

**Willogoleche Wind Farm Offset Area**  
**Monitoring Report 2022**

# Willogoleche Wind Farm Offset Area Monitoring Report 2022

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Prepared by EBS Ecology for ENGIE

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## GLOSSARY AND ABBREVIATION OF TERMS

%	Percent / Percentage
BOM	Bureau of Meteorology
DSE	Dry Sheep Equivalent
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Commonwealth)
DEW	Department of Environment and Water
DEWR	Department of the Environment and Water Resources (now DAWE)
DotEE	Department of the Environment and Energy (Commonwealth) (now DAWE)
DPIRD	Department of Primary Industries and Regional Development (Western Australia)
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
EBS	Environmental and Biodiversity Services, <i>trading as</i> EBS Ecology
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
GPS	Global Positioning System
Ha(s)	Hectare(s)
Iron-grass NTG	Iron Grass Natural Temperate Grassland of South Australia
km	kilometre(s)
LMR	Landscape Management Region
LSA Act	<i>Landscape South Australia Act 2019</i>
m	metre(s)
m <sup>2</sup>	square metre(s)
mm	millimetres
NRMDB	Natural Resources Murray-Darling Basin
NY NRM	Northern and Yorke Natural Resources Management Board (superseded, now Landscape South Australia, Northern and Yorke)
NPW Act	<i>National Parks and Wildlife Act 1972</i>
NTG	Natural Temperate Grassland
NVC	Native Vegetation Council
OMP	Offset Management Plan
PCQM	Point-centred Quarter Method
PPH	Perennial plants per hectare
Project	the Willogoleche Wind Farm
SA	South Australia(n)
SD	Standard Deviation
sp.	species
spp.	species (plural)
ssp.	sub species
TEC	Threatened Ecological Community
WTG	Wind Turbine Generator
WWF	Willogoleche Wind Farm

## EXECUTIVE SUMMARY

### **Background**

ENGIE have established an Offset Area to meet the conditions associated with the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval for the Willogoleche Wind Farm (WWF) (EPBC 2011/5850). The main aim of the Offset Area is to protect and restore a representative patch of an Iron-grass Natural Temperate Grassland community, to provide an overall biodiversity gain that adequately compensates for the impacts associated with the development of the WWF. The Offset Area is required because of impacts to EPBC Act listed Threatened Ecological Community (TEC) Iron-grass Natural Temperate Grassland of South Australia (Iron-grass NTG). Landscape features and management requirements for the Offset Area are outlined in the *Willogoleche Wind Farm Offset Management Plan EPBC 2011/5850* (OMP), which includes minimum targets for key indicators and management actions required to meet the targets, as well as monitoring and reporting requirements. This report details the results of the 2022 survey (year 4 of monitoring) of the Offset Area.

### **Methodology**

Monitoring of the Offset Area commenced in 2018 (baseline year 0) using the Point Centre Quarter Method (PCQM) and qualitative observations in designated Assessment Sites. In 2019 (year 1) monitoring was supplemented with additional methods including - (1) an assessment of the EPBC Act Condition Class of the Assessment Sites and (2) grassland health indicator data (percentage (%) cryptogams, % litter, % bare ground, % rock and % native cover). In 2021 (year 3) monitoring of grassland health indicators was supplemented with the addition of a *Lomandra* tussock presence / absence count at quadrats. In 2022 (year 4) no new methods were added and all previous methods were utilised to assess the key EPBC Offset monitoring indicators.

### **Summary of results and discussion**

In 2022 the Offset Area was found to have generally improved in condition since the baseline survey in 2018, with increased plant health (height, percent dead material) and reduced grazing pressure. While the actual grazing regime implemented is not known, it appeared that grazing had been ceased all together, resulting in high weed and litter cover. If allowed to continue without an appropriate grazing regime, gains in the health of the grassland since 2018 are likely to be lost in subsequent years.

A total of 18 native species were found across the Offset Area in 2022. A decrease or plateau in species diversity was recorded at both Site 1 and Site 2 respectively. In 2022, Site 1 recorded a species diversity of 17 (down from 20 in 2021 and 2020), while Site 2 maintained a lower species diversity of 14 which was also observed in the previous year and is lower than what was observed in 2019 (when EPBC ramble survey method was introduced). As such, Site 2 now does not meet criteria of Condition Class B assessed under the TEC listing criteria for Commonwealth INTG Listing Advice.

Site health attributes were within the benchmark goal range for most attributes for both sites, however a decline in the cover of cryptogams and an increase in litter indicate a reduction in site health across the sites. A high rainfall year in 2020, followed by above average rainfall in the two months prior to the 2022 survey enabled a proliferation of weed species across the Offset Area, which is likely to have resulted in the high litter cover observed during both the 2021 and 2022 surveys. Coupled with an inappropriate (non-

existent) grazing regime, the inter-tussock space between Lomandra and native grasses was not ideal for promoting the regeneration of native grass or herbaceous species.

### **Recommendations**

The following actions are recommended:

- Resume periodic grazing in the Offset Area between May and November, allowing maximum 7 days grazing followed by at least 4 weeks rest.
- No grazing is to occur during late spring / early summer to allow native seed set (i.e., between November and May).
- Manage grazing according to seasonal conditions by:
  - Reducing grazing duration and frequency in dry conditions and do not enable grasses to be grazed to less than 5 cm in height.
  - Start grazing later in winter and stop earlier in spring.
- Weed control should focus on removal of isolated patches of weeds identified in the 2022 survey, including:
  - Removal of large *Cynara cardunculus* (Artichoke Thistle) near Site 1.
  - Remove singular *Medicago sativa* (Alfalfa) plant from Site 1 to prevent its spread.
  - Control patch of *Foeniculum vulgare* (Fennel) along south-eastern fence line of Offset Area.
- Management actions undertaken by the landholder in relation to the EBPC Offset Area, should be recorded (using the Activity Record Datasheet, and Paddock Monitoring Sheets provided in the Appendices of this report) and reported annually to enable management actions to be linked to condition outcomes including:
  - Timing, duration and intensity (stocking rate) of grazing
  - Targeted weed control (i.e., spot spraying, hand removal)
- As part of the OMP an annual review is recommended as part of the annual monitoring and reporting program, including liaison between the landholder, ENGIE and ecological consultant(s). It is recommended that following finalisation of this report, a meeting between involved parties be arranged to discuss management actions going forwards. Following the initial five-year period (2018-2022), a review of the management plan is to be undertaken using the data collated thus far, in association with landholder input, to inform the 2022-2042 management plan to be submitted to the property owners, Federal Minister (through the Department of Climate Change, Energy, the Environment and Water [DCCEEW]) and the Native Vegetation Council (NVC) for approval.

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# 1 INTRODUCTION

ENGIE have established an Offset Area to meet the conditions associated with the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval for the Willogoleche Wind Farm (WWF) (EPBC 2011/5850). The Offset Area is required because of impacts to the EPBC Act listed Threatened Ecological Community (TEC) Iron-grass Natural Temperate Grassland of South Australia (INTG).

The Offset Area was established and placed under Heritage Agreement (under State legislation) (HA 1602), registered on 9<sup>th</sup> August 2019, and must be managed for condition improvement consistent with EPBC Offsets Policy. The main aim of the Offset Area is to protect and restore a representative patch of an INTG community, to provide an overall biodiversity gain that adequately compensates for the impacts associated with the development of the WWF. Under the *EPBC Act 1999 Environmental Offsets Policy* (DSEWPac 2012), the patch must meet a series of Offset Principles outlined in the document to deliver an overall conservation outcome that improves or maintains the health, diversity, and productivity of the environment as it relates to these matters. Management of the Offset Area is outlined within the *Willogoleche Wind Farm Offset Management Plan* (OMP) (EBS 2017) which includes minimum targets for key indicators and management actions required to meet the targets, as well as monitoring and reporting requirements. Refer to the OMP (EBS 2017) for more detail.

## 1.1 Objectives

The original condition of the Offset Area was established during initial assessment of the site in 2013 (EBS 2013), based on the core management objectives for the Offset Area, as listed in the OMP (EBS 2017). The OMP was submitted to the Minister for approval on the 18<sup>th</sup> of January 2017, three months prior to the commencement of construction, and was approved by the Minister on the 3<sup>rd</sup> of February 2017.

Permanent monitoring sites were not established in 2013, therefore quantitative baseline data was collected for the first time in 2018 (year 0) (EBS 2018), and annually since 2019 (year 1). Table 1 outlines the monitoring schedule and other important dates associated with the Offset Area. The 2022 survey represents year 4 of monitoring and was undertaken using refined methods with results presented in the current report.

As per the OMP the current report aims to:

- Describe the year 4 monitoring methodology and present the year 4 monitoring results.
- Compare year 4 monitoring results to baseline monitoring (2018 year 0) and subsequent annual monitoring.
- Measure the condition of the Offset Area against goals set out in the OMP.
- Provide discussion and recommendations regarding management of the Offset Area.
- Provide discussion and recommendations regarding the monitoring program.

**Table 1. Schedule of important dates, monitoring and Offset Area milestones.**

Year	Phase	Date(s)	Comment
2014	Approval	28 <sup>th</sup> January 2014	EBPC Approval granted with conditions.
2017	Planning	18 <sup>th</sup> January 2017	Offset Management Plan (OMP) submitted.
2017	Approval	3 <sup>rd</sup> February 2017	OMP approved
2017	Approval	2 <sup>nd</sup> February 2017	Heritage Agreement under <i>Native Vegetation Act 1999</i> over the Offset Area confirmed.
2018	Baseline (year 0)	8 <sup>th</sup> October 2018	Offset Area baseline survey.
2019	Approval	9 <sup>th</sup> August 2019	Heritage Agreement registered.
2019	Monitoring (year 1)	13 <sup>th</sup> November 2019	New methodology added.
2020	Monitoring (year 2)	18 <sup>th</sup> November 2020	
2021	Monitoring (year 3)	5 <sup>th</sup> November 2021	PCQM methodology altered, and new method added.
2022	Monitoring (year 4)	4 <sup>th</sup> November 2022	

## 2 BACKGROUND

### 2.1 Offset Area

The Willogoleche Wind Farm (WWF; the Project) is located approximately six kilometres (km) west of the township of Hallett in the Mid North of South Australia. The Project comprises of 32 wind turbines, an electrical substation, operation and maintenance facility and associated access tracks and infrastructure. Construction works for the WWF commenced on 9 September 2017 and sectional completion was achieved on 12 November 2019. However, the WWF had been generating and exporting electricity to the grid during the commissioning and optimisation process for several months prior to the date of sectional completion.

The Offset Area is located adjacent to the WWF boundary on Woodman Road, within two kilometres of WWF in the southwest vicinity as indicated in Figure 1. The Offset Area is approximately four hectares (ha) in size and located within a larger area of *Lomandra multiflora* subsp. *dura* Open Tussock Grassland that is utilised for grazing (EBS 2017).

The Offset Area was in poor to moderate condition at the time of writing the OMP, meeting the criteria for a condition Class C Grassland (EBS 2017), based on criteria outlined in the listing advice (TSSC, 2007).

### 2.2 Monitoring Program Objectives

The proposed management of the Offset Area aims to address the following key Recovery Actions from the National Recovery Plan for the Iron-grass Natural Temperate Grassland of South Australia ecological community (Turner, 2012):

- Strategy 3: Increase the area of the EPBC listed Iron-grass Natural Temperate Grassland secured and managed for conservation.
- Strategy 4: Maintain or improve the condition and integrity of the EPBC listed Iron-grass Natural Temperate Grassland remnants using 'best practice' strategies.
- Strategy 5: Increase the area of occupancy of the EPBC listed Iron-grass Natural Temperate Grassland ecological community across its natural range.

Based on the Commonwealth listing Advice (TSSC 2007), the core management objectives for the Offset Area as listed in the OMP (EBS 2017) include:

- Increase the condition classification for the site from a **Condition Class C** to a **Condition Class B** (or higher).
- Increase the diversity of native flora species from nine to above 15 species.
- Increase the number of broad-leaved herbaceous flora species (in addition to disturbance resistance species) to three or more species.
- Increase the number of perennial native grass species to four or more species.
- Increase the density of tussock grass species to one per metre.
- Manage feral animal populations.

- Establish long-term scientific monitoring sites to demonstrate attainment of condition class targets.

