HILLGROVE RESOURCES

EPBC-ACT CONTROLLED ACTION

EPBC 2013/6965

NATIVE VEGETATION MANAGEMENT PLAN COMPLIANCE REPORT FOR THE

KANMANTOO COPPER MINE EXTENSION

2019/ 2020

Hillgrove Resources – 11th December 2020

Cover Picture – Mine Rd SEB-Offset Area: (175 Mine Rd); Native grass sward establishment is highlighted in the right side of the photograph and growth of mid-story and canopy species representative of a reconstructed Peppermint Box Grassy Woodland community can be seen on either side of the native grass sward. The 141 Mine Rd and 175 Mine Rd plantings now show landscape-scale conversion of cropping land into native vegetation communities with minimal weed competition.

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1.0 Definitions

Abbreviation	Definition
141 Mine Rd	Hillgrove-owned property & designated SEB-Offset area, 141 Mine Rd Kanmantoo SA 5252
Acacia pycnantha (A. pycnantha)	Open woodland community dominated by *Acacia pycnantha*
DAWE	Australian Department of Agriculture, Water and the Environment
Botanic Gardens	South Australian Seed Conservation Centre, Botanic Gardens of Adelaide
BushRAT	Bushland Rapid Assessment Technique/ DEWNR SA
CD	Compact Disk
CEO	Hillgrove's Chief Executive Officer, Mr Lachlan Wallace
DEM	Department for Energy and Mining SA
DEW	Department of Environment, and Water, SA
DSD	Department of State Development, South Australia
DPC	Department of Premier and Cabinet, South Australia
EBS Ecology	Fauna and Flora Consultancy division of the EBS Group, Adelaide SA
EBS Restoration	Ecological restoration division of the EBS Group, Adelaide SA
EM	Hillgrove's Environment Manager (Ms Catherine Davis)
EPBC 2013/6965	Approval granted to disturb vegetation under provisions of the EPBC Act
EPBC Act	Ecosystem and Biodiversity Conservation Act (1999)
Eucalyptus odorata (E. odorata)	Critically endangered grassy woodland community dominated by *Eucalyptus odorata*
Ferguson's	Hillgrove-owned property & designated SEB-Offset area, adjacent to Mine Rd Kanmantoo SA 5252
Hillgrove	Hillgrove Resources Ltd/ Hillgrove Copper Pty Ltd
KCM	Kanmantoo Copper Mine
LFA	Landscape Function Analysis/ Ludwig & Tongway (1997)
Lomandra effusa (L. effusa)	Critically endangered natural temperate grassland vegetation community dominated by *Lomandra effusa*
LOM-Extension	Life of Mine Extension
Lot 25	Hillgrove-owned property & designated SEB-Offset area, adjacent to Mine Rd Kanmantoo SA 5252
ML	Mining Lease 6345
Mulawa	Hillgrove-owned property & designated SEB-Offset area, 175 Mine Rd Kanmantoo SA 5252
NRM Act	Natural Resources Management Act 2004 (SA)
NVMP	Native Vegetation Management Plan
PEPR	Program for Environmental Protection and Rehabilitation
SA	South Australia
SEB x:1	A native vegetation condition rating for SEB-Offset purposes
SEB-Offset	Significant Environmental Benefit - Offset. New vegetation areas established to offset clearance.
SMA	Seed Multiplication Area/ 5ha seed multiplication plot
SPA	Seed Production Area/ 1ha intensive seed farm

1.1 Executive Summary

This compliance report describes our progress against the approval conditions listed in EPBC 2013/6965 during the 2019-2020 reporting period from01Sep19 to 31Aug20. Please refer to our 2014/2015, 2015/2016, 2016/2017, 2017/2018 and 2018/2019 EPBC compliance reports for details relating to approval conditions discharged in previous reporting periods. Previous compliance reports can be accessed via the following link;

http://www.hillgroveresources.com.au/environment

Navigate down the page to 'Environmental Protection and Biodiversity Conservation Act (EPBC)', 'Compliance Reports:', and select the report you wish to download. The following historic and current reports are available on our web page;

- ***2015 EPBC Act Compliance Report***
- ***2016 EPBC Act Compliance Report***
- ***2017 EPBC Act Compliance Report***
- ***2018 EPBC Act Compliance Report***
- ***2019 EPBC Act Compliance Report***
- ***2020 EPBC Act Compliance Report***

Hillgrove Resources have worked towards complying with the approval granted by EPBC 2013/6965. During the 2019/2020 reporting period Hillgrove have continued to consolidate the topsoil pre-stripping and direct seeding carried out on approximately 10.15ha of the Mine Rd areas commenced in April 2018. This brings the total area of SEB-offset commenced at Mine Rd to 20.3ha since April 2015, including the rehabilitation and direct seeding of a gully-erosion channel and direct seeding of the headlands associated with the topsoil pre-strip rows.

Topsoil pre-stripping and direct seeding was also further consolidated on new land areas totalling 13.35ha at 'Lot 25' and 'Ferguson's'. Topsoil pre-stripping and direct seeding was completed on approximately half of the available land area at Ferguson's/Lot 25, or 6.7ha of these new blocks in April 2018. The total area of EPBC SEB-offset commenced at all sites by the end of the 2019/2020 reporting period is approximately 27ha. A further 239 *Diuris behrii* orchid seedlings were planted at various locations with the Mine Rd SEB-offsets and within the ML during this reporting period.

Seed production programs and wild-seed seed collection programs continued. Adequate seed supplies were available for approximately 43ha of rehabilitation hydroseeding within the ML during 2020 (this was ML rehabilitation and does not relate to EPBC 2013/6365). Approximately 566kg of native seed was harvested dried and packaged during this reporting period. Poor winter rainfall impacted the overall volume of seed which was harvested in 2019/ 2020. Preliminary figures suggest that more than 700kg of grass seed has been harvested during spring 2020, reflecting significantly improved plant growth following higher than average rainfall in 2020. This will be reported in further detail by the 2020/2021 EPBC Compliance Report when the result of additional seed collection program is known. The use of external/commercial seed supplies has not been necessary to date with adequate seed supplies available from in-house programs.

Our SEB-offset establishment program during 2019 was constrained by commercial considerations. A revised NVMP will be required and it will present a revised SEB-offset program for consideration. The revised program will seek to the topsoil pre-strip method of SEB-offset establishment. We will have sufficient land available for a 1:1 exchange of land assigned for the creation of SEB-offset areas within Hillgrove-owned properties from the 'old NVMP to a new NVMP'.

1.2 Background

The Kanmantoo Copper Mine (ML6345) is located approximately 45km SE of Adelaide, near the townships of Kanmantoo and Callington. The 440ha mining lease (ML) is on the eastern side of the Mt Lofty ranges, within a 425mm rainfall zone. The Kanmantoo Copper Mine (KCM) is operated by Hillgrove Copper Pty Ltd. The current mining operation is the third cycle of mining on-site since the 1850's. The ML contains a range of remnant native vegetation, including stands of Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia and Iron–grass (*Lomandra effusa)* Natural Temperate Grassland of South Australia, both of which are listed as critically endangered under the EPBC Act (1999). The ML's vegetation has been significantly altered by more than 150-years of agriculture and mining; however, remnant stands of native vegetation can be found within the ML, varying in condition from SEB-Offset classes of 2:1 to 8:1 in some areas. The clearance of 1.8ha of Peppermint Box grassy woodland and 3.4ha of Iron-grass natural temperate grassland was required to allow extension of mining activities until 2019 under the *Life of Mine Extension proposal*, ('the LOM Extension').

The LOM Extension was approved under a revised Program for Environmental Protection and Rehabilitation (PEPR), regulated by the South Australian Department for Energy and Mining, or DEM (formerly Department of Premier & Cabinet SA' (DPC), and prior to that, Department of State Development (DSD), henceforth the 'Regulator'). Both clearances were deemed 'controlled actions' under the EPBC Act, requiring approval by the Australian Department of the Environment and Energy (ADEE) (Now the Department of Agriculture, Water and the Environment (DAWE)) before the LOM Extension PEPR could be approved by the Regulator. An NVMP was written to encompass the controlled actions associated with the LOM Extension. The NVMP was subsequently approved by the DAWE and permission to proceed with both controlled actions was granted by the DAWE under the conditions outlined in the approval document for this action Ref: EPBC 2013/6965 dated 6th May 2014. Both controlled actions subsequently commenced on 11Sep14, with due notice given to the DAWE and the Regulator.

This document is an annual compliance report demonstrating that the controlled actions have been carried out within the 13 conditions attached to EPBC 2013/6965 and that progress has been made against the delivery of SEB-offsets required by EPBC 2013/6965. This report has been published as close as possible to 'within '*3-months of every 12-month anniversary of the commencement of the action*', as required by the approval granted on 06May14.

2.0 Conditions associated with Controlled Action EPBC 2013/6965

The following table lists the conditions applied to Controlled Action EPBC 2013/6965 and Hillgrove's compliance with each condition. Details associated with Hillgrove's actions relating to each condition during the period from 11Sep18 to 10Sep19 are presented in section 3 (below).

Condition No.	Conditions applied to the approval of EPBC 2013/6965	Compliance with condition (✓ or X)
1	The person undertaking the action must not clear more than 1.8ha of the ecological community *Peppermint Box Grassy Woodland* of South Australia within ML 6345	✓ (See 3.1, below)
2	The person undertaking the action must not clear more than 3.4 ha of the ecological community *Iron-grass Natural Temperate Grassland of South Australia* within ML 6345	✓ (See 3.2, below)

Condition No.	Conditions applied to the approval of EPBC 2013/6965	Compliance with condition (✓ or X)
3	The person taking the action must prepare and submit a Kanmantoo Copper Mine Native Vegetation Management Plan (NVMP) for the Minister's written approval prior to commencing the action. The NVMP must include the following;	✓
3a	Management actions are undertaken to improve the ecological quality of Peppermint Box and Iron-grass communities within ML6345 and offset lands and protect (them) from degradation for the duration of the action	✓
3b	Regeneration and revegetation strategies implemented for Peppermint Box and Iron-grass communities within the proposed SEB-Offset areas to improve the ecological quality of these areas	✓
3c	An ecological monitoring program is undertaken to monitor success of management actions within the NVMP and define measurable targets of management actions, performance indicators and adaptive management framework for the duration of the action's impact	✓
4	To compensate for the loss of 1.8ha of *Peppermint Box* and 3.4ha of *Iron-grass* communities, the person taking the action must secure the lands identified as the SEB-Offset Areas… as a conservation offset	✓
5	The person taking the action must provide written evidence to the Department of their compliance with Condition 4… to clearly define the location and boundaries of the offset sites prior to the commencement of the action	✓
6	Within 30-days after the commencement of the action, the person taking the action must advise the Department in writing of the actual date of commencement	✓
7	The person taking the action must maintain accurate records substantiating all activities associated with or relevant to these conditions of approval… and make them available upon request to the Department	✓ Agreed/ Ongoing record keeping is undertaken
8	Within 3-months of every 12-month anniversary of the commencement of the action, the person taking the action must publish a report on their website addressing compliance with each of the conditions of this approval	**X** 2019/20 report publication delayed
9	Upon direction of the Minister, the person taking the action must ensure that an independent audit of compliance is conducted and a report submitted to the Minister	✓ Agreed. No audit yet requested
10	If the person undertaking the action wishes to carry out any activity otherwise than in accordance with the NVMP as specified in the conditions, the person taking the action must submit to the Department for the Minister's written approval a revised version of the NVMP	✓ Agreed.
11	If the Minister believes that it is necessary or convenient for the better protection of listed threatened species and ecological communities to do so, the Minister may request that the person taking the action make specified revisions to the NVMP and submit the revised NVMP for the Minister's written approval	✓ Agreed. No request received as of 11Sep20
12	If at any time after 5-years from the date of this approval, the person taking the action has not substantially commenced the action, then the person taking the action must not substantially commence the action without the written agreement of the Minister	✓ Agreed. The action was commenced on 11Sep14

Condition No.	Conditions applied to the approval of EPBC 2013/6965	Compliance with condition (✓ or X)
13	Unless otherwise agreed to in writing by the Minister, the person taking the action must publish the NVMP referred to in these conditions of approval on their website. The NVMP must be published on the website within 1-month of being approved. The NVMP must remain on their website for the life of the action.	✓ Published on Hillgrove's web page

3.0 Details of compliance with EPBC 2013/6965 conditions

Details of Hillgrove's compliance with each condition associated with EPBC 2013/6965 can be summarised as follows: (Figure 1, below, illustrates extent of clearance as of 01Jan15)

3.1 Peppermint Box clearance areas

In accordance with the approved NVMP, no more than 1.8ha of *Peppermint Box (Eucalyptus odorata) Grassy Woodland* of South Australia was cleared within ML 6345 between the commencement date of 11Sep14 and the 1st anniversary of commencement on 11Sep15.

3.2 *Iron-grass* clearance areas

In accordance with the approved NVMP, no more than 3.4ha of 8:1 *Iron grass Natural Temperate Grassland* of South Australia and 1.01ha of 6:1 and 4:1 *Iron grass Natural Temperate Grassland* of South Australia was been cleared within ML 6345 between the commencement date of 11Sep14 and the 1st anniversary of commencement on 11Sep15. Precise areas of *Iron grass Natural Temperate Grassland* of South Australia cleared within ML 6345 after 11Sep14' are highlighted by Figure 2, below

Figure 1: PEPR-Approved clearance limit

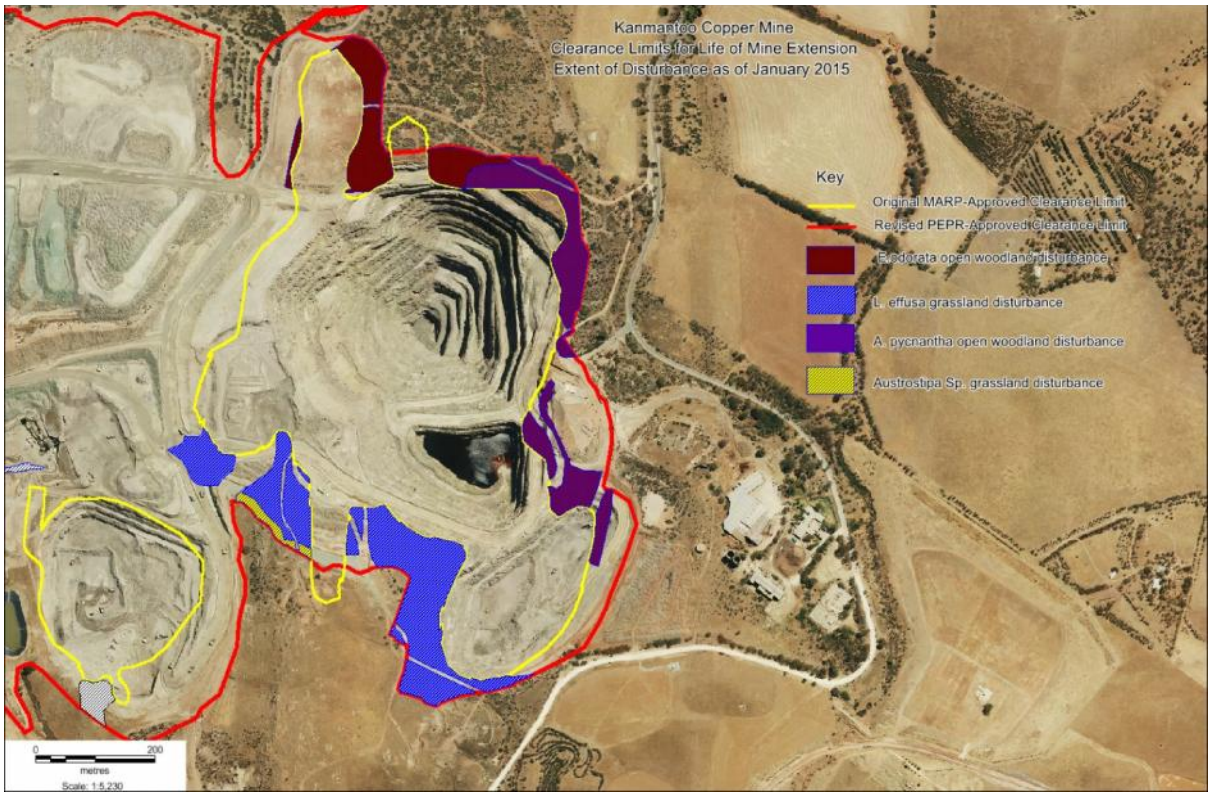


Figure 2: Disturbance of vegetation communities as of January 2015

3.3 Native Vegetation Management Plan Submission

A Native Vegetation Management Plan (NVMP) was written to address the disturbance of vegetation communities and provision of SEB-Offsets associated with the controlled actions approved by EPBC 2013/6965. Hillgrove's NVMP for controlled action EPBC 2013/6965 was approved on the 6th of May 2013. It specifically addresses the following approval conditions:

> 3a. Management actions designed to improve the ecological quality of Peppermint Box grassy woodland and Iron-grass natural temperate grassland and offset lands for the duration of the action
>
> 3b. Regeneration and revegetation strategies for Peppermint Box woodland and Iron-grass natural temperate grassland within the proposed 'SEB-Offset areas' to improve the ecological quality of these areas
>
> 3c. An ecological monitoring program to monitor the success of the management actions in the NVMP and define measurable targets of management actions, performance indicators and an adaptive management framework for the duration of the action's impact on Peppermint Box grassy woodland and Iron-grass natural temperate grassland

3.4 Security of SEB-Offset areas

The areas of Peppermint Box grassy woodland and Iron Grass natural temperate grassland disturbance approved under EPBC 2013/6965 are illustrated in Figure 2, above. SEB-offsets for this action are illustrated in Figure 3, below.

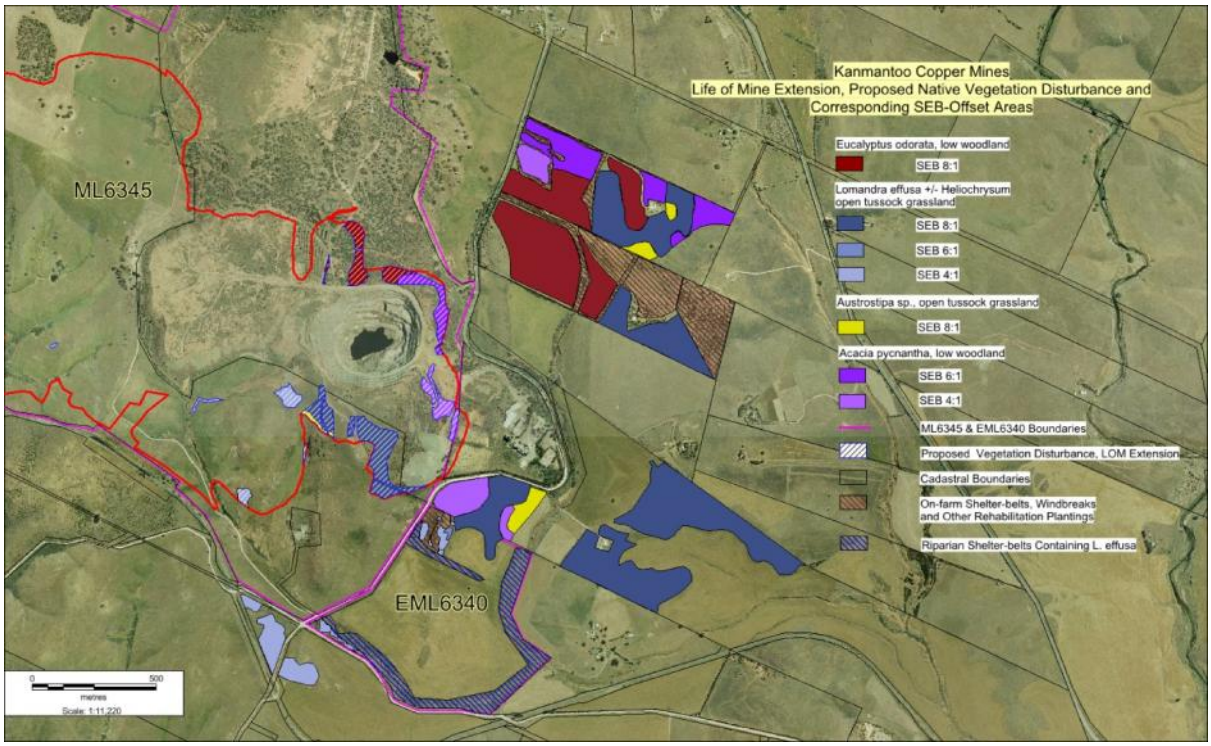


Figure 3: Approved disturbance areas and approved SEB-Offsets associated with action EPBC 2013/6965

All SEB-Offsets are located directly adjacent to the Kanmantoo Copper Mine on Hillgrove-owned properties. Hillgrove has quarantined the SEB-Offset areas from future development and has designated them as 'SEB-Offset blocks' to the exclusion of all other activities. Details of the land titles associated with each land parcel and the SEB-Offsets assigned to each patch are described below and in the NVMP on p30, 'Table 3', and in Figure 4, below.

Property Name	Parcel ID: Title ID & (Owner)	Allocated Offset Patches (ref NVMP)	Offset Types
141 Mine Rd	F160800 A61: CT5548/435 (Hillgrove)	38, 39, 40, 41, 42, 43, 44, 45, 46, 47	E. odorata (8:1), L. effusa (8:1), Austrostipa (8:1), A. pycnantha (6:1 & 4:1)
Mulawa	F1636 A1: CT5516/79 (Hillgrove)	48, 49, 50	E. odorata (8:1), L. effusa (8:1)
Ferguson	D80644 A21: CT5863/768 (Hillgrove)	51, 55	L. effusa (8:1)
Lot 25 Back-Callington Rd/ Éclair Mine Rd (Carmen's East)	D60948 A25: CT5892/419 (Hillgrove) D4767 A4: CT5552/582 (Hillgrove) and D30934 Q1: CT5366/650 (Hillgrove)	52, 53, 54, 56, 57, 58, 62 59, 60, 61	L. effusa (8:1, 6:1 & 4:1), Austrostipa (8:1) L. effusa (4:1)

Figure 4: Hillgrove-owned properties and their assigned SEB-Offsets

Hillgrove intends to establish the designated SEB-Offset areas as conservation areas protected under Heritage Agreements (or similar), as stated in the NVMP on p31. This has not occurred as Hillgrove will seek approval to move our SEB-offset establishment onto equivalent areas of remnant vegetation or other owned by Hillgrove, under a revised NVMP to be submitted for approval or seek payment into a fund when such an instrument is developed as part of the current review of the Act.

As of the 11th of September 2014, onwards, conventional farming operations have been modified or progressively withdrawn from the SEB-Offset areas highlighted above. Note the Google Earth image in Figure 5 (below), dated November 2018, illustrating that SEB-Offset work has commenced on '141 Mine Rd' and 'Mulawa', and the Google Earth image in Figure 6 (below) dated November 2018, illustrating that SEB-Offset works have commenced on the patches labelled Ferguson's/Lot 25 and Lot 25 .

3.5 Written evidence of compliance: SEB-Offset area establishment

2019/ 2020 Reporting Period

The Google Earth image in Figure 5, below, illustrates the completion of topsoil pre-stripping and direct seeding in the Mine Rd SEB-Offset areas designated in the NVMP as patches 38, 39, 40,41,48 and 49 on 141 Mine Rd and Mulawa. The combined areas within both blocks (including headlands and a rehabilitated gully erosion feature) total approximately 20.3ha.

Figure 5: SEB-Offset completion of sowing at 141 Mine Rd and Mulawa – November 2018 image

Note the red-brown strips within the yellow highlighted blocks in Figure 5, which demonstrate that topsoil has been pre-stripped and direct-seeded between the adjacent 2015 direct-seeded rows. An erosion gully, previously running through 141 Mine Rd was rehabilitated, formed into a broad gently sloping grassed waterway and direct seeded with native plant species as a component of the topsoil pre-stripping operation in April/May 2018.

Both 141 Mine Rd and Mulawa have been extensively maintained since 2015, with mowing, selective brushcutting, selective weed spraying, hand weeding, tube-stock planting and slashing for fire risk reduction being among the many activities undertaken.

The Google Earth image in Figure 6, also illustrates that SEB-Offset works have commenced on the patches labelled Ferguson's/Lot 25 and Lot 25. The total area of new SEB-offsets commenced on Ferguson's/ Lot 25 in 2018 was approximately 6.68ha or approximately half of the available area of 13.35ha.

All areas have been intensively managed and maintained during the 2019/2020 reporting period, however, further planting of the inter-row strips at Ferguson's Lot 25 or in other new areas did not continue as planned in autumn 2020, due to commercial restrictions.

Details of work completed during this reporting period is summarised by the 2020 EBS Progress report, see Appendix 1…

Figure 6 GE Image November 2018, SEB Offset Commencement on Ferguson's & Lot 25. Note the red/brown strips, which have been pre-stripped, ripped and direct seeded with native seed mixes.

3.6 Notification of commencement

As reported previously, notification of commencement of the action covered by EPBC 2013/6965 on 11th September 2014 was forwarded to Justin Williams by Catherine Davis on the 9th of October 2014 as per the following email…

From: Catherine Davis [mailto:catherine.davis@hillgroveresources.com.au]
Sent: Thursday, 9 October 2014 6:41 PM
To: Williams, Justin
Subject: RE: EPBC 2013/6965 : final approval decision [SEC=UNCLASSIFIED]

Dear Justin,
In accordance with the conditions of referral EPBC 2013/6965

6. **Within 30 days after the commencement of the action, the person taking the action must advise the Department in writing of the actual date of commencement.**

We wish to notify the department of commencement of the action to clear Native Vegetation for the purpose of expansion of the mine pit occurred 11th September 2014.

Regards,

HILLGROVE RESOURCES

Catherine Davis | Environment Manager | Kanmantoo Copper Mine
Ecbir Mine Road (cnr Back Callington Road), Kanmantoo SA 5252
W hillgroveresources.com.au | T 08 8538 6800 | F 08 8538 5255 | M 0408 396 964

Confirmation of notification receipt by Justin was forwarded to Catherine on the 10th of October 2014 as per the following email…

From: Williams, Justin [mailto:Justin.Williams@environment.gov.au]
Sent: Friday, 10 October 2014 8:17 AM
To: Catherine Davis
Cc: Strike, Kelly
Subject: FW: EPBC 2013/6965 : final approval decision [SEC=UNCLASSIFIED]

Hi Catherine,

I have forwarded the information to the post approval officer responsible for your project.

Action Officer: Kelly Strike
AWD Section: Approval Monitoring South

Regards,

Justin Williams
Assessment Officer
South West Section
West Assessment Branch
Department of the Environment
GPO Box 787 Canberra, ACT 2601
Phone: 02 6275 9492
justin.williams@environment.gov.au
http://www.environment.gov.au/epbc/index.html

Australian Government
Department of the Environment

3.7 Record keeping: Implementation of the Offset and NVMP

Hillgrove maintains a range of records associated with delivery of the outcomes required by our NVMP and the conditions associated with EPBC 2013/6965. A range of preparatory activities and studies have been undertaken by Hillgrove as previously reported in the 2014/2015, 2015/2016 and 2016/2017 EPBC compliance reports. Details of activities undertaken, studies completed and records of progress under the NVMP are documented in this compliance report and the reports posted on Hillgrove's Web Page.

<u>Documentary evidence of progress on actions specified by the NVMP for Year 1 to year 6 (11Sep14 to 11Sep20) is as follows:</u>

3.7.1 Item 1; 'Removal of grazing/cropping pressure – summer 2014 to spring 2020'

A map highlighting land management limitations for the 2019/2020 reporting period was provided to our share farmers in autumn 2020 (see Figure 7, below). Instructions to our sharefarmers will be amended in future years as the area of cropping land used to progressively establish SEB-offsets is expanded.

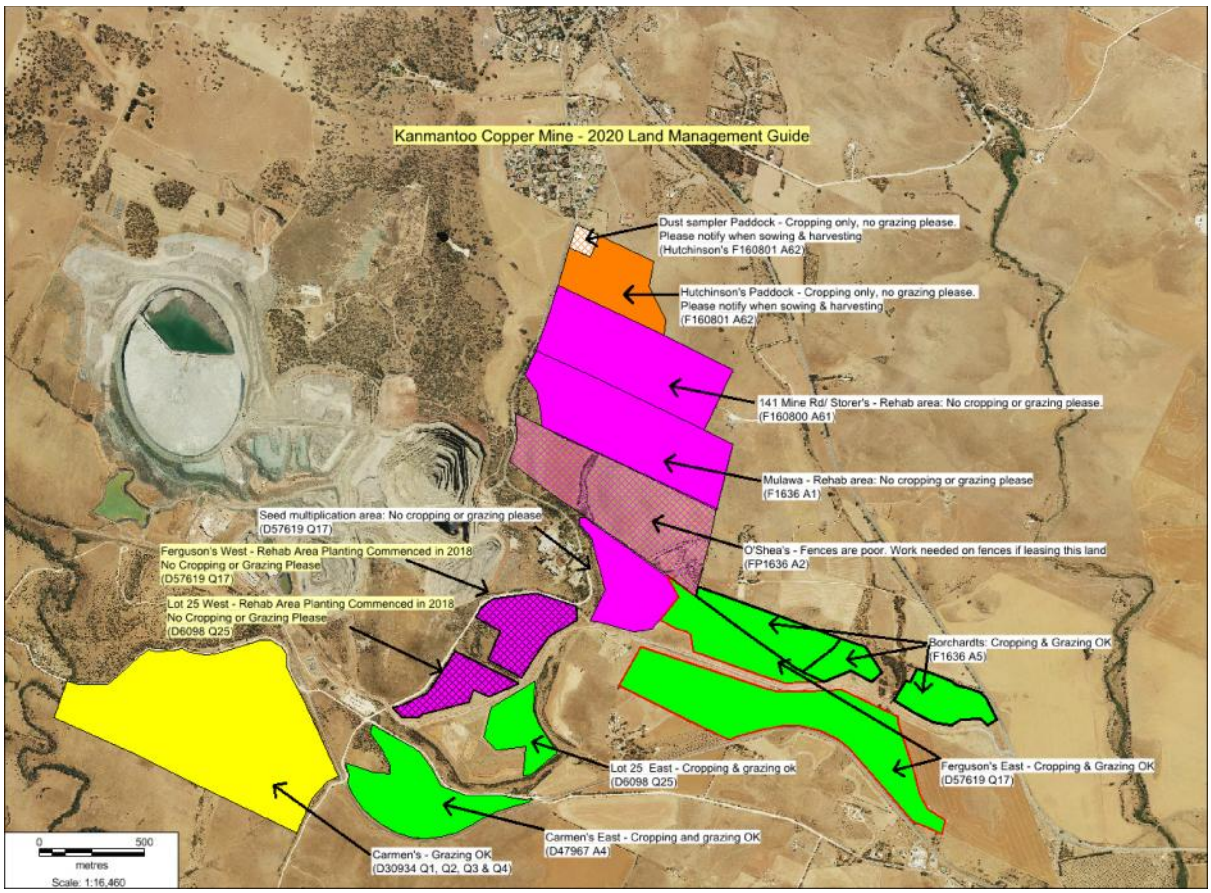


Figure 7: **Hillgrove's Land management instructions to our sharefarmer, autumn 2020.**

3.7.2 Item 2: Schedule offset programs

A program of progressive SEB-Offset commencements associated with our initial ML conditions and EPBC 2013/6965, coincides with the scheduled completion of mine landforms in accordance with the Mine Plan and the projected availability of local-provenance native seed for hydroseeding and direct seeding.

