Silverton Wind Farm:

Vegetation Monitoring Report - 2019

FINAL REPORT

Prepared for GE Renewable Energy

30 June 2020

Biosis offices

NEW SOUTH WALES

Albury
Phone: (02) 6069 9200
Email: albury@biosis.com.au

Newcastle
Phone: (02) 4911 4040
Email: newcastle@biosis.com.au

Sydney
Phone: (02) 9101 8700
Email: sydney@biosis.com.au

Western Sydney
Phone: (02) 9101 8700
Email: sydneyoffice@biosis.com.au

Wollongong
Phone: (02) 4201 1090
Email: wollongong@biosis.com.au

VICTORIA

Ballarat
Phone: (03) 5304 4250
Email: ballarat@biosis.com.au

Melbourne (Head Office)
Phone: (03) 8686 4800
Email: melbourne@biosis.com.au

Wangaratta
Phone: (03) 5718 6900
Email: wangaratta@biosis.com.au

Document information

Report to:	GE Renewable Energy
Prepared by:	Renée Woodward
Biosis project no.:	30951
File name:	30951.SilvertonWF.VegMonFNL01.20200630.docx
Citation:	Biosis 2020. Silverton Wind Farm: Vegetation Monitoring Report – 2019. Report for GE Renewable Energy. Author: Woodward R, Biosis Pty Ltd, Albury. Project no. 30951

Document control

Version	Internal reviewer	Date issued
Draft version 01	Matt Looby	12/06/2020
Final version 01	Renée Woodward	30/06/2020

Acknowledgements

Biosis acknowledges the contribution of the following people and organisations in undertaking this study:

- GE Renewable Energy: Alana Philp, Katie Sage, Michael Brownlie.
- Leaseholders Blore and Lawrence
- NSW Environment, Energy and Science Group for access to the BioNet Atlas of NSW Wildlife.

Biosis staff involved in this project were:

- Ewan Kelly, Georgina Zacks, Matilda Terry (field survey)
- Matilda Terry (assistance with reporting)
- Julian Turner (mapping)

© Biosis Pty Ltd

This document is subject to copyright and may only be used for the purposes in respect of which it was commissioned and in accordance with the Terms of Engagement of the commission. Unauthorised use of this document in any form whatsoever is prohibited.

Disclaimer:

Biosis Pty Ltd has completed this assessment in accordance with the relevant federal, state and local legislation and current industry best practice. The company accepts no liability for any damages or loss incurred as a result of reliance placed upon the report content or for any purpose other than that for which it was intended.

Contents

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Tables

Figures

Photos

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

1. Introduction

1.1 Project background

Biosis Pty Ltd was commissioned by GE Renewable Energy (GE) to undertake the 2019 monitoring of the vegetation of Silverton Wind Farm (STWF) in accordance with the operational Biodiversity Adaptive Management Plan (BAMP) (Biosis 2018a). Silverton Wind Farm is located approximately 5 kilometres north of Silverton and 25 kilometres north-west of Broken Hill in the Unincorporated Area of the Far West District of New South Wales (NSW) (Figure 1). The turbines are located on the ridgelines in and around the Mundi-Mundi and Barrier Ranges.

The Silverton Wind Farm project is being undertaken by the Powering Australian Renewables Fund (PARF), a partnership between AGL, QIC and Future Fund. PARF engaged GE-CATCON (a consortium led by GE and Civil and Allied Technical Construction Pty Ltd (hereafter referred to as CATCON) under an Engineer, Procure and Construct (EPC) Contract to deliver the Silverton Wind Farm works. GE is now responsible for management of the STWF site during the operational phase. TransGrid (Network Service Provider – NSW) provides the connection works.

Condition 18(c) of the Project Approval required that prior to the commencement of construction, a Biodiversity Management Plan was to be prepared for the project for the site. The BAMP (Biosis 2018a) was developed to satisfy that condition and the Statement of Commitments (2009) for the operational phase of the wind farm (See BAMP Appendix 2 for details). In particular, the BAMP specifies the implementation, monitoring and reporting activities for the recovery of the critically endangered Porcupine Grass Sparse Woodland (PGSW) as recommended in the recovery plan (Biosis 2018b).

This report has been prepared to document condition of PGSW at STWF for the first year following the baseline surveys conducted in 2018 (Biosis 2020) as a component of the monitoring and adaptive management approach outlined in the BAMP. In particular, monitoring of PGSW in conjunction with factors that influence vegetation condition, such as climatic conditions, feral goat and introduced flora populations, is to be undertaken as an initial three year investigation following the baseline survey in 2018.

The purpose of this monitoring is to inform refinement of on-going management to improve the condition of PGSW within the wind farm area. A comprehensive review of monitoring and management will be undertaken after three years to ensure there is a net gain in the conservation value of this community, being after surveys in spring 2021.

1.2 Purpose

This document provides the 2019 vegetation survey results of the PGSW community within STWF.

The objectives of this investigation are to:

- Conduct 2019 vegetation monitoring of the PGSW community in accordance with the requirements of the BAMP.
- Liaise with landholders to gather goat population data.
- Collation and mapping of any additional data on weed populations.
- Analyse and report on the condition based on spring 2019 survey results.
- Compare monitoring results from 2019 with to the baseline survey conducted in 2018 (Biosis 2020).

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

These measures of diversity, structure and function will assist in site management decision-making and provide evidence to demonstrate the attainment of a net improvement in vegetation health and condition.

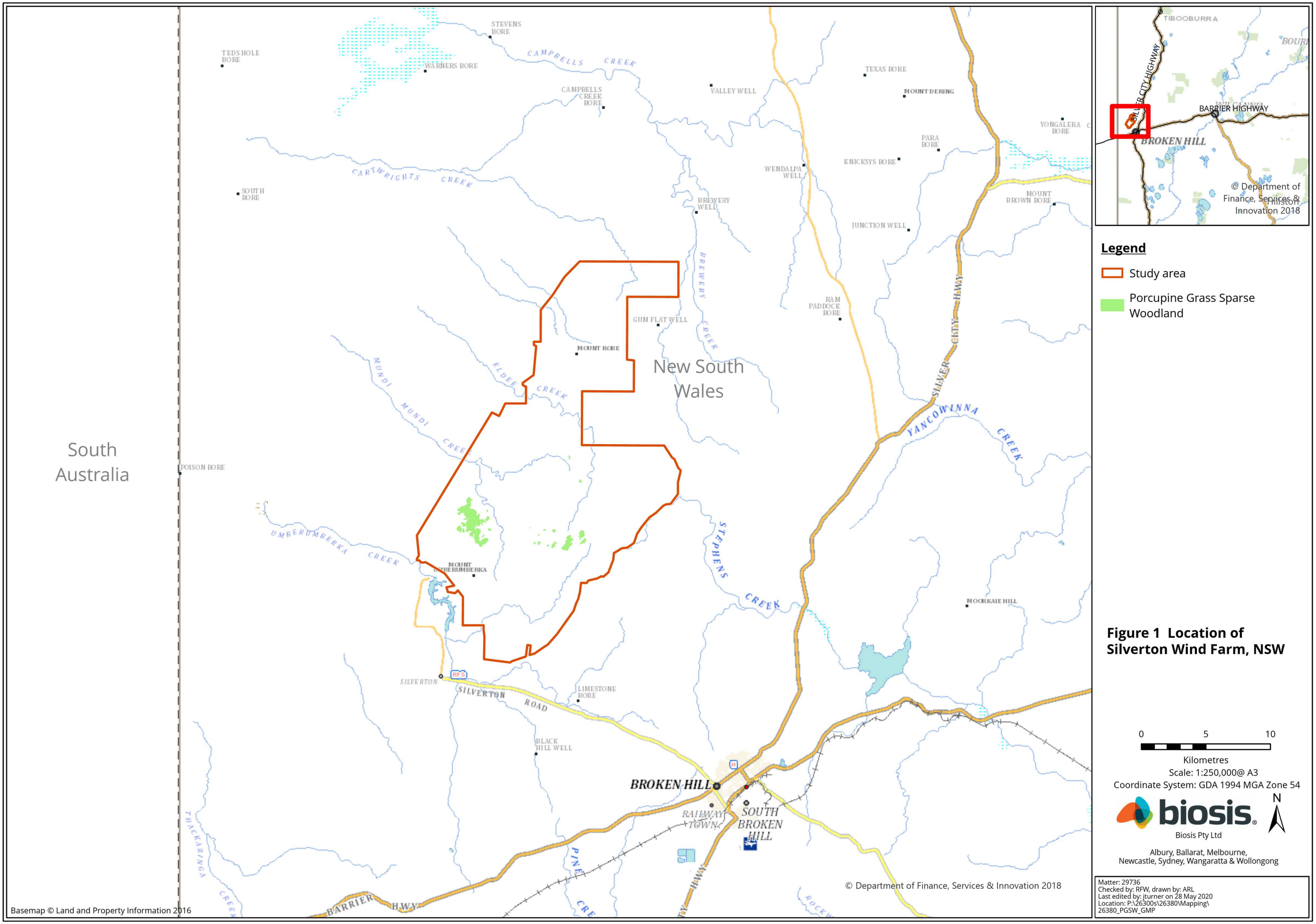
1.3 Relationship to other plans

The primary document relevant to this report is the baseline vegetation monitoring report (Biosis 2020), prepared following the baseline survey in 2018.

For further background to the project, this Vegetation Monitoring report is also to be read in conjunction with the BAMP (Biosis 2018a), which describes the specific monitoring and management measures to be undertaken during the operational phase of the wind farm to protect and enhance the biodiversity values of the study area. In particular, it provides a cohesive document that details the methods, actions, monitoring and reporting identified for the Barrier Range Dragon Management Plan (Biosis 2018c), Goat Management Plan (Biosis 2018d), Porcupine Grass Sparse Woodland Recovery Plan (Biosis 2018b) and Vegetation Management Plan (Biosis 2018e), into one cohesive implementation document. This allows for an integrated approach to on-ground monitoring and management of biodiversity at the Silverton Wind Farm site.

1.4 Current land management

The Silverton Wind Farm has been constructed on NSW Crown Land offered as leasehold under the authority of the *Western Lands Act 1901*. The land supporting PGSW is currently used by two independent lessees for grazing purposes, including grazing by Feral Goats, under two separate General Purpose Leases. A wind farm lease (Special Purpose Lease) was assigned to PARF as part of financial close on the Silverton Wind Farm project.



Legend

- Study area
- Porcupine Grass Sparse Woodland

Figure 1 Location of Silverton Wind Farm, NSW

0 5 10

Kilometres

Scale: 1:250,000@ A3

Coordinate System: GDA 1994 MGA Zone 54

N

biosis

Biosis Pty Ltd

Albury, Ballarat, Melbourne,
Newcastle, Sydney, Wangaratta & Wollongong

Matter: 29736
Checked by: RFW, drawn by: ARL
Last edited by: jturner on 28 May 2020
Location: P:\26300s\26380\Mapping\
26380_PGSW_GMP

2. Methods

In accordance with the BAMP and associated plans, vegetation monitoring commenced with the collection of baseline data in 2018. This was followed by a program of management, regular monitoring and subsequent adaptive response to monitoring results.

2.1 Pre-survey climate

Monthly climate data for the duration of the monitoring program has been downloaded from the Bureau of Meteorology website http://www.bom.gov.au. Data from the weather station at Broken Hill Airport (Station ID 047048) is analysed, as it is the nearest to the study area.

Climate data analysed includes:

- Monthly rainfall total
- Monthly minimum and maximum temperature
- Average rainfall by month
- Average minimum and maximum temperature.

2.1.1 Dynamic nature of arid lands

The Silverton Wind Farm is located in the arid zone, where the climate is noted not only for low average rainfall, but high variability in rainfall between years. Extended drought periods are interspersed by rainfall events of varying magnitude, stimulating the growth of flora from dormant seedbanks. Large infrequent rainfall events also provide cues for the recruitment of long-lived perennial plants through flushes of biomass, fruits and seeds (Keith & Tozer 2012). This increased plant growth also triggers population increases in associated fauna species, as resources become abundant.

This inherent variability makes it difficult to detect true change resulting from management actions, particularly in the short term. Having climate data at hand will assist in monitoring the interrelatedness of seasonal weather events and management activities.

2.2 Monitoring sites

Twenty stratified survey sites (quadrats and associated subplots) have been established and permanently marked within the three known variants of the community, according to area of the variant and proximity to an established goat proof fence (Biosis 2020).

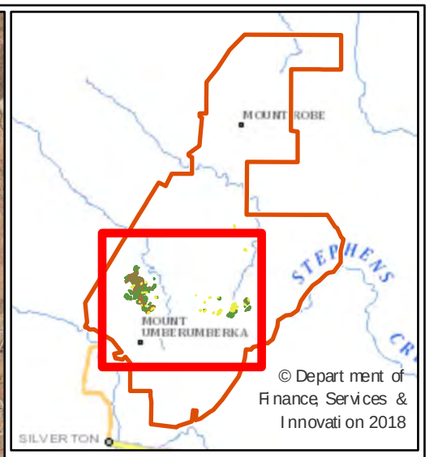
In accordance with the NSW vegetation survey standards (Sivertsen 2009), each survey site comprises a 20 x 20 metre quadrat, with woody stems recorded in an associated 0.1 hectare plot. To measure fine scale responses, additional 5 x 5 metre subplots have also been established using the same south-west (SW) corner as the 20 x 20 metre quadrat. The quadrat location was recorded in the SW corner, and the quadrat was aligned with two sides from the SW corner following magnetic north and east. This plot layout is shown in Figure 3.

