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ENGIE

WILLOGOLECHE WIND FARM

Lomandra Grassland Monitoring Report 2024

FINAL

August 2025

WILLOGOLECHE WIND FARM

Lomandra Grassland Monitoring Report 2024

FINAL

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
ENGIE

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Abbreviations

Abbreviation	Terms
%	Percent / Percentage
±	Standard error of mean
Annual (plant)	A plant that completes its entire life cycle, from seed germination to flower and the production of seed, within a single growing season (which can be 12 months or less). All roots, stems and leaves of the plant die annually.
Assessment Site	Monitoring transect and immediate (50 metre) surrounding area combined.
BCMM NAYP	Bushland Condition Monitoring Manual
Biennial (plant)	A plant that requires two years to complete its life cycle.
BOM	Bureau of Meteorology
cm	Centimetre(s)
COEMP	Construction and Operational Environmental Management Plan
Condition Class A	The highest quality representation of Iron-grass Natural Temperate Grassland
Condition Class B	Iron-grass Natural Temperate Grassland of high quality with less native species diversity than Condition Class A.
Condition Class C	Iron-grass Natural Temperate Grassland that is typically significantly degraded, but amenable to rehabilitation.
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Commonwealth)
Declared plant	A weed that is regulated under the *Landscape South Australia Act 2019* due to its threat to primary industry, the natural environment and public safety.
DEW	Department for Environment and Water (South Australian)
EBS Ecology	EBS Ecology Pty Ltd (which is now Umwelt)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ha	Hectare(s)
INTG	Iron-grass Natural Temperate Grassland of South Australia
LSA Act	*Landscape South Australia Act 2019*
m^2	Square metre(s)
m^3	Metres cubed
MNES	Matter(s) of National Environmental Significance (protected by the EPBC Act)
NRMDB	Natural Resources Murray-Darling Basin
NAYP	Northern Agricultural and Yorke Peninsula
NRM	Natural Resources Management
NY NRM	Northern and Yorke Natural Resources Management
NPW Act	*National Parks and Wildlife Act 1972*
OEMP	Operational Environmental Management Plan
PCQM	Point-centre Quarter Method
Perennial (plant)	A plant that persists for many growing seasons
PIRSA	Primary Industries and Regions South Australia
PPH	Perennial plants per hectare
Project	the Willogoleche Wind Farm

Abbreviation	Terms
SA	South Australia
sp.	Species
spp.	Species (plural)
ssp.	Subspecies
TEC	Threatened Ecological Community
Umwelt	Umwelt (Australia) Pty Ltd
Weed	A plant species which does not naturally occur in an area.
WTG	Wind turbine Generator
WWF	Willogoleche Wind Farm

Executive Summary

An annual Lomandra Grassland Monitoring program has been undertaken at seven patches of *Iron-grass Natural Temperate Grassland of South Australia* (INTG) within the Willogoleche Wind Farm (WWF; the Project) since 2017. Initial assessment of the seven patches of INTG determined that six patches met the criteria for INTG 'Condition Class B' and one patch met the criteria for INTG 'Condition Class C' (EBS Ecology 2010).

As INTG (also referred to as Lomandra Grassland) is protected by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), a monitoring program is required to be implemented in accordance with the *Willogoleche Wind Farm Construction and Operational Environmental Management Plan* (COEMP) (EBS Ecology 2017), which was revised to the *Willogoleche Wind Farm Operational Environmental Management Plan* (OEMP) (EBS Ecology 2019a) after construction works were completed.

Both the COEMP and OEMP include management measures to avoid and/or minimise impacts to INTG / Lomandra Grassland within the WWF, as well as requirements for a monitoring program to be implemented annually during construction and annually during the first five years post construction (i.e. during operation), to monitor for potential impacts and ensure the INTG is not reducing in condition/quality.

This report presents the results of the annual Lomandra Grassland Monitoring undertaken at WWF in 2024, which is the fifth year of monitoring during operation. It outlines the methodology used for data collection, presents and discusses the results, and provides comparison with baseline data collected in 2017 and annual monitoring data collected throughout the duration of the Lomandra Grassland Monitoring program. In particular, it reports on the overall status of each of the seven patches of INTG with regard to EPBC Act INTG Condition Class and comments on whether operation of the WWF negatively impacts on the INTG. Importantly, this report also provides recommendations to maintain the health of the INTG and ensure the management requirements of the OEMP are fulfilled and compliance with the conditions of the Project's EPBC Act approval is achieved.

The Lomandra Grassland Monitoring undertaken in 2024 involved the same methodology used in previous monitoring events, including data collection via the Point-Centred Quarter Method (PCQM), quadrat sampling for Grassland Health Indicators, and ramble survey, at previously established Assessment Sites within each of the seven patches of INTG.

Descriptive data and any observations of changes or constants between 2017 and 2024 are provided in this report. Statistical analysis could be conducted in future years when there is enough data to ascertain if any changes to INTG health are occurring over the period of the monitoring program.

A summary of the Lomandra Grassland Monitoring results for 2024 are as follows:

- INTG at all seven Assessment Sites met the criteria for INTG Condition Class B.
- The average spacing between perennial plants and average perennial plant height were the lowest recorded to date, while the average perennial plants per ha and average basal cover were the highest recorded to date (all data collected via PCQM).

- *Rytidosperma* spp. (Wallaby grass) had greatest average relative importance score (out of the four most common grass species measured) across all Assessments Sites, however the frequency of the species has been decreasing since the baseline survey (2017).
- The condition of all Assessment Sites was within the 'healthy' benchmark range, based on Bushland Condition Monitoring Manual (BCMM) for the Northern Agricultural and Yorke Peninsula (NAYP) Regions Community 3.2 (Grassland) indicators, such as species diversity, species life form, percent native cover, cryptogam cover and bare ground cover.
- A total of 37 native flora species were observed across all Assessment Sites, which is one more species compared to 2023, but not as high as the 43 native species recorded in 2022.
- One new flora species, *Cheilanthes austrotenuifolia* (Annual Rock-fern), was recorded, located at Site 2.
- For Grassland Health Indicators, the average percentage across all Assessment Sites for:
    - Bare ground was 14.11%, which is a large increase compared to the 2.06% in 2023 and higher than the 9.48% recorded initially in 2019.
    - Cryptogam was 31.64%, which is an increase compared to the 14.43% in 2023, but lower than the 44.26% recorded initially in 2019.
    - Litter cover was 28.89%, which is lower than the 64.54% in 2023 and 52.81% recorded initially in 2019.
    - Native cover was 16.1%, which is a slight decrease from the 18.41% in 2023 but similar to the 16.56% recorded initially in 2019.
    - Rock cover was 9.94%, which is similar to the 8.27% in 2023 and range of 8.27–10.91% recorded in previous years.
- The frequency of Lomandra tussocks in 2024 was 0.37, which is similar to the 0.34 recorded in 2023.

Data collected in 2024 and across the entire Lomandra Grassland Monitoring program to date, indicates that the seven patches of INTG within the WWF remain in a stable condition and are not currently being negatively impacted by operation of the wind farm. It is evident that many observed changes between years, such as species diversity, weed and native cover, and plants per hectare are not necessarily indicative of long-term trends, but rather, are attributable to seasonal climatic variation or impacts from grazing. Weed invasion remains to be the primary threat to the health of the seven patches of INTG at WWF.

The following recommendations should be considered for future monitoring at WWF:

- Continue to conduct the Lomandra Grassland Monitoring program to determine whether operation of the wind farm negatively impacts the INTG.
- Continue to implement the monitoring methodology described in this report.
- Undertake weed management actions as outlined in the WWF Weed Assessment Report 2024 (Umwelt 2025), to ensure that weed spread is detected and addressed promptly, as this is considered the main threat to INTG attributable to the operation of WWF, in particular:

- Actively engage landholders to undertake best practice weed control (grazing, slashing, spraying, physical removal) at WWF.
- Continue low-level sheep grazing, preferably in winter months, to ensure inter-tussock spaces are kept open for the recruitment of broad-leaved herbs.
- Reduce sheep grazing during spring to prevent overgrazing and inability for broad-leaved herbs to recruit.

- Ensure any management actions (including weed management and grazing management) undertaken by ENGIE and/or landholders are communicated and documented to enable long term monitoring observations to be correlated with land management. This includes recording:
  - Approximate grazing regime (stocking density, type and duration) for the 12 months prior to survey for each Site (if different).
  - Location and method of any targeted weed control undertaken within WWF or Lomandra Grassland to enable tracking of success.
- Undertake ongoing evaluation of monitoring techniques to supplement or amend the current methodology (if required).

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1.0 Introduction

An annual Lomandra Grassland Monitoring program has been undertaken at seven patches of *Iron-grass Natural Temperate Grassland of South Australia* (INTG) within the Willogoleche Wind Farm (WWF; the Project) since 2017. As INTG (also referred to as Lomandra Grassland) is protected by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), a monitoring program is required to be implemented in accordance with the *Willogoleche Wind Farm Construction and Operational Environmental Management Plan* (COEMP) (EBS Ecology 2017), which was revised to the *Willogoleche Wind Farm Operational Environmental Management Plan* (OEMP) (EBS Ecology 2019a) after construction works were completed.

Both the COEMP and OEMP include management measures to avoid and/or minimise impacts to INTG / Lomandra Grassland within the WWF, as well as requirements for a monitoring program to be implemented annually during construction and annually during the first five years post construction (i.e. during operation), to monitor for potential impacts and ensure the INTG is not reducing in condition/quality.

This report presents the results of the annual Lomandra Grassland Monitoring undertaken at WWF in 2024, which is the fifth year of monitoring during operation, as outlined in **Table 1.1**. Previous Lomandra Grassland Monitoring reports are also listed in **Table 1.1** and should be referred to for more information on previous Lomandra Grassland Monitoring undertaken at WWF (including previous methodology and results). Note that EBS Ecology became Umwelt (Australia) Pty Ltd in July 2024.

Table 1.1 Lomandra Grassland Monitoring Completed at WWF

Year	Report	Monitoring phase	Reference
2017	*Willogoleche Wind Farm Lomandra Grassland Monitoring Report 2017* (This report contains baseline data for the seven INTG patches prior to construction.)	During construction.	EBS Ecology 2018
2018	*Willogoleche Wind Farm Lomandra Grassland Monitoring Report 2018*	During construction.	EBS Ecology 2019b
2019	*Willogoleche Wind Farm Lomandra Grassland Monitoring Report 2019*	Completion of construction / commencement of operation.	EBS Ecology 2020
2020	*Willogoleche Wind Farm Lomandra Grassland Monitoring Report 2020*	1st year of operation.	EBS Ecology 2021
2021	*Willogoleche Wind Farm Lomandra Grassland Monitoring Report 2021*	2nd year of operation.	EBS Ecology 2022
2022	*Willogoleche Wind Farm Lomandra Grassland Monitoring Report 2022*	3rd year of operation.	EBS Ecology 2023
2023	*Willogoleche Wind Farm Lomandra Grassland Monitoring Report 2023*	4th year of operation.	EBS Ecology 2024
2024	This report.	5th year of operation.	This report.

1.1 Objectives

The objectives of this report are to:

- Describe the methodology used for the 2024 monitoring event.
- Present the results of the 2024 monitoring event and compare to baseline and subsequent annual monitoring event results.
- Comment on the Condition Class status of the INTG patches within the WWF.
- Comment on whether operation of the WWF impacts on INTG.
- Provide further recommendations on the monitoring methodology (if required).
- Provide recommendations to ensure the requirements of the OEMP are met and compliance with the conditions associated with the Project's EPBC Act approval is achieved.

2.0 Background

2.1 Willogoleche Wind Farm

The Willogoleche Wind Farm (WWF; the Project) is located approximately 6 km west of the township of Hallett in the Mid North of South Australia (**Figure 2.1**). With 32 Wind Turbine Generators (WTGs) the WWF has a generation capacity of 119 Megawatts, giving it the capability of powering 80,000 homes across SA (ENGIE 2025).

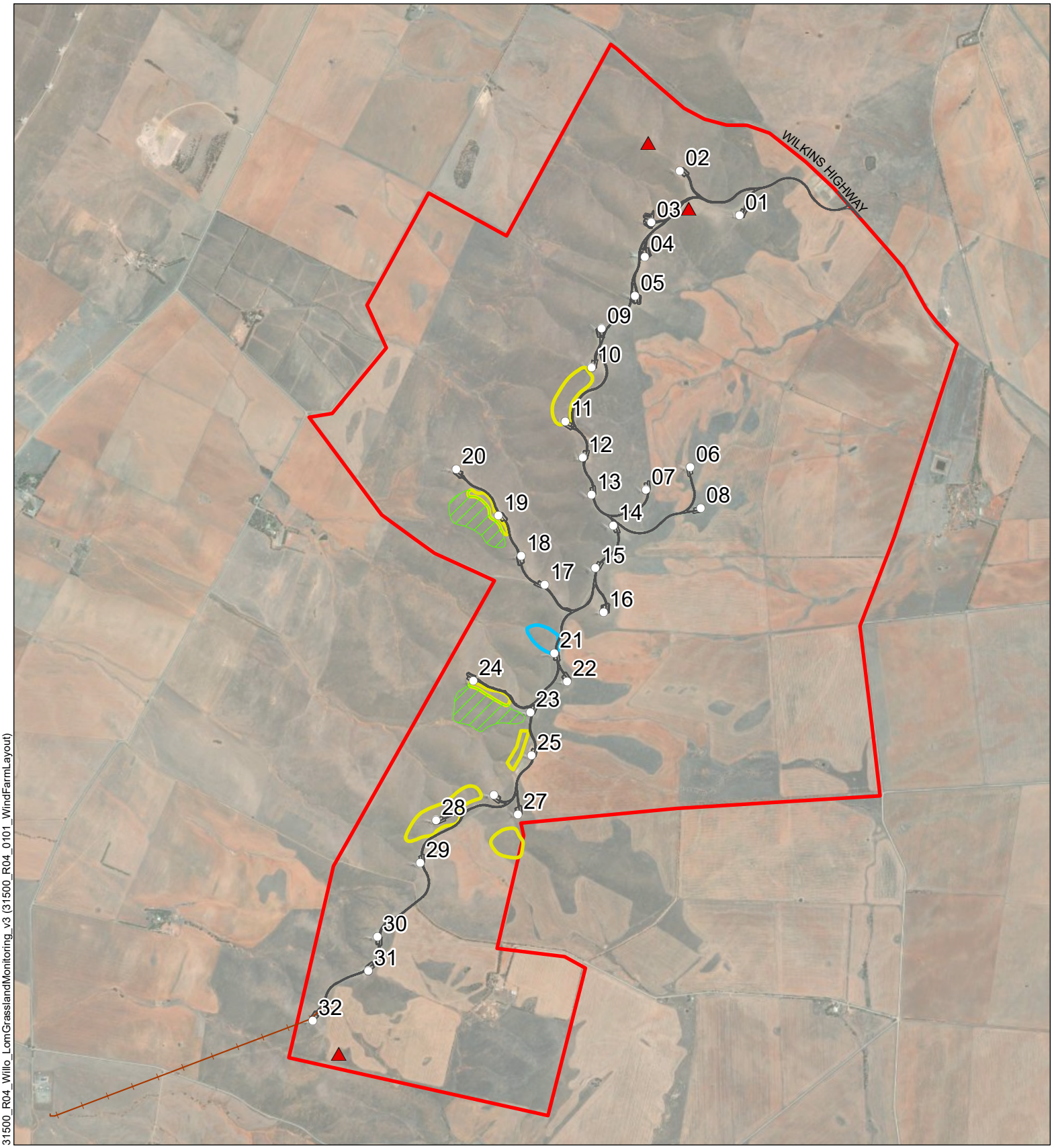
Construction works for the WWF commenced on 9 September 2017 and sectional completion was achieved on 12 November 2019. Willogoleche Power, on behalf of ENGIE, has been operating the WWF since 12 November 2019 and it is expected to be operational for approximately 25 years, until around 2044.

2.2 INTG and EPBC Act Approval Conditions

During the planning phase of the WWF, initial assessments of the site were conducted to identify potential ecological impacts associated with the Project. As part of these assessments, it was identified that the Project Area contained patches of grassland vegetation that included *Lomandra* (Iron-grass) species, which could constitute INTG protected by the EPBC Act. Further assessment of these patches of grassland, in accordance with the condition class criteria outlined in the *Commonwealth Listing Advice on Iron-grass Natural Temperate Grassland of South Australia* (TSSC 2007) and *EPBC Act Policy Statement 3.7 – Peppermint Box (Eucalyptus odorata) Grassy Woodland of South Australia and Iron-grass Natural Temperate Grassland of South Australia* (DEWR 2007), determined that six patches met the criteria for INTG 'Condition Class B' and one patch met the criteria for INTG 'Condition Class C' (EBS Ecology 2010) (**Figure 2.1**). Condition Class A represents the highest quality of the community, whereas Condition Class B is also of high quality but shows less species diversity, with both protected by the EPBC Act. While Condition Class C is not protected by the EPBC Act, it represents an area which is considered intact enough to be amenable to rehabilitation.

INTG is a Threatened Ecological Community (TEC) and recognised as a Matter of National Environmental Significance (MNES) which is protected by the EPBC Act. In accordance with the EPBC Act, actions that have, or are likely to have, a significant impact on a MNES require approval from the Australian Government Department (the Department) responsible for administrating the EPBC Act. As construction, and potentially operation, of the WWF would impact on INTG, EPBC Act Approval was sought and subsequently received on 28 January 2014 (EPBC 2011/5850), prior to the commencement of construction. The approval is subject to several conditions, including implementation of an Environmental Management Plan for the operation of the wind farm which details management actions to minimise potential impacts on INTG. As such, the *Willogoleche Wind Farm Construction and Operational Environmental Management Plan* (COEMP) (EBS Ecology 2017) was prepared and implemented, and after construction works were completed, the COEMP was revised to the *Willogoleche Wind Farm Operational Environmental Management Plan* (OEMP) (EBS Ecology 2019a). A summary of important dates and annual monitoring completed to date is provided in **Appendix 1**.

Figure 2.1 Overview of Willogoleche Wind Farm, Including the Seven Patches of INTG



Willogoleche Wind Farm project boundary
Wind turbine
Met mast
Windfarm infrastructure
Electranet Interconnect

Iron-grass Natural Temperate Grassland of South Australia
Category B
Category C
Approximate extent of Lomandra Grassland



31500_R04_Willo_LomGrasslandMonitoring_v3 (31500_R04_0101_WindFarmLayout)

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Data Source: Umwelt (2025), ESRI (2025), DEW (2022), DIT (2022)

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GDA 1994 MGA Zone 54

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2.3 INTG and OEMP

The objectives of the OEMP are to minimise the potential impacts of operation of the WWF on the INTG patches by:

- Identifying potential impacts to the INTG
- Establishing management actions to avoid, minimise and/or mitigate the impacts
- Monitoring and auditing to detect attributable impacts
- Implementing contingency responses and corrective actions where required.

The OEMP acknowledges that there is potential for environmental impacts, particularly to the INTG patches, during operation of the WWF. However, as the site is no longer subject to construction activities, the likelihood and risk of impact is significantly less than during construction works. In assessing the potential environmental impacts, particularly to the Iron-Grass NTG TEC, associated with operation of the WWF, the following has been taken into consideration:

- The site of the WWF comprises farm land predominantly used for sheep grazing and cereal cropping
- The site contains numerous natural drainage lines, some of which have been crossed for access purposes
- Operation activities are limited to the use of access tracks and hard stands at the base of each turbine.

The potential environmental impacts, particularly to the INTG, during operation of the WWF include:

- Introduction of new weeds and/or increase in weed occurrence
- Increase in feral animals
- Soil erosion and sedimentation
- Fire.

Threats to INTG that are not a considered a direct or indirect impact from WWF operation or construction include inappropriate grazing regimes, dry climatic conditions (drought), litter accumulation, and grazing by native herbivores. Threats may lead to a loss of INTG patch size, increased patchiness of INTG, an undesirable increase of dominant species (e.g., native grasses) and loss of more vulnerable and herbaceous species within INTG.

Within the OEMP, the responsibility for management measures to avoid and/or minimise impacts to INTG within the WWF is shared between ENGIE and the landholders. For example, while the landholder is responsible for management of weeds, feral animals and grazing, ENGIE is responsible for management of erosion and sediment, and the INTG / Lomandra Grassland Monitoring program, which as stated previously, is to be implemented annually during construction and annually during the first five years post construction (i.e. during operation), to monitor for potential impacts and ensure the INTG is not reducing in condition/quality. After this timeframe, the monitoring program and frequency will be reviewed and modified subject to approval by the Department.

2.3.1 INTG Monitoring Indicators

The OEMP outlines that the seven patches of INTG within the WWF will be monitored for potential impacts from operation of the wind farm and to ensure they are not reducing in condition / quality. The OEMP outlines indicators for monitoring of the INTG using metrics such as:

- Grassland health (i.e., percent (%) dead material, regeneration)
- Dominant species cover and abundance
- Vegetation composition (i.e., plant species diversity)
- Seedling recruitment and regeneration
- Soil surface condition (i.e., bare ground, cryptogamic crust).

As such, these indicators have formed the basis of the Lomandra Grassland Monitoring program, which has been further developed over time. Refer to **Section 3.0** for more detail on the methodology implemented during the Lomandra Grassland Monitoring program.

2.4 Climate

Climate in the Mid North region where the WWF and offset area are located, consists of mild winters and hot summers, with rain occurring predominantly in the winter months (NY NRM 2018).

Monthly rainfall data for the period of November 2016 (approximately two years prior to the baseline Offset Area monitoring survey in November 2018) through to the end of October 2024, is presented in **Figure 2.2**. Rainfall data from November 2016 until January 2024 has been obtained from the Bureau of Meteorology (BOM) Hallett (Lorraine) weather station (#21024), which is located approximately 7 km west-south-west of the southern extent of the WWF and offset area (BOM 2025a). However, as climate data for the Hallett (Lorraine) weather station is not yet available past January 2024, rainfall data for February to October 2024 has been sourced from the BOM Yongala (#019062) weather station (BOM 2025b).

Average annual rainfall at the Hallett (Lorraine) weather station is 467.2 mm (BOM 2025a). Below average annual rainfall occurred in 2017, 2018 (when the baseline assessment was undertaken) and 2019. Above average annual rainfall occurred in 2020, 2021 and 2022, while 2023 and 2024 (until the time of the Offset Area monitoring survey) had below average rainfall.

Rainfall in the 12 months preceding the 2024 monitoring survey totalled 228 mm. The months of November 2023 to January 2024 experienced slightly higher than average monthly rainfall. However, each month from February 2024 up to the monitoring survey in October 2024 experienced rainfall much lower than average.

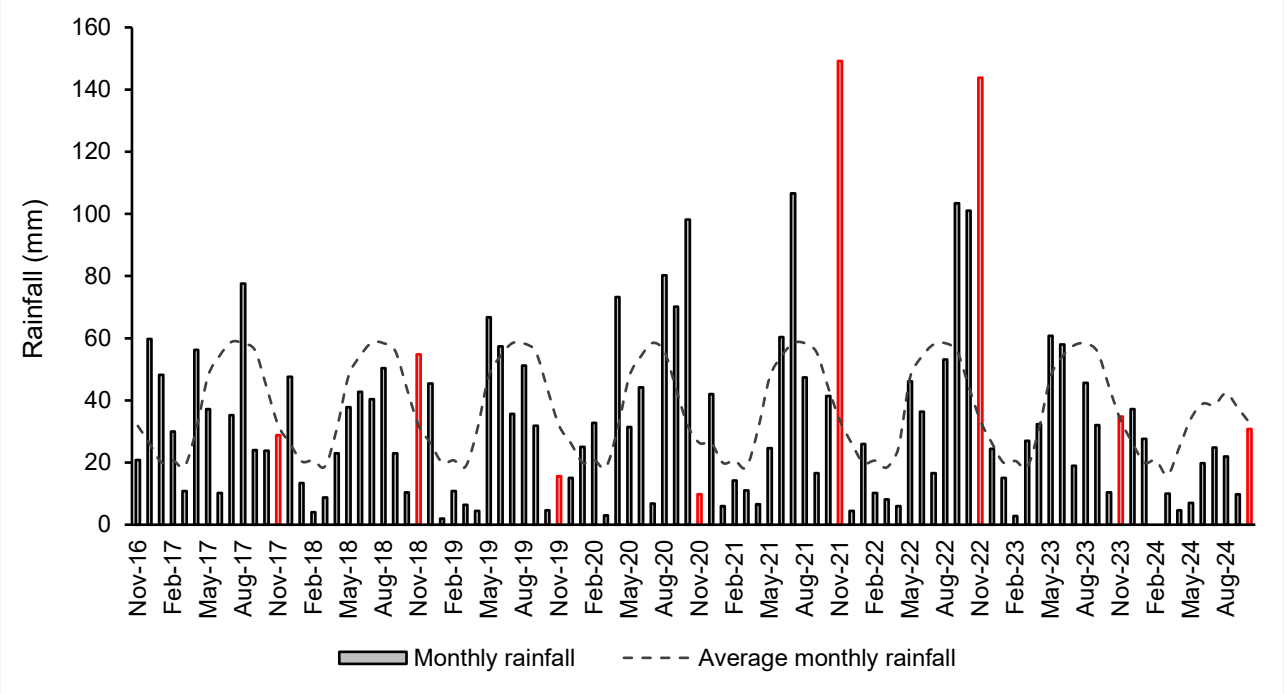


Figure 2.2 Monthly Rainfall Data for November 2016 to October 2024 (with Monitoring Survey Periods Highlighted in Red)

Source: BOM Hallett (Lorraine) weather station # 21024 and Yongala weather station (#019062) (BOM 2025a; 2025b).

3.0 Methodology

The 2024 Lomandra Grassland Monitoring involved data collection along a 50 m monitoring transect, together with a ramble survey, within each previously established Assessment Site, as explained below. The field survey work was undertaken from 21 to 23 October 2024 by Umwelt Ecologist N. Piscioneri and Senior Environmental Consultant E. Tremain.

3.1 Assessment Sites

Seven Assessment Sites, one within each patch of INTG, were surveyed. Each Assessment Site consists of a 50 m long monitoring transect established during the initial Lomandra Grassland Monitoring event in 2017, and 25 m either side of the monitoring transect, creating a 50 m x 50 m (0.25 ha) 'Assessment Site'.

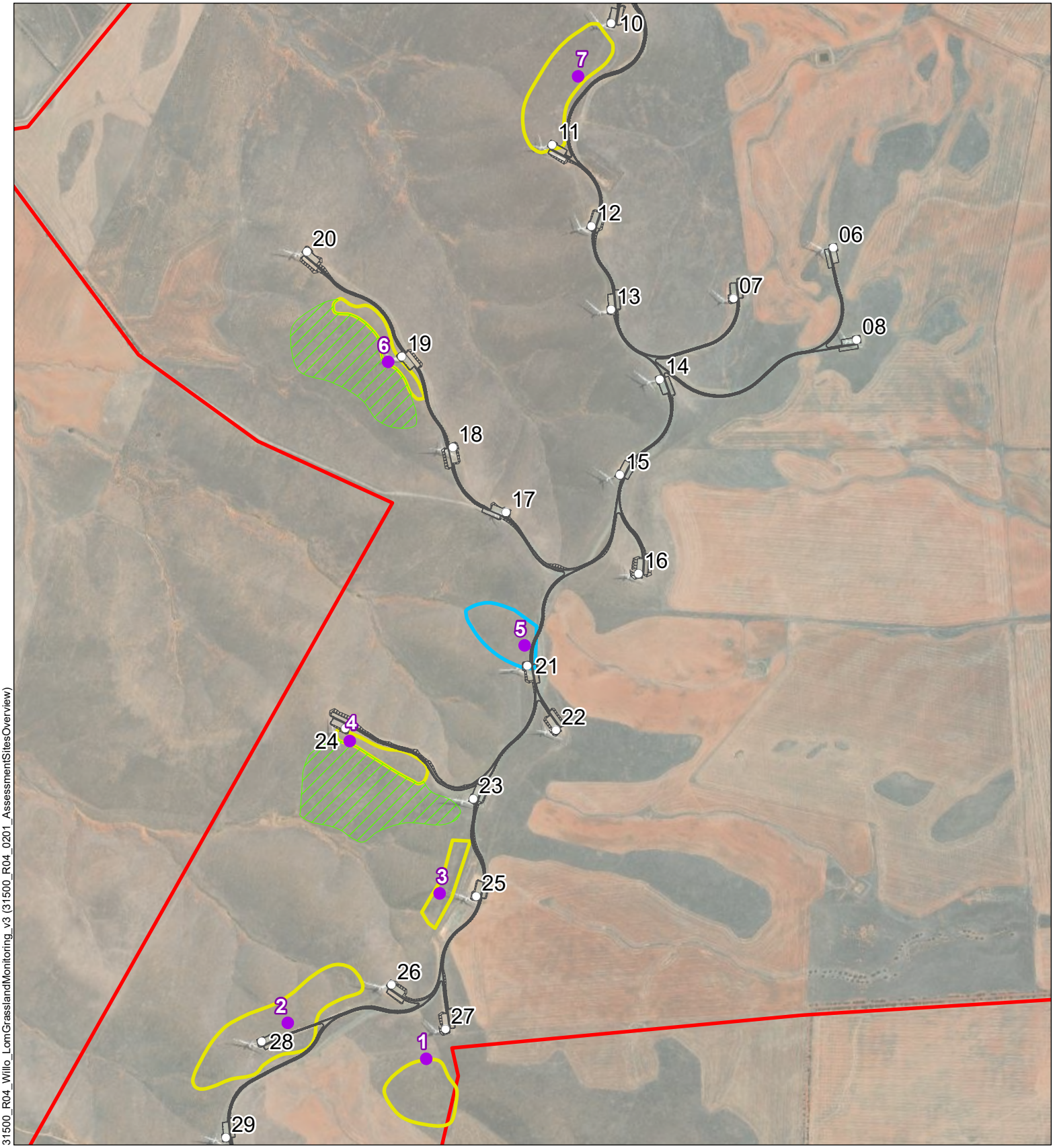
The location of each Assessment Site is shown in **Figure 3.1** and described in **Table 3.1**, along with the Condition Class of the INTG TEC patch it is located within. Refer to **Appendix 2** for more detailed maps showing the location of each Assessment Site, including the 50 m long monitoring transects.

