 22 September to 9 October 2023.

The landowner also committed to sharing annual management activities by providing an extract of the farm management app currently used to collect this information. This will be used in lieu of activity datasheets.

A full report on this meeting will be provided in the next annual monitoring report (2024).

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10 APPENDICES

Appendix 1 – GPS coordinates of each monitoring quadrat markers.

Monitoring quadrat	Northeast		Southeast		Southwest		Northwest	
	Easting	Northing	Easting	Northing	Easting	Northing	Easting	Northing
1	(redacted)							
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

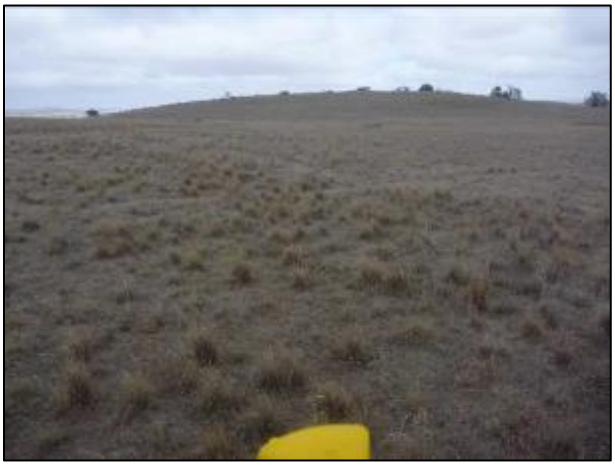
Appendix 2 – Vegetation monitoring quadrat photographs.

Quadrat 1 photographs

	
Baseline PBTL (2016)	2020
	
2018	2021
	
2019	2022

	
2023	2024

Quadrat 2 photographs

	
Baseline PBTL (2016)	2020
	
2018	2021
	
2019	2022

	
2023	2024

Quadrat 3 photographs

	
Baseline PBTL (2016)	2020
	
2018	2021
	
2019	2022

	
2023	2024

Quadrat 4 photographs

	
Baseline PBTL (2016)	2020
	
2018	2021
	
2019	2022

	
2023	2024

Quadrat 5 photographs

<table>
<tr><td></td><td></td></tr>
<tr><td>Baseline PBTL (2016)</td><td>2020</td></tr>
<tr><td></td><td></td></tr>
<tr><td>2018</td><td>2021</td></tr>
<tr><td></td><td></td></tr>
<tr><td>2019</td><td>2022</td></tr>
</table>

	
2023	2024

Quadrat 6 photographs

	
Baseline PBTL (2016)	2020
	
2018	2021
	
2019	2022

	
2023	2024

Quadrat 7 photographs

	
Baseline PBTL (2016)	2020
	
2018	2021
	
2019	2022

	
2023	2024

Quadrat 8 photographs

	
Baseline PBTL (2016)	2020
	
2018	2021
	
2019	2022

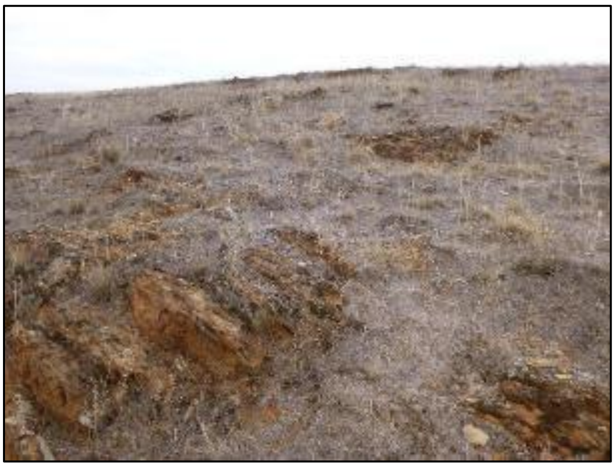
	
2023	2024

Quadrat 9 photographs

No photo, site established in 2018	
Baseline PBTL (2016)	2020
	
2018	2021
	
2019	2022

	
2023	2024

Quadrat 10 photographs

No photo, site established in 2018	
Baseline PBTL (2016)	2020
	
2018	2021
	
2019	2022

	
2023	2024

Quadrat 11 photographs

No photo, site established in 2018	
Baseline PBTL (2016)	2020
	
2018	2021
	
2019	2022

	
2023	2024

Quadrat 12 photographs

No photo, site established in 2018	
Baseline PBTL (2016)	2020
	
2018	2021
	
2019	2022

	
2023	2024

Appendix 3 – Vegetation monitoring data tables.