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Wrangee Road

2.2

2.3



Legend

- Study area
- Infrastructure
- Infrastructure with PGSW downslope
- Goat fencing
- Turbine
- Vegetation monitoring site
- O&M building

PGSW structural variants

- Porcupine grass with eucalypts
- Porcupine grass only
- Eucalypts only

Figure 2.1 Location of permanent vegetation monitoring sites - Overview

0 500 1,000

Metres

Scale 1:37,500 @A3

Coordinate System: GDA 1994 MGA Zone 54

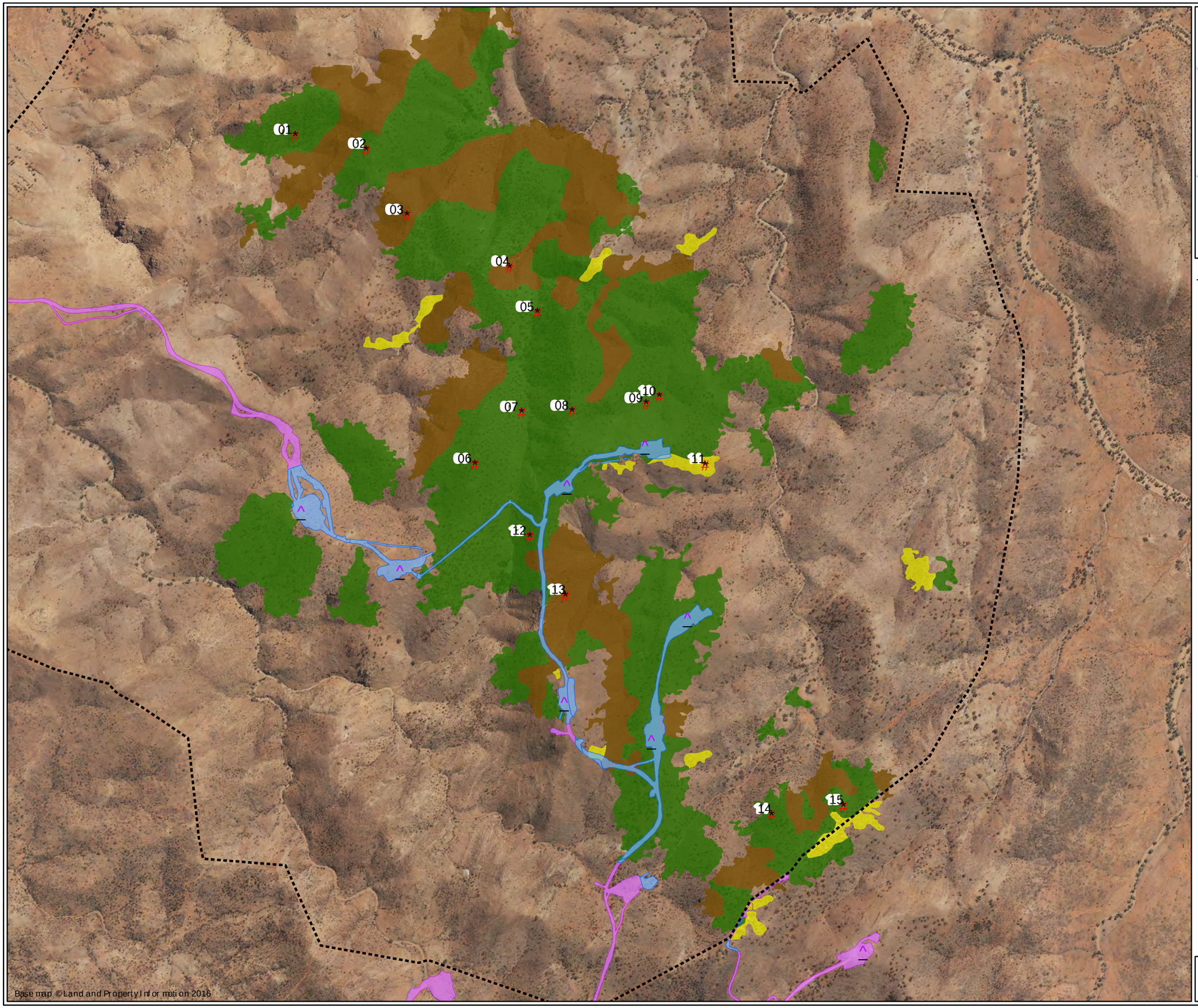
biosis

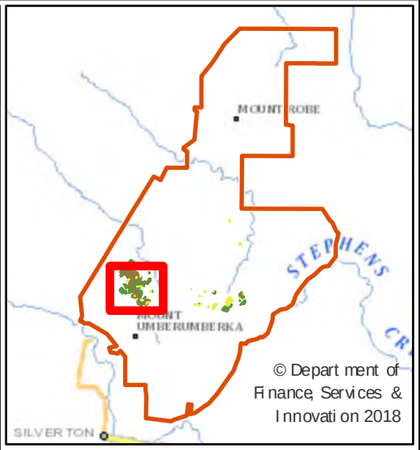
Biosis Pty Ltd

Albury, Ballarat, Melbourne, Newcastle, Sydney, Wangaratta & Wollongong

Matter: 29736
Checked by: RFW drawn by: JPT
Last edited by: jturner on 29 May 2020
Location: P:\26300s\26380\Mapping\26380_PGSW_GMP

Base map © Land and Property Information 2016





Legend

- Study area
- Infrastructure
- Infrastructure with PGSW downslope
- Goat fencing
- Turbine
- Vegetation monitoring site

PGSW structural variants

- Porcupine grass with eucalypts
- Porcupine grass only
- Eucalypts only

Figure 2.2 Location of permanent vegetation monitoring sites - Goat fence / west

0 500

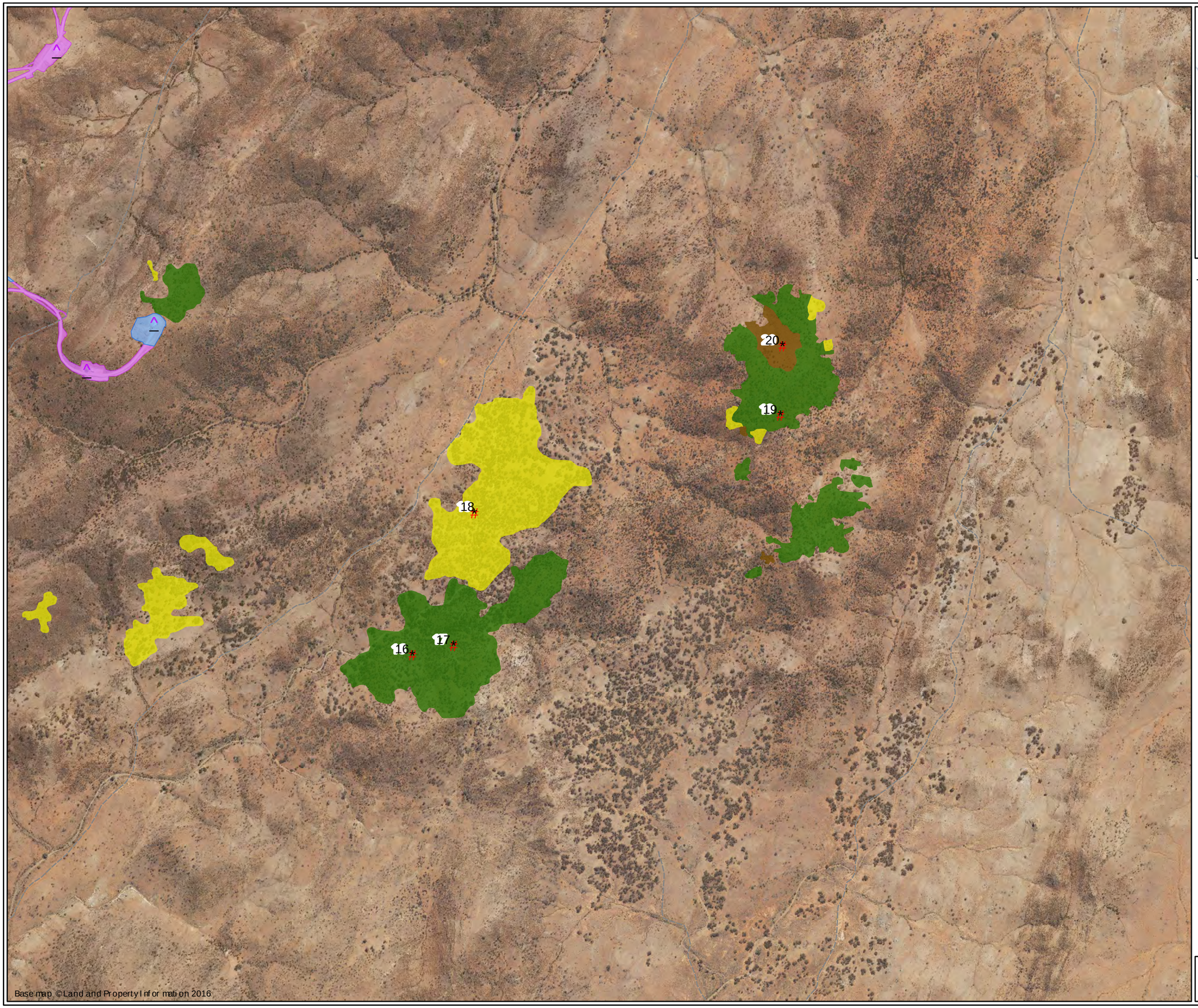
Metres
Scale 1:12,500 @A3
Coordinate System GDA 1994 MGA Zone 54

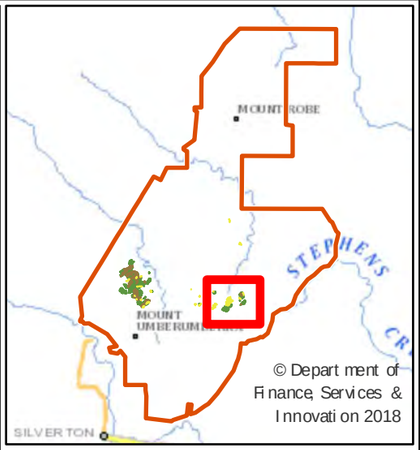
biosis

Biosis Pty Ltd

Albury, Ballarat, Melbourne, Newcastle, Sydney, Wangaratta & Wollongong

Matter: 29736
Checked by: RFW drawn by:JPT
Last edited by: jturner on 29 May 2020
Location: P:\26300s\26380\ Mapping\ 26380_PGSW_GMP





Legend

- Study area
- Infrastructure
- Infrastructure with PGSW downslope
- Turbine
- Vegetation monitoring site

PGSW structural variants

- Porcupine grass with eucalypts
- Porcupine grass only
- Eucalypts only

Figure 2.3 Location of permanent vegetation monitoring sites - outside goat fence / east

0 500

Metres
Scale 1:12,500 @A3
Coordinate System GDA 1994 MGA Zone 54

biosis

Biosis Pty Ltd

Albury, Ballarat, Melbourne, Newcastle, Sydney, Wangaratta & Wollongong

Matter: 29736
Checked by: RFW drawn by: JPT
Last edited by: jturner on 29 May 2020
Location: P:\26300s\26380\Mapping\26380_PGSW_GMP

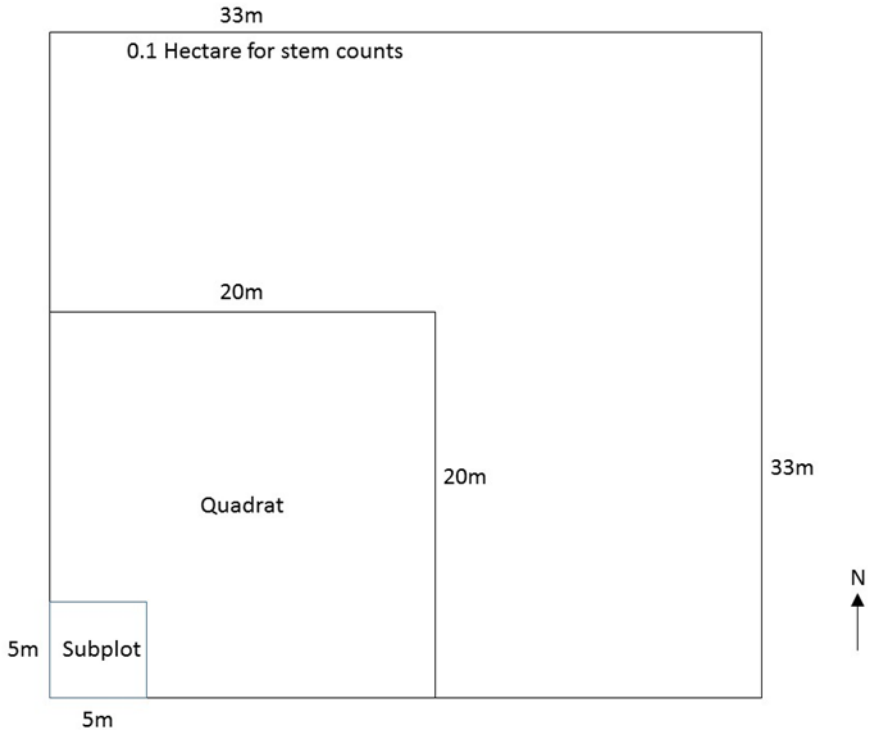


Figure 3 Monitoring plot layout

Survey of the monitoring sites was conducted by two qualified botanists (Ewan Kelly and Georgina Zacks) supported by a research assistant (Matilda Terry) between the 28 and 30 October 2019.

The monitoring sites were prepared for survey as follows:

- Prior to commencing survey, site locations, aerial photography and layers identifying existing infrastructure and existing ecological data were loaded into hand held tablet computers running ArcGIS Collector to allow navigation across the wind farm.
- Sites were accessed on foot and by vehicle.
- Where site marking required renewal, sites were remarked by re-drilling into the rock in the SW corner of a site using a hammer drill, into which a ring bolt was attached using epoxy glue. The rock was sprayed with pink spray paint to increase visibility, and a numbered tag was attached to the ring bolt using a cable tie (See Appendix 1).
- ArcGIS collector was used for opportunistic data collection. Quadrat data was collected digitally using Survey123.

2.3 Photopoint monitoring

Photopoints were captured at each site using the following method:

- Site photos were captured with reference to the 2018 baseline photo set using the Open Camera Application on the hand held tablet. Cameras were set to a suitable resolution, and geotagging function turned on so all photos have associated coordinates.
- Camera date and time was checked for accuracy and 'time stamp' function was turned on.

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

- On arriving at the survey site, Open Camera was started and given time to calibrate to the survey location to ensure accuracy of geotagged co-ordinates.
- A minimum of 12 site photos were captured as follows:
  - Photo of the site tag.
  - From the SW corner (including the corner in image), a portrait and a landscape photo was captured at bearings 0, 45 and 90 degrees.
  - From both the NE corner (including the corner in image), a portrait and a landscape photo was captured at bearings 270, 225 and 180 degrees.
- Field photos have the following requirements:
  - Ensure tapes are placed around the quadrat before taking photos.
  - All strata are to be in view.
  - Step back to ensure corner of the plot is included.
  - Capture ground and sky unless located in a valley and no sky visible.

Any additional photos were also captured as appropriate to capture site condition/species.

2.4 Feral goats

2.4.1 Goat management infrastructure

Exclusion fencing was erected around the majority of the PGSW by leaseholder Blore in May 2014 as part of the Mundi Mundi Conservation Project (Blore 2008), funded by the Total Grazing Pressure Program, Western Local Land Services (LLS). The goat proof fence was erected to temporarily exclude and manage goats for the purposes of protecting PGSW and endangered Barrier Range Dragon. Under the funding agreement, PGSW fencing maintenance is the responsibility of the leaseholder but no timeframes are specified.

2.4.2 Landholder estimates of goat populations

At the time of the vegetation survey, data on the annual goat population over the preceding year have been requested from leaseholders within the project area.

2.4.3 Scat counts

Abundance and grazing activity by herbivores, including goats, are regularly estimated by scat counts. These have been shown to correlate with actual densities of animals (Russell, Letnic, & Fleming 2011).

Macropod, goat and rabbit scats were counted in all 5 x 5 metre subplots as an approximate measure of herbivore activity. Counts in the ongoing monitoring are of all recent/fresh (black) scats. Counts are absolute, for statistical assessment on a continuous scale (Biosis 2018a).

The scats of large macropods likely to occur on the site (e.g. Red Kangaroo *Macropus rufus*, Eastern Grey Kangaroo *M. giganteus*, Western Grey Kangaroo *M. fuliginosus* and Euro *M. robustus*) cannot not be reliably differentiated and so the results for these species have been pooled (Russell, Letnic, & Fleming 2011).

2.5 Condition of PGSW

Porcupine Grass Sparse Woodland is a distinctive and naturally restricted community first identified by NGH Environmental (2008a) following baseline surveys for the Silverton Wind Farm Project. Given the highly

restricted distribution of the community, it was subsequently listed as a critically endangered community (NSW Scientific Committee 2010) under the NSW *Threatened Species Conservation Act 1995* (replaced by the *Biodiversity Conservation Act 2016* (BC Act). This community has been formally assigned to the Plant Community Type (PCT) PCT359: Porcupine Grass - Red Mallee - Gum Coolibah hummock grassland / low sparse woodland on metamorphic ranges on the Barrier Range, Broken Hill Complex Bioregion (OEH 2017a).