The following map illustrates the projected total area of mine landform rehabilitation and SEB-offset commencements proposed between 2015 and 2020. These areas are collectively associated with our initial ML approval and the NVMP approved by EPBC 2013/6965.

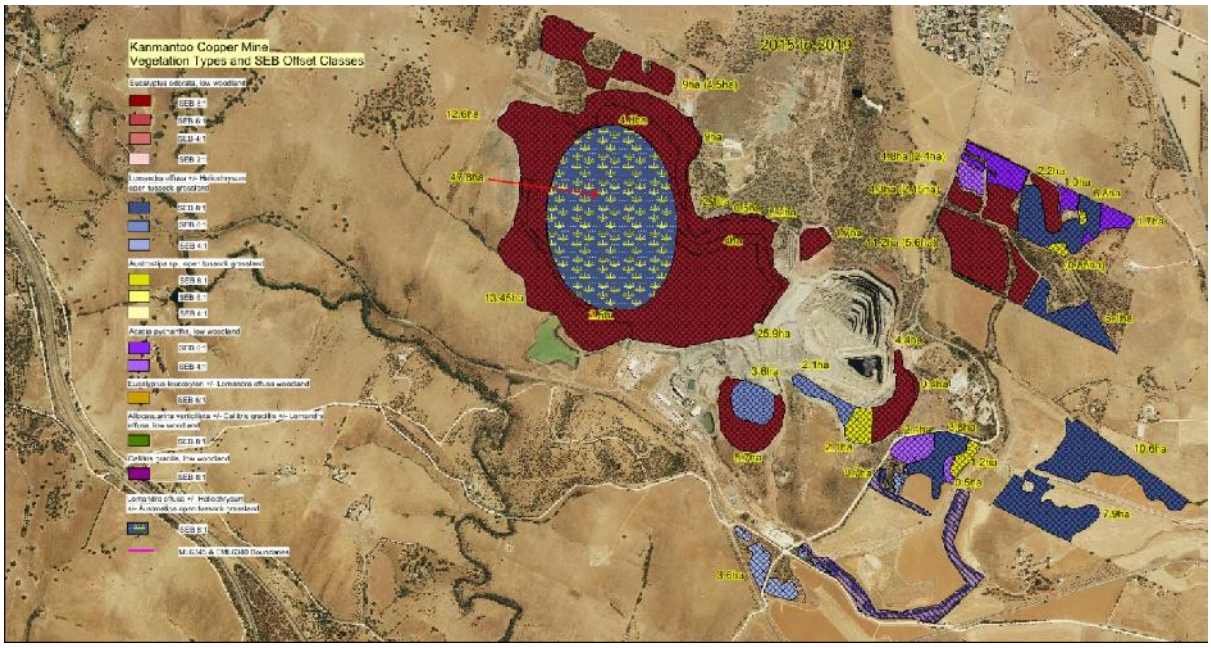


Figure 8: Projected cumulative area of Mine rehabilitation and SEB-Offset program commencements, 2015 to 2020.

Figure 9 (below), illustrates the areas within the ML and outside the ML where rehabilitation and delivery of SEB-offsets were commenced by September 2018.

Please note: It is apparent that the planned schedule of SEB-offset commencements to be delivered by our NVMP by 2020 have become unachievable and a revision of our NVMP for EPBC 2013/6965 will be necessary.

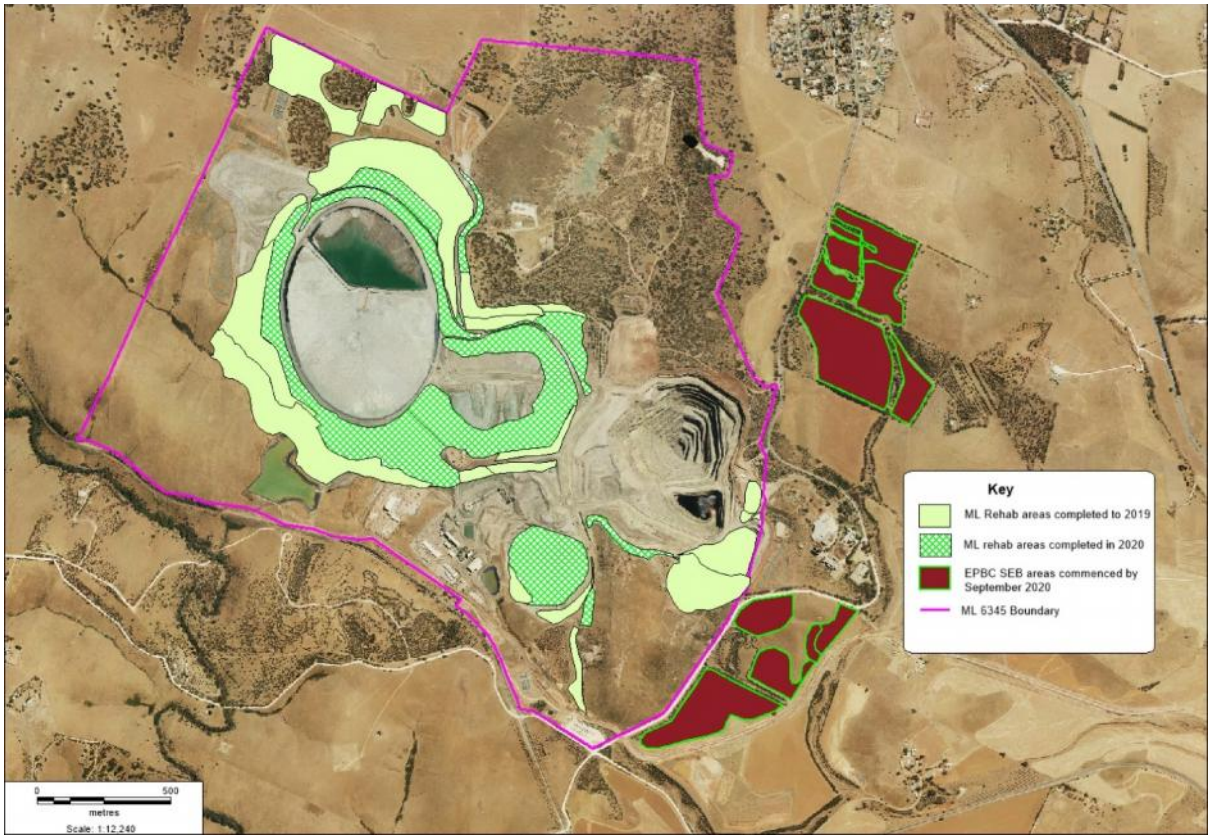


Figure 10: Mine rehabilitation and SEB-Offset program: Summary of Areas Commenced by September 2020.

Summary of Progress on delivery of SEB Offsets approved by *EPBC* 2013/6965

2019/ 2020 Reporting Period

Unfortunately, a combination of operational constraints did not allow our mine rehabilitation and EPBC SEB-offset programs to proceed as planned during the 2019/2020 reporting period.

Progress during this reporting period was highlighted by the consolidation of vegetation establishment in the areas of 141 Mine Rd, Mulawa, Ferguson's/Lot 25 & Lot 25. Approximately 27ha of EPBC SEB-offsets have now been commenced under EPBC 2013/6965.

Intensive weed control and land management programs continued on all EPBC SEB-offsets commenced to date. This acted to reduce weed competition and weed seed-set through precision-brushcutting, spot-spraying, hand weeding and selective boom spraying. Careful mowing and selective boom-spraying of the strips sown in 2018 also reduced weed seed set and competition by remnant grassy weeds. Tractor-slashing and selective spraying of the direct-seeded headlands and the rehabilitated erosion channel in the Mine Rd blocks also reduced weed competition and assisted native grass establishment.

Progress towards ensuring seed reserve capacity for future SEB-offset establishment programs continued during this reporting period. Spring/summer 2019-2020 provided significant quantities mixed *Rytidosperma* and *Austrostipa* seed from maturing native grass swards at Mine Rd, in addition to seed harvested from our SPA and SMA. Significant quantities of mixed grass seed were also harvested during this reporting period from the areas sown on Ferguson's/ Lot 25 during 2018-2019. Seed from these areas was collected using hand-propelled 'grass grabbers' and a large ATV-mounted grass grabber. Seed from diverse range of local species was also collected by our wild-seed collection program from the ML and near-mine region.

The following table illustrates work conducted within all aspects of our SEB-offset program by EBS-Restoration and Hillgrove staff during the 2019/2020 reporting period. Approximately 330 person-days of input was required to execute the 2019/2020 SEB-offset program (note table in Figure 11, below). This work also included weed control and other vegetation enhancement activities undertaken in remnant Peppermint Box and Iron-grass vegetation areas within the ML.

Kanmantoo Copper Mine												
EBS Day Sheet Records: 01Sep19 to 31Aug20												
SEB-Offset Establishment and Maintenance Activities												
(Includes 'Woodland Enhancement' work on ML)												
	Month & Year x Hours per Task											
Task & Location	**Sep-19**	**Oct-19**	**Nov-19**	**Dec-19**	**Jan-20**	**Feb-20**	**Mar-20**	**Apr-20**	**May-20**	**Jun-20**	**Jul-20**	**Aug-20**
Admin (office),Meetings, Inductions, returns,	2	2										
Boom spray / Tractor spray, SEB Maintenance Mine Rd (38,40,41,48,49)							8			12		
Boom Spray/ Tractor spray SMA						8	8		16	4		
Boom spray/ Tractor spray, SEB Maint. Fergs							8		20			
Boom Spray/ Tractor spray, SEB Maint. Lot 25 (A63)							8		24			
Brush cut/ spot spray Lot 25 (A63)		16	23									
Brush cut/spot spray Mine Rd areas	8	68	8	20		8		8				64
Bushcare/ Woodland areas								112				
Equipment servicing and general program maintenance	5	6	1									
Fumigate rabbit warrens/ Rabbit control									4	4	4	
Fence repairs										4		
Mowing with Front deck mower (A38, A39, A41, A40, A48, A49)	44	24	8									
Mowing with front deck mower (SPA, NW Corner)		16										
Mowing with front deck mower (Access Rd & surrounds)		8										
Mowing with front deck mower (Mine Rd)			8									
Orchid planting/ Orchid maintenance; SEB & EPBC areas										68	4	
Property management	3	56	8	16	32	32		4	8			
Report writing/ Annual progress report												60
SEB Maintenance / Mine Rd (38, 39, 40, 41, 48, 49)	8		48						24			
SEB Maintenance in Lomandra Paddock (Mc F Hill, Car E/BC Rd)		30	8						8	4		
SEB Maintenance/ Ferguson's/ A52, A43		3	4									
SEB Maintenance/ Lot 25 (A63)		3	4									
SEB Maintenance & Spraying/ SPA, NW Corner, N-TSF		24		32	32	8	16	56				
SEB Maintenance/ Emily Batter, Smelter Rd				16								
Seed collection			330	48	56	60	52	28				
Seed processing/ cleaning/ batching/ transport				48	48	52	64	28	16			
SMA Maintenance						4	8		12			
SPA maintenance	22	24				4						
Spot spray or brush cut SMA						8		24	8	10		
Spot spray or brush cut SPA						4						
Spot Spray Ferguson's (A43, A52, A54, A62)	32					2	12	8		9		
Spot Spray Lot 25 (A63)						2	4	8		17	8	
Spot spray Mine Rd (38, 39, 40, 41, 48, 49)				8			20		12		104	40
Tractor Slash fire breaks, roadways and block perimeters	4	40										
Tractor slash Ferg's (A43, A52, A62, A54)	16	12	4	4								
Tractor slash Lot 25 (A63)	12	12	8	4								
Tractor slash Mine Rd SEB		16	4	8								
Tractor slash SMA		20	4									
Tractor slash & maintain dust sampler areas	22											
Totals (hours/month)	**178**	**380**	**470**	**204**	**168**	**192**	**208**	**276**	**152**	**132**	**120**	**164**
% of Total Effort by Month	**6.7%**	**14.4%**	**17.8%**	**7.7%**	**6.4%**	**7.3%**	**7.9%**	**10.4%**	**5.7%**	**5.0%**	**4.5%**	**6.2%**
Total Hours (Sep19 to Aug20)	**2644**											
Total Days (Sep1 to Aug20)	**330.5**											

Figure 11: Table summarising the 2019/2020 SEB-offset work program by EBS

Detail of progress by EBS during this reporting period is summarised by the EBS annual Report. See Appendix 1.

Pictorial record of SEB-Offset establishment on assigned SEB-Offset areas

The following photographs document the progress of SEB-offset establishment on the Mine Rd offset areas since commencement in 2015 and document the development of new SEB-offset areas at Ferguson's and Lot 25 commenced in 2018.

SEB-Offset establishment on assigned SEB-Offset areas… 141 Mine Rd

Figure 12: 141 Mine Rd, SW Corner; April 2015, following crop residue removal by grazing and prior to preparation for direct seeding

Figure 12A: 141 Mine Rd, SW Corner; November 2018. Note the emergence of canopy and mid-story species from the strips which were direct-seeded in 2015 and the completion of topsoil pre-strip/ direct seeding on weedy pasture inter-rows

Figure 12B: 141 Mine Rd, SW Corner; November 2019.

Figure 12C: 141 Mine Rd, SW Corner; November 2020.

Mine RD Blocks, (Continued): – 'Mulawa' NE Corner of the 'main block'

Figure 13: 'Mulawa', April 2015. Photograph was taken following removal of cropping residues by grazing and prior to preparation for direct seeding.

Figure 13A: 'Mulawa' NW Corner, November 2018. Photograph was taken following 3-years of managing the initial rows, which were topsoil pre-stripped and direct seeded in 2015 and completion of the remaining topsoil pre-stripping and direct-seeding rows in May 2018.

Figure 13B: 'Mulawa' NW Corner, May 2020.

Figure 13C: 'Mulawa' NW Corner, November 2020.

Mine RD Blocks, (Continued): – 'Mulawa' SW Corner of the 'main block'

Figure14: Mulawa SW Corner, main paddock: October 2016, growth of direct seeded strips.

Figure 14A: Mulawa SW Corner, Main Paddock, November 2018

Figure 14B: Mulawa SW Corner, Main Paddock, May 2020

Figure 14C: Mulawa SW Corner, Main Paddock, November 2020

Mine RD Blocks, (Continued): – '141 Mine Rd' Central

Figure 15: 141 Mine Rd Central; Native grass establishment, November 2015

Figure 15A: 141 Mine Rd Central; Canopy and mid-story establishment, November 2018

Figure 15B: 141 Mine Rd Central, May 2020

Figure 15C: 141 Mine Rd Central, November 2020

Mine RD Blocks, (Continued): – 'Mulawa' NW Corner of the 'main block'

Figure 16: Mulawa, NW Corner; November 2015, Grass establishment following direct seeding

Figure 16A: Mulawa, NW Corner; November 2018, note growth of canopy and mid-story species and completion of topsoil pre-stripping and direct seeding on adjacent rows.

Figure 16B: Mulawa :175 Mine Rd – Spring 2019

Figure 16C: Mulawa: 175 Mine Rd – November 2020

Commencement of new SEB-offset provision at Ferguson's and Lot 25 during April 2018

Figure 17: Ferguson's, lower block looking SW – November 2018

Figure 17A: Ferguson's, lower block looking SW – May 2020

Figure 17B: Ferguson's, lower block looking SW – November 2020

Figure 18: Ferguson's, upper block looking NE – November 2018

Figure 18A: Ferguson's upper block looking NE – May 2020. Note establishment of native grass and broad-leaved species in the foreground

Figure 18B: Ferguson's upper block looking NE – November 2020.

Figure 19: Ferguson's/Lot 25 - November 2018 (note green seedlings indicating strong native grass establishment in the foreground)

Figure 19A: Ferguson's/Lot 25 in spring 2019 – Note strong native grass establishment

Figure 19B: Ferguson's/Lot 25, May 2020

Figure 19C: Ferguson's/Lot 25, November 2020

Figure 20: Lot 25 – November 2018

Figure 20A: Lot 25, highlighting native grass sward establishment – spring 2019

Figure 20B: Lot 25, – November 2020

3.7.3 Item 3; Survey of revegetation plots

As reported previously, vegetation surveys and fauna surveys were conducted on the SEB-Offset patches after commencement of the action covered by EPBC 2013/6965. See previous compliance reports for details…

2019/2020 Reporting Period

EBS conducted a fauna survey of the ML and Mine Rd SEB-offset areas during late September 2019. The 2020 fauna survey occurred in late September 2020 and will be included in the 2020/2021 EPBC Compliance Report.

The 2019 fauna survey can be viewed in Appendix 2. The 2019 fauna survey Executive Summary is as follows…

EXECUTIVE SUMMARY

EBS Ecology (EBS) has been engaged by Hillgrove Resources since 2011 to conduct an annual fauna monitoring program over the Kanmantoo Copper (Kanmantoo Mine) Mining Lease (ML). The fauna monitoring program was undertaken in accordance with the conditions and outcomes required in the Program for Environment Protection and Rehabilitation (PEPR) for Kanmantoo Mine. As such, there must be no net adverse impacts on native fauna abundance or diversity in the ML and in adjacent areas.

The fauna monitoring program aimed to determine whether Kanmantoo Mine had met its conditions and outcomes detailed in the PEPR by:

- Conducting roaming transect surveys to record the abundance and diversity of birds;
- Performing targeted spotlighting surveys to record the abundance of the Common Brushtail Possum (*Trichosurus vulpecula*) as well as other nocturnal fauna; and
- Opportunistically recording all other fauna species encountered within the Project area.

The 2019 bird surveys recorded a total of 686 birds from 55 species over the Project area. This included three State threatened species. In 2019, species richness was the third highest on record at Kanmantoo Mine. The total abundance of birds was slightly lower than that recorded in 2018. However, over the lifetime of the fauna monitoring program, the abundance and species richness of birds has shown annual fluctuations, which may be driven by factors such as rainfall, availability of food resources and the presence (or absence) of nomadic and flocking species.

Twenty-two (22) Common Brushtail Possums were observed within the ML during the 2019 spotlight survey, while no individuals were observed in the Significant Environmental Benefit (SEB) area. To date there have been no observations of Common Brushtail Possums within the SEB area due to an absence of suitable habitat. Over the lifetime of the fauna monitoring program the number of Common Brushtail Possums has remained relatively stable, despite annual fluctuations.

The results from the 2019 fauna monitoring program confirm that there is no significant change in native fauna abundance or diversity within the ML and in adjacent areas. Hence, Hillgrove Resources has satisfied the condition (13) and outcome (21) required within the PEPR relating to the conservation of fauna. The ecological indicators measured between 2011 and 2019, suggest that the overall 'abundance and diversity' of fauna species have not decreased during this period across the monitoring area as shown in the results table below.

Year	Bird Species Richness	Bird Abundance	Bird pest richness	Bird pest abundance	Possum abundance	Pest vertebrate abundance	Pest vertebrate species richness
2011	40	304	2	3	14.3	44	3
2012	59	669	3	57	44	11	2
2013	48	575	4	42	26.5	2	1
2014	31	381	2	6	9	2	1
2015	50	948	2	55	21	40	3
2016	42	530	1	37	14	12	4
2017	52	1042	3	14	30	4	3
2018	56	700	5	21	20	11	2
2019	55	686	4	39	22	4	2
Mean	**48**	**648**	**2.9**	**30**	**22**	**14**	**2.3**

EBS recommends the following measures to improve the ongoing management and monitoring of fauna within the Kanmantoo Mine Project area:

- Continue the fauna monitoring program at the same time each year (early spring);
- Reduce spotlighting effort to biennial surveys within the SEB areas due to the low likelihood of Common Brushtail Possums using these areas within the life of mine;
- Conduct a control program to reduce the numbers of Western Grey Kangaroos (*Macropus fuliginosus*), European Rabbits (*Oryctolagus cuniculus*) and European Brown Hares (*Lepus europaeus*) within the Project area to reduce impacts on remnant and planted native vegetation.

EBS conducted a landscape function analysis (LFA) survey of the ML and Mine Rd SEB-offset areas during late September 2019. See Appendix 3.

Results from the 2019 LFA survey indicate that high-quality vegetation swards are successfully being established at the Mine Rd. SEB-offset area. LFA parameters for the new vegetation areas continue to be on a trajectory towards the development a level of vegetation diversity comparable with high-quality analogue sites. The structural diversity of these sites is expected to develop in time, as vegetation matures and succession in mid-story and canopy species delivers fallen timber and other associated niches to the landscape.

The following Executive Summary from the 2019 LFA report summarises the results obtained;

EXECUTIVE SUMMARY

A long-term Landscape Function Analysis (LFA) monitoring program is in place to measure the ongoing environmental management, restoration and Significant Environmental Benefit (SEB) offset program components of the Kanmantoo Copper Mine operations in South Australia.

The vegetation monitoring program is now in its eighth year, commencing in 2011 but excluding 2016 when the site was not monitored. Two nationally threatened ecological communities occur within the Project Area: *Eucalyptus odorata* (Peppermint Box) Open Woodland and *Lomandra effusa* (Scented Mat-rush) +/- *Lomandra multiflora* subsp. *dura* (Stiff Mat-rush) Open Tussock Grassland, which are both listed as critically endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Permanent LFA monitoring sites, established in these communities at the beginning of the monitoring program (2011-2013) are used as baselines to guide restoration targets for rehabilitation and SEB areas.

This report provides LFA monitoring results for the 2019 monitoring program and compares these results with those from previous years and with the reference (analogue) sites. The 2019 monitoring included an assessment of 24 existing sites and the establishment and collection of baseline data for a further four new sites. The new sites were established as analogue sites in modified grassland ecosystems on hillslopes adjacent to the mine area. These will be used to guide future restoration activities for hillslopes currently impacted by mining activities.

Across the Project Area the restoration sites exist in various states of rehabilitation. However, most rehabilitation sites are indicating successful germination and survival with positive trends toward analogue landscape function indices and restoration goals. In general, the LFA indicators have shown positive rehabilitation trends over the life of the Kanmantoo monitoring program (2011-2019). Rehabilitation plots have typically reached a level of 'self-sustaining communities', relative to analogue sites, after a period of only 3-4 years. Based on the initial success rates of restoration activities across the Kanmantoo Mine Area, it is likely that ongoing works will result in functional trends similar to those observed using LFA to date. This includes initial low values, followed by a rebound period whereby plant cover produces high stability, infiltration and nutrient cycling values before stabilising towards analogue values.

Ecological vegetation attributes such as plant species richness (and whether species are native or exotic) are currently not recorded as part of the LFA monitoring method, limiting the ability of the current program to determine species abundance and diversity or the success of species of interest used in revegetation and seeding mixes. Species composition and germination success should be considered as part of ongoing monitoring to provide information on how species respond to restoration methods, thus informing future rehabilitation activities.

The ongoing monitoring design should continue to adapt to maximise the efficiency and effectiveness of detecting changes in LFA monitoring sites to inform and improve restoration outcomes. Ongoing annual review and adaptation of the monitoring program is recommended, altering factors such as frequency of assessment, indicators measured and sampling locations.

3.7.4 Item 4: Install rabbit-proof fencing

2019/ 2020 Reporting Period

Fencing maintenance during this reporting period involved minor repairs identified during fence inspections. The removal of livestock from 141 Mine Rd/ Mulawa, Ferguson's/Lot25 and surrounding Hillgrove-owned properties, continues to reduce fence damage and incursion by livestock. Fence damage this season was due to limbs falling from trees during storm events and Kangaroos moving to and from the Mine Rd SEB-offset areas.

3.7.5 Item 5: Source equipment and engage contractors

EBS Restoration is the principal contractor responsible for SEB-Offset establishment, weed control and feral animal control on designated SEB areas as outlined in the NVMP. EBS-Ecology is the principal contractor responsible for fauna & flora surveying.

2019/ 2020 Reporting Period

Hunter Brothers Earthmovers were initially engaged as the contractors responsible for 'topsoil pre-stripping' and land preparation process during the initial 2015 program at Mine Rd, however they were unavailable during 2018 and Eichler Earthmovers were invited to carry out works during that reporting period. Eichler's demonstrated that they had access to the equipment and expertise necessary to effectively carry out topsoil pre-stripping, land ripping, erosion gully rehabilitation and topsoil stockpile construction. Eichler's will be invited to carry out future work programs on our behalf.

All contractors have proven continuing competence within Hillgrove's programs on the ML and SEB-offset areas adjacent to the ML (in particular, EBS Restoration). They have demonstrated access to the equipment and expertise necessary to effectively deliver SEB-Offset outcomes associated with Hillgrove's offset program.

3.7.6 Item 6; Weed and feral animal control

Details of weed and feral animal control programs to date can be found in previous EPBC compliance reports…

2019/ 2020 Reporting Period

Considerable weed control work was completed in the SEB-offsets during this reporting period. Activities including brushcutting, mowing, spot-spraying and selective boom-spraying, are summarised as 'maintenance tasks' in Figure 11 (above), which highlights overall monthly EBS labour inputs by task for this reporting period.

Feral animal control was carried out during this reporting period at several sites associated with offset plantings.

Kangaroo numbers have steadily increased in recent years, both within the ML and in the surrounding region. Kangaroo populations will be monitored and a culling program may be instigated if they adversely impact the establishment of SEB-offset areas.

An integrated feral animal control program will resume on-site during the 2020/2021 reporting period if warranted.

3.7.7 Item 7: Investigative Studies

Several investigative studies were conducted in preparation for the establishment of SEB-Offset plantings on the designated offset patches.

These studies have been discussed in detail in previous compliance reports. Please refer to previous EPBC Compliance Reports for details

2019/2020 Reporting Period

No new investigative studies were commenced during this reporting period. Further investigative studies will be scheduled in future reporting periods as required.

3.7.8 Item 8: Enhancement of Native Vegetation Remnants

Vegetation condition assessment suggests there is potential to improve the overall quality of remnant vegetation areas within the ML and on adjacent Hillgrove-owned properties.

2019/2020 Reporting Period

Vegetation enhancement works during this reporting period have continued to improve vegetation condition in a section of McFarlane Hill within the ML and in two additional areas outside the ML, either side of the intersection between Mine Rd and Back-Callington Rd, labelled as ‘Carmen’s East’ and ‘Lot 25’, below. The green highlighted areas (below) will be adjacent to SEB-offsets and will provide linkages to SEB-offsets when they are established.

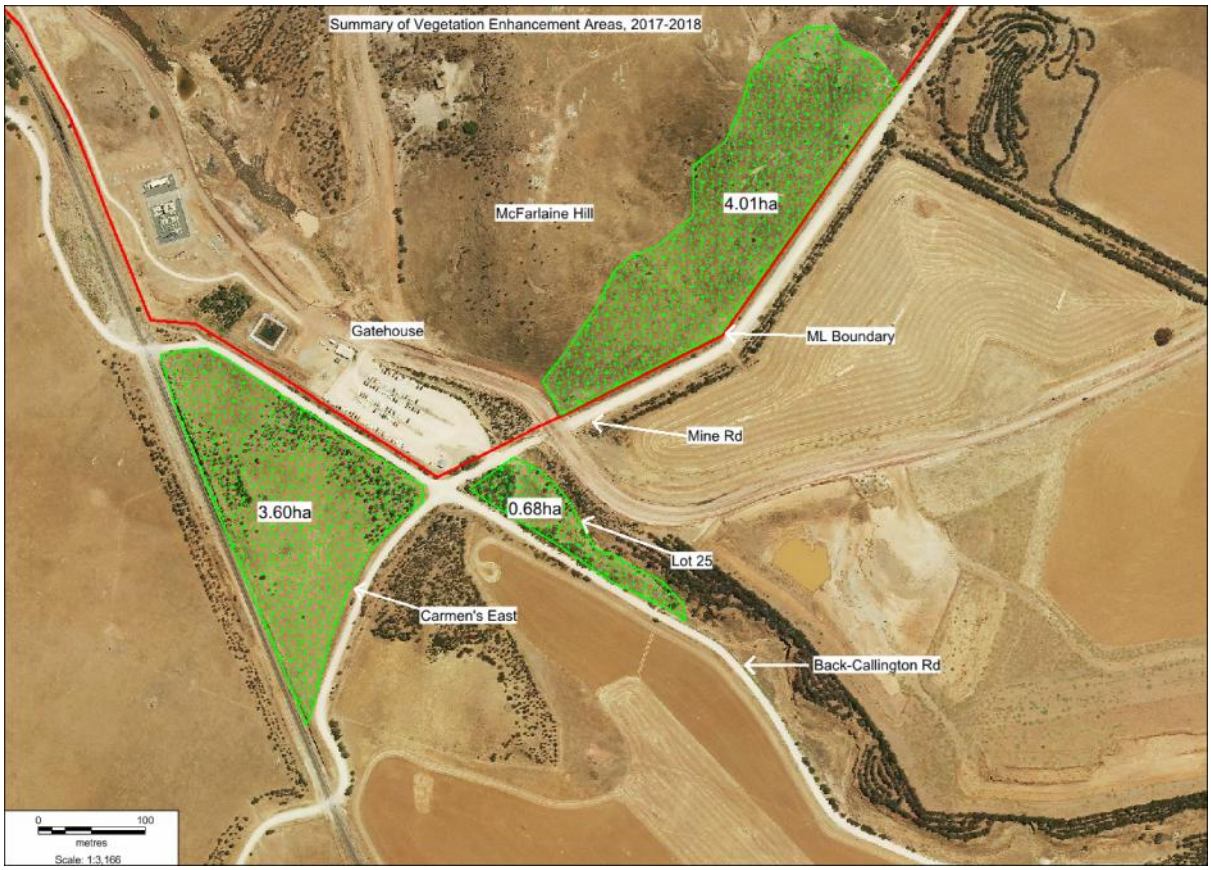


Figure 21: Vegetation Enhancement commenced during the 2017/ 2018 reporting period

The green highlighted areas contain *Iron-grass Natural Temperate Grasslands* with moderate species diversity totalling 8.29ha. These areas are degraded by a significant cover of *Scabiosa atropurpurea* (pincushion daisy), in association with a range of other broad-leaved and grassy weeds. Vegetation enhancement work included tractor-slashing and precision brushcutting to knock down the Scabiosa plants, followed by several rounds of selective spot-spraying to kill the plant crowns and seedlings (see Figure 22, below). Other broad-leaved weeds, including bridal creeper, thistles and cotton bush were targeted during spot-spraying.