The OMP outlines a range of ecological indicators and desired outcomes, presented in Table 2.

**Table 2. Ecological indicators and desired outcomes (EBS 2017).**

Ecological indicator	Suggested method	Desired outcome	Interim 5 yr. target	Interim 10 yr. target	Target (16 years)
Plant species diversity	Two 50 x 50 m quadrats (ramble survey)	Increase in native species diversity from 9 (observed in 2017) to 15 or more species.	11	13	15+
Perennial native grass species diversity	Two 50 x 50 m quadrats (ramble survey)	Increase native grass species from two to four or more species.	3	4	4
Broad-leaf native herbaceous species diversity	Two 50 x 50 m quadrats (ramble survey)	Increase the broad-leaf native herbaceous species from one to three or more (excluding disturbance resistant species).	1	2	3
Density of Tussock Grassland Species including native grass and iron-grass)	Two 50 m point count transects.	Increase density of tussock species to one per metre.	1 per 10 metres (m)	1 per 5 m	1 per m

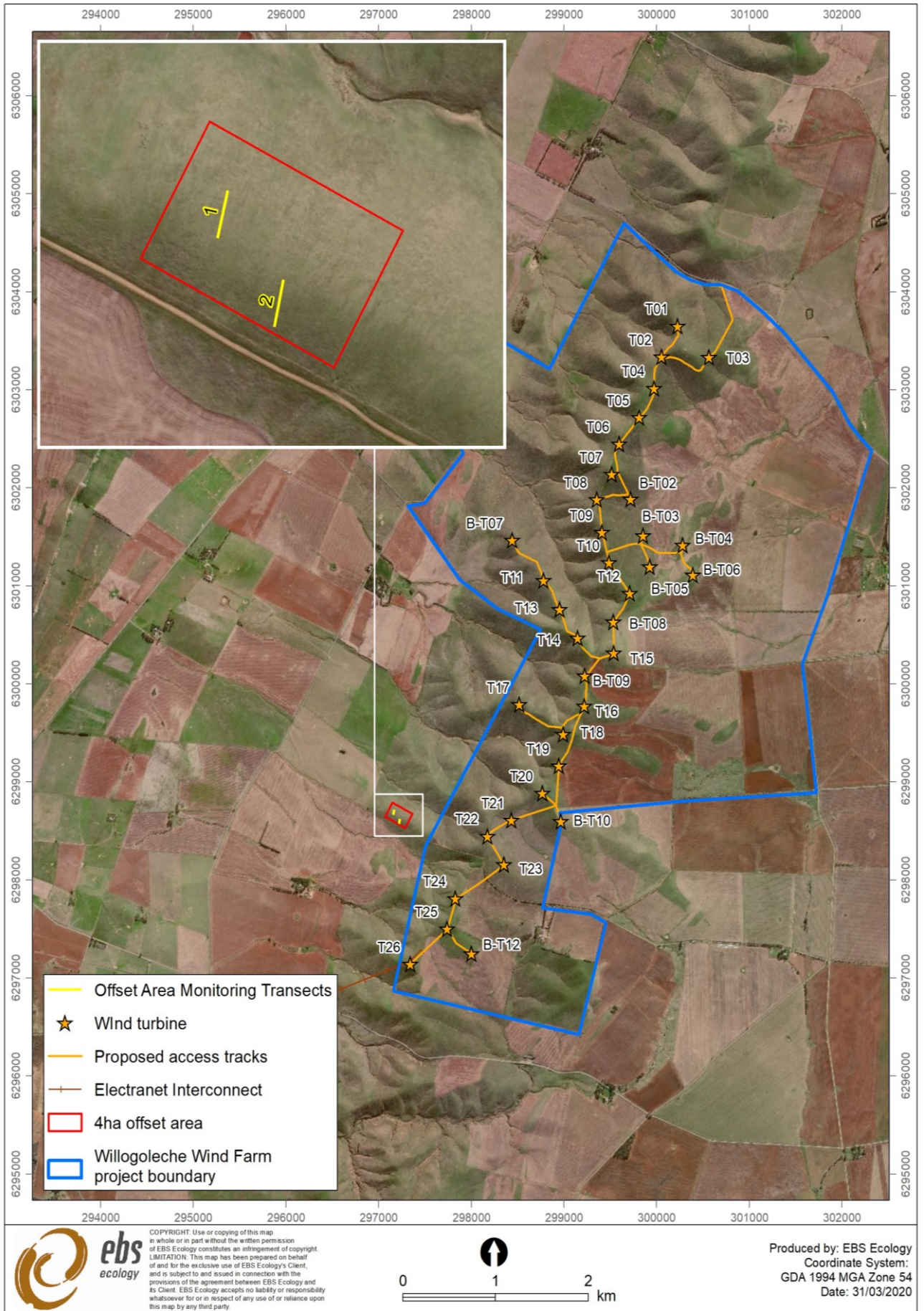


Figure 1. Location of the Willogoleche Wind Farm (WWF), including the Offset Area and monitoring transects (inset).

## 2.3 Climate

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

### 2.3.1 Rainfall

Rainfall data 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. Monthly rainfall data for the period of November 2016 (approximately one year prior to the initial Lomandra Grassland Monitoring Assessment in November 2017) to the date end November 2022, is presented in (Figure 2).

Average rainfall at the Hallett (Lorraine) weather station is 463.4 millimetres (mm). Above average annual rainfall has been recorded in the region for 2020 and 2021, but particularly dry years were experienced in 2018 and 2019, recording 23.45% and 34.8% less rainfall than average, respectively. 2022 experienced approximately average rainfall, with dry weather experienced from February to May (summer and autumn) followed by below average rainfall events in June and July (winter). The two months prior to the survey period experienced above average rainfall.

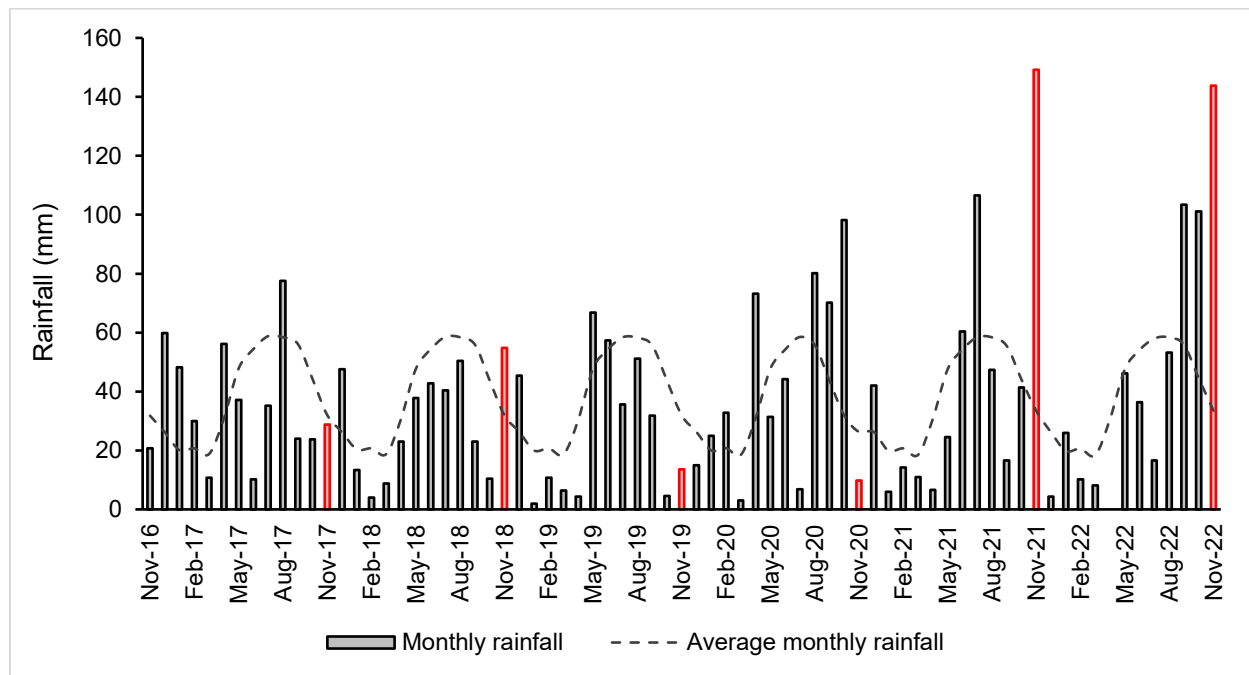


Figure 2. Monthly rainfall data for November 2016 to November 2022. Source: Hallett (Lorraine) Bureau of Meteorology (BOM) weather station # 21024 (BOM 2022). Survey periods are highlighted in red. Note that the above average rainfall in November 2022 was experienced after the survey was completed.

## 3 METHODOLOGY

### 3.1 Survey Timing

The 2022 field survey was undertaken from 2 to 4 November by EBS Ecologists H. Merigot and N. Piscioneri.

### 3.2 Assessment Sites

Two 50 metre (m) long monitoring transects have been established within the Offset Area (Table 3, Figure 3). Photographs looking along each transect were taken at the start (0 m) and end point (50 m) in 2022 and 2021. Photos were only taken at the start (north) point in 2018. Photographs for each year are provided in [Appendix 1](#).

In 2019, additional methods including a 50 x 50 m 'ramble survey' were added to allow for a more rigorous assessment of vegetation and to enable assessment of the sites against the condition class criteria for INTG TEC listing, as indicated in Table 3. The monitoring transect and immediate surrounding area combined, is referred to as an 'Assessment Site'.

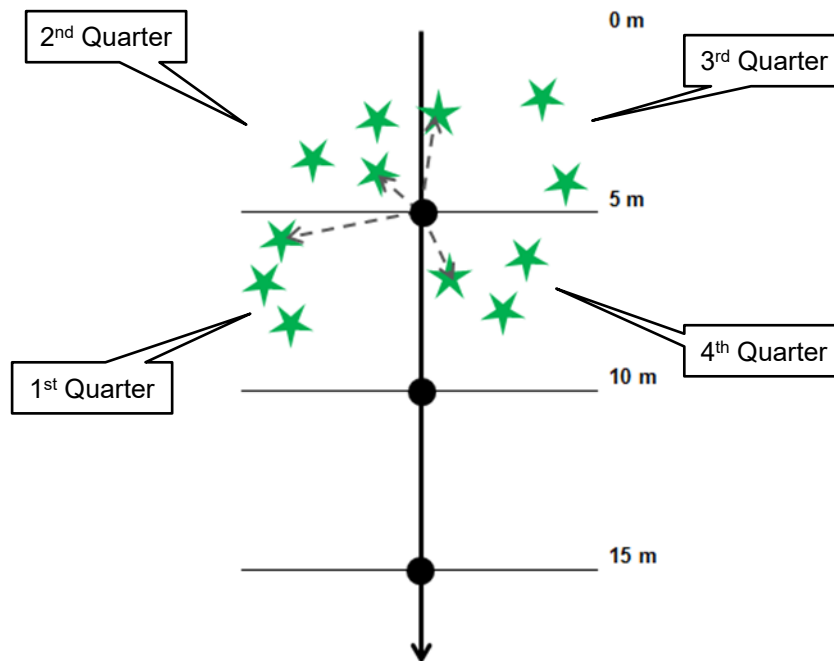
**Table 3. Site and transect location details; and direction of the EPBC assessment (from the transect).**

Assessment Site/ Monitoring Transect	Location	Extent of transect	Zone	Easting	Northing	TEC Condition Class (2019)	*EPBC Assessment Direction
1	Running approximately north-south in the northwest vicinity of the offset.	North	54H	297168	6298716	Category B	25 m either side of existing transect.
		South		297156	6298666		
2	Running approximately north-south in the southeast vicinity of the offset.	North	54H	297230	6298623	Category B	25 m either side of existing transect.
		South		297219	6298572		

### 3.3 Point-centred Quarter Method (PCQM)

In 2022, the PCQM methodology used in previous assessments was repeated. Methodology was slightly altered in 2021 based on feedback from the 2020 survey results. PCQM involves surveying ten (10) sample points along a 50 m transect, assessing perennial plant parameters at five metre intervals (starting at zero metres). 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), 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 1x1 m<sup>2</sup> quadrats, due to the number of small grasses (i.e. *Rytidosperma spp.*) making counts very time consuming. Similar to 2021, measurements in 2022 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.