Table 3.1 Assessment Site Location Details and INTG TEC Condition Class (As Assessed in 2010)

Assessment Site	Location Details	INTG TEC Condition Class
1	Approximately 80 m south-west of WTG 27	Class B
2	Approximately 30 m north-east of WTG 28	Class B
3	Approximately 80 m west of WTG 25	Class B
4	Approximately 20 m south of WTG 24	Class B
5	Approximately 50 m north of WTG 21 (but adjacent access track)	Class C
6	Approximately 10 m west of WTG 19	Class B
7	Approximately 180 m south-west of WTG 10 (but 20 m west of access track)	Class B

Photographs looking along each monitoring transect were taken at the start (0 m; eastern end) and end point (50 m; western end) and are provided in **Appendix 3**, alongside photographs taken during previous Lomandra Grassland Monitoring events for visual comparison. Other photographs, for example of threatened flora species, were taken opportunistically.

Figure 3.1 Overview of Lomandra Grassland Monitoring Sites



Willogoleche Wind Farm project boundary

Wind turbine

Windfarm infrastructure

Lomandra Grassland Monitoring Site

Iron-grass Natural Temperate Grassland of South Australia

Category B

Category C

Approximate extent of Lomandra Grassland



31500_R04_Willo_LomGrasslandMonitoring_v3 (31500_R04_0201_AssessmentSitesOverview)

umwelt Environmental & Social Consultants

Data Source: Umwelt (2025), ESRI (2025), DEW (2022), DIT (2022)

Date Exported: 9/07/2025 12:07 PM
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GDA 1994 MGA Zone 54

N

0 250 500 m

3.2 Point-centred Quarter Method (PCQM)

In 2024, the PCQM methodology used in previous monitoring events was repeated. Methodology was slightly altered in 2021 based on feedback from the 2020 survey results. PCQM involves surveying ten sample points along a 50 m transect, assessing perennial plant parameters at 5 m intervals (starting at 0 m). Each sample point is further divided into four quarters by placing a range pole (or similar) perpendicular to the transect line, then the distance from the sample point to the nearest native perennial plant in each of the four quarters is measured and recorded (**Figure 3.2**), resulting in assessment of 40 perennial plants per transect (Tongway & Hindley 2004). The PCQM is used instead of other methods, for example tussock counts in 1 m x 1 m quadrats, due to the number of small grasses (i.e. *Rytidosperma* spp.) making counts very time consuming.

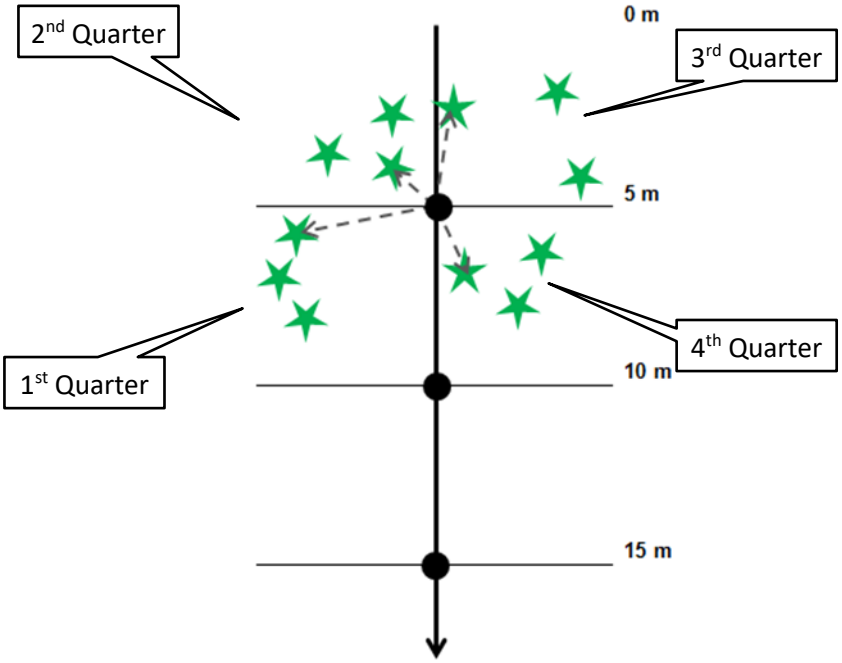


Figure 3.2 The Point-centred Quarter Method Involves Collecting Data on the Closest Native Perennial Plant (Indicated by a Green Star) in Four Quarters at Each Sample Point

(Image adjusted from Tongway & Hindley 2004.)

Consistent with measurements taken since 2021, measurements in 2024 were limited to the four most dominant perennial grass species to enable more robust analysis.

At each sample point along the transect, the four distance measures are averaged to represent the distance (d) at each sample point, and then these distances are averaged to calculate the average distance of all sample points on a transect.

In addition to the species, the canopy width (spread) in cm, plant height(cm) (to the top of the leaves) and basal width (cm) (rootstock width of tussock at the ground) of each of the 40 perennial plants is recorded (Tongway & Hindley 2004).

Previously, the PCQM data has been used to calculate percentage cover and volume of perennial plants in metres cubed (m^3). However, given that canopy width is highly variable dependent on seasonal conditions and is sensitive to grazing, it is considered that trends may be more evident and meaningful if basal area (m^2) is used, which also provides an indication of land function, and influences the relative importance of a species within an ecosystem. A summary of data collected via PCQM in 2024 and how the data was then analysed, along with the purpose of data collection, desired and undesired data trends for grassland health, potential data limitations and recommendations for future monitoring, is provided in **Table 3.2**.

From the data collected the following indices can be derived:

1. The density of plants per unit area for each species.
2. Basal cover per unit area (m^2/ha).
3. Importance value of each species, where:
    a. *Relative density*: percentage of points a species is recorded at (maximum n = 40 per site).
    b. *Relative cover*: basal area as a percentage of all species recorded at the site.
    c. *Relative frequency*: normalised absolute frequency which is the percentage of sample points at which a species occurs (maximum n = 10) (may total over 100 given that up to four species may be present at each sample point for an absolute frequency of 400).
    d. *Relative importance*: Gives weight to three factors of relative density, cover, and frequency. This means that plants with a small basal area can be dominant only if there are enough of them widely distributed across the transect.

Table 3.2 Data Collected Via PCQM in 2024, Analysis Approaches, Purpose of Data Collection, Desired Data Trends and Usefulness of the Data

Parameter	Data Collected	Analysis	Purpose	Desired Trend	Undesirable Trend	Comment	Recommendation
Cover (m^2)	Basal width	PCQM	Determine basal cover (m^2) of perennial plants.	Stable or slight increase.	Significant increase or decrease.	Based on several years of monitoring, it was deemed that PCQM had some limitations. Therefore in 2019, the method was supplemented with additional data collection methods. In 2020 these PCQM measures were reviewed again to determine a more appropriate and indicative method moving forward, and in the 2021 survey basal width and PPH were used as the primary indicator of plant health for this survey method.	**Continue** to monitor using PCQM. However, supplement with collecting total percentage native cover data (as undertaken in 2019). E.g. measure using % native cover in 1 m x 1 m quadrats. In 2020 basal width was used to calculate cover (m^2) to provide information on maturity of perennial plants, and the actual ground cover, rather than projected canopy cover which is highly variable depending on seasonal conditions and/or grazing.
Volume (m^3)	Canopy width breadth, height and canopy density (%)	PCQM	Determine volume of vegetation in metres cubed (m3).	Ideally stable or increase, but data is not meaningful.	Ideally stable or increase.		No longer analysed as part of this report.
Density of Perennial Plants per ha (PPH)	Distance from PCQM centre point	PCQM	Determine the number of perennial plants per hectare.	Stable or slight increase.	Significant increase or decrease.		**Continue** to monitor using PCQM. Counts of total number of grass tussocks per 1 m x 1 m quadrat was collected at three sites to enable a comparison with PCQM data. Only the four most dominant or important indicator species to measure were included in the PCMQ in 2021 (Lomandra, Aristida, Austrostipa spp., Rytidosperma spp.)

Parameter	Data Collected	Analysis	Purpose	Desired Trend	Undesirable Trend	Comment	Recommendation
% Dead material	Percentage of green material on tussocks (canopy density)	Average % dead material	Determine tussock dieback, a useful indicator in grassland health.	Stable or decreasing	Increasing	Potentially useful indicator of plant health.	**Continue** to measure percentage dead material of 40 plants per transect.
Canopy size of tussock (in cm)	Canopy width	Average canopy width	Aims to detect changes on the canopy size of tussocks (will detect grazing pressure and seasonal conditions).	Stable or increasing size	Decreasing	Potentially useful indicator of plant size.	No longer analysed as part of this report. Height is deemed a more robust and suitable indicator of grazing pressure. Basal width is deemed a more suitable indicator of cover.
Height of plant (in cm)	Height of plant	Average height	Aims to detect changes in height – useful for determining grazing pressure.	Stable or increasing height	Decreasing	Valuable to collect data on plant size trends. Height is deemed a more robust and suitable indicator of grazing pressure. Basal width is deemed a more suitable indicator of cover.	**Continue** to measure plant height of 40 plants per transect (from ground to tip of leaves, not seed/flower head).

3.3 Quadrat Sampling of Grassland Health Indicators

Following on from the methods introduced in 2019 and 2021, the 2024 survey measured the following five grassland health indicator attributes (life forms), as well as the presence or absence of *Lomandra* spp., in each of the ten 1 m x 1 m quadrats indicated in **Figure 3.3** at each Assessment Site, to further inform trends in grassland condition and health within the WWF:

- Percentage (%) cryptogams (including on rock surfaces)
- % litter (an estimation of all annual exotic plant material (dead or alive) and dry debris as a measure of residual dry biomass)
- % bare ground
- % total native cover
- % rock
- *Lomandra* spp. presence or absence (added to methodology in 2021).

Lomandra is a long-lived tussock with deep roots which hold soils together, also acting as a seed trap and providing protection from heavy grazing due to their unpalatability (NRMDB 2019). Based on recommendations of the 2020 report, the 2021 survey added a frequency score for *Lomandra* ssp. to the 1 m x 1 m quadrat sampling method to gain a better understanding of its distribution across each site and provide a comparison for the PCQM.

The following three grassland health indicator attributes are compared to the unofficial benchmark values for Grasslands in the Northern Lofty botanical region, which are set out within the *Bushland condition monitoring manual: Northern Agricultural & Yorke Peninsula Regions* (Pedler et al. 2007):

- (%) cryptogams (benchmark of ~50%)
- % litter (benchmark of <25%)
- % bare ground (benchmark of <5%).

An overview of the purpose of the data collected the desired and undesired trends, comments and recommendations for future monitoring are provided in **Table 3.3**.

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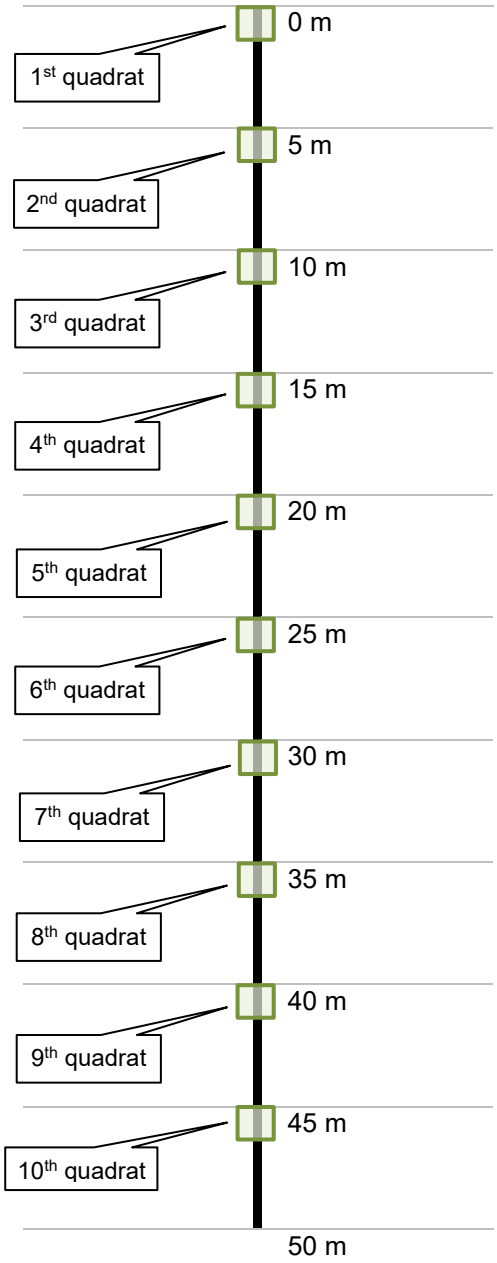


Figure 3.3 Schematic of a 50 m Long Transect with Ten 1 m² Quadrats, Surveyed at 5 m Intervals (Not to Scale)

Table 3.3 Grassland Health Indicator Attributes, Desired and Undesired Trends, Comments and Recommendations

Attribute	Purpose	Desired Trend	Undesirable Trend	Comments / Recommendation
% cryptogams	Presence of cryptogams indicates soil health, stability and nutrient cycling.	Increasing/ benchmark	Decreasing The unofficial benchmark values for cryptogams (with moss and lichen cover) comprises up to 50% for Grasslands in the Northern Lofty botanical region (Pedler, Croft & Milne, 2007).	Continue to monitor.
% litter including exotic annual grass (the majority of litter)	Will monitor percentage of the site covered in dead annual grass material which indicates a high % of weeds, some loss of patchiness and may inhibit germination of native species.	Decreasing	Increasing (generally indicates increased weeds in the grassland system).	Continue to monitor.
% bare ground (meaning exposed dirt free of litter, moss, plants (dead or alive), rock or cryptogams)	Will monitor soil disturbance and potential for soil loss or erosion. Can increase due to dry conditions, increased livestock or weed invasion.	Decreasing/ benchmark (native species often germinate in bare ground so some may be desirable).	Increasing. The unofficial benchmark values for % bare ground in Grasslands in the Northern Lofty botanical region is approximately <5% (Pedler, Croft & Milne, 2007).	Continue to monitor.
% total native cover (all perennial and annual species)	Will determine trends in the total native cover and determine if site becomes overgrown or experiences significant losses of vegetation.	Stable or slight increase	Significant increase (loss of patchiness) or significant decrease.	Consider also collecting percentage cover of various life forms (forbs, grasses, shrubs etc.) to better inform cover of different components.
% rock	Data collected to obtain full picture of structural attributes. Rock cover does not need to be collected in future years.	Stable	Significant change.	Monitor as an indicator of observer variability.
Frequency of Lomandra (% of quadrats)	Data collected to supplement PCQM when prevalence of perennial tussock grasses limit recording of Lomandra tussocks.	Stable or increasing	Decreasing frequency.	First data collected in 2021. Continue to monitor.

3.4 Ramble Survey

In addition to the PCQM sampling and grassland health indicator surveys methods outlined above, a ramble survey was undertaken at each Assessment Site, to record any native species present, particularly threatened species and other species that may not have been recorded by the PCQM or Quadrat Sampling (as they were not present within the ten quadrats along the monitoring transect). The ramble survey was undertaken within a 25 m buffer either side of the existing monitoring transect (a total of 0.25 ha).

The data collected is used to determine the condition class of the INTG patches within the WWF, in accordance with *EPBC Act Policy Statement 3.7. Peppermint Box (Eucalyptus odorata) Grassy Woodland of South Australia and Iron-grass Natural Temperate Grassland of South Australia* (DEWR 2007) (**Table 3.4**). Subsequently it was also determined if the condition of INTG has changed, or remained stable since the baseline assessment was undertaken in 2017.

Table 3.4 EPBC INTG TEC Condition Class Criteria (DEWR 2007)

Condition Class	Minimum Size	Diversity of Native Species[1]	No. of Broad-leaved Herbaceous Species[1] in Addition to Identified Disturbance Resistant Species[2]	No. of Perennial Grass Species[1] (Excluding Lomandra)	Tussock count[3] (Including Lomandra)
Listed ecological community					
A	0.1 ha	>30	≥10	>5	1/m
B	0.25 ha	>15	≥3	>4	1/m
Degraded patches amenable to rehabilitation					
C	No minimum	>5	No minimum	>1	No minimum

1: As measured in a 50 x 50 m quadrat.

2: Disturbance resistant species: *Ptilotus spathulatus* forma *spathulatus*, *Sida corrugata*, *Oxalis perennans*, *Convolvulus angustissimus*, *Euphorbia drummondii*, and *Maireana enchylaenoides.*

3: As measured along a 50 m transect.

The ramble survey was first introduced in 2018 in the form of a rapid assessment in the immediate area surrounding the monitoring transect, to understand the Condition Class status of the INTG. From 2019 onwards, the ramble survey was undertaken within a 25 m buffer either side of the monitoring transect, creating a 50 m x 50 m (0.25 ha) area and matching the extent of each Assessment Site (**Appendix 2**).

3.5 Opportunistic Observations

In addition to the PCQM, quadrat sampling and ramble surveys outlined above, any opportunistic observations of, for example, grazing and erosion, when travelling on access tracks between Assessment Sites, were also recorded.

3.6 Data Analysis

As the Lomandra Grassland Monitoring program commenced in 2017, and new methods were added in 2019 and in 2021, there is not enough data to undertake any meaningful statistical analysis. However, descriptive data and any observations of changes or constants between 2017 and 2024 are reported in **Section 4.0** (Results) and **Section 5.0** (Discussion). Statistical analysis could be conducted in future years when there is enough data to ascertain if any changes within the Assessment Sites are occurring over the period of the monitoring program. Analysis tools used for each survey methodology are detailed below.

3.6.1 PCQM

PCQM data was used to calculate the following parameters at each of the Assessment Sites.

Density (Plants/Ha) - Perennial Plants Per Hectare (PPH)

Absolute density of perennial plants is defined as the number of plants per unit area. The distances measured using the PCQM method are used to calculate density without having to count every perennial plant in an area. The estimate works by calculating the mean distance from the centre-point (sum of the nearest point-to-perennial distances in the quarters surveyed, divided by the number of quarters), for each site, and for all sites combined in any given year.

Using this calculation, density per m^2 is calculated using the formula *1/mean density*^{2}. This number can then be extrapolated to calculate the average number of perennial plants per hectare by multiplying the result by 10,000 (as there are 10,000 m^2 in a ha).

Ground cover (m^2/ha) (Basal Width)

Basal cover or basal area is determined by considering the cross-sectional area of plants near the ground, where the diameter at ground level of a perennial plant (such as a grass tussock) is measured and then converted to calculate an approximate area (m^2) or 'footprint' of the individual plant.

In a dry year you might expect to have a higher average basal width, but lower density due to greater distance from the centre point to the nearest plant. Whereas in good seasons, you might expect the opposite, due to a denser coverage of emergent grasses. Plants such as *Lomandra* sp., which are long lived and slow growing, should remain relatively stable in basal width, but may be variable in their relative frequency, appearing less in good years due to the presence of numerous other grasses filling in the space close to the PCQM point.

Plant Height Based on Averages of Plants Measured

Plant height can be used as a 'grazing coefficient' within grasslands, where grasses typically reach a standard range in foliage height (note, measure is of foliage height *not* flowering stalks) regardless of seasonal conditions. When compared with other measures such as basal width, average height of plants can be used to determine if plants are juvenile, mature and / or heavily grazed, and to what extent. Additionally, plant height can be correlated to dominance of species, with the average height of grasses at a site likely to be correlated with a higher abundance of 'tall grasses' or mature Lomandra.

Dead Material (%) Based on Averages of Plants Assessed

The percentage of dead material can be used in combination with other variables to determine the health of plants. For example, where basal width has reduced but spacing of plants has not, a high amount of dead material may represent a decline in health of perennial native grasses. Where basal width is reduced and spacing of plants *has* reduced too, it may be indicative of grass recruitment (i.e., young plants).

Relative Importance

Data from the PCQM can be used to calculate an 'importance value', which provides an indication of distribution of species across the site. The measure weighs up factors of relative density (percentage of sample points species identified at), relative cover (basal area as a percentage of all species recorded at the

site) and relative frequency (a measure of distribution along the transect). The relative importance value can have a maximum of 100 which would represent for example, a single species found at every sample point. The data is analysed using the methods described by K. Mitchell (2015) using data analysis tool 'R', in addition to using standard averages to determine trends.

Relative importance is shown for the four most dominant species found across sites, *Rytidosperma* spp. (Wallaby Grass), *Austrostipa* spp. (Spear-grass), *Aristida* spp. (Wire Grass) and *Lomandra multiflora* ssp. *dura* (Hard Mat-rush).

3.6.2 Quadrat Sampling for Grassland Health Indicators

Percentage cover data is collected for grassland health indicators including litter, bare ground, cryptogams, and rock. Results for each were calculated across each Assessment Site and the WWF based on average values using Microsoft Excel. In 2021, an additional measure was added to supplement PCQM methodology to determine frequency of Lomandra tussocks within the 10 quadrats.

3.6.3 EPBC Condition Ramble Survey

Species recorded during the ramble survey were combined with those recorded during the PCQM and quadrat survey to create a species list for each site. Total species diversity and numbers of species from each life form (non-disturbance resistant broad-leaved herb and native grasses) are tallied and compared with EPBC condition class criteria for INTG (described in **Section 3.4**).

3.7 Limitations

The PCQM is typically used in woodland ecosystems, where trees and shrubs remain relatively stable over time, and as such, the same individuals are measured repeatedly. In grassland environments, perennial plants are subject to considerable seasonal variation, with grass regeneration likely to strongly influence the composition and density estimates, which may not be reflective of a healthy or otherwise ecosystem, but rather of a fluctuating one. The PCQM can be influenced by aggregated (clumped) species and estimates of PPH could vary significantly if the transect is not placed in the exact same location each year, or if seasonal variation resulted in a proliferation of regenerating species. For example, *Lomandra multiflora* ssp. *dura* was not recorded at Site 2 using the PCQM at all in 2017, but in subsequent years was detected at a density of 3062 to 3815 PPH. This does not suggest that it was not present at the Site in 2017, but rather, the methods failed to detect it, either by the placement of the transect, or various seasonal factors that resulted in other species being closer to the centre point. Starting in 2021, additional presence / absence data was collected for Lomandra tussocks in each of the ten 1 m x 1 m quadrats to help counteract this issue and better inform this indicator with more reliability.

Grassland ecosystems are highly variable according to seasonal conditions and therefore visual estimates of cover, which can already be subjective due to observer experience, can cause variation and error in the data which may not necessarily be caused by the effects of WWF or management. Measures that should remain relatively stable over time (such as rock cover), can be used as indicators of this kind of observer variation, and cover of more permanent and or slow growing features, such as cryptogamic crust and *Lomandra* spp. could then be used with more confidence in the long term.

Exotic species that were live were not considered as litter during the 2022 and 2023 survey, although this was the method originally used. The significant presence of live exotic species in 2022 would have distorted final estimations of dry biomass and conflated results. However, this does limit the comparative capabilities of the litter results across the entire monitoring program.

Weed invasion and abundance is not recorded or reported as part of this Lomandra Grassland Monitoring Report but data is collected and reported on in the *Willogoleche Wind Farm Weed Assessment Report 2024* (Umwelt 2025). Weeds are potentially the most likely threat to INTG within the WWF as a direct result of the WWF operation.

4.0 Results

4.1 PCQM Data

The results of the 2024 PCQM data are summarised in **Table 4.1** and **Table 4.2** below. More detailed results are provided in the following subsections (**Section 4.1.1** to **4.1.7**) and are then explained further and discussed in relation to results of previous years in **Section 5.1**.

Table 4.1 Summary of 2024 Lomandra Grassland Monitoring PCQM Results

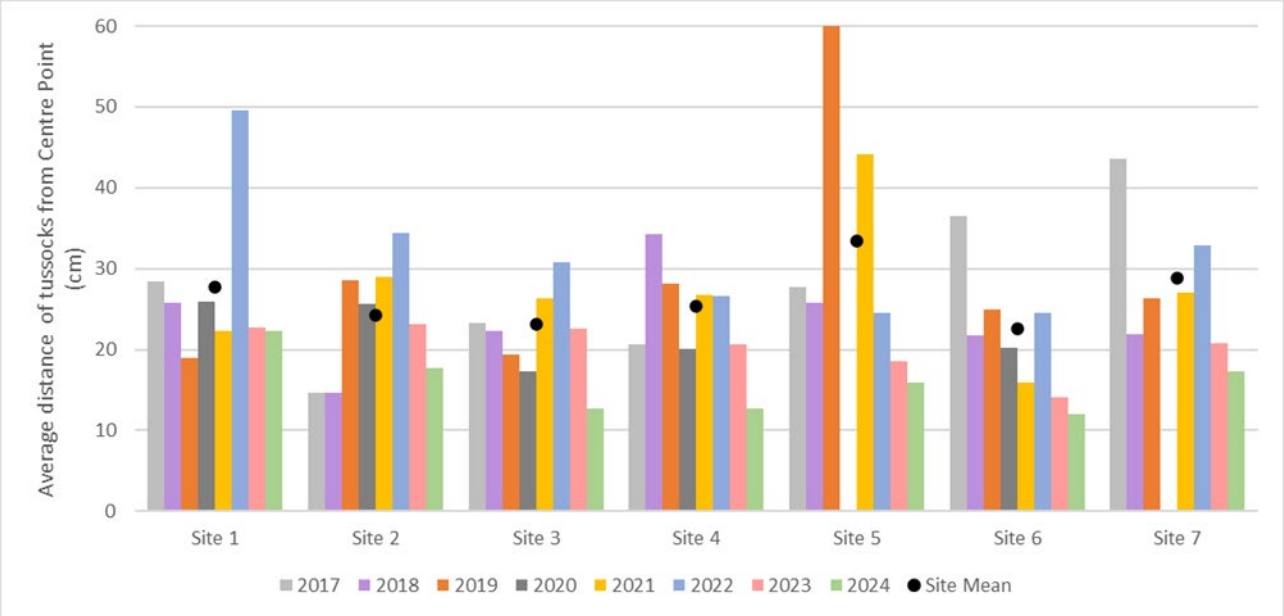
Assessment Site	Perennial Plants per Hectare (PPH)	Spacing of Perennial Plants (cm)	Average Basal Area per Plant (cm^2)	Basal Coverage (m^2/ha)	Average Plant Height (cm)	% Dead Material
1	201,994	22.25	18.74	2,446.42	5.35	38.87
2	316,505	17.775	18.43	537.88	3.8	49.75
3	615,148	12.75	48.75	3,210.64	5.37	49.50
4	615,148	12.75	14.39	640.95	3.67	26.75
5	398,053	15.85	30.24	4,375.04	5.6	32.12
6	688,693	12.05	24.71	1,334.87	3.9	36.00
7	336,063	17.25	33.96	5,008.92	8.27	25.00
Mean	**453,086**	**15.81**	**27.03**	**2,507.82**	**5.14**	**36.86**

Table 4.2 Summary of 2024 Dominant Perennial Grasses and Their Density (Estimated Number of Plants per Hectare) At Each Site, Calculated From PCQM Data

Scientific Name	Common Name	Assessment Site							Mean per ha
		1	2	3	4	5	6	7	
***Aristida* spp.**	Brush-wire Grass	390,625	114,909	250,000	591,716	591,716	-	510,204	408,195
***Austrostipa* spp.**	Spear-grass	143,947	367,309	1,029,196	565,323	356,890	1,643,655	223,841	618,594
***Lomandra* spp.**	Hard Mat-rush	756,144	-	-	-	147,929	189,036	100,000,0	523,277
***Rytidosperma* spp.**	Wallaby Grass	227,699	330,566	645,330	634,736	219,727	655,329	633648	478,148

4.1.1 Spacing of Perennial Plants

The average distance from the PCQM centre point to the nearest tussock for all Assessment Sites (referred to hereafter as 'Sites') in 2024 was 15.81 cm (mean) ± 3.66 cm (standard error of mean) which is the lowest recorded to date. In 2024, the recorded average distance at each site was recorded below each Site's overall mean for all years of monitoring. The largest average distance in 2024 of 22.25 cm was recorded at Site 1, while the shortest average distance of 12.05 cm was recorded at Site 6 (**Graph 4.1**).