Figure 22: Brushcutting *Scabiosa* to improve vegetation condition – Carmen's East

3.7.9 Item 9: Adjustment of boundaries and resurvey

On-ground surveys did not indicate that either the SEB-Offset patch boundaries or the initially mapped property boundaries required adjustment during this reporting period.

3.7.10 Item 10: Build-up seed reserves/ order seeds

As reported previously, Hillgrove has invested considerable effort into the development of our seed production, seed collection, broad-acre seed multiplication and seed storage capacity. Our programs collect, multiply and nurture local-provenance genetic material. Within seed multiplication areas, particular care is taken to support the growth of parent plants with minimal inputs to prevent possible epigenetic creep that could be fostered if we allowed seeds to be grown under 'soft' conditions, for example, through fertilising or over-irrigation to drive seed production volume at the expense of seed quality. Hillgrove has not purchased additional seed from external sources to date, with all direct seeded patches being established using locally collected or locally grown seed.

2019/ 2020 Reporting period

This reporting period has been characterised by significantly lower rainfall than normal in the first part of the reporting period. By the end of the reporting period (11Sep20), this trend had reversed and we had received 356mm of rainfall, which was approximately 8% more than our average YTD rainfall of 330mm. By the 24th of November 2020, YTD rainfall had increased to 527mm, or 33% above the average YTD rainfall of 396mm. This resulted in better than average growing conditions and will result in elevated seed availability during the next reporting period (2020/2021). The EBS annual progress report summarises seed production and processing activities during the current reporting period as follows…

1.1 Seed collection, cleaning and management of seed

Beginning in November 2019, EBS Restoration commenced the annual seed collection works. Initially bulk grass species were collected, which form the basis of the seed mixes for future rehabilitation works. Additional species consisting of under, mid and over storey were collected through until April of 2020, from various locations on and around the mine lease and seed production areas.

As with previous years, the grass collections were undertaken utilising Grass Grabbers, with the pre-stripped areas sown in 2018 providing the majority of the seed collected. These areas adjacent to the Access road, and in the Mulawa/141 Mine road strips are easily accessible and provide a plentiful resource of clean seed.

Approximately 540 kilograms of grass seed (primarily *Austrostipa sp.* and *Rytidosperma spp*) were harvested from these strips, underscoring the value of the overall seeding program in terms of providing a valuable seed resource as well as habitat revegetation.

The Seed Production Area provided understorey species, such as *Atriplex semibaccata* and *Enchylaena tomentosa*, with the infill plantings from the previous year already providing seed. This is also the case with species such as *Acacia acinacea*, *Cullen australasicum* and *Allocasuarina verticillata* producing seed from plants which were sown in 2015 in the strips along Mine road and the Access road.

Calostemma purpureum seed was collected from the hillside adjacent to the access road during March of 2020 (Refer Figure 6), with the seed immediately dispersed among the pre-stripped rows to provide further enhancement and diversity.

Drying of collected seed was once again carried out in the EBS warehouse, with smaller amounts of seed being dried on site in the shed at Fergusons house, and the relocated container which was previously located at the SPA.

Seed is stored in the EBS warehouse, and the inventory is regularly updated to ensure older collections are used first for seeding programs. Regular turnover of seed stock is easily achieved through these processes.

Details of seed reserves are contained in the 2019/2020 EBS annual report, see Appendix 1

3.7.11 Item 11: Land preparation

During the 2017/2018 reporting period, Eichler Earthmovers provided earthmoving services for SEB-offset establishment. They replaced the Cat 623 Scraper used by Hunter Brothers in 2015, with a land plane towed by a Case IH STX380 tractor to lift topsoil and remove it from the planting bays (see Figure 24, below). While this was an effective equipment combination, we observed higher than expected weed germination in the pre-stripped areas the 2018/2019 reporting period. We addressed this through a combination of mowing to reduce grassy weed seed-set and selective herbicide spraying to remove broadleaved weeds. Ongoing monitoring of weed emergence during autumn 2020 has indicated that weed control and management efforts have effectively suppressed weed emergence, indicating that the land plane is suitable for continued use in future years.

Figure 23: Picking up windrowed topsoil with a Case IH/ Land Plane combination – 141 Mine Rd.

3.7.12 Item 12: Planting programs

2017/2018 Reporting Period

As mentioned in previous compliance reports, approximately 10.15ha of topsoil pre-stripping and direct seeding was completed on the remainder of the Mulawa/ 141 Mine Rd blocks during April 2018 and 6.7ha of new SEB-offset area was also commenced on Ferguson's and Lot 25. Collectively, this brings the total area of SEB-offsets 'commenced' to approximately 27ha by the end of this reporting period.

2019/2020 Reporting Period

Further expansion of SEB-offset plantings did not proceed as planned during this reporting period. Commercial constraints in previous years have caused the proposed planting program to deviate from that originally approved in our NVMP for EPBC 2013/6965. A proposal to vary our NVMP will be submitted for consideration.

3.7.13 Item 13: Assess results and adjust methods

Initial results from topsoil pre-strip trials for SEB-Offset establishment within the NW corner of the ML, Smelter Rd and Mine Rd have proven very promising with strong stands of native vegetation established during the first 7-years of establishment. Figures 24 to 24D (below), illustrates the sequence of native vegetation establishment with minimal weed competition on the 'Smelter Rd' SEB-Offset trail area within the ML.

Preliminary observations from the nearby Mine Rd SEB-Offset patches indicate they are trending towards the promising result we have observed on the Smelter Rd trial area. *Ongoing observations indicate that an adjustment to planting methodology is not warranted at this stage.*

Figure 24: Rehabilitation of Smelter Rd just prior to direct seeding, April 2012. Smelter Rd provides an analogue site for the Mine Rd plantings. It provides a benchmark to track the development of direct-seeded vegetation using the topsoil pre-strip technique.

Figure 24A: Establishment of native vegetation in the third year following topsoil pre-strip (Smelter Rd, Kanmantoo Copper Mine), October 2015. Note *A. pycnantha* beginning to emerge above grasses.

Figure 24B: Smelter Rd rehabilitation, Year 4 – October 2016, *A. pycnantha* and *Atriplex* spp. emerging from a well-established *Rytidosperma* (Wallaby Grass)/ *Stipa* sward. This patch will mature to form a grassy-woodland vegetation association dominated by an *A. pycnantha*, *E. odorata* and *A. verticillata* overstorey.

Figure 24C: Smelter Rd rehabilitation, Year 5 – July 2017, *A. pycnantha, A. verticillata* and *Atriplex* spp. emerging from a maturing *Rytidosperma* (Wallaby Grass)/ *Austrostipa* sward. This patch is developing into an *A. pycnantha* open woodland community.

Figure 24D: Smelter Rd rehabilitation, Year 6 – December 2018, *A. pycnantha, A. verticillata* and *Atriplex* spp. emerging from a maturing *Rytidosperma* (Wallaby Grass)/ *Austrostipa* sward. This photograph was taken 5-months later than the photograph in 2017 and in a very dry season, so the density of herbaceous species appears to have reduced due to reduced winter growth and grazing by kangaroos this season. The mid-story and canopy species continue to mature and this area is progressing well towards forming an *A. pycnantha* open woodland community.

Figure 24E: Smelter Rd rehabilitation, Year 8 – November 2020

3.7.14 Item 14: Replanting program

Initial results have been promising. Replanting was not warranted at this stage of the SEB-Offset establishment program. Establishment within the new Mine Rd, Ferguson's and Lot 25 plots was assessed during late spring 2020. Replanting was not considered to be necessary, due to strong vegetation establishment and manageable weed competition.

3.7.15 Item 15: Establish heritage (or other) agreement

All areas allocated for SEB-Offset establishment are on Hillgrove-owned land. Both Hillgrove's CEO and our Environment Manager have undertaken to allow the establishment of Heritage Agreements (or similar instruments) over the SEB-Offset patches, with the Heritage Agreements (or similar) to be lodged against the Land Titles for each property.

Though Heritage Agreements (or similar) are not currently established for the Mine Rd or the Ferguson's/ Lot 25 patches, it is Hillgrove's intention to proceed with establishment in the foreseeable future.

3.7.16 Item 16: Inspect and maintain fences

The removal of livestock from the Mine Rd patches and adjacent Hillgrove-owned land has significantly reduced livestock pressure on the ageing fences surrounding 141 Mine Rd, Mulawa, Ferguson's and Lot 25. Fence inspections were carried out during autumn/ winter 2019. Most fence repairs were related to damage caused by falling trees during winter and kangaroo movement between properties.

3.8 EPBC Act - Compliance Report for EPBC 2013/6965

This report is intended to satisfy Hillgrove's obligation to prove compliance with the conditions associated with EPBC 2013/6965. We believe that we have adequately addressed the NVMP and we are making progress in all areas.

This report and previous compliance reports for Controlled Action EPBC 2013/6965 can be found via the link;

http://www.hillgroveresources.com.au/environment

Navigate down the page to 'Environmental Protection and Biodiversity Conservation Act (EPBC)', 'Compliance Reports:', and select the report you wish to download. The following reports are available on our web page;

- ***2015 EPBC Act Compliance Report***
- ***2016 EPBC Act Compliance Report***
- ***2017 EPBC Act Compliance Report***
- ***2018 EPBC Act Compliance Report***
- ***2019 EPBC Act Compliance Report***
- ***2020 EPBC Act Compliance Report***

3.9 Participation in audit (if required)

Hillgrove will actively assist with an audit of our compliance with EPBC 2013/6965 if requested to do so.

2016/2017 Reporting Period

Hillgrove participated in a site inspection by the ADE and DEM (DSD) staff on 18May17. A report of this inspection was returned to Hillgrove on 29Aug17. A copy of the inspection report can be accessed via Hillgrove's web page via the link;

http://www.hillgroveresources.com.au/environment

Navigate down the page to 'Environmental Protection and Biodiversity Conservation Act (EPBC)', 'Supporting Documents:', and select:

'Mining Inspection Report Kanmantoo Copper Mine May 2017'

Hillgrove received no further requests for audits or inspections from Regulators during the 2019/2020 reporting period.

3.10 Approval for non-approved activities

Non-approved activities have not been undertaken during this reporting period.

3.11 Revision of NVMP (if required by the Minister)

Mine activities have proceeded in accordance with approvals. A formal request for revision of the NVMP has not been received from The Minister at the time of writing this report.

Due to SEB-offset and mine rehabilitation program deferrals as a result of difficult operating conditions for Hillgrove between 2015 and 2019, we will voluntarily seek to revise the current NVMP as soon as possible.

The 'topsoil pre-strip method' of SEB-offset establishment has proven to be so successful, that a revision of the land areas currently allocated for SEB-offset establishment will be requested in an amended NVMP. This would see a 1 for 1 exchange of Hillgrove-owned land currently under cropping, for the areas currently allocated to SEB-offsets under this approval. This would result in no change to the total area of each category of SEB-offset delivered under this approval, but it would significantly improve the likelihood of achieving a high-quality outcome for the SEB-offset program overall. If these changes are approved, Hillgrove would seek to operate under a revised NVMP for EPBC 2013/6965 as soon as possible.

3.12 5-year sunset date for commencement

Work commenced according to approvals on the 11th of September 2014. Subsequently, the 5-year sunset date for commencement will not apply to this approval.

3.13 Publication of Native Vegetation Management Plan

Hillgrove have published our NVMPs on our web page. They can be accessed via the following link;

http://www.hillgroveresources.com.au/environment

Navigate down the page to 'Environmental Protection and Biodiversity Conservation Act (EPBC)', 'Supporting Documents:', and select:

NVMP LOM Extension

Or

NVMP Addenda Giant Cutback

4.0 Conclusions

Hillgrove Resources continue to actively work towards complying with the approval granted by EPBC 2013/6965.

Vegetation disturbance associated with EPBC 2013/6965 was commenced on 11Sep14 and continued to the approved limit of disturbance during the initial reporting period (11Sep14 to 11Sep15). Vegetation disturbance has not subsequently extended beyond the limit described by the approved NVMP.

Hillgrove have addressed all of the elements outlined by our Controlled Action. Progress has been made on the establishment of SEB-Offset areas, with approximately 27ha of plantings commenced by the end of the 2017/2018 reporting period.

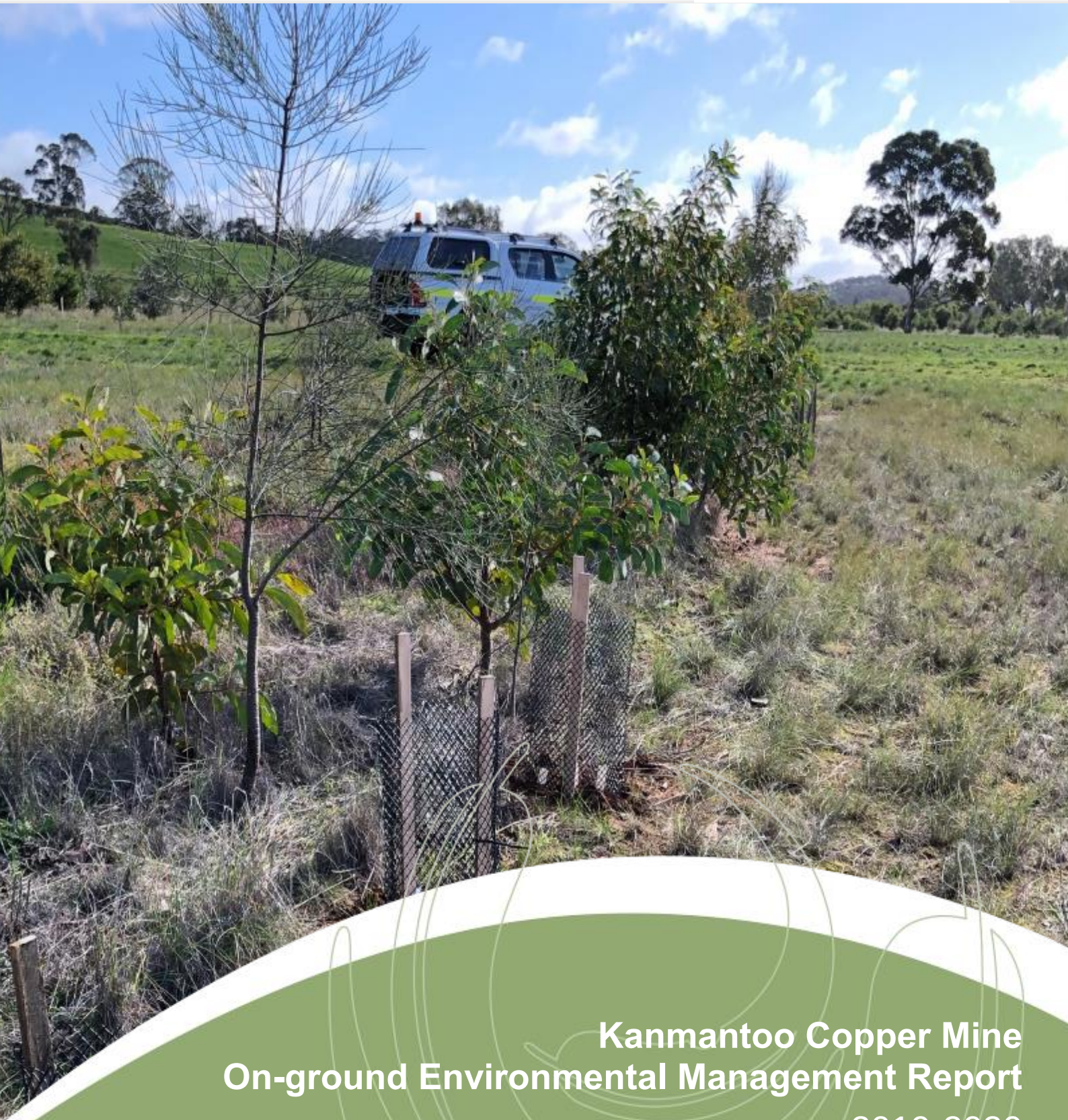
Seed production programs and wild-seed seed collection programs are continuing. Adequate seed supplies were available for the future SEB-offset plantings and the Mine landform rehabilitation hydroseeding program.

Observations continue to suggest that the topsoil pre-strip technique is well suited to the conversion of farming land to native vegetation with minimal follow-on weed competition. Management programs during 2019/2020 further consolidated the initial plantings and provided an excellent basis for the resumption of topsoil pre-strip and direct seeding in future years.

Hillgrove will continue to work actively towards establishment of our assigned SEB-Offsets and look forward to requesting a revision to our NVMP as soon as possible. We hope to report further progress against our revised NVMP in the 2020/ 2021 Compliance Report.

Appendix 1. EBS 2020 Progress Report

ebs restoration



Kanmantoo Copper Mine
On-ground Environmental Management Report
2019-2020

Kanmantoo Copper Mine
On-ground Environmental Management Report
2019-2020 final

27/08/2020

Prepared by EBS Restoration for Hillgrove Resources

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Front cover photo: *Diuris behrii* transplants amongst seeded rehabilitation

EXECUTIVE SUMMARY

On behalf of Hillgrove Resources, EBS Restoration has undertaken the majority of the rehabilitation activities at the Kanmantoo Mine since 2011. A range of environmental programs have been carried out within the Mine lease and associated properties with the aim of assisting Hillgrove Resources to meet their obligations under the relevant mining act.

Key outcomes from the 2019-2020 (01 Sep 2019 to 31 Aug 2020) reporting period include:

- Annual seed collection program continued into the 2019-2020 period, with approximately 566 kilograms of seed collected, including 539 kilograms of grass seed.
- Provision of seed management services, including supply of seed to enable Hillgrove Resources to carry out 43 hectares of remediation works through their hydroseeding program.
- Reintroduction of 239 *Diuris behrii* native orchids onto the Mine lease and surrounding properties.
- Ongoing management of all areas of existing vegetation, hand seeded and hydroseeded locations through weed control activities such as spraying, tractor slashing and brushcutting and woody weed control where appropriate.
- Continued maintenance of the Seed Production Area (SPA) to ensure a continued source of material for the works programs. Tasks include infrastructure maintenance, weeding and slashing.
- Maintenance and enhancement of the Seed Multiplication Area (SMA). Activities undertaken include broadacre slashing, spraying and targeted weed control.
- Fire and risk reduction activities including firebreak boundary slashing, pedestrian access works and infrastructure maintenance.
- Pest control activities including rabbit control, and exclusion of grazing risks to vegetation through tree guarding and fence repairs.

To date, approximately 140 hectares of hydroseeding, hand seeding and pre-strip method seeding have been carried out on areas within the Mine lease and adjacent properties (including re-treatment of recalcitrant areas). These areas are continually maintained where necessary to the point where some locations are already self- sustaining communities of native habitat. The majority of these locations were previously degraded farmland or waste landforms. With proper management these locations will remain a valuable asset to Hillgrove Resources and the local community.

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1 INTRODUCTION

In accordance with requirements under the *Mining Act 1971* a PEPR (Program for Environmental Protection and Rehabilitation) this report outlines on-ground environmental management actions undertaken between September 2019 – September 2020. This report has been prepared for the Kanmantoo Copper Mine and Hillgrove Resources.

On-ground environmental action undertaken during the reporting period by EBS Restoration (September 2019 - September 2020) include:

- Provision of project management services
- Seed collection, cleaning, storage and inventory
- Provision of seed mixes for hydroseeding program
- Ongoing maintenance within rehabilitation locations including: direct seeded pre-strips, hand direct seeding, hydroseeding and existing vegetation
- Management and improvement of the Seed Production Area (SPA)
- Management and improvement of the Seed Multiplication Area (SMA)
- Ongoing management of declared weeds within the mine lease and associated properties
- General maintenance activities as instructed by Hillgrove resources, including infrastructure maintenance
- Tractor slashing and brushcutting to reduce fire and hazard risk along boundaries and fence lines
- Invasive pest control

1.1 Seed collection, cleaning and management of seed

Beginning in November 2019, EBS Restoration commenced the annual seed collection works. Initially bulk grass species were collected, which form the basis of the seed mixes for future rehabilitation works. Additional species consisting of under, mid and over storey were collected through until April of 2020, from various locations on and around the mine lease and seed production areas.

As with previous years, the grass collections were undertaken utilising Grass Grabbers, with the pre-stripped areas sown in 2018 providing the majority of the seed collected. These areas adjacent to the Access road, and in the Mulawa/141 Mine road strips are easily accessible and provide a plentiful resource of clean seed.

Approximately 540 kilograms of grass seed (primarily *Austrostipa sp*. and *Rytidospema sp*) were harvested from these strips, underscoring the value of the overall seeding program in terms of providing a valuable seed resource as well as habitat revegetation.

The Seed Production Area provided understorey species, such as *Atriplex semibaccata* and *Enchylaena tomentosa*, with the infill plantings from the previous year already providing seed. This is also the case with species such as *Acacia acinacea*, *Cullen australasicum* and *Allocasuarina verticillata* producing seed from plants which were sown in 2015 in the strips along Mine road and the Access road.

Calostemma purpureum seed was collected from the hillside adjacent to the access road during March of 2020 (Refer Figure 6), with the seed immediately dispersed among the pre-stripped rows to provide further enhancement and diversity.

Drying of collected seed was once again carried out in the EBS warehouse, with smaller amounts of seed being dried on site in the shed at Fergusons house, and the relocated container which was previously located at the SPA.

Seed is stored in the EBS warehouse, and the inventory is regularly updated to ensure older collections are used first for seeding programs. Regular turnover of seed stock is easily achieved through these processes.

Refer Appendix 2 for September 2020 Seed Inventory

Table 1. 2019-2020 seed collection tally

Species	Batch number	Collection location	Collection date	Amount Sept 2019
Austrostipa / Rytidosperma mix	EBSKAN249	Kanmantoo mine site and surrounds	Nov-19	539.500
Einadia nutans	EBSKAN250	Kanmantoo mine site and surrounds	Dec-19	0.075
Chrysocephalum semipapposum	EBSKAN251	Kanmantoo mine site and surrounds	Nov-19	1.390
Chrysocephalum apiculatum	EBSKAN252	Kanmantoo mine site and surrounds	Nov-19	0.680
Helichrysum leucopsideum	EBSKAN253	Kanmantoo mine site and surrounds	Nov-19	1.980
Podolepis rugata	EBSKAN254	Kanmantoo mine site and surrounds	Dec-19	0.445
Olearia pannosa	EBSKAN255	Kanmantoo mine site and surrounds	Nov-19	0.390
Ptilotus spathulatus	EBSKAN256	Kanmantoo mine site and surrounds	Nov-19	0.120
Hardenbergia violacea	EBSKAN257	Kanmantoo mine site and surrounds	Dec-19	0.380
Allocasuarina verticillata	EBSKAN258	Kanmantoo mine site and surrounds	Nov-19	2.650
Acacia acinacea	EBSKAN259	Kanmantoo mine site and surrounds	Nov-19	0.625
Vittadinia sp. Mix	EBSKAN260	Kanmantoo mine site and surrounds	Nov-19	5.800
Maireana brevifolia	EBSKAN261	Kanmantoo mine site and surrounds	Mar-20	2.500
Atriplex semibaccata	EBSKAN262	SPA	Feb-20	6.200
Enchylaena tomentosa	EBSKAN263	SPA	Feb-20	3.000
Convolvulus sp.	EBSKAN264	SPA	Feb-20	0.400
Cullen australasicum	EBSKAN265	Kanmantoo mine site and surrounds	Jan-20	0.520
Dodonaea viscosa	EBSKAN266	Kanmantoo mine site and surrounds	Nov-19	0.150
Einadia nutans	EBSKAN267	SPA	Jan-20	0.021
Maireana rohrlachii	EBSKAN268	SPA	Dec-19	0.030
Gonocarpus tetragynus	EBSKAN269	SPA	Nov-19	0.035
		Total		**566.891**

Figure 1 *Rytidosperma* grass mix collection with Grass grabber

Figure 2 Bales of *Rytidosperma* and *Austrostipa* grass mixes post collection, ready for drying

Figure 3*. Rytidosperma* grass mixes drying in warehouse

Figure 4 *Chrysocephalum semipapposum* , collected from SPA, drying in Fergusons shed

1.2 2020 Revegetation

Revegetation activities during the 2019-2020 period were limited to the continuation of the *Diuris behrii* program. Utilising the expertise of the Native Orchid Society of South Australia (NOSSA) to multiply specimens from rescued plants, another 200 clones and 39 mother plants were reintroduced to the area during June of 2020.

Previous years planting techniques and locations have proven to be successful, with an estimated survival rate of at least 80 percent. This was a key factor in utilising the same planting techniques and locations for the 2020 plantings. As with previous years, mesh tree guards were used to ensure ventilation and exclusion from predation. Foliage from *Allocasuarina verticillata* was again used as a light mulch after planting.

Careful hand weeding and spot spraying were carried out around plantings to reduce competition and increase the chances of successful establishment. Ongoing weed control will be performed where necessary.

Refer Figures 7, 8 and 9 for Diuris photos and planting locations

Table 2 Revegetation list 2020

Genus	***Species***	***Planted***
Diuris	*behrii*	*239 (pots)*
	Total	*239*

Figure 5 Dried collections of *Helichrysum* and *Chrysocephalum* prior to cleaning

Figure 6 *Calostemma purpureum* collected for dispersal amongst revegetation areas

Figure 7 *Diuris behrii* plants prior to reintroduction

Figure 8 Reintroduction of *Diuris behrii* on Mulawa property, amongst revegetation

Figure 9 Revegetation locations 2019 and 2020

1.3 Management of Seed Production Area (SPA)

Following the minor overhaul of the Seed Production Area (SPA) during 2018-2019, the SPA has shown early signs of benefitting from the works carried out.

Vigorous growth of new plantings of species such as *Atriplex semibaccata*, *Cullen australasicum* and *Maireana rohrlachii* have resulted in good amounts of seed collected from these species shortly after planting during the previous year (refer Figure 10 for *Atriplex semibaccata*)

Maireana rohrlachii is listed as rare within the Kanmantoo region (*2018 Seeds of SA*), and the individuals planted within the SPA were grown from seed collected within the mine lease (refer Figure 11)

The overhaul of the irrigation pump provided a reliable water source during the summer months. Additional hand watering was required during the heatwave just prior to Christmas. This was carried out during the early mornings to ensure the survival of key species within the SPA (refer Figure 11).

Although the overhaul of the SPA during the previous year reduced the ongoing maintenance during the 2019-2020 period, regular minor repairs are still needed due to the age of the SPA.
These tasks included:

- Minor repairs to subsurface irrigation
- Patching repairs to ground weed matting
- Removal of dead and damaged plant material
- Liquid fertilising of new plantings before heat waves
- Hand weeding, brushcutting and spot spraying to control weeds
- Tractor slashing of broadacre grasses

The storage container which had been located at the SPA was also relocated to Fergusons property (outside the mine lease) and will be used for storage and additional seed drying space.
Ongoing works will continue in the SPA to provide a stable source of seed, particularly for species which prove to be difficult to locate or collect from in their natural habitat.

Figure 10 *Atriplex semibaccata* collected from 2019 SPA plantings, drying in shed

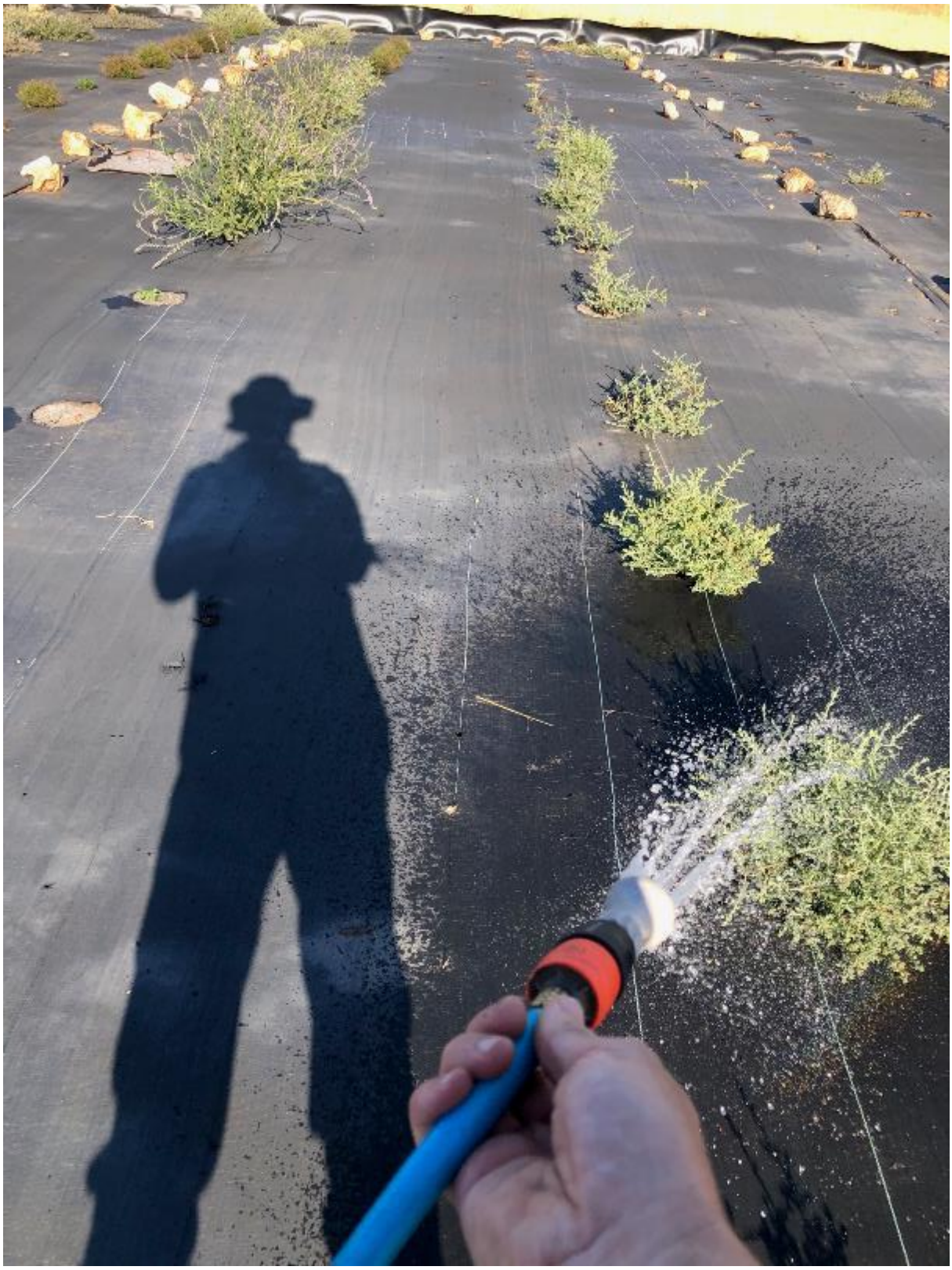

Figure 11 Hand watering of SPA during December 2019 heatwave (*Maireana rohrlachii* shown in foreground)

Figure 12 *Chrysocephalum apiculatum* amongst NW corner seeded strips

1.4 Management of Seed Multiplication Area (SMA)

Works carried out within the SMA during 2019-2020 were targeted towards weed control within the existing grass plots, along with more detailed weed control in the new Vittadinia plot, which was seeded in 2019.