**Figure 3. 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, 2005).**

In addition to the species, the canopy width (spread) in centimetres (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 2005). 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. Table 4 provides a summary of data collected as part of the PCQM in 2022 for the WWF and how the data was then analysed. The purpose of data collection, the desired data trends to indicate grassland health, potential data limitations and a recommendation for future monitoring is also provided in Table 4 (on the following page).

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 4. Data collected as part of the PCQM in 2022 for the Offset Area, analysis approaches, purpose of data collection, desired data trends and recommendation.**

Parameter	*Data collected	Analysis	Purpose	Desired trend	Undesirable trend	Comment	Recommendation
Cover (m <sup>2</sup> )	Basal width	PCQM	Determine basal cover (m <sup>2</sup> ) 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.	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 1m x 1m quadrats.
Volume (m <sup>3</sup> )	Canopy width breadth, height and canopy density (%)	PCQM	Determine volume of vegetation in metres cubed (m <sup>3</sup> ).	Ideally stable or increase, but data is not meaningful.	Ideally stable or increase.		In 2020 these PCQM measures were reviewed again to determine a more appropriate and indicative method moving forwards, and in the 2021 survey basal width and PPH were used as the primary indicator of plant health for this survey method.
Density (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.  Only the four most dominant or important indicator species to measure were included in the PCQM in 2021 and 2022 ( <i>Lomandra</i> , <i>Aristida</i> , <i>Austrostipa spp.</i> , <i>Rytidosperma spp.</i> )
% 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.	<b>Continue</b> to measure percentage dead material of 40 plants per transect.
Canopy size of tussock (in cm)	Canopy width	Average canopy width	Aims to 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.	Re-evaluate measuring canopy size as part of 5 year review. Height is deemed a more robust and suitable indicator of grazing pressure.
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.	<b>Continue</b> to measure plant height of 40 plants per transect (from ground to tip of leaves, not seed/flower head)

### 3.4 Ramble Survey

In addition to the PCQM sampling outlined above a ramble survey was undertaken across a 0.25 ha (50 x 50 m) quadrat in the immediate area of the Assessment Site to record any native species present and their estimated cover. The data from this search can then be used to determine the condition class of INTG patches as outlined in the *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 5) and if they have remained stable or otherwise since the baseline assessment was undertaken in 2018.

**Table 5. EPBC Iron-grass TEC condition score parameters (DEWR, 2007).**

Condition class	Minimum size	Diversity of native species <sup>1</sup>	No. broad-leaved herbaceous species <sup>1</sup> in addition to identified disturbance resistant species <sup>2</sup>	No. perennial grass species <sup>1</sup>	Tussock count <sup>3</sup>
<b>Listed ecological community</b>					
A	0.1 ha	>30	≥10	>5	1/m
B	0.25 ha	>15	≥3	>4	1/m
<b>Degraded patches amenable to rehabilitation</b>					
C	No minimum	>5	No minimum	>1	No minimum
* <sup>1</sup> as measured in a 50 x 50 m quadrat; <sup>2</sup> disturbance resistant species: <i>Ptilotus spathulatus</i> , <i>Sida corrugata</i> , <i>Oxalis perennans</i> , <i>Convolvulus angustissimus</i> , <i>Euphorbia drummondii</i> , and <i>Maireana enchylaenoides</i> ; and <sup>3</sup> as measured along a 50 m transect.					

### 3.5 Grassland Health Indicators

Following on from the methods introduced in 2019, the 2022 survey measured the following five grassland health indicator attributes (lifeforms) in each of the 10 quadrats indicated in Figure 4, at each site, to further inform trends in grassland condition and health:

- 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; and
- % rock.

An overview of the purpose of the data collected the desirable result trends and comments / recommendations for future monitoring are provided in Table 6.

Iron-grass 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, 2018). Following recommendations from 2020, a frequency score for *Lomandra spp.* presence/absence was added to the 1 x 1 m<sup>2</sup> quadrat sampling method in 2021 and recorded again in 2022 to gain a better understanding of its distribution across each site.

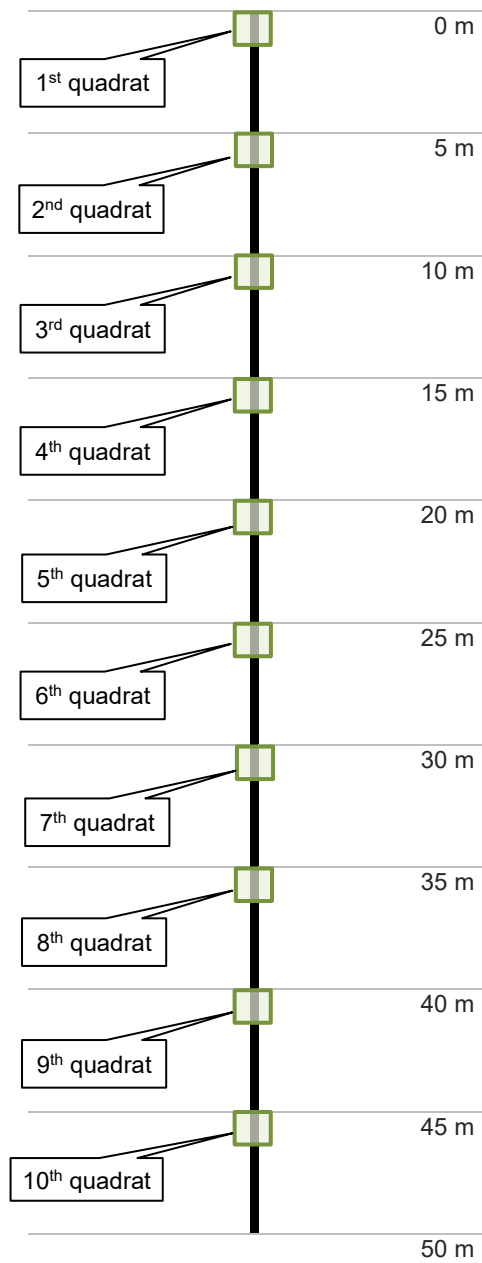


Figure 4. Schematic of a 50 m long transect with ten 1 m<sup>2</sup> quadrats, surveyed at 5 m intervals (not to scale).

Table 6. Grassland health indicators.

Attribute	Purpose	Desired trend	Undesirable trend	Comment / recommendation
<b>% cryptogams</b>	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.
<b>% litter including exotic annual grass (the majority of litter)</b>	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). The unofficial benchmark values for % litter for Grasslands in the Northern Lofty botanical region is approximately <25%.	Continue to monitor.
<b>% bare ground (meaning exposed dirt free of litter, moss, plants (dead or alive), rock or cryptogams)</b>	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.
<b>% total native cover (all perennial and annual species)</b>	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.	Continue to monitor. Consider also collecting percentage cover of various lifeforms (forbs, grasses, shrubs etc.) to better inform cover of different components.
<b>% rock</b>	Data collected to obtain full picture of structural attributes. Rock cover does not need to be collected in future years.	Stable	NA	Monitor annually as an indicator of observer variability.
<b>Frequency of Lomandra (% of quadrats)</b>	Data collected to supplement PCQM when prevalence of perennial tussock grasses limit recording of Lomandra tussocks.	Stable or increasing	Decreasing	First data collected in 2021. Continue to monitor.

### 3.6 Statistical Analysis

As the Offset Area monitoring commenced in 2018, and new methods were added in 2019, it is too early in the program to undertake any meaningful statistical analysis. Descriptive data and any observations of changes or constants between 2018 and 2022 are reported in Section 4 (Results) and Section 5 (Discussion). Statistical analysis will be conducted in future years when there is enough data to ascertain if any changes within the Offset Area are occurring over the period of the monitoring program. Analysis tools used for each survey methodology are detailed below.

#### 3.6.1 PCQM

At each of the two INTG sites within the offset area, PCQM data was used to calculate the following parameters.

##### **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<sup>2</sup> is calculated using the formula  $1/\text{mean density}^2$ . 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<sup>2</sup> in a hectare).

##### **Ground cover (m<sup>2</sup>/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<sup>2</sup>) 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 behriana* (Brush-wire Grass) and *Lomandra multiflora ssp. dura* (Hard Mat-rush).

**3.6.2 EPBC condition ramble survey**

Species recorded during the EPBC condition ramble survey were combined with those recorded during the quadrat survey to create a species list for each site. Total species diversity and numbers of species from each lifeform (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).

**3.6.3 Quadrat sampling for weeds and grassland health indicators**

Percentage cover data is collected for each weed species occurring within each quadrat and for grassland health indicators including litter, bare ground, cryptogams, and rock. Results for each were calculated across each site and the Offset Area 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.

**3.7 Weed Survey**

To assess weed cover in the Offset Area 2022, the methodology used for the WWF Weed Assessment was applied at the two monitoring transects. This involved recording the individual weed species and coverage (as a percentage of area covered) within a quadrat one square metre (1 m<sup>2</sup>) in size, at five metre intervals (starting at zero metres) (Figure 4), resulting in a total of ten quadrats being assessed per 50 m transect.

General notes on weed cover were also made whilst traversing the Offset Area and during the Ramble survey. It is of note that the total percentage litter was also determined as part of the grassland health data, where dry material largely represents dead exotic species.

### 3.8 Limitations

The PCQM is typically used 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 same location each year, or if seasonal variation resulted in a proliferation of regenerating species. For example, species such as *Lomandra multiflora* ssp. *dura* may not be recorded at all in years where high regeneration of other perennial grasses (such as *Rytidosperma*) fill the inter-tussock space. This does not suggest it is not present, rather that methods failed to detect it, either by the placement of the transect, or various seasonal factors. Starting in 2021 additional presence / absence data was collected for *Lomandra* tussocks in each of the 10-1x1m quadrats to help counteract this issue.

Similarly, 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 be used with more confidence in the long term.

## 4 RESULTS

### 4.1 INTG Offset Summary

The results of the 2022 monitoring are summarised in Table 7 to Table 9 and explained and discussed in relation to survey results of previous years in the relevant sections below.

Table 7. Summary of 2022 INTG monitoring results based on PCQM and ramble survey.

Monitoring Transect	Perennial plants per hectare (PPH)	Spacing of perennial plants (cm)	Basal width (cm)	Plant Height (cm)	% dead material	Rare flora (# of species)	Species diversity
1	76521	36.15	7.05	19.73	47.50	1	17
2	8261	110.03	9.64	30.23	42.88	1	14

Table 8. Number of species of each lifeform based on the 2022 (0.25 ha) ramble survey at each site.

*Lifeform	Number of species of each lifeform at each of the 50m x 50m ramble quadrats	
	Site 1	Site 2
Broad-leaf Herb	5	6
Disturbance resistant Broad-leaf Herb	5	3
Grass / Sedge	6	5
Shrub	1	-
<b>Total</b>		
<b>Tussock density</b>	<b>7.65/ m<sup>2</sup></b>	<b>0.83/ m<sup>2</sup></b>
<b>*EPBC Class</b>	<b>B</b>	<b>C</b>

Refer to Section 3.5 for condition classes and lifeform descriptions.

Table 9. Summary of 2022 results relating to grassland health baseline data and comparison with benchmark.

Monitoring Transect	% Cryptogams	% Litter	% Bare ground	% Rock	% Native cover	% Lomandra presence
1	4.90	71.10	0.70	2.20	17.60	0.40
2	1.70	93.00	0.15	1.75	3.80	0.20
<b>Offset Area Mean</b>						
<b>*Benchmark (goal)</b>	<b>50%</b>	<b>&lt;25%</b>	<b>&lt;5%</b>	<b>N/A</b>	<b>N/A</b>	<b>N/A</b>

\* Unofficial benchmark values for Grasslands in the Northern Lofty botanical region (Pedler et al. 2007). Green indicates where benchmark goal has been met.

## 4.2 PCQM

Table 10 summarises the findings of the PCQM survey in 2022 with an annual comparison of results since the initial survey in 2018. Results of each attribute are discussed further in Sections 4.2.1 to 4.2.6.