Table 10. The presence of native species recorded per monitoring quadrat (Q) in 2023.

Scientific Name	Common Name	Conservation Status		New in 2023	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
		EPBC Act	NPW Act													
Acacia pycnantha	Golden Wattle	-	-													✓
Acaena novae-zelandiae	Bidgee Widgee	-	-													✓
Allocasuarina verticillata	Drooping Sheoak	-	-		✓		✓		✓							✓
Anthosachne scabra	Common Wheat-grass	-	-													
Aristida behriana	Bruch Wire-grass	-	-		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Asperula conferta	Common Woodruff	-	-		✓											✓
Atriplex semibaccata	Berry Saltbush	-	-													
Austrostipa scabra group	Falcate-awn Spear-grass	-	-		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Austrostipa sp.	Spear-grass	-	-		✓	✓	✓	✓	✓	✓				✓	✓	✓
Boerhavia dominii	Tar-vine	-	-						✓		✓		✓			
Bursaria spinosa	Bursaria	-	-													✓
Calocephalus citreus	Lemon Beauty-heads	-	-		✓		✓								✓	✓
Calostemma purpureum	Pink Garland-lily	-	-													
Cheilanthes distans	Bristly Cloak-fern	-	-		✓											✓
Cheilanthes sp.		-	-			✓				✓		✓				
Chloris truncata	Windmill Grass	-	-													
Convolvulus remotus	Grassy Bindweed	-	-		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Convolvulus sp.	Bindweed	-	-			✓										
Cryptandra campanulata	Long-flower Cryptandra	-	R		✓		✓		✓						✓	✓
Cryptandra sp. Floriferous (W.R.Barker 4131)	Pretty Cryptandra	-	-													✓
Dichanthium sericeum ssp.	Silky Blue-grass	-	-													
Dysphania melanocarpa	Black Crumbweed	-	-													
Einadia nutans	Climbing Saltbush	-	-													
Elymus sp.		-	-													
Enneapogon nigricans	Black-head Grass	-	-		✓				✓	✓	✓		✓		✓	✓
Euphorbia drummondii group		-	-		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓

Scientific Name	Common Name	Conservation Status		New in 2023	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
		EPBC Act	NPW Act													
Eutaxia microphylla	Common Eutaxia	-	-	✓			✓									✓
Glycine rubiginosa	Twining Glycine	-	-													
Gonocarpus elatus	Hill Raspwort	-	-		✓											✓
Juncus aridicola	Inland Rush	-	-		✓		✓	✓	✓							
Lagenophora huegelii	Coarse Bottle-daisy	-	-	✓			✓									
*Lepidium africanum**	Common Peppercress	-	-		✓					✓			✓	✓		
Liliaceae sp.	Lily Family	-	-		✓	✓				✓						
Lomandra effusa	Scented Mat-rush	-	-													
Lomandra multiflora ssp. dura	Hard Mat-rush	-	-		✓		✓	✓			✓				✓	✓
Lomandra sororia	Sword Mat-rush	-	-										✓			✓
Lomandra sp.		-	-													
Lysiana exocarpi ssp. exocarpi	Harlequin Mistletoe	-	-		✓											✓
Maireana aphylla	Cotton-bush	-	-													
Maireana enchylaenoides	Wingless Fissure-plant	-	-		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
Maireana rohrlachii	Rohrlach's Bluebush	-	R							✓						
Oxalis perennans	Native Sorrel	-	-						✓		✓	✓				✓
Panicum decompositum	Native Millet	-	-												✓	
Rumex dumosus	Wiry Dock	-	R		✓						✓		✓			
Rumex sp.		-	-		✓				✓			✓				
Rytidosperma caespitosum	Common Wallaby-grass	-	-		✓	✓	✓	✓	✓		✓	✓	✓			✓
Rytidosperma sp.		-	-											✓		
Salsola australis	Buckbush	-	-													
Sida corrugata var.	Corrugated Sida	-	-				✓	✓	✓		✓	✓			✓	✓
Sida petrophila	Rock Sida	-	-													
Sida sp.		-	-													
Teucrium racemosum	Grey Germander	-	-													
Themeda triandra	Kangaroo Grass	-	-		✓		✓	✓	✓	✓	✓	✓		✓	✓	✓
Thysanotus sp.		-	-	✓												✓
Triodia irritans	Spinifex	-	-												✓	✓
Vittadinia blackii	Narrow-leaf New Holland Daisy	-	-										✓			