Although the SMA was once the primary source for native grass seed for the revegetation program, recent years have seen a marked decline in the output of these plots. This is likely due to a combination of factors such as soil depletion, ground compaction and adverse seasonal conditions.

While the SMA showed signs of improvement at harvest time during 2019, the decision was made to concentrate seed collection on the pre-stripped/ direct seeded areas along the access road, and Mulawa/141 Mine road. A far more efficient collection was the result, with the grasses at the SMA being left to discharge their seed naturally in the anticipation of greater recruitment and enhancement in future years.

Regular weed control has been carried out within the grass plots and surrounding verges, including spot spraying, brushcutting, as well as tractor slashing and boom spraying. These works will give any grass seeds a greater chance at establishing among the bare areas between existing plants, without competition from introduced species.

In 2019, a large concrete slab was removed from the SMA by Hillgrove staff (refer Figures 15 and 16, 2018-2019 report). This remediation area was cultivated and seeded with a mixture of *Vittadinia* species, including *blackii, cuneata* and *gracilis.* This plot is intended to serve the purpose of the existing *Vittadinia* plot in the SMA, which was sown in 2013 and has become overgrown with native grasses. Positive results have been observed, with multiple patches of Vittadinia species already self-seeding (refer Figure 13).

The SMA should continue to be a valuable resource for several species into the future, albeit in a reduced capacity.

Figure 13 Remediated SMA *Vittadinia* plot, showing multiple germinants

1.5 Direct Seeded Pre-stripped areas

A program of direct seeding has been carried out since 2014 within the Mine lease and associated offset properties. Since this time approximately thirty-four hectares of degraded farm land has been rehabilitated with the aim of establishing a diverse habitat of native vegetation. Although no further seeding works were carried out during the 2019-2020 period, continued maintenance works have been undertaken to enhance and protect the existing areas.

The seeding works are carried out utilising heavy earthmoving equipment to remove the top 100mm of topsoil, which greatly reduces the amount of weed seed and phosphates from the area to be seeded.
The exposed soil is then ripped and cultivated in preparation for hand broadcast of a diverse mix of native species. Overall, this method has proven extremely effective to date, with recruitment of plants from sown seed observed in the majority of the seeded areas.

This method has also proven to be valuable for supplying an easily accessible seed source, especially for native grasses (refer section 1.6. for weed control techniques and activities)

Table 3 Kanmantoo Pre-stripped Seeding Program - dates and locations

Kanmantoo Pre-stripped Seeding Program		
Year	Location	Approximate area (hectares)
2014	North West corner of Mine lease	4
2014	Smelter Road	0.9
2015	North West corner of Mine lease	4
2015	Mine Road / Mulawa	7
2018	Mine Road / Mulawa	8
2018	Mine Road / Mulawa edges (erosion gully and surrounds)	3.7
2018	Access road sites (lot 25 / Ferguson's)	6.6
Total		34.2

1.6 Maintenance and enhancement of existing vegetation and seeded areas.

Areas included within existing vegetation and seeded areas consist of any remnant vegetation or rehabilitation sites within the Mine lease and properties owned or leased by Hillgrove Resources.

These sites include native woodlands, pockets of remnant vegetation, pre-stripped, hand seeded and hydroseeded areas.

Existing vegetation maintenance

Ongoing maintenance and enhancement of existing vegetation has been carried out throughout the 2019-2020 period, with broadleaf and woody weed control being the priority.
Kavanagh woodlands and areas of remnant vegetation adjacent to Gates 2 and 3 were treated primarily for control of Tree tobacco (*Nicotiana glauca),* Artichoke thistle (*Cynara cardunculus*) and Bridal creeper (*Asparagus asparagoides*). Tree tobacco was treated with the cut and swab method, while the thistle and bridal creeper were targeted with the appropriate chemicals via backpack and long line spray units.

Targeted spraying of Gorse (*Ulex europaeus*) regrowth was undertaken along the western boundary during the summer months. Safe vehicle access to this area can be an issue due to the steep and rocky terrain, therefore a long line spray unit mounted on the back of an all-terrain vehicle was used for this purpose. Previous applications of herbicide have slowly reduced the population of Gorse in this area, with remnant *Lomandra effusa* grassland existing along sections of the western boundary.

Weed control was also carried out on the southern face of McFarlane hill, with species targeted including Artichoke thistle, Horehound (*Marrubium vulgare*) and Scabiosa (*Scabiosa atropurpurea*).
McFarlane hill has responded well in previous years to targeted control of these weed species, with a good cover of native *Lomadra effusa* present in the area and also isolated individuals of the rare *Maireana rohrlachii,* which were used a seed source for revegetation activities in other areas of the Mine.

Seeded areas maintenance

Pre-stripped areas

Pre- stripped/ direct seeded sites across the Mine lease and associated properties encompasses a total area of approximately 34 hectares. These locations are easily accessible, and a variety of maintenance activities are performed regularly to conserve and enhance these assets. Activities performed include:

- Broadacre spraying of selective herbicide to control broadleaf weeds in newer seeded strips, Seeded strips less than two years old generally have little broadleaf native species emerging,

therefore application of a broadleaf weed herbicide is possible in these situations. These spraying events are carried out using best practices to avoid off target damage.

- Broadacre spraying of all paths, topsoil stockpiles and bare areas within the boundaries of the seeded properties. This reduces the overall weed load on-site and lessens the likelihood of introduction of new weed species into rehabilitation areas.

- Tractor slashing of native grasses immediately post-harvest. Removal of the spent seed heads and top 50 percent of the grass enables the plant to develop a stronger root system, and the mulched material forms a ground layer of cover and nutrients for the topsoil.

- Continued target spraying and selective brushcutting of introduced species throughout all seeded strips. Broadleaf weeds such as Salvation jane (*Echium plantagineum*) and Capeweed (*Arctotheca calendula*) are sprayed before they reach maturity. Spraying is carried out with a combination of backpack units, and long line spraying based off a vehicle mounted unit. Selective brushcutting is also carried out on introduced grasses such as Wild oat (*Avena fatua*) prior to seed setting. Follow up spraying is often not necessary on annual species such as these, with the waste material once again adding organic matter to the soil.

Hydroseeded and Hand Seeded areas

Primary maintenance tasks focussed around the hydroseeding areas consider aspects of the surfaces, such as steep terrain and friable nature of the dried hydroseeding mixture underfoot. Woody weeds treated within seeded surfaces include Tree tobacco, *Acacia saligna*, and *Albizia* species. These are generally poisoned and left in situ to avoid further disturbance to the hydroseeded surface.

Backpack spraying was also undertaken in various hydroseeded locations, primarily targeting Artichoke thistle, Horehound and Scabiosa. Areas which had both backpack spraying and woody weed control undertaken included the North TSF slopes, surfaces behind the workshop compounds, and the South side of McFarlane hill.

The three main hand seeded locations consist of the SAMR (adjacent to Gate 2), Smelter road and the Emily rehab surface. Targeted spraying has occurred in all these locations throughout 2019-2020, with brushcutting also being undertaken on the Smelter road site to reduce exotic grasses. Broadleaf weeds targeted on all sites include Scabiosa, Salvation jane and Horehound. Woody weed control was also performed on the SAMR and Emily surfaces to control small amounts of Tree tobacco and *Acacia saligna.*

1.7 Hydroseeding

During March of 2020 EBS Restoration facilitated the supply of seed for the continuation of the hydroseeding program. It was estimated that a minimum of 40 hectares of seeding would be completed, therefore requiring the appropriate amount of mixed seed to be available.

There were approximately 30 bales remaining from the 2019 hydroseeding program stored in the EBS warehouse, so these were used for the bulk of the seed required.

The addition of a dryland pasture mix was to be added into each batch for the 2020 program, therefore allowing the existing bales (approximately 15 kilograms each) to be reduced to around 10 kilograms per bale to allow for the addition of the pasture mix.

The pasture mix was procured by Hillgrove resources and should enable a more rapid cover of vegetation to the seeded areas, providing stability and nutrients while the native seed slowly emerges and eventually outcompetes.

An additional 40.5kg of seed was mixed in 2020 (Refer Table 4) and added to the remaining 2019 hydroseeding mixes to match the total number of hectares seeded for 2020.

Refer Appendix 2 for hydroseeding locations undertaken during 2020

Table 4 2019 Hydroseeding species mix and totals

Species	Batch number	2019 Hydroseeding mix grasses (total 43 bales)		2019 Hydroseeding mix 43 bales. purple = all bales. Orange = 35 bales only		3 Extra Bails April 2019	
		Location	Amount kg	Location	Amount kg	Location	Amount kg
Acacia pycnantha	EBSKAN20				10.500		0.750
Acacia paradoxa	EBSKAN21				1.010		
Acacia menzelii	EBSKAN24				0.170		
Clematis microphylla	EBSKAN72				0.209		
Acacia acinacea	EBSKAN73				0.356		
Ptilotus spathulatus	EBSKAN78				0.041		
Eucalyptus odorata	EBSKAN94				0.898		
Eucalyptus socialis	EBSKAN96				0.025		
Convolvulus remotus	EBSKAN102				0.320		
Atriplex semibaccata (half chaff)	EBSKAN107				11.500		
Eucalyptus calycogona	EBSKAN110				0.180		
Rytidosperma sp. (Danthonia)	EBSKAN113		27.000				
Vittadinia blackii	EBSKAN114		12.100				
Chloris truncata	EBSKAN116		3.000				
Hardenbergia violacea	EBSKAN126				0.343		
Rhagodia crassifolia	EBSKAN134				0.125		
Einadia nutans	EBSKAN139				0.170		
Vittadinia blackii	EBSKAN157						0.750
Helichrysum leucopsideum	EBSKAN160				0.037		
Convolvulus remotus	EBSKAN164				0.055		
Dicanthium sericeum	EBSKAN173		7.000				
Convolvulus remotus	EBSKAN174				0.880		
Enchylaena tomentosa	EBSKAN176				12.900		0.750
Atriplex semibaccata	EBSKAN177				3.200		
Eucalyptus odorata	EBSKAN184						0.090
Kennedia prostrata	EBSKAN185				0.080		
Enneapogon nigricans	EBSKAN186		4.000				
Convolvulus erubens	EBSKAN190				1.450		
Rytidosperma sp. (Danthonia)	EBSKAN191		36.500				
Austrostipa sp.	EBSKAN193		20.000				
Senna artimissioides	EBSKAN195				2.940		
Bursaria spinosa	EBSKAN197				1.280		
Rytidosperma sp. (Danthonia)	EBSKAN198		22.000				
Austrostipa/Rytidosperma mix sp.	EBSKAN199		324.000				
Enneapogon nigricans	EBSKAN203		1.000				
Chrysocephalum apiculatum	EBSKAN208				0.036		
Kennedia prostrata	EBSKAN209				0.215		
Maireana brevifolia	EBSKAN215				0.600		
Allocasuarina verticillata	EBSKAN218				2.080		
Dodonaea viscosa	EBSKAN219				2.510		
Callitris gracillis	EBSKAN220				2.340		
Austrostipa / Rytido mix	EBSKAN225		99.000				36.000
Eucalyptus odorata	EBSKAN226				0.875		

Species	Batch number	2019 Hydroseeding mix grasses (total 43 bales)		2019 Hydroseeding mix 43 bales. purple = all bales. Orange = 35 bales only		3 Extra Bails April 2019	
		Location	Amount kg	Location	Amount kg	Location	Amount kg
Allocasuarina verticillata	EBSKAN227				2.625		0.300
Callitrus gracillis	EBSKAN228						0.150
Themeda triandra	EBSKAN231		8.000				
Cullen australisicum	EBSKAN233				0.105		
Chrysocephalum semipapposum	EBSKAN242				0.930		
Vittadinia mix	EBSKAN243		11.500				
Maireana brevifolia	EBSKAN247				1.700		0.300
Atriplex semibicatta	EBSKAN248						0.750
Total			**575.100**		**62.685**		**39.840**

Species	Batch number	2020 hydroseeding program - additional with 2019 mixes	
		Location	amount
Velleia paradoxa	EBSKAN28		0.015
Cymbopogon ambiguus	EBSKAN92		3.800
Senecio quadridentatus	EBSKAN142		0.007
Vittadinia blackii	EBSKAN157		0.700
Podolepis rugata	EBSKAN161		0.027
Gonocarpus tetragynus	EBSKAN163		0.078
Olearia pannosa	EBSKAN214		0.022
Austrostipa / Rytidosperma mix	EBSKAN225		34.500
Eucalyptus odorata	EBSKAN226		0.037
Callitris gracillis	EBSKAN228		0.183
Chrysocephalum apiculatum	EBSKAN241		0.035
Maireana brevifolia	EBSKAN247		1.000
Einadia nutans	EBSKAN250		0.075
		total used	**40.479**

1.8 Fire reduction programs

Annual hazard reduction works were undertaken during October of 2019. As with the previous year, the early start to the fire season necessitated an earlier than usual program, consisting primarily of tractor slashing and brushcutting.

Although the bulk of work consisted of cutting firebreaks along boundaries and fence lines, pedestrian areas and active work areas such as infrastructure were also cleared to reduce the risk of snake activity and trip hazards in these areas.

Follow up weed spraying of a complete knockdown herbicide was also carried out where possible to reduce the regrowth of vegetation.

EBS Restoration has invested in suitable equipment for hazard and fire reduction tasks, including a tractor and heavy-duty slashing deck with demountable fire- fighting unit to ensure theses activities can be undertaken safely and efficiently.

1.9 Pest management

Control of introduced rabbits (*Orycotolagus cuniculus*) has taken place during winter of 2020, with warren fumigation and destruction occurring in several locations across properties outside of the mine lease. Locations treated have been mapped with GPS (refer Figure 9) and will be monitored for activity, where follow up treatments will be delivered when necessary.

Treatment consists of locating and sealing all escape holes within the warren system, and delivery of Aluminium phosphide into the remaining warren entrance, which is then sealed (refer Figure 16). This process is undertaken within all relevant safety and pest management licensing requirements.

Kangaroo (*Macropus fuliginosus*) grazing of seeded areas is ongoing throughout many of the rehabilitation areas. Along with destruction of juvenile native seedlings, weed seeds can also be dispersed between areas through faeces. Observations have occurred where juvenile plants are only protected from such grazing pressures through natural exclusion, for example *Goodenia sp*. being sheltered underneath a thorny *Acacia paradoxa* (refer Figure 17).

Minor repairs to boundary fences have been carried out throughout 2019-2020, with the purpose of reducing grazing pressure in seeded and revegetated areas.

During May of 2020, a four- wheel drive vehicle entered an active rehabilitation site (*Lomandra effusa* grassland) adjacent to the front gate of the Hillgrove Mine (refer Figure 18). Noticeable damage to remnant Lomandra plants and niche seeding trial plots has occurred as a result. Tyre damage from this incident has since been filled in and lightly seeded with native grassland mix. Follow up weed control will occur as there is a high likelihood of broadleaf weed germination through the affected areas. The temporary entrance gate to the site was closed over and efforts made to prevent further access to the site.

Figure 14 Active Rabbit warren complex, North end of Lot 25

Figure 15 Fumigation of active warren complex, Lot 25

Figure 16 *Acacia paradoxa* sheltering *Goodenia* seedlings from grazing damage

Figure 17 Vehicle damage to Lomandra rehabilitation area

APPENDIX

Appendix 1 Seed inventory - September 2020

Species	Batch number	Collection location	Collection date	Amount Sept 2020
Acacia pycnantha	EBSKAN20	Kanmantoo mine site	Dec-11	25.710
Eucalyptus camaldulensis	EBSKAN25	Kanmantoo mine site	2011	0.965
Velleia paradoxa	EBSKAN28	Kanmantoo mine site and surrounds	Dec-12	0.015
Arthropodium sp.	EBSKAN50	Kanmantoo mine site and surrounds	Dec-12	0.105
Cymbopogon ambiguus	EBSKAN92	SPA	Dec-13	14.800
Acacia argyrophylla	EBSKAN93	Kanmantoo mine site and surrounds	Dec-13	11.920
Eucalyptus phenax	EBSKAN95	Kanmantoo mine site	Feb-14	0.108
Enteropogon acicularis	EBSKAN99	SPA	Dec-13	1.400
Cassinia arcuata	EBSKAN108	Kanmantoo mine site and surrounds	2014	1.400
Callitris canescens	EBSKAN111	Kanmantoo mine site and surrounds	2014	0.080
Goodenia pinnatifida	EBSKAN115	SPA	Dec-14	0.050
Cymbopogon ambiguus	EBSKAN117	SPA	Dec-14	7.500
Helichrysum leucopsideum	EBSKAN128	SPA and surrounds	Dec-14	0.010
Senecio quadridentatus	EBSKAN142	SPA	Feb-15	0.089

Species	Batch number	Collection location	Collection date	Amount Sept 2020
Enneapogon nigricans	EBSKAN143	SPA	Feb-15	0.600
Bothriochloa macra	EBSKAN145	SPA	Feb-15	4.000
Convolvulus erubescens	EBSKAN148	SPA		1.800
Olearia pimeleoides	EBSKAN149	Kanmantoo mine site	Oct-15	0.011
Olearia pannosa	EBSKAN150	Surrounds	Oct-15	0.005
Santalum acuminatum	EBSKAN151	Surrounds	Oct-15	0.013
Eucalyptus calycogona	EBSKAN154	Kanmantoo mine site	Jan-16	0.071
Eucalyptus odorata	EBSKAN155	Kanmantoo mine site	Dec-15	0.757
Vittadinia blackii	EBSKAN157	SMA	Oct-15	2.500
Chrysocephalum semipapposum	EBSKAN158	SPA	Nov-15	0.040
Helichrysum leucopsideum	EBSKAN160	SPA	Nov-15	0.037
Podolepis rugata	EBSKAN161	SPA	Dec-15	0.250
Gonocarpus tetragynus	EBSKAN163	SPA	Nov-15	0.078
Bothriochloa macra	EBSKAN169	SPA	Nov-15	4.000
Enneapogon nigricans	EBSKAN171	SPA	Nov-15	1.000
Cymbopogon ambiguus	EBSKAN172	SPA	Nov-15	2.500
Enchylaena tomentosa	EBSKAN176	SPA	Feb-16	2.850
Kennedia prostrata	EBSKAN178	SPA	Dec-16	0.055
Enchylaena tomentosa	EBSKAN180	SPA	Apr-17	2.900
Eucalyptus odorata	EBSKAN184	Kanmantoo mine site and surrounds	Jan-17	0.033
Themeda triandra	EBSKAN189	SPA	Jan-17	1.500
Bursaria spinosa	EBSKAN196	Kanmantoo mine site and surrounds	Feb-16	0.038

Species	Batch number	Collection location	Collection date	Amount Sept 2020
Themeda triandra (includes stalks)	EBSKAN200	SPA / SMA	Dec-17	56.000
Chloris truncata	EBSKAN201	SMA	Jan-18	7.500
Aristida behriana	EBSKAN202	SMA	Dec-17	0.800
Austrostipa blackii	EBSKAN204	surrounding area	Nov-17	1.900
Vittadinia sp. Mix	EBSKAN205	surrounding area	Nov-17	0.260
Eucalyptus leucoxylon	EBSKAN207	surrounding area	Feb-18	0.033
Lomandra effusa	EBSKAN210	surrounding area	Nov-17	0.450
Helichrysum leucopsideum	EBSKAN211	surrounding area	Nov-17	0.031
Arthropodium sp.	EBSKAN213	surrounding area	Nov-17	0.013
Olearia pannosa	EBSKAN214	surrounding area	Nov-17	0.022
Eucalyptus socialis	EBSKAN216	surrounding area	Feb-18	0.052
Eucalyptus calycogona	EBSKAN217	surrounding area	Feb-18	0.030
Acacia pycnantha	EBSKAN221	surrounding area	Dec-17	2.650
Bolboschoenus caldwellii	EBSKAN222	surrounding area	Nov-17	0.350
Lomandra effusa	EBSKAN223	surrounding area	Nov-17	0.400
Vittadinia sp. Mix	EBSKAN224	SMA	Feb-18	0.500
Austrostipa / Rytidosperma mix	EBSKAN225	Kanmantoo mine site and surrounds	Nov-18	239.000
Eucalyptus odorata	EBSKAN226	mine lease	Jan-19	1.615
Allocasuarina verticillata	EBSKAN227	Kanmantoo mine site and surrounds	Nov-18	3.785
Callitris gracillis	EBSKAN228	Kanmantoo mine site and surrounds	Jan-19	0.610
Callitris preissii	EBSKAN229	surrounding area	Jan-19	9.580
Convolvulus sp	EBSKAN230	SPA	Feb-19	0.654
Aristida behriana	EBSKAN232	SMA	Feb-19	1.000

Species	Batch number	Collection location	Collection date	Amount Sept 2020
Helichrysum leucopsideum	EBSKAN234	Kanmantoo mine site and surrounds	Nov-18	0.060
Ptilotus spathulatus	EBSKAN235	Kanmantoo mine site and surrounds	Nov-18	0.022
Lotus australis	EBSKAN236	Mine rd and SMA	Nov-18	0.013
Kennedia prostrata	EBSKAN237	SPA	Dec-18	0.220
Hardenbergia violacea	EBSKAN238	SPA	Dec-18	0.068
Podolepis rugata	EBSKAN239	Kanmantoo mine site and surrounds	Nov-18	0.080
Clematis microphylla	EBSKAN240	surrounding area	Dec-18	0.267
Chrysocephalum apiculatum	EBSKAN241	mine lease	Dec-18	0.200
Chloris truncata	EBSKAN244	SMA	Jan-19	1.700
Enneapogon nigricans	EBSKAN245	SMA	Jan-19	2.100
Enchylaena tomentosa	EBSKAN246	SPA	Feb-19	4.000
Maireana brevifolia	EBSKAN247	mine lease and surrounds	Feb-19	5.700
Atriplex semibaccata	EBSKAN248	SPA	Feb-19	1.250
Austrostipa / Rytidosperma mix	EBSKAN249	Kanmantoo mine site and surrounds	Nov-19	539.500
Einadia nutans	EBSKAN250	Kanmantoo mine site and surrounds	Dec-19	0.075
Chrysocephalum semipapposum	EBSKAN251	Kanmantoo mine site and surrounds	Nov-19	1.390
Chrysocephalum apiculatum	EBSKAN252	Kanmantoo mine site and surrounds	Nov-19	0.680
Helichrysum leucopsideum	EBSKAN253	Kanmantoo mine site and surrounds	Nov-19	1.980

Species	Batch number	Collection location	Collection date	Amount Sept 2020
Podolepis rugata	EBSKAN254	Kanmantoo mine site and surrounds	Dec-19	0.445
Olearia pannosa	EBSKAN255	Kanmantoo mine site and surrounds	Nov-19	0.390
Ptilotus spathulatus	EBSKAN256	Kanmantoo mine site and surrounds	Nov-19	0.120
Hardenbergia violacea	EBSKAN257	Kanmantoo mine site and surrounds	Dec-19	0.380
Allocasuarina verticillata	EBSKAN258	Kanmantoo mine site and surrounds	Nov-19	2.650
Acacia acinacea	EBSKAN259	Kanmantoo mine site and surrounds	Nov-19	0.625
Vittadinia sp. Mix	EBSKAN260	Kanmantoo mine site and surrounds	Nov-19	5.800
Maireana brevifolia	EBSKAN261	Kanmantoo mine site and surrounds	Mar-20	2.500
Atriplex semibaccata	EBSKAN262	SPA	Feb-20	6.200
Enchylaena tomentosa	EBSKAN263	SPA	Feb-20	3.000
Convolvulus sp.	EBSKAN264	SPA	Feb-20	0.400
Cullen australasicum	EBSKAN265	Kanmantoo mine site and surrounds	Jan-20	0.520
Dodonaea viscosa	EBSKAN266	Kanmantoo mine site and surrounds	Nov-19	0.150
Einadia nutans	EBSKAN267	SPA	Jan-20	0.021
Maireana rohrlachii	EBSKAN268	SPA	Dec-19	0.030
Gonocarpus tetragynus	EBSKAN269	SPA	Nov-19	0.035

Species	Batch number	Collection location	Collection date	Amount Sept 2020
			Total	998.996

Appendix 2 2020 Hydroseeding program

EBS Restoration

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Appendix 2. 2019 Fauna Survey

Kanmantoo

Fauna Survey 2019

Kanmantoo Fauna Survey 2019

13 December 2019

Version 1

Prepared by EBS Ecology for Hillgrove Resources

Document Control					
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1	25/10/2019	Drs Stuart Collard & Marina Louter	Emma Tremain	25/10/2019	Draft
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Cover photograph: Open Peppermint Box (*Eucalyptus odorata*) woodland at Kanmantoo Copper Mine in South Australia.

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EXECUTIVE SUMMARY

EBS Ecology (EBS) has been engaged by Hillgrove Resources since 2011 to conduct an annual fauna monitoring program over the Kanmantoo Copper (Kanmantoo Mine) Mining Lease (ML). The fauna monitoring program was undertaken in accordance with the conditions and outcomes required in the Program for Environment Protection and Rehabilitation (PEPR) for Kanmantoo Mine. As such, there must be no net adverse impacts on native fauna abundance or diversity in the ML and in adjacent areas.

The fauna monitoring program aimed to determine whether Kanmantoo Mine had met its conditions and outcomes detailed in the PEPR by:

- Conducting roaming transect surveys to record the abundance and diversity of birds;
- Performing targeted spotlighting surveys to record the abundance of the Common Brushtail Possum (*Trichosurus vulpecula*) as well as other nocturnal fauna; and
- Opportunistically recording all other fauna species encountered within the Project area.

The 2019 bird surveys recorded a total of 686 birds from 55 species over the Project area. This included three State threatened species. In 2019, species richness was the third highest on record at Kanmantoo Mine. The total abundance of birds was slightly lower than that recorded in 2018. However, over the lifetime of the fauna monitoring program, the abundance and species richness of birds has shown annual fluctuations, which may be driven by factors such as rainfall, availability of food resources and the presence (or absence) of nomadic and flocking species.

Twenty-two (22) Common Brushtail Possums were observed within the ML during the 2019 spotlight survey, while no individuals were observed in the Significant Environmental Benefit (SEB) area. To date there have been no observations of Common Brushtail Possums within the SEB area due to an absence of suitable habitat. Over the lifetime of the fauna monitoring program the number of Common Brushtail Possums has remained relatively stable, despite annual fluctuations.

The results from the 2019 fauna monitoring program confirm that there is no significant change in native fauna abundance or diversity within the ML and in adjacent areas. Hence, Hillgrove Resources has satisfied the condition (13) and outcome (21) required within the PEPR relating to the conservation of fauna. The ecological indicators measured between 2011 and 2019, suggest that the overall ‘abundance and diversity’ of fauna species have not decreased during this period across the monitoring area as shown in the results table below.

Year	Bird Species Richness	Bird Abundance	Bird pest richness	Bird pest abundance	Possum abundance	Pest vertebrate abundance	Pest vertebrate species richness
2011	40	304	2	3	14.3	44	3
2012	59	669	3	57	44	11	2
2013	48	575	4	42	26.5	2	1
2014	31	381	2	6	9	2	1
2015	50	948	2	55	21	40	3
2016	42	530	1	37	14	12	4
2017	52	1042	3	14	30	4	3
2018	56	700	5	21	20	11	2
2019	55	686	4	39	22	4	2
Mean	**48**	**648**	**2.9**	**30**	**22**	**14**	**2.3**

EBS recommends the following measures to improve the ongoing management and monitoring of fauna within the Kanmantoo Mine Project area:

- Continue the fauna monitoring program at the same time each year (early spring);
- Reduce spotlighting effort to biennial surveys within the SEB areas due to the low likelihood of Common Brushtail Possums using these areas within the life of mine;
- Conduct a control program to reduce the numbers of Western Grey Kangaroos (*Macropus fuliginosus*), European Rabbits (*Oryctolagus cuniculus*) and European Brown Hares (*Lepus europaeus*) within the Project area to reduce impacts on remnant and planted native vegetation.

GLOSSARY AND ABBREVIATION OF TERMS

BOM	Bureau of Meteorology
EBS	EBS Ecology
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
ha	hectares
Kanmantoo (Mine)	Kanmantoo Copper
km	Kilometre(s)
LOM	Life of Mine
ML	Mining Lease
mm	Millimetre(s)
PEPR	Program for Environment Protection and Rehabilitation
Project area	Combined area of the ML and SEB areas
SA	South Australia/South Australian
SEB	Significant Environmental Benefit

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1 INTRODUCTION

EBS Ecology (EBS) has been engaged by Hillgrove Resources since 2011 to conduct an annual fauna monitoring program over the Kanmantoo Copper (Kanmantoo Mine) Mining Lease (ML). The 2019 monitoring program marks the sixth year that EBS has also monitored the Significant Environmental Benefit (SEB) areas, located adjacent to the Kanmantoo ML. The Kanmantoo ML and the Kanmantoo SEB area in combination are named herein as the Project area. The fauna monitoring program was undertaken in accordance with the conditions and outcomes required in the Program for Environment Protection and Rehabilitation (PEPR) for Kanmantoo.

1.1 Objectives

The objective of the fauna monitoring program is to meet the conditions and outcomes as outlined in the PEPR. With regards to fauna (Condition 13), "*the lessee must in constructing and operating the Lease, ensure that there is no adverse impacts from the site operations on the native fauna abundance or diversity in the Lease area and in adjacent areas*". As such, the Outcome (21) required is "*no net adverse impacts from the site operations on native fauna abundance or diversity in the lease area and in adjacent areas*". More specifically, the fauna monitoring program aimed to determine the abundance and diversity of fauna within the Project area by:

- Conducting roaming transect surveys to record the abundance and diversity of birds;
- Performing a targeted spotlighting survey to record the abundance of Common Brushtail Possums (*Trichosurus vulpecula*) as well as other nocturnal fauna species; and
- Opportunistically recording all other fauna species encountered within the Project area.

1.2 Project area

The Project area is located approximately 45 km south-east of Adelaide in the eastern Mount Lofty Ranges of South Australia (SA) and 1.5 km south-west of the Kanmantoo township (Figure 1). The area is representative of a transitional zone on the eastern face of the Mount Lofty Ranges, between the Adelaide Hills woodland regions and the Murray River Plains mallee. It has a long-term average rainfall of 469 mm (Figure 3 – BOM 2019b) and encompasses a variety of soil types and geological structures, conducive to an assortment of vegetation types and habitat niches.