As detailed in Section 2.1.3 of the PGSW Recovery Plan (Biosis 2018b), variations in species and structural diversity of PGSW is common in its limited geographic range. The PCTs with which PGSW intergrades do not include the characteristic Red Mallee, Gum Coolabah or Porcupine Grass (OEH 2017a). Therefore, PGSW occurs as:

- Porcupine Grass hummock grassland with key eucalypt species present.
- Porcupine Grass hummock grassland without key eucalypt species present.
- Eucalypt species present without/with minimal Porcupine Grass.

Although the community determination (NSW Scientific Committee 2010) identifies Porcupine Grass as a typical community dominant, areas with a canopy layer dominated by Red Mallee and/or Gum Coolabah located on rocky hills containing (or able to be identified as previously having contained) Porcupine Grass, are considered to be part of the listed threatened community, even if these areas currently do not contain Porcupine Grass (Biosis 2018b).

The following section details the monitoring methods to measure the condition of PGSW over time as required by the BAMP.

2.5.1 Vegetation condition

Vegetation condition (floristics and structure) was measured in the 20 permanent quadrats, each measuring 20 x 20 metres, using a simplified form of the NSW vegetation survey standards (Sivertsen 2009). Abundance of all flora species will be recorded in a nested 5 x 5 metre subplot (Section 2.5.3).

The quadrat location is recorded in the SW corner, and the quadrat is aligned with two sides from the SW corner following magnetic north and east (Figure 3). Within the 20 x 20 metre quadrats (30 x 30 metre for woody stem sizes), the following variables were recorded:

- Structure of vegetation (vegetation strata type, height, dominant species and percent cover of strata), including percent cover of litter, cryptograms, rock and bare ground.
- Projective Foliage Cover (PFC) of all plant species assessed as a relative percentage cover.
- Lineal metres of coarse woody debris (CWD) >10 centimetres diameter.
- Woody stem sizes (within the 30 x 30 metre quadrat).
- Tree health (observations of canopy intactness, insect damage, mistletoe load, epicormic/lignotuber growth etc.).
- Whether regeneration is observed for each woody species.
- Disturbance notes.

A reference specimen has been collected for all plant species where sufficient material was available.

2.5.2 Grazing pressure

Woody species occur in low abundance within the community. Therefore the assessment of all woody individuals within the 20 x 20 metre quadrats has been undertaken through an adaptation of the method

used by AREA Environmental Consultants and Communication to assess the browsing impacts of goats in Mutawintji NP (AREA 2017). This method is provided in Appendix 2.

For all woody species (or selected key woody species) within each quadrat the following has been documented:

- Height, width at widest point, height of browse line (the boundary between upper normal plant growth and lower stripped and eaten-back growth that indicates the height reached in feeding by the larger browsers) for plants > 2 metres tall
- Condition above browse line:
  - Good = No dead wood.
  - Dead Wood Fair = Trees with >50% dead wood.
  - Dead Wood Poor = Trees with <50% dead wood.
- Condition below browse line including all plants less than 2 metres in height:
  - Unbrowsed.
  - Low-Moderate browsing.
  - High-Intense browsing.
- Totally browsed (no living growth below browse line).

A condition state of each woody plant to show the current browse state:

- **Uninterrupted** - Fresh new growth with no or very little sign of browsing. Plant growing periodically in relation to natural growth stimuli (rainfall and temperature).
- **Arrested** - Plant in hedged or topiarised form due to intense browsing. New growth continuously eaten and not extending beyond previous browse levels preventing the plant from growing to its natural potential.
- **Retrogressed** - Death of all or some stems previously browsed with new growth occurring from the lower stems. Stem death arises from stresses induced by browse.
- **Released** - New growth from browsed stem not browsed due to temporary or permanent relaxation of browse pressure or plant grown beyond browse line.

Due to a field data collection error, the condition of a proportion of woody stems in the 20 x 20 metre plots was not recorded in the field. This was evident in a comparison with the 2018 browse data and photopoint monitoring data. Therefore, analysis of condition is only able to be summarised from the stems that were monitored in 2019. This error will be rectified in the browse assessments in 2020.

2.5.3 Finer scale responses

Nesting of additional smaller subplots is required for measuring fine scale responses of annual plant abundance, which will improve the ability to identify individual species responses to management actions and climatic conditions.

Twenty 5 x 5 metre subplots have been established using the same SW corner as the 20 x 20 metre quadrats (Figure 3). Within these subplots, absolute abundances of all flora species were recorded.

2.6 Introduced flora species

2.6.1 Ongoing monitoring

In addition to existing weed mapping data for the study area, any additional records arising from the ongoing monitoring during the operational phase of the wind farm will be mapped. Following handover of management from CATCON, GE are responsible for monitoring and subsequent management of introduced weed species focussing on three key areas:

- Existing weed populations.
- Areas of construction disturbance.
- Opportunistic observations of new populations documented during the monitoring program.

Inspections will occur more frequently as required, particularly at one and three months following significant rain events (> 25 millimetres) to ensure no new weed incursions have established, or if required following maintenance inspections.

Locations of populations of introduced species observed during ongoing site management by GE operational staff, the future site manager or during ecological monitoring programs are to be provided to the Project Ecologist who will map them in the annual vegetation monitoring report and shapefiles will be provided for inclusion in an annual weed management program.

2.7 Qualifications

Ecological surveys provide a sampling of flora and fauna at a given time and season. There are a number of reasons why not all species will be detected at a site during survey, such as low abundance, patchy distribution, species dormancy, seasonal conditions, and migration and breeding behaviours. In many cases these factors do not present a significant limitation to assessing the overall biodiversity values of a site.

The current monitoring was conducted in spring during an extended drought, which is not an optimal time for survey. As a result of the extended dry conditions, species diversity and abundance is expected to be low relative to any survey conducted following greater rainfall.

2.8 Mapping

Mapping was conducted using hand-held GPS-enabled tablets and aerial photo interpretation. The accuracy of this mapping is therefore subject to the accuracy of the tablets (generally ± 7 metres) and dependent on the limitations of aerial photo rectification and registration.

Mapping has been produced using a Geographic Information System (GIS). Electronic GIS files which contain our flora spatial data are available to incorporate into GE mapping projects informing ongoing management of the site.

2.9 Data analysis

Prior to analysis, field data was collated and reformatted in Microsoft Excel 2016 then tabulated for analysis. Analyses were undertaken in R version 3.5.3 within RStudio version 1.2.1335 focussing on:

- Climatic conditions prior to survey.
- Species composition within the PGSW community.

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

- Species richness at each site.
- Cover and abundance of introduced and native flora.
- Ground layer responses (vegetation, litter and bare ground, litter)
- Condition of woody species (particularly the condition above and below the browse line if present)
- Natural regeneration.
- Targeted analyses to investigate the influence of:
  - Position relative to the goat fence (in or out).
  - Structural variant of PGSW community.

3. Results

3.1 Pre-survey climate

In the year prior to survey in October 2019, the extended drought had continued to result in ongoing low monthly rainfall totals relative to the long-term average Figure 4, particularly from April This was also reflected in the lower number of rain days through that period Figure 5. Total rainfall in the pre-survey 12 month period was 123.2 millimetres, greater than that in the year prior to the 2018 monitoring (73.0 millimetres), but still well below the long term mean of 247.7 millimetres.

Summer 2018-19 was hot, with monthly average temperatures 1.1 - 4.5 degrees hotter than average Figure 6. In January 2019, the maximum daily temperature record of 45.3 (2001) was equalled or exceeded on four days, with a new record temperature of 46.3 degrees Celsius occurring on 16 January (Figure 7).

Otherwise, average monthly temperatures data did not vary greatly from the long-term average Figure 6.