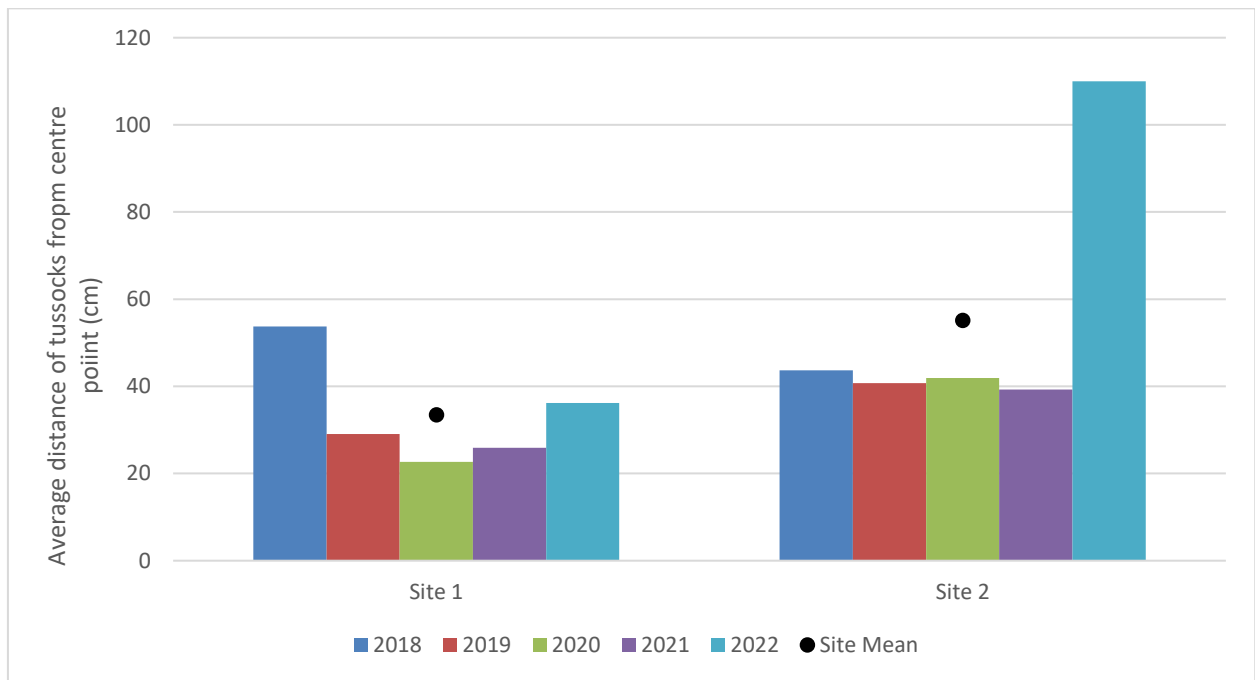
**Table 10. Summary of INTG monitoring results based on PCQM and ramble survey.**

Monitoring Transect	Perennial plants per hectare (PPH)	Average spacing of perennial plants (cm)	Average basal width (cm)	Average plant Height (cm)	Average dead material (%)	Rare flora (# of species)	Species diversity
<b>2022</b>							
1	76521	36.15	7.05	19.73	47.50	1	17
2	8261	110.03	9.64	30.23	42.88	1	14
<b>2021</b>							
1	149074	25.90	3.85	20.88	46.63	1	20
2	64870	39.26	6.3	23.98	30.48	1	14
<b>2020</b>							
1	194,708	22.70	16.15	16.74	23.78	1	20
2	56,892	41.90	18.03	21.53	48.74	0	21
<b>2019</b>							
1	118,497	29.05	8.30	9.60	49.80	1	17
2	60,221	40.75	11.60	11.10	50.40	1	19
<b>2018</b>							
1	33,916	54.30	8.90	2.75	53.50	0	9
2	52,485	43.65	8.60	2.40	53.75	0	9
<b>Mean</b>	<b>81,544</b>	<b>44.31</b>	<b>9.84</b>	<b>15.88</b>	<b>44.56</b>		

**4.2.1 Spacing of perennial plants**

The average perennial plant distance from centre point in 2022 was 36.15cm ± 12.35cm (standard deviation) at Site 1, and 110.03cm ± 30.73cm (standard deviation) at Site 2 (Table 10, Figure 5). The standard deviation from the mean (averaged for 10 sample points) at Site 1 has progressively decreased and was lower in 2022 than in all other years inferring that the density of perennial plants was more consistent across this site (i.e., no large bare patches). Conversely, the standard deviation from the mean at Site 2 was much higher in 2022 than in previous years, inferring that the density of perennial plants was less consistent across this site (i.e. more bare patches and/or weed cover).

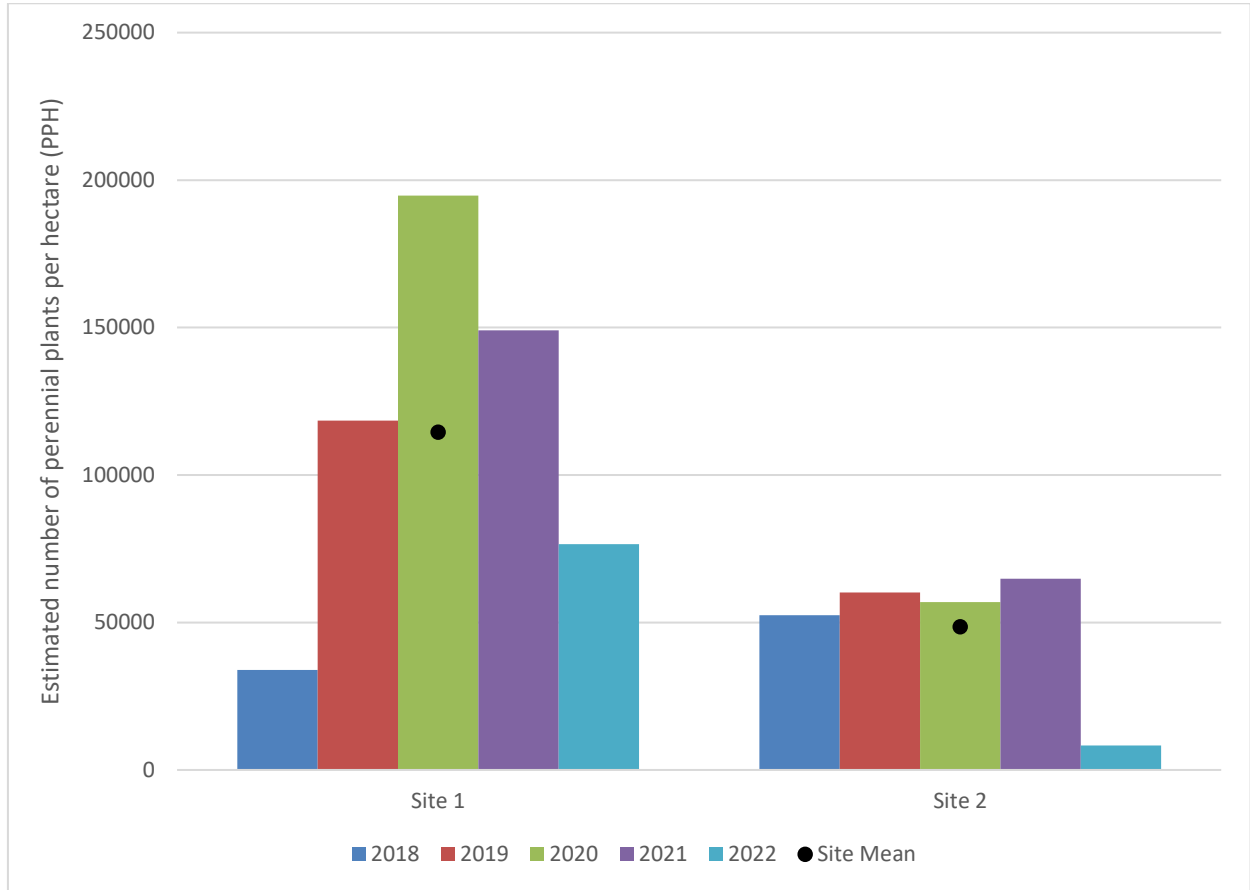
Plant spacing at Offset Site 1 has decreased from 53.70cm in 2018 to 36.15cm in 2022. Offset Site 2 had remained relatively stable up until 2022, until spacing increased substantially from 39.26cm in 2021 to 110.02cm in 2022. Plant spacing at Offset Site 2 was also far greater than all other previous years (43.65 in 2018, 40.75 in 2019 and 41.93 in 2020).



**Figure 5. Average distance (cm) of grass tussocks from PCQM centre point for each year of the survey.**

**4.2.2 Perennial plants per hectare (PPH)**

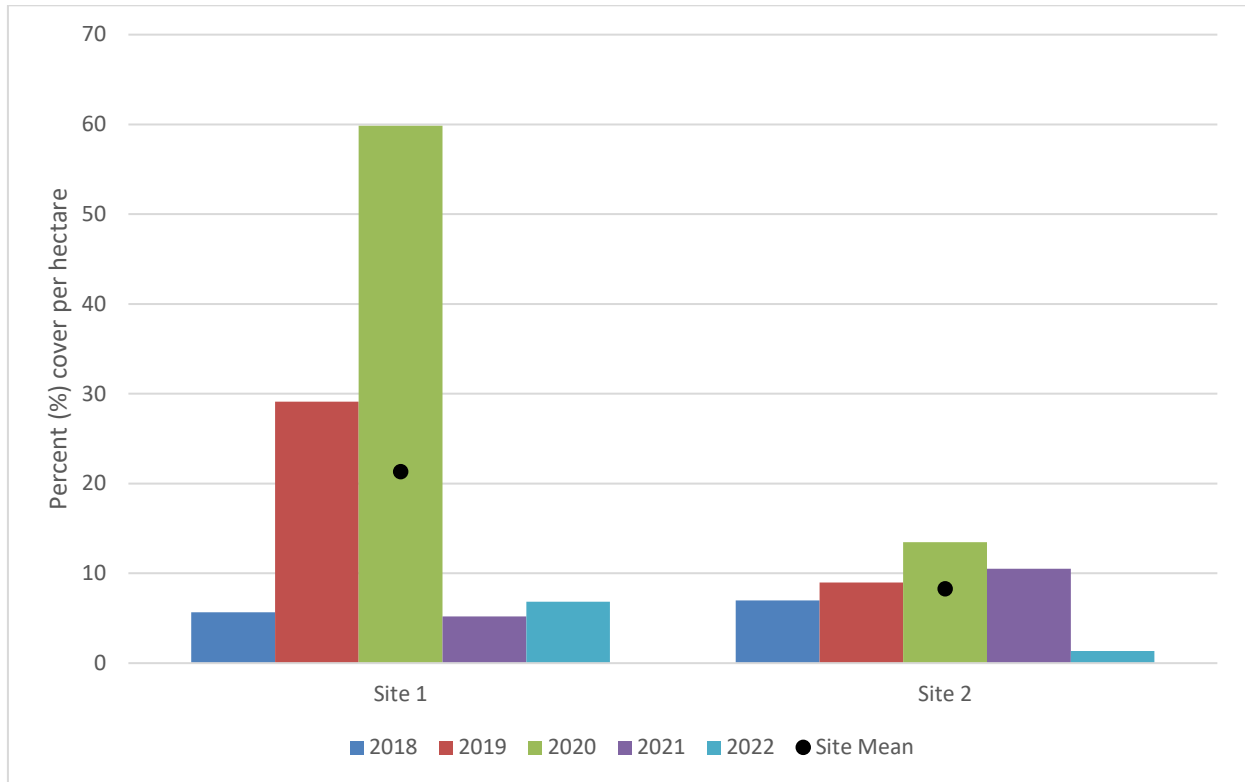
As in previous reporting years, the perennial plant density in 2022 was markedly different between the two sites, with an estimate of 76,521 plants per hectare (PPH) at Site 1 and 8,260 PPH for Site 2 (Figure 6). This represents a reduction in PPH since the previous reporting period for Site 1 (149,074) and Site 2 (64,870).