The Project area has a history of mining activity, which started in the mid-nineteenth century and then continued between 1971 and 1976 (Hillgrove Resources 2007). Over the past 150 years, much of the ML has been extensively cleared for cropping, whilst most of the vegetated areas have been grazed by domestic stock. As a result, only small remnant patches of native vegetation in the ML have persisted, including native grasslands and woodland communities.

The SEB offset areas are located adjacent to the Kanmantoo Mine (Figure 2). SEB offset areas associated with the Life of Mine (LOM) extension have been located as near as possible to the ML on suitable Hillgrove Resources owned land parcels. The SEB areas are approximately 109.5 hectares (ha) and comprised of five properties (Figure 2), which have been managed under a mixed cropping / sheep grazing regime for over 100 years. Cropping has been confined to the flats and grazing has been on crop stubble and the higher/rockier areas. Consequently, only small remnant patches of native vegetation remain in the SEB areas, including native grasslands and a mallee community.

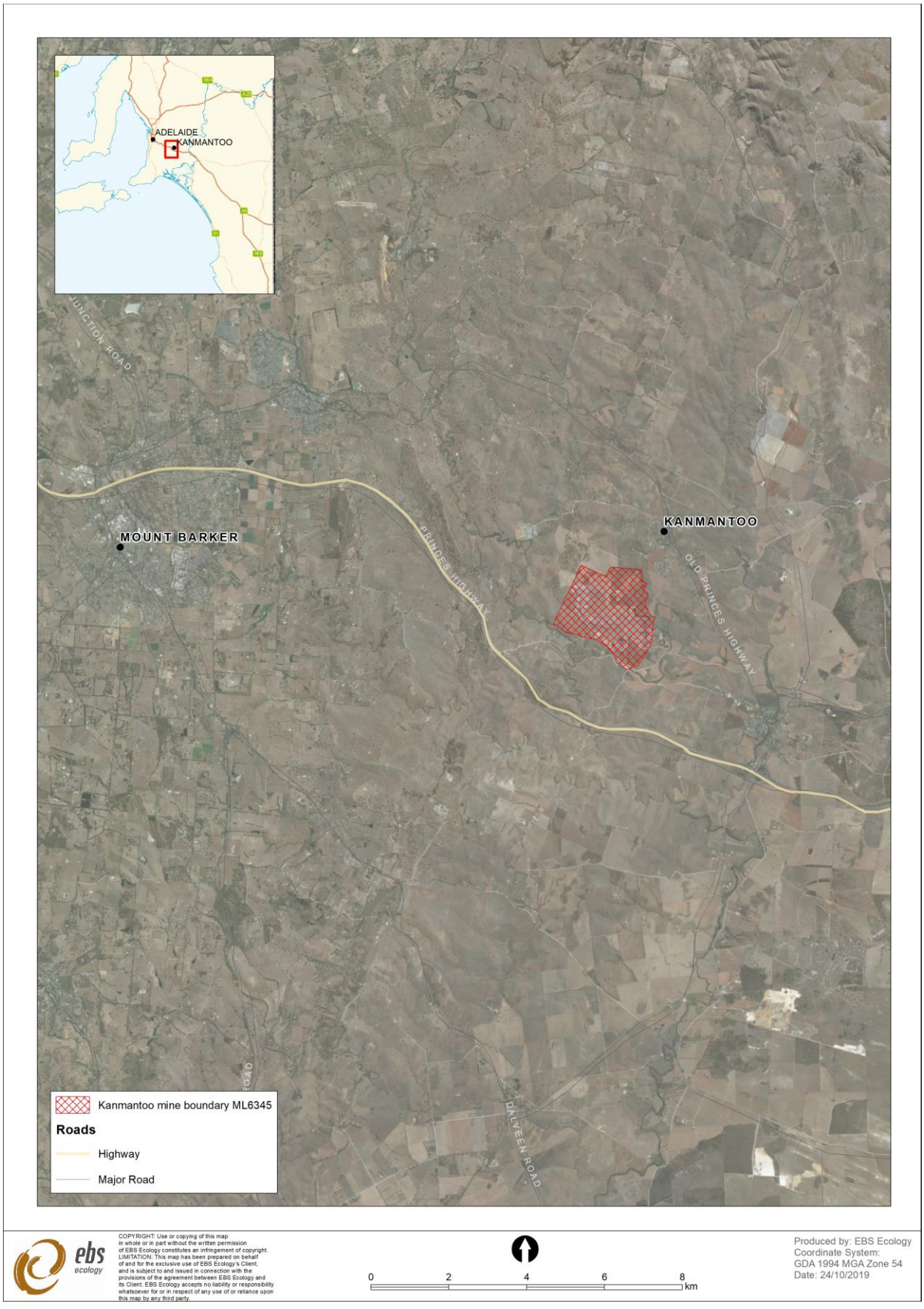

Figure 1. Location of Kanmantoo Mine with respect to local townships and Adelaide, South Australia.

Figure 2. Location of the Kanmantoo ML and SEB areas over the Project area.

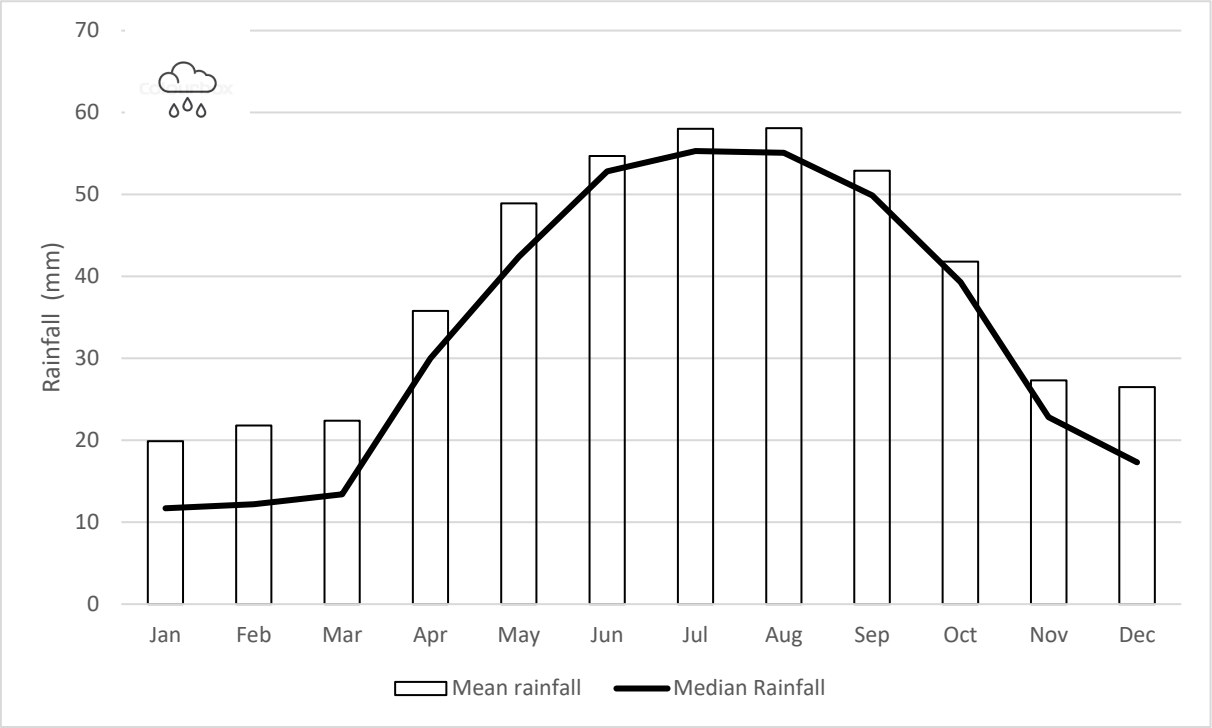

Figure 3. Mean and Median monthly rainfall at Kanmantoo Weather Station (23724) from 1874-2019 (BOM 2019b).

2 METHODS

2.1 Field Survey

The field survey was conducted by Stuart Collard (Senior Ecologist) and supported by Emma Tremain (Senior Environmental Officer) in late September 2019 to ensure consistency with previous fauna surveys of the Project area.

2.1.1 Weather conditions and rainfall

Weather conditions over the 2019 fauna survey period were characterised by mild mornings and mild afternoon temperatures (BOM 2019a) with light-moderate winds. Long term rainfall data (1874-2019) was sourced from Kanmantoo weather station (BOM 2019b). Rainfall at Kanmantoo shows annual variability, particularly over the 2011 to 2019 timeframe, as annual rainfall ranged from the lowest in 2018 (366.2 mm) to the highest in 2016 (696.8 mm) (BOM 2019b). Overall, 2011-13 and 2016-17 had above average rainfall (> 469 mm), while 2014-15 and 2018 were below average rainfall (Figure 4) (BOM 2019b). It must be noted that there is missing rainfall data for the years 2012/13 and 2017/18 and therefore their rainfall totals may be greater than the values presented in Figure 4. Furthermore, rainfall data for 2019 is limited to the months Jan-Aug, as at the time of the current report rainfall records for Sept-Dec were not yet available. Therefore, rainfall totals of 2019 are likely to be greater than the values presented in Figure 4.

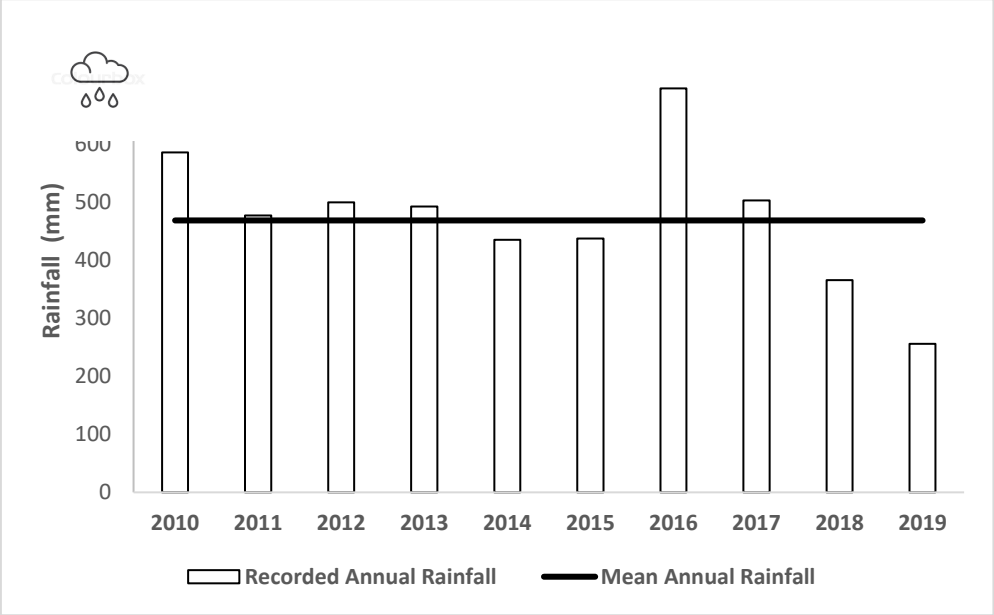

Figure 4. Mean annual rainfall at Kanmantoo weather station (23724) from 2010 to 2019.

Note: There is missing data for Oct 2012 and Oct 2017 and therefore, the total rainfall for these years may be lower than the true value (BOM 2019a). Annual Rainfall data for 2019 is limited to the months Jan-Aug, as at the time of the reporting rainfall records for Sept-Dec were not available. Therefore, the total rainfall for 2019 may be higher than the true value (BOM 2019a).

2.1.2 Survey effort per year

Mining Lease

Fauna within the ML has been monitored annually since 2011 (Table 1). Bird monitoring transects within the ML varied in number (11 to 15) before the sites were formalised in 2015, however, the areas within which birds were surveyed were comparable between years. Since 2015, the same bird monitoring transects have been monitored annually.

The spotlighting transect locations have remained consistent since the inaugural year of monitoring in 2011. However, the number of spotlighting nights has reduced from three nights (2011) to one night (2014 to present).

Significant Environmental Benefit Areas

The SEB areas were monitored for the first time in 2014 (Table 1). However, monitoring in 2014 solely focused on spotlighting possums, though, opportune observations of birds were also made. The number of spotlight nights (1) and the transects surveyed have remained consistent since inception in 2014. In 2015, nine bird monitoring transects were established. Each bird monitoring transect is monitored annually.

Table 1. Fauna survey effort per year within the ML and SEB areas of Kanmantoo Mine.

Year	ML		SEB	
	Bird transects	Spotlight nights	Bird sites	Spotlight nights
2011	15*	3	N.M.	N.M.
2012	11*	2	N.M.	N.M.
2013	11*	2	N.M.	N.M.
2014	12*	1	N.M.	1
2015	14	1	9	1
2016	14	1	9	1
2017	14	1	9	1
2018	14	1	9	1
2019	14	1	9	1

***sites not formalised**
N.M. = not monitored

2.1.3 Birds

Twenty-three (23) bird transects are located over the Project area; 14 in ML and nine in the SEB area (Figure 5). These transects have been strategically positioned to represent the main habitat types and rehabilitation areas across the Project area. Each transect was surveyed by a single surveyor, who walked the entire length of the transect. Surveys were conducted only during suitable weather conditions (i.e. fine, cool-mild weather with light or no wind). Surveys are not conducted during periods of strong wind or precipitation. The following information was recorded for each bird observed:

- Species;
- Number of individuals per species;
- Behaviour of individuals (foraging, resting, or flying); and

- The substrates individual birds were using (ground, shrub, or tree).

Furthermore, all birds heard were recorded to species and the number of individuals estimated.

2.1.4 Common Brushtail Possum targeted survey

Spotlighting was conducted over repeated routes within the ML and SEB areas to systemically determine the numbers of Common Brushtail Possums in the Project area (Figure 5). The ML was surveyed from a vehicle, while the SEB area was surveyed from a vehicle as well as by foot as well as. The spotlighting routes within the ML and SEB were surveyed over one night for two hours each. All surveys commenced at least one hour after sunset.

The following information was recorded for each possum observed:

- Number of individuals;
- GPS location; and
- Habitat.

Any other fauna species observed opportunistically during spotlighting were also recorded.

2.1.5 Opportunistic observations

Any fauna species recorded within the ML or SEB area outside of systematic surveys were noted as opportune. For each opportune record, the following information was recorded:

- Species;
- Number of individuals;
- GPS location;
- Method, i.e. sight or sound; and
- Habitat.

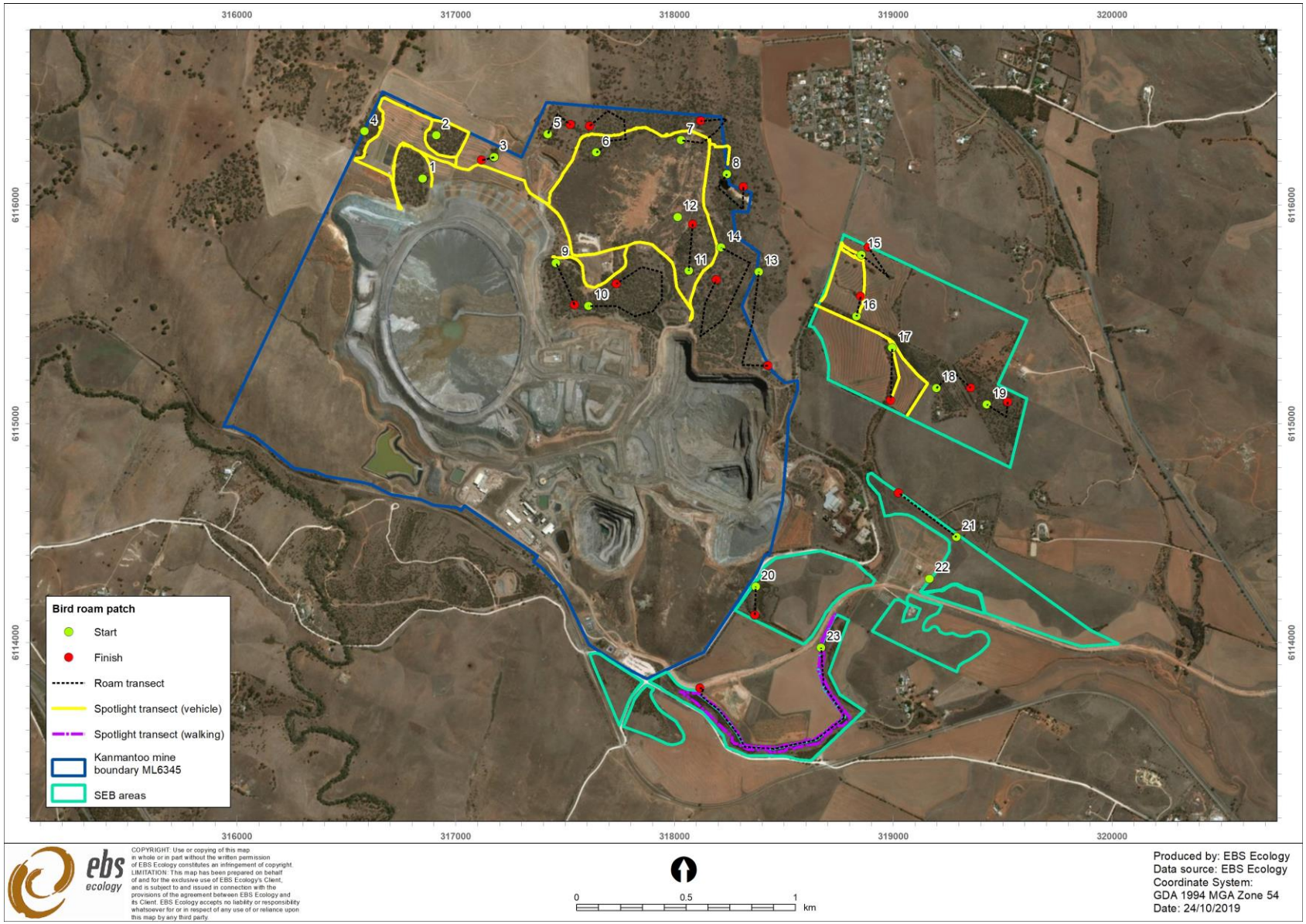

Figure 5. Locations of bird survey transects and spotlight (Common Brushtail Possum targeted survey) transects (vehicle and on foot) over the Project area.

3 RESULTS

3.1 Bird Survey 2019

3.1.1 Species richness

Fifty-five (55) bird species were recorded over the Project area at survey sites and opportunistically in 2019 (Appendix 1). The families of birds with the greatest representation were:

- Meliphagidae (Honeyeaters) six species;
- Psittaculidae (Parrots) five species;
- Acanthizidae (Australian Warblers) four species;
- Columbidae (Pigeons & Doves);
- Cacatuidae (Cockatoos); and
- Pachycephala (Whistlers) three species.

Five species were observed at Kanmantoo Mine for the first time in 2019, which were:

1. Long-billed Corella (*Cacatua tenuirostris*);
2. Mistletoebird (*Dicaeum hirundinaceum*);
3. Rufous Songlark (*Megalurus mathewsi*);
4. Southern Boobook (*Ninox boobook*); and
5. Golden Whistler (*Pachycephala pectoralis*).

3.1.2 Bird abundance

A total of 686 birds from 55 species were recorded over the Project area at survey sites and opportunistically in 2019 (Appendix 1). The most abundant species over the Project area in 2019 were:

- White-winged Chough (*Corcorax melanorhamphos*) (58 individuals);
- Yellow-rumped Thornbill (*Acanthiza chrysorrhoa*) (57 individuals); and
- Crimson Rosella (*Platycerus elegans*) (44 individuals).

3.1.3 Threatened species

Three bird species that have a threatened status in South Australia were observed in 2019. The State 'Rare' White-winged Chough (*Corcorax melanorhamphos*), was abundant, primarily within the ML, but this species was also recorded in the SEB area (Figure 6). The State 'Rare' Elegant Parrot (*Neophema elegans*) was widespread over the ML area. The State 'Vulnerable' Diamond Firetail (*Stagonopleura guttata*) was found at two locations in the ML and two locations within the SEB area (Figure 6).

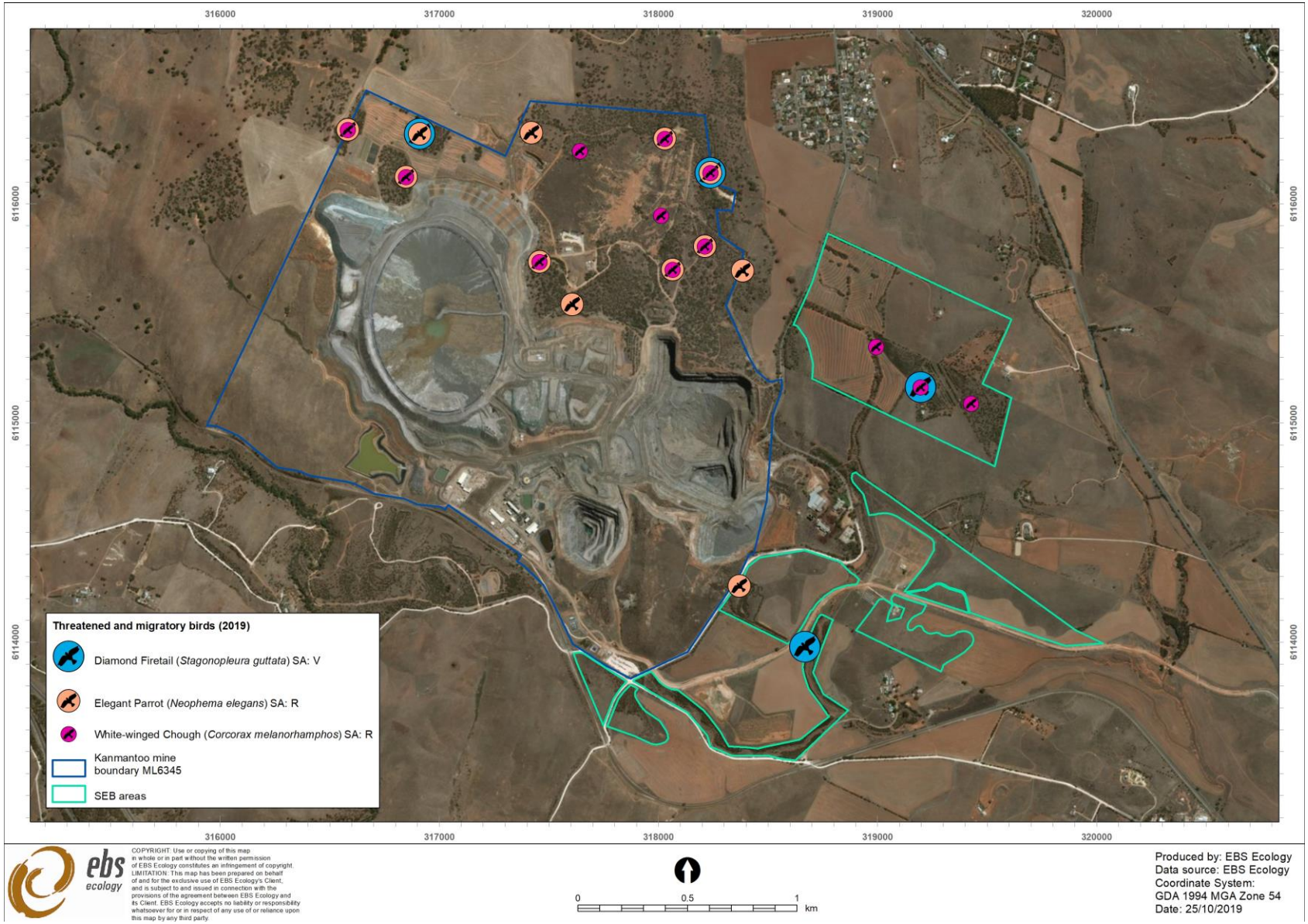

Figure 6. Locations of State threatened bird species observed during the 2019 fauna monitoring program.

3.2 Bird Survey 2011-2019

3.2.1 Species richness

The species richness of birds at Kanmantoo Mine has fluctuated over the lifetime of the fauna monitoring program (Figure 7). The mean bird species richness recorded per year over the monitoring program is 48.1 μ ± 3.0 S.E. (2011-2019). Fewer bird species were recorded from 2011 to 2014 due to lower search effort, with survey sites confined to the ML only (*see* Section 2.1.2 above).

In 2019, species richness was the third highest on record at Kanmantoo Mine with a total of 55 bird species observed.

Due to greater consistency in search effort since 2015, species richness is relatively stable between 50 to 56 species after a low species count in 2014 (Figure 7). Variability in species richness does not appear to be correlated with rainfall (Figure 7).

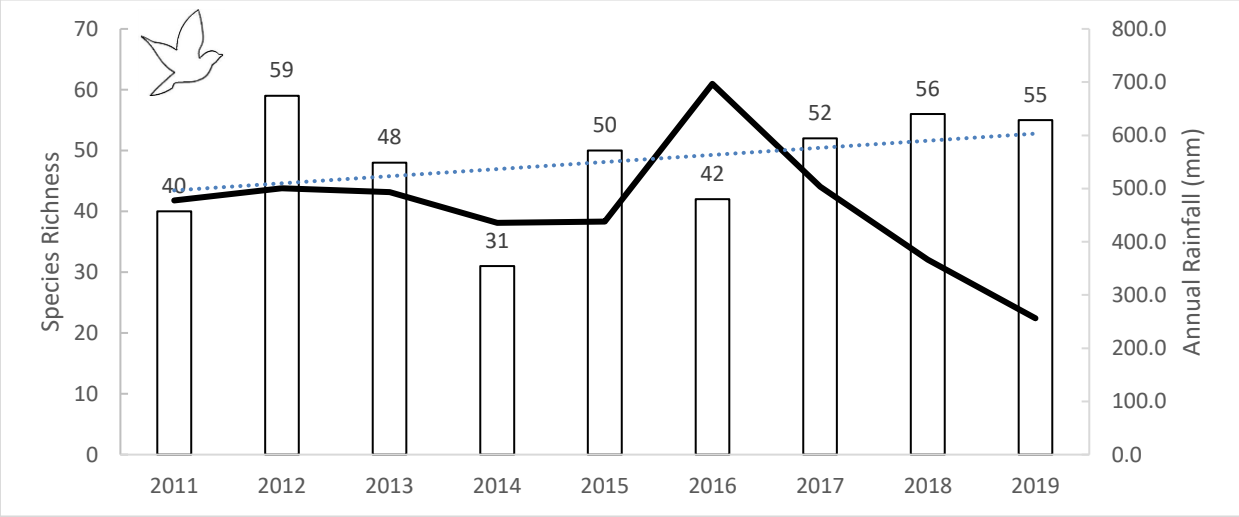

Figure 7. Bird species richness recorded over the fauna monitoring program 2011-2019 in relation to annual rainfall. *Please note that monitoring was confined to the ML from 2011 to 2014 and expanded to include SEB areas from 2015*.

Note: Annual Rainfall data for 2019 is limited to the months Jan-Aug, as at the time of the reporting rainfall records for Sept-Dec were not available. Therefore, the total rainfall for 2019 may be higher than the true value (BOM 2019a).

3.2.2 Bird abundance

The abundance of birds at Kanmantoo Mine has fluctuated over the lifetime of the fauna monitoring program (Figure 8). The average number of birds recorded per year over the monitoring program is 648.3 μ ± 79.8 S.E. (2011-2019). Fewer birds were recorded from 2011 to 2014 due to lower search effort, with survey sites confined to the ML only.

In 2019, species richness was the third highest on record at Kanmantoo Mine with a total of 686 individuals observed. Bird abundance in 2019 was substantially less compared to the abundances in 2015 (948 individuals) and 2017 (1042 individuals). However, the total number of birds observed at Kanmantoo in 2019 was similar that recorded in 2018 (Figure 8).

Despite greater consistency in search effort since 2015, bird abundance has remained variable between years. Variability in bird abundance does not appear to be strongly correlated with rainfall (Figure 8). However, the higher total abundance in 2017 may be linked to the high rainfall in the previous year.

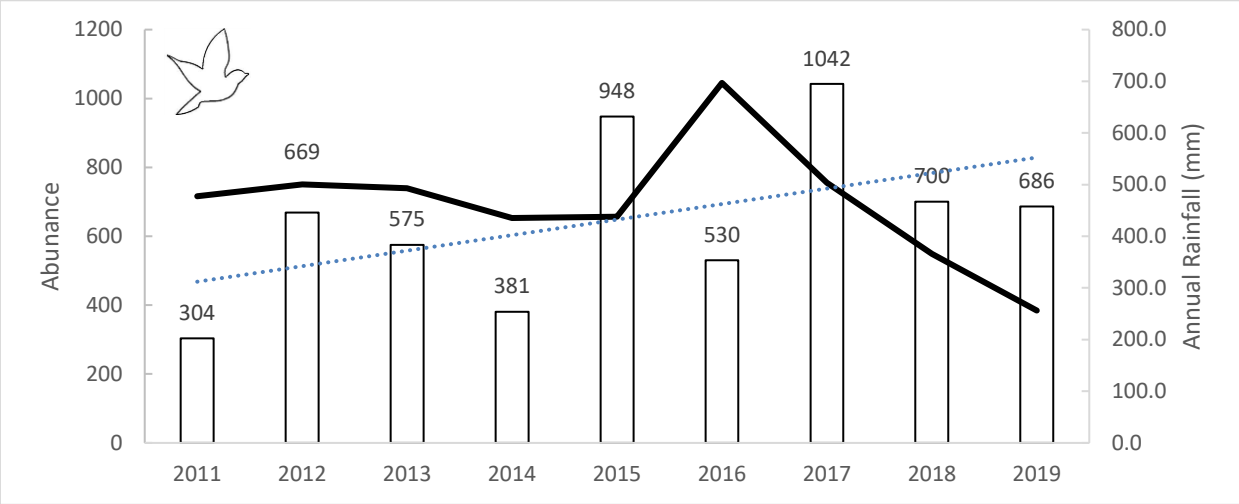

Figure 8. Bird abundance recorded over the fauna monitoring program 2011-2019 in relation to annual rainfall. *Please note that monitoring was confined to the ML from 2011 to 2014 and expanded to include SEB areas from 2015*.

Note: Annual Rainfall data for 2019 is limited to the months Jan-Aug, as at the time of the reporting rainfall records for Sept-Dec were not available. Therefore, the total rainfall for 2019 may be higher than the true value (BOM 2019a).

3.2.3 Threatened species

A total of eight State threatened species have been observed at Kanmantoo Mine over the lifetime of the fauna monitoring program and in 2019 three of these species were observed (Table 2).

Table 2. Bird species of conservation significance recorded at Kanmantoo Mine between 2011 and 2019.