Scientific Name	Common Name	Conservation Status		New in 2023	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12
		EPBC Act	NPW Act													
Vittadinia cuneata var.	Fuzzy New Holland Daisy	-	-		✓		✓	✓	✓	✓	✓					
Vittadinia gracilis	Woolly New Holland Daisy	-	-				✓	✓	✓	✓			✓	✓	✓	✓
Wahlenbergia sp.	Native Bluebell	-	-													
Walwhalleya proluta	Rigid Panic	-	-		✓	✓	✓		✓		✓	✓				
Xanthorrhoea quadrangulata	Rock Grass-tree	-	-		✓										✓	✓
Xanthorrhoea sp.	Yacca/Grass-tree	-	-													
		Total plant Species		**New in 2023**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**
				3	25	10	19	12	19	14	15	12	13	8	16	29

EPBC Act: *Environment Protection and Biodiversity Conservation Act 1999*. NPW Act: *National Parks and Wildlife Act 1972*. R: Rare.

Table 11. The presence of weed species recorded per monitoring quadrat (Q) in 2023.

Scientific name	Common name	New in 2023	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	# of Quadrat 2023	# of Quadrat 2022	# of Quadrat 2021	# of Quadrat 2020
Aira sp.	Hair-grass				✓	✓	✓		✓	✓			✓	✓	7	2	0	0
Avena barbata	Bearded Oat		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	12	12	12	12
Avena sativa	Cultivated Oat		✓								✓	✓			3	1	0	0
Bromus diandrus	Great Brome		✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	10	8	1	4
Bromus hordeaceus	Soft Bromus	✓					✓	✓	✓	✓					4	0	0	0
Bromus rubens		✓									✓	✓			2	0	0	0
Carthamus lanatus	Saffron Thistle			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	11	8	9	6
Centaurea melitensis	Malta Thistle							✓						✓	2	2	0	0
Chondrilla juncea	Skeleton Weed							✓	✓	✓					3	3	0	0
Chrozophora tinctoria				✓				✓		✓					3	3	1	0
Cichorium intybus	Chicory							✓	✓	✓				✓	4	2	1	0
Cucumis myriocarpus	Paddy Melon		✓								✓				2	8	4	5
Echium plantagineum	Salvation Jane		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	12	12	10	12
Eragrostis curvula	African Love-grass														0	3	0	0
Erodium cicutarium	Cut-leaf Herons-bill														0	2	0	12
Heliotropium curassavicum	Smooth Heliotrope														0	5	5	0
Heliotropium europaeum	Common Heliotrope														0	9	11	6
Hordeum glaucum/leporinum				✓											1	4	3	1
Hordeum marinum		✓	✓	✓							✓	✓			4	0	0	0
Hypochaeris radicata	Rough Cats-ear			✓	✓	✓							✓	✓	5	6	2	1
Lactuca serriola	Prickly Lettuce	✓	✓							✓			✓		3	0	0	0
Lepidium africanum	Common Peppercress		✓					✓			✓	✓			4	2	1	2
Lolium sp.	Ryegrass														0	0	3	1

Scientific name	Common name	New in 2023	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	# of Quadrat 2023	# of Quadrat 2022	# of Quadrat 2021	# of Quadrat 2020
Malva sp.				✓							✓				2			
Marrubium vulgare	Horehound		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	11	10	6	10
Medicago minima	Woolly Burr-medic			✓	✓			✓	✓	✓	✓	✓	✓	✓	9	5	6	0
Moraea setifolia	Thread Iris			✓		✓				✓	✓	✓		✓	6	4	10	12
Onopordum acaulon	Horse Thistle		✓					✓	✓	✓	✓				5	8	7	3
Onopordum acanthium		✓								✓					1	0	0	0
Picnomon acarna	Soldier Thistle			✓		✓			✓	✓	✓	✓			6	3	0	0
Poa bulbosa		✓	✓		✓						✓	✓			4	0	0	0
Polygonum aviculare	Wireweed					✓	✓								2	2	1	1
Reseda lutea	Cut-leaf mignonette		✓	✓	✓								✓		4	1	0	1
Rosa canina	Dog Rose		✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	10	7	8	7
Rumex sp.			✓				✓			✓					3	4	3	0
Salvia verbenaca	Wild Sage		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	12	12	9	12
Solanum nigrum	Black Nightshade														0	1	0	0
Sonchus oleraceus	Common Sow-thistle		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	11	10	8	4
Sonchus sp.	Sow-thistle						✓								1	2	0	0
Tribulus terrestris	Caltrop														0	0	0	2
Trifolium angustifolium			✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	10	12	12	0
Trifolium campestre	Hop Clover		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	11	8	11	12
Trifolium repens					✓							✓			2	0	1	0
Trifolium vesiculosum	Arrow-leaf Clover	✓		✓							✓	✓			3	0	0	0
Trifolium sp.					✓										1	0	0	0
Triticum aestivum	Common Wheat	✓	✓	✓			✓			✓					4	0	0	0
Verbascum virgatum	Twiggy Mullein	✓					✓		✓						2	0	0	0
Xanthium spinosum	Bathurst Burr		✓												1	2	2	1