**Figure 6. PPH at each Offset Site based on results of the PCQM.**

**4.2.3 Basal cover**

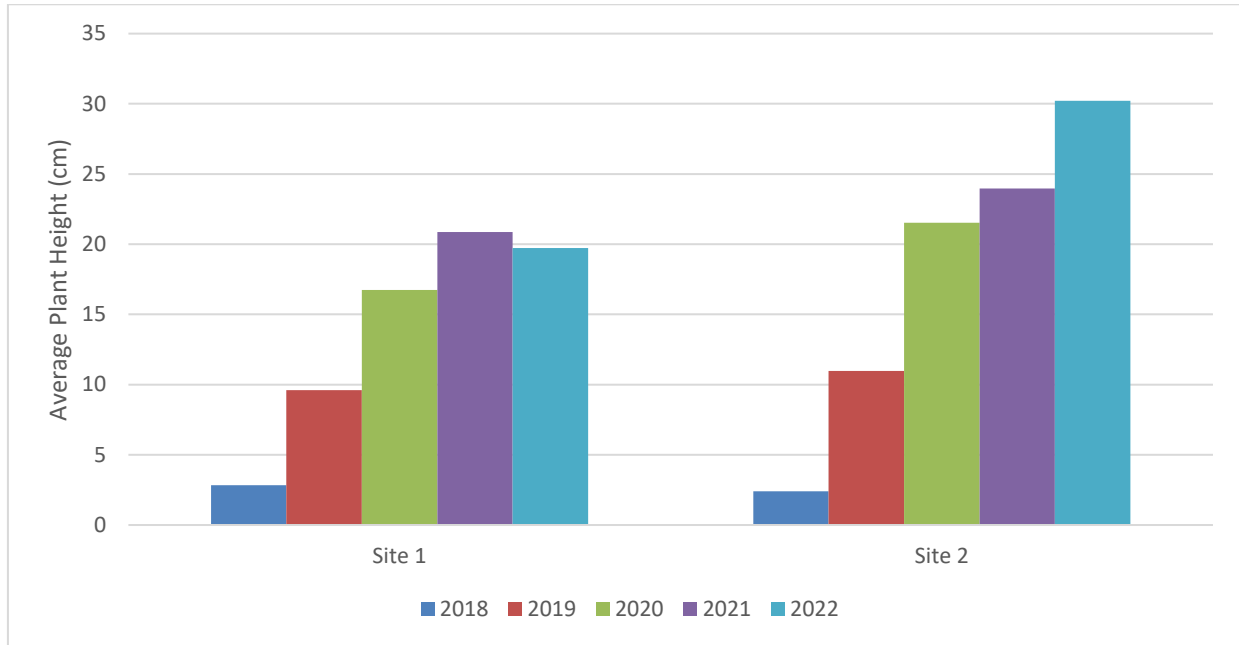
In 2022, Site 1 had a 6.83% basal coverage, which is similar to the previous year’s monitoring in 2021 (5.19%) but substantially lower than both 2020 (59.84%) and 2019 (29.13%). The level of cover recorded is slightly higher but very similar to the baseline survey in 2018 in which 5.67% basal cover per hectare was recorded. Basal coverage has remained relatively steady over the years at Site 2 with the exception of 2022 in which 1.33% cover per hectare was recorded compared to 10.50% in 2021 and 13.45% in 2020. This is below the five-year average of 8.25% at this site (Figure 7).



**Figure 7. Percent basal cover, representing the percent of each hectare covered by a perennial plant species, measured using PCQM.**

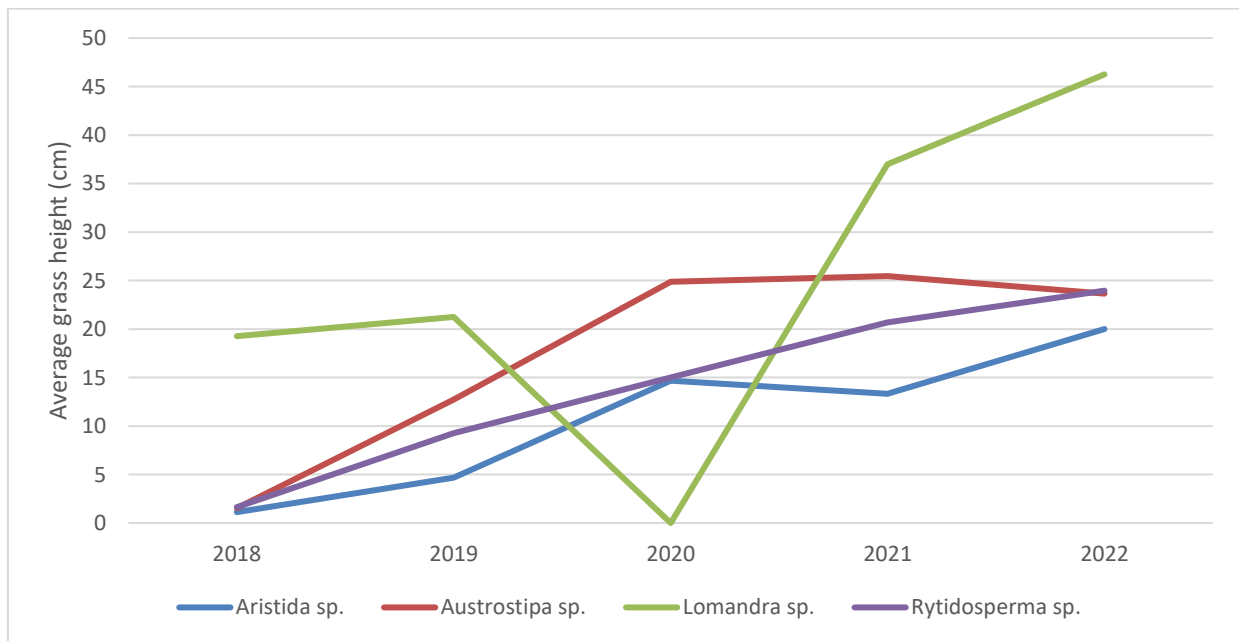
**4.2.4 Plant height**

In 2022 the average perennial plant height was 24.98cm (Site 1: 19.73cm; Site 2: 30.22cm), substantially higher than the baseline survey in 2018 (2.62cm) when heavy grazing was observed across the Offset Area (Figure 8).



**Figure 8. Plant height at each Assessment Site within the Offset Area for all years of survey.**

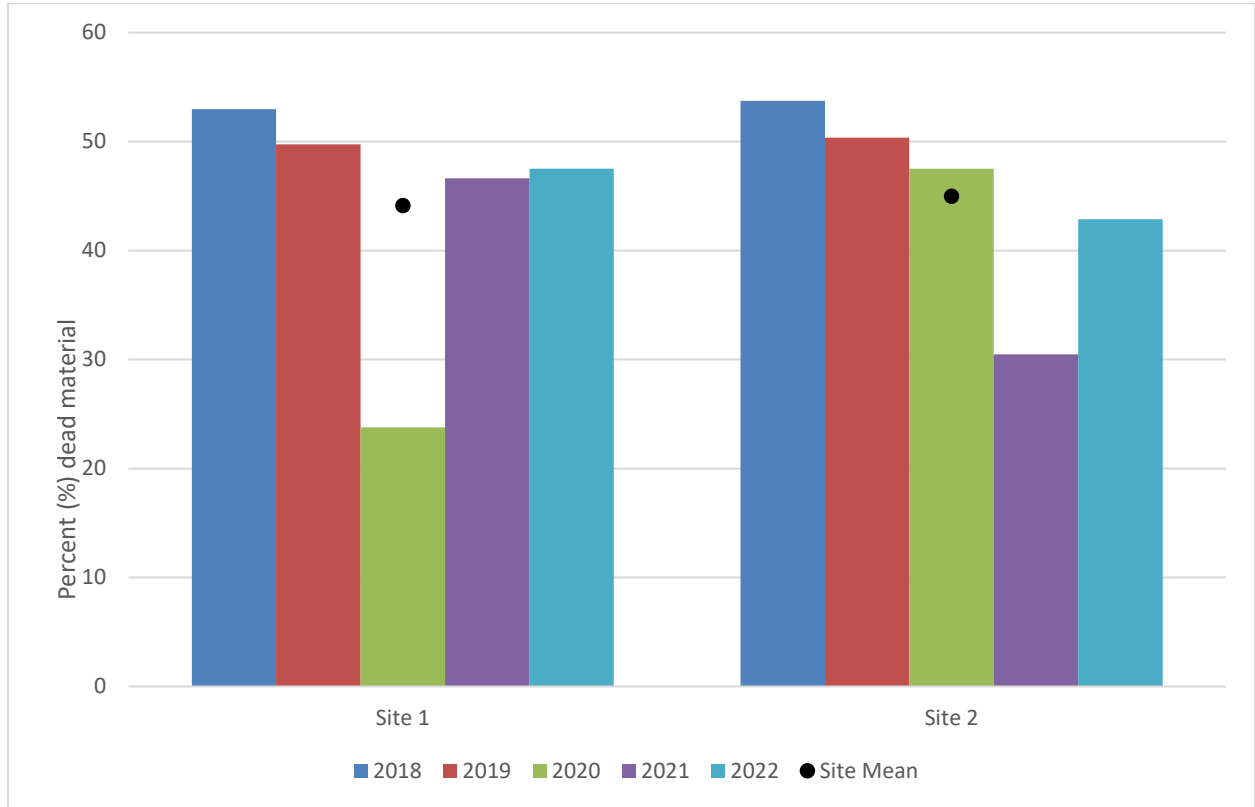
Figure 9 indicates that the grasses *Aristida*, *Austrostipa* and *Rytidosperma* are at their typical expected growth height, with an increase from 2018 followed by a plateau following good rainfall. The long-lived and slow growing *Lomandra* species has doubled in height since the baseline survey averaging 46cm in 2022, compared to 37cm high in 2021 and 19 cm in 2018 (note that *Lomandra* was not recorded in the 2020 PCQM survey due to the prevalence of other juvenile grasses filling the inter-tussock space).



**Figure 9. Average perennial grass height (five most common grasses) across monitoring years.**

**4.2.5 Plant health (Percentage dead plant material)**

In 2022, the percentage of dead plant material estimated per tussock was 45.19% across both sites. Both sites recorded a very similar percentage with Site 1 averaging 44.12% and Site 2 averaging 45.00% dead plant material per tussock. Both sites recorded a lower percentage than the baseline survey where 52.97% was recorded for Site 1 and 3.75% was recorded for Site 2. (Figure 10).



**Figure 10. Percentage of dead material observed per tussock (average) for each year of the survey.**

#### 4.2.6 Species composition

The most frequently recorded perennial plant species was *Austrostipa sp.* which accounted for 76.25% of all perennial plant records in the PCQM survey across both sites. At both Site 1 and Site 2, *Austrostipa sp.* was the most frequently recorded grass where it occurred at 67.50% (Site 1) and 85% (Site 2) of the 40 sample points at each site respectively. This differs to previous monitoring years in which *Rytidosperma sp.* was the most frequently recorded perennial plant species. *Lomandra sp.* were detected at both Site 1 and Site 2 for the first time since 2019, having not been picked up at both survey sites or at all in the 2020 reporting period due to its low density.

The *relative importance* score showed that *Austrostipa sp.* was the dominant grass in terms of cover and frequency at Site 1 (50.52) and Site 2 (73.18). This differs to 2021 in which *Rytidosperma sp.* was the most dominant grass in terms of cover and frequency. Results in 2022 for Site 2 are similar to 2020 in which *Austrostipa sp.* was the most dominant grass with a *relative importance* of 33.99. *Aristida sp.* has declined in *relative importance* at both Site 1 and Site 2 (

Figure 11).