Species name	Common name	EPBC	SA	2011	2012	2013	2014	2015	2016	2017	2018	2019
Calyptorhynchus funereus	Yellow-tailed Black Cockatoo		V		7			8		65		
Corcorax melanorhamphos	White-winged Chough		R	22	24	16	34	97	36	45	76	58
Falco peregrinus	Peregrine Falcon		R	2	2			4	1			
Myiagra inquieta	Restless Flycatcher		R								1	
Melanodryas cucullata cucullata	Hooded Robin		R	2								
Microeca fascinans fascinans	Jacky Winter		R			1						
Neophema elegans	Elegant Parrot		R	7	16	12	9	19	55	28	27	30
Stagonopleura guttata	Diamond Firetail		V	6	16	4		5		4	13	6
Number of threatened species per year				**5**	**5**	**4**	**2**	**5**	**3**	**4**	**4**	**3**

SA: South Australia (*National Parks and Wildlife Act 1972*). **Conservation Codes:** V: Vulnerable. **R:** Rare. **EPBC:** *Environment Protection and Biodiversity Conservation Act 1999*.

Three of the eight species of conservation concern have been recorded consistently within the Kanmantoo Mine: The White-winged Chough and Elegant Parrot are the only two threatened species that have been recorded on each annual survey since 2011, while the Diamond Firetail has been observed for seven of

the nine survey years. The abundance of White-winged Choughs and Elegant Parrots appears to be stable, if not, steadily increasing, while the numbers of Diamond Firetails also appear stable (Figure 9).

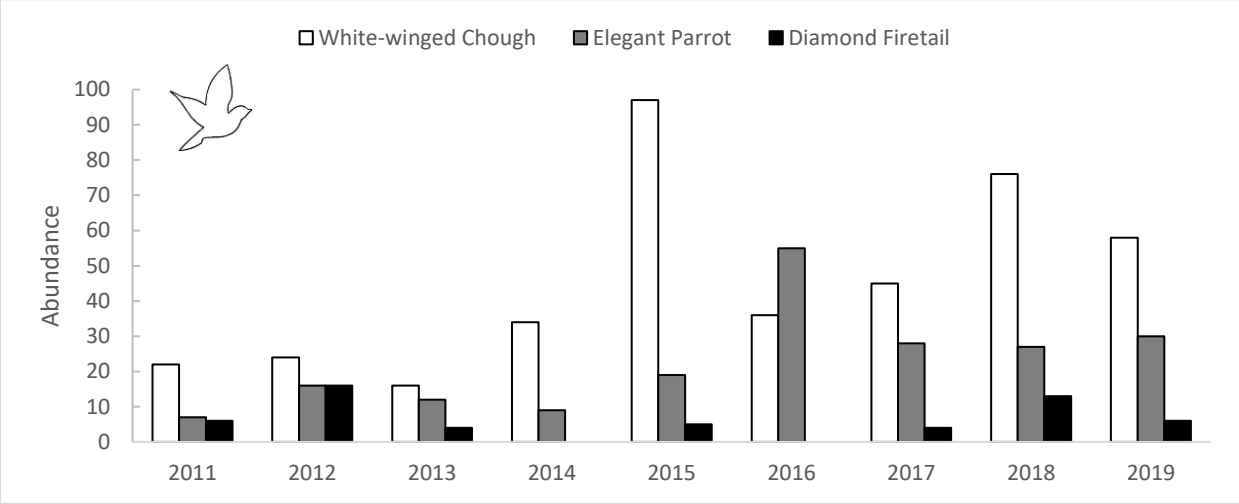

Figure 9. Number of individual White-winged Choughs, Elegant Parrots and Diamond Firetails recorded over the Kanmantoo Mine fauna monitoring program 2011-2019.

The remaining 5 of the eight species of conservation concern have been recorded inconsistently within the Kanmantoo Mine: The Peregrine Falcon (*Falco peregrinus*) has been observed in four survey years, the Yellow-tailed Black Cockatoo (*Calyptorhynchus funereus*) on three surveys, while the Jacky Winter (*Microeca fascinans fascinans*), Hooded Robin (*Melanodryas cucullata cucullata*) and Restless Flycatcher were observed only on one survey (Table 2). Due to the low number of records of these species, trends in the number of individuals that are utilizing the Kanmantoo Mine cannot be assessed.

3.3 Possum survey 2019

In 2019 a total of 22 Common Brushtail Possums was observed within the ML, while no observations of the species occurred in the SEB area (Figure 11; Table 3).

3.4 Possum survey 2011-2019

To date there have been no observations of Common Brushtail Possums within the SEB area. In the ML, the number of individuals observed per night has ranged from the lowest of 9 individuals in 2014 to the highest of 44 individuals in 2012.

The average number of possums observed per night is 22.3 μ ± 3.5 S.E. (2011-2019). Over the lifetime of the fauna monitoring program the numbers of Common Brushtail Possums have fluctuated annually (Table 3). Since 2015 numbers of Common Brushtail Possums have been relatively stable ranging from 14 to 30 individuals.

Table 3. Observations of Common Brushtail Possums 2011-2019.

	2011	2012	2013	2014	2015	2016	2017	2018	2019
Number observed	43	88	53	9	21	14	30	20	22
Number of nights surveyed within ML	3	2	2	1	1	1	1	1	1
Average number of possums observed per night	14.3	44.0	26.5	9.0	21.0	14.0	30.0	20.0	22.0

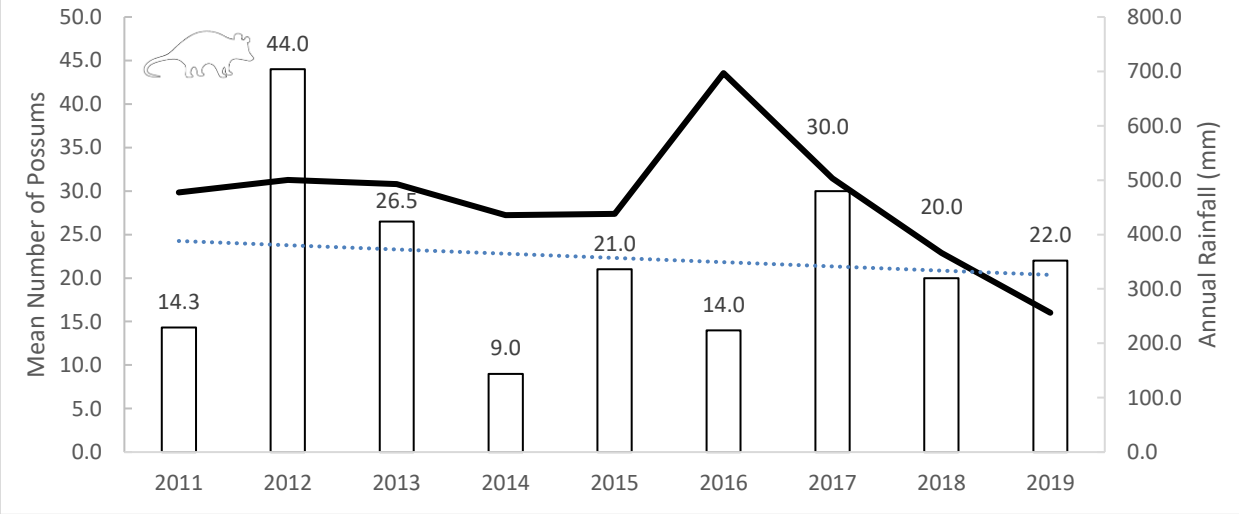

Figure 10. Mean possum abundance recorded over the fauna monitoring program 2011-2019 in relation to annual rainfall. *Please note that monitoring was confined to the ML from 2011 to 2014 and expanded to include SEB areas from 2015*.

Note: Annual Rainfall data for 2019 is limited to the months Jan-Aug, as at the time of the reporting rainfall records for Sept-Dec were not available. Therefore, the total rainfall for 2019 may be higher than the true value (BOM 2019a).

3.5 Opportunistic observations 2019

3.5.1 Frogs

No frogs were observed or heard during the 2019 survey, possibly due to the dry seasonal conditions.

3.5.2 Pest and over-abundant species

The Western Grey Kangaroo (*Macropus fuliginosus*) was the most abundant mammal species recorded in the Project area. This species was most abundant within the ML (28 individuals) compared with the SEB area (six individuals). A single Common Ringtail Possum (*Pseudocheirus peregrinus*) was observed during the spotlight surveys in *E. odorata* woodland within the ML area. Two introduced mammal species were recorded in small numbers in 2019; the Rabbit (*Oryctolagus cuniculus*) and the European Brown Hare (*Lepus europaeus*).

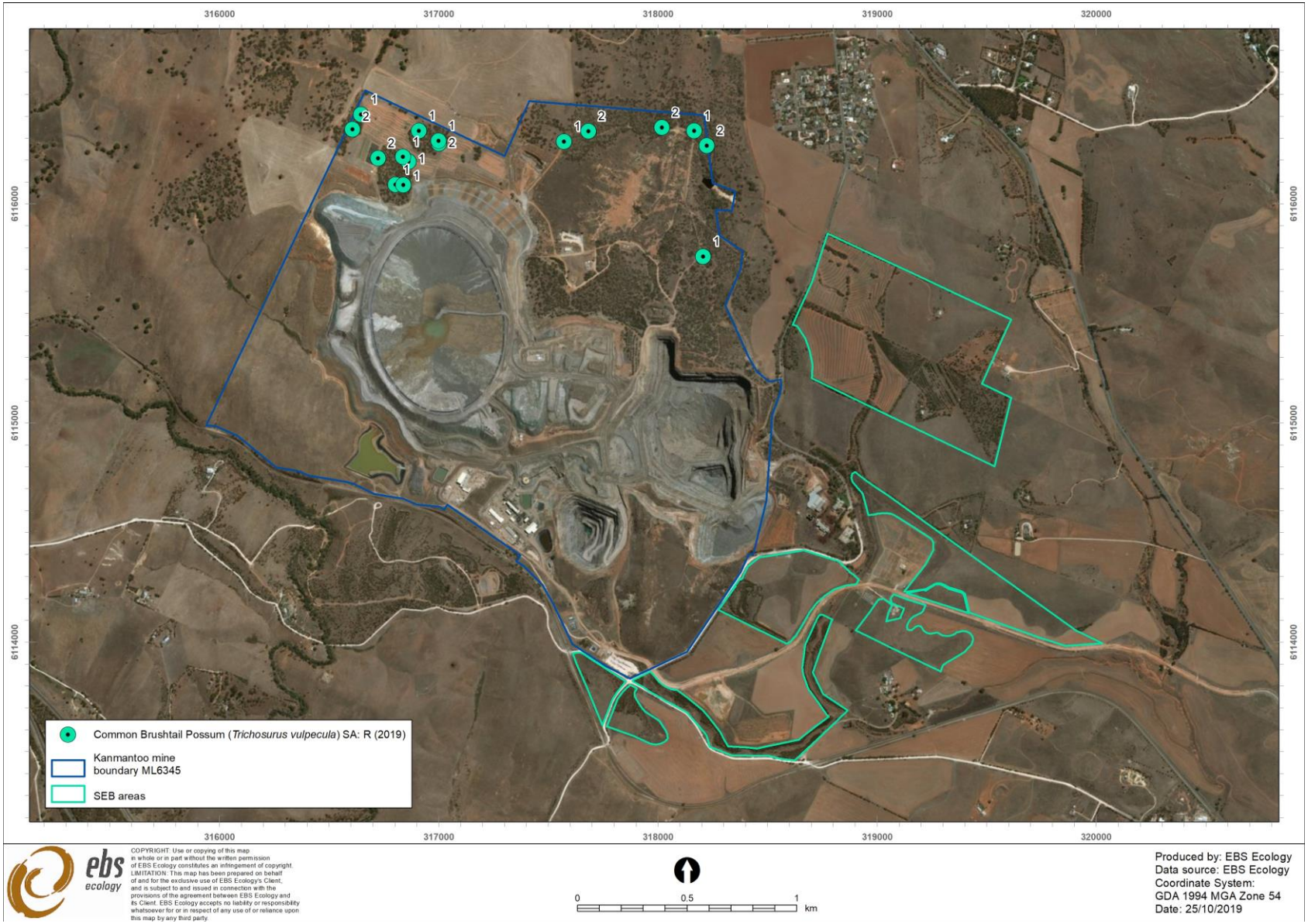

Figure 11. Locations and number of Common Brushtail Possums (*Trichosurus vulpecula*) observed during the 2019 fauna survey at Kanmantoo Mine.

4 DISCUSSION

4.1 Birds

The results of the 2019 survey suggest little change in the species richness and abundance of the bird community within the Project area, compared with the 2018 survey. The small variations in the numbers of threatened species is expected, due to changing seasonal conditions, movements and resource availability across the site.

Fluctuations in the number of birds observed at Kanmantoo Mine appear to be in part influenced by the presence of nomadic and flocking species and variations in the numbers of ground foraging species as well as nectivorous species. For example, a flock of 260 Black-faced Woodswallows (*Artamus cinereus*), a nomadic species, and 65 Yellow-tailed Black Cockatoos, a flocking species, were observed in the 2017 survey, greatly increasing the total number of birds recorded for the monitoring program that year. There were no large flocking events during the 2019 survey, although a higher than usual number of migratory species (e.g. White-winged Triller and Rufous Songlark) may be indicative of the drier than usual conditions prevalent across much of south-eastern Australia.

Annual rainfall data does not appear to be correlated with bird abundance or species richness (Figure 7; Figure 8). However, if rainfall data were treated with greater sensitivity, such as looking at the quantity and timing of rainfall within a given year and linking this to the flowering requirements for dominant tree and shrub species, such as Peppermint Box (*Eucalyptus odorata*), then the variability in the number and species richness of nectivorous species may be further explained. Likewise, determining how the rainfall influences soil moisture and the growth of understorey weeds may help explain the variability in the numbers of ground-foraging bird species.

Given the variable nature of the bird community at Kanmantoo Mine, it is imperative that a suite of indicator species is identified to determine whether the mine has impacted on birds. Indicator species should be resident, woodland-dependent species that are not favoured by impaired tree health nor human mediated landscapes (Read *et al.* 2015). The following species found within the Project area meet these criteria:

1. Brown Treecreeper (*Climacteris picumnus*);
2. Diamond Firetail (*Stagonoplerua guttata*);
3. Grey Shrike-thrush (*Colluricincla harmonica*);
4. Rufous Whistler (*Pachycephala rufiventris*);
5. White-winged Chough (*Corcorax melanorhamphos*); and
6. Yellow-rumped Thornbill (*Acanthiza chrysorrhoa*).

The abundance of these species shows variability between years, however, none of the species has been identified to be in decline since the fauna monitoring program commenced in 2011 (Table 4).

It is recommended that future monitoring should focus upon these six indicator species when analysing the impact of the mine for future years in order to determine whether Kanmantoo Mine has satisfied its requirements under the PEPR. It is important to maintain the same level of monitoring effort so that trends for these indicator species can continue to be accurately monitored over time.

Table 4. Observations of the abundance of indicator species 2011-2019.

Species name	Common name	EPBC	SA	2011	2012	2013	2014	2015	2016	2017	2018	2019
Acanthiza chrysorrhoa	Yellow-rumped Thornbill			33	43	31	21	90	43	38	54	57
Climacteris picumnus	Brown Treecreeper			5	12	17	9	8	11	5	10	11
Colluricincla harmonica	Grey Shrike-thrush			4	1	3	3	14	13	4	8	15
Corcorax melanorhamphos	White-winged Chough		R	22	24	16	34	97	36	45	76	58
Pachycephala rufiventris	Rufous Whistler			6	9	6	2	3	6	9	10	2
Stagonopleura guttata	Diamond Firetail		V	6	16	4		5		4	13	6

Some other notable trends and observations from the dataset more generally include:

- Yellow Thornbills have only been recorded in 2018 & 2019 with no previous records;
- There were no Varied Sitella records in 2017, 2018 and 2019, compared with small numbers on the previous 6 survey years;
- White-winged Trillers were in high abundance in 2019, coinciding with a general influx of northern migrants;
- A general increasing trend for Elegant Parrot and New Holland Honeyeater during the data collection period; and
- Diamond Firetail recorded in revegetation area in 2019.

Each year that the survey runs, new species continue to be added to the cumulative species for the Project area (5 new species in 2019). This can be attributed, in part to natural cycles such as seasonal variation and bird migration. However, the changes can also reflect local-scale changes in the vegetation structure and composition of the vegetation communities at the Project area. In particular, it is expected that as the areas of remnant and restored habitat within and outside the ML area mature and improve, this will provide habitat for an increased number and potentially greater diversity of birds.

4.2 Brushtail Possum

Common Brushtail Possums were restricted to the remnant Peppermint Box (*Eucalyptus odorata*) woodlands of the ML, with no individuals observed within the SEB area. The occurrence of Common Brushtail Possums within the ML is associated with the availability of den sites in the form of hollows within Peppermint Box. Common Brushtail Possums prefer large hollows that are deeper than 1 m (Inions *et al.* 1989). Such hollows take approximately 200 to 400 years to develop in other eucalypt species (Inions *et al.* 1989), and therefore, the habitat within the SEB area may only become suitable after centuries without intervention. Even with the installation of possum boxes, Common Brushtail Possums may not colonise the SEB areas located outside the ML as dispersal is uncommon for adult and even for juvenile possums.

Furthermore, crossing a fragmented landscape would make them vulnerable to Red Fox (*Vulpes vulpes*) predation (Byrom *et al.* 2015), which may delay potential colonisation. Additionally, food resources within the SEB areas may be insufficient until the planted Peppermint Box trees reach maturity, which could take over 20 years.

4.3 Pest and over-abundant species

Grazing pressure from over-abundant native and pest herbivore species could be negatively impacting the quality of remnant vegetation in the ML and the success of revegetation. Western Grey Kangaroos, rabbits and hares were all frequently sighted throughout the ML and their control through shooting and baiting may be warranted to ensure that native fauna species are not adversely impacted by reduced habitat quality.

5 CONCLUSION

The results from the 2019 fauna monitoring program confirm that there is no discernible loss of native fauna abundance or diversity in the Mine Lease area and in adjacent SEB areas as demonstrated by the results of the bird and Common Brushtail Possum surveys. As such, Hillgrove Resources has satisfied the condition (13) and outcome (21) required for fauna conservation within the PEPR.

The ecological indicators measured between 2011 and 2019, suggest that the overall 'abundance and diversity' of fauna species have not decreased during this period across the monitoring area Table 5.

Table 5. Indices of vertebrate abundance and diversity measured from 2011-2019 across the Project area.

Year	Bird Species Richness	Bird Abundance	Bird pest richness	Bird pest abundance	Possum abundance	Pest vertebrate abundance	Pest vertebrate species richness
2011	40	304	2	3	14.3	44	3
2012	59	669	3	57	44	11	2
2013	48	575	4	42	26.5	2	1
2014	31	381	2	6	9	2	1
2015	50	948	2	55	21	40	3
2016	42	530	1	37	14	12	4
2017	52	1042	3	14	30	4	3
2018	56	700	5	21	20	11	2
2019	55	686	4	39	22	4	2
Mean	**48**	**648**	**2.9**	**30**	**22**	**14**	**2.3**

6 RECOMMENDATIONS

EBS recommends the following measures to improve the management and monitoring of fauna within the Kanmantoo Mine Project area:

- Continue the fauna monitoring program at the same time each year (early spring) with annual analysis of trajectories for threatened and indicator fauna species;
- Change to biennial spotlighting within the SEB areas due to the low likelihood of Common Brushtail Possums using/colonising these areas in the short-term;
- Conduct a control program to reduce the numbers of Western Grey Kangaroos, rabbits and hares within the Project area. These are likely to be adversely affecting remnant and planted native vegetation and associated faunal communities.

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8 APPENDIX

Appendix 1. Total bird species observed during the period (2011-2019) spring surveys in both the ML and SEB areas (point counts and opportunistic).

SPECIES NAME	COMMON NAME	EPBC	SA	Exotic	2011	2012	2013	2014	2015	2016	2017	2018	2019
Acanthagenys rufogularis	Spiny-cheeked Honeyeater									2		2	4
Acanthiza chrysorrhoa	Yellow-rumped Thornbill				33	43	31	21	90	43	38	54	57
Acanthiza nana	Yellow Thornbill											19	14
Accipiter cirrocephalus	Collared Sparrowhawk				3							1	
Aegotheles cristatus	Australian Owlet-nightjar							1	1		1		
Alauda arvensis	Eurasian Skylark			*	1		3		3		1	2	
Anas gracilis	Grey Teal					16				6	10	1	
Anas superciliosa	Pacific Black Duck					1				10	9		
Anthochaera carunculata	Red Wattlebird				1	16	5	1	15	1	27	9	15
Anthus australis	Australian Pipit					5	4				6		2
Aphelocephala leucopsis	Southern Whiteface				6	9					3		2
Aquila audax	Wedge-tailed Eagle				3	8				1			
Artamus cinereus	Black-faced Woodswallow				2	3					260		
Artamus cyanopterus	Dusky Woodswallow						8	2	13	5	3	2	2
Artamus personatus	Masked Woodswallow						4						
Artamus superciliosus	White-browed Woodswallow						2						
Aythya australis	Hardhead					1					4	1	
Cacatua galerita	Sulphur-crested Cockatoo									1	3	14	2
Cacatua sanguinea	Little Corella				2			1	54	2	9		

SPECIES NAME	COMMON NAME	EPBC	SA	Exotic	2011	2012	2013	2014	2015	2016	2017	2018	2019
Cacatua tenuirostris	Long-billed Corella												7
Cacomantis pallidus	Pallid Cuckoo					1			1				
Caligavis chrysops	Yellow-faced Honeyeater											1	
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo		V			7					65		
Carduelis carduelis	European Goldfinch			*								8	5
Chalcites basalis	Horsfield's Bronze-Cuckoo				1						2		
Chalcites osculans	Black-eared Cuckoo					1							
Chenonetta jubata	Australian Wood Duck					3			19		2		
Cincloramphus crualis	Brown Songlark					2	1						
Climacteris picumnus	Brown Treecreeper				5	12	17	9	8	11	5	10	11
Colluricincla harmonica	Grey Shrike-thrush				4	1	3	3	14	13	4	8	15
Columba livia	Feral Pigeon [Rock Dove]			*		20	20				2		
Coracina novaehollandiae	Black-faced Cuckoo-shrike				1	2	4	4	3		6	3	1
Corcorax melanorhamphos	White-winged Chough		R		22	24	16	34	97	36	45	76	58
Corvus mellori	Little Raven				5	3	15	12	26	11	65	24	17
Dacelo novaeguineae	Laughing Kookaburra								1			1	1
Daphoenositta chrysoptera	Varied Sittella				7	5	21	4	3	5			
Dicaeum hirundinaceum	Mistletoebird												1
Egretta novaehollandiae	White-faced Heron					1				1	1		
Elanus axillaris	Black-shouldered Kite				3	2	1						
Elseyornis melanops	Black-fronted Dotterel					3					5		
Eolophus roseicapilla	Galah				12	17	17	15	60	18	43	30	28

SPECIES NAME	COMMON NAME	EPBC	SA	Exotic	2011	2012	2013	2014	2015	2016	2017	2018	2019
Epthianura albifrons	White-fronted Chat					33	18		2			1	
Falco berigora	Brown Falcon				4	6	1	3	4	2	4	4	2
Falco cenchroides	Nankeen Kestrel				3	2	1	1		3	1	2	1
Falco peregrinus	Peregrine Falcon		R		2	2			4	1			
Gallina tenebrosa	Dusky Moorhen					3							
Gavicalis virescens	Singing Honeyeater				7	8	6	4	14	12	4	28	13
Geopelia placida	Peaceful Dove											1	1
Glossopsitta concinna	Musk lorikeet					6				2	18	3	19
Glossopsitta porphyrocephala	Purple-crowned Lorikeet					20							
Grallina cyanoleuca	Magpie-lark				2	1	1	2	3	1	2		5
Gymnorhina tibicen	Australian Magpie				32	16	15	34	57	48	65	22	29
Hieraaetus morphnoides	Little Eagle								1				
Hirundo neoxena	Welcome Swallow				2	6	17		1	37	32	13	6
Lalage tricolor	White-winged Triller					3						1	13
Lichenostomus pencillatus	White-plumed Honeyeater					18	30	7					
Malurus cyaneus	Superb Fairy-wren				4		1		4			4	4
Megalurus mathewsi	Rufous Songlark												6
Melanodryas cucllata cullata	Hooded Robin (South East ssp)		R		2								
Melithreptus brevirostris	Brown-headed Honeyeater					6	18	11	19	3	18	32	29
Melithreptus lunatus	White-naped Honeyeater											2	
Merops ornatus	Rainbow Bee-eater				7	7	1	2	3	1	4		
Microeca fascinanas	Jacky Winter		R				1						

SPECIES NAME	COMMON NAME	EPBC	SA	Exotic	2011	2012	2013	2014	2015	2016	2017	2018	2019
Milvus migrans	Black Kite						1						
Myiagra inquieta	Restless Flycatcher		R									1	
Neochmia temporalis	Red-browed Finch											1	4
Neophema elegans	Elegant Parrot		R		7	16	12	9	19	55	28	27	30
Ninox boobook	Southern Boobook												1
Ocyphaps lophotes	Crested pigeon					9	4			4	2	5	5
Pachycephala pectoralis	Golden Whistler												1
Pachycephala rufiventris	Rufous Whistler				6	9	6	2	3	6	9	10	2
Pardalotus punctatus	Spotted Pardalote					3							
Pardalotus striatus	Striated Pardalote				15	26	32	15	26	9	26	37	38
Passer domesticus	House Sparrow			*		10	8	1				4	11
Petrochelidon nigricans	Tree Martin				12	38	32	50	68	4	41	28	37
Petroica goodenovii	Red-capped Robin								1			1	
Phaps chalcoptera	Common Bronzewing						1			2	1	2	2
Phylidonyris novaehollandiae	New Holland Honeyeater						2		21	12	13	25	25
Platycercus elegans	Adelaide Rosella				33	49	64	42	85	58	65	51	44
Podargus strigoides	Tawny Frogmouth								1		1		1
Pomatostomus superciliosus	White-browed Babbler								8	1	5	13	17
Psephotus haematonotus	Red-rumped Parrot				10	57	27	56	19	15	25	13	12
Ptilotula penicillata	White-plumed Honeyeater				16				13	8	20	28	18
Rhipdura albiscapa	Grey Fantail											9	6
Rhipidura leucophrys	Willie Wagtail				10	11	11	8	22	13	11	19	14

SPECIES NAME	COMMON NAME	EPBC	SA	Exotic	2011	2012	2013	2014	2015	2016	2017	2018	2019
Sericornis frontalis	White-browed Scrubwren						1						
Smicrornis brevirostris	Weebill				3		61	20	56	15	8	18	14
Stagonopleura guttata	Diamond Firetail		V		6	16	4		5		4	13	6
Sturnus vulgaris	Common Starling			*	2	27	11		52	37	11	6	22
Tachybaptus novaehollandiae	Australasian Grebe					8	1				4	2	
Tadorna tadornoides	Australian Shelduck									13			
Threskiornis spinicollis	Straw-necked Ibis								6				
Todiramphus sanctus	Sacred Kingfisher					1							
Tribonyx ventralis	Black-tailed Native Hen				6	3							
Tribonyx ventralis	Black-tailed Native Hen				6	3							
Trichoglossu haematodus	Rainbow Lorikeet				2	8	11	2					3
Turdus merula	Common Blackbird			*				5				1	1
Tyto delicatula	Eastern Barn Owl										1	1	
Vanellus miles	Masked Lapwing					3			4	2		1	1
Zosterops lateralis	Silvereye						4					3	1
		Total Abundance			**304**	**669**	**575**	**381**	**948**	**530**	**1042**	**700**	**686**
		Total Diversity			**40**	**59**	**48**	**31**	**50**	**42**	**52**	**56**	**55**

SA: South Australia (*National Parks and Wildlife Act 1972*). **VU/V: Conservation Codes:** V: Vulnerable. **R:** Rare.

EPBC: *Environment Protection and Biodiversity Conservation Act 1999*.

*Denotes introduced species

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Appendix 3. 2019 LFA Report

ebs ecology

Kanmantoo Copper Mine

Landscape Function Analysis Report

Kanmantoo Copper Mine: Landscape Function Analysis Report 2019

2 December 2019

Version 1

Prepared by EBS Ecology for Hillgrove Resources

Document Control					
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GLOSSARY AND ABBREVIATION OF TERMS

AN sites	LFA analogue sites
BOM	Bureau of Meteorology
EBS	EBS Ecology
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
Hillgrove	Hillgrove Resources Limited
IWL	Integrated Waste Landform
Kanmantoo	Kanmantoo Copper Mine
LFA	Landscape Function Analysis: an environmental monitoring technique which is internationally recognized as a method of measuring and monitoring ecosystem function and rehabilitation progress.
ML	Mining Lease
m²	square metres
mm	millimetres
NV Act	*Native Vegetation Act 1991*
PEPR	Program for Environmental Protection and Rehabilitation
Project Area	Kanmantoo mine lease (ML) and SEB areas
RH sites	LFA rehabilitation sites
RT	Rehabilitation Transect
SSA	Soil Surface Assessments
SEB	Significant Environmental Benefit
ssp.	sub-species
spp.	species (plural)
SSA	Soil Surface Assessment
TSF	Tailings Storage Facility
WRL	Waste Rock Landform

EXECUTIVE SUMMARY

A long-term Landscape Function Analysis (LFA) monitoring program is in place to measure the ongoing environmental management, restoration and Significant Environmental Benefit (SEB) offset program components of the Kanmantoo Copper Mine operations in South Australia.

The vegetation monitoring program is now in its eighth year, commencing in 2011 but excluding 2016 when the site was not monitored. Two nationally threatened ecological communities occur within the Project Area: *Eucalyptus odorata* (Peppermint Box) Open Woodland and *Lomandra effusa* (Scented Mat-rush) +/- *Lomandra multiflora* subsp. *dura* (Stiff Mat-rush) Open Tussock Grassland, which are both listed as critically endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Permanent LFA monitoring sites, established in these communities at the beginning of the monitoring program (2011-2013) are used as baselines to guide restoration targets for rehabilitation and SEB areas.

This report provides LFA monitoring results for the 2019 monitoring program and compares these results with those from previous years and with the reference (analogue) sites. The 2019 monitoring included an assessment of 24 existing sites and the establishment and collection of baseline data for a further four new sites. The new sites were established as analogue sites in modified grassland ecosystems on hillslopes adjacent to the mine area. These will be used to guide future restoration activities for hillslopes currently impacted by mining activities.

Across the Project Area the restoration sites exist in various states of rehabilitation. However, most rehabilitation sites are indicating successful germination and survival with positive trends toward analogue landscape function indices and restoration goals. In general, the LFA indicators have shown positive rehabilitation trends over the life of the Kanmantoo monitoring program (2011-2019). Rehabilitation plots have typically reached a level of 'self-sustaining communities', relative to analogue sites, after a period of only 3-4 years. Based on the initial success rates of restoration activities across the Kanmantoo Mine Area, it is likely that ongoing works will result in functional trends similar to those observed using LFA to date. This includes initial low values, followed by a rebound period whereby plant cover produces high stability, infiltration and nutrient cycling values before stabilising towards analogue values.