Scientific name	Common name	New in 2023	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	# of Quadrat 2023	# of Quadrat 2022	# of Quadrat 2021	# of Quadrat 2020
	Total Weed Species	**New in 2023**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**						
		9	21	19	16	16	18	16	19	22	21	21	15	17				

Table 12. Native and weed species diversity of each quadrat in 2018, 2019, 2020, 2021, 2022 and 2023.

Quadrat	Native Diversity						Weed diversity					
	2018	2019	2020	2021	2022	2023	2018	2019	2020	2021	2022	2023
1	6	8	23	18	27	23	2	7	9	10	15	21
2	4	4	9	7	9	10	4	8	16	13	23	19
3	5	8	16	15	22	19	3	6	9	12	13	16
4	4	6	11	11	15	12	1	6	11	10	12	16
5	8	10	14	17	23	18	3	7	9	12	15	18
6	6	8	15	13	16	14	3	7	15	14	14	16
7	4	5	12	12	15	15	4	6	9	13	12	19
8	4	8	11	10	12	11	5	6	8	17	15	22
9	5	8	15	15	20	12	7	6	13	15	17	21
10	3	4	14	11	16	7	4	6	11	13	20	21
11	8	7	10	8	20	16	5	5	8	6	15	15
12	12	13	20	21	25	29	1	4	9	11	12	17
Mean	**5.75**	**7.42**	**14.92**	**13.17**	**18.33**	**15.5**	**3.50**	**6.17**	**10.58**	**12.25**	**15.25**	**18.42**

Table 13. The number of quadrats that each native and weed species were recorded in the SEB Offset Area in 2018, 2019, 2020, 2021 and 2022.

Scientific name	Common Name	Number of quadrats					
		2018	2019	2020	2021	2022	2023
Native species							
Acacia pycnantha	Golden Wattle	0	0	0	1	1	1
Acaena novaezealandiae	Sheeps Burr	0	0	0	1	2	1
Allocasuarina verticillata	Drooping Sheoak	1	3	5	5	5	4
Anthosachne scabra	Common Wheat-grass	0	0	0	0	0	0
Aristida behriana	Brush Wire-grass	12	12	12	12	12	12
Asperula conferta	Common Woodruff	0	0	1	1	2	2
Atriplex semibaccata	Berry Saltbush	0	0	1	0	1	0
Austrostipa scabra group	Falcate-awn Spear-grass	12	12	11	11	12	11
Austrostipa sp.	Spear-grass	0	0	12	6	10	9
Boerhavia dominii	Tar-vine	0	0	3	4	4	3
Bursaria spinosa	Bursaria	1	1	1	1	1	1
Calocephalus citreus	Lemon Beauty-heads	1	3	3	3	4	4
Calostemma purpureum	Pink Garland-lily	0	0	0	0	1	0
Cheilanthes distans	Bristly Cloak-fern	0	2	2	0	5	2
Cheilanthes sp.		0	0	0	0	1	3
Compositae sp.	Daisy Family	0	0	1	0	0	0
Chloris truncata	Windmill Grass	0	0	0	0	3	0
Convolvulus remotus	Grassy Bindweed	0	0	0	7	9	11
Convolvulus sp.	Bindweed	2	4	7	1	2	1
Cryptandra campanulata (previously Cryptandra amara)	Long-flower Cryptandra	1	3	6	6	5	5
Cryptandra sp. floriferous	Pretty Cryptandra	1	3	0	0	2	1