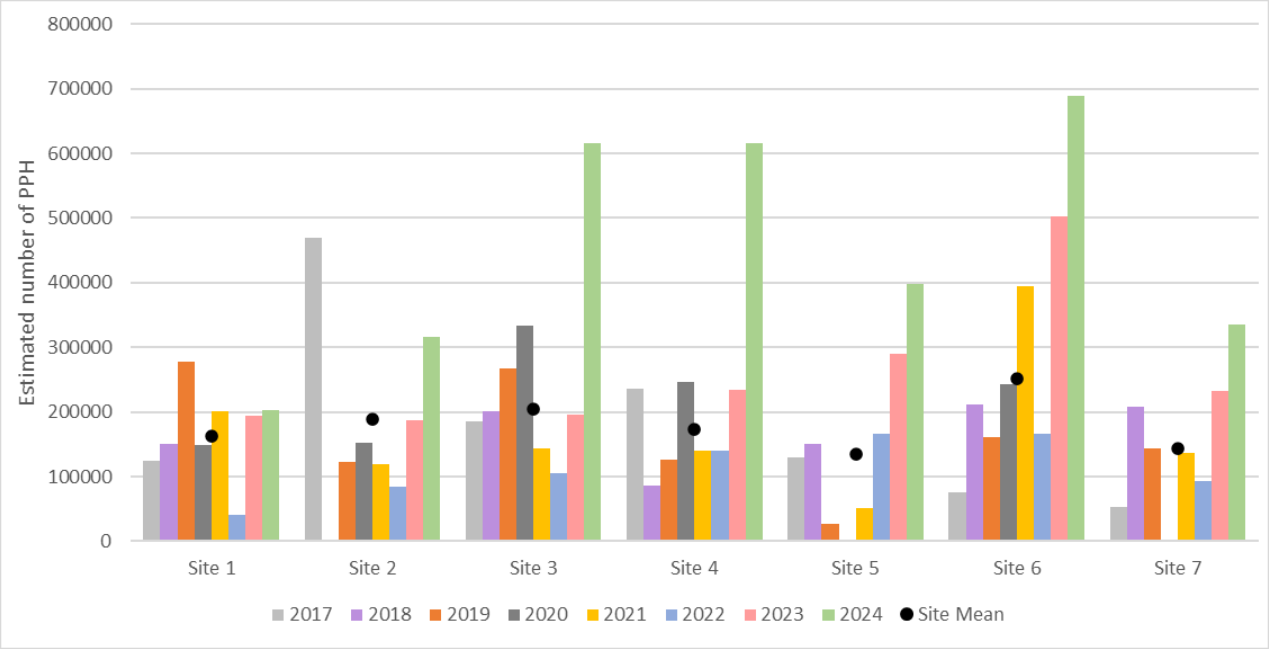


Graph 4.1 Average Distance (cm) of Grass Tussocks From PCQM Centre Point (2017–2024), With Site Mean for All Years

PCQM data was not collected at Site 5 or 7 in 2020 due to covid-19 state-wide lockdown impacting survey.

4.1.2 Perennial Plants Per Hectare (PPH)

In 2024, the mean PPH for all Sites was 453,086 ± 185,500.86 which is the highest recorded to date. The mean PPH in 2024 increased by 190,845 compared to 2023 and 271,226 compared to 2017. Most Sites, apart from Sites 1 and 2, recorded the highest PPH to date in 2024. In 2024, Site 6 recorded the highest mean PHH of 688,693, while Site 1 recorded the lowest mean PPH of 201,994 (**Graph 4.2**).



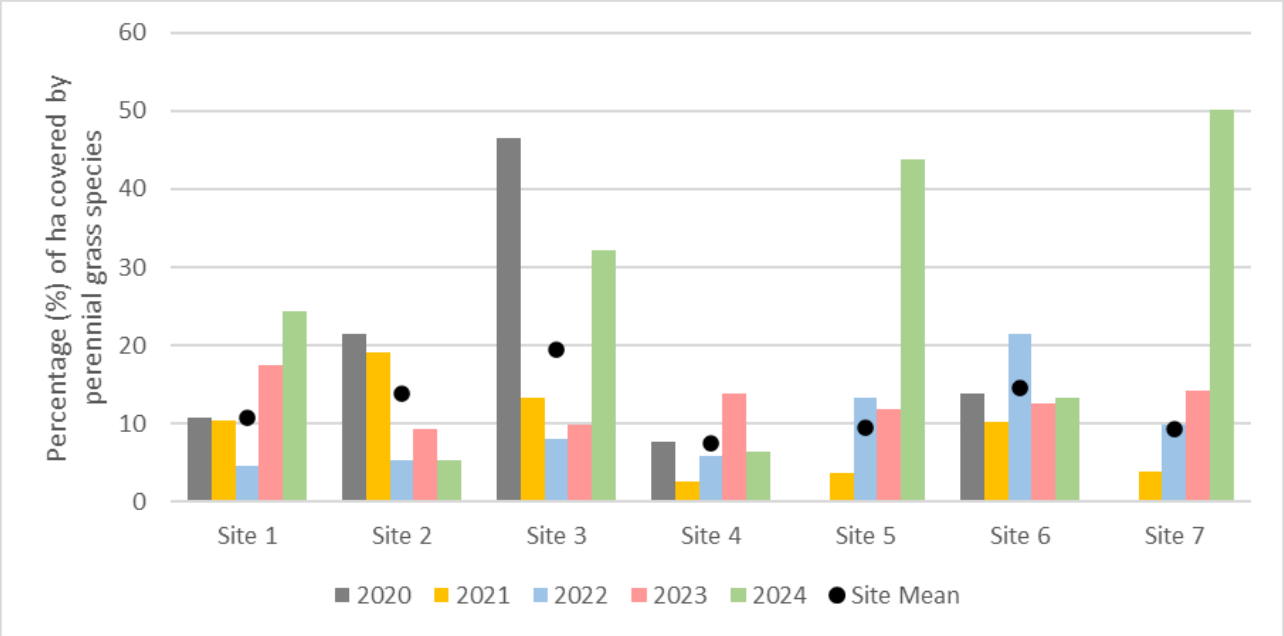
Graph 4.2 PPH at Each Site (2017–2024), With Site Mean for All Years

PCQM data was not collected at Site 5 or 7 in 2020 due to covid-19 state-wide lockdown impacting survey.

4.1.3 Basal Cover

The basal cover of perennial native grasses averaged 25.08% in 2024 (i.e., 25.08% of each hectare is covered by the four dominant perennial grass species across all Sites). Average basal cover in 2024 increased from 12.75% in 2023 and was the highest since basal cover was recorded (2020). Each site recorded a higher average basal cover in 2024 compared to 2023, apart from Site 4 which decreased from 13.94% in 2023 to 6.41% in 2024.

In 2024, the basal cover recorded at Sites varied between 5.38% (Site 2) and 50.09% (Site 7). The Site which recorded the greatest mean cover has differed each year, with Site 7 having the greatest basal cover in 2024, Site 1 in 2023, Site 6 in 2022, Site 2 in 2021 and Site 3 in 2020. In 2024, the average basal coverage for Site 7 has been the highest that has been recorded to date (**Graph 4.3**).



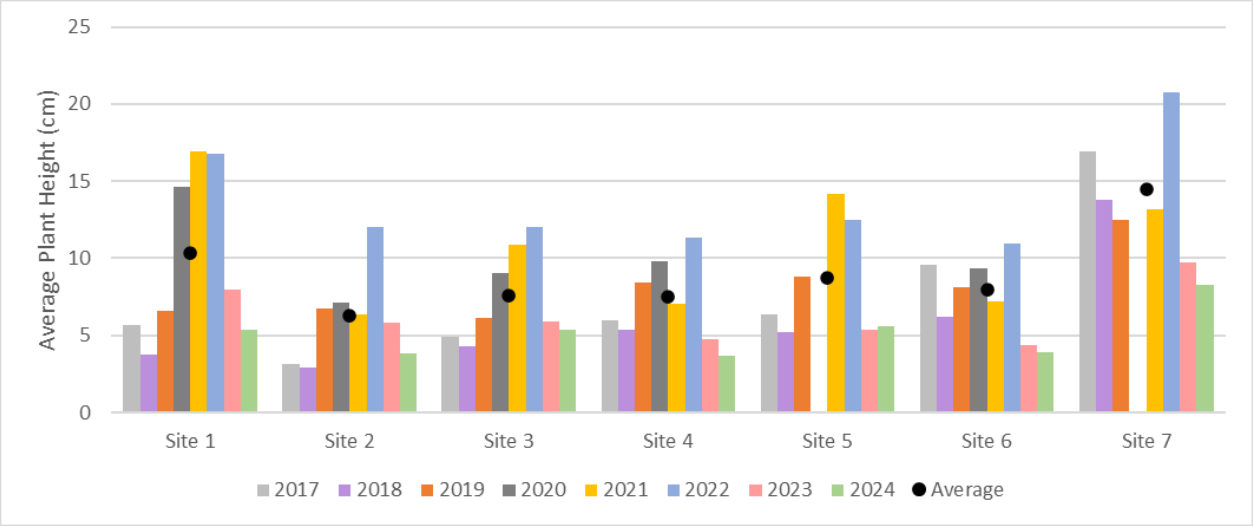
Graph 4.3 Percent (%) Basal Cover of Perennial Plants per Hectare (10,000 m^2) (2020–2024), With Site Mean for All Years

The basal cover measure was added to the methodology in 2020, so there are no results available prior to 2020. PCQM data was not collected at Site 5 or 7 in 2020 due to covid-19 state-wide lockdown impacting survey.

4.1.4 Plant Height

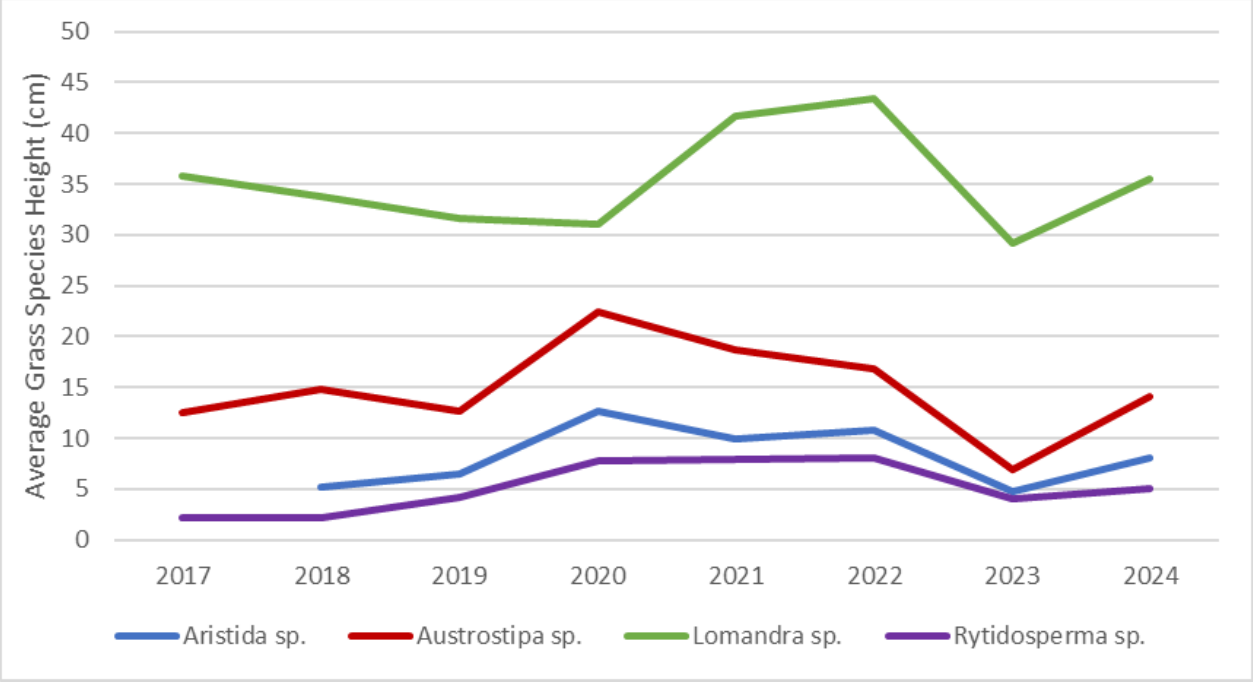
The average perennial plant height of all Sites in 2024 was 5.14 ± 1.61 cm which is lowest to date. The average height in 2024 was 1.14 cm less than the average height in 2023 and 2.36 cm less than the baseline (2017). The lowest average height in 2024 of 3.67 cm was recorded at Site 4, while Site 7 had the highest average height of 8.27 cm. However, both Sites were recorded to have their lowest average height to date along with Site 4 (**Graph 4.4**).

All four dominant grasses were recorded to have an increase in height in 2024 compared to 2023 and the baseline survey (2017) (**Graph 4.5**). However, the height of all species in 2024 was lower than the species mean height across all years.



Graph 4.4 Average Perennial Plant Height at Each Site (2017–2024), With Average for All Years

PCQM data was not collected at Site 5 or 7 in 2020 due to covid-19 state-wide lockdown impacting survey.

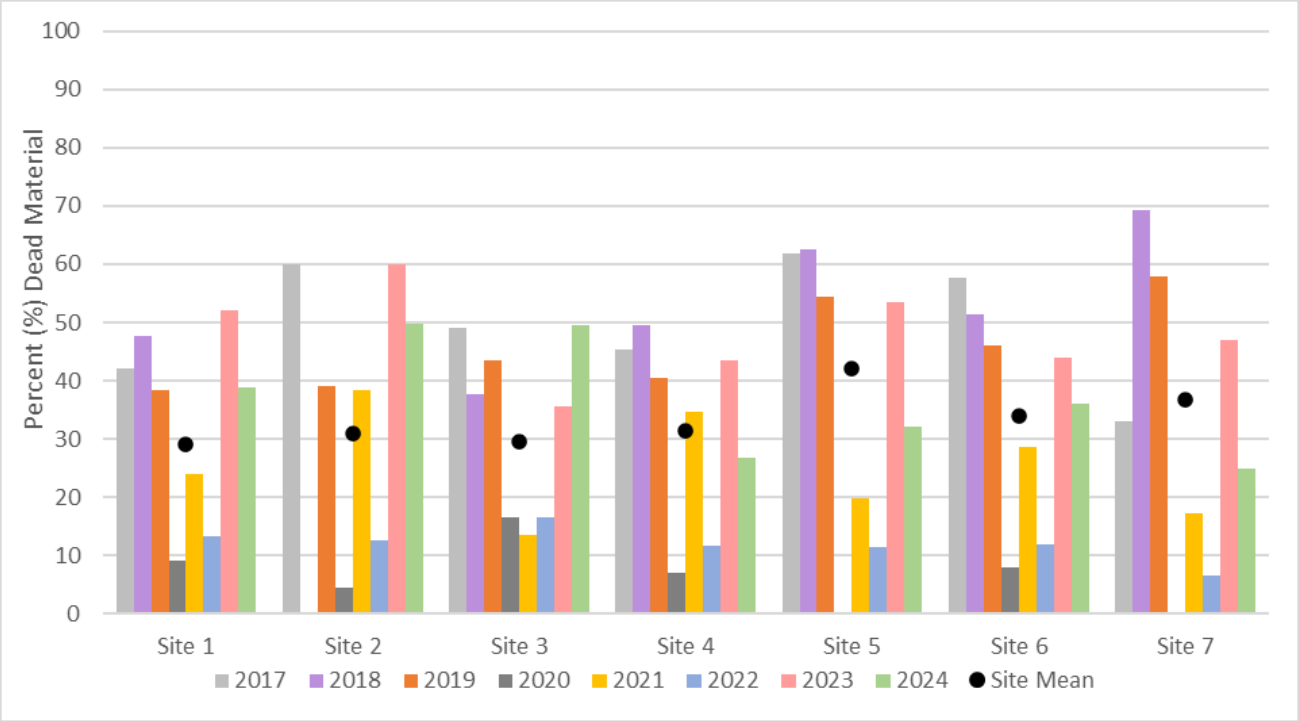


Graph 4.5 Average Perennial Grass Height (Four Most Common Grasses) at All Sites (2017–2024)

4.1.5 Plant Health

The average percentage of dead plant material per perennial plant (i.e. tussock) for 2024 was 36.86 ± 9.97%, which is a decrease from 2023 where the average was 47.93%. The average percentage of dead material has declined since the baseline survey (2017) when the average percentage was 49.86%. At Site 1, 2, 3, and 6 the 2024 average percentage of dead material per tussock is higher than Site mean across all years, which is likely caused by the low averages that were recorded from 2020 to 2022 (**Graph 4.6**).

In 2024, Site 2 had the highest average percentage of dead material with 49.75%, while Site 7 had the lowest at 25%.



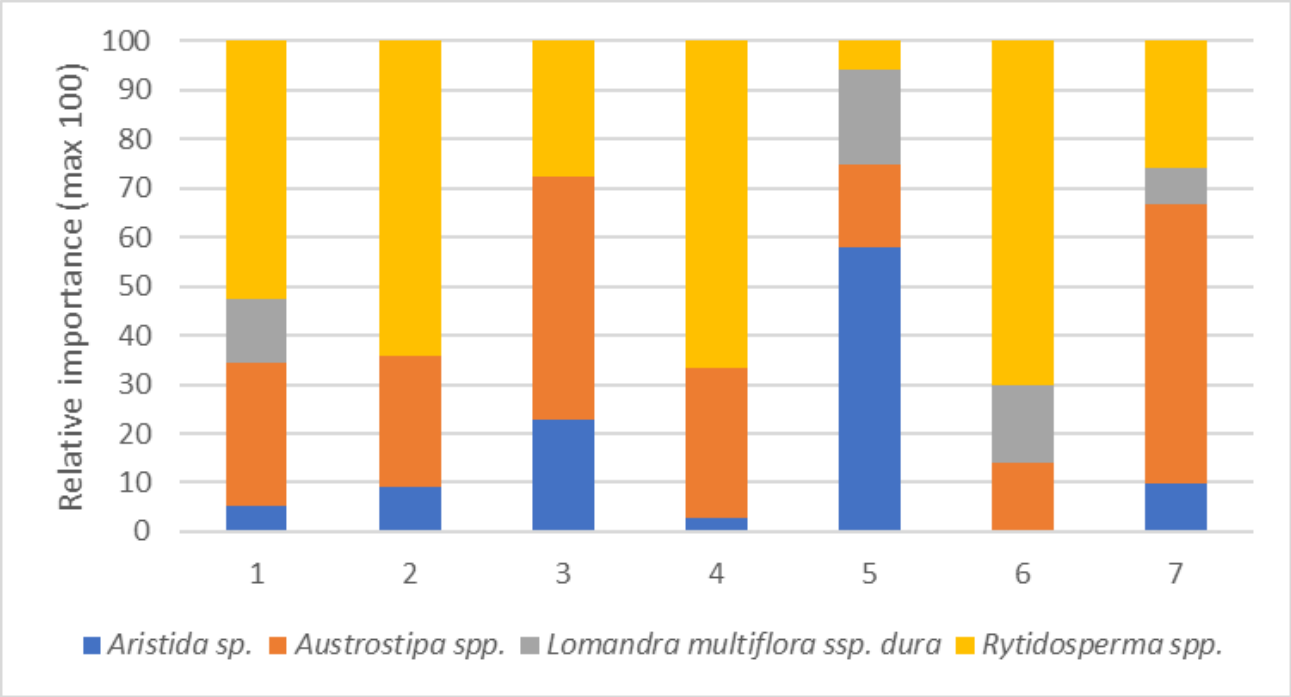
Graph 4.6 Average Percentage of Dead Material per Perennial Plant (2017–2024), With Site Mean for All Years

PCQM data was not collected at Site 5 or 7 in 2020 due to covid-19 state-wide lockdown impacting survey.

4.1.6 Species Composition

Relative importance scores were calculated for each of the four most common grasses measured in 2024. *Rytidosperma* spp. scored consistently highly across most Sites apart from Sites 3, 5 and 7, with an average of 57.38 ± 15.79, with the species being the most dominant at Site 6 (80.63). In comparison, *Austrostipa* spp. and *Aristida* sp. were the most dominant species at Sites 3, 5 and 7, with *Austrostipa* spp. the most dominant at Site 7 (57.08) and *Aristida* sp. the most dominant at Site 5 (57.83). Generally, *Austrostipa* spp. was the second most dominant with an average of 32.02 ± 15.88 across all Sites, followed by *Aristida* sp. with 15.36 ± 20.11, which was not present at Site 6. *Lomandra multiflora* ssp. *dura* was the least dominant across all Sites with an average of 7.86 ± 8.18 and was not present at Sites 2, 3, and 4.

The contribution of each species to the final relative importance score at each Site is shown in **Graph 4.7**.



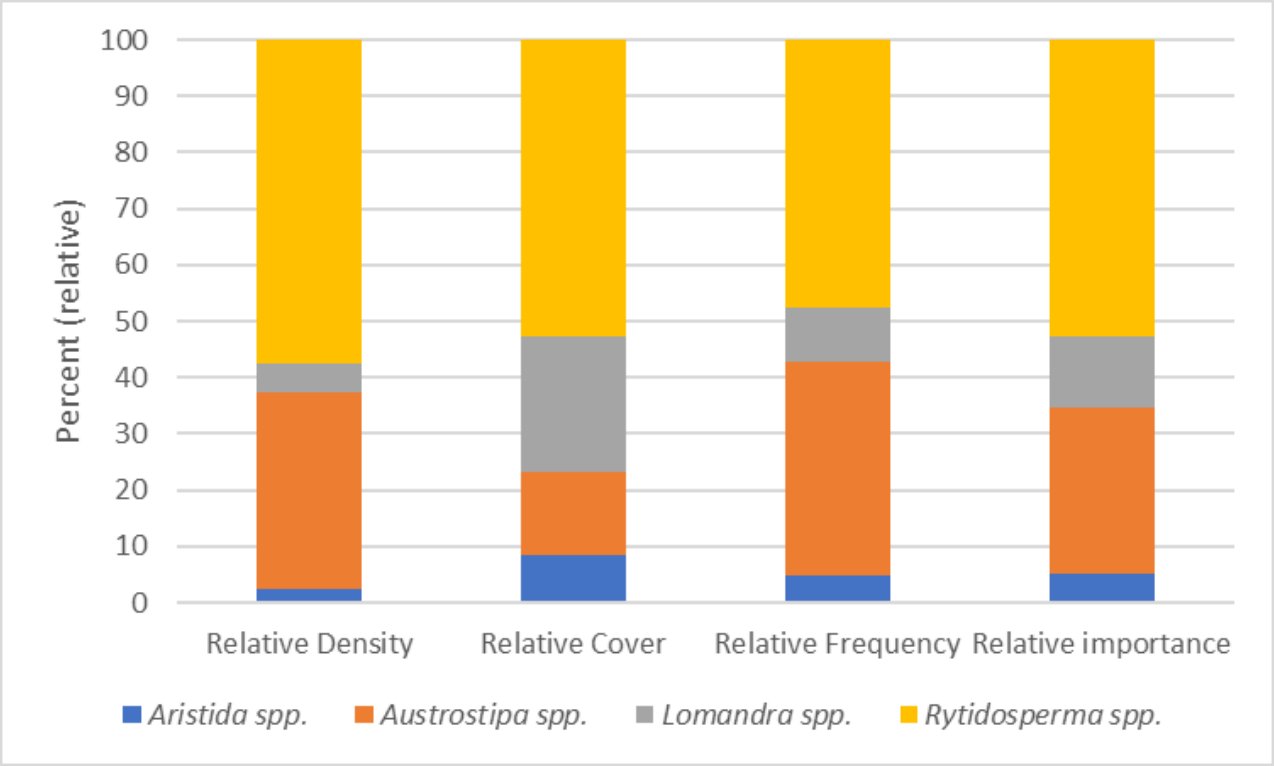
Graph 4.7 Relative Importance Score of the Four Most Common Perennial Species in 2024

4.1.7 Site Summaries

Frequency of occurrence is measured as the number of sample points (max 40) at which a species is recorded. Changes may indicate a change in the prevalence or composition of grass species at a site over time.

Site 1

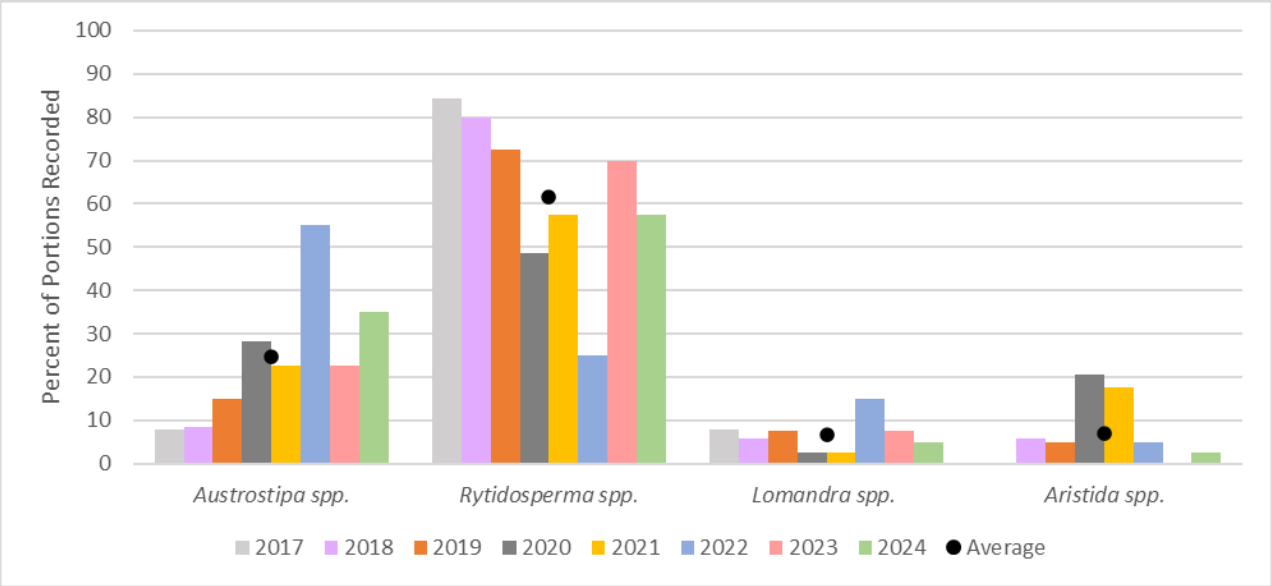
Site 1 had an average density of 37.96 perennial native tussocks per square metre, and 24.46% basal coverage per ha. All four species were recorded via PCQM at Site 1 in 2024, with *Rytidosperma* spp. scoring the greatest relative importance at 52.63%. *Austrostipa* spp. was recorded with the second greatest relative importance at 29.29%, followed by *Lomandra* spp. (12.83%) and *Aristida* sp. (5.25%) (**Graph 4.8**).



Graph 4.8 Relative Density, Cover, Frequency and Importance of Perennial Plants at Site 1 in 2024

Site 1 has shown an increase of *Austrostipa* spp. and Aristida spp. frequency while both the frequency of *Rytidosperma* spp. and *Lomandra* spp. decreased from 2023 to 2024. The frequency trends of the species since the baseline survey shows that *Austrostipa* spp. has been increasing, *Rytidosperma* spp. has been decreasing, and both *Lomandra* spp. and *Aristida* spp. has been remaining level at Site 1 (**Graph 4.9**).