Ecological vegetation attributes such as plant species richness (and whether species are native or exotic) are currently not recorded as part of the LFA monitoring method, limiting the ability of the current program to determine species abundance and diversity or the success of species of interest used in revegetation and seeding mixes. Species composition and germination success should be considered as part of ongoing monitoring to provide information on how species respond to restoration methods, thus informing future rehabilitation activities.

The ongoing monitoring design should continue to adapt to maximise the efficiency and effectiveness of detecting changes in LFA monitoring sites to inform and improve restoration outcomes. Ongoing annual review and adaptation of the monitoring program is recommended, altering factors such as frequency of assessment, indicators measured and sampling locations.

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1 INTRODUCTION

A long-term monitoring program using Landscape Function Analysis (LFA) has been implemented by Hillgrove Resources Limited (Hillgrove) to measure the ongoing environmental management, restoration and Significant Environmental Benefit (SEB) offset program components of the Kanmantoo Copper Mine (Kanmantoo) in South Australia.

Hillgrove has an obligation to meet its rehabilitation objectives associated with the Program for Environmental Protection and Rehabilitation (PEPR) for Kanmantoo. Part of the PEPR requires monitoring of nominated areas commissioned to offset clearance of native vegetation associated with mine operations and infrastructure. The monitoring is specifically undertaken to measure the progress of a restoration program over time using the Landscape Function Analysis (LFA) methodology of Tongway and Hindley (2004).

LFA is a tool that brings together a number of different components that, when measured together over time, provide an accurate indication of how a distinct rehabilitation area is performing, and advancing toward a functioning system. The intention of the Kanmantoo LFA monitoring program is to achieve a time series trajectory of land condition across the mine site, enabling critical indicators to be identified, their values analysed and utilised for revision of future management activities (i.e. adaptive management) if required. A comparison with data collected from reference (analogue) sites with similar characteristics, but under ambient conditions, will account for seasonal and external effects beyond the control of the manager and enables a direct comparison of performance. For a system to be developing towards sustainability, it must be accumulating resources faster than they are lost. A functional landscape is one where vital resources such as water, plant litter and topsoil are retained and efficiently used (cycled) within the boundaries of the landscape and released very slowly (Tongway and Ludwig, 2006). LFA provides a rapid assessment of this functionality. When applied over time, results can be analysed to identify trends in the progress of the rehabilitation or remediation.

Within the Kanmantoo Project Area, the target landscape functionality of natural areas (as characterised by reference sites established within native vegetation communities) is compared with rehabilitated opencast mines and rehabilitated slopes of tailings dams. Soil surface quality indicators and landscape indices at Kanmantoo are similar to those observed by van de Walt *et al*. (2012) in platinum mining operations in South Africa. In particular, patches vegetated with grasses and shrubs showed higher functionality than sparsely vegetated interpatch areas.

Since 2011, EBS Ecology has worked with Hillgrove Resources to undertake the ongoing LFA monitoring program across the Kanmantoo Project Area. Details of the monitoring program and associated methodologies and design are detailed in *Kanmantoo Mine Vegetation Monitoring – Landscape Function Analysis* (EBS Ecology, 2011).

1.1 Objectives

The primary objectives of the 2019 LFA monitoring program are to:

- Repeat LFA at a selection of pre-existing sites established since 2011 at Kanmantoo;
- Provide results of ongoing LFA monitoring data assessed in 2019 across the Kanmantoo Project Area and compare with analogue sites and data from previous years;
- Discuss what the program results have revealed to this point and comment on trends observed;
- Establish and assess new analogue/baseline LFA sites in hillslope grassland areas.

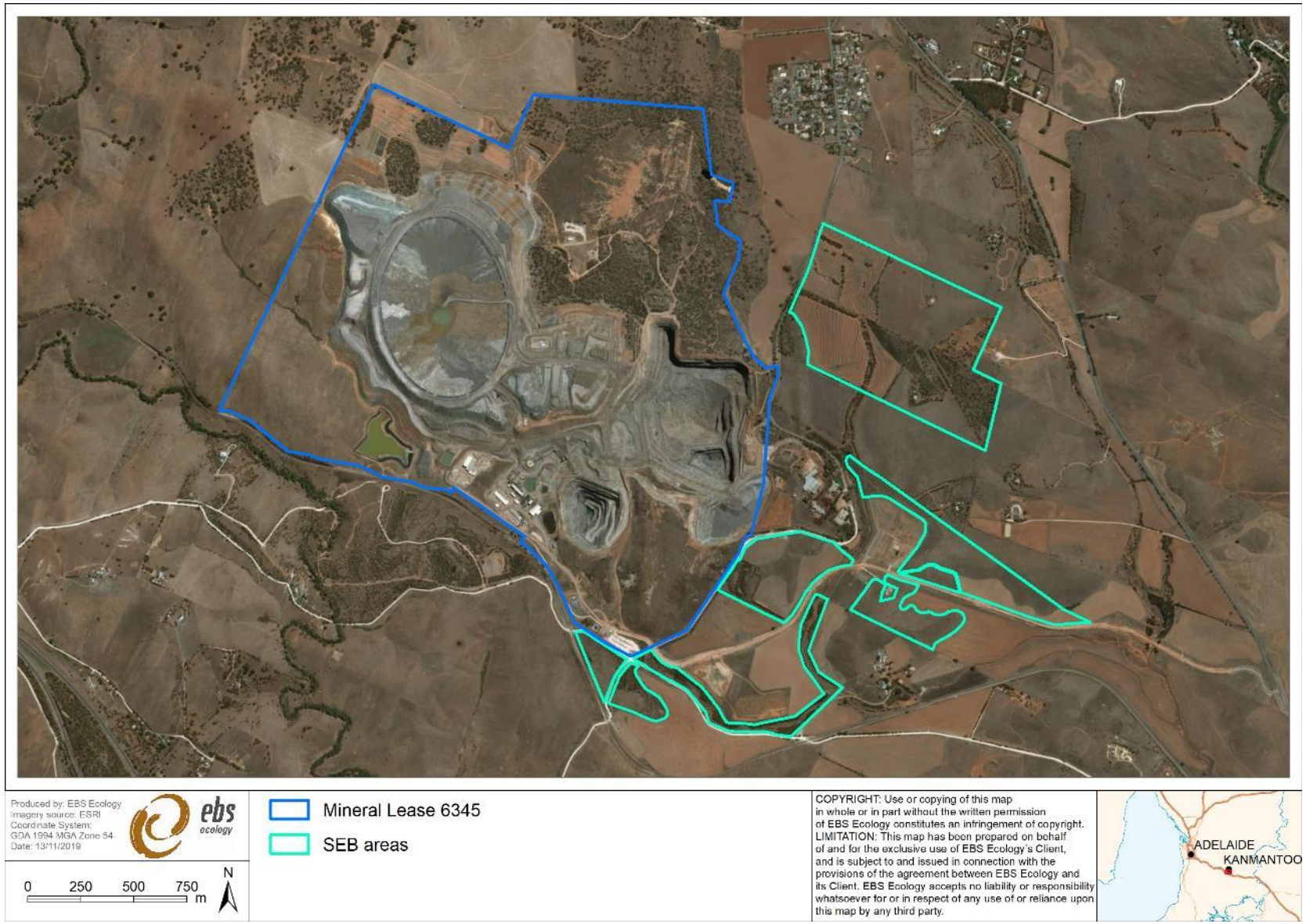

Figure 1. Location of the Mining Lease and Significant Environmental Benefit areas over the Project Area.

2 BACKGROUND

A land condition and restoration monitoring program has been undertaken at the Kanmantoo Mine over a number of years, with the initial baseline surveys commencing in 2011. To date, fifty-one (51) permanent LFA monitoring sites have been established across the Kanmantoo (Mining Lease) ML and SEB areas. These sites comprise a mix of baseline (analogue) and restoration/rehabilitation sites and each site has been monitored at different times and frequencies since 2011, based on changing restoration activities and monitoring priorities over time (Appendix 1). Analogue sites were assessed (using the LFA method) in order to provide baseline data against which to compare future rehabilitation trajectories. These included three *Lomandra effusa* (Scented Mat Rush) Grassland sites, six *Eucalyptus odorata* (Peppermint Box) Woodland sites and three *Austrostipa scabra* ssp. (Spear Grass) Grassland sites.

Initially, the areas set aside for vegetation restoration were highly degraded areas of pastoral land historically utilised for sheep and / or cattle grazing. The soil cover comprised mostly exotic pasture species such as *Avena barbata* (Wild Oat), *Phalaris aquatica* (Phalaris), *Festuca* sp. (Fescue) and *Lolium* spp. (Perennial Rye grass). Remnant woodlands consisted of mature *Eucalyptus odorata* (Peppermint Box) trees devoid of understorey native vegetation. In 2013, a vegetation rehabilitation program commenced with a variety of proven restoration techniques employed, including inter row stripping, tubestock planting and hydroseeding. These methods aim to replicate the compositional, structural and functional characteristics observed in local vegetation communities present in the Pre-European period as closely as possible.

In the Kanmantoo Mine Native Vegetation Management Plan (Coffey 2010), a series of measures associated with achieving a SEB under the NV Act were developed to offset clearance for the Kanmantoo Mine. These measures included protection of quality remnant native vegetation and improving the condition of more degraded remnant native vegetation within the Project Area; and revegetation of pasture and disturbed areas aiming to reduce biomass of exotic species and restore native vegetation communities. Under the existing restoration program, four primary methods are being utilised:

- Direct seeding with native seed (following ripping / soil removal);
- Planting native flora seedlings (tube stock);
- Hydroseeding and hand broadcasting of seed on Tailings Storage Facility (TSF) walls;
- Weed control and bush care; and
- Translocation of significant flora such as *Diuris behrii* (Cowslip Orchid).

Using these methods, approximately 97 hectares have been managed for rehabilitation / restoration since the program commenced (Figure 2). LFA monitoring has been progressively established to assess these restored areas. Monitoring results are compared with analogue sites that were assessed in the initial stages of the monitoring program (i.e. 2011-2013) to measure progress towards a 'functional' state (Tongway and Hindley 2004).

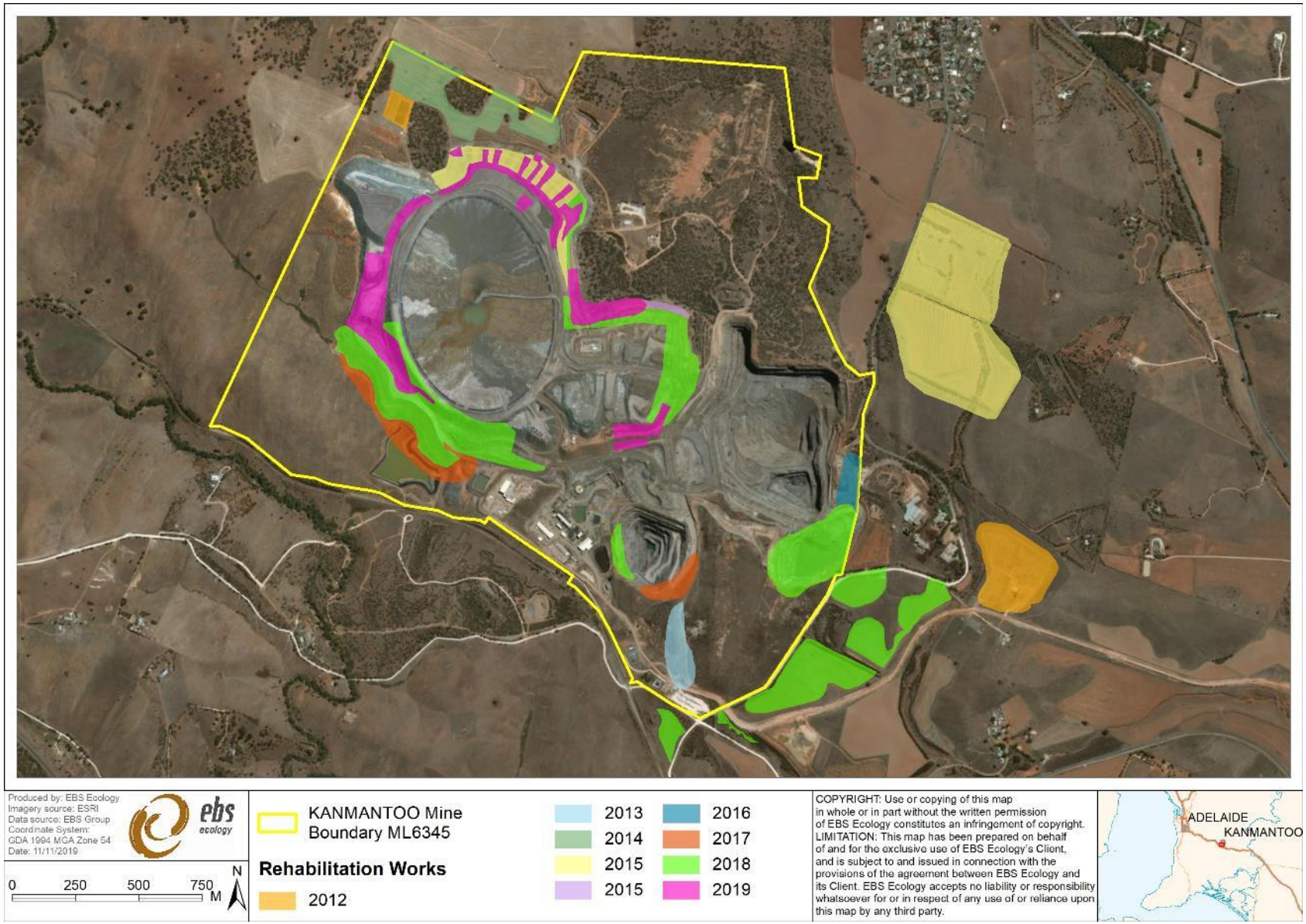

Figure 2. Rehabilitation and restoration activities at Kanmantoo Mine 2012-2019.

3 METHODOLOGY

3.1 Monitoring Program

3.1.1 Vegetation rehabilitation monitoring - Landscape Function Analysis (LFA)

LFA monitoring sites are established in areas that enable Hillgrove to report on its required lease conditions under the current PEPR. LFA sites have been strategically positioned to enable evaluation of the LFA program, the following attributes of rehabilitation areas have been considered:

- Location of monitoring sites;
- representation of vegetation communities; and
- effectiveness of analogue versus rehabilitation sites as comparable data.

LFA rehabilitation (RH) sites

The 2019 LFA Monitoring program included assessment of 28 sites, comprised of 24 existing transects and four new grassland analogue transects (Table 1, Figure 3).

Analogue sites were initially established in three different vegetation community types:

1. *Eucalyptus odorata* (Peppermint Box) Woodland (ODO)
2. *Lomandra effusa* (Scented Mat-rush) +/- *Lomandra multiflora* subsp. *dura* (Stiff Mat-rush) Open Tussock Grassland (LOM)
3. *Austrostipa scabra* ssp. (Spear Grass) Grassland sites (STI)

LFA Analogue (AN) sites

Additional analogue sites have since been established to match restoration priorities in the following two communities:

1. **Derived *Acacia pycnantha* (Golden Wattle) low woodlands (ACA) – established in 2014**

   Examples of this community are located at the north-eastern end of the pit along the degraded edge of the *Eucalyptus odorata* open woodland (Figure 1). The current community is more accurately described as a *Eucalyptus odorata* open woodland with the overstorey removed, where *Acacia pycnantha* is now dominating as an interim climax community. The sites were therefore considered suitable as analogue sites to obtain LFA target reference figures for *Acacia pycnantha* low woodland rehabilitation sites.

2. **Modified hillslope grasslands (GRA) – established in 2019**

   Two of these sites were established within the ML on ‘Carmens’ paddock, west of the dam and two sites were located outside of the ML on the southern side of Back Callington Road near the weather / dust monitoring station (Figure 3).

Table 1. Selection of existing LFA rehabilitation (RH) sites and newly established analogue (AN) sites assessed in 2019, also LFA showing assessment history from 2011-2019.

	Site type	Site name	2011	2012	2013	2014	2015	2017	2018	2019
1	RH	**KANODORT20**						✔	✔	✔
2	RH	**KANODO RT21**							✔	✔
3	RH	**KANODO RT19**						✔	✔	✔
4	RH	**KANODO RT18**						✔	✔	✔
5	RH	**KANODO RT17**					✔	✔	✔	✔
6	RH	**KANODO RT16**					✔	✔	✔	✔
7	RH	**KANODO RT15**					✔	✔	✔	✔
8	RH	**KANODO RT14**					✔	✔	✔	✔
9	RH	**KANODO RT13**					✔	✔	✔	✔
10	RH	**KANODO RT12**					✔	✔	✔	✔
11	RH	**KANODO RT11**					✔	✔	✔	✔
12	RH	**KANODO RT10**					✔	✔	✔	✔
13	RH	**KANODO RT07**					✔	✔	✔	✔
14	RH	**KANODO 9**				✔	✔	✔	✔	✔
15	RH	**KANODO 8**				✔	✔	✔	✔	✔
16	RH	**KANODO 6**	✔	✔	✔	✔	✔	✔	✔	✔
17	RH	**KANODO 4**	✔	✔	✔	✔	✔	✔	✔	✔
18	RH	**KANODO 5**	✔	✔	✔	✔	✔	✔	✔	✔
19	RH	**KANLOM RT02**							✔	✔
20	RH	**KANLOM RT01**						✔	✔	✔
21	RH	**KANGRA RT01**			✔	✔	✔	✔	✔	✔
22	RH	**KANACA RT03**							✔	✔
23	RH	**KANACA RT02**						✔	✔	✔
24	RH	**KANACA RT01**						✔	✔	✔
25	AN	**KANGRA 10**								✔
26	AN	**KANGRA 11**								✔
27	AN	**KANGRA 12**								✔
28	AN	**KANGRA 13**								✔

Data collection and analysis were undertaken in accordance with the LFA procedures manual developed by Tongway & Hindley (2004). Details of the rehabilitation monitoring program and associated methodologies are detailed in *Kanmantoo Mine Vegetation Monitoring – Landscape Function Analysis* (EBS Ecology, 2011). A summary of all sites monitored since 2011 is provided at Appendix 1.

3.1.2 Other monitoring related to rehabilitation

The 2019 fauna monitoring program included monitoring of avifauna (birds) and Possums (primarily Common Brushtail – *Trichosurus vulpecula*). Twenty-three avian transects are located over the Project Area; 14 within the Mining Lease (ML) and nine within the SEB area. Results from the Spring 2019 fauna survey are detailed in EBS Ecology (2019).

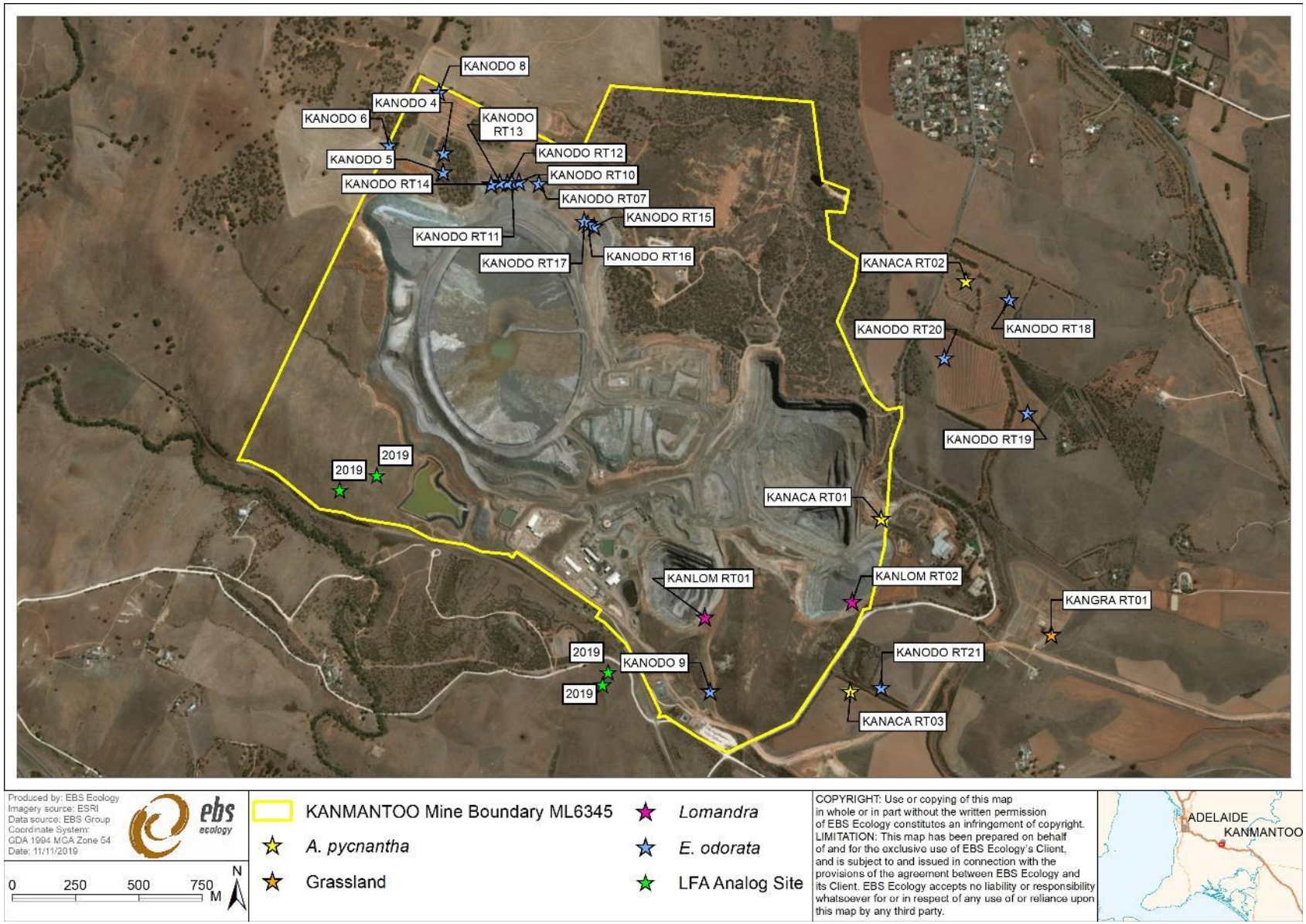

Figure 3. LFA monitoring sites assessed at Kanmantoo Mine in October 2019.

4 LFA RESULTS 2019

4.1 Climate

The nearest reliable long-term climate dataset is located at Kanmantoo (BOM station 23724) for which a long term mean annual rainfall of 468.9 mm has been recorded (Figure 4). The 2018 rainfall total (366 mm) was much reduced from the long-term average and was the lowest total recorded since the rehabilitation program inception. This follows on from two years (2016 and 2017) of above average rainfall. The 2019 rainfall data is below average up to and including the month of September as dry conditions prevailed across much of south-eastern Australia.

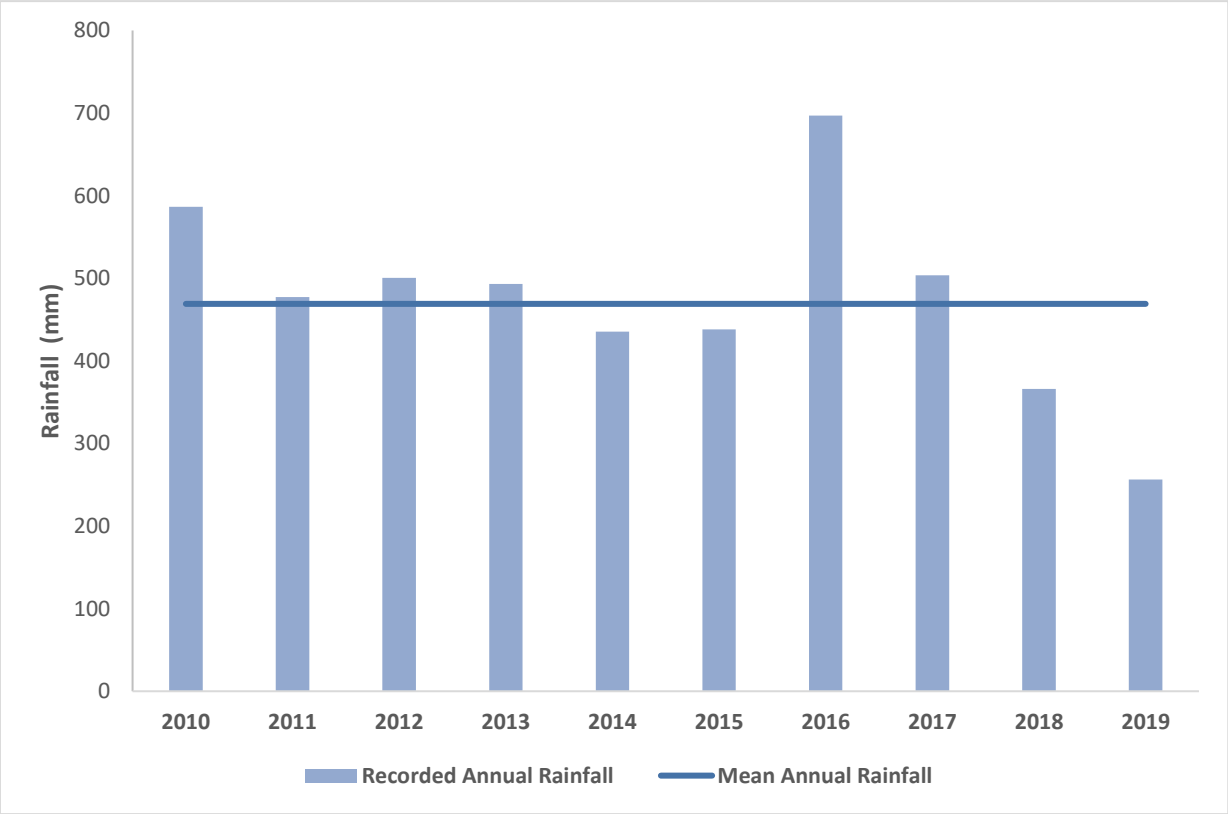

Figure 4. Recorded annual rainfall (2010-2019) and long-term mean annual rainfall (468.9 mm) at Kanmantoo (BOM, 2019). Note that total rainfall for 2019 is calculated up to the end of September 2019.

4.2 LFA Soil Surface Assessment results

Results for Soil Surface Assessments (SSA) for individual zones and their contribution to whole of site values are provided in Appendix 2. Baseline data obtained from multiple analogue sites of the same vegetation association were combined to obtain average values (e.g. KANODO 1, 2 and 3) that are used as target values for rehabilitation sites (see chart columns with error bars below).

4.3 *Eucalyptus odorata* (Peppermint Box) Woodland rehabilitation sites

4.3.1 KANODO 04

Site KANODO 04 had soil surface indices approaching analogue values (Figure 5) for stability, infiltration and nutrients after a general reducing trend compared with previous years. The shrub patch recorded as a very small element in 2017 and not observed in 2018, was more extensive in 2019. Branch complex proportion was also more extensive in 2019 (Figure 6). Landscape organisation was consistent with previous years' observations (Table 2). Visually, this site appears to show little change from previous years (Appendix 2).

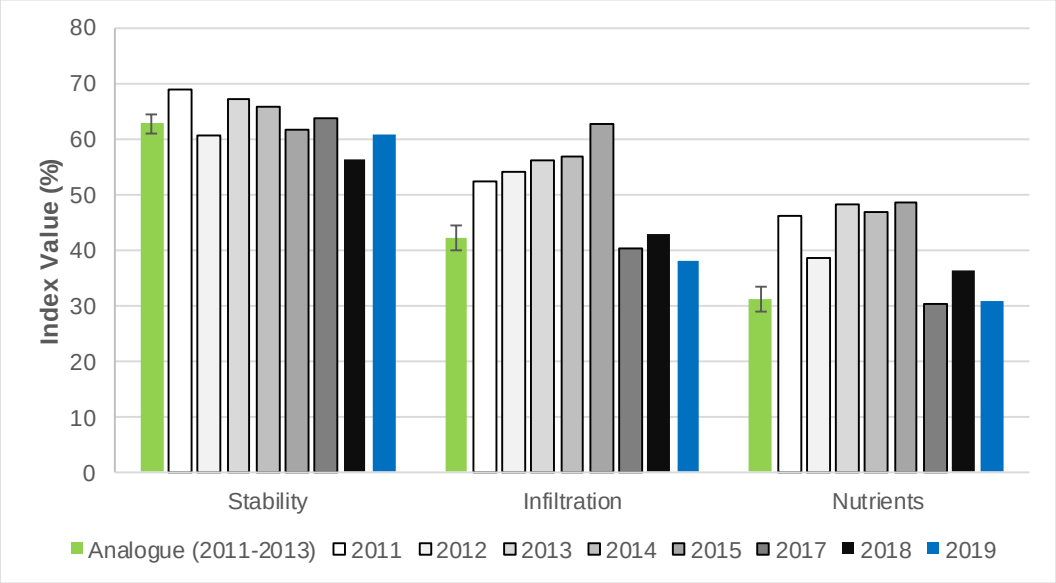

Figure 5. Landscape function indices change (2011-2019) for KANODO 4 with respect to mean analogue site values (2011-2013).

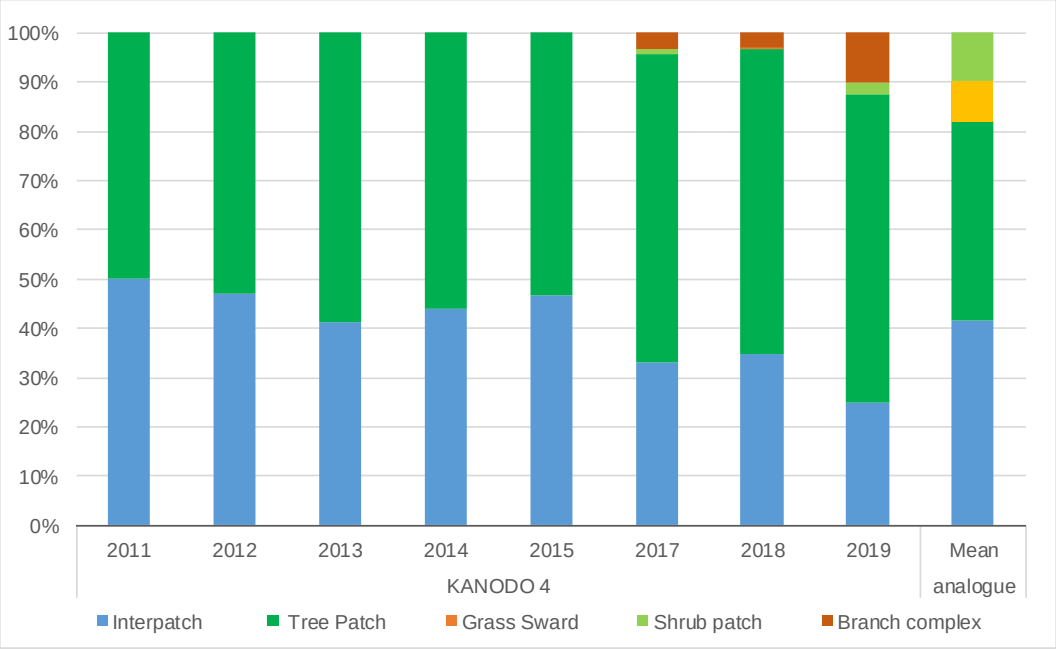

Figure 6. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANODO 4 2011-2019.