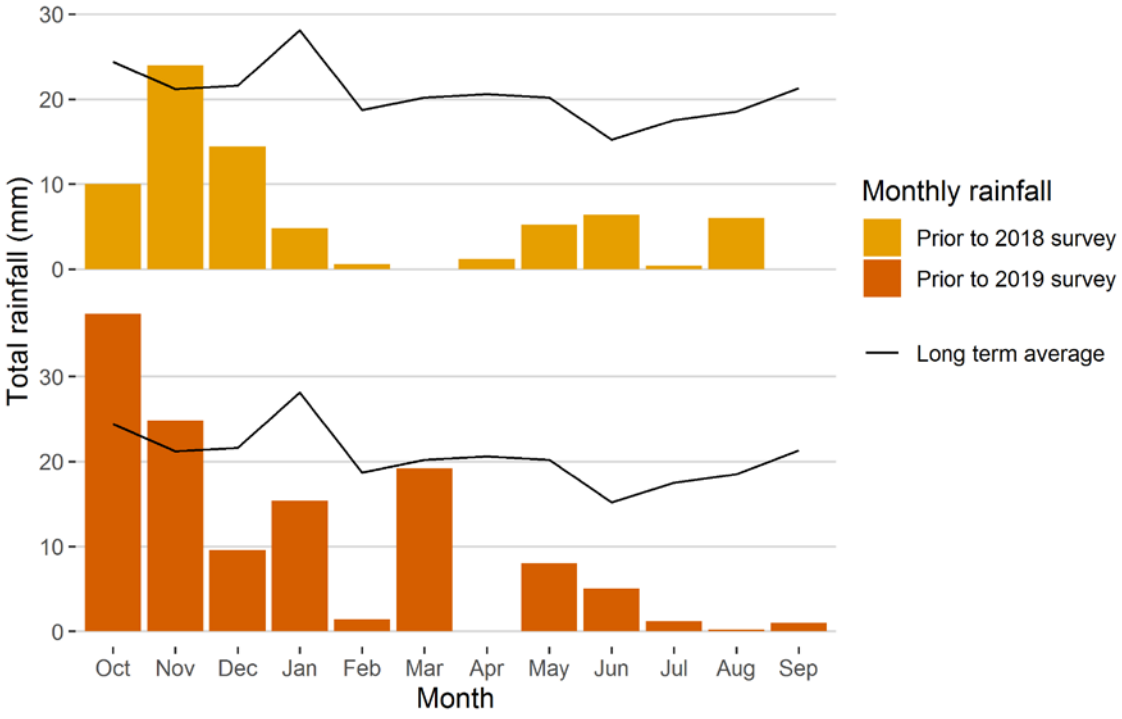


Figure 4 Monthly rainfall totals in the year prior to each survey

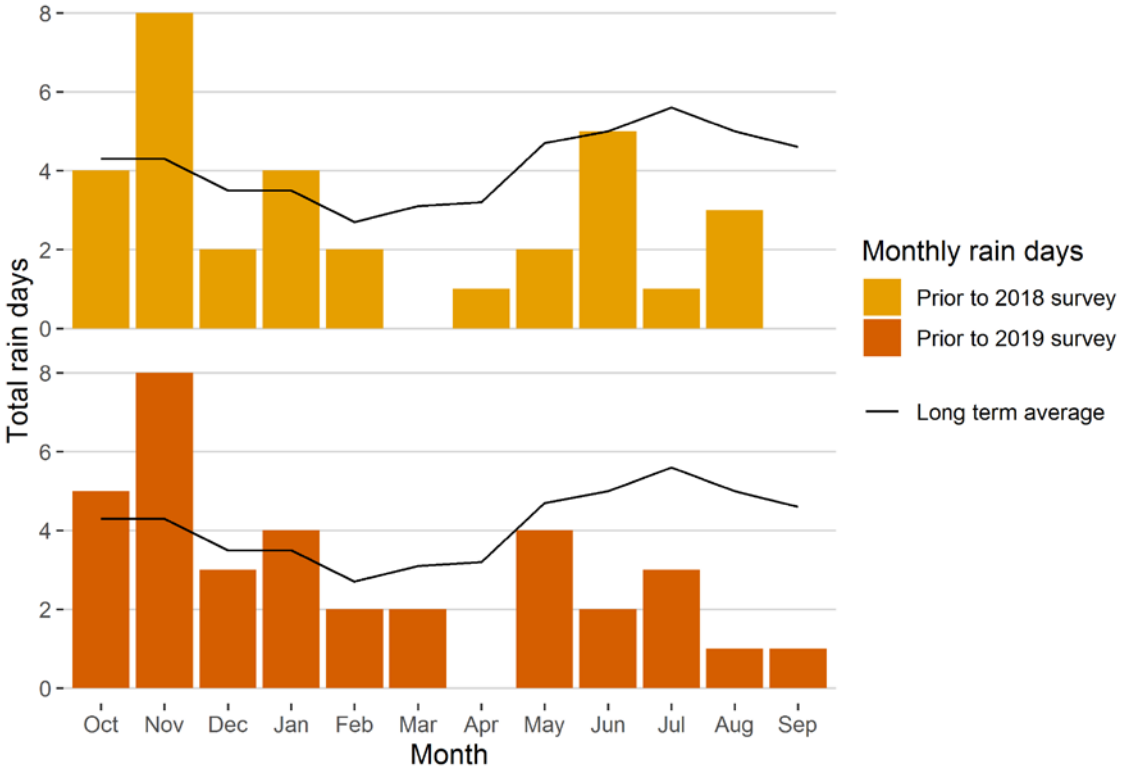


Figure 5 Monthly rain days in the year prior to each survey

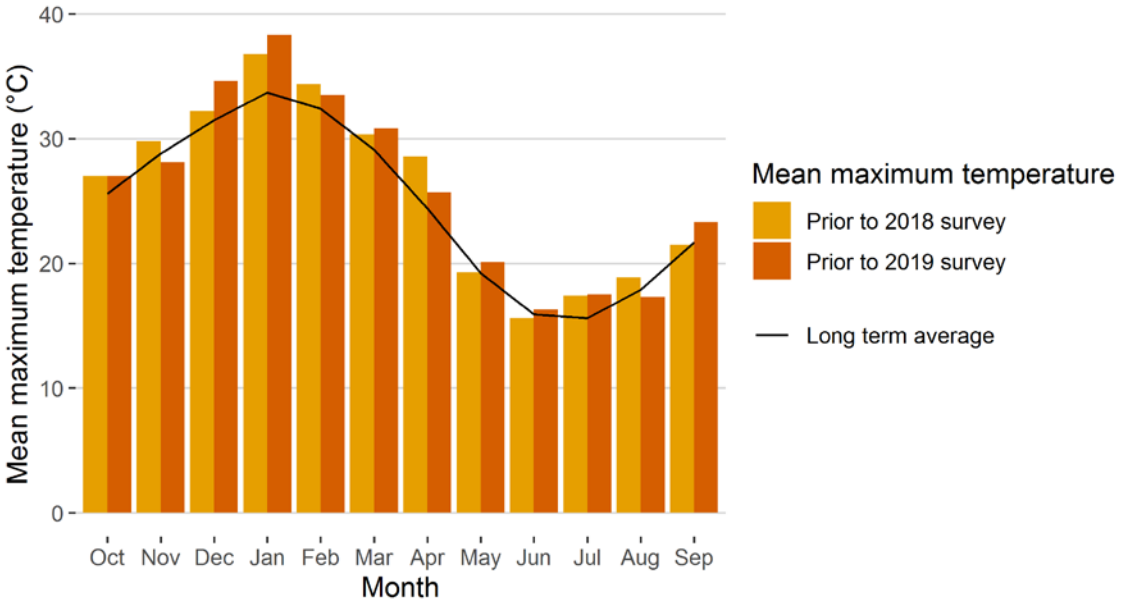


Figure 6 Mean monthly temperature maximums in the year prior to survey

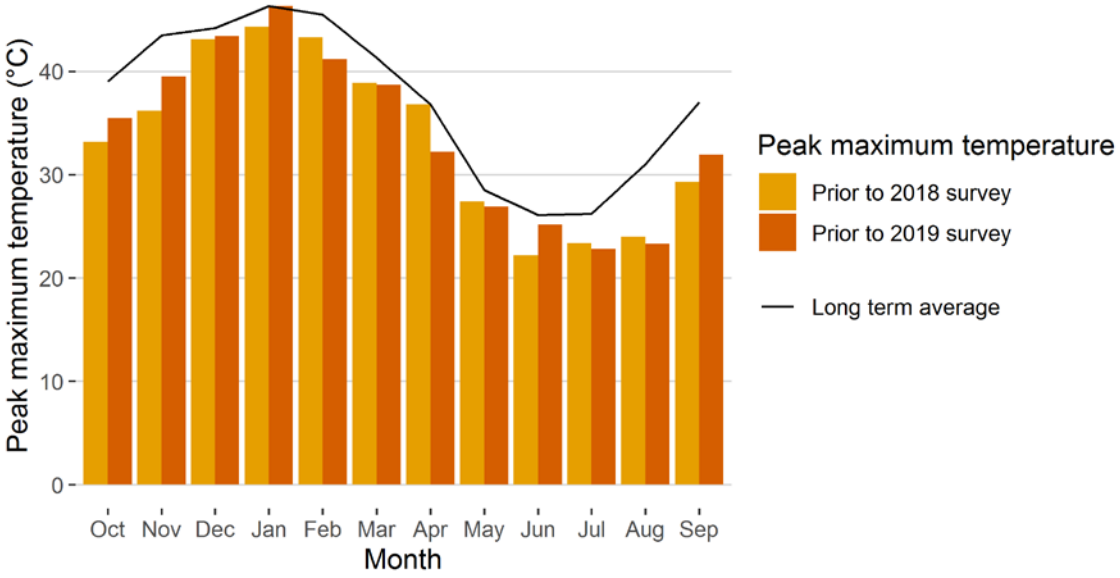


Figure 7 Peak monthly temperature minimums in the year prior to survey

Biosis ecologists were also on-site between 11 and 13 December 2017 to map and validate the full extent of PGSW (Biosis 2018b). While the far west was already in drought in 2017 (annual rainfall in 2017 was 108.6 millimetres), the impact of the extended very dry conditions in 2018 and 2019 on PGSW is evident in a photographic comparison of the three survey periods (first photograph not from the same location as subsequent photos which were taken with a similar landscape view). The poor condition of Porcupine Grass tussocks has increased its vulnerability to collapse, particularly following trampling by goats or macropods (Photo 3).

Photo 1 Condition of PGSW, 13 December 2017

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Photo 2 **Condition of PGSW, 23 October 2018**

Photo 3 **Condition of PGSW, 28 October 2019. Note the poor condition of Porcupine Grass tussocks in the foreground.**

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

3.2 Sites assessed

Twenty monitoring plots, established during baseline survey in October 2018, were re-monitored in 2019 (Table 1 and Figure 2).

Although PGSW06 is located in the Porcupine Grass with eucalypts variant, the above ground parts of the only Red Mallee *Eucalyptus socialis* in the plot have died since the 2018 survey. This individual could potentially resprout from the lignotuber if conditions improve.

Table 1 Location of monitoring plots (GDA94 Zone 54)

Site Number	Community variant	Goat fence	Zone	Easting	Northing
PGSW01	Porcupine Grass with eucalypts	In	54	521924.2	6485480.2
PGSW02	Porcupine Grass with eucalypts	In	54	522175.9	6485428.3
PGSW03	Porcupine Grass only	In	54	522320.7	6485195.8
PGSW04	Porcupine Grass only	In	54	522685.1	6485009.8
PGSW05	Porcupine Grass with eucalypts	In	54	522784.2	6484850.5
PGSW06	Porcupine Grass with eucalypts	In	54	522562.6	6484310.6
PGSW07	Porcupine Grass with eucalypts	In	54	522728.6	6484495.0
PGSW08	Porcupine Grass with eucalypts	In	54	522907.6	6484499.1
PGSW09	Porcupine Grass with eucalypts	In	54	523171.1	6484526.2
PGSW10	Porcupine Grass with eucalypts	In	54	523218.3	6484551.7
PGSW11	Eucalypts only	In	54	523381.2	6484307.8
PGSW12	Porcupine Grass with eucalypts	In	54	522757.4	6484054.3
PGSW13	Porcupine Grass only	In	54	522884.2	6483842.9
PGSW14	Porcupine Grass with eucalypts	In	54	523617.0	6483063.6
PGSW15	Porcupine Grass with eucalypts	In	54	523872.6	6483094.8
PGSW16	Porcupine Grass with eucalypts	Out	54	530012.5	6482542.8
PGSW17	Porcupine Grass with eucalypts	Out	54	530159.0	6482577.0
PGSW18	Eucalypts only	Out	54	530233.0	6483046.8
PGSW19	Porcupine Grass with eucalypts	Out	54	531321.0	6483395.5
PGSW20	Porcupine Grass only	Out	54	531328.7	6483641.8

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

3.3 Photopoint monitoring

Photo-point monitoring was undertaken in conjunction with quadrat monitoring between 28 and 30 October 2019.

Comparison of the photos taken at the 20 monitoring quadrats between 2018 and 2019 reveals little change in perennial plant cover (Appendix 1). As indicated in Section 3.1, these photos highlight the declining condition of PGSW due to the continued dry conditions. In particular, the structure of the Porcupine Grass hummocks and condition of tree and shrub canopies is declining at many sites. Additionally, the lack of ground cover species between the tussocks is evident, particularly when compared with Photo 1, which was taken in December 2017, during the mapping of the extent of PGSW.

3.4 Feral Goats

3.4.1 Goat management infrastructure

A goat fence was constructed around PGSW in May 2014 to exclude and manage goats for the purposes of protecting PGSW and the endangered Barrier Range Dragon (Figure 8). When goats are grazed in the PGSW, they are harvested approximately every two months, with an average of approximately 500 goats in within the fenced area.

Since 2014, goats have been excluded from within the goat fence during the following periods:

- June 2014 to April 2015
- September 2015 to February 2016
- August 2017 to present, excluding during construction of the wind farm within the goat fence when the gate remained open to provide site access. Mustering of goats continued during construction in the area.

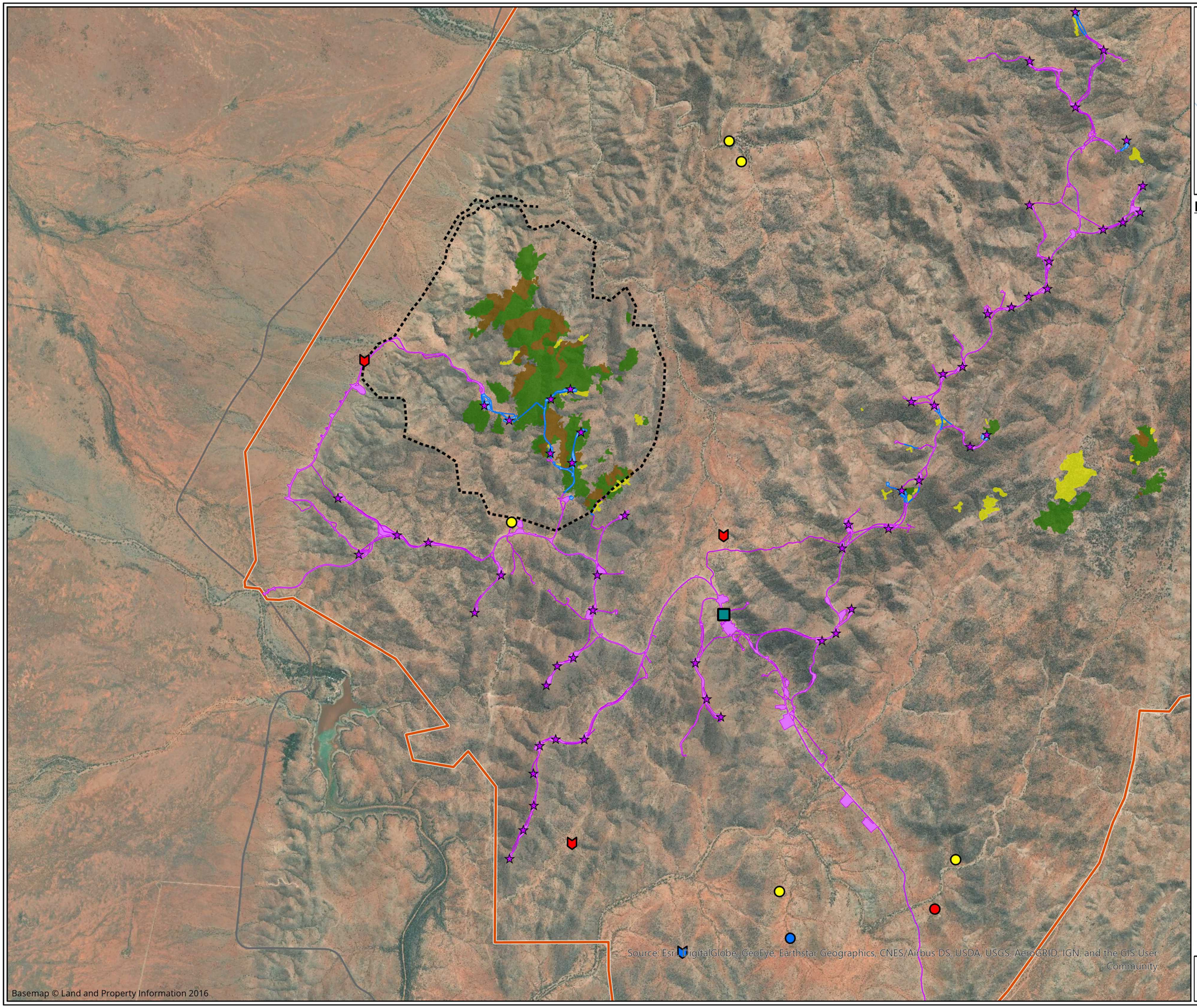
3.4.2 Landholder estimates of feral goat population

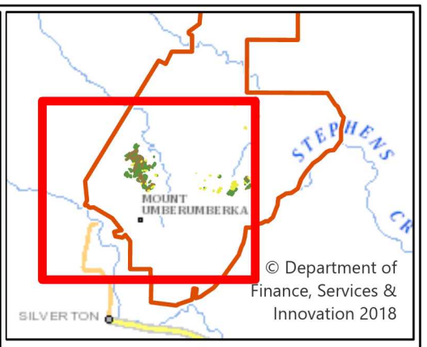
Conversations with the two leaseholders that manage land supporting PGSW indicated that 2019 goat numbers continue to be low when compared with average and good rainfall years, and lower than in 2018 (Table 2).

Aerial mustering of goats has continued through 2019, with high market prices continuing to ensure the economic viability of this method (Table 2). This combination of drought, additional infrastructure and aerial mustering continues to see the removal of a greater proportion of goats from the landscape, with leaseholders reporting low numbers of individuals across their properties.

Additionally, leaseholder Lawrence would stock around 8000 to 9000 sheep across their property in a good year, but in 2019 they carried about 4000 sheep.

© Biosis 2020 – Leaders in Ecology and Heritage Consulting





Legend

- Study area
- Infrastructure
- Infrastructure with PGSW downslope
- Turbine
- O&M building

PGSW structural variants

- Porcupine grass with eucalypts
- Porcupine grass only
- Eucalypts only

Goat management infrastructure

- Yard
- Fencing

Trapped

- Dam
- Trough

Untrapped

- Dam
- Trough

Figure 8 Infrastructure for goat management

0 0.5 1 1.5 2 2.5

Kilometres
Scale 1:50,000 @ A3
Coordinate System: GDA 1994 MGA Zone 54

N

biosis
Biosis Pty Ltd

Albury, Ballarat, Melbourne,
Newcastle, Sydney, Wangaratta & Wollongong

Matter: 29736
Checked by: RFW, drawn by: JPT
Last edited by: jturner on 29 May 2020
Location: P:\26300s\26380\Mapping\
26380_PGSW_GMP

Table 2 Estimates of goat numbers provided by leaseholders

Timing	Blore (inside goat fence)	Lawrence (outside goat fence)	Anecdotal price per head
2008/9 (During drought at time of the EIS (NGH Environmental 2008a))	Around 7000 goats a year	2159 – 1973*	
2012-14 (High rainfall period post Millennium Drought)	Around 6000 in the year (Goat fence installed in April 2014)	Around 8000 a year (Additional management infrastructure in place)	$30
2018	Around 50-100 from within goat fence	3239	
2019	About 50	2694 '10 goat mob is big', hardly any kids observed during autumn/spring breeding	$150

*Combination of low numbers due to drought, and lack of management infrastructure

3.4.3 Scat counts

Counts of recent herbivore scats in the 5 x 5 metre subplots are summarised in Figure 9. Scats of goats and macropods were significantly lower in 2019, with macropod scats more common than goat scats. This aligns with the anecdotal evidence regarding declining goat and macropod abundance from the leaseholders discussed in Section 3.4.2.

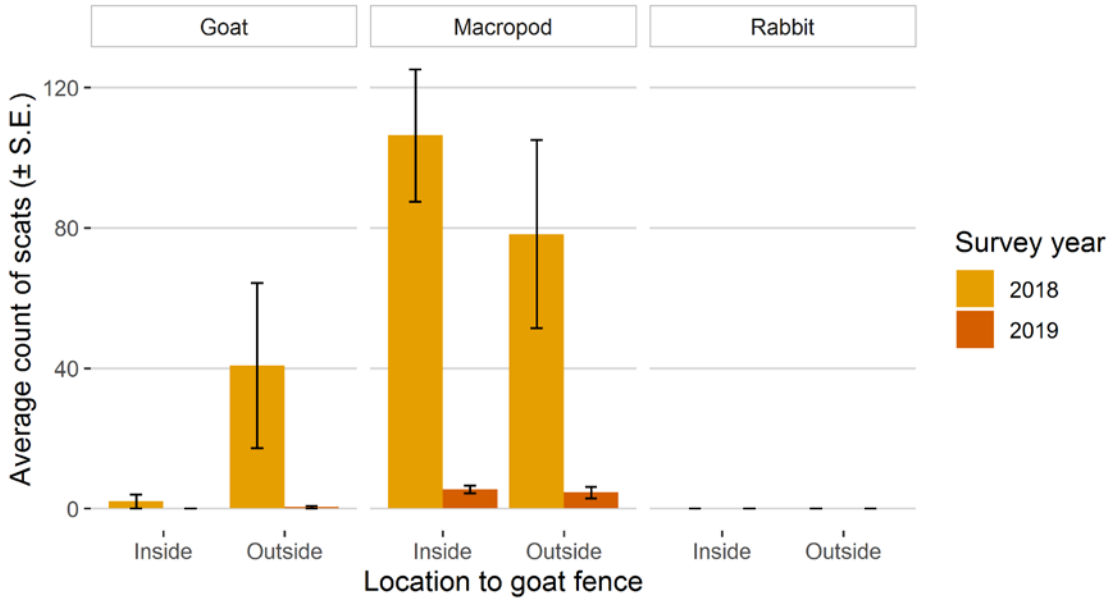


Figure 9 Recent/fresh herbivore scats recorded in 5 x 5 metre subplots

3.5 Condition of PGSW

3.5.1 Species composition of the community

As in the baseline vegetation monitoring (Biosis 2020), extended dry conditions prior to survey resulted in low species diversity and abundance within PGSW. In combination with the unbalanced survey design (due to area of extent of the structural variants inside and outside the goat fence), all data analysis needs to be reviewed cautiously as a small increase in species richness can have a disproportionately large impact on analysis results. It is anticipated that the longer-term monitoring to continue over the next two years will provide increased robustness of analysis results. Additionally, while the 5 x 5 metre subplots have been monitored to capture baseline species diversity and abundance, flora presence was insufficient to inform detailed analysis in this 2019 assessment.