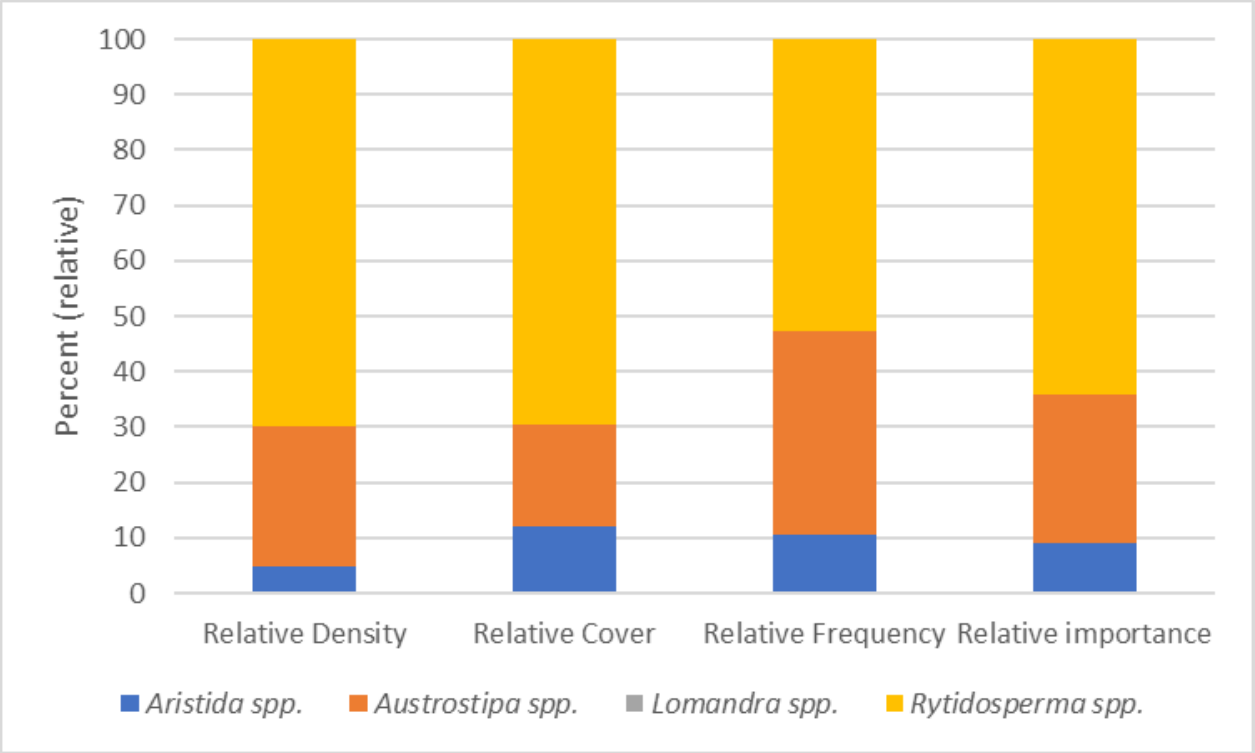
In 2024 Site 1 was observed to be very dry and heavily grazed.



Graph 4.9 Site 1 Frequency of Occurrence (Percent of Quarters Recorded) for 2017–2024, With Average for All Years

Site 2

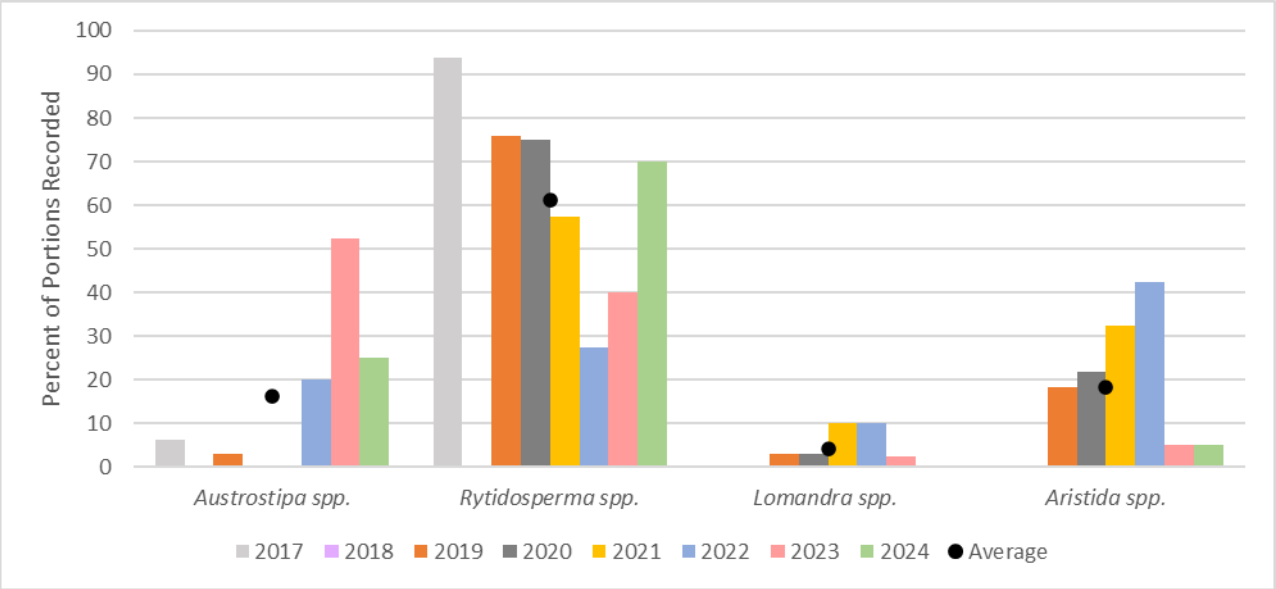
Site 2 had an average density of 27.09 perennial native tussocks per square metre, and 5.38% basal coverage per hectare. Only three perennial native grass species were recorded via PCQM at Site 2 in 2024 as *Lomandra* spp. was not recorded. *Rytidosperma* spp. was found to have the greatest relative importance at 64.06, followed by *Austrostipa* spp. with 26.75 and *Aristida* spp. with 9.19 (**Graph 4.10**).



Graph 4.10 Relative Density, Cover, Frequency and Importance of Perennial Plants at Site 2 in 2024

The frequency of occurrence for *Rytidosperma* spp. has increased at Site 2 in 2024, while it has decreased for *Austrostipa* spp. since 2023. The frequency of occurrence for *Aristida* spp. has remained level in 2024 compared to the previous year (2023). The frequency of occurrence trends at Site 2 since the baseline survey (2017) show that *Austrostipa* spp. has been increasing, *Rytidosperma* spp. has generally been decreasing (but increased again in 2024), *Lomandra* spp. has remained fairly level, and *Aristida* spp. was increasing until 2023 when it decreased (**Graph 4.11**).

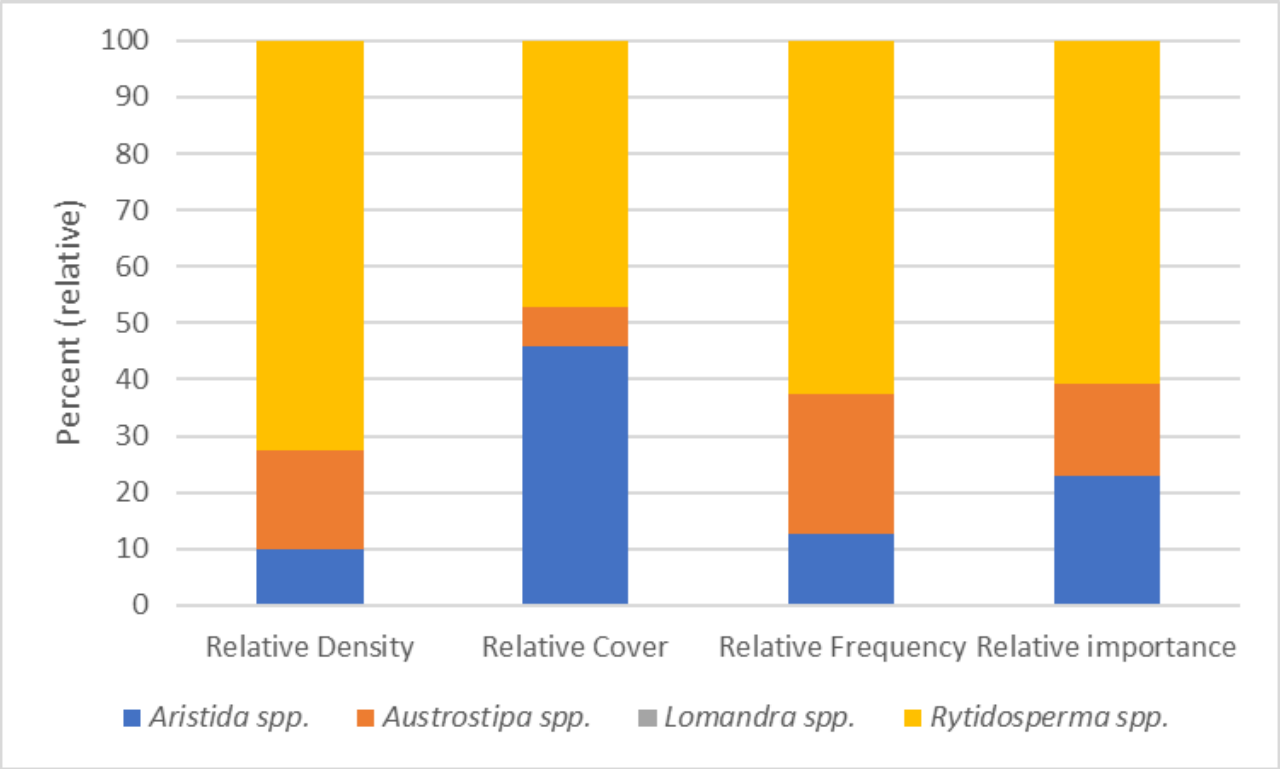
In 2024 Site 2 was observed to be moderately grazed with minimal animal scat. Small amounts of debris (for example plant material litter) was observed to have accumulated throughout the site, potentially as a result of rain and water flow.



Graph 4.11 Site 2 Frequency of Occurrence (Percent of Quarters Recorded) for 2017–2024, With Average for All Years

Site 3

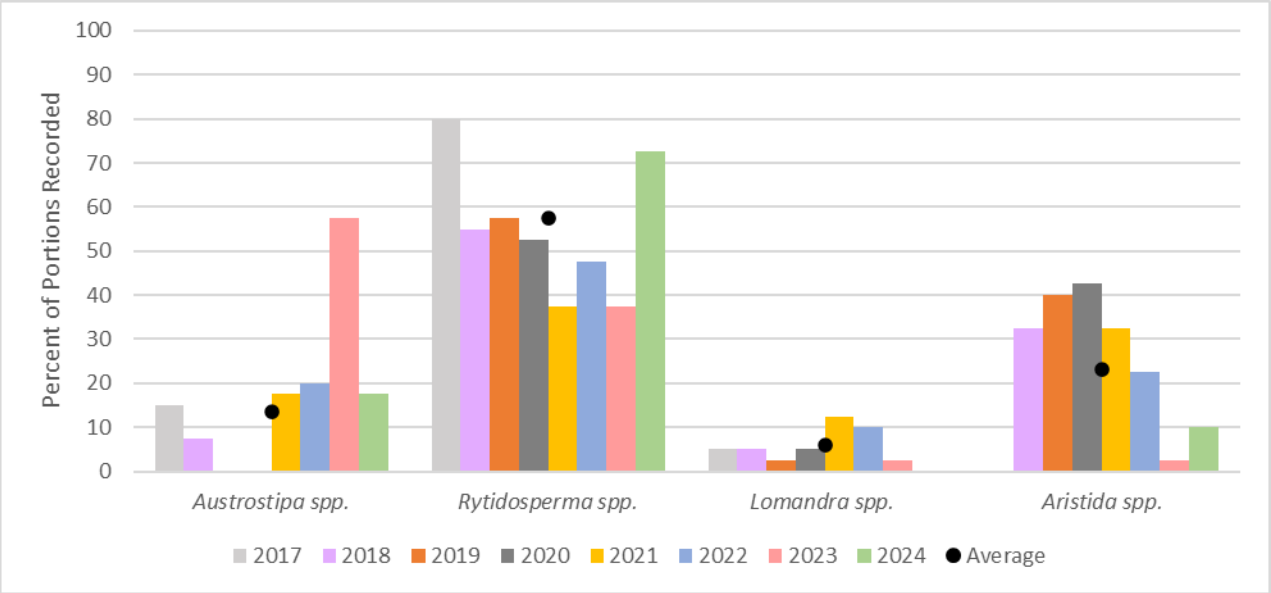
Site 3 had an average density of 64.15 perennial native tussocks per square metre, and 32.11% basal coverage per hectare. Only three species were recorded via PCQM at Site 3 in 2024 as *Lomandra* spp. was not recorded. The relative importance shows that *Rytidosperma* spp. (60.07) was the most dominant species, followed by *Aristida* spp. (22.82) and *Austrostipa* spp. (16.47). *Aristida* spp. had the highest relative cover despite having the lowest density and frequency of the three species (**Graph 4.12**).



Graph 4.12 Relative Density, Cover, Frequency and Importance of Perennial Plants at Site 3 in 2024

The frequency of occurrence for *Rytidosperma* spp. has increased at Site 3 in 2024, while it has decreased for *Austrostipa* spp. and *Aristida* spp. since 2023. The frequency of occurrence trends since the baseline survey (2017) shows that *Rytidosperma* spp. and *Aristida* spp. have been decreasing while *Austrostipa* spp. and *Lomandra* spp. have remained level (**Graph 4.13**).

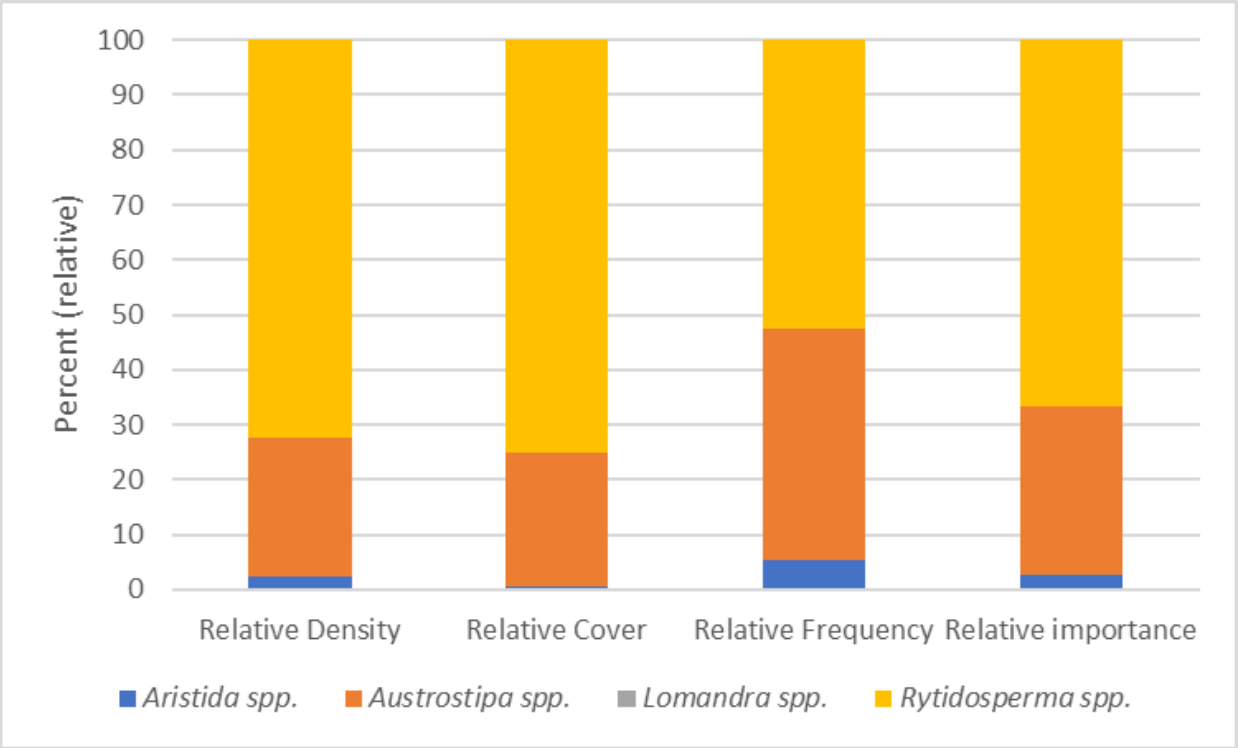
Site 3 is subject to significant edge effects due to the presence of a fence line and was observed to be very dry and heavily grazed in 2024.



Graph 4.13 Site 3 Frequency of Occurrence (Percent of Quarters Recorded) for 2017–2024, With Average for All Years

Site 4

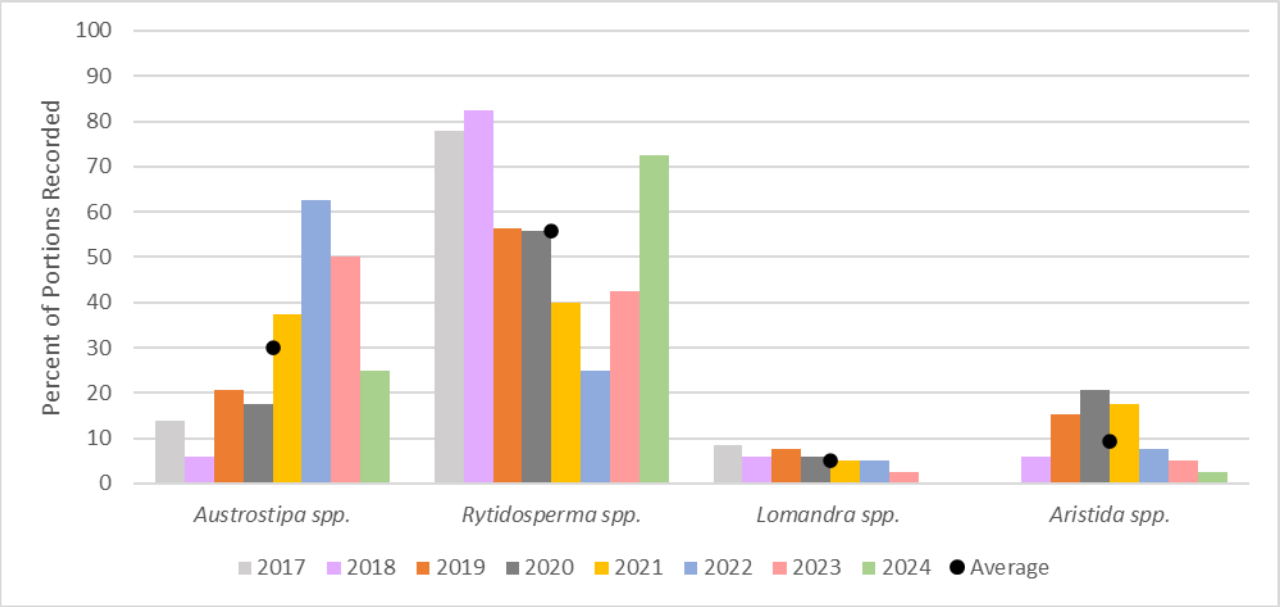
Site 4 had an average density of 59.73 perennial native tussocks per square metre, and 6.41% basal coverage per hectare. Only three perennial grass species were recorded via PCQM at Site 4 in 2024 as *Lomandra* spp. was not recorded. *Rytidosperma* spp. had the greatest relative importance with 66.77, followed by *Austrostipa* spp. with 30.46 and *Aristida* spp. with 2.77 (**Graph 4.14**).



Graph 4.14 Relative Density, Cover, Frequency and Importance of Perennial Plants at Site 4 in 2024

The frequency of occurrence for *Rytidosperma* spp. has increased at Site 4, while it has decreased for each of the other perennial species since 2023. Despite the recent frequency of occurrence trends at Site 4, trends since the baseline survey (2017) show that *Rytidosperma* spp. and *Lomandra* spp. have been decreasing, *Austrostipa* spp. has been increasing, and *Aristida* spp. was increasing until 2020 after which it has been decreasing (**Graph 4.15**).

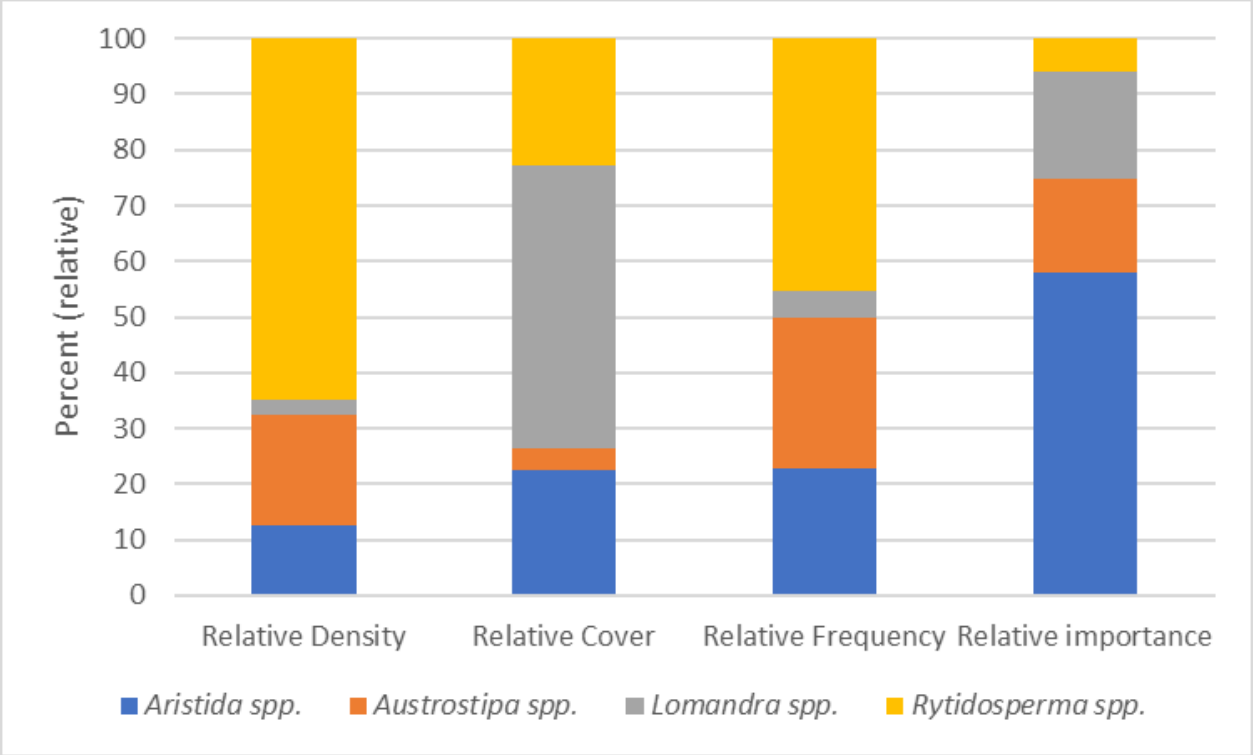
In 2024, Site 4 was observed to be very dry and heavily grazed, with animal scat present but minimal animal tracks.



Graph 4.15 Site 4 Frequency of Occurrence (Percent of Quarters Recorded) for 2017–2024, With Average for All Years

Site 5

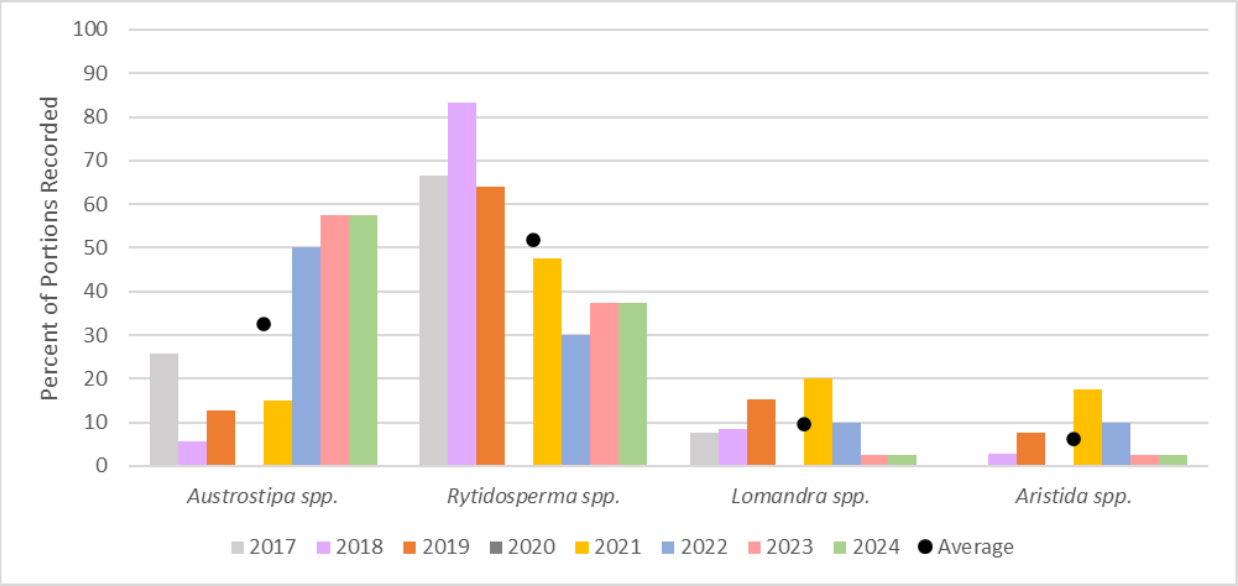
Site 5 had an average density of 36.55 perennial native tussocks per square metre, and 43.75% basal coverage per hectare. All four perennial grass species were recorded via PCQM at Site 5 in 2024, with *Aristida* spp. having the highest relative importance value of 57.83. *Rytidosperma* spp. had the greatest relative density of 65 and frequency of 45.45. The relative importance value for both *Austrostipa* spp. (17) and *Lomandra* spp. (19.31) were similar and *Lomandra* spp. had the greatest relative cover of 50.88 (**Graph 4.16**).



Graph 4.16 Relative Density, Cover, Frequency and Importance of Perennial Plants at Site 5 in 2024

The frequency of occurrence for all four perennial grass species at Site 5 remained level from 2023 to 2024. The trends at Site 5 since the baseline survey (2017) show that *Rytidosperma* spp. has been decreasing, *Austrostipa* spp. has been increasing, and *Aristida* spp. and *Lomandra* spp. have generally remained level (**Graph 4.17**).

In 2024 Site 5 was observed to be very dry and heavily grazed, with sheep scat and tracks present.

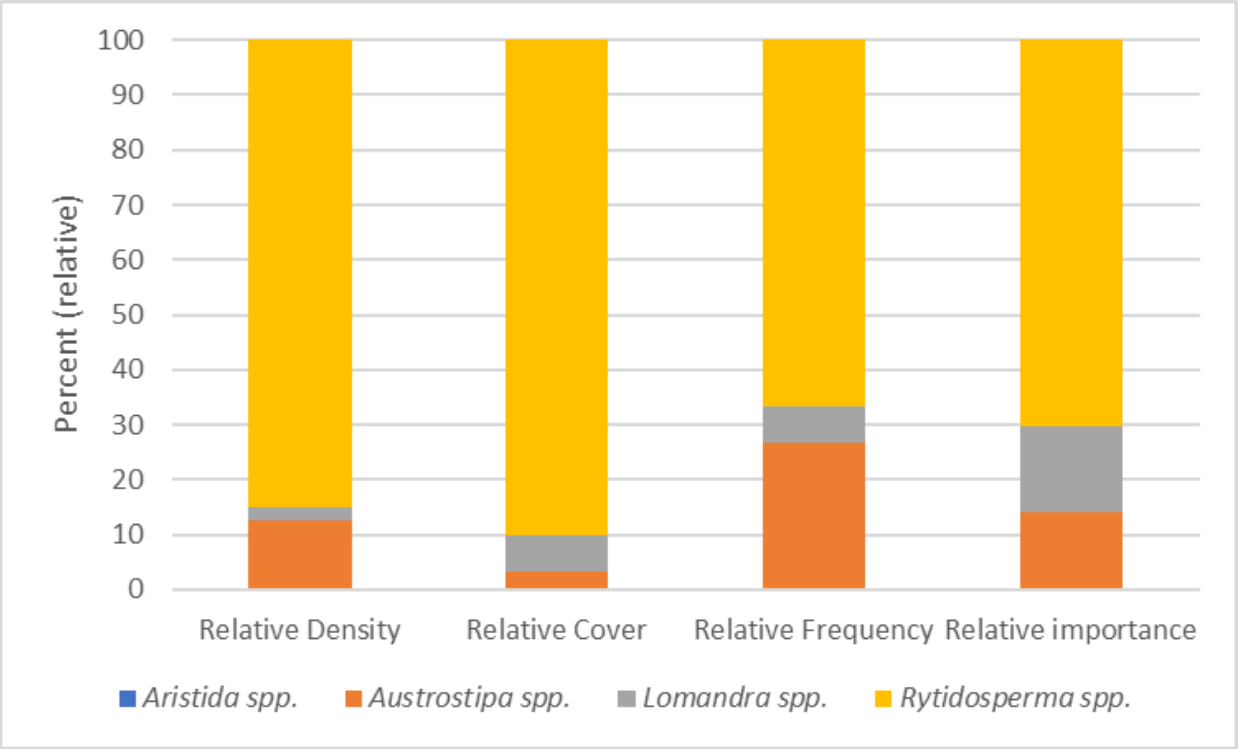


Graph 4.17 Site 5 Frequency of Occurrence (Percent of Quarters Recorded) for 2017–2024, With Average for All Years

PCQM data was not collected at Site 5 in 2020 due to covid-19 state-wide lockdown impacting survey.