Scientific name	Common Name	Number of quadrats					
		2018	2019	2020	2021	2022	2023
Dianella sp.	Flax-lily	0	0	0	1	0	0
Dichanthium sericeum ssp.	Silky Blue-grass	0	0	0	1	1	0
Dysphania melanocarpa	Black Crumbweed	0	0	1	0	2	0
Einadia nutans ssp.	Climbing Saltbush	0	0	1	0	0	0
Elymus scaber		0	0	0	1	0	0
Elymus sp.		0	0	0	1	1	0
Enneapogon nigricans	Black-head Grass	4	3	4	6	9	7
Euphorbia drummondii	Spurge	1	5	12	10	12	11
Eutaxia microphylla	Common Eutaxia	0	0	0	0	0	2
Glycine rubiginosa	Twining glycine	0	2	1	1	0	2
Gonocarpus elatus	Hill Raspwort	0	0	3	1	4	1
Juncus aridicola	Inland Rush	0	0	1	3	4	4
Lagenophora huegelii	Coarse Bottle-daisy	0	0	0	0	0	1
Liliaceae sp.	Lily Family	0	0	1	0	1	3
Lomandra effusa	Scented Mat-rush	0	0	0	1	0	0
Lomandra multiflora ssp. dura	Hard Mat-rush	0	0	4	6	8	6
Lomandra sororia	Sword Mat-rush	0	0	2	2	3	2
Lomandra sp.	Mat-rush	2	1	0	0	0	0
Lysiana exocarpi ssp. exocarpi	Harlequin Mistletoe	0	0	2	2	2	2
Maireana aphylla	Cotton-bush	0	0	1	0	0	0
Maireana enchylaenoides	Wingless Fissure-plant	6	4	11	10	12	11
Maireana rohrlachii	Rohrlach's Bluebush	0	0	1	1	1	1
Oxalis perennans	Native Sorrel	0	0	12	1	6	4
Panicum decompositum	Native Panic	0	0	0	1	0	1
Pleurosorus rutifolius	Blanket Fern	0	0	2	0	0	0
Rumex dumosus	Wiry Dock	0	0	2	1	1	3
Rytidosperma caespitosum	Common Wallaby-grass	3	9	10	11	11	9
Rytidosperma sp.	Wallaby-grass	0	0	2	0	0	1
Salsola australis	Buckbush	0	1	0	1	2	0
Sida corrugata	Corrugated Sida	0	0	0	0	7	7
Sida petrophila	Rock Sida	0	0	1	0	0	0
Sida sp.	Sida	2	1	0	3	0	0
Teucrium racemosum	Grey Germander	2	1	2	0	0	0
Themeda triandra	Kangaroo Grass	6	7	7	9	11	10
Thysanotus sp.		0	0	0	0	0	1
Triodia irritans.	Spinifex	3	3	4	3	3	2
Vittadinia blackii	Narrow-leaf New Holland Daisy	1	2	2	4	6	1
Vittadinia cuneata var.	Fuzzy New Holland Daisy	0	0	7	7	9	6
Vittadinia gracilis	Woolly New Holland Daisy	5	2	0	6	7	8
Wahlenbergia sp.	Native Bluebell	0	0	3	0	1	0