Across all surveys to date, 94 native and six introduced flora species have been recorded. The current survey documented 44 native species, of which *Leiocarpa semicalva*, Fruit-salad Plant *Pterocaulon sphacelatum* and Mulga Mitchell Grass *Thyridolepis mitchelliana* had not been previously recorded in the community (Appendix 4). No introduced species were recorded in the 2019 vegetation monitoring.

Despite the ongoing dry conditions, species richness within each site was slightly higher in 2019 than in during the baseline survey in 2018 (Table 3 and Figure 10). It is possible that this is due to a number of small rainfall events in August and September (Figure 4), allowing a number of species to regenerate, such as *Leiocarpa semicalv*a, Fruit-salad Plant, Pygmy Sunray *Rhodanthe pygmaea*, Potato Bush *Solanum ellipticum* and Pointed Twin-leaf *Zygophyllum apiculatum* (Figure 11). Although most of the Porcupine Grass tussocks were grey and senescing, there was evidence of a minor rainfall response in a tussock PGSW16 (Photo 4).

Table 3 Summary statistics of species richness in 20x20 metre quadrats (n=20)

Statistic	2018	2019
Minimum	3.00	5.00
1st quartile	7.00	7.00
Median	**8.00**	**8.00**
Mean	**8.85**	**9.15**
3rd quartile	11.25	10.5
Maximum	14.00	18.0
Number of species recorded (native / introduced)	53 / 2	44 / 0

Photo 4 Limited new growth in a Porcupine Grass tussock at PGSW16

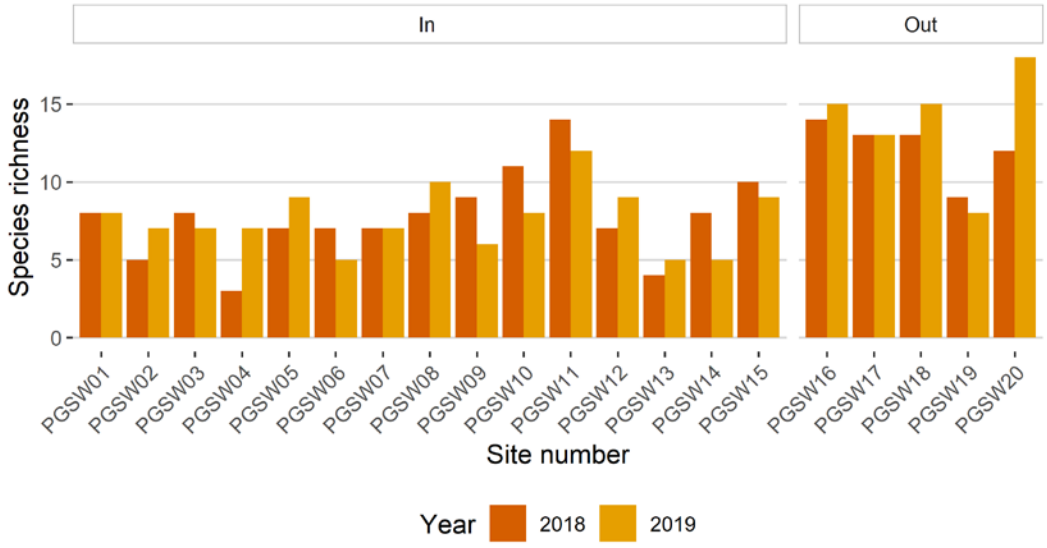


Figure 10 Change in species richness in 20 x 20 metre quadrats from 2018 to 2019

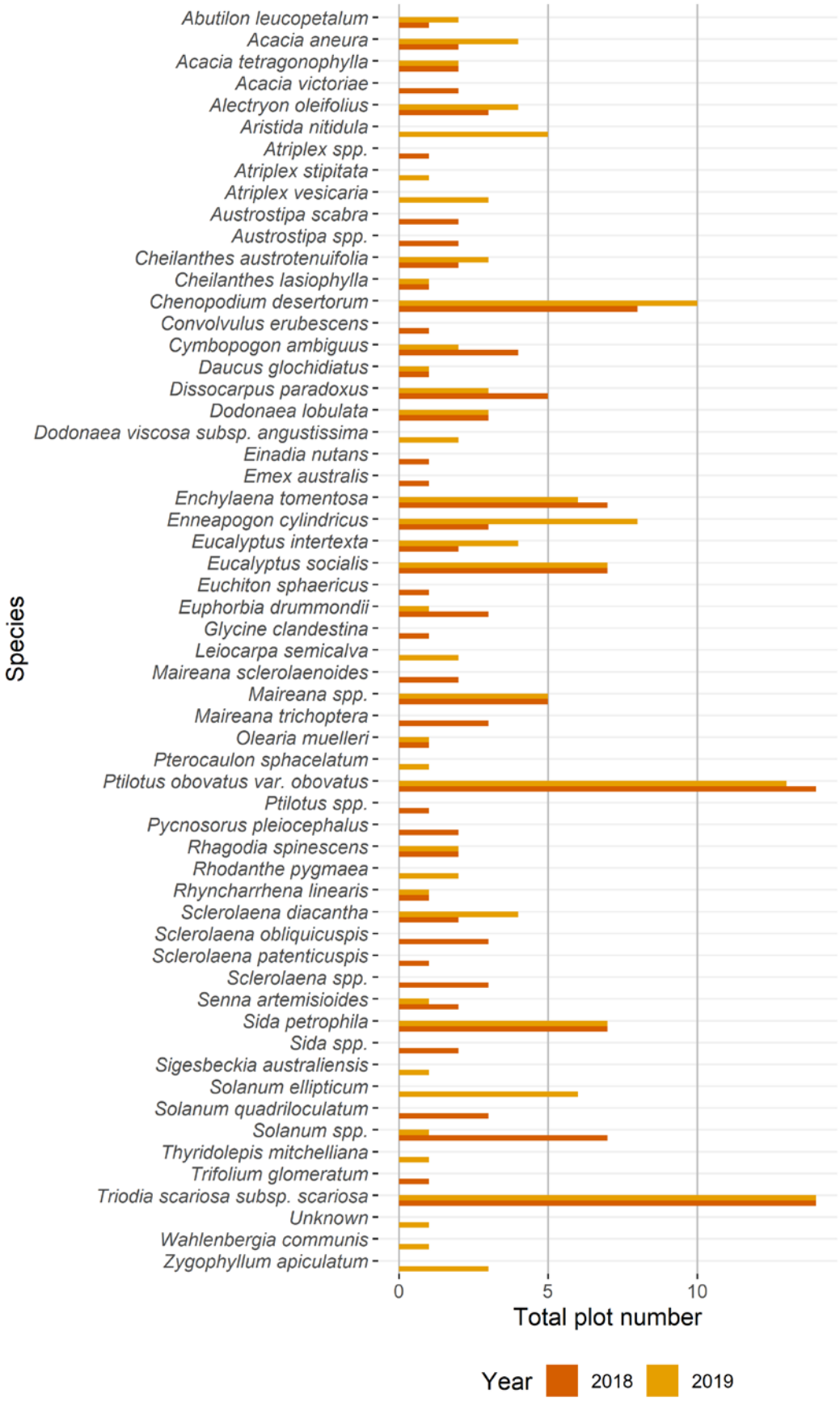


Figure 11 Count of total number of plots in which each species was recorded

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

As in 2018, this analysis indicates that species richness is lower in sites within the goat fence (Figure 12). As indicated in the baseline survey, the areas of PGSW outside the goat fence were in less rugged terrain, potentially with greater soil depth and topographic protection than those within the goat fence. The species recorded in the 20 x 20 metre quadrats each year by position relative to the goat fence are detailed in Figure 13.

Similarly, this analysis of the structural variants continues to indicate that the two monitoring plots within the *eucalypts only* variant are the most floristically diverse, with the *Porcupine Grass with eucalypts* variant supporting a few additional species per monitoring plot than the *Porcupine Grass only* vegetation (Figure 14).

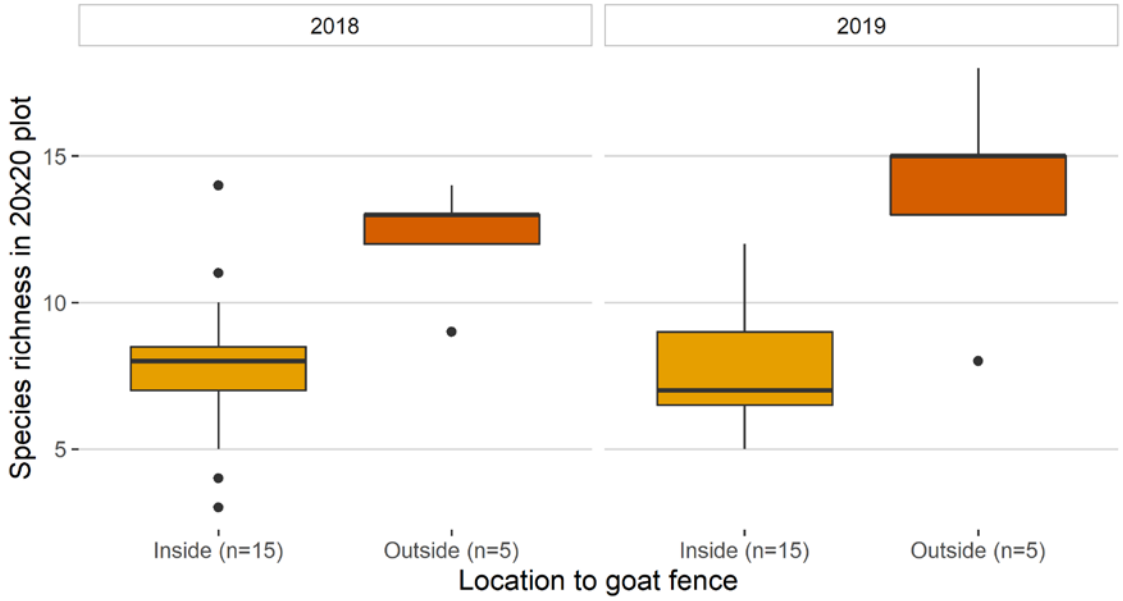


Figure 12 Species richness in 20 x 20 metre quadrats by position relative to the goat fence

Figure 13 Count of total number of plots in which each species was recorded by position relative to the goat fence

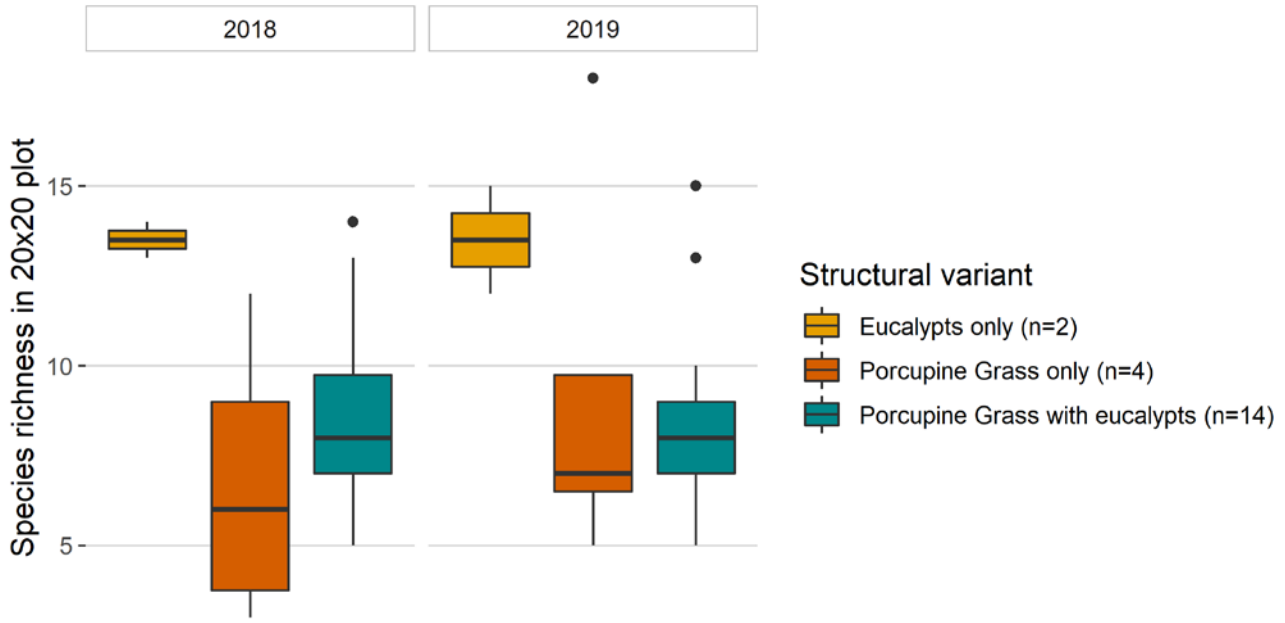


Figure 14 Species richness in 20 x 20 metre quadrats by PGSW structural variant

3.5.2 Threatened flora

As detailed in Section 2.2.4 of the Vegetation Management Plan (VMP) (Biosis 2018e), three threatened plant species (species listed under either the NSW *Biodiversity Conservation Act 2017* (BC Act) or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)) were identified as having the potential to be affected by the Silverton Wind Farm works (NGH Environmental 2008a, NGH Environmental 2008b). These include: Showy Indigo *Indigofera longibractea*, Yellow-keeled Swainsona *Swainsona flavicarinata* and Creeping Darling Pea *Swainsona viridis*. Additionally, there are unconfirmed records of Purple Wood Wattle *Acacia carneorum* on the flats of the Mundi Mundi sandplain surrounding Silverton Wind Farm (Blore 2008). It has not been found on the hills, where PGSW occurs. This species is listed as vulnerable under both the BC Act and the EPBC Act.

As in 2018, none of the above listed species have been recorded within PGSW during the current survey, nor have any other threatened flora species.

3.5.3 Condition of woody species

Woody species occur in low numbers in the PGSW community, and individuals were under-recorded in 2019 (Section 2.5.2). While in 2018, the overall condition of woody species tended to be higher inside the goat fence, in 2019 the overall condition of all species was found to be generally lower inside the goat fence Figure 15), which included the condition above and below the browse line (Figure 16 and Figure 17). No species were observed in a retrogressed state in 2019, however it is noted that a number of individuals had died between surveys (Photo 5), including the single Red Mallee in PGSW06.