Site 6

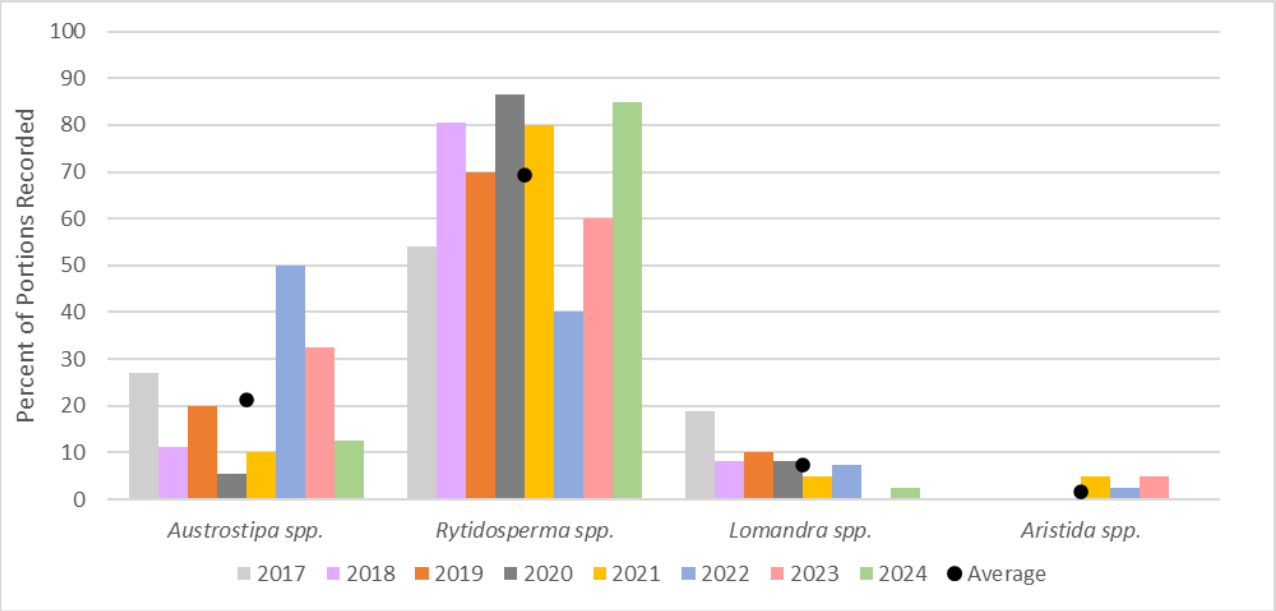
Site 6 had an average density of 82.93 perennial native tussocks per square metre, and 13.35% basal coverage per hectare. Only three perennial native grasses were recorded via PCQM at Site 6 in 2024 as *Aristida* spp. was not recorded. *Rytidosperma* spp. was found as the dominant species with the greatest relative importance value at 70.63, whereas the relative importance for *Austrostipa* spp. and *Lomandra* spp. was only 14.17 and 15.6, respectively (Graph 4.18).



Graph 4.18 Relative Density, Cover, Frequency and Importance of Perennial Plants at Site 6 in 2024

Rytidosperma spp. has been the most dominant species at Site 6 with the highest frequency of occurrence since the baseline survey (2017), and apart from 2022, has been increasing since 2017. The frequency of occurrence for both *Austrostipa* spp. and *Lomandra* spp. has generally been lower the baseline survey (2017). *Aristida* spp. has only been recorded at a low frequency in 2021, 2022 and 2023 (**Graph 4.19**).

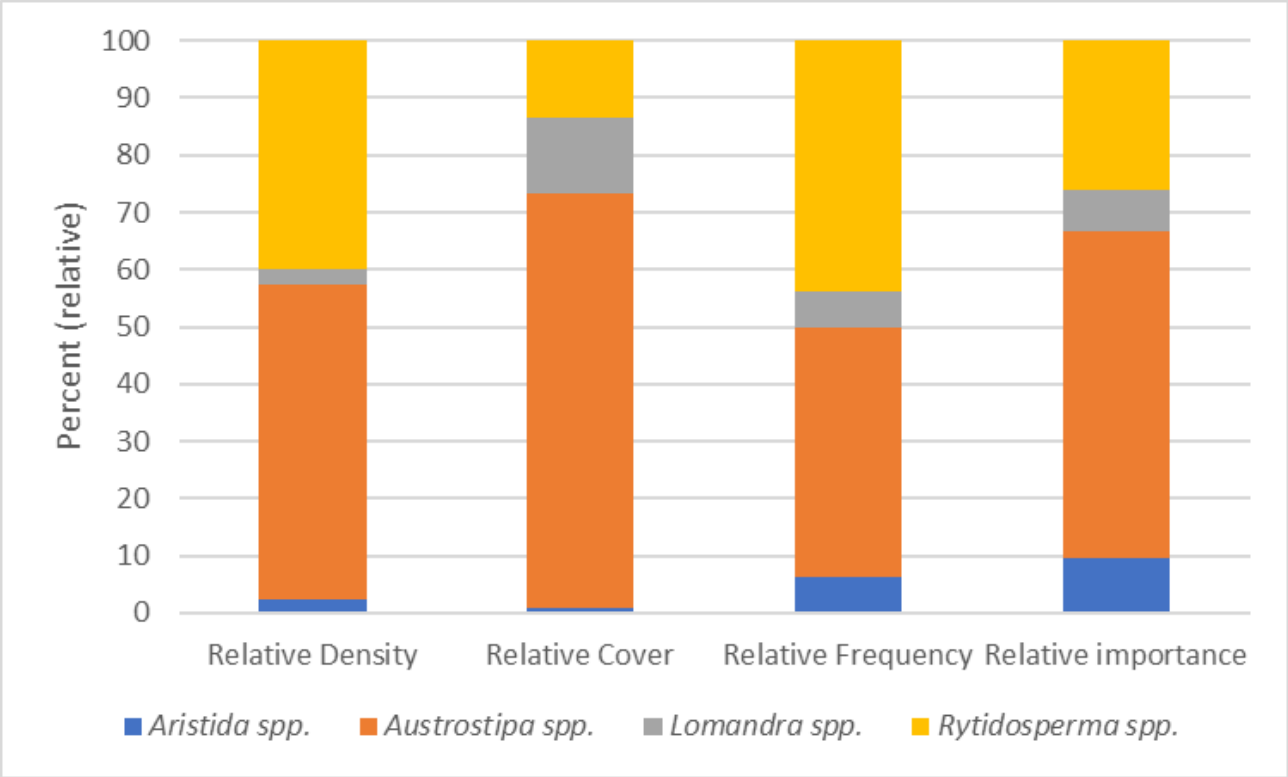
In 2024 Site 6 was observed to be very dry, with evidence of grazing and animal scats present.



Graph 4.19 Site 6 Frequency of Occurrence (Percent of Quarters Recorded) for 2017–2024, With Average for All Years

Site 7

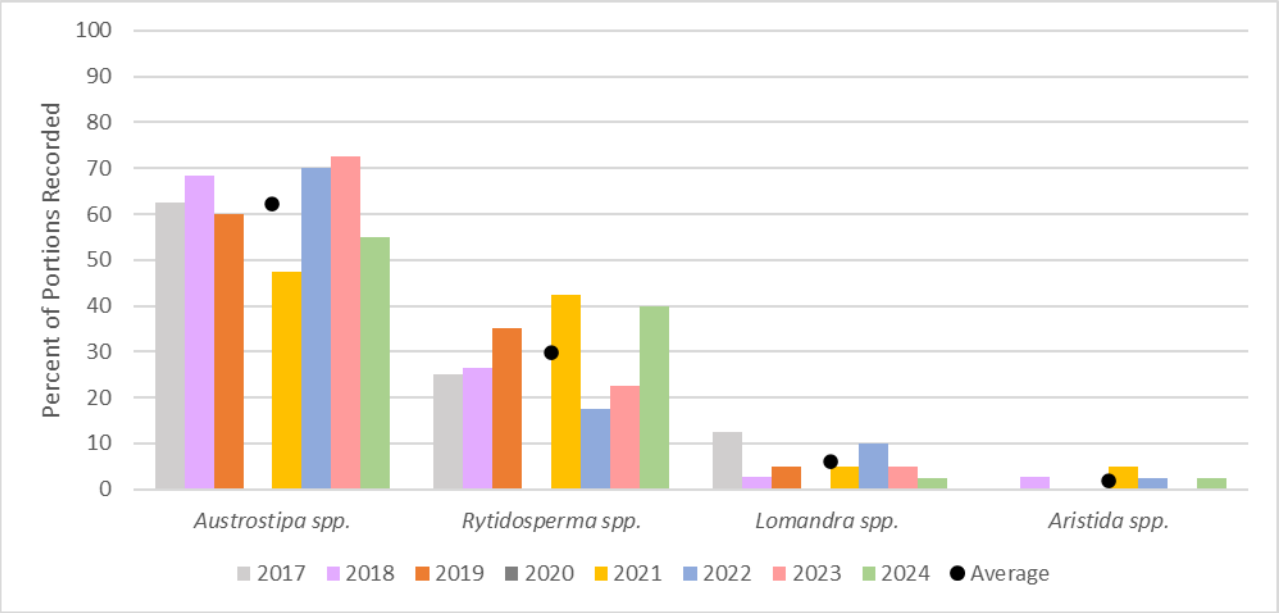
Site 7 had an average density of 57.80 perennial native tussocks per square metre, and 50.09% basal coverage per hectare. Four species were recorded at Site 7, with *Austrostipa* spp. being the dominate grass by having the greatest relative importance value (57.08). *Rytidosperma* spp. was found to occur at the same relative frequency at 43.75 as *Austrostipa* spp. but had a lower relative importance value (32.44). The relative importance of both *Aristida* spp. (9.67) and *Lomandra* spp. (7.25) was found to be low (**Graph 4.20**).



Graph 4.20 Relative Density, Cover, Frequency and Importance of Perennial Plants at Site 7 in 2024

The frequency of occurrence for *Rytidosperma* spp. has increased since 2023, while it has decreased slightly for *Austrostipa* spp. and *Lomandra* spp. since 2023. The frequency trend (overall average) of each perennial plant since the baseline survey has only slightly changed, with only a slight increase for *Austrostipa* spp. and *Rytidosperma* spp. and a slight decrease for *Lomandra* spp. (**Graph 4.21**).

In 2024 Site 7 was observed to be very dry, with grazing evident, animal tracks and scat present.

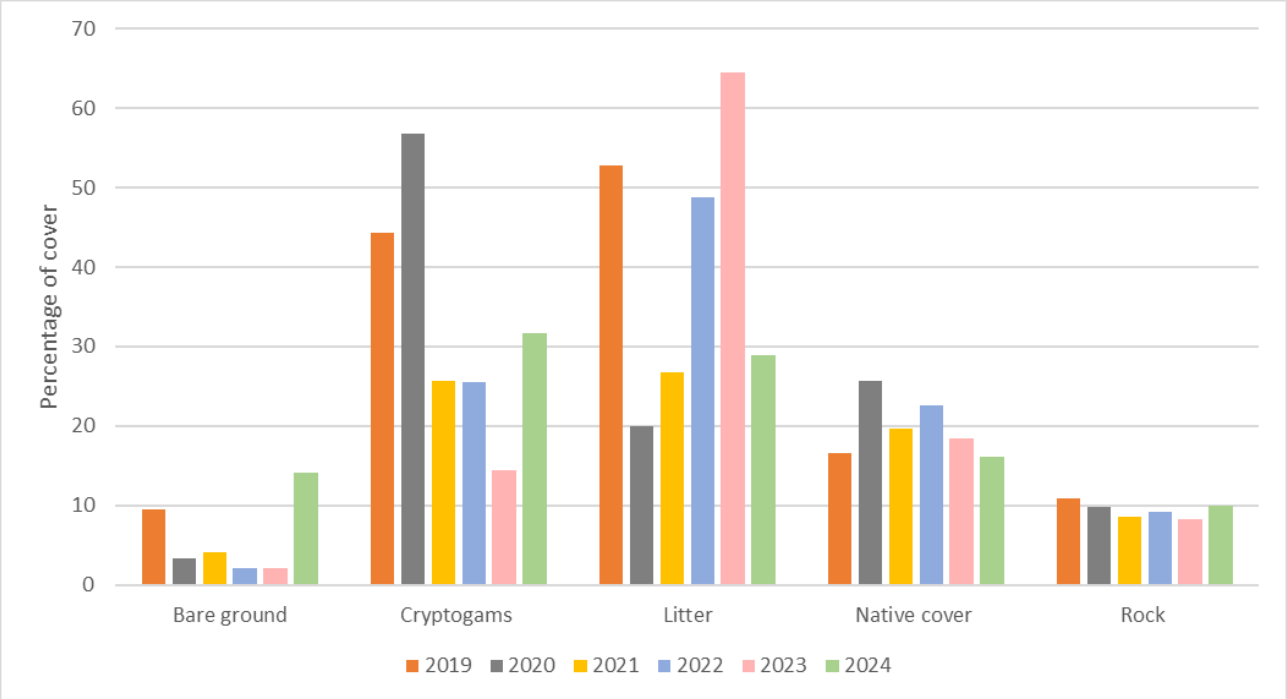


Graph 4.21 Site 7 Frequency of Occurrence (Percent of Quarters Recorded) for 2017–2024, With Average for All Years

PCQM data was not collected at Site 5 in 2020 due to covid-19 state-wide lockdown impacting survey.

4.2 Grassland Health Indicators (via Quadrat Sampling)

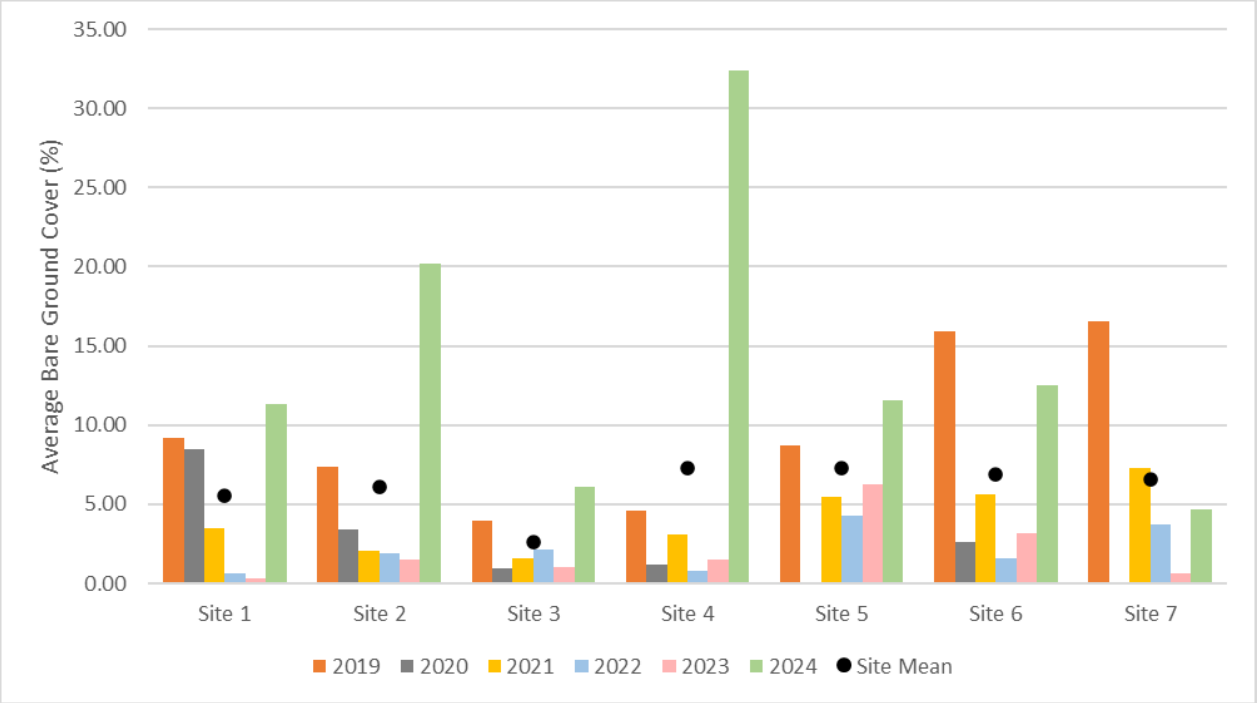
A summary of the percentage cover recorded for each life form is presented in **Graph 4.22** and described in detail for each life form below. Generally, apart from litter, life forms have remained consistent across sites over the monitoring program (with this data collected from 2019 onwards).



Graph 4.22 Annual Comparison of Average (Percentage) Life Form Cover at All Assessment Sites

4.2.1 Bare Ground

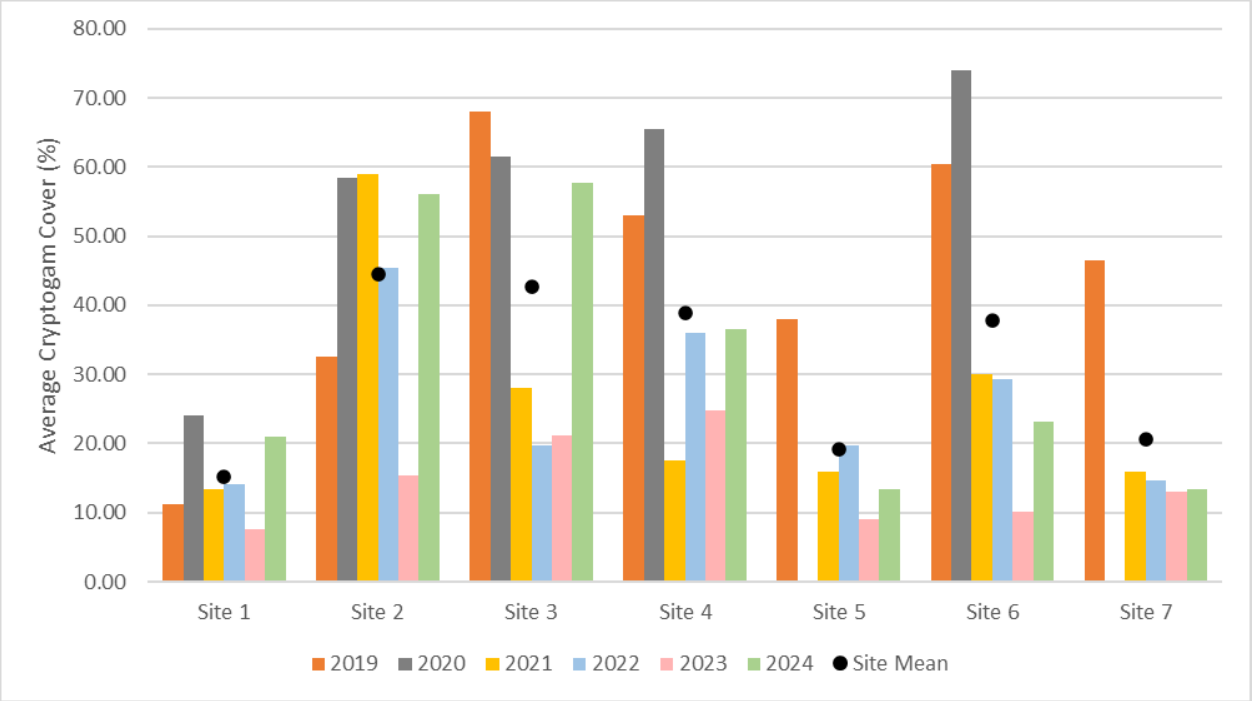
For the first time, the average percentage of bare ground recorded at 14.11%, is larger than the 9.48% recorded initially in 2019. The average percentage of bare ground had a large increase in 2024 compared to 2023 when it was 2.06%. In 2024, Site 7 had the lowest amount of bare ground at 4.7%, and was the only Site to record a lower average compared to the Site mean over the course of the monitoring program. In 2024, the highest proportion of bare ground occurred at Site 4 at 32.4%, which is the largest average recorded to date (**Graph 4.23**).



Graph 4.23 Average Bare Ground at Each Assessment Site (2019–2024), With Site Mean

4.2.2 Cryptogam

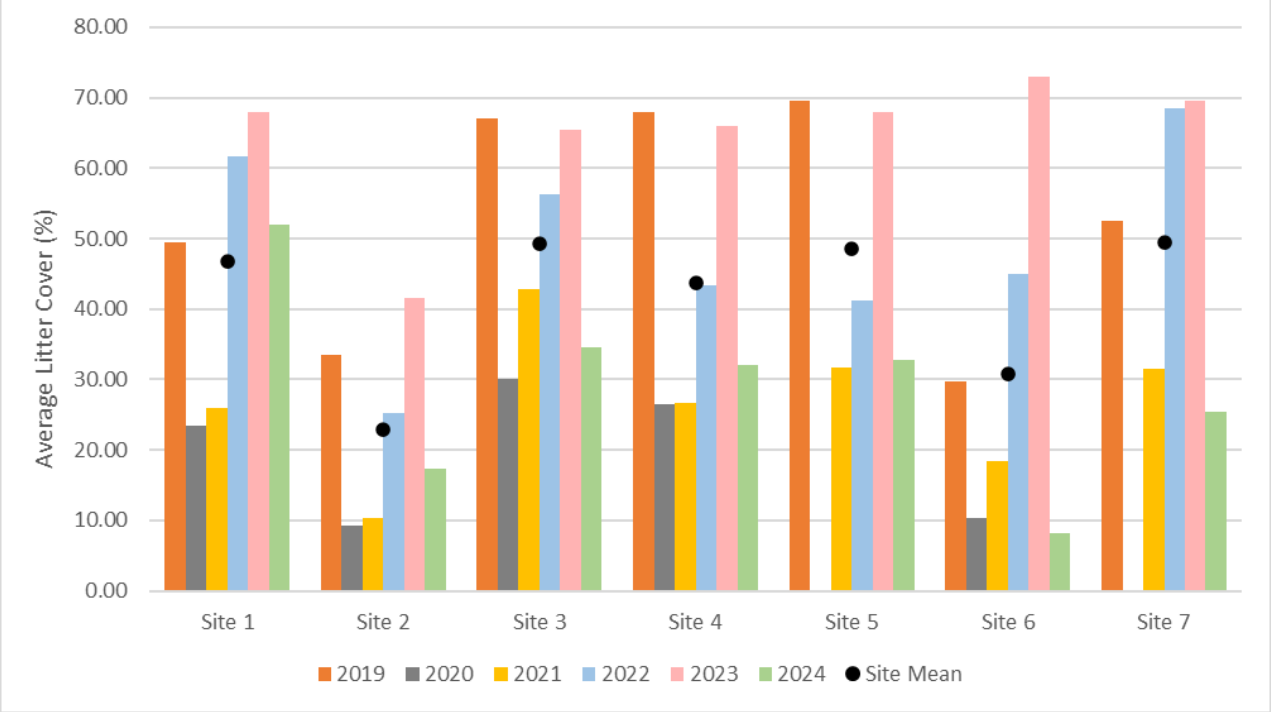
In 2024, cryptogamic crust averaged 31.64% across all Assessment Sites, which is an increase from the 14.43% in 2023. However, the average in 2024 is still lower than the average of 44.26% recorded initially in 2019. In 2024, some Sites including Sites 1, 2 and 3 had a greater average than their Site mean, while Site 4, 5, 6 and 7 had a lower average than their Site mean (**Graph 4.24**).



Graph 4.24 Average Cryptogam Cover at Each Assessment Site (2019–2024), With Site Mean

4.2.3 Litter Cover

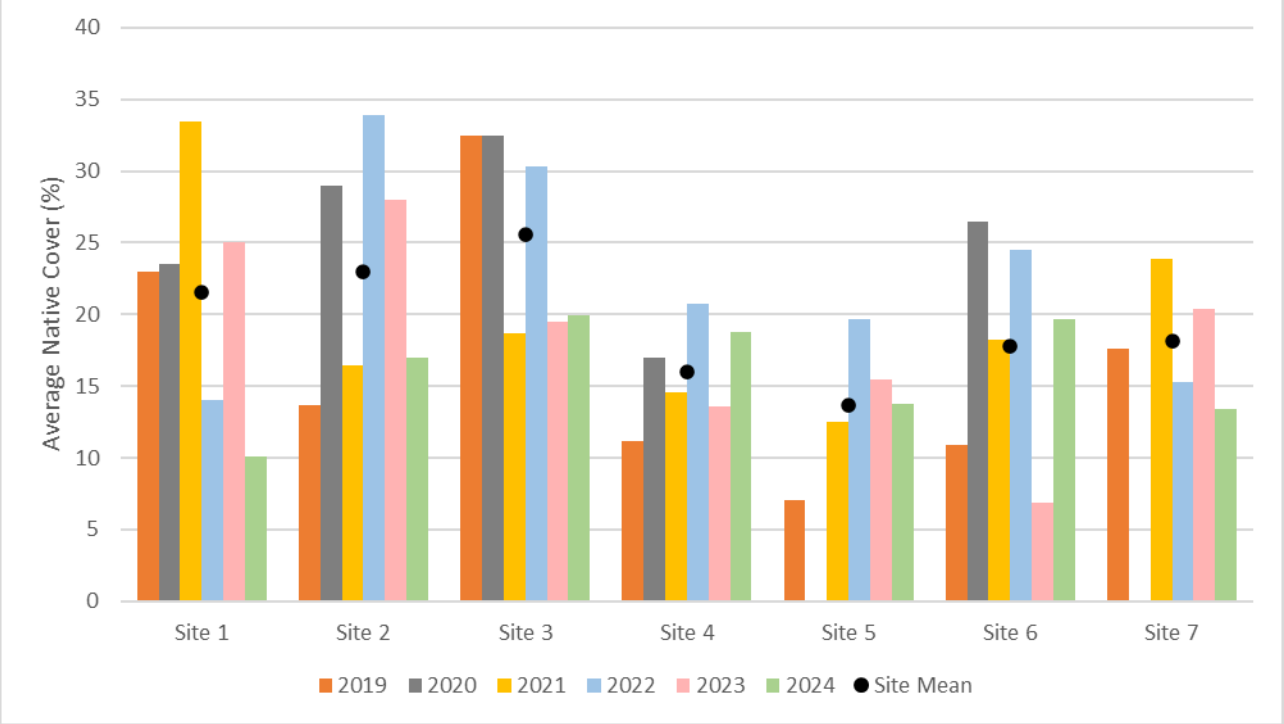
In 2024, the average litter cover of 28.89% across all Assessment Sites was lower than the 64.54% in 2023 and the 52.81% in the initial survey (2019). In 2024, each Site apart from Site 1 had a lower average cover of litter than the Sites mean, with the lowest being Site 6 with only 8.1%. In 2024, Site 1 had the highest proportion of litter cover of 52% (**Graph 4.25**).



Graph 4.25 Average Litter Cover at Each Assessment Site (2019–2024), With Site Mean

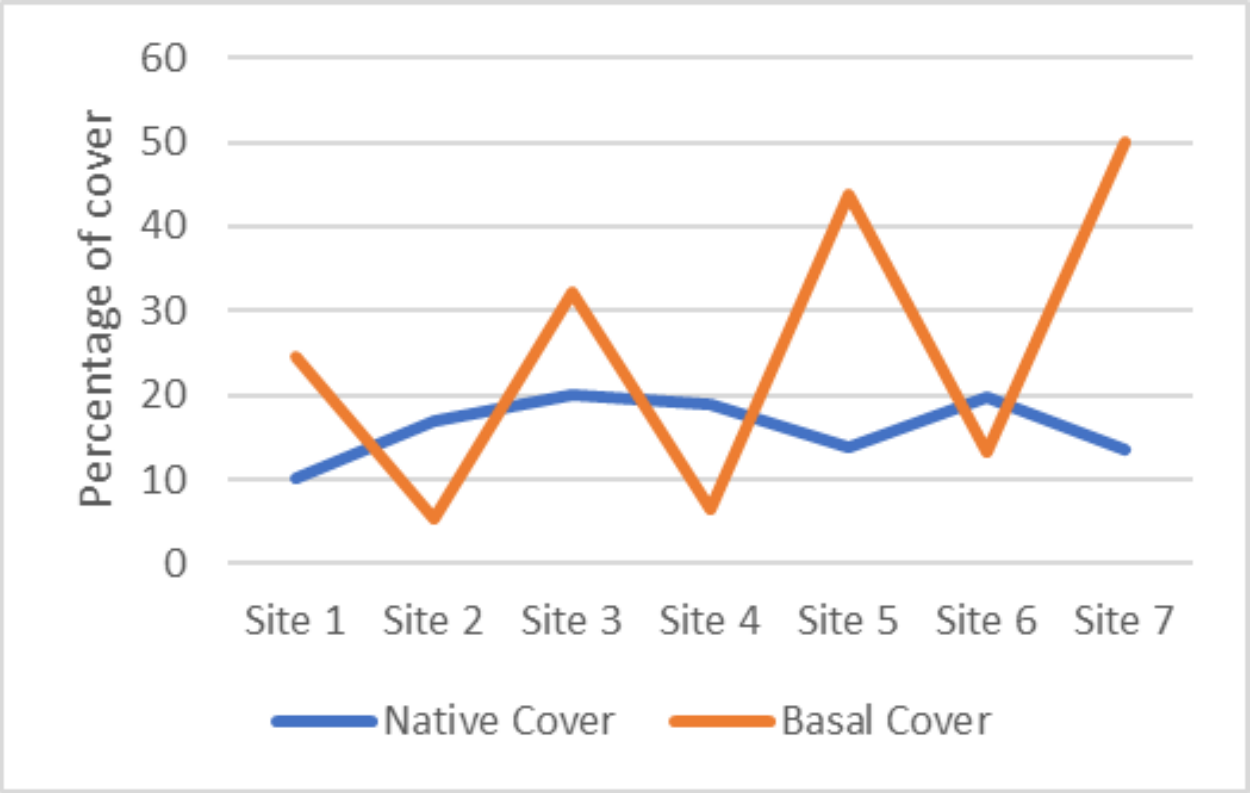
4.2.4 Native Cover

The average native cover across all Assessment Sites in 2024 was 16.1%, which is a slight decrease from the 18.41% recorded in 2023, but is similar to the 16.56% recorded in initially in 2019. All Sites, apart from Site 4 and 6, recorded a lower percentage of native cover during 2024 compared to their Site mean (**Graph 4.26**).