Scientific name	Common Name	Number of quadrats					
		2018	2019	2020	2021	2022	2023
Walwhalleya proluta	Rigid Panic	1	2	2	3	11	6
Xanthorrhoea quadrangulata	Yacca/Grass-tree	3	3	3	2	3	3
Xanthorrhoea sp.	Yacca/Grass-tree	0	0	0	0	0	0
Totals native species within SEB Offset Area		**20**	**23**	**42**	**40**	**45**	**43**
Weed species							
Aira sp.	Hair-grass	0	0	0	0	2	7
Avena barbata	Bearded Oat	12	12	12	12	12	12
Avena sativa	Cultivated Oat	0	0	0	0	1	3
Bromus diandrus	Great Brome	0	0	4	1	8	10
Bromus hordeaceus	Soft Brome	0	0	0	0	0	4
Bromus rubens	Red Brome	0	0	0	0	0	2
Carthamus lanatus	Saffron Thistle	3	6	6	9	8	11
Centaurea melitensis	Malta Thistle	0	0	0	0	2	2
Chondrilla juncea	Skeleton Weed	0	0	0	0	3	3
Chrozophora tinctoria	Turnsole	0	0	0	1	3	3
Cichorium intybus	Chicory	0	1	0	1	2	4
Cucumis myriocarpus	Paddy Melon	1	2	5	4	8	2
Echium plantagineum	Salvation Jane	1	9	12	10	12	12
Eragrostis curvula	African Love-grass	0	0	0	0	3	0
Erodium cicutarium	Cut-leaf Heron's-bill	0	0	12	0	2	0
Heliotropium curassavicum	Smooth Heliotrope	2	5	0	5	5	0
Heliotropium europaeum	Common Heliotrope	3	2	12	11	9	0
Hordeum glaucum/leporinum		0	0	1	3	4	1
Hordeum marinum		0	0	0	0	0	4
Hypochaeris radicata	Rough Cat's Ear	0	0	1	2	6	5
Lactuca serriola	Prickly Lettuce	0	0	0	0	0	3
Lepidium africanum	Common Peppercress	0	0	2	1	2	4
Lolium sp.	Rye-grass	0	1	1	3	0	0
Malva sp.	Mallow	1	0	0	0	0	2
Marrubium vulgare	Horehound	6	7	10	6	10	11
Medicago minima	Woolly Burr-medic	0	0	0	6	5	9
Moraea setifolia	Thread Iris	0	5	12	10	4	6
Onopordum acaulon	Horse Thistle	0	0	3	7	8	5
Onopordum acanthium		0	0	0	0	0	1
Picnomon acarna	Soldier Thistle	0	0	0	0	3	6
Poa bulbosa		0	0	0	0	0	4
Polygonum aviculare	Wireweed	0	0	1	1	2	2
Reseda lutea	Cut-leaf Mignonette	0	0	1	0	1	4
Rosa canina	Dog Rose	3	2	7	8	7	10
Rumex sp.		0	3	0	3	4	3

Scientific name	Common Name	Number of quadrats					
		2018	2019	2020	2021	2022	2023
Salvia verbenaca	Wild Sage	6	10	12	9	12	12
Solanum nigrum	Black Nightshade	0	0	0	0	1	0
Sonchus oleraceus	Common Sow-thistle	0	0	4	8	10	11
Sonchus sp.	Sow-thistle	1	3	0	0	2	1
Tribulus terrestris	Caltrop	0	0	2	0	0	0
Trifolium angustifolium		0	0	0	12	12	10
Trifolium campestre	Hop Clover	0	0	12	11	8	11
Trifolium repens		0	0	0	1	0	2
Trifolium resupinatum		0	0	0	0	0	3
Trifolium sp.	Narrow-leaf Clover	2	9	0	0	0	1
Triticum aestivum	Common Wheat	0	0	0	0	0	4
Verbascum virgatum	Twiggy Mullein	0	0	0	0	0	2
Vulpia sp.	Fescue	0	0	1	0	0	9
Xanthium spinosum	Bathurst Burr	1	0	1	2	2	1
Total weed species within SEB Offset Area		**13**	**15**	**23**	**26**	**34**	**42**

Table 14. Mean plant spacing (cm) at each quadrat in 2018, 2019, 2020, 2021 and 2022.

Quadrat	Mean plant spacing (cm)					
	2018	2019	2020	2021	2022	2023
1	24.0	22.2	30.7	18.1	12.9	17.7
2	37.5	22.5	41.5	33.9	26.9	33.6
3	15.3	21.2	23.5	20.1	15.4	26.9
4	24.5	24.5	17.7	22.9	13.3	21.0
5	32.4	31.6	40.3	29.5	19.1	35.9
6	19.7	91.1	76.8	23.4	26.7	31.7
7	23.5	30.1	69.9	24.2	20.2	24.3
8	37.7	44.9	58.1	27.8	24.7	33.9
9	49.2	38.6	45.2	31.1	27.3	31.1
10	47.4	99.8	216.9	33.2	24.9	27.8
11	21.6	24.2	29.1	26.9	19.2	18.8
12	23.6	48.3	33.5	20.3	19.8	18.6
Mean	**29.70**	**41.58**	**56.93**	**26.00**	**20.85**	**26.74**

Table 15. Mean number of tussocks per hectare in each quadrat in 2018, 2019, 2020, 2021 and 2022.