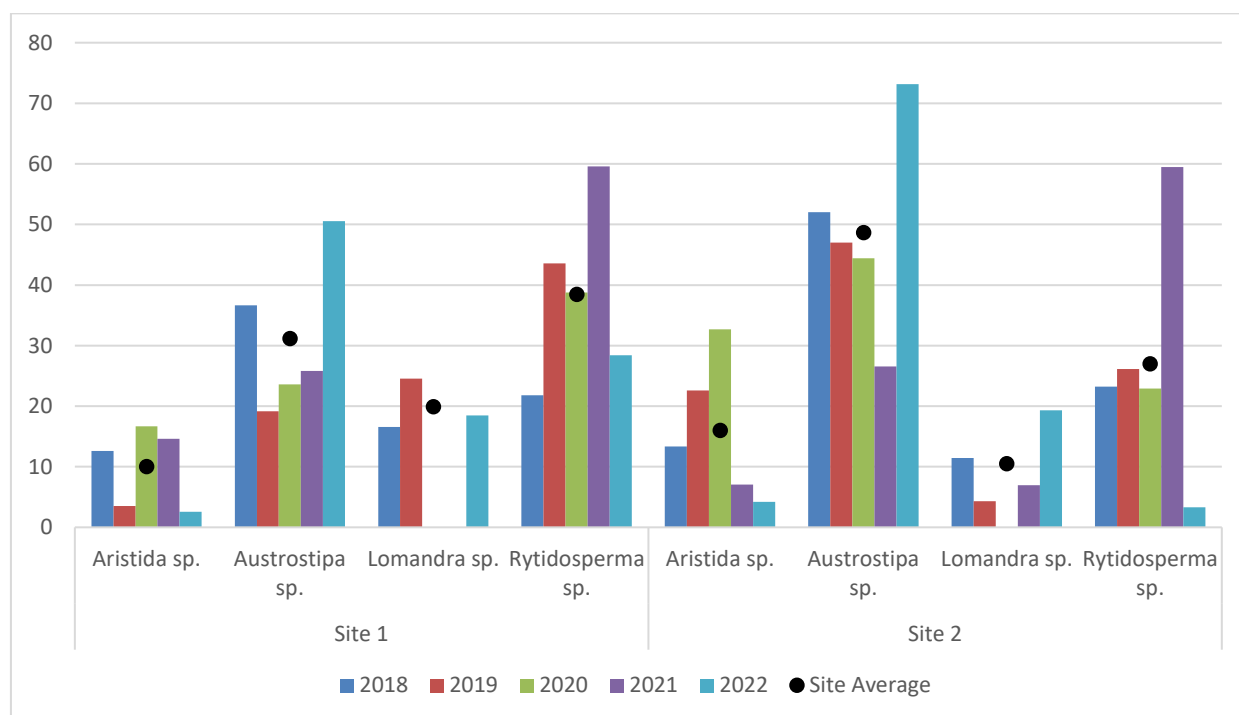


Figure 11. Relative importance of perennial native grasses across all years.

A reduction in grazing pressure was evident by taller and healthier tussocks across the site during the ramble survey, however *Avena barbata* (Bearded Oat) and *Lolium sp.* (Rye Grass) remains an issue, having a smothering impact across the Offset Area, as noted in both 2021 and 2020. In addition, the re-emergence of annual weed species such as *Echium plantagineum* (Salvation Jane) and *Salvia verbenaca var.* (Wild Sage) was evident following good rainfall in the two months prior to the survey period (see Section 2.3).

### 4.3 Ramble Survey

A total of 18 native species were observed during the EPBC ramble survey (in conjunction with the transect search) in the Offset Area in 2022 (Table 11). Site 1 was found to remain in Condition Class B, however species diversity at Site 2 was 14, which is lower than the threshold ( $\geq 15$  species) required for listing as Condition Class B (Table 12). Species diversity at Site 2 was also 14 in 2021, meaning that this site has been lower than the threshold for two consecutive years. Of note, for Site 2, the number of tussocks per metre squared was  $0.83/m^2$  which is also lower than the threshold ( $\geq 1/m^2$ ). Table 12 summarises the findings at each site in relation to the EPBC Criteria across all survey years to date.

**Table 11. Native species recorded at each Lomandra Grassland Monitoring Site in 2022.**

Lifeform	Scientific	Common	Site	
			1	2
Broad-leaf Herb	<i>Arthropodium strictum</i>	Chocolate Lily	✓	✓
	<i>Calostemma sp.</i>	Garland Lily		✓
	<i>Convolvulus remotus</i>	Australian Bindweed	✓	✓
	<i>Crassula sp.</i>		✓	✓
	<i>Rumex dumosus*</i>	Wiry Dock	✓	✓
	<i>Vittadinia gracilis</i>	Woolly New Holland Daisy	✓	✓
DR Broad-leaf Herb	<i>Convolvulus angustissimus</i>	Bindweed	✓	✓
	<i>Maireana enchylaenoides</i>	Wingless Fissure-plant	✓	✓
	<i>Oxalis perennans</i>	Native Sorrel	✓	
	<i>Ptilotus spathulatus</i>	Pussy-tails	✓	
	<i>Sida corrugata var. angustifolia</i>		✓	✓
Grass	<i>Aristida behriana</i>	Brush Wire-grass	✓	
	<i>Austrostipa blackii</i>	Crested Spear-grass	✓	✓
	<i>Austrostipa scabra sp. scabra</i>	Rough Spear-grass	✓	✓
	<i>Austrostipa sp.</i>	Spear-grass	✓	✓
	<i>Rytidosperma sp.</i>	Wallaby-grass	✓	✓
Sedge	<i>Lomandra multiflora ssp. dura</i>	Hard Mat-rush	✓	✓
Shrub	<i>Scleranthus pungens</i>	Prickly Knawel	✓	

\*NPW Act 1972 SA Rare species

Table 12. EPBC Criteria by site for each year of the survey since baseline assessment in 20118, EPBC minimum criteria at top of table in green.

Site (Size)	Year	Native species	Non-disturbance resistant herbaceous species	Native Grasses (excluding Lomandra)	Tussocks per m <sup>2</sup>	Condition
>0.1ha	-	≥30	≥10	≥5	≥1/m <sup>2</sup>	A
>0.25ha	-	≥15	≥3	≥4	≥1/m <sup>2</sup>	B
No min.	-	≥5	-	≥1	-	C
Site 1	2018	9	NA	7	~3.39 / m <sup>2</sup>	C
	2019	17	3	4	~11.85 / m <sup>2</sup>	B
	2020	20	7	7	~19.47 / m <sup>2</sup>	B
	2021	20	8	8	~14.91 / m <sup>2</sup>	B
	2022	17	5	5	~7.65/ m <sup>2</sup>	B
Site 2	2018	9	NA	4	~5.25 / m <sup>2</sup>	C
	2019	19	4	5	~6.02 / m <sup>2</sup>	B
	2020	20	5	7	~5.69 / m <sup>2</sup>	B
	2021	14	6	5	~6.49 / m <sup>2</sup>	C
	2022	14	3	4	~0.83/ m <sup>2</sup>	C

\*Condition class estimated without all EPBC criteria values available

Red highlights where goal has not been met and value falls short of EPBC Class B listing.

#### 4.3.1 Rare Flora

One *National Parks and Wildlife Act 1972* (NPW Act) listed Rare species, *Rumex dumosus* (Wiry Dock) was found across the Offset Area and was present at both monitoring sites. This species was also observed in previous years.



Figure 12. A closeup of *Rumex dumosus* (Wiry Dock) observed by EBS Ecology in 2022.

**4.3.2 Grassland health indicators – baseline data**

Table 13 provides a summary of the grassland health indicator results in comparison to benchmark scores for the community and results from the 2019 survey, when methods were first introduced. Both sites showed a decrease in quality since the baseline survey in 2019, with lower cryptogam cover, higher exotic 'litter cover' and less native cover. Bare ground has continued to decrease and is within the range considered 'healthy' according to the benchmark condition scores outlined for Mid-North Grasslands (Pedler et al. 2007), however it is likely that this reduction in bare ground is attributable to higher weed cover, not native cover.

In 2022, *Lomandra sp.* was present in 40% of quadrats (i.e. 4 quadrats) at Site 1 and at 20% of quadrats at Site 2 (i.e. 2 quadrats). This would be considered within the mid to low range for density of *Lomandra sp.*, with INTG's typically having a density of 10 % to 70 % of ground area cover (Turner 2012). Though tussocks appeared healthier in 2022, minimal regeneration was noted within the Offset Area.

**Table 13. Summary of results relating to grassland health baseline data and comparison with benchmark.**

Monitoring Transect	% Cryptogams	% Litter	% Bare ground	% Rock	% Native cover	% <i>Lomandra</i> presence
<b>2022</b>						
1	4.90	71.10	0.70	2.20	17.60	0.40
2	1.70	93.00	0.15	1.75	3.80	0.20
<b>2021</b>						
1	8.9	55.5	1.9	2.4	13.7	0.2
2	4.6	63.5	0.9	3.1	10.4	0.1
<b>2020</b>						
1	55	24	1.7	8.2	26	NA
2	16.5	39.5	7.6	6.8	24.7	NA
<b>2019</b>						
1	56.50	56.00	12.90	7.00	20.80	NA
2	42.50	73.45	13.50	12.80	15.30	NA
<b>Offset Area Mean</b>	<b>30.67</b>	<b>51.99</b>	<b>6.42</b>	<b>6.72</b>	<b>18.48</b>	<b>0.15</b>
<b>*Benchmark (goal)</b>	<b>~50%</b>	<b>&lt;25%</b>	<b>&lt;5%</b>	<b>NA</b>	<b>NA</b>	

\* Unofficial benchmark values for Grasslands in the Northern Lofty botanical region (Pedler et al. 2007). Green highlights where goal has been met.

### 4.3.3 Weeds

Based on the cover ratings assessed in 1m x 1m transects along Offset Area monitoring transects, the total mean average percentage weed cover in 2022 was 88.35%, with Site 2 maintaining a higher weed cover total of 98.45% compared to 78.25% at Site 1 (Table 14). These figures are much higher than those observed in the initial weed assessment in 2019 and in all other previous years of monitoring thereafter.

Two weeds listed as Declared under the *Landscape South Australia Act 2019* (LSA Act) were observed in the Offset Area, *Echium plantagineum* (Salvation Jane) and *Cynara cardunculus* (Artichoke Thistle). The management requirements for each Declared weed species is provided in Table 15.

**Table 14. Average coverage (%) of weed species (quadrat sampling) at each Assessment Site in 2022.**

Species	Common	Site 1 (%)	Site 2 (%)	Average Offset Area Weed cover per species (%)
<i>Aira sp.</i>	Hair-grass	0.05	0.00	0.05
<i>Avena barbata</i>	Bearded Oat	50.00	52.50	102.50
<i>Echium plantagineum</i>	Salvation Jane	2.50	6.00	8.50
<i>Erodium cicutarium</i>	Cut-leaf Heron's-bill	0.50	0.00	0.50
<i>Hypochaeris radicata</i>	Rough Cat's Ear	0.05	0.20	0.25
<i>Lepidium africanum</i>	Common Peppergrass	0.30	0.00	0.30
<i>Lolium sp.</i>	Rye Grass	0.25	9.20	9.45
<i>Medicago polymorpha</i> var. <i>polymorpha</i>	Burr-medic	4.30	9.00	13.30
<i>Salvia verbenaca</i>	Wild Sage	0.05	14.00	14.05
<i>Sonchus oleraceus</i>	Sow Thistle	0.10	0.00	0.10
<i>Trifolium angustifolium</i>	Narrow-leaved clover	0.60	3.25	3.85
<i>Trifolium arvense</i>	Rabbit foot clover	18.70	4.00	22.70
<i>Vulpia sp.</i>	Fescue	0.85	0.30	1.15
<b>Total weed coverage (%)</b>		<b>78.25</b>	<b>98.45</b>	<b>176.70</b>

**Table 15. Declared weeds observed in the Offset Area.**

Scientific Name	Common Name	LSA Act Requirements
<i>Cynara cardunculus</i>	Artichoke Thistle	<ul style="list-style-type: none"> <li>• Take reasonable steps to kill plants and prevent spread.</li> <li>• Must not be traded or sold in any way, including as a contaminant of anything.</li> <li>• Must not be transported on a public road including as a contaminant of anything.</li> </ul>
<i>Echium plantagineum</i>	Salvation Jane	<ul style="list-style-type: none"> <li>• Take reasonable steps to kill plants and prevent spread.</li> <li>• Must not be traded or sold in any way, including as a contaminant of anything.</li> <li>• Must not be transported on a public road including as a contaminant of anything.</li> </ul>

*Avena barbata* (Wild-Oat) has shown the greatest increase since 2019, with an average of 51.25% in 2022 compared to just 1.23% coverage in 2019. *Trifolium arvense* (Rabbitfoot Clover) has also increased, with an average of 11.35% in 2022, compared to 1.28% in 2021 and 6.85% in 2020. Declared weed *Echium plantagineum* (Salvation Jane) was again observed in 2022, with an average coverage of 4.25% after it was absent in 2021. Most weed species have increased in average cover in 2022 as a result of good rainfall in the two months prior to the survey period in 2022 (see Section 2.3).

*Aira sp.* (Hair-grass) was recorded for the first time within the Offset Area in 2022, observed at Site 1, with an average cover of 0.05%. A singular *Medicago sativa* (Alfalfa) was also observed again in the Offset Area at Site 1, during the ramble survey. It is a common agricultural plant species used primarily as stock fodder and for human consumption.