Graph 4.26 Average Native Cover at Each Assessment Site (2019–2024), With Site Mean

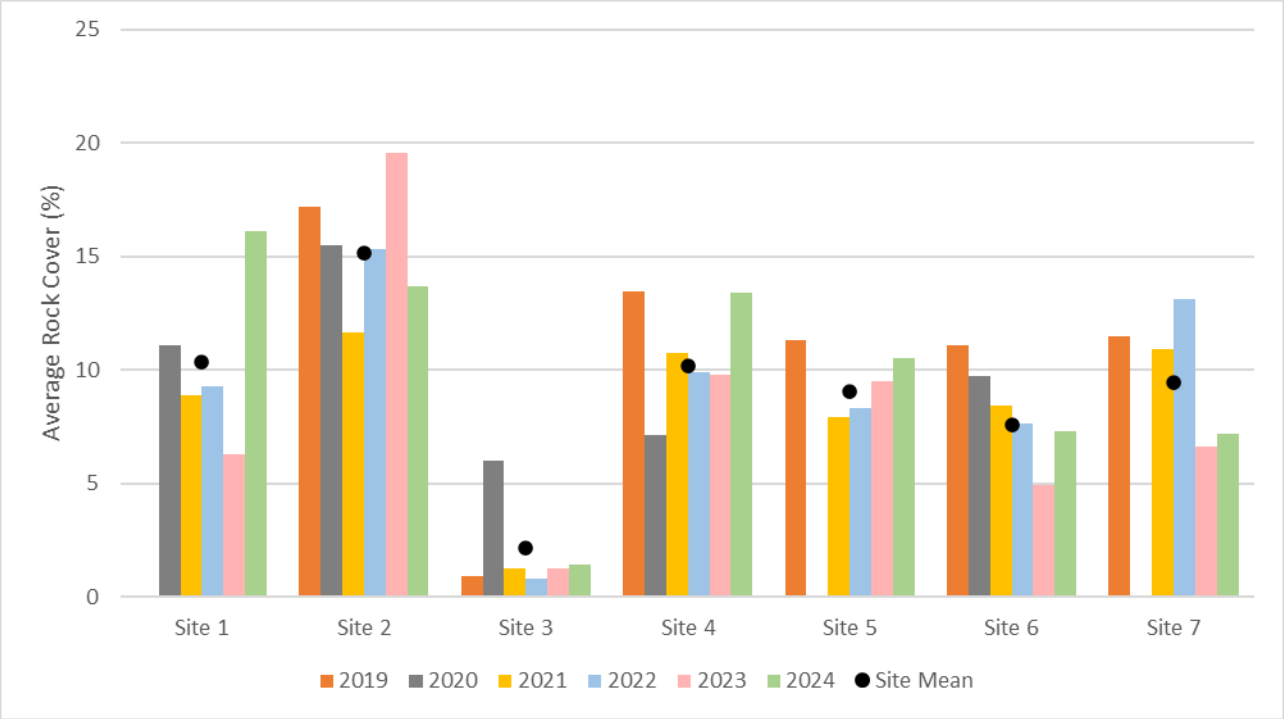
As a comparison of methods, average native cover (recorded via Quadrat Sampling) at each Assessment Site in 2024 has been plotted against the average basal cover of perennial native grasses (recorded via PCQM) at each Assessment Site in 2024, and shows a comparable relationship (**Graph 4.27**). On average in 2024, the projected foliage cover was 75.41% lower than the basal coverage, although this was highly variable between Sites.



Graph 4.27 Native Cover (from Quadrat Sampling) Compared to Basal Cover (From PCQM) at Each Assessment Site in 2024

4.2.5 Rock

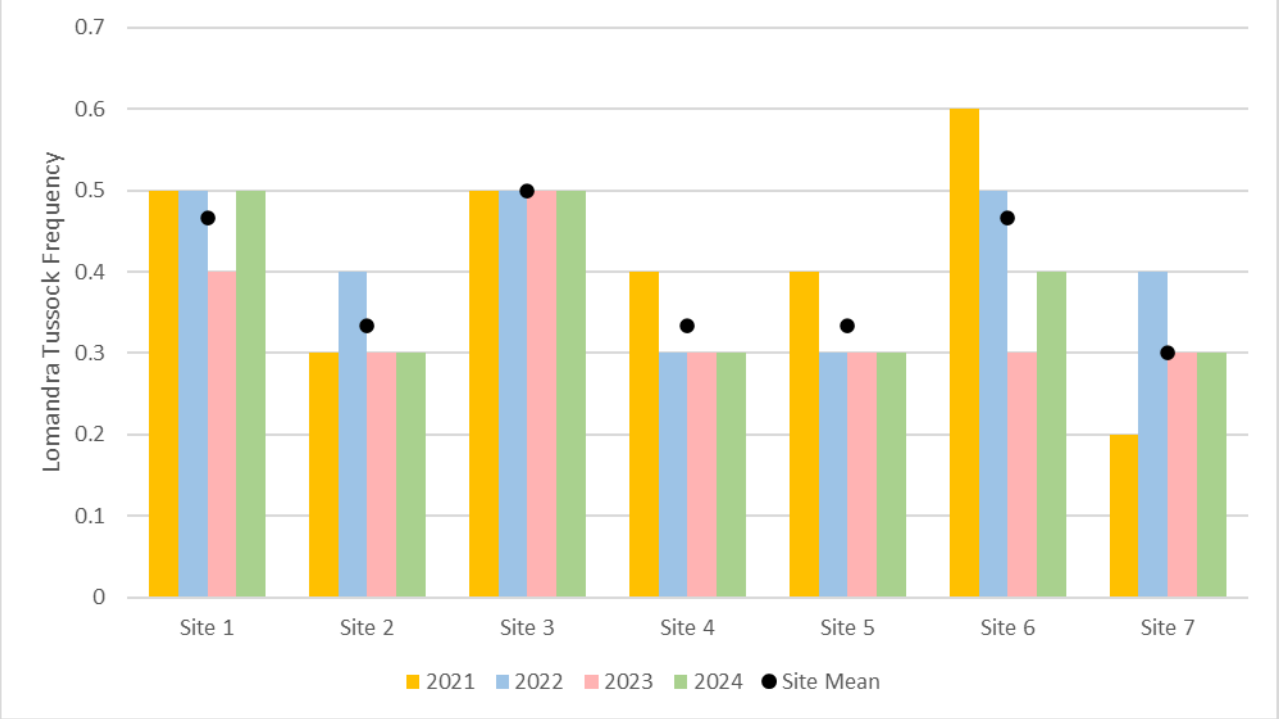
Average rock cover across all Assessment Sites remained broadly similar across monitoring years, averaging 10.91% in 2019, 9.89% in 2020, 8.54% in 2021, 9.19% in 2022, 8.27% in 2023, and 9.94% in 2024. Site 2 has consistently had the greatest proportion of rock cover across monitoring years, while Site 3 has consistently had the lowest (**Graph 4.28**). Ideally there would be little change in rock cover between years.



Graph 4.28 Average Rock Cover at Each Assessment Site (2019-2024), With Site Mean

4.2.6 Lomandra Tussock Frequency

The frequency of *Lomandra* is presented in **Graph 4.29**, where 0.5 is equivalent to 50 percent of quadrats (n=10). In 2024, most Sites recorded a similar frequency of Lomandra tussocks compared to 2023, with a mean frequency of 0.34 recorded for 2023 and 0.37 recorded for 2024 and a general difference of 0.1 between years (if any).



Graph 4.29 Lomandra Tussock Frequency at Each Assessment Site (2021–2024), With Site Mean

4.3 Ramble Survey

4.3.1 Native Flora

A total of 37 native flora species were observed across all Assessment Sites in 2024 (**Table 4.3**), which is an increase of one species compared to 2023, but a decrease compared to 2022 when 43 native species were observed.

One new flora species, *Cheilanthes austrotenuifolia* (Annual Rock-fern), was observed in 2024, located at Site 2.

Table 4.3 Native Flora Species Recorded At Each Assessment Site in 2024

Life form	Scientific Name	Common Name	Assessment Site							Occupancy (n=7)
			1	2	3	4	5	6	7	
Broad-leaf Herb	*Asperula conferta*	Common woodruff		✓	✓	✓				3
	Cheilanthes austrotenuifolia	Annual Rock-fern		✓						1
	Chenopodium desertorum ssp. *microphyllum*	Small leaved Goosefoot	✓	✓	✓	✓	✓	✓	✓	7
	Convolvulus remotus	Australian Bindweed		✓	✓		✓	✓	✓	5
	Crassula sp.	Crassula/Stonecrop					✓			1
	Einadia nutans	Climbing saltbush		✓	✓			✓	✓	4
	Leptorhynchos squamatus	Scaly buttons	✓							1
	*Ptilotus erubescens**	Hairy-tails			✓					1
	*Rumex dumosus**	Wiry Dock	✓	✓	✓	✓	✓	✓		6
	Stackhousia monogyna	Creamy candles		✓						1
	Triptilodiscus pygmaeus	Common Sunray		✓						1
	Vittadinia cuneata var. *cuneata*	Fuzzy New Holland Daisy		✓			✓		✓	3
	Vittadinia gracilis	Woolly New Holland Daisy	✓	✓	✓	✓	✓	✓	✓	7
	Vittadinia megacephala	Giant New Holland Daisy		✓						1
	Wahlenbergia luteola	Yellow-wash Bluebell		✓	✓			✓	✓	4
	Wahlenbergia stricta	Tall Bluebell	✓		✓	✓	✓	✓	✓	6
Disturbance Resistant Broad-leaf Herb	*Convolvulus angustissimus*	Bindweed	✓	✓	✓			✓	✓	5
	Euphorbia drummondii group	Spurge	✓	✓	✓	✓	✓		✓	6
	Maireana enchylaenoides	Wingless Fissure-plant	✓	✓	✓	✓	✓	✓	✓	7
	Oxalis perennans	Native Sorrel	✓	✓	✓	✓	✓	✓	✓	7
	Ptilotus spathulatus	Pussy-tails	✓	✓	✓	✓	✓	✓	✓	7
	Sida corrugata var. *angustifolia*	Corrugated Sida	✓	✓	✓	✓	✓	✓	✓	7

Life form	Scientific Name	Common Name	Assessment Site							Occupancy (n=7)
			1	2	3	4	5	6	7	
Grass	*Anthosachne scabrous*	Common wheat grass	✓							1
	Aristida behriana	Brush Wire-grass	✓			✓	✓	✓	✓	5
	Austrostipa blackii	Crested Spear-grass	✓	✓	✓	✓	✓	✓	✓	7
	Austrostipa gibbosa	Swollen spear-grass	✓							1
	Austrostipa nitida	Balcarra Grass	✓	✓	✓	✓	✓	✓	✓	7
	Austrostipa scabra ssp. *scabra*	Rough Spear-grass	✓	✓	✓	✓	✓	✓	✓	7
	Enneapogon nigricans	Black-head Grass					✓			1
	Rytidosperma sp.	Wallaby-grass	✓	✓	✓		✓	✓	✓	6
Sedge	*Juncus* sp.	Rush				✓				1
	Lomandra multiflora ssp. *dura*	Hard Mat-rush	✓	✓	✓	✓	✓	✓	✓	7
Shrub	*Atriplex semibaccata*	Berry Saltbush		✓		✓	✓			3
	Bursaria spinosa	Sweet Bursaria				✓	✓			2
	*Cryptandra campanulate**	Long-flower Cryptandra		✓	✓	✓	✓	✓	✓	6
	Maireana aphylla	Cotton-bush		✓	✓			✓	✓	4
	Scleranthus pungens	Prickly Knawel		✓	✓	✓	✓	✓	✓	6
		Species Diversity Per Site	**19**	**27**	**23**	**20**	**23**	**21**	**22**	

** National Parks and Wildlife Act 1972* SA Rare species

4.3.2 INTG TEC Condition Class

In 2024, all seven Assessment Sites were found to meet the criteria for INTG TEC Condition Class B (**Table 4.4**). Refer to **Table 4.3** for the life form data for each native species observed at each Assessment Site in 2024.

INTG TEC Condition Class data for each Assessment Site across all survey years to date is also summarised in **Table 4.4**.

Table 4.4 INTG TEC Condition Class Data for Each Site for 2018-2024 (With Criteria in Green)

Assessment Site (Size)	Year	Diversity of Native Species[1]	No. of Broad-leaved Herbaceous Species[1] in Addition to Identified Disturbance Resistant Species[2]	No. of Perennial Grass Species[1] (Excluding *Lomandra*)	Tussock Count[3] (Including *Lomandra*)	INTG TEC Condition
>0.1 ha	-	≥30	≥10	≥5	≥1/m^2	A
>0.25 ha	-	≥15	≥3	≥4	≥1/m^2	B
No min.	-	≥5	-	≥1	-	C
Site 1 (>9 ha)	*2010	27	12	5		B
	2018	17	5	10		B
	2019	23	10	4		B
	2020	-	-	-	14.5/m^2	B**
	2021	27	10	9		B
	2022	23	13	5		B
	2023	23	8	8		B
	2024	19	5	7		B
Site 2 (4.3 ha)	*2010	24	13	5		B
	2018	-	-	-		NA
	2019	27	10	5		B
	2020	25	9	5	12.6/m^2	B
	2021	26	11	6		B
	2022	28	13	5		B
	2023	22	8	6		B
	2024	27	12	4		B
Site 3 (1.8 ha)	*2010	26	12	4		B
	2018	16	4	5		B
	2019	17	5	3^		C
	2020	27	8	7	33.4/m^2	B
	2021	20	6	4		B
	2022	27	13	5		B
	2023	24	10	6		B
	2024	23	9	4		B

Assessment Site (Size)	Year	Diversity of Native Species[1]	No. of Broad-leaved Herbaceous Species[1] in Addition to Identified Disturbance Resistant Species[2]	No. of Perennial Grass Species[1] (Excluding *Lomandra*)	Tussock Count[3] (Including *Lomandra*)	INTG TEC Condition
Site 4 (1.8 ha)	*2010	22	9	5		B
	2018	17	5	4		B
	2019	21	7	4		B
	2020	23	7	5	21.6/m^2	B
	2021	24	7	5		B
	2022	23	8	4		B
	2023	22	7	5		B
	2024	20	5	4		B
Site 5 (1.8 ha)	2010*	13^	4	4		C
	2018	13^	2^	4		C
	2019	22	9	4		B
	2020	21	6	4	NA	B**
	2021	20	7	4		B
	2022	23	9	4		B
	2023	22	7	6		B
	2024	23	7	6		B
Site 6 (2.0 ha)	*2010	18	5	4		B
	2018	11^	3	3^		C
	2019	19	6	4		B
	2020	19	4	4	22.5/m^2	B
	2021	22	7	5		B
	2022	29	13	6		B
	2023	21	6	6		B
	2024	21	7	5		B
Site 7 (6.5 ha)	2010*	23	8	5		B
	2018	17	4	4		B
	2019	25	11	4		B
	2020	-	-	-	-	B**
	2021	21	5	4		B
	2022	23	11	5		B
	2023	21	7	5		B
	2024	22	7	5		B

*2010 results are based on the 2010 EPBC Assessment (EBS Ecology 2010)

**Condition class estimated without all EPBC criteria values available (due to covid-19 state-wide lockdown in 2020 impacting survey).

^ Value falls short of EPBC Class B listing.

4.3.3 Rare Plants

To date, four plants listed as Rare by Schedule 9 of the *National Parks and Wildlife Act 1972* (NPW Act) have been identified over the course of the monitoring program and were recorded again in 2024 (**Table 4.5**), including:

- *Austrostipa gibbosa* (Swollen spear-grass) which was identified for the first time in 2022 at Site 1. It is possible that this species was missed in past survey years due to the general difficulty in identifying grass species. In 2024, the species was recorded only at Site 1, but it is possible that it was present on other Assessment Sites but due to most grasses being spent or heavily grazed (the heads are the identifying feature) it was not possible to identify to species level, so was recorded as *Austrostipa* sp.

- *Cryptandra* specimens had been observed at several sites in previous years but were unable to be identified to species level, due to impacts of heavy grazing and absence of flowers (**Figure 4.1**). Based on previous records (EBS Ecology 2010), and the location of the plants, it is likely that these specimens are the Rare listed species *Cryptandra campanulata* (Long-flowered Cryptandra) (previously named *Cryptandra amara* var. *longiflora*). In 2024, the *Cryptandra* specimens were identified at all Sites, apart from Site 1, and remained in poor condition.

- *Ptilotus erubescens* (Hairy tails) was identified at Site 3 in 2024. Due to its small, inconspicuous nature it is also possible that this species was present at other Sites and in previous years when it was not recorded, but was not detected, especially if it was not in flower (**Figure 4.2**).

- *Rumex dumosus* (Wiry Dock) was detected at all sites apart from Site 7 in 2024 and was observed in both its winter (green) form and summer (red) dried tumbleweed form (**Figure 4.3** and **Figure 4.4**).

Table 4.5 State Rare Flora Observed at Assessment Sites (2017–2024)

Species Name	Common Name	Year	Assessment Site						
			1	2	3	4	5	6	7
Cryptandra campanulata	Long-flowered Cryptandra / Bitter Cryptandra	2017	-	-	-	-	-	-	-
		2018	✓	-	-	-	-	✓	✓
		2019	✓	✓	-	✓	-	✓	✓
		2020	-	✓	✓	✓	✓	✓	-
		2021	✓	✓	✓	✓	✓	✓	✓
		2022	✓	✓	✓	✓	✓	✓	✓
		2023	✓	✓	✓	✓	✓	✓	✓
		2024	-	✓	✓	✓	✓	✓	✓
Ptilotus erubescens	Hairy tails	2017	-	-	-	-	-	-	-
		2018	-	-	✓	-	-	-	-
		2019	✓	-	✓	-	✓	-	✓
		2020	-	✓	✓	✓	-	-	-
		2021	-	-	-	-	-	-	-

Species Name	Common Name	Year	Assessment Site						
			1	2	3	4	5	6	7
		2022	-	-	-	-	-	-	-
		2023	✓	-	-	-	-	-	-
		2024	-	-	✓	-	-	-	-
Rumex dumosus	Wiry Dock	2017	-	-	-	-	-	-	-
		2018	✓	-	✓	✓	-	✓	✓
		2019	✓	✓	✓	✓	✓	✓	✓
		2020	-	✓	✓	✓	✓	✓	-
		2021	✓	✓	-	✓	✓	✓	✓
		2022	✓	✓	✓	✓	✓	✓	✓
		2023	✓	✓	✓	✓	✓	✓	✓
		2024	✓	✓	✓	✓	✓	✓	-
Austrostipa gibbosa	Swollen-head Spear Grass	2017	-	-	-	-	-	-	-
		2018	-	-	-	-	-	-	-
		2019	-	-	-	-	-	-	-
		2020	-	-	-	-	-	-	-
		2021	✓	-	-	-	-	-	-
		2022	✓	-	-	-	-	-	-
		2023	✓	-	-	-	-	-	-
		2024	✓	-	-	-	-	-	-



Figure 4.1 A Heavily Grazed *Cryptandra campanulata* Specimen



Figure 4.2 *A Ptilotus erubescens* Specimen



Figure 4.3 *A Rumex dumosus* (Wiry dock) Specimen in Transitional Phase



Figure 4.4 *A Rumex dumosus* (Wiry dock) in Summer Form

5.0 Discussion

Native grasslands are naturally occurring areas that have few or no trees and few shrubs (<10%) and are dominated by native grass tussocks and a diversity of annual and perennial herbs (DAWE 2008). In SA, INTGs are unique ecological communities in which Iron-grass (*Lomandra multiflora* spp. *dura* and/or *L. effusa*) forms a characteristic and dominant component of the vegetation, commonly occurring with native perennial grasses and other herbaceous species (Turner 2012).

5.1 PCQM

The *Bushland Condition Monitoring Manual* (BCMM) for the Northern Agricultural and Yorke Peninsula (NAYP) Regions (Pedler et al. 2007b) states that a grassland in good condition can have perennial native grass coverage of up to 50%, with tall tussocks accounting for around 5% and low tussocks representing 5 - 10% cover. Basal cover, calculated from PCQM data, was variable across the Assessment Sites, ranging from 5.38% at Site 2 to 50.09% at Site 7, with an average of 25.08%. All sites were within the moderate to healthy grassland range and the increase in the average to make it the highest thus far is a desirable outcome.

Parameters measured via PCQM as part of the Lomandra Grassland Monitoring relating to grassland health are presented in (**Table 5.1**) and indicate how the 2024 results compare to the desired trend for each parameter.

Table 5.1 PCQM Measurement Parameters Summary for 2024

Parameter	Purpose	Benchmark year	Desired trend	Undesirable trend	Trend observed in 2024
Cover (m^2)	Determine basal cover (m^2) of perennial plants.	2019	Stable or slight increase.	Significant increase or decrease.	Increasing
Density (PPH)	Determine the number of perennial plants per hectare.	2017	Stable or slight increase.	Significant increase or decrease.	Increasing
% Dead material	Determine tussock dieback, a useful indicator in grassland health.	2017	Stable or decreasing	Increasing	Decreasing
Height of plant (in cm)	Aims to detect changes in height – useful for determining grazing pressure.	2017	Stable or increasing height	Decreasing	Decreasing

5.1.1 Spacing of Perennial Plants

Spacing of perennial plants can be used to determine the density of plants on a site and can be an indicator of changes in tussock density which may relate to seasonal conditions or long-term changes at a site. The smaller the spacing of perennial plants from the centre point, the higher the density of perennial plants, and so a downward trend would indicate an increase in perennial plant density. In 2022 measurements of perennial plants were limited to the four most common grass genus' occurring across the site (*Aristida behriana*, *Austrostipa* spp., *Rytidosperma* spp., and *Lomandra* spp.). Where multiple species of one genus occurred, such as *Austrostipa*, they were grouped by genus.

There is no evident trend across sites in relation to perennial plant spacing (**Section 4.1.2**) and a lack of an obvious trend may indicate natural variation. Factors such as climatic variability and grazing intensity may influence perennial plant spacing, by causing fluctuations in the number of juvenile plants and / or plant mortality. These factors can be extrapolated from other measures such as average basal width (juveniles) or foliage height (grazing). Alternatively, the slight change to the methodology after 2019, only measuring the four most common perennial grass species, may be responsible for some variation observed between previous years.

The increase of perennial plant spacing and decrease the average distance of perennial plants from the centre point (**Section 4.1.1**) may indicate that the base of perennial plants was easier to locate, differentiate and subsequently measure, likely related to a reduction of cover and live plant material (**Section 4.1.3** and **Section 4.1.5**, respectfully).

5.1.2 Basal Cover

Basal cover can be sensitive to factors such as stage of growth but can also be used as an indicator of grassland maturity and regeneration. Basal cover is regarded as a more stable measure of cover than canopy, particularly for perennial grasses, as the tussock bases persist even in drought conditions (DPIRD 2020). It is intended that through long-term monitoring, basal area can be used to track variation due to seasonal conditions, as well as to detect changes in the dominance of perennial plants over time.

In a dry year a higher average basal width may be expected, but lower density due to greater distance from the centre point to the nearest plant (due to dieback). Conversely, in good seasons that have received adequate rainfall, you might expect the opposite, due to a denser coverage of emergent / regenerating perennial grasses. Long-lived, slow growing plants such as Iron-grass should remain relatively stable in basal width, but may be variable in their relative frequency, appearing less in good years due to the presence of numerous other grasses filling in the space close to the PCQM centre point. Frequency counts of Lomandra in the quadrat surveys should help to determine if there have been changes in the distribution or frequency of tussocks regardless of seasonal conditions.

There is no evident trend across Assessment Sites in relation to basal cover across the monitoring program, with a decline from 2020 to 2021 then an increase from 2021 to 2024 (**Section 4.1.3**). Despite the lack of an obvious trend, and overall decline since the baseline survey to 2023 occurred, possibly due to 2021 and 2022 being consecutively good years for spring rainfall. The increase of basal cover from 2022 to 2024 indicates minimal regeneration between years and/or lack of emergent plants in recent years.

5.1.3 Plant Height

Plant height can be used as a ‘grazing coefficient’ in grasslands, as even with variable seasonal conditions when the density or health or grasses may be reduced, height of tussocks should reach their natural range without grazing.

Heavy grazing has been noted in all years across the entirety of the monitoring program, including during the 2024 survey. Although the presence of grazing has remained constant over time, plant height has fluctuated, being higher on average in 2021 and 2022. The increase in height from 2020 can be attributed to higher-than-average spring rainfall. All other years had an average or lower than average spring rainfall, which when combined with grazing, causes a doubled effect of reduced fodder leading to increased completion, resulting in higher grazing pressure.

The 2024 results of most Assessment Sites resembled the baseline survey in 2017. However, the average height across all Sites in 2024 of 5.14 cm is the lowest to date. This is lower than the seven-year average of 9.79 cm. Mirroring previous years, Site 1 and Site 7 had the highest average grass height, although this did not appear to be linked to the frequency of tall grasses such as *Austrostipa* (Spear-grass), which is classified as a 'Tall Grass' in the BCMM for NAYP (Pedler et al. 2007a; 2007b). Rather, average grass height appeared to be influenced by grazing intensity, with Site 1 and Site 7, having lower grazing impacts and therefore healthier and taller grass tussocks.

The average height of all grass species has decreased since 2022 (**Section 4.1.4**) but similar to previous years, *Lomandra* spp. was the tallest on average. This is likely due to it being less palatable than tussocks like *Rytidosperma* spp. which has consistently had the lowest height and is the most palatable of the species on offer. A lower height is expected for *Aristida* spp. because its habit is low and sprawling.

5.1.4 Plant Health

Percentage dead material is an indicator of plant health but can vary widely depending on factors such as seasonal conditions, time of year and grazing pressure. A stable or downward trend is desirable over a long-term dataset, however from year to year, it is likely to be highly variable.

Percentage dead material increased significantly in 2023 compared to the previous three years. However, in 2024, the percentage of dead material decreased and is now lower than the baseline mean (**Section 4.1.5**). The return to average rainfall in the month leading up to the survey in 2024, likely resulted in healthier tussocks in the 2024 survey and during the 2020–2022 period, compared to 2023.

5.1.5 Species Composition

Rytidosperma spp. was found to be either the most or second most dominant species across all Assessment Sites in 2024. However, the frequency of this species has been dropping since the baseline survey at majority of the sites. Whereas *Austrostipa* spp. has been increasing in frequency at most Sites since the baseline survey and was the most dominant species in the two previous surveys. The frequency and relative importance for both *Lomandra* spp. and *Aristida* spp. has been variable across each Site and since the baseline survey. The variability of *Lomandra* spp. and *Aristida* spp. may reflect these species being recorded because of their proximity to the PCQM centre point being further or closer than *Austrostipa* spp. or *Rytidosperma* spp. individuals.

Differences in the assemblages of grasses at a Site may be related to a combination of factors including their growth pathway (C3: cool season, or C4: warm season), grazing frequency, timing and intensity and palatability. Understanding the grazing regimes undertaken annually at each site is likely to increase understanding of these trends and will enable a more definitive determination of the cause for variation.

5.2 Grassland Health Indicators

Overall, grassland health indicators from the 2024 Lomandra Grassland Monitoring indicate a moderately healthy functioning INTG at all Assessment Sites, with no observable impact attributable to the construction or operation of WWF. Variation between sites and between years is likely to be primarily caused by a combination of factors such as seasonal variability, observer differences and variation in grazing regime from year to year. Further discussion on grassland health indicators is provided in the sub-sections below.