Quadrat	Mean tussocks per hectare					
	2018	2019	2020	2021	2022	2023
1	-	150,000	204,000	230,000	302,000	140,000
2	-	120,000	76,000	50,000	54,000	20,000
3	-	190,000	200,000	190,000	256,000	110,000
4	-	160,000	231,000	110,000	281,000	130,000
5	-	100,000	95,000	90,000	151,000	50,000

Quadrat	Mean tussocks per hectare					
	2018	2019	2020	2021	2022	2023
6	-	100,000	84,000	50,000	88,000	50,000
7	-	90,000	90,000	120,000	153,000	120,000
8	-	70,000	60,000	60,000	74,000	60,000
9	80,000	80,000	103,000	30,000	66,000	20,000
10	60,000	30,000	10,000	20,000	63,000	20,000
11	120,000	150,000	111,000	90,000	166,000	150,000
12	120,000	130,000	195,000	100,000	321,000	210,000
Mean	**95,000**	**114,167**	**121,583**	**94,815**	**164,583**	**90,000**

Table 16. Mean number of juvenile tussocks per hectare in each quadrat in 2018, 2019, 2020, 2021 and 2022.

Quadrat	Mean juvenile tussocks per hectare					
	2018	2019	2020	2021	2022	2023
1	-	30,000	99,000	10,000	13,000	8,000
2	-	10,000	59,000	0	3,000	1,000
3	-	40,000	13,000	10,000	9,000	14,000
4	-	10,000	36,000	0	13,000	4,000
5	-	20,000	33,000	0	8,000	2,000
6	-	10,000	16,000	0	10,000	0
7	-	10,000	130,000	20,000	26,000	11,000
8	-	3,000	49,000	10,000	11,000	3,000
9	1,000	5,000	158,000	0	1,000	1,000
10	6,000	10,000	308,000	0	3,000	4,000
11	1,200	20,000	68,000	0	4,000	7,000
12	30,000	20,000	64,000	0	19,000	7,000
Mean	**9,550**	**15,667**	**86,083**	**4,400**	**9,911**	**5,167**

Table 17. Mean plant basal width (cm) at each quadrat in 2018, 2019, 2020, 2021 and 2022.

Quadrat	Mean plant basal width (cm)					
	2018	2019	2020	2021	2022	2023
1	12.9	6.7	7.1	6.6	8.6	6.5
2	8.5	7.0	5.1	4.7	5.0	2.6
3	7.2	6.2	5.8	6.9	6.7	5.8
4	8.7	6.1	5.7	6.2	6.3	3.2
5	6.3	5.4	6.3	6.7	8.7	4.0
6	9.8	4.9	7.6	7.1	6.6	6.4
7	11.4	13.2	11.3	5.2	8.3	6.7
8	13.5	8.2	11.3	10.4	6.8	6.2
9	6.9	6.3	6.4	4.4	6.0	3.7
10	9.1	6.6	7.7	6.1	6.9	2.8
11	11.9	8.8	8.3	8.8	7.5	6.1
12	8.8	9.8	12.8	11.6	4.5	5.3
Mean	**9.58**	**7.43**	**7.95**	**7.06**	**6.80**	**4.94**

Table 18. Mean plant height (cm) at each quadrat in 2018, 2019, 2020, 2021 and 2022.

Quadrat	Mean plant height (cm)					
	2018	2019	2020	2021	2022	2023
1	21.0	9.4	12.6	22.6	38.1	30.0
2	14.0	3.5	8.1	19.7	21.8	14.7
3	13.6	5.5	10.3	29.2	17.1	18.2
4	10.7	3.5	8.2	22.5	25.0	14.3
5	14.5	5.7	9.6	30.5	25.3	13.3
6	17.3	4.3	10.1	26.7	21.7	12.0
7	27.9	15.9	18.0	18.6	52.7	28.9
8	19.8	7.0	12.6	20.6	25.6	28.4
9	10.0	5.0	8.0	28.3	22.7	8.5
10	9.5	5.8	11.8	14.3	14.7	10.4
11	13.6	7.8	12.0	14.4	13.6	17.8
12	16.6	9.1	16.0	21.8	24.1	30.4
Mean	**15.71**	**6.88**	**11.44**	**22.43**	**25.19**	**18.9**

Table 19. Percentage dead material on tussocks (%) in each quadrat in 2018, 2019, 2020, 2021 and 2022.