Declared weed (Category 3) *Cynara cardunculus* (Artichoke Thistle), which was first noted near Site 1 in 2020, was present and thriving in 2022 (Figure 13). It requires follow up treatment (spot spraying of targeted broad-leaf herbicide, hand pulling and/or timed grazing) and monitoring to ensure it does not spread within the Offset Area. *Foeniculum vulgare* (Fennel) identified near the southern boundary fence was still present in 2022. Treatment using manual removal is recommended to remove the patch.

Site 1 was noted to be in poor to fair condition with slightly lower density of weeds and litter than Site 2, and a more evenly distributed cover of native herbaceous species. No erosion or other evidence of sheep grazing such as livestock tracks and scats were observed.

Site 2 was noted to be in poor condition, dominated by *Avena barbata* (Wild Oats), *Trifolium spp.* (Clover) and *Lolium spp.* (Rye Grass). *Lomandra* tussock density was very low, there was a low regeneration of native species and low broad-leaved herb density. *Salvia verbenaca* (Wild Sage) was found to be dominant at the western extent of the transect in 2022 (quadrats 7 to 10) as previously noted in 2021. State Rare species *Rumex dumosus* (Wiry Dock) was scattered across the site and no erosion or other evidence of sheep grazing such as livestock tracks and scats were observed.



Figure 13. *Cynara cardunculus* (Artichoke thistle) still requires follow up treatment.

## 5 DISCUSSION

### 5.1 Summary of Condition

The Offset Area is still in its early years of the 16-year OMP. Significant improvements are expected to become more evident in years to come. The 2022 survey highlighted the importance of establishing the correct grazing regime within the grassland ecosystem. A high level of grazing, coupled with drought conditions in the baseline survey of 2018 resulted in the INTG being in poor condition. The combination of a bumper year in 2020 and in 2022 with high rainfall resulting in extensive weed growth and, lack of evidence of any grazing has resulted in weedy winter grasses such as *Avena sp.* and *Lolium sp.* smothering the Offset Area. The 2022 results again recorded lower native species diversity, and potentially declining health of grass tussocks (excluding *Lomandra*) at both sites as previously noted in 2021.

The Offset Area has visibly improved in terms of a reduction in grazing pressure on native plants. In previous years, the combination of drought and unrestricted grazing was evident in the poor health and condition of perennial grass tussocks and PCQM plant attributes such as height and percentage dead material. In 2019 it was noted that grazing pressure had reduced since 2018, but with continued drought conditions the improvement of flora condition was minimal. In 2020 the combination of reduced grazing and increased rainfall improved conditions within the Offset Area. In 2022, above average rainfall in the two months prior to the survey period, coupled with reduced grazing led to a substantial increase in weed species across the Offset Area.

Prior to the 2021 survey, the Offset Area had been on a positive trajectory, with increased rainfall and reduced grazing pressure resulting in new records of native flora species and grassland health indicators reaching the desired range. Unfortunately, increased rainfall in 2020, followed by above average rainfall in the two months prior to the 2022 survey, created opportunities for weed species to set seed, and without an adaptive grazing regime implemented subsequently, the condition of the Offset Area has deteriorated as a result. Results demonstrates the importance of continued adaptive management to maintain the positive trajectory of flora conditions.

A carefully implemented and managed grazing regime as outlined in the Offset Management Plan (OMP) (EBS 2017) is imperative to continue to the previously recorded positive trend, and to limit the likelihood of weedy species dominating the grassland and shading out opportunities for new growth of broad-leaved native herbaceous species.

### 5.2 PCQM

The PCQM results indicate an overall improvement in INTG condition since the 2018 survey, with an increase in plant height and basal width in 2022 (Table 16). However, other factors such as an increase in the spacing of perennial plants and reduced species diversity may indicate interaction with other confounding factors. Changes may indicate an improvement in the size and quantity of individual grasses in the Offset Area or results may be due to variability in data parameters and annual fluctuations. Trends may become more apparent as the dataset increases.

**Table 16. Summary of INTG monitoring results based on the PCQM and ramble surveys averaged across Site 1 and Site 2.**

Year	Perennial plants per hectare (PPH)	Spacing of perennial plants (cm)	Basal width (cm)	Plant Height (cm)	% dead material	Rare flora (# of species)	Species diversity
Mean 2018	43,201	48.98	8.8	2.6	53.6	0	9
Mean 2019	89,359	34.9	10	10.4	50.6	1	18
Mean 2020	125,800	32.3	17.27	19.14	36.3	1	20.5
Mean 2021	106,927	32.58	5.08	22.43	38.55	1	17
Mean 2022	42,391	73.09	8.34	24.98	45.19	1	15.5
*Trend	- ve	- ve	+ ve	+ ve	- ve	+ve	- ve

\*+ ve: indicates desirable (positive) trend (since baseline). – ve indicates undesirable (negative) trend (since baseline).

### **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 (such as proliferation of juvenile plants after a good season) or long-term changes at a site (decline in density). 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.

Both Offset Area sites are showing an upward to stable trend in average perennial plant spacing since 2018, with the mean spacing of perennial plants in 2022 an outlier (73.09). Previous survey years have indicated a higher density of plants since the baseline survey, or annual growth of perennial tussocks in the area but given the above average rainfall prior to the 2022, many weed species were in abundance and smothered both sites making perennial grass species difficult to locate.

### **Perennial plants per hectare (PPH)**

Since the baseline survey in 2018, PPH has remained relatively stable at Site 2, but PPH increased markedly between 2018 and 2019 at Site 1. In 2022, PPH decreased substantially at both sites directly related to the increase in the spacing of perennial plants. It is possible that the high level of grazing, coupled with dry seasonal conditions led to a low density of grasses in the first year of survey. Following an apparent reduction in stocking density and / or a reduction in frequency and duration of grazing, grasses may have repopulated at this site. It is currently unclear why the same trend hasn't been observed at Site 2.

### **Basal cover**

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<sup>2</sup>) or 'footprint' of the individual plant (based on a circular tussock). This parameter 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 reported instead of plant foliage cover as it 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 hoped that over the life of the Project, basal cover can be used to track variation due to seasonal conditions, as well as detect changes in the dominance of perennial plants over time. In 2022, only the

four most dominant perennial native grasses were recorded (*Aristida sp.*, *Austrostipa sp.*, *Lomandra sp.* and *Rytidosperma sp.*), with the aim to improve rigour and meaningfulness of data over time.

Basal cover per hectare was higher in 2022 than in 2021 for both Site 1 and Site 2, but lower than the baseline survey in 2018 for Site 1 but not for Site 2 when heavy grazing and general poor condition of the Offset Area was noted. While the average basal width of plants at both sites was higher in 2022 than in 2021, both sites recorded lower basal width than what was recorded in 2020 and 2019. It is unclear due to this fluctuation whether this represents an increase or decrease in the recruitment of juvenile plants. However, as the average spacing of plants has changed markedly in 2022, it suggests that this kind of increase in 2022 when compared to 2021 may be representative of perennial tussock dieback and the subsequent growth of any tussocks that remain. Dieback may be attributable to the high weed load observed across the Offset Area, following substantial rainfall in the 2020 survey period and in the two months prior to the 2022 survey period. A lack of grazing in this critical time has seemingly favoured the spread and growth of weedy species at the detriment of native grasses and these results highlight the importance of achieving the correct balance between too much and not enough grazing.

### **Plant height**

Seasonal conditions and time of year are likely to impact the height of grasses to an extent by influencing their growth vigour, however it is likely that grazing intensity and timing would have the largest impact, as grasses are likely to obtain their typical growth form in the absence of grazing. Conditions within the Offset Area in 2022 were again indicative of minimal or no grazing, with most grasses reaching their full potential height, like what was observed in 2021 and 2020 following a high rainfall year. The average foliage height of perennial grasses in the Offset Area has increased incrementally since the baseline survey at both Offset Sites. Above average rainfall in the two months prior to the 2022 survey was recorded which may attribute to some of this growth but grass height is more closely related to the subjected level of grazing, with a cease in grazing allowing grasses to reach and maintain their typical height.

All four of the common grass species have increased in average height over the course of the five monitoring years since grazing has seemingly ceased, with an increase from 2018 followed by a plateau following good rainfall in 2020 and 2022 when grasses presumably achieved their expected natural growth form. *Lomandra* tussocks have doubled in height since the baseline survey when heavy grazing was observed on the species, despite *Lomandra sp.* being considered unpalatable to stock. Results in 2022 indicate that existing *Lomandra* tussocks are recovering following impacts from heavy grazing and are within the expected height range of 30-60 cm for this species (see Figure 9, p. 22) (eFlora SA 2007).

### **Plant health (percentage dead material)**

Percentage dead material is an indicator of plant health, but this parameter 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, percentage dead material is likely to be highly variable. A high percentage of dead material coupled with a decrease in basal area of plants may indicate declining plant health. Site 2 has shown a steady increase in plant health site 2018, however in 2022 results at Site 1 were equivalent to the poor health observed in 2018, 2019 and 2021 in drought condition and under influence of grazing. The 2022 results align with the 2021 results for Site 1 which may indicate a decline in health.

## **Species composition**

*Relative importance* scores showed a decline in the prevalence of *Rytidosperma* (replaced by *Austrostipa* at both Site 1 and Site 2). 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.

### **5.3 Ramble and grassland health indicators**

Site 2 did not meet the criteria for Condition Class B in 2022, due to an insufficient number of native species observed at the site and a low tussock density per metre squared to qualify. In all other areas (broad-leaved herbaceous species and grass species) the site was above the threshold. Due to the high density of exotic grasses and sparse cover of native plants it is likely that some additional species were present, but undetectable at the time of survey and the site is therefore likely to meet the criteria for listing as a TEC. Site 2 remains in better condition than when the baseline survey was undertaken in 2018, when only nine native species were recorded. Regardless, a decline in the number of species detected since the previous reporting period from 21 (in 2020) to 14 in 2021 and 2022, indicates that the site may have reduced in condition. Tussock density per metre squared was lower than the threshold for the first time in 2022 and should be monitored accordingly. Management actions should be adapted and modified to ensure that a decline does not continue.

In 2022 grassland health attributes were not within the desired benchmark for the community in most cases. Average cover of native vegetation and cryptogamic crust within the Offset Area has reduced, while exotic litter cover remained high. It is possible that a reduction in recorded cover of cryptogams, bare ground and rock is attributable to the high litter cover observed, and the weeds obscuring view of the ground at both sites. High litter cover observed in 2022 may be attributable to the above average rainfall received in the two months prior to the 2022 survey and may be attributable to the density of weeds observed in 2020 and associated dieback of these annual species. Additionally, in dry seasonal conditions (such as those noted in 2021), cryptogam cover can be more difficult to detect as it becomes dry and difficult to distinguish from the soil.

Native herbaceous species require an inter-tussock space to grow, and within reason, the greater the gap the greater the abundance and diversity of non-grass herbs (Pedler *et al.* 2007). As exotic grasses and herbs continue to fill the inter-tussock space, density and diversity of herbaceous species will continue to decline within the Offset Area. A managed grazing regime as per the schedule outlined the OMP is likely to help restore this balance.

Continuing to monitor these attributes will provide an indication of meaningful change over time, and ideally these scores will be consistently within the benchmark range regardless of seasonal conditions.

### **5.4 Weeds**

Weed cover per species was not reported in 2018 and so comparisons between years can only be made for 4 years, during which variable seasonal conditions were experienced. Overall weed cover in 2022 has increased since 2021 and was higher than all previous survey years due to above average rainfall received

in the two months prior to the 2022 survey. *Avena barbata* (Bearded Oat) has increased in dominance across the Offset Area. Appropriately timed grazing should reduce the dominance of weedy species, including *Avena barbata* (Bearded Oat). Prevalence of weeds should continue to be monitored to gain a clearer understanding of how seasonal conditions influence weed growth and prevalence, and if weed cover is changing within the Offset Area over time.

There remains significant improvement that can occur within the Offset Area and it is important to monitor grassland attributes, grazing pressure and weed cover and ensure livestock are removed in spring to allow herbs to set seed and regenerate and ensure that vulnerable species are not lost from the system. It may be desirable to remove livestock in mid (rather than late) spring to facilitate regeneration, particularly during times of dry climatic conditions when there is reduced available feed. Conversely, following years of higher rainfall, livestock should be introduced earlier in the season to enable grazing of annual weedy species before they set seed. Management actions including stocking levels and grazing timetables should be recorded and provided to ecological consultants each year, to enable adaptable land management recommendations based on the results of the annual monitoring survey.