Weed invasion remains to be the primary threat to the health of the seven patches of INTG at WWF. Refer to the *Willogoleche Wind Farm Weed Assessment Report 2024* (Umwelt 2025) for detail on the status of weeds at the WWF. The future stability of the seven patches of INTG at WWF rely on ongoing weed maintenance along roadside verges and WTG hard-stand areas, to prevent the gradual encroachment of weeds into the INTG grasslands.

5.2.1 Bare Ground

Bare ground refers to soil surface that is not adequately protected by vegetation or litter against accelerated erosion. In grasslands, small bare areas occur naturally in a well-dispersed mosaic with the vegetation, in which cases grasses, litter and cryptogamic crust species such as moss and lichen will provide a degree of protection, binding the soil and protecting it from erosion. In cases where grazing is too heavy this balance may be disturbed, loosening the surface of the soil, and exacerbating erosion caused by wind or runoff.

Erosion has been identified as a possible impact to INTG at WWF, potentially caused by increased stormwater runoff from WTG hard-stands. Fluctuations in bare ground may be a function of seasonality, particularly where sites have a high cover of annual weed species. Healthy sites should have a steady cover of perennial native species. The average percentage of bare ground has decreased since it was first recorded in 2019 and is within the desired 'healthy' range for this community.

5.2.2 Cryptogams

An important feature of grassland communities is the inter-tussock space between grasses, which in a healthy ecosystem is covered with a cryptogamic crust consisting of moss and lichen and supports a diversity of herbaceous plants. The structure of these grasslands creates an important ecological niche, with the grass tussocks providing filtration of water runoff for erosion control, and the cryptogamic crust holding the surface soil in place and providing seed collection and open feeding grounds for grassland fauna.

Cryptogamic crust averaged 31.34% across all Sites in 2024 and has been variable across the duration of the monitoring program (**Section 4.2.2**). The BCMM NAYP benchmark for this community indicates that up to 50% cover signifies a healthy inter-tussock space. It is not clear if a reduction in observed cryptogamic crust is a result of observer variation, seasonal conditions (making the crust less easily identifiable), or an actual reduction in cover. A cover of 31% is still within the healthy range for a community of this type, however this attribute should continue to be measured. As the reduction is not paired with a notable increase in bare ground, it is unlikely to be attributable to impacts such as erosion caused by stock trampling.

5.2.3 Litter Cover

Litter can be difficult to visually estimate due to a poor definition and/or understanding of litter in the sense of including live and dead *exotic* annual vegetation as a measure of predicted coverage on the ground after drying off. It is measured to indicate a variable which may impact on seedling germination of native plants. The BCMM NAYP guideline for litter cover in this ecosystem is <25%. In the NAYP region, and in grasslands across Australia, weed invasion is a widespread issue, with weeds accounting for more than 19% of the plant species present in Iron-grass NTG (Beeton 2007), in line with the average exotic litter cover score of 28.89% recorded in 2024.

Litter cover of 28.89% recorded in 2024 is much lower than the 52.81% recorded initially in 2019. This cover is slightly above the desired level and should continue to be monitored.

5.2.4 Native Cover

Broad-leaved herbs and twiners/vines, for example *Convolvulus* spp. (Bindweed), *Arthropodium* spp. (Lily) and *Wahlenbergia* spp. (Bluebell), should occur in the spaces between the grasses and tussocks, but many of these are annual or only seasonally evident, and together may contribute up to 30% cover. While no direct measure of the cover of these life forms was recorded at Assessment Sites, a diversity of these species were present at all Sites, and in high enough numbers for each Site to meet INTG Condition Class B (**Table 4.3** and **Table 4.4**).

5.2.5 Rock

Rock cover is not anticipated to show much change over the life of the wind farm, but is useful as an observer comparison, to indicate if there are inconsistencies with the method. In 2024 the average rock cover of 9.94% was on par with previous years, indicating that variation between observers is unlikely to explain any significant variation in estimations in 2024 or previous reporting years.

5.3 Ramble Survey

Species diversity is important because it creates adaptability and resilience within a grassland, where some species are adapted for dry conditions and others for wet, some grow in summer and others in winter, some are short lived and others slow growing. The diversity means that at all times of the year there should be something growing, providing live functioning roots year-round to provide a more resilient and erosion resistant ecosystem and reducing problems such as dust storms. A complex root system in turn creates a diverse soil ecosystem, which improves nutrient cycling and water holding capacity (NRMDB 2019).

All Sites surveyed in 2024 had 19–27 native species within the 50 m x 50 m area, representing what would be a ‘good’ to ‘excellent’ condition score given the BCMM for NAYP scores are based on a 30 m x 30 m area (**Table 4.3**). Across all Sites surveyed in 2024, there was an increase of one native species recorded compared to 2023. However, there was a drastic decrease in 2023, where the native diversity went from 43 in 2022 to 36 in 2023. The absent native species in 2023 were generally cryptic herbaceous plants that flower when conditions are optimal and the dry spring conditions that year were not favourable to such species. However, species diversity has remained constant across monitoring years since 2019 suggesting that most species present have been identified.

6.0 Recommendations

Data collected in 2024 and across the entire Lomandra Grassland Monitoring program to date, indicates that the seven patches of INTG within the WWF remain in a stable condition and are not currently being negatively impacted by operation of the wind farm. It is evident that many observed changes between years, such as species diversity, weed and native cover, and plants per hectare are not necessarily indicative of long-term trends, but rather, are attributable to seasonal climatic variation or impacts from grazing. As such, the following recommendations should be taken into consideration to maintain the health of the seven patches of INTG at WWF and to be able to determine non-seasonal variation.

6.1 Monitoring Methodology

Repeat monitoring, using the current methodology:

- Measure distance to nearest plant using PCQM (40 plants).
- Measure metrics of 40 perennial plants including basal width, height and percentage of dead material.
- Continue to record only the four most dominant perennial grasses at each Assessment Site using the PCQM (*Rytidosperma* spp., *Austrostipa* spp., *Aristida behriana*, *Lomandra* ssp.).
- Continue to report 'Importance Value' based on the basal width, frequency and dominance of perennial grasses measured using PCQM (in place of plant volume and canopy cover which is deemed more relevant when using PCQM for woodland sites).
- Continue to measure the percentage cover of bare ground, litter, cryptogams, native cover and rock (grassland health indicators).
- Continue to monitor presence/absence of Lomandra tussocks in each quadrat (n=10) at all Assessment Sites.
- Continue to undertake ramble survey within each Assessment Site for species diversity and determination of INTG TEC Condition Class.
- Continue to search for threatened flora within each Assessment Site.
- Continue to undertake annual weed assessment (independently of Lomandra Grassland Monitoring program).

6.2 Other Recommendations

- Continue to conduct the Lomandra Grassland Monitoring program to determine whether operation of the wind farm negatively impacts the INTG.
- Undertake weed management actions as outlined in the WWF Weed Assessment Report 2024 (Umwelt 2025), to ensure that weed spread is detected and addressed promptly, as this is considered the main threat to INTG attributable to the operation of WWF, in particular:
    - Actively engage landholders to undertake best practice weed control (grazing, slashing, spraying, physical removal) at WWF.

- Continue low-level sheep grazing, preferably in winter months, to ensure inter-tussock spaces are kept open for the recruitment of broad-leaved herbs.
- Reduce sheep grazing during spring to prevent overgrazing and inability for broad-leaved herbs to recruit.

- Ensure any management actions (including weed management and grazing management) undertaken by ENGIE and/or landholders are communicated and documented to enable long term monitoring observations to be correlated with land management. This includes recording:
  - Approximate grazing regime (stocking density, type and duration) for the 12 months prior to survey for each Site (if different).
  - Location and method of any targeted weed control undertaken within WWF or Lomandra Grassland to enable tracking of success.
- Undertake ongoing evaluation of monitoring techniques to supplement or amend the current methodology (if required).

7.0 References

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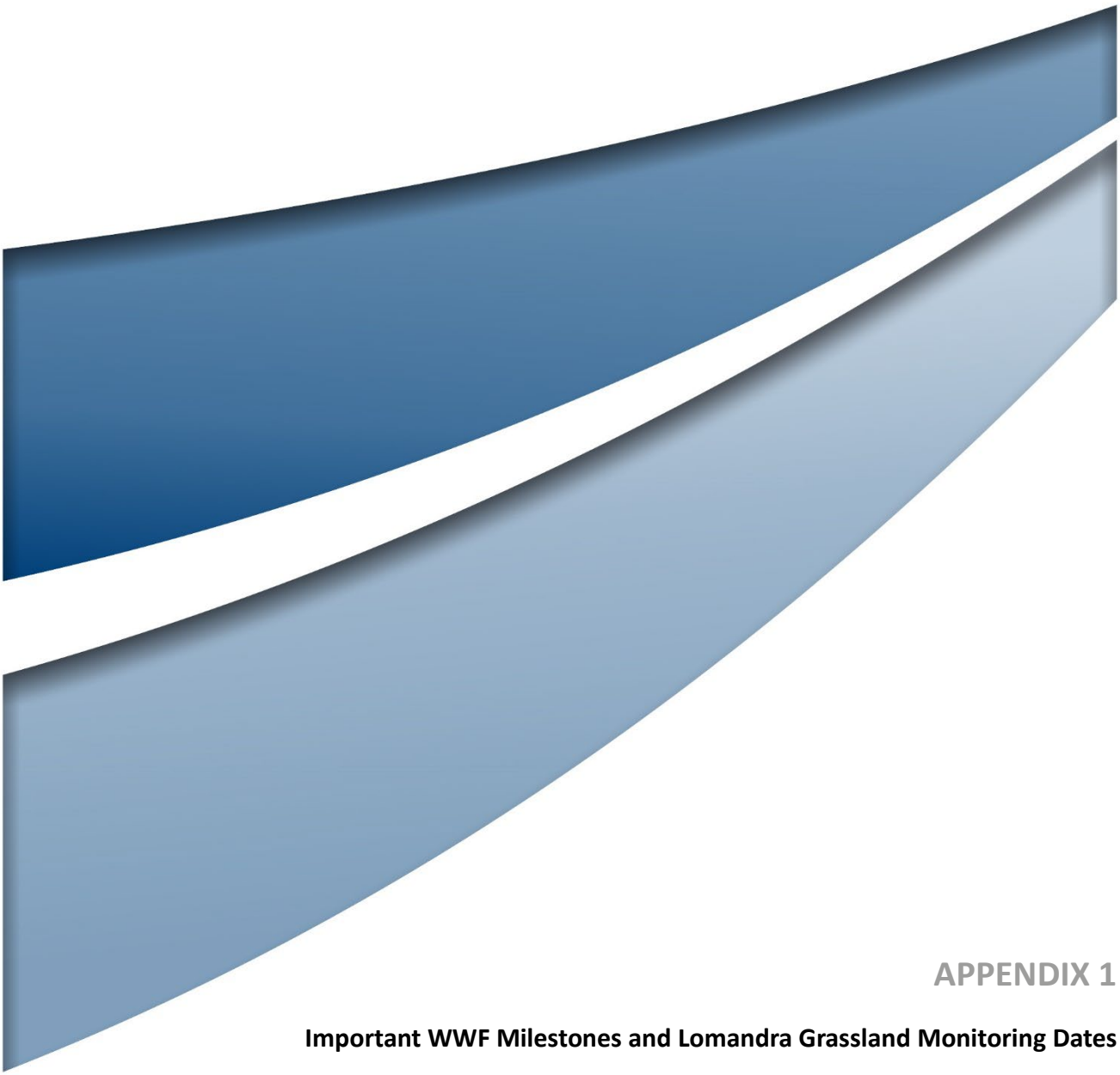
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APPENDIX 1

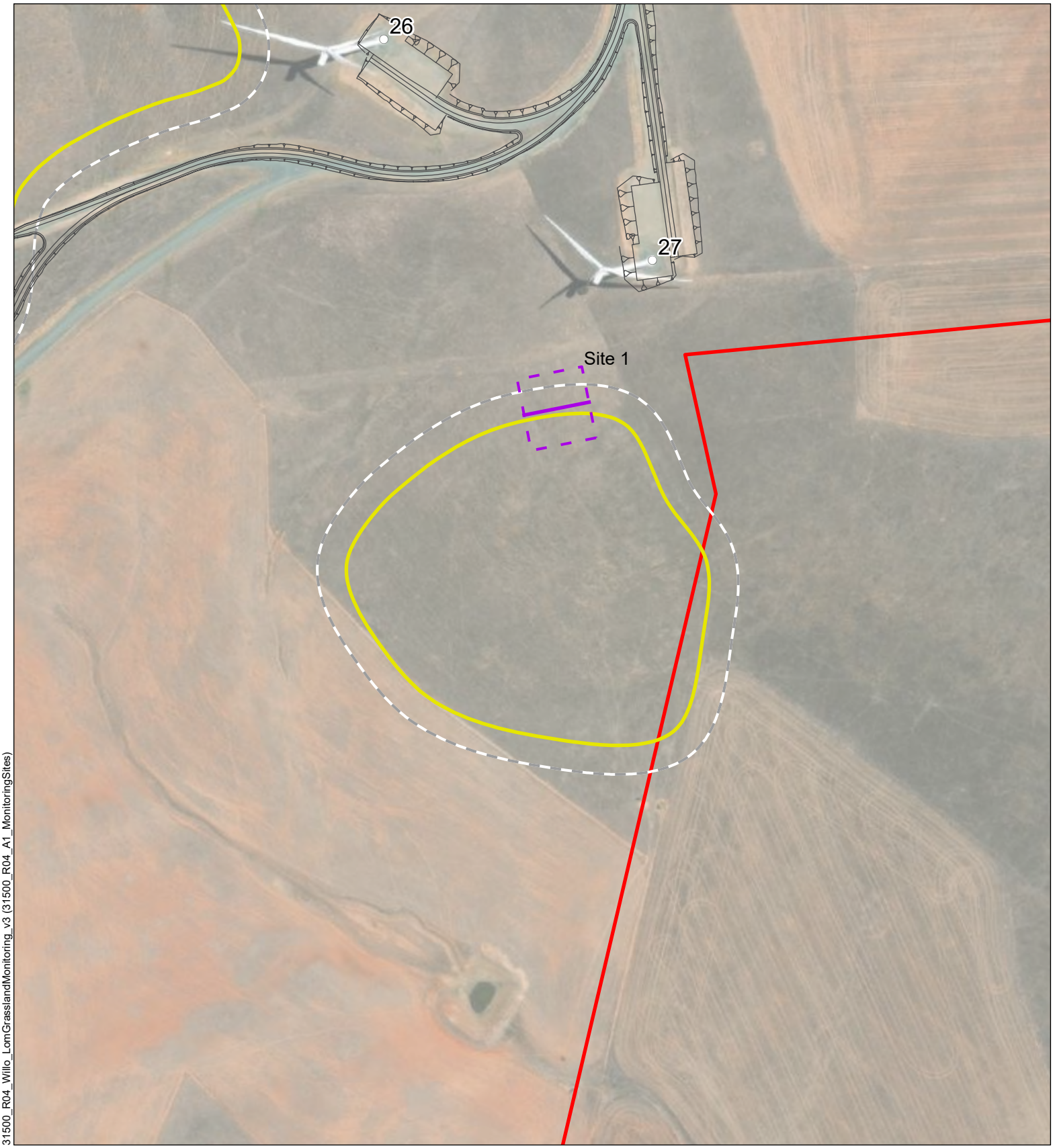
Important WWF Milestones and Lomandra Grassland Monitoring Dates

Year	Phase	Date(s)	Comment
2010	EPBC Assessment	12–13 October 2010	Six INTG Condition Class B sites and one INTG Condition Class C site identified.
2014	Approval	28 January 2014	EPBC Approval granted with conditions.
2016	Approval	12 December 2016	Variation to Conditions attached to EPBC Approval received.
2017	Construction commenced	4 September 2017	The 'action'.
2017	Baseline	13–15 November 2017	Lomandra Grassland Monitoring completed and considered the 'Baseline' for condition of sites. *Willogoleche Wind Farm Lomandra Grassland Monitoring Report 2017* (EBS Ecology 2018)
2018	Construction	13–14 November 2018	Monitoring undertaken during construction. *Willogoleche Wind Farm Lomandra Grassland Monitoring Report 2018* (EBS Ecology 2019b)
2019	Operation commenced	12 November 2019	Willogoleche Power, on behalf of ENGIE, commenced operation of WWF.
2019	Operation	11–13 November 2019	Monitoring undertaken at the completion of construction / commencement of operation (Operation Year 0). New methodology added. *Willogoleche Wind Farm Lomandra Grassland Monitoring Report 2019* (EBS Ecology 2020)
2020	Operation	16–18 November 2020	Monitoring undertaken during operation (Operation Year 1). *Willogoleche Wind Farm Lomandra Grassland Monitoring Report 2020* (EBS Ecology 2021)
2021	Operation	2–5 November 2021	Monitoring undertaken during operation (Operation Year 2). PCQM methodology altered, and new method added. *Willogoleche Wind Farm Lomandra Grassland Monitoring Report 2021* (EBS Ecology 2022)
2022	Operation	2–4 November 2022	Monitoring undertaken during operation (Operation Year 3). *Willogoleche Wind Farm Lomandra Grassland Monitoring Report 2022* (EBS Ecology 2023)
2023	Operation	1–3 November 2023	Monitoring undertaken during operation (Operation Year 4). Grassland health indicators altered. *Willogoleche Wind Farm Lomandra Grassland Monitoring Report 2023* (EBS Ecology 2024)
2024	Operation	21–23 October 2024	Monitoring undertaken during operation (Operation Year 5). This report.

APPENDIX 2

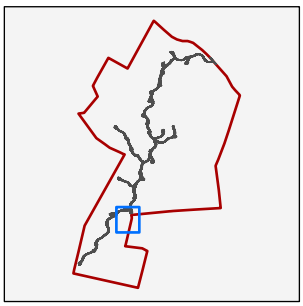
Assessment Site Location Maps

Lomandra Grassland Monitoring Site 1



Willogoleche Wind Farm project boundary
Windfarm infrastructure
Monitoring transect
25m Transect Buffer (Ramble Area)
Lomandra Grassland Buffer (20m)

Iron-grass Natural Temperate Grassland of South Australia
Category B



31500_R04_Willo_LomGrasslandMonitoring_v3 (31500_R04_A1_MonitoringSites)

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Environmental & Social Consultants

Data Source: Umwelt (2025), ESRI (2025), DEW (2022), DIT (2022)

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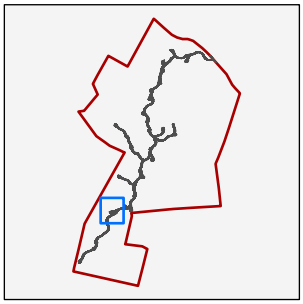
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Lomandra Grassland Monitoring Site 2



Willogoleche Wind Farm project boundary
Windfarm infrastructure
Monitoring transect
25m Transect Buffer (Ramble Area)
Lomandra Grassland Buffer (20m)

Iron-grass Natural Temperate Grassland of South Australia
Category B



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Lomandra Grassland Monitoring Site 3



31500_R04_Willo_LomGrasslandMonitoring_v3 (31500_R04_A1_MonitoringSites)

Willogoleche Wind Farm project boundary

Windfarm infrastructure

Monitoring transect

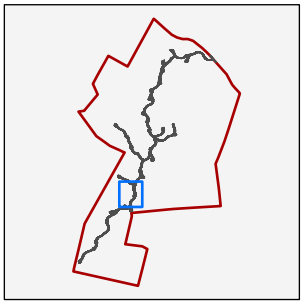
25m Transect Buffer (Ramble Area)

Lomandra Grassland Buffer (20m)

Iron-grass Natural Temperate Grassland of South Australia

Approximate extent of Lomandra Grassland

Category B



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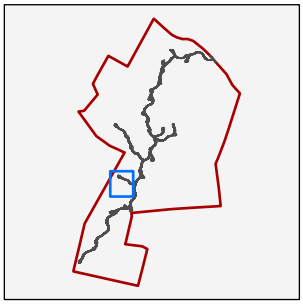
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Lomandra Grassland Monitoring Site 4



Willogoleche Wind Farm project boundary
Windfarm infrastructure
Monitoring transect
25m Transect Buffer (Ramble Area)
Lomandra Grassland Buffer (20m)

Iron-grass Natural Temperate Grassland of South Australia
Approximate extent of Lomandra Grassland
Category B



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Lomandra Grassland Monitoring Site 5



Willogoleche Wind Farm project boundary

Windfarm infrastructure

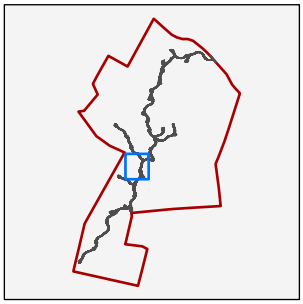
Monitoring transect

25m Transect Buffer (Ramble Area)

Lomandra Grassland Buffer (20m)

Iron-grass Natural Temperate Grassland of South Australia

Category C



31500_R04_Willo_LomGrasslandMonitoring_v3 (31500_R04_A1_MonitoringSites)

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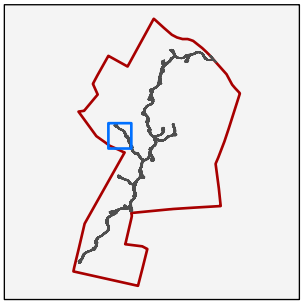
Lomandra Grassland Monitoring Site 6



Willogoleche Wind Farm project boundary
Windfarm infrastructure
Monitoring transect
25m Transect Buffer (Ramble Area)
Lomandra Grassland Buffer (20m)

Iron-grass Natural Temperate Grassland of South Australia

Approximate extent of Lomandra Grassland
Category B



31500_R04_Willo_LomGrasslandMonitoring_v3 (31500_R04_A1_MonitoringSites)

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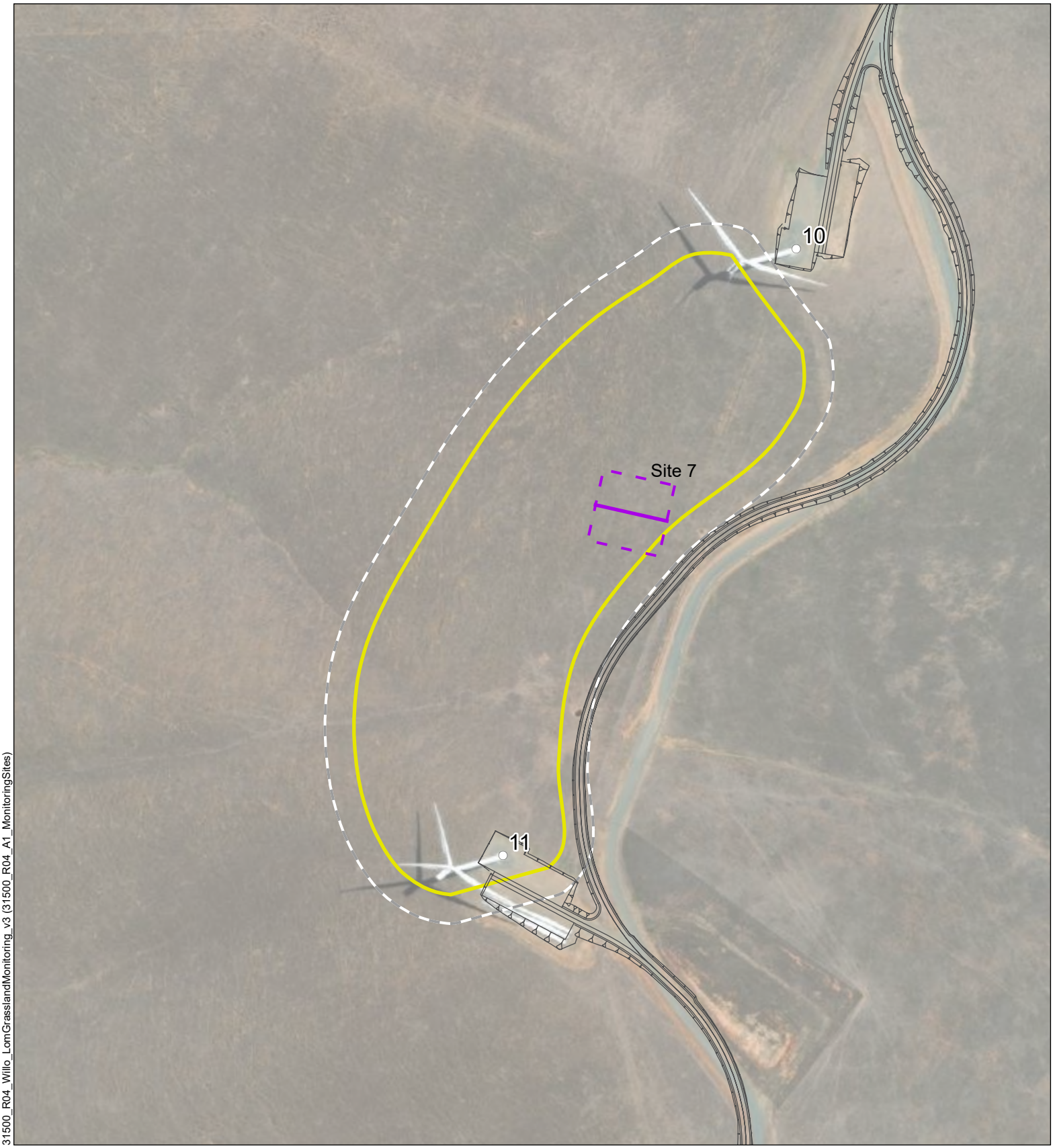
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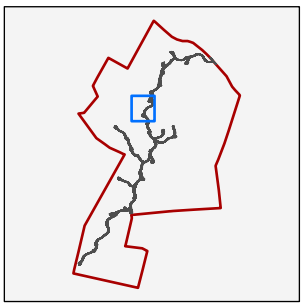
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Lomandra Grassland Monitoring Site 7



Willogoleche Wind Farm project boundary
Windfarm infrastructure
Monitoring transect
25m Transect Buffer (Ramble Area)
Lomandra Grassland Buffer (20m)