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Photo 5 Woody individuals at PGSW19 that have died, likely due to extended drought

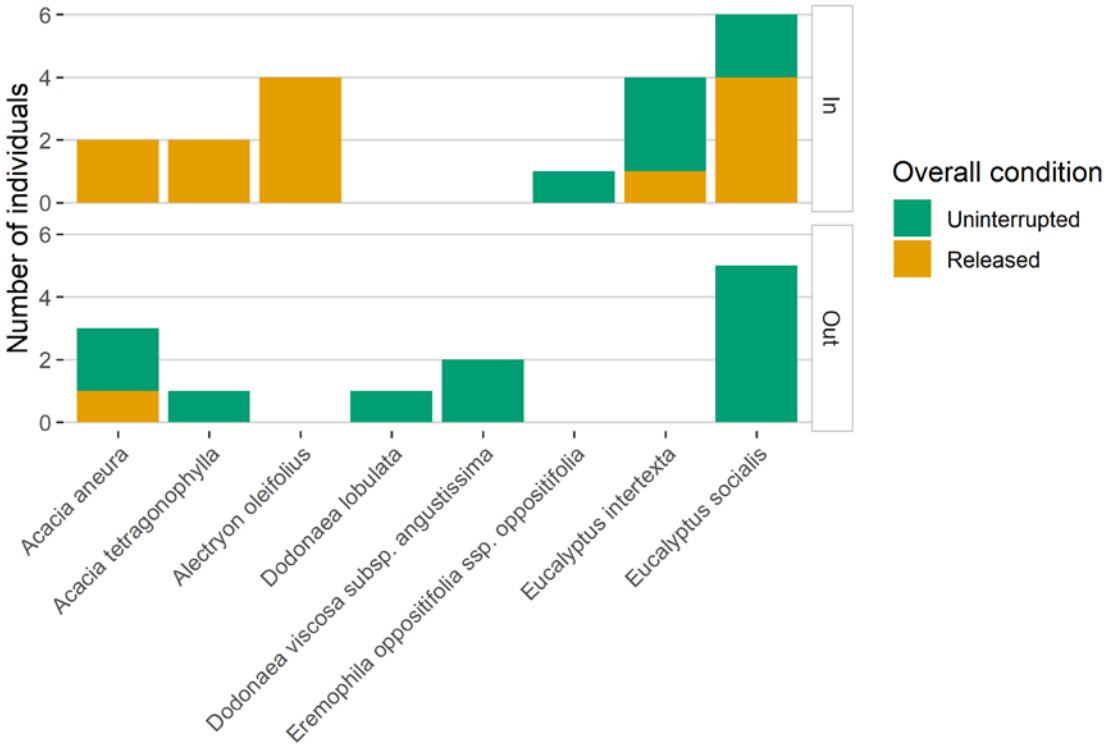


Figure 15 Overall condition of woody species recorded in 2019

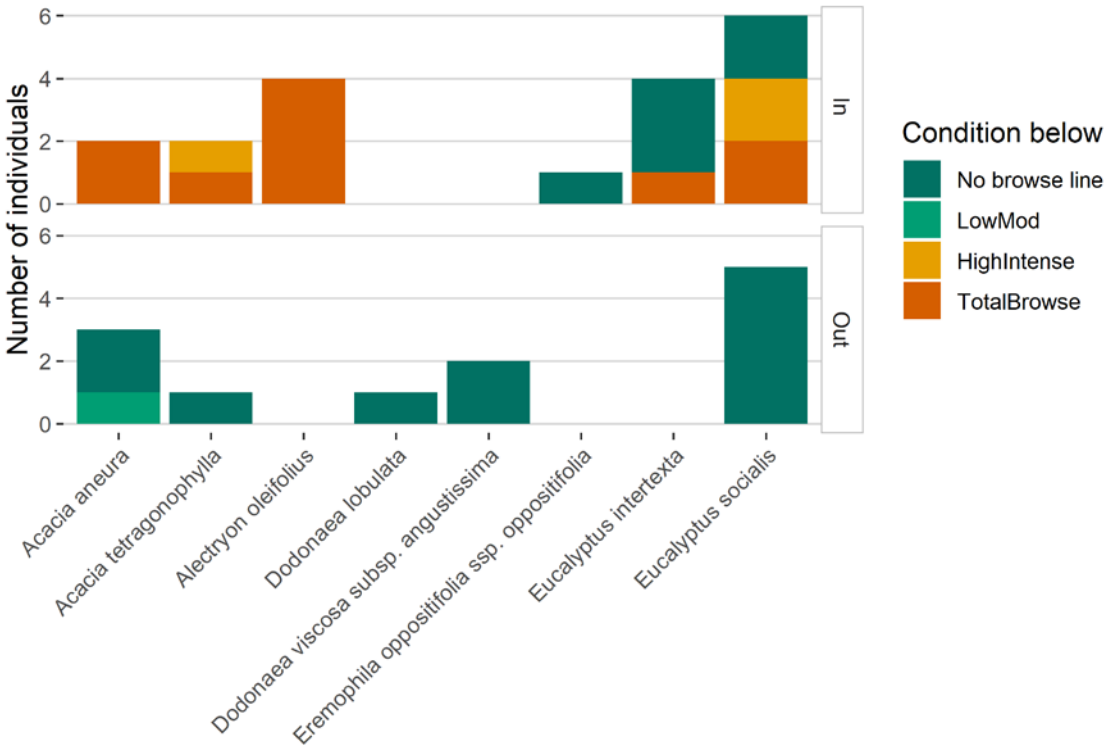


Figure 16 Condition of woody species below the browse line in 2019

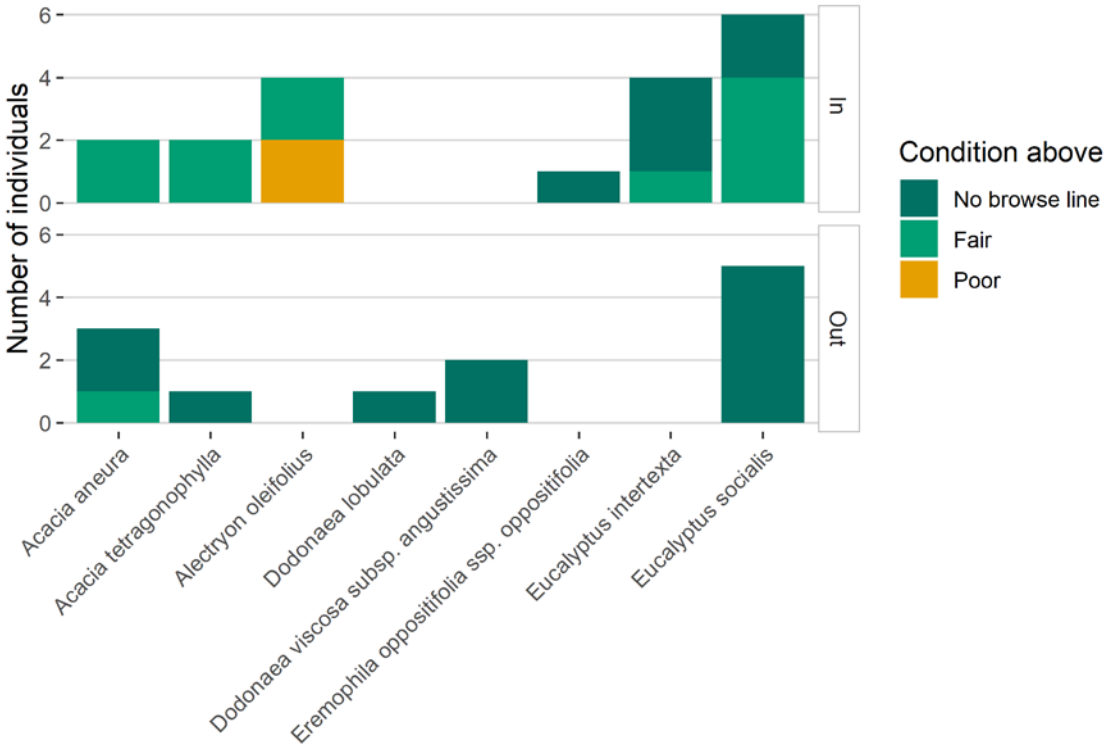


Figure 17 Condition of woody species above browse line in 2019

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

3.5.4 Litter cover

In 2018, litter cover was generally higher in the 20 x 20 metre monitoring plots outside the goat fence compared with those outside the goat fence. Litter cover has decreased overall in 2019, with a greater decrease in sites outside the goat fence such that sites both inside and outside the goat fence support 15 - 20 per cent litter cover on average.

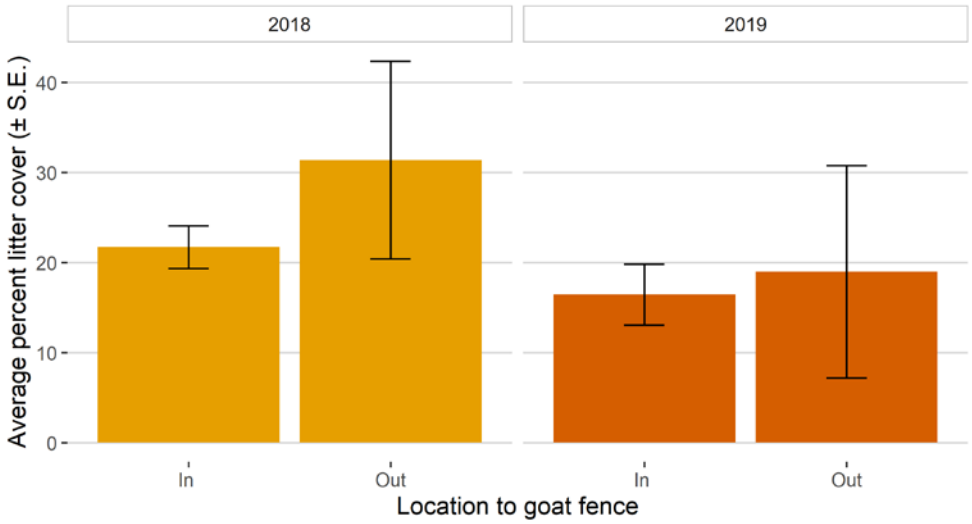


Figure 18 Change in litter cover within the 20 x 20 metre monitoring plots

3.6 Introduced flora species

Environmental close out information from CATCON from the construction of the wind farm is currently being finalised. Therefore, baseline monitoring of pre and post construction conditions has not been be completed.

Only two introduced species, Three -cornered Jacks *Emex australi*s and Clustered Clover *Trifolium glomeratum* were recorded at PGSW13 during the 2018 baseline monitoring of PGSW (Biosis 2020). These species were not observed at the site during the 2019 survey.

No introduced species were observed in the 2019 vegetation monitoring.

Introduced species observed in previous surveys are detailed in Appendix 3. It is likely that these species will persist in the soil seed bank and are likely to be present in greater numbers following high autumn-winter rainfall. These introduced species will have potential to disperse throughout the study area, particularly within areas of soil disturbance resulting from construction.

Following finalisation of handover of management from CATCON, an audit of the condition of construction disturbance will be completed to inform on-going management of these areas. In particular, the management of weed incursions will then be implemented in accordance with the BAMP (Biosis 2018a).

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

4. Discussion and conclusions

The extended severe drought documented in the baseline surveys in 2018 (Biosis 2020) has continued to the time of the present survey (Section 3.1). Therefore, the floristic composition and condition of the vegetation within the community is low, as evidenced by the low site species richness (Section 3.5.1) and visible decline in the condition of Porcupine Grass tussocks (Photo 1, Photo 2 and Photo 3) and other woody individuals (Photo 5). However, it is possible that a number of small rainfall events prior to the 2019 survey have initiated some minor recovery (Photo 4) and increase in species richness (Section 3.5.1), ongoing rainfall is required to improve the condition of the extant individuals and enable the recruitment of new plants within the community.

The drought conditions continue to impact on feral goats, with reduced numbers in the landscape due to a combination of low levels of palatable vegetation and increased goat management by leaseholders in the area (Section 3.4.2). Numbers of recent goat scats recorded at all sites were very low (Section 3.4.3), suggesting that the population density is low throughout the landscape. Similarly, macropod numbers appear to be declining in the area (Figure 9) which is a typical response to declining resources in the landscape.

The assessment of goat populations in Section 3.4 indicates that the goat fence (in combination with the ongoing drought and high market value for goats) is improving management of goats within that area. However, in 2019 this is again contradicted in data regarding the condition of the vegetation (Section 2.5), particular species richness (Figure 12 and Figure 13). Biosis field staff indicated that the areas of PGSW outside the goat fence were in less rugged terrain, potentially with greater soil depth, fertility and topographic protection than those within the goat fence. These factors may also be influencing variability in site condition, in conjunction with the climate and grazing pressures. This has not been analysed in detail to date, but it is recommended that a more detailed investigation be undertaken in 2020 to understand the potential influence of landscape position factors on the local condition of PGSW.

Litter cover has declined since 2018. This decline is likely to be primarily due to a lack of replenishment due the current drought. It is likely that litter browsing is also occurring, as goats are generalists that can feed on low nutrient fibrous vegetation, including litter in adverse conditions (Russell, Letnic, & Fleming 2011). As a result of reduced litter cover, there has been an increase in bare ground. Higher levels of litter can provide better seed germination conditions than bare ground through increased nutrient capture and retention, leading to increased vegetation cover in the medium to long term (Russell, Letnic, & Fleming 2011). Therefore this decrease in litter also indicates a decline in the condition of PGSW.

Of the woody individuals monitored in 2019, none were observed in the Arrested and Retrogressed form (Figure 15). However within the goat fence, the majority of individuals have been subject to high or total consumption of vegetation below the browse line (Figure 16). Condition above the browse line (where present) was generally poor to fair (Figure 17). Again, this is likely to due to a combination of drought and browsing impacts. This declining health was also indicated in the tree health assessments within the 20 x 20 quadrats, which documented that woody species at all sites but one had dead branchlets in the canopy, with dead trees documented at three sites and main trees branches dead at another three sites. It is to be expected that pressure on the woody species will have increased during the current drought periods, both by feral goats as well as by macropods. Therefore it is unlikely that the condition of these individuals will improve until rainfall increases. It is recommended that future tree health assessments document tree heath of the canopy for each woody individual, as the current method does not clearly capture canopy health of unbrowsed individuals.

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

As with feral goats, the incidence of introduced flora species remains low (Section 3.6). However, introduced flora are likely to occur in greater numbers following high autumn-winter rainfall, particularly within areas of soil disturbance resulting from construction. No introduced flora were recorded within or near the PGSW community in 2019.

As discussed in Section 2.1.1, arid lands are dynamic and extended drought periods are interspersed by rainfall and flood events of varying magnitude, stimulating the growth of flora from dormant seedbanks. It is anticipated that the maintenance of improved goat management will result in increased plant species diversity, abundance and cover within the goat fence as species have increased opportunities for recruitment, survival and growth (Keith & Tozer 2012).

As outlined in the Goat Management Plan (Biosis 2018d), harvesting feral goats by leaseholders has led to a reduction in goat numbers generally. The focus on goat management, however, has now moved to maintaining goats at a level where they remain economically viable for harvest. This change in management focus presents its own set of challenges, as a commercial approach often conflicts with conservation management, where eradication or suppression at very low numbers is the goal (Russell, Letnic, & Fleming 2011). The maintenance of commercial numbers of feral goats within the landscape may ultimately be at odds with the conservation management of PGSW. In regards to goat management,

In particular, the impacts of the extended drought on the PGSW community are likely to be similar to the impacts of fire outlined in the BAMP (Biosis 2018a). Young plant growth may be more palatable to herbivores than older biomass, (Keith & Tozer 2012), limiting recruitment and opportunities for replenishing the soil seed bank. Therefore, it is recommended that feral goats are to continue to be excluded from PGSW from the present until at least one year following the declared end of this extended drought to allow recruitment and recovery of the community. If total grazing pressure is contained following drought, recruitment can occur and improvement in vegetation condition would be expected. Therefore, ongoing mustering will also need to occur in the fenced area to actively remove any stray goats during the exclusion period. It is recommended that resumption of grazing is only undertaken based on advice from the Project Ecologist and following an assessment of ongoing vegetation monitoring data.