## **5.5 Progress against minimum targets for key indicators in the OMP**

The key indicators that have been set as targets for the management of the Offset Area (Refer OMP (EBS 2017)), the status of the site and the trend are indicated in Table 17. Values indicate that the Offset Area has maintained benchmark goals for listing as a Condition Class B INTG site and has generally improved in condition since establishment in 2018.

However, Site 2 recorded a decrease in the diversity of native species, from 21 in 2020 to just 14 in both 2021 and 2022. Similarly, the density of tussocks per metre squared in 2022 was 0.83/m<sup>2</sup>, which was also below the threshold value. While the diversity of native species is still higher than the original condition, it indicates impacts of reduced grazing were short-lived, and it seems that a lack of grazing has allowed weed species to proliferate locally and smother the inter-tussock space that native herbaceous species required at Site 2. A substantial increase in the weed cover in 2022 may be why the density of tussocks per metre squared was so low as exotic grasses and herbs (which later die off) continue to fill the inter-tussock space. It is possible that that some additional species were present at the site, but were not detected, due to the high cover of weedy grasses.

While initially, heavy grazing and drought conditions were thought to be responsible for the poor condition of the Offset Area, a change in seasonal conditions and an apparent cease of grazing has seemingly raised problems. Overall, the health of individual tussocks within the Offset Area has increased, however an increase in exotic species and exotic species cover following better seasonal conditions has likely led to a decline in species diversity, which is likely to continue if an adaptive grazing regime isn't implemented.

**Table 17. Status of the Offset Area in relation to TEC condition indicators as per the Iron-grass NTG listing criteria and OMP (DotEE 2007).**

Attribute Description	Goal	Current status		Reached benchmark for Class B Iron-grass NTG site
		Site 1	Site 2	
Increase the diversity of native species from nine (baseline value) to above 15.	15 (or more)	17	14	No (Site 2)
Increase the number of broad-leaved herbaceous species (in addition to disturbance resistance species) to three or more.	3 (or more)	5	6	Yes
Increase the number of perennial native grass species to four or more species.	4 (or more)	6	5	Yes
Increase the density of tussock grass species to one per metre.	>1 / m <sup>2</sup>	7.65/ m <sup>2</sup>	0.83 / m <sup>2</sup>	No (Site 2)
<b>Status</b>		<b>Class B</b>	<b>Class C</b>	

Red highlights where benchmark has not been met.

## 5.6 Recommendations

### 5.6.1 Grazing management

Grazing management recommendations remain largely the same as previous reporting periods (but are repeated for clarity). Ideally a grazing management plan that allows for indigenous species to set seed and compete a full lifecycle, while reducing the density of annual invasive species which smother and outcompete indigenous species for light and moisture resources is undertaken on a rotational basis. The following approach is recommended.

- The grazing period is between 30 April and 15 November at the latest. However, during dry conditions, it is recommended that livestock are introduced later (i.e., mid-winter) and removed earlier (e.g., mid-spring). Spring is the growing season for most plants in the grassland and in favourable conditions, a week should be acceptable as a maximum grazing period provided there is enough feed. The time allowed for spelling between grazing events will vary according to the conditions and the time of year. An average of 35 days is likely to be adequate. However, longer spelling and shorter grazing durations will assist in facilitating native plants and herbaceous species to flower and set seed.
- Optimally, grazing should be timed to coincide with the elongation of annual grass stems, prior to development of seed heads. Grazing at this time will reduce seed set of annual weedy grasses while enabling soil seed bank and recruitment of native perennial grasses to improve.
- At no time should animals be left in any paddock for longer than seven days, irrespective of the amount of feed in the paddock. After seven days, any actively growing plants will be in danger of being overgrazed. Moving the animals onto fresh native grassland pasture and allowing the grazed pastures to rest and plants to recover, with a return grazing later in the season, will result in healthier grassland and better animal performance.

Grazing management requires adjusting to reflect climatic conditions and although it is a useful tool in weed control and reducing thatch on grasses, during extreme dry conditions livestock numbers require adjusting accordingly to enable plants to reshoot and retain enough green plant material to survive.

As per the OMP ENGIE must ensure that the Landholder:

Provides the necessary information for ENGIE to submit the *Activity Record Datasheet* (Appendix 2. Activity Record Datasheet), at the end of each financial year (for 10 years, until 2027, as stated in OMP).

1. Provides the necessary information to ENGIE to complete and submit the *Paddock Monitoring Sheet* (Appendix 3. Paddock Monitoring Sheet) to assist with management of the grazing program.

Provision of these important records to ENGIE and to contractors (in this case EBS Ecology) undertaking annual ecological monitoring will enable monitoring of grassland health and condition to be attributable to management actions and determine impacts and any necessary changes to management to provide the desired outcome for the Offset Area.

As part of the OMP an annual review is recommended as part of the annual monitoring and reporting program, including liaison between the landholder, ENGIE and ecological consultant. It is recommended that following finalisation of this report, a meeting between involved parties be arranged to discuss management actions going forwards. Following the initial five-year period (2018-2022), a review of the management plan is to be undertaken using the data collated in association with landholder input, to inform the 2022-2042 management plan to be submitted to the property owners, Commonwealth (through DCCEEW) and the NVC for approval.

### **5.6.2 Weed management**

Weeds should be managed opportunistically and without the use of selective herbicides due to sensitivity of native species. Woody weed and targeted herbaceous species can be manually managed within the Offset Area. Based on the 2022 survey the following weed control measures are recommended:

- Use short term winter grazing to control winter active grassy weeds such as Wild Oats.
- Graze earlier (i.e., late autumn) in above average (summer) rainfall years, and later (i.e., mid-late winter) in lower-than-average rainfall years.
- Remove singular *Medicago sativa* (Alfalfa) plant from Site 1 to prevent its spread.
- Remove small patch of *Cynara cardunculus* (Artichoke Thistle) near Site 1 by hand pulling preferably, ensuring trap root is removed to prevent re-establishment. Alternatively, cut flower stems opportunistically before reaching maturity to reduce seed production.
- Remove small patch of *Foeniculum vulgare* (Fennel) from south-eastern edge of Offset Area by hand pulling and continue to monitor disturbed patch to prevent re-establishment in these areas.
- Monitor the site for new weeds and control promptly to avoid spread.

There is potential for the introduction of additional weeds associated with the introduction of new stock to the property. Sheep can readily carry weed seed in the wool from a previous property which can be accidentally deposited on the new property. There may be a need for a quarantine procedure before introducing new stock into the Offset Area, where stock could be kept outside the site for a minimum period

of seven days prior to entry to the Offset Area paddocks. A quarantine procedure would not be necessary when the sheep are from the same property.

The requirements for Declared Weeds in the Offset Area, including *Cynara cardunculus* (Artichoke Thistle) and *Echium plantagineum* (Salvation Jane) is highlighted in Table 15.

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## 7 APPENDICES

### 7.1 Appendix 1. Photo Points

#### 7.1.1 Offset Site 1

2022



Transect 1 start (looking south) 2022



Transect 1 end (looking north) 2022

2021

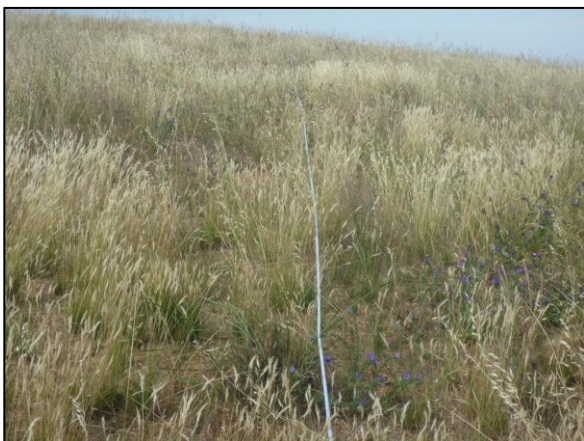


Transect 1 start (looking south) 2021



Transect 1 end (looking north) 2021

2020



Transect 1 start (looking south) 2020



Transect 1 end (looking north) 2020

2019



Transect 1 start (looking south) 2019



Transect 1 end (looking north) 2019

2018



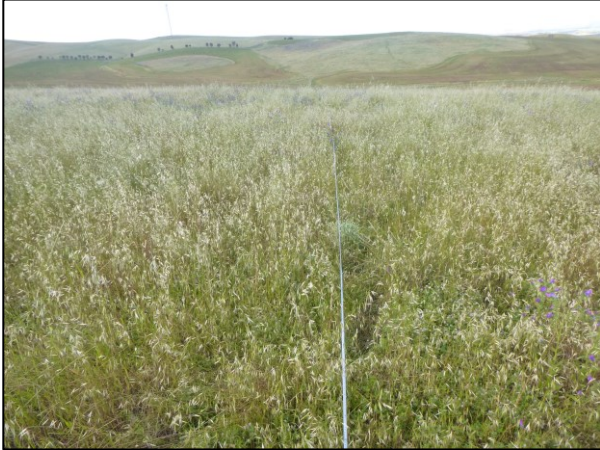
Transect 1 start (looking south) 2018

N/A

Transect 1 end 2018

7.1.2 Offset Site 2

2022

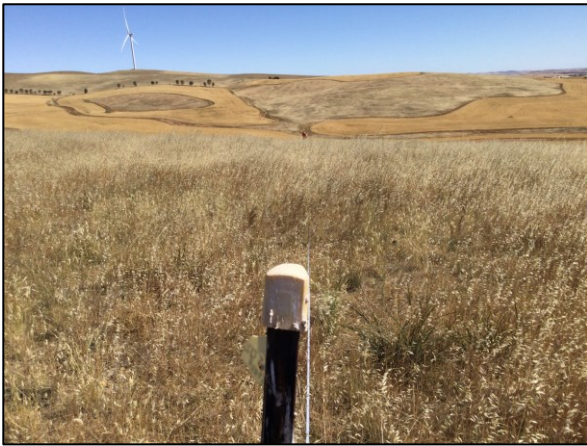


Transect 2 start (looking south) 2022



Transect 2 end (looking north) 2022

2021



Transect 2 start (looking south) 2021



Transect 2 end (looking north) 2021

2020

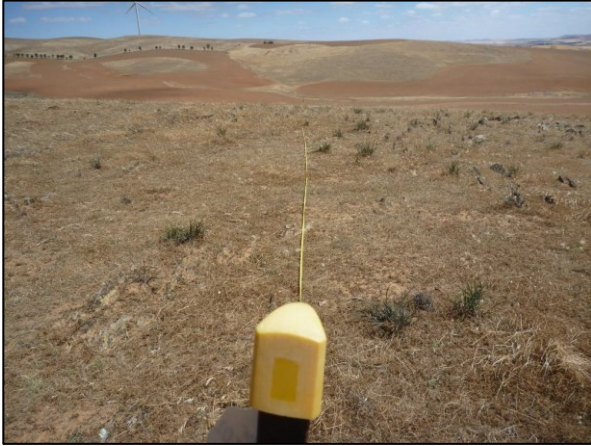


Transect 2 start (looking south) 2020



Transect 2 end (looking north) 2020

2019

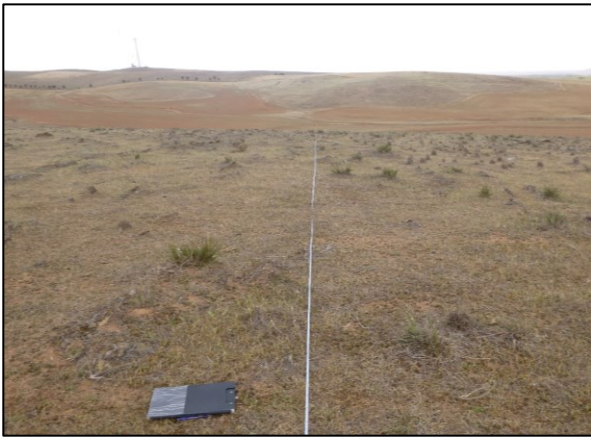


Transect 2 start (looking south) 2019



Transect 2 end (looking north) 2019

2018



Transect 2 start (looking south) 2018

N/A

Transect 2 end 2018







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