Iron-grass Natural Temperate Grassland of South Australia
Category B



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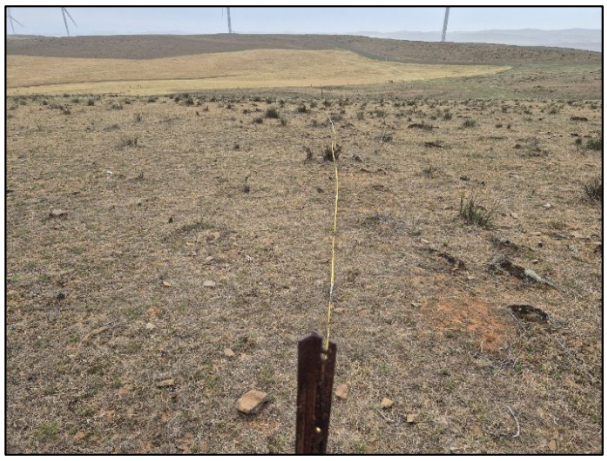
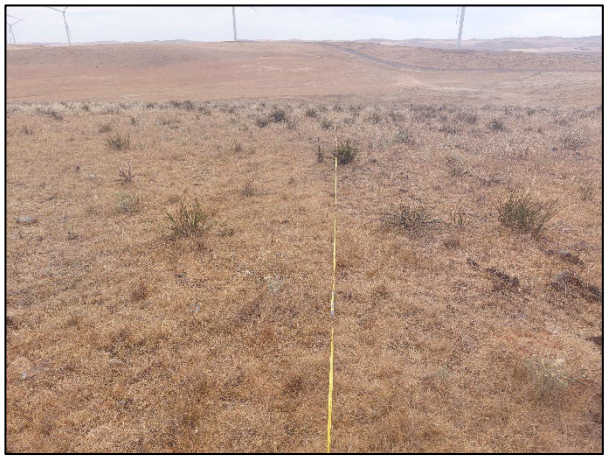
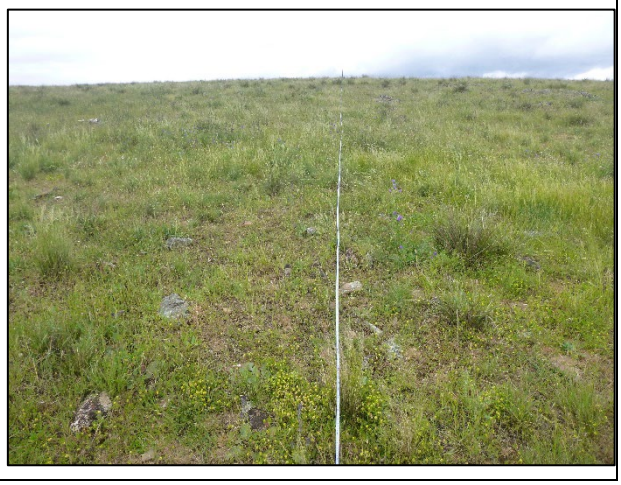
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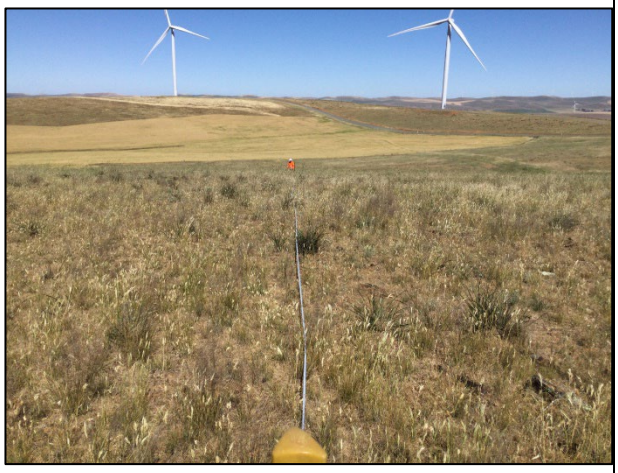
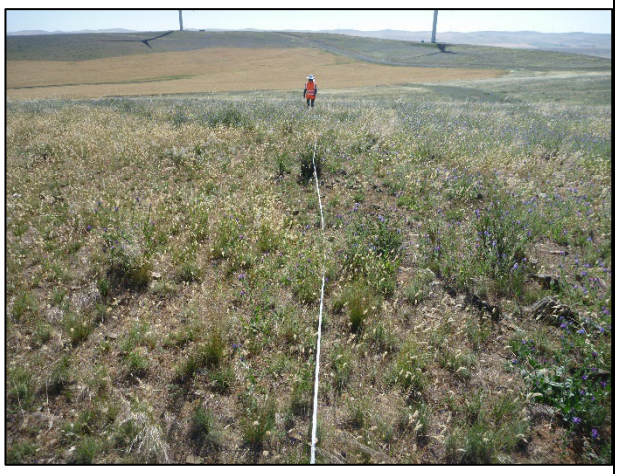
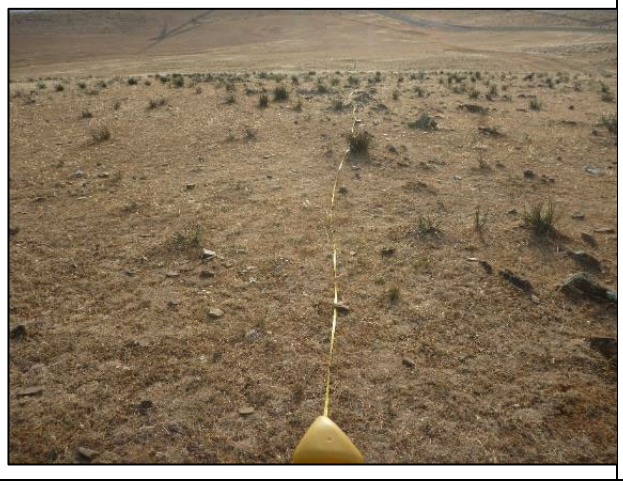
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APPENDIX 3

Assessment Site Photographs

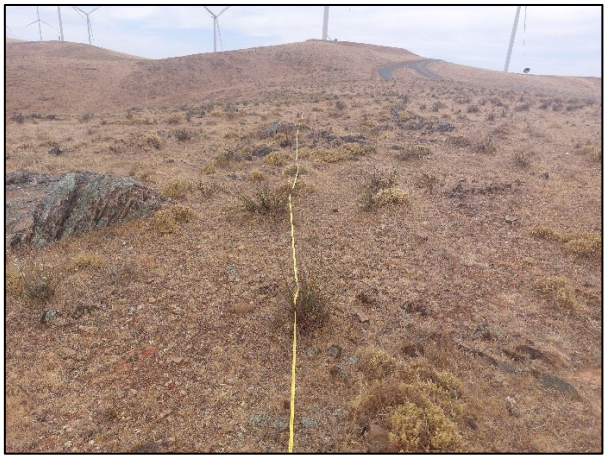
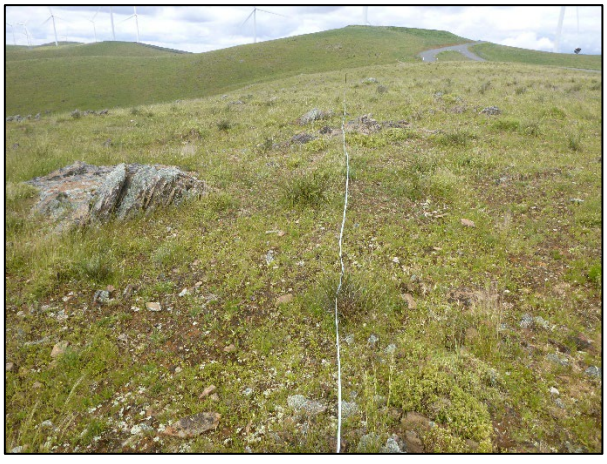
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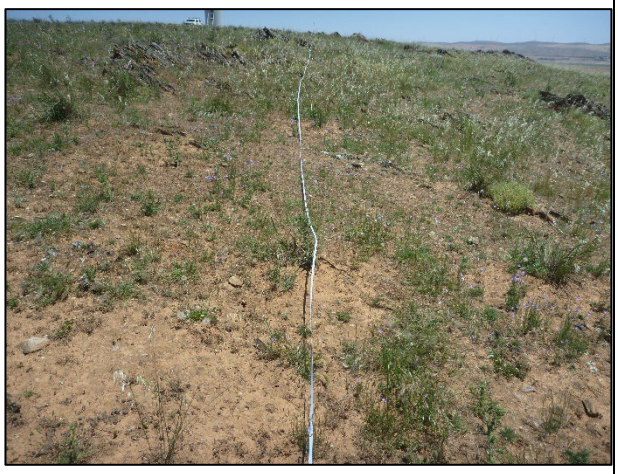
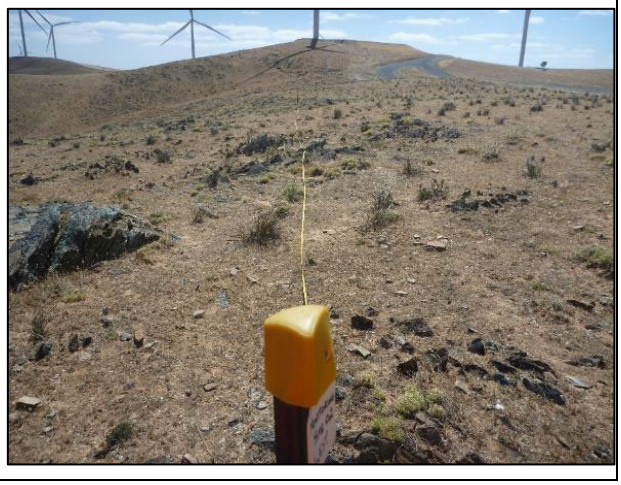
	Transect Start (0 m; eastern end, looking west)	Transect End (50 m; western end, looking east)
2024		
2023		
2022		

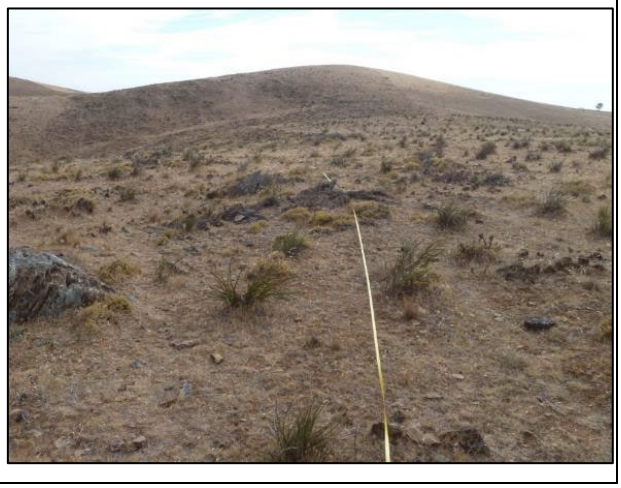
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2021		
2020		
2019		

	Transect Start (0 m; eastern end, looking west)	Transect End (50 m; western end, looking east)
2017		

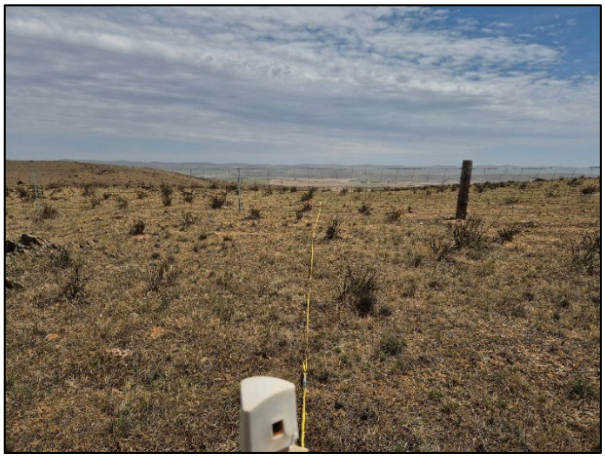
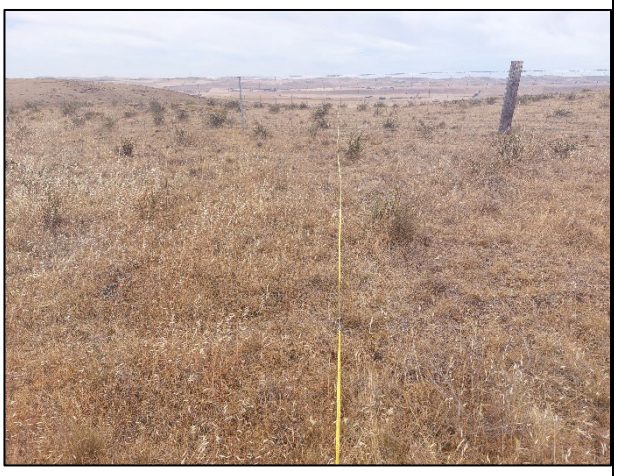
Assessment Site 2

	Transect Start (0 m; Eastern End; Looking West)	Transect End (50 m; Western End, Looking East)
2024		
2023		
2022		

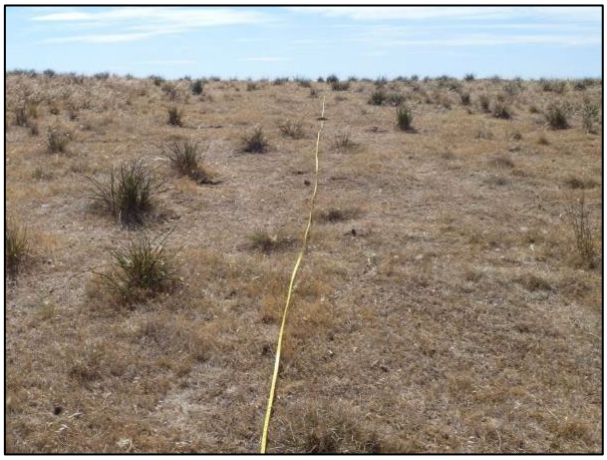
	Transect Start (0 m; Eastern End; Looking West)	Transect End (50 m; Western End, Looking East)
2021		
2020		
2019		

	Transect Start (0 m; Eastern End; Looking West)	Transect End (50 m; Western End, Looking East)
2017		

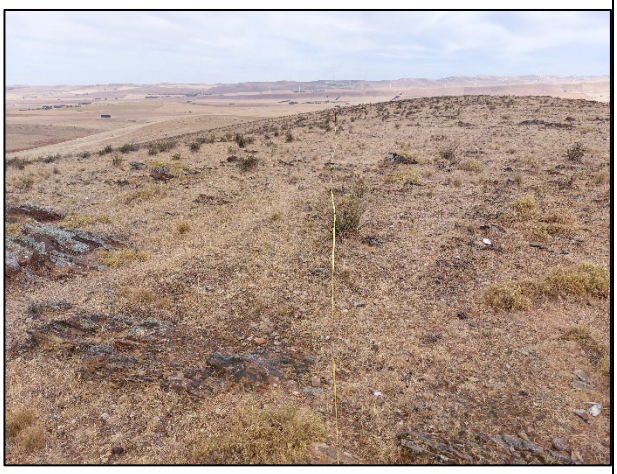
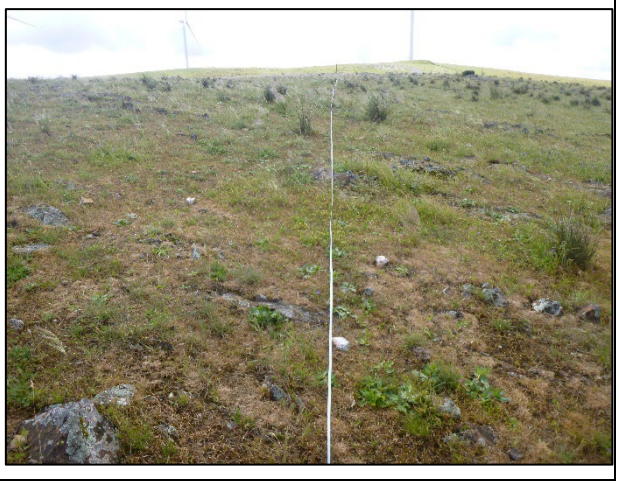
Assessment Site 3

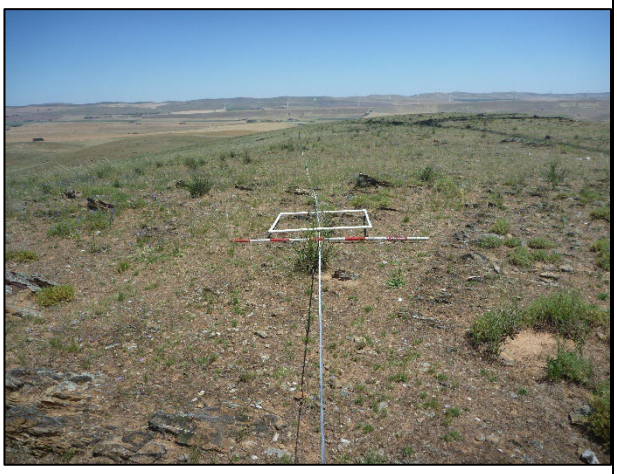
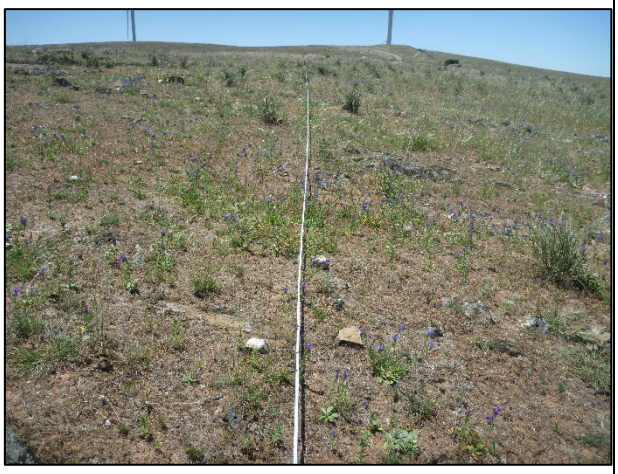
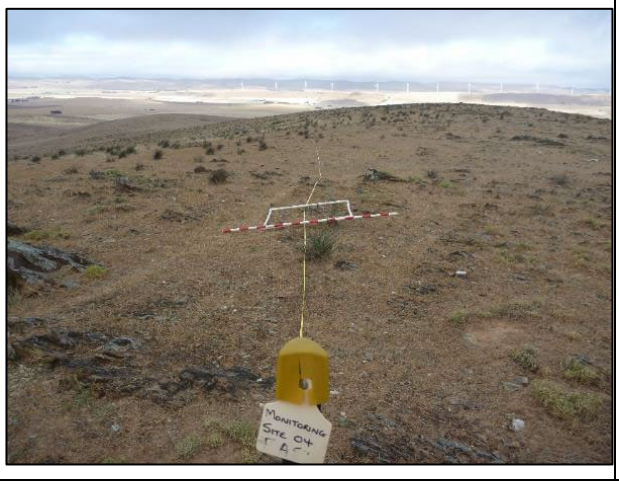
	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2024		
2023		
2022		

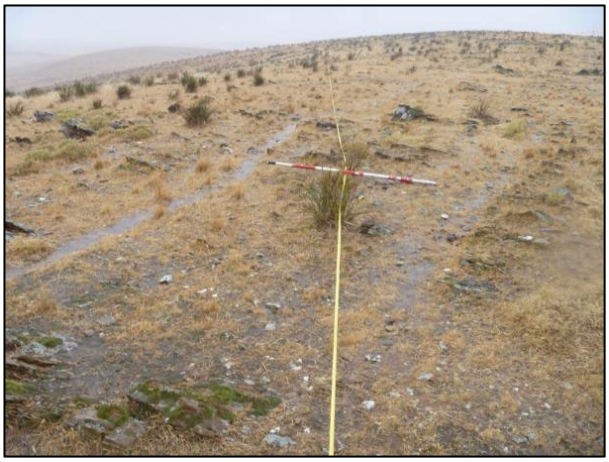
	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2021		
2020		
2019		

	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2017		

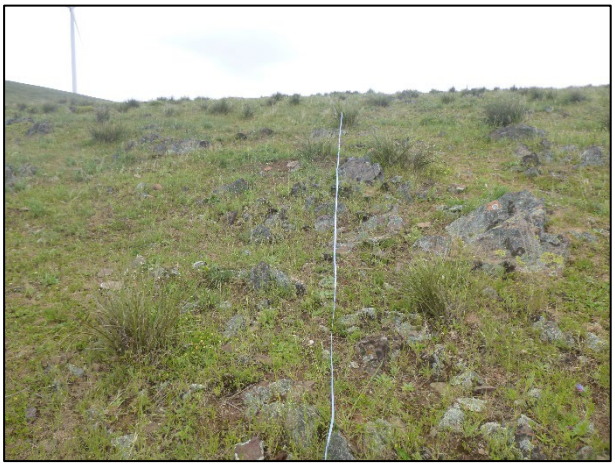
Assessment Site 4

	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2024		
2023		
2022		

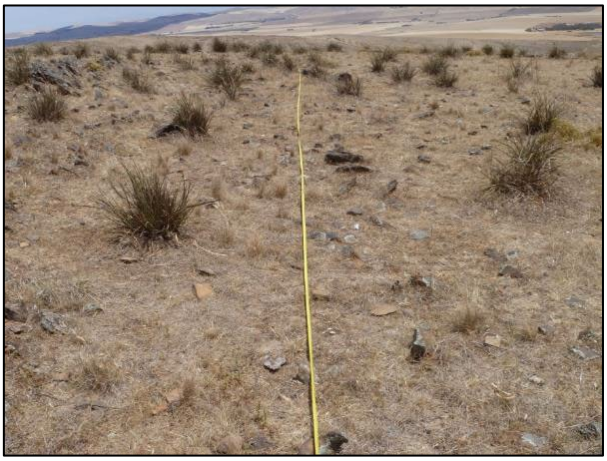
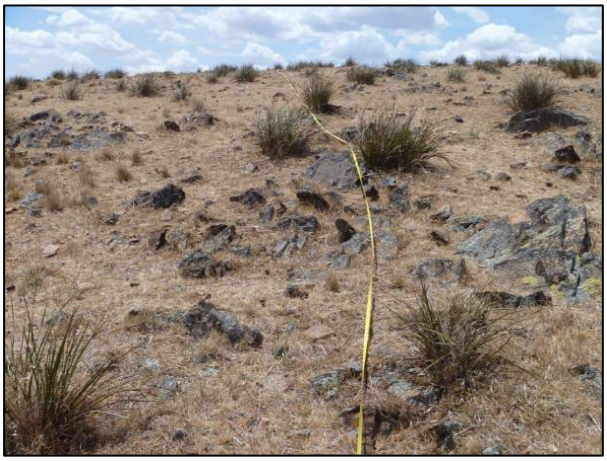
	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2021		
2020		
2019		

	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2017		

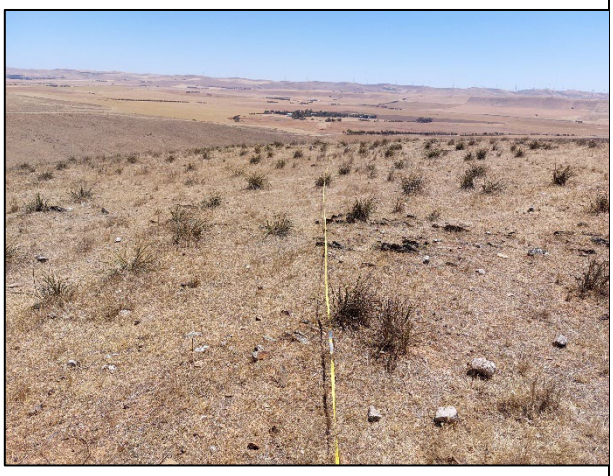
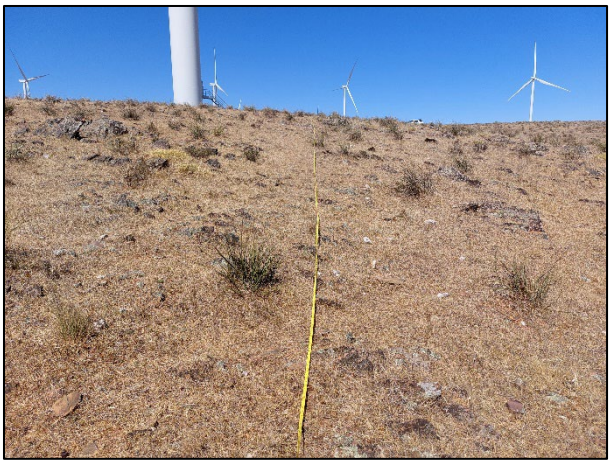
Assessment Site 5

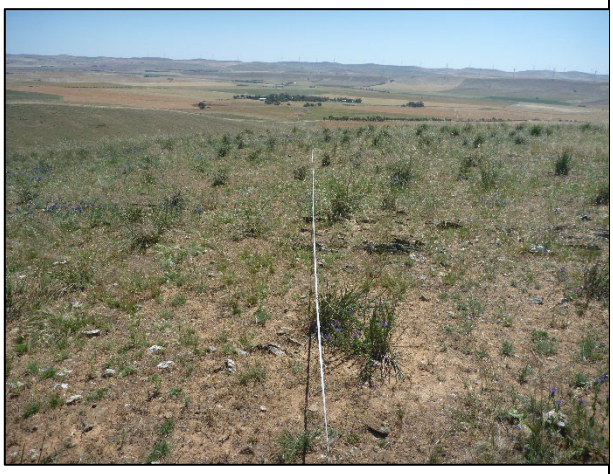
	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2024		
2023		
2022		

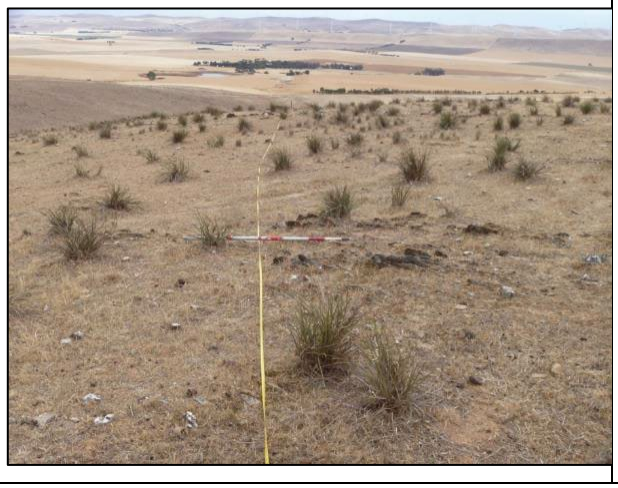
	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2021		
2020		
2019		

	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2017		

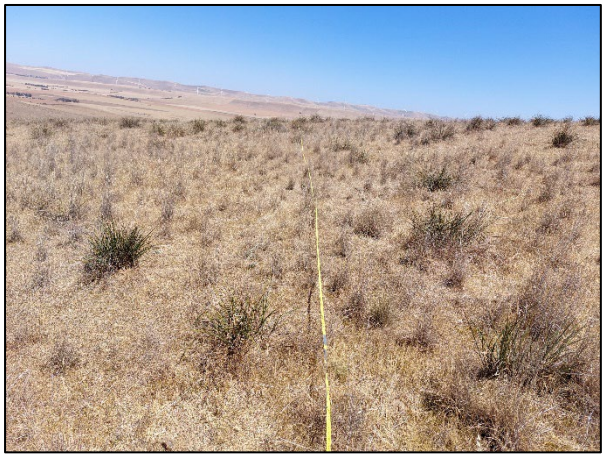
Assessment Site 6

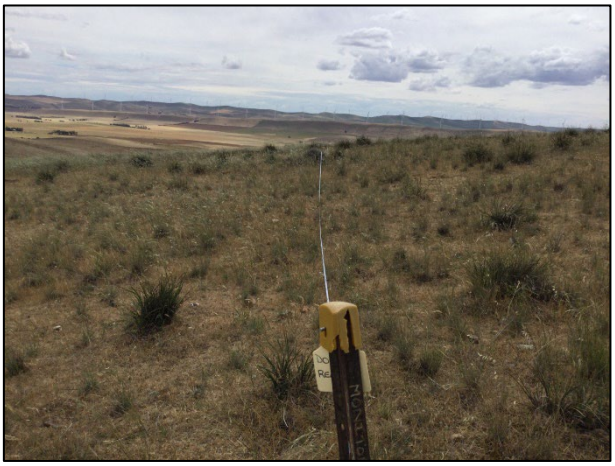
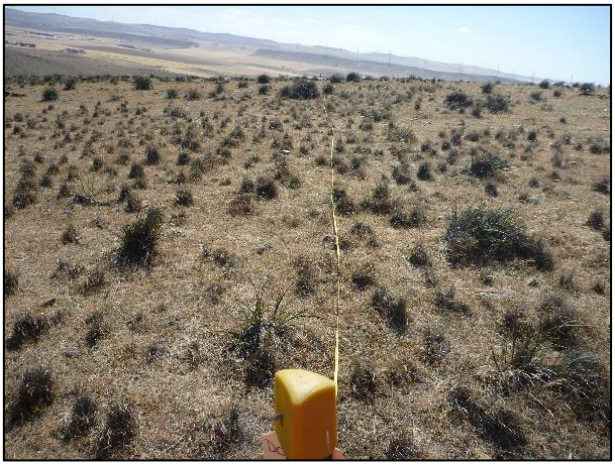
	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2024		
2023		
2022		

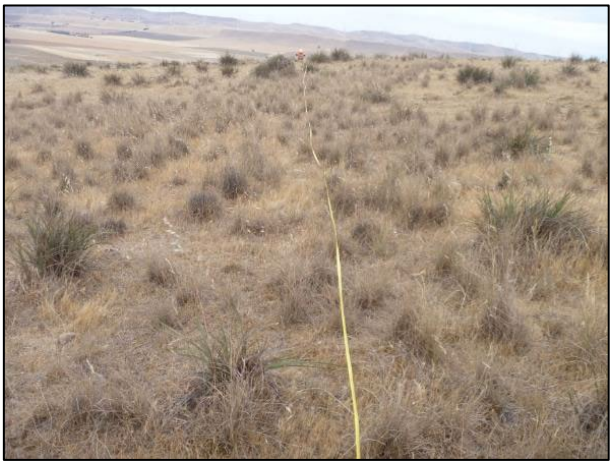
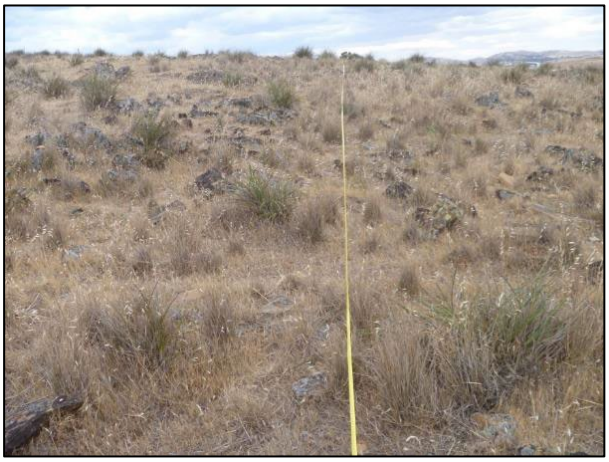
	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2021		
2020		
2019		

	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2017		

Assessment Site 7

	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2024		
2023		
2022		

	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2021		
2020		
2019		

	Transect Start (0 m; Eastern End, Looking West)	Transect End (50 m; Western End, Looking East)
2017		



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