Additionally, it will be critical to monitor and manage any populations of introduced flora species in the initial post-drought period to ensure weed incursions at the wind farm remain low. The implementation of the monitoring and management recommendations in the BAMP for introduced species are to commence at confirmation of formal handover of management responsibility from CATCON.

It is likely that the ongoing monitoring of PGSW (to 2021) will align with a favourable growing season allowing the observation of additional species. This will provide an important opportunity to gain further insight into the composition of the Critically Endangered PGSW as well as the influence of the current management regimes. The recovery of the community following the drought is should also provide insight regarding its overall condition. If diversity and cover respond quickly then it is probably resilient, if there is little recovery then health of the community may be compromised. These insights will inform future conservation management of the community.

References

AREA 2017. *Barrier ranger dragon save our species project: Vegetation monitoring plots in the Mutawintji National Park*, Unpublished report prepared for Office of Environment and Heritage. AREA Pty LTd.

Biosis 2018a. *Silverton Wind Farm Operational Biodiversity Adaptive Management Plan*, Report to GE Renewable Energy. Woodward. R. Clancy. R. Smales. I.Biosis Pty Ltd. Project no. 26380. Melbourne, VIC.

Biosis 2018b. *Silverton Wind Farm: Porcupine Grass Sparse Woodland Recovery Plan*, Report prepared for GE Renewable Energy. Woodward. R, Biosis Pty Ltd, Albury, NSW. Project No. 26380.

Biosis 2018c. *Silverton Wind Farm: Barrier Range Dragon Management Plan*, Report prepared for GE Renewable Energy. Smales. I, Biosis Pty Ltd, Melbourne, VIC. Project No. 26380.

Biosis 2018d. *Silverton Wind Farm: Goat Management Plan*, Report prepared for GE Renewable Energy. Author: Clancy. R, Biosis Pty Ltd, Albury, NSW. Project No. 26380.

Biosis 2018e. *Silverton Wind Farm: Vegetation Management Plan*, Report prepared for GE Renewable Energy. Cutler. S, Price. P, Biosis Pty Ltd, Albury, NSW. Project No. 26380.

Biosis 2020. *Silverton Wind Farm: Vegetation Monitoring Report - 2018*, Report for GE Renewable Energy. Author: Woodward R, Biosis Pty Ltd, Albury. Project no. 29736.

Blore J 2008. Mundi Mundi Range and Belmont Plains Conservation Program, Groundcover Program Application to Western CMA 2008.

Keith D & Tozer M 2012. 'The influence of fire, herbivores and rainfall on vegetation dynamics in the mallee: a long term experiment', *Proceedings of the Linnean Society of New South Wales*, 134: A39–A59.

NGH Environmental 2008a. *Proposed development of Stage 1, Silverton Wind Farm, far western New South Wales. Biodiversity Assessment-Final, March 2008*, Report prepared for Silverton Wind Farm Developments Pty Ltd. Sass. S, Marshall. B, NGH Environmental, Bega, NSW.

NGH Environmental 2008b. *Proposed development of Stage 1, Silverton Wind Farm, far western New South Wales Biodiversity Addendum Final*, Report for Silverton Wind Farm Developments Pty Ltd. Authors Sass S & Simpson K. NGH Environmental, Bega, NSW.

NSW Scientific Committee 2010. *Porcupine Grass - Red Mallee - Gum Coolabah hummock grassland / low sparse woodland in the Broken Hill Complex Bioregion - critically endangered ecological community listing – final determination*, accessed 11 August 2017, http://www.environment.nsw.gov.au/determinations/porcupinegrassFD.htm.

OEH 2017a. *Vegetation Information System: Classification*, *BioNet Vegetation Classification New South Wales Government Office of Environment and Heritage*, accessed 11 August 2017, http://www.environment.nsw.gov.au/research/Visclassification.htm.

OEH 2017b. *Vegetation Information System: Flora Survey*, *BioNet Vegetation Classification New South Wales Government Office of Environment and Heritage*, accessed 18 December 2017, https://www.environment.nsw.gov.au/asmslightprofileapp/account/login?returnUrl=http%3a%2f%2fwww.environment.nsw.gov.au%2fAtlasApp%2fdefault.aspx Managing Vertebrate Pests: feral goat.

Russell B, Letnic M, & Fleming P 2011. 'Managing Feral Goat impacts by manipulating their access to water in the rangelands', *The Rangeland Journal*, 33: 143–153.

Sivertsen D 2009. Native Vegetation Interim Type Standard, New South Wales Department of Environment, Climate Change and Water.

WLLS 2017. *Western Regional Strategic Weed Management Plan 2017-2022*, Report prepared by New South Wales Western Local Land Services, Sydney, NSW.

Appendices

Appendix 1 Photopoint monitoring

Year	Site tag	Looking north-east	Looking south-west
Site 1 Inside goat fence **PCT359 - Porcupine Grass hummock grassland with key eucalypt species present**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Year	Site tag	Looking north-east	Looking south-west
Site 2 Inside goat fence **PCT359 - Porcupine Grass hummock grassland with key eucalypt species present**			
2018			
2019			

Year	Site tag	Looking north-east	Looking south-west
Site 3 Inside goat fence **PCT359 - Porcupine Grass hummock grassland without key eucalypt species present**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Year	Site tag	Looking north-east	Looking south-west
Site 4 Inside goat fence PCT359 - Porcupine Grass hummock grassland without key eucalypt species			
2018			
2019			

Year	Site tag	Looking north-east	Looking south-west
Site 5 Inside goat fence **PCT359 - Porcupine Grass hummock grassland with key eucalypt species**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Year	Site tag	Looking north-east	Looking south-west
Site 6 Inside goat fence **PCT359 - Porcupine Grass hummock grassland with key eucalypt species**			
2018			
2019			

Year	Site tag	Looking north-east	Looking south-west
Site 7 Inside goat fence **PCT359 - Porcupine Grass hummock grassland with key eucalypt species.**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Year	Site tag	Looking north-east	Looking south-west
Site 8 Inside goat fence **PCT359 - Porcupine Grass hummock grassland with key eucalypt species.**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Year	Site tag	Looking north-east	Looking south-west
Site 9 Inside goat fence **PCT359 - Porcupine Grass hummock grassland with key eucalypt species**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Year	Site tag	Looking north-east	Looking south-west
Site 10 **Inside goat fence** **PCT359 - Porcupine Grass hummock grassland with key eucalypt species**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Year	Site tag	Looking north-east	Looking south-west
Site 11 Inside goat fence **PCT359 - Eucalypt species present without/with minimal Porcupine Grass**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Year	Site tag	Looking north-east	Looking south-west
Site 12 **Inside goat fence** **PCT359 - Porcupine Grass hummock grassland with key eucalypt species present**			
2018			
2019			

Year	Site tag	Looking north-east	Looking south-west
Site 13 **Inside goat fence** **PCT359 - Porcupine Grass hummock grassland without key eucalypt species present**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Year	Site tag	Looking north-east	Looking south-west
Site 14 Inside goat fence **PCT359 - Porcupine Grass hummock grassland with key eucalypt species present**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Year	Site tag	Looking north-east	Looking south-west
Site 15 **Inside goat fence** **PCT359 - Porcupine Grass hummock grassland with key eucalypt species present**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Year	Site tag	Looking north-east	Looking south-west
Site 16 **Outside goat fence** **PCT359 - Porcupine Grass hummock grassland with key eucalypt species present**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

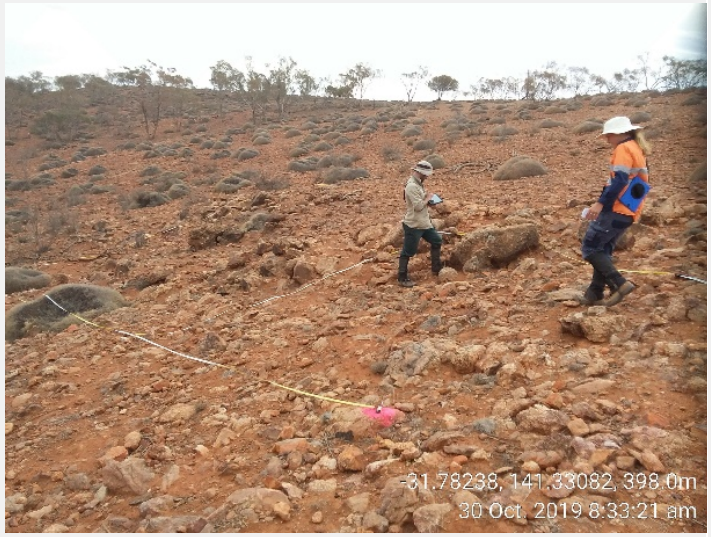
Year	Site tag	Looking north-east	Looking south-west
Site 17 **Outside goat fence** **PCT359 - Porcupine Grass hummock grassland with key eucalypt species present**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Year	Site tag	Looking north-east	Looking south-west
Site 18 **Outside goat fence** **PCT359 - Eucalypt species present without/with minimal Porcupine Grass**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Year	Site tag	Looking north-east	Looking south-west
Site 19 **Outside goat fence** **PCT359 - Porcupine Grass hummock grassland with key eucalypt species present**			
2018			
2019			

Year	Site tag	Looking north-east	Looking south-west
Site 20 **Outside goat fence** **PCT359 - Porcupine Grass hummock grassland without key eucalypt species present**			
2018			
2019			

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

Appendix 2 Browsing condition – from AREA 2017

© Biosis 2020 – Leaders in Ecology and Heritage Consulting

2.1.2 Belt transects (Appendix 1)

The length and width of belt transects were determined to ensure an accurate representation of the overall plant density and diversity was captured within each habitat.

Belt transects were either 50 or 100 metres in length except for the vegetation exclosure which was 20 metres in length and either 2, 4 or 10 metres wide (**Table 2-1**).

Within each belt transect all trees and shrubs were identified (samples taken) and details recorded included:

- Height, width at widest point, height of browse line for plants > 2m.
- Condition above browse line:
    - Good = No dead wood.
    - Dead Wood Fair = Trees with < 50% dead wood.
    - Dead Wood Poor = Trees with > 50% dead wood).
- Condition below browse line including all plants less than 2m in height:
    - Unbrowsed.
    - Low-Moderate browsing.
    - High-Intense browsing.
    - Totally browsed (no living growth below browse line).
- Presence or absence of regeneration.
- A condition state to show the current state of plants.

2.1.3 Condition state (Appendix 1)

Condition states were based on McDonald, J. (2009) and assessed as follows:

- **Uninterrupted** - Fresh new growth with no or very little sign of browsing. Plant growing periodically in relation to natural growth stimuli (rainfall and temperature) (see **Table 2-2** Fig 1 and Fig 2)
- **Arrested** - Plant in hedged or topiarised form due to intense browsing. (see **Table 2-2** Fig 3 and Fig 4) New growth continuously eaten and not extending beyond previous browse levels preventing the plant from growing to its natural potential.
- **Retrogressed** - Death of all or some stems previously browsed with new growth occurring from the lower stems. (see **Table 2-2** Fig 5 and Fig 6). Stem death arises from stresses induced by browse.
- **Released** - New growth from browsed stem not browsed due to temporary or permanent relaxation of browse pressure. or Plant grown beyond browse line. (**Table 2-2** Fig 7 and 8)

Examples of how these relate to plants seen in the field are provided on **Table 2-2.**

Table 2-2: Condition states based on McDonald, J. (2009)

Uninterrupted Note: All stems and foliage intact from the base upwards		
	Fig 1. Acacia aneura (Mulga) uninterrupted at 3m	**Fig 2.** Dodonea viscose sub spatulata uninterrupted at 3 m

Arrested Note: Plants have been intensely browsed and the growth form is hedged with plants unable to grow to full potential		
	Fig 3. Dodonea viscose sub spatulata severely arrested	**Fig 4.** Marieana pyramidata arrested

Retrogressed

Note: Plants re-sprouting from the lower part of the plant and many previously browsed stems are dead

Fig 5. Acacia aneura (Mulga) retrogressed

Fig 6. Marieana pyramidata retrogressed

Released

Note: Plants are established trees or have managed to grow beyond a distinct browse line.

Fig 7. Acacia aneura (Mulga) released

Fig 8. Flindersia maculosa (Leopard wood) released

Appendix 3 Introduced flora species recorded

Notes to table:

Source of Records
A – 2018 Baseline monitoring (Biosis 2020)
B - NGH Environmental (NGH Environmental 2008b)
C – NGH Environmental (NGH Environmental 2008a)
D – PGSW TS determination (NSW Scientific Committee 2010)
E – VIS flora survey database (OEH 2017b)
F – PGSW PCT description (NSW Scientific Committee 2010)

Weed status:
* WoNS
# NSW State priority weed (WLLS 2017)
^ NSW regional priority weed (WLLS 2017)
~ NSW other regional weed/species of concern (WLLS 2017)

*note no new records of exotic species were documented in the present survey.