Quadrat	Dead material on grass tussocks (%)					
	2018	2019	2020	2021	2022	2023
1	-	77	30	59	17	55
2	-	86	42	94	9	24
3	-	66	28	74	20	66
4	-	82	17	88	16	52
5	-	83	51	73	17	67
6	-	96	56	88	15	81
7	-	88	52	58	11	46
8	-	94	46	82	11	46
9	97	97	40	95	15	55
10	96	95	52	95	21	36
11	97	83	44	84	25	58
12	79	70	22	78	23	70
Mean	**92.25**	**84.74**	**39.91**	**80.67**	**16.66**	**54.67**

Table 20. Mean percentage (%) weed cover within 1 x 1 m quadrats in 2018, 2019, 2020, 2021 and 2022.

Quadrat	Mean weed cover (%) (1 x 1 m quadrats)					
	2018	2019	2020	2021	2022	2023
1	-	10	36	36	1	30
2	-	41	84	90	4	4
3	-	5	16	26	1	18
4	-	19	57	48	1	43
5	-	21	60	39	2	12
6	-	53	79	69	3	15
7	-	31	76	62	1	17

Quadrat	Mean weed cover (%) (1 x 1 m quadrats)					
	2018	2019	2020	2021	2022	2023
8	-	86	63	74	9	1
9	62	89	79	97	2	2
10	88	98	96	94	2	2
11	7	19	68	62	2	19
12	1	1	4	5	2	10
Mean	**39.50**	**31.98**	**59.73**	**58.50**	**2.41**	**14.42**

Table 21. Percentage (%) weed cover within 1 ha quadrats in 2018, 2019, 2020, 2021 and 2022.

Quadrat	Weed cover (%) (1 ha quadrat)					
	2018	2019	2020	2021	2022	2023
1	-	30	30	40	1	25
2	-	30	60	90	5	15
3	-	5	20	30	1	25
4	-	25	30	50	2	50
5	-	25	40	40	5	20
6	-	40	60	70	5	20
7	-	25	50	60	5	25
8	-	70	60	70	10	10
9	70	70	75	90	3	10
10	80	85	85	90	3	10
11	10	20	50	60	3	25
12	2	1	5	5	2	10
Mean	**40.50**	**35.50**	**48.33**	**57.92**	**4**	**20.42**

Table 22. Percentage (%) cryptogram cover at each quadrat in 2020, 2021 and 2022.

Quadrat	Cryptogram cover (%)			
	2020	2021	2022	2023
1	25.1	5	2	1
2	2.1	0	0	0
3	58.1	6	14	2
4	25.6	1	7	3
5	30.3	4	2	3
6	11.5	3	0	2
7	15	2	1	1
8	1.3	1	0	1
9	2.2	0	4	5
10	1.3	0	13	1
11	16	0	18	9
12	55	18	8	7
Mean	**20**	**3**	**6**	**2.92**

Table 23. Percentage (%) bare ground at each quadrat in 2020, 2021 and 2022.

Quadrat	Bare ground cover (%)			
	2020	2021	2022	2023
1	5.8	2	2	54
2	8.1	1	1	0
3	11.6	3	3	2
4	7.6	6	12	1
5	13.4	6	2	1
6	8	2	2	0
7	5.6	1	1	1
8	16.1	1	0	2
9	4.4	0	3	0
10	0.2	0	0	0
11	2.8	0	6	2
12	13.1	6	4	9
Mean	**8**	**2**	**3**	**6**

Table 24. Percentage litter at each quadrat in 2022 and 2023.

Quadrat	Litter cover (%)	
	2022	2023
1	69	54
2	89	99
3	77	63
4	66	44
5	73	81
6	89	83
7	74	48
8	89	91
9	88	96
10	78	100
11	49	66
12	38	20
Mean	**73.25**	**70.42**

Appendix 4 – Annual record sheets

Activity Record Datasheet - *To be filled in by landholders as work progresses, then issued to NEON at the end of each financial year.*

Management Action (e.g. fox baiting / shooting, boxthorn control)	**Date**	**Time spent on task** (hrs / days)	**Comments** (Completed/more remaining/ follow up required – provide estimate of time remaining)

Paddock Monitoring Sheet - ***To be filled in by landholders as grazing management progresses.***

Paddock Name:...

Paddock Size	Date in	Date out	A. Grazing Days	B. Estimate of feed left (kg/DM/ha)	C. Sheep number and type	D. DSE rating	E. Total DSE of mob	F. Feed utilised (kg)	G. Rest Period (days)	I. DSE days/ha	J. DSE days/ha/yr

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