Table A 1 Introduced flora species recorded at Silverton Wind Farm

Scientific name	Common name	Source					
		A	B	C	D	E	F
Acetosa vesicaria	Bladder Dock				x		
Alyssum linifolium			x				
Arctotheca calendula	Capeweed		x				
Brassica tournefortii~			x				
Bromus diandrus~	Great Brome		x				
Carrichtera annua~	Ward's Weed		x				
Carthamus lanatus	Saffron Thistle		x	x			
Cenchrus setaceum	Fountain Grass			x			
Centaurea melitensis	Maltese Cockspur		x				
Chenopodium murale	Nettle-leaf Goosefoot		x				
Chloris virgata	Feathertop Rhodes Grass			x			
Echium plantagineum	Patterson's Curse		x	x			
Emex australis	Three -cornered Jacks	x					
Erodium cicutarium	Common Storksbill		x				
Erodium malacoides			x				
Hedypnois rhagadioloides	Cretan Weed			x			
Herniaria cinerea	Hairy Rupturewort		x				
Hordeum leporinum~	Barley Grass		x				
Hypochaeris glabra	Smooth Catsear		x				
Lamarckia aurea	Goldentop		x				
Limonium lobatum~	Winged Sea Lavender		x				
Lycium ferocissimum#*^	African Boxthorn		x	x			
Lysimachia arvensis	Scarlet Pimpernel		x				
Malva parviflora	Small-flowered Mallow		x				
Medicago minima	Woolly Burr Medic		x				

Scientific name	Common name	Source					
		A	B	C	D	E	F
Mesembryanthemum nodiflorum	Small Ice Plant		x				
Rostraria pumila	Roughtail		x				
Salvia verbenaca	Vervain		x				
Schismus barbatus	Arabian Grass		x				
Silene nocturna			x				
Sisymbrium erysimoides	Smooth Mustard		x	x			
Sonchus oleraceus~	Common Sowthistle		x				
Tagetes minuta	Stinking Rodger			x			
Taraxacum officinale	Dandelion			x			
Trifolium glomeratum	Clustered Clover	x					
Urtica urens	Small Nettle		x				
Verbascum virgatum	Twiggy Mullein			x			
Vulpia myuros	Rat's Tail Fescue		x				

Appendix 4 Flora recorded within PGSW

Notes to tables:

Status – EPBC Act:	**Source of Records**
CE – Critically Endangered	A – PGSW Recovery Plan (Biosis 2018b)
EN – Endangered	B – EIS Biodiversity addendum (NGH Environmental 2008b)
VU – Vulnerable	C – PGSW TS determination (NSW Scientific Committee 2010)
Status – BC Act:	D – VIS flora survey database (OEH 2017b)
E1 – endangered species (Part 1, Schedule 1)	E – PCT description (OEH 2017a, Appendix 4)
E2 – endangered population (Part 2, Schedule 1)	F – 2018 Baseline monitoring (Biosis 2020)
E4 – presumed extinct (Part 4, Schedule 1)	G – 2019 Vegetation monitoring (This report)
E4A – critically endangered	
V – vulnerable (Part 1, Schedule 2)	

Table A4.1 Flora species recorded within PGSW

Scientific name	Common name	EPBC Act	BC Act	Source						
				A	B	C	D	E	F	G
Native species										
Abutilon fraseri	Dwarf Lantern-flower				x					
Abutilon leucopetalum	Desert Chinese Lantern			x	x				x	x
Acacia aneura	Mulga Wattle			x	x	x		x	x	x
Acacia salicina	Willow Wattle					x		x		
Acacia tetragonophylla	Curara, Dead Finish			x	x	x	x	x	x	x
Acacia victoriae	Prickly Wattle			x		x	x	x	x	x
Alectryon oleifolius	Boonaree, Western Rosewood			x					x	x
Amyema maidenii	Nyinkin			x						
Amyema preissii	Wireleaf Mistletoe			x						
Aristida nitidula	Flat-awned Threeawn			x						x
Asteraceae spp.	Daisy								x	
Atriplex angulata	Angular Saltbush					x	x	x		
Atriplex pumilio	Mat Saltbush			x						
Atriplex spp.	A Saltbush								x	
Atriplex stipitata	Mallee Saltbush			x	x			x	x	x
Atriplex vesicaria	Bladder Saltbush					x		x		x
Austrostipa scabra	Rough Spear-grass				x				x	x
Austrostipa spp.	Speargrass				x				x	x
Boerhavia dominii	Tarvine			x						
Brachyscome ciliaris	Variable Daisy				x					
Brachyscome lineariloba	Hard-head Daisy				x					

Scientific name	Common name	EPBC Act	BC Act	Source						
				A	B	C	D	E	F	G
Bulbine semibarbata	Leek Lily				x					
Calotis hispidula	Bogan Flea			x	x					
Cheilanthes austrotenuifolia	Rock fern			x					x	x
Cheilanthes lasiophylla	Woolly Cloak-fern			x					x	x
Cheilanthes sieberi subsp. *sieberi*	Mulga Fern					x		x		
Chenopodium desertorum	Frosted Goosefoot			x		x	x	x	x	x
Convolvulus erubescens	Blushing Bindweed								x	x
Cymbopogon ambiguus	Lemon Grass, Scent Grass			x		x	x	x	x	x
Daucus glochidiatus	Native Carrot				x	x		x	x	x
Dissocarpus paradoxus	Cannonball Burr			x					x	x
Dodonaea lobulata	Lobed Leaf Hop Bush				x				x	x
Dodonaea viscosa subsp. *angustissima*	Narrow-leaf Hop-bush					x		x		x
Einadia nutans	Climbing Saltbush			x					x	
Enchylaena tomentosa	Ruby Saltbush			x	x	x	x	x	x	x
Enneapogon cylindricus	Jointed Nineawn					x		x	x	x
Eremophila oppositifolia subsp. *oppositifolia*	Weeooka				x					
Eriochloa crebra	Cup Grass			x						
Erodium crinitum	Blue Heron's-bill				x					
Eucalyptus intertexta	Gum Coolibah			x	x	x	x	x	x	x
Eucalyptus socialis	Red Mallee			x	x	x	x	x	x	x
Euchiton sphaericus	Star Cudweed								x	
Euphorbia drummondii	Caustic Weed			x					x	x
Glycine clandestina	Twining Glycine			x					x	x
Goodenia pusilliflora	Small-flower Goodenia				x					
Hibiscus sturtii var. *sturtii*	Hill Hibiscus			x						
Leiocarpa semicalva										x
Lepidium papillosum	Warty Peppercress				x					
Maireana pyramidata	Black Bluebush				x	x		x	x	
Maireana sclerolaenoides	Woolly-fruit Bluebush				x				x	
Maireana sedifolia	Pearl Bluebush			x	x					
Maireana spp.	Cotton Bush								x	
Maireana trichoptera	Hairy-wing Bluebush				x				x	x
Maireana triptera	Three-wing Bluebush				x					
Marsdenia australis	Doubah, Native Pear			x						
Myriocephalus rhizocephalus	Woolly-heads				x					

Scientific name	Common name	EPBC Act	BC Act	Source						
				A	B	C	D	E	F	G
Olearia muelleri	Mueller's Daisy Bush								x	
Omphalolappula concava	Burr Stickseed				x					
Oxalis perennans	Grassland Wood-sorrel			x						
Pittosporum angustifolium	Weeping Pittosporum				x					
Poaceae spp.	Grass								x	
Podolepis capillaris	Invisible plant			x	x					
Pterocaulon sphacelatum	Fruit-salad Plant									x
Ptilotus obovatus	Smoke Bush, Cotton bush			x	x	x	x	x	x	
Ptilotus obovatus var. *obovatus*	Silver Tails								x	x
Ptilotus spp.									x	
Pycnosorus pleiocephalus									x	x
Rhagodia spinescens	Spiny Saltbush, Berry Saltbush			x	x				x	x
Rhagodia ulicina	Spiny Goosefoot			x						
Rhodanthe microglossa	Clustered Sunray				x					
Rhodanthe pygmaea	Pygmy Sunray				x					x
Rhyncharrhena linearis	Purple Pentatrope								x	x
Salsola tragus	Buckbush								x	
Sclerolaena diacantha	Grey Copperburr				x				x	x
Sclerolaena lanicuspis	Woolly Copperburr				x					
Sclerolaena obliquicuspis	Limestone Copperburr					x	x	x	x	
Sclerolaena patenticuspis	Spear-fruit Copperburr			x					x	
Sclerolaena spp.	Copperburr, Poverty-bush								x	x
Senna artemisioides subsp. *X artemisioides*	Silver Cassia				x	x		x	x	x
Setaria paspalidioides	Bristle Grass			x						
Sida ammophila	Sand Sida								x	
Sida petrophila	Rock Sida			x	x	x	x	x	x	x
Sida spp.	A Sida								x	
Sisymbrium erysimoides	Smooth Mustard				x					
Solanum ellipticum	Potato Bush				x				x	x
Solanum quadriloculatum	Tomato Bush				x				x	x
Solanum spp.	Nightshade								x	
Solanum sturtianum	Thargomindah Nightshade			x		x	x	x		x
Stenopetalum lineare	Narrow Thread-petal				x					
Tetragonia moorei	Annual Spinach				x					
Thyridolepis mitchelliana	Mulga Mitchell Grass									x

Scientific name	Common name	EPBC Act	BC Act	Source						
				A	B	C	D	E	F	G
Triodia scariosa subsp. *scariosa*	Porcupine Grass			x	x	x	x	x	x	x
Vittadinia cuneata	Fuzzweed			x						
Wahlenbergia communis	Tufted Bluebell			x						x
Zygophyllum apiculatum	Pointed Twin-leaf				x					x
Zygophyllum iodocarpum	Violet Twin-leaf				x					
Zygophyllum ovatum	Dwarf Twin-leaf				x					
Exotic species										
Acetosa vesicaria	Bladder Dock					x				
Carrichtera annua	Ward's Weed				x					
Emex australis	Three -cornered Jacks								x	
Limonium lobatum	Winged Sea-lavender				x					
Sonchus oleraceus	Common Sow-thistle				x					
Trifolium glomeratum	Clustered Clover								x	

Appendix 5 PCT 359 - Porcupine Grass - Red Mallee - Gum Coolabah hummock grassland low sparse woodland

VIS Classification - Community Profile Report

Plant Community Type ID (PCT ID): 359

PCT Classification Confidence Level: High

PCT Common Name: Porcupine Grass - Red Mallee - Gum Coolabah hummock grassland / low sparse woodland on metamorphic ranges on the Barrier Range, Broken Hill Complex Bioregion

PCT Scientific Name: *Eucalyptus socialis , Eucalyptus intertexta / Acacia tetragonophylla , Maireana pyramidata , Acacia aneura s. lat. , Acacia aneura , Dodonaea viscosa subsp. angustissima / Triodia scariosa subsp. scariosa , Sida petrophila , Chenopodium desertorum , Cymbopogon ambiguus*

Photo 1:

Original Entry: jbenson 21/02/2008 21/02/2008

Vegetation Description: This community contains an unusal occurrence of Red Mallee and Gum Coolabah growing in a Porcupine Grass dominated landscape on rocky ranges in the arid zone. Hummock grassland to low sparse woodland with the ground cover dominated by the hummock grass Porcupine Grass (Triodia scariosa subsp. scariosa). Scattered trees include Red Mallee (Eucalyptus socialis) with Gum Coolabah (Eucalyptus intertexta). Shrubs are very sparse and include Acacia aneura sens lat., Acacia victoriae subsp. arida., Acacia tetragonophylla, Maireana pyramidata, Enchylaena tomentosa, Senna form taxon 'artemisioides' and Atriplex vesicaria. The ground cover is dominated by Triodia scariosa subsp. scarisa. Other ground cover species include Ptilotus obovatus var. obovatus, Chenopodium desertorum, Sida petrophila, Cymbopogon ambiguous, Solanum sturtianum, Cheilanthes sieberi subsp. sieberi, Daucus glochidiatus, Atriplex angulata, Enneapogon cylindricus and Sclerolaena obliquicuspis. Occurs in the arid climate zone on soils composed of eolian red sandy loam or lithosols deposted over rocky outcrops composed of Proterozoic gneiss, phyllite, schist, sandstone and slate (Willyama complex), with a relief to 200 m forming rocky hills in the Umberumberka Range section of the Barrier Range sub-region in the Broken Hill Complex Bioregion, north of Silverton. Grades into widespread hill Mulga communities such as (ID123) and contains elements of ID169 Curly Mallee open woodland that occurs further north on the Barrier Range near Corona but the ground cover in ID169 is not dominated by Triodia. Past disturbance may include cutting of trees for use in fencing and towns such as Silverton. A short term and averted threat was a proposed wind farm (plans now modified to lessen impact on plant community). The main long term threat is grazing by goats or stock. Reduced rainfall and hotter temperatures due to climate change could also impact on the regeneration of shrub and tree species. The combination of its very limited extent and current threats leads to an assessment of this community as being threatened requiring protection and management, particulalry reduction of grazing pressure.

Emergent species: None

Upper Stratum Species: Eucalyptus socialis; Eucalyptus intertexta;

Mid Stratum Species: Acacia tetragonophylla; Maireana pyramidata; Acacia aneura s. lat.; Dodonaea viscosa subsp. angustissima; Acacia salicina; Senna form taxon 'artemisioides'; Acacia victoriae subsp. arida; Enchylaena tomentosa;

Ground Stratum Species: Triodia scariosa subsp. scariosa; Sida petrophila; Cymbopogon ambiguus; Ptilotus obovatus var. obovatus; Chenopodium desertorum; Solanum sturtianum; Cheilanthes sieberi subsp. sieberi; Daucus glochidiatus; Atriplex vesicaria; Atriplex angulata; Enneapogon cylindricus; Sclerolaena obliquicuspis;

Threatened Plants: Not Assessed

Threatened Fauna: Melastoma affine (Blue Tongue); Delma australis (Marble-faced Delma);
Diagnostic Species: Not Assessed
Height Class (Walker & Hopkins 1990): 2 - Range:0.26-0.50m (Low)
Vegetation Formation: Arid Shrublands (Acacia sub-formation);
Vegetation Class: Stony Desert Mulga Shrublands;
NSW Landscape Name: Barrier Ranges;
Classification source: Surveyed and mapped by NGH Environmental Pty Ltd (2008). Part of broad map unit 27 in Pickard & Norri
Authority: Surveyed and mapped by NGH Environmental Pty Ltd (2008). Part of broad map unit 27 in Pickard & Norris (1994). Occurs in the Umberumberka Land System (Walker 1991). Some possible links to Floristic Group 9 in Playfair & Robinson (1997) in the North Olary Plains of South Australia. Community very distinct, although there was no plot data existed as of 2008.
Pre-Euopean Mapped Or Modelled: Not mapped or modelled
Current Extent Mapped Or Modelled: Not mapped
Adequacy of plot sampling: None ***Number of plotsto define PCT:*** 0
IBRA Bioregion: Broken Hill Complex (>70%);
IBRA Sub-Region: Barrier Range (Not known); Barrier Range Outwash (Not known);
LGA: Unincorporated (>70%);
Lithology: Phyllite , Gneiss , Pegmatite , Slate
Landform Pattern: Hills
Landform Element: Hillcrest , Hillslope
Pre-European Extent: 500 ha ±30%. Estimated from extant vegetation maps: full range
Pre-European Extent Accuracy: 30
Pre-European Comments: A highly resticted community occurring on the southern Barrier Range - comprising a very small part of the 34,000 ha Umberumberk Land System (Walker 1991). Based on mapping in NGH Environmental Pty Ltd (2008) and reports on some futher unmapped areas on the Barrier Range (S. Sass pers. comm.).
Current Extent: Not Assessed
Current Extent Accuracy: 30
Current Extent Comments: Mostly not cleared due to its occurrence on rocky hills in the arid zone but some trees may have been cut in the past for smelters at Silverton. Grazing by goats may reduce regeneration of woody species. Part of the current extent is mapped by NGH Environmental Pty Ltd (2008) with about 200 ha of other arears unmapped as of 2009.
PCT Percent cleared: 20.00
% accuracy (of PCT % cleared estimate): +/-30
Variation and Natural Disturbance: It is unusal for Red Mallee to grow on rocky ranges and this may also be the western-most occurence of Gum Coolabah in NSW. Some areas on the ranges are devoid of trees and are true hummock grasslands - other areas contain scattered trees.
Fire Regime: Fire is infrequent. The hummock grass could burn occasionally depending on fuel loads.
Associated TEC Degreee of Fit:

Associated TEC Comments:

Citations: (Pickard J. & Norris E., 1994 ; Playfair R. & Robinson A., 1997 ; Walker P., 1991 ; NGH Env., 2008)
Full Reference Details: (27; 295; 386; 400;). Pickard, J. & Norris, E.H. (1994) The natural vegetation of north-western New South Wales: notes to accompany the 1:1 000 000 vegetation map sheet. Cunninghamia 3(3): 423-464; Playfair, R.M. & Robinson, A.C. (1997) (eds.) A biological survey of the North Olary Plains, South Australia 1995-1997. (Natural Resources Group, Department of Environment and Natural Resources: South Australia); Walker, P.J. (1991) Land systems of western New South Wales. Technical Report No. 25 (Soil Conservation Service of New South Wales: Sydney); NGH Environmental (2008) Biodiversity Assessment: Stage 1 Proposed Silverton Wind Farm. Prepared for Silverton Wind Farm Developments Pty Ltd;
Profile source:
PCT Definition Status: Approved