Table 1. Summary of the landscape organisation data for KANODO analogue and KANODO4 rehabilitation site 2011-2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.6**
KANODO4 Rehabilitation 2011	0.6	269.1	9	0.5
KANODO4 Rehabilitation 2012	0.6	291.3	6.32	0.529
KANODO4 Rehabilitation 2013	0.7	309.6	5.5	0.6
KANODO4 Rehabilitation 2014	0.6	300.2	7.88	0.6
KANODO4 Rehabilitation 2015	0.6	275.5	5.9	0.5
KANODO4 Rehabilitation 2017	1.3	270.8	2.55	0.67
KANODO4 Rehabilitation 2018	1.3	268.7	2.65	0.65
KANODO4 Rehabilitation 2019	1.5	306.4	1.91	0.75

4.3.2 KANODO 05

KANODO 05 showed indices with slightly reduced values from 2018. All indices continue to decrease, consistent with the ongoing trend for this site (Figure 7). Transect proportions indicated a continued increase in complexity associated with greater shrub and branch complex cover, components that were initially absent in the degraded, unrestored community (Figure 8). This was also reflected in the landscape organisation summary with patchiness increasing towards analogue values (Table 2).

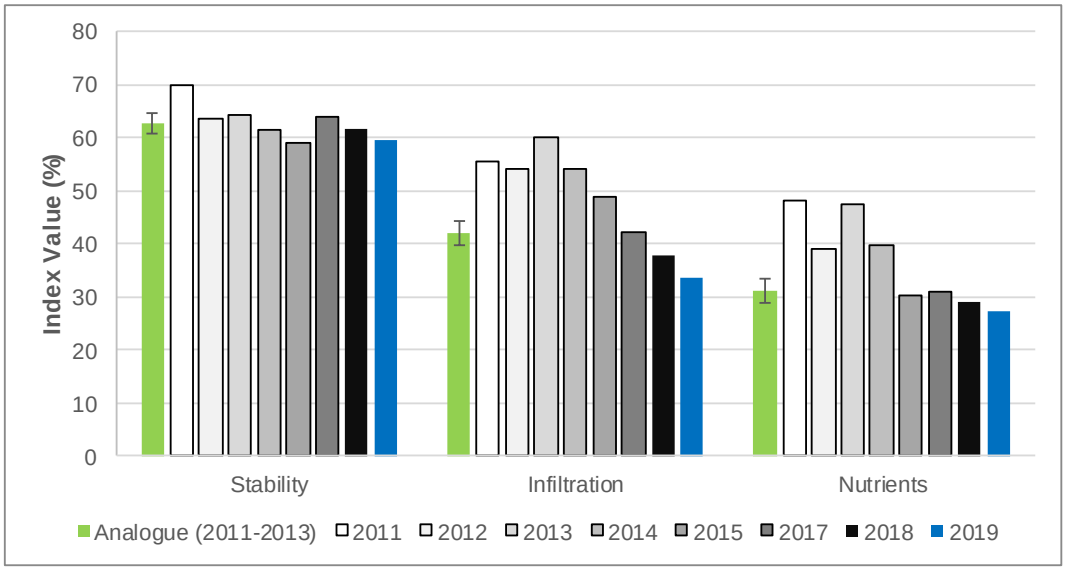

Figure 7. Landscape function indices change (2011-2019) for KANODO5 with respect to mean analogue site values (2011-2013).

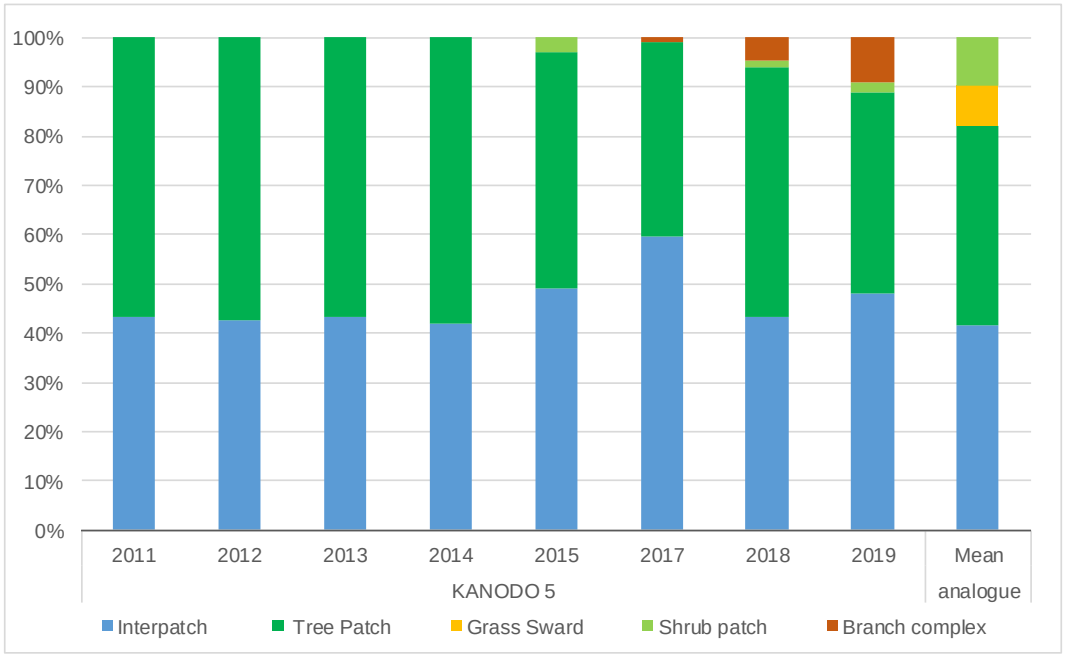

Figure 8. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANODO05.

Table 2. Summary of the landscape organisation data for KANODO analogue and KANODO5 rehabilitation site 2011-2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.6**
KANODO5 Rehabilitation 2011	0.35	324.6	8.21	0.57
KANODO5 Rehabilitation 2012	0.68	252	4.7	0.57
KANODO5 Rehabilitation 2013	0.45	249.50	6.38	0.57
KANODO5 Rehabilitation 2014	0.45	256.60	4.61	0.58
KANODO5 Rehabilitation 2015	1.1	195.99	1.97	0.5
KANODO5 Rehabilitation 2017	0.9	226.0	5.28	0.4
KANODO5 Rehabilitation 2018	1.6	178.9	2.74	0.57
KANODO5 Rehabilitation 2019	2.5	146	1.93	0.52

4.3.3 KANODO 06

KANODO 06 landscape function values (Figure 9), transect proportion (Figure 10) and landscape organisation values (Table 3) showed small variability from previous years which demonstrate low rates of change within the remnant communities. It is possible that the very high numbers of kangaroos do not allow very rapid recolonisation and establishment of herbaceous species. Qualitatively, the transect appears to have marginally increased shrub growth from previous years.

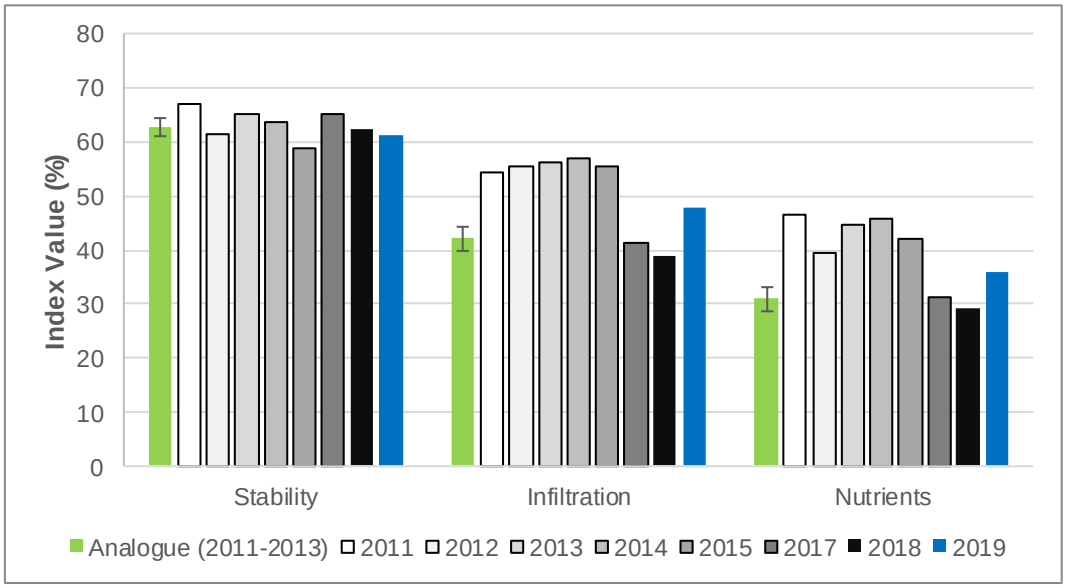

Figure 9. Landscape function indices change (2011-2019) for KANODO6 with respect to mean analogue site values (2011-2013).

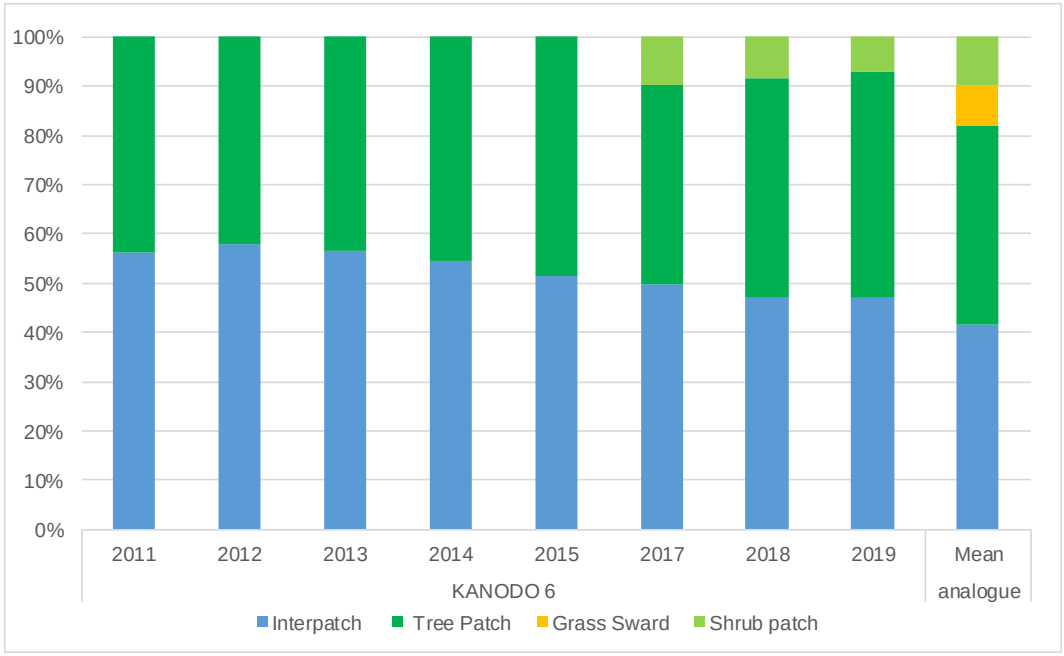

Figure 10. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANODO06.

Table 3. Summary of the landscape organisation data for KANODO analogue and KANODO6 rehabilitation site 2011-2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.6**
KANODO6 Rehabilitation 2011	0.43	194.68	12.9	0.44
KANODO6 Rehabilitation 2012	0.2	194.00	5.92	0.4
KANODO6 Rehabilitation 2013	0.44	196.04	12.97	0.44
KANODO6 Rehabilitation 2014	0.43	208.9	12.56	0.45
KANODO6 Rehabilitation 2015	0.43	215.00	6.1	0.47
KANODO6 Rehabilitation 2017	1.3	171.0	4.59	0.50
KANODO6 Rehabilitation 2018	1.3	168.3	3.1	0.53
KANODO6 Rehabilitation 2019	1.3	174	3.62	0.53

4.3.4 KANODO 08

This site has performed well with a transition from an exotic grassland into a moderately complex restored area. All functional indices increased in 2019 with gradual increases in the stability indicator evident each year since monitoring began in 2014 (Figure 11). The shrub cover evident in previous years was absent from the site in 2019, potentially due to dry conditions and/or the impact of total grazing pressure (Figure 16). Patchiness across the site continued to increase relative to analogue values (Table 4).

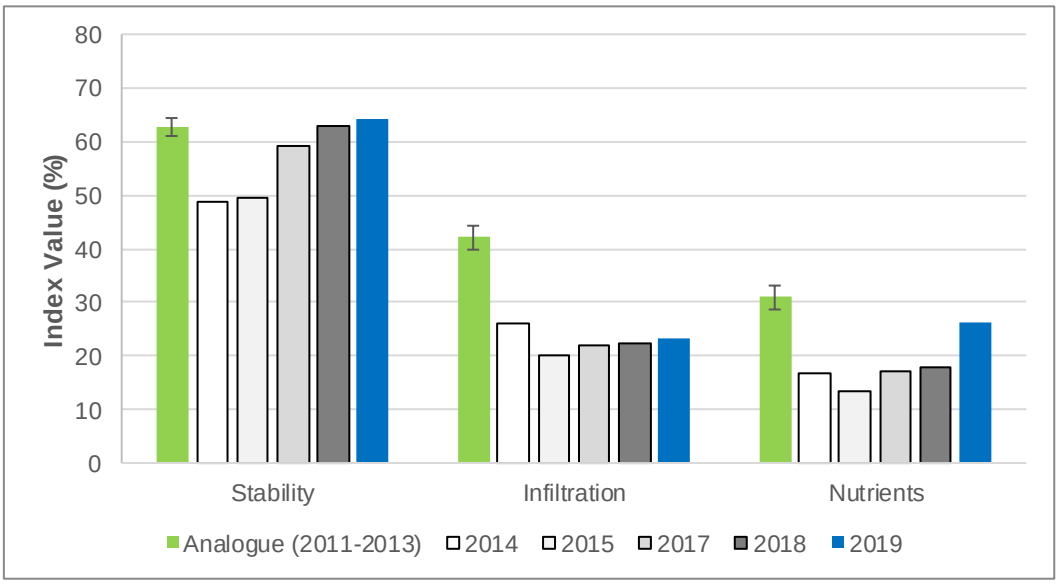

Figure 11. Landscape function indices change (2014-2019) for KANODO 08 with respect to mean analogue site values (2011-2013).

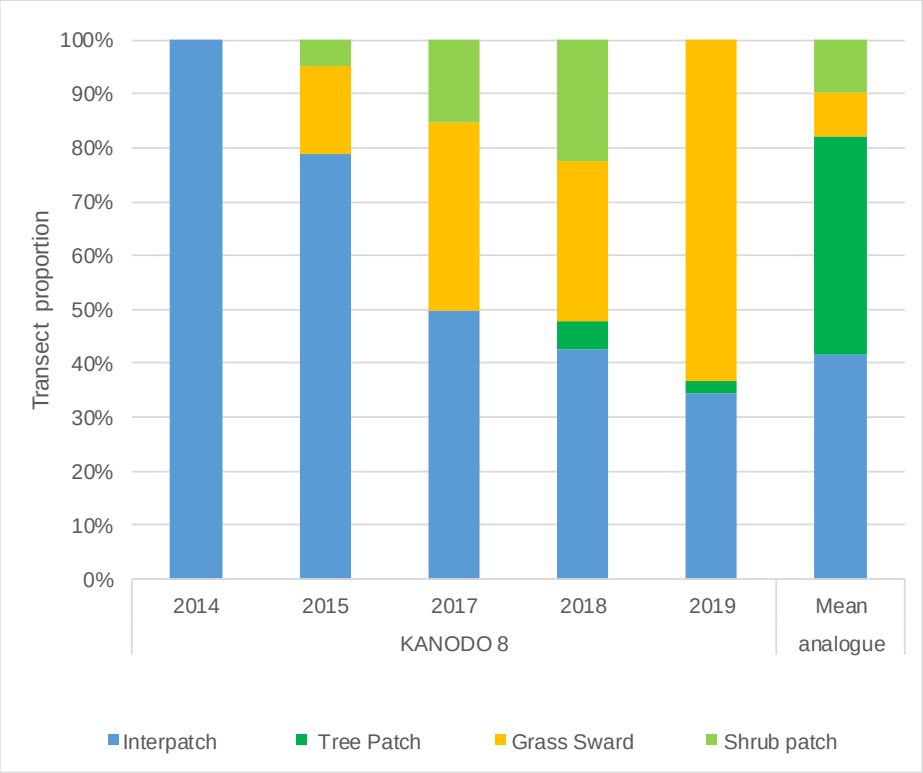

Figure 12. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANODO 08.

Table 4. Summary of the landscape organisation data for KANODO analogue and KANODO 08 rehabilitation site 2014-2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.40**	**1.80**	**0.6**
KANODO8 Rehabilitation 2014	0	0	20	0
KANODO8 Rehabilitation 2015	4.5	20	1.5	0.21
KANODO8 Rehabilitation 2017	1.3	17.1	4.59	0.37
KANODO8 Rehabilitation 2018	10.9	5.3	0.41	0.57
KANODO8 Rehabilitation 2019	11.8	12.4	0.29	0.65

4.3.5 KANODO 09

KANODO 09 is a good example of a successful restoration area, with soil surface indicators all close to or exceeding analogue values (Figure 13).Trees and shrubs are starting to establish, with shrubs detected within the LFA transect for the first time in 2019 (Figure 14), resulting in an increase in patchiness as the structural complexity of the vegetation increases (Table 5).

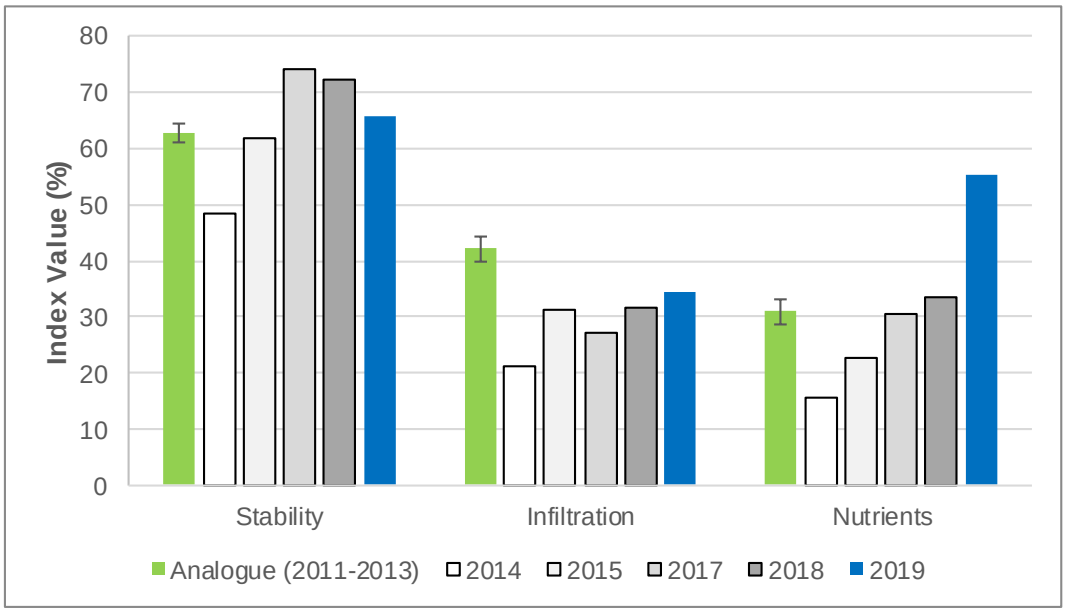

Figure 13. Landscape function indices change (2014-2019) for KANODO 09 with respect to mean analogue site values (2011-2013).

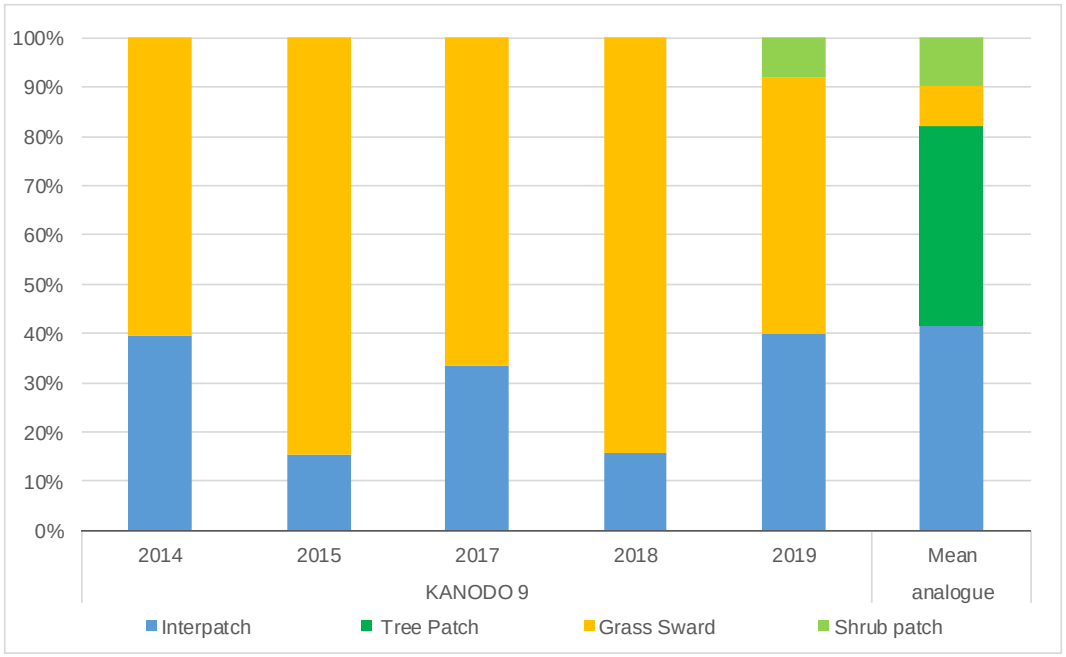

Figure 14. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANODO 09.

Table 5. Summary of the landscape organisation data for KANODO analogue and KANODO 09 rehabilitation site 2014-2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.40**	**1.80**	**0.6**
KANODO9 Rehabilitation 2014	3.6	95.50	1.09	0.61
KANODO9 Rehabilitation 2015	1.9	136.20	0.80	0.90
KANODO9 Rehabilitation 2017	4.8	111.30	0.76	0.70
KANODO9 Rehabilitation 2018	2.0	166.90	0.67	0.84
KANODO9 Rehabilitation 2019	6.0	83	0.71	0.60

4.3.6 KANODO RT 07

KANODO RT 07 showed increases in soil infiltration and nutrients and stabilisation towards analogue value for soil stability as chenopod groundcover shrubs and native perennial grasses continue to establish (Figure 15). The dieback of much of the organic material after a high flush growth phase is likely to be the cause of the continued increase in nutrients. A reduction in shrub cover compared with 2018 may be due to natural successional processes or drier climatic conditions (Figure 16).

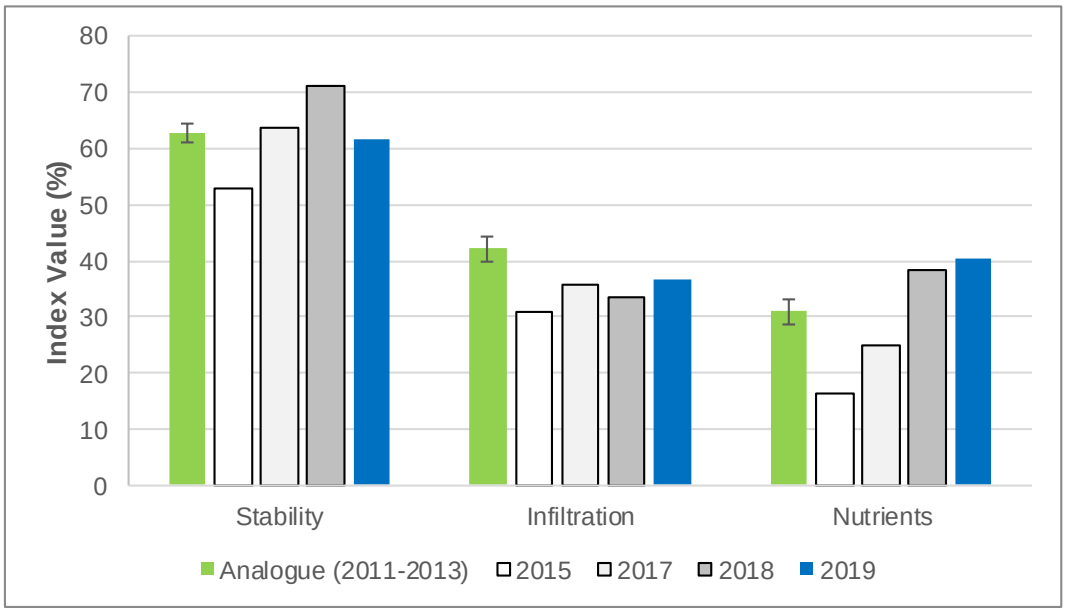

Figure 15. Landscape function indices change (2015-2019) for KANODO RT 07 with respect to mean analogue site values (2011-2013).

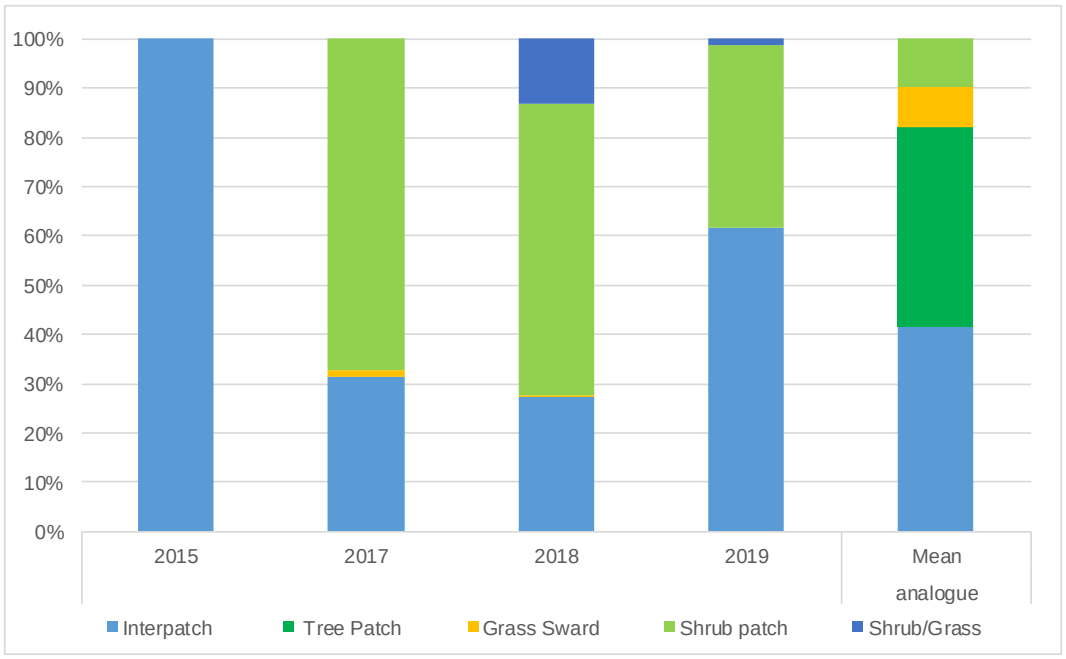

Figure 16. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANODO RT 07.

Table 6 Summary of the landscape organisation data for KANODO analogue and KANODO RT 07 rehabilitation site 2015-2019.

Site Type	No. of patch zones per 10m	Total patch area (m²)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.4**	**1.80**	**0.6**
KANODO_RT07 Rehabilitation 2015	0	0	1.50	0
KANODO_RT07 Rehabilitation 2017	3.1	79.9	1.28	0.68
KANODO_RT07 Rehabilitation 2018	3.1	83.1	1.10	0.73
KANODO_RT07 Rehabilitation 2019	5.6	8.7	1.10	0.38

4.3.7 KANODO RT 10

KANODO RT 10 remains below mean analogue values, but with infiltration and nutrients increasing from 2018 (Figure 17). Grass sward and shrub cover decreased from 2018 but tree cover was evident for the first time (Figure 18). The landscape organisation index still exhibits a community of many small patches in contrast to the mean analogue sites (Table 7). This will develop as the overstorey begins to have an influence on the understorey and ground layer vegetation strata.

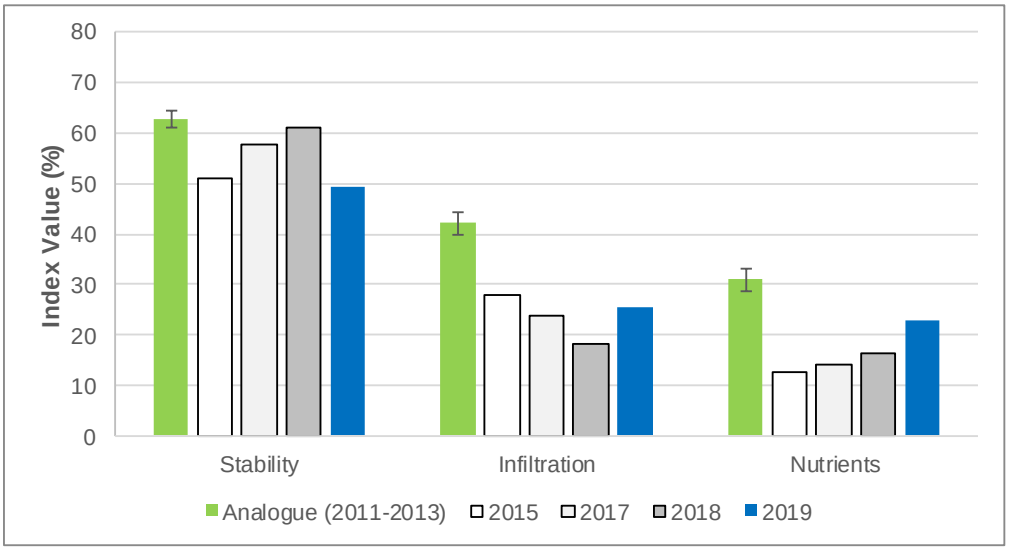

Figure 17. Landscape function indices change (2015-2019) for KANODO RT 10 with respect to mean analogue site values (2011-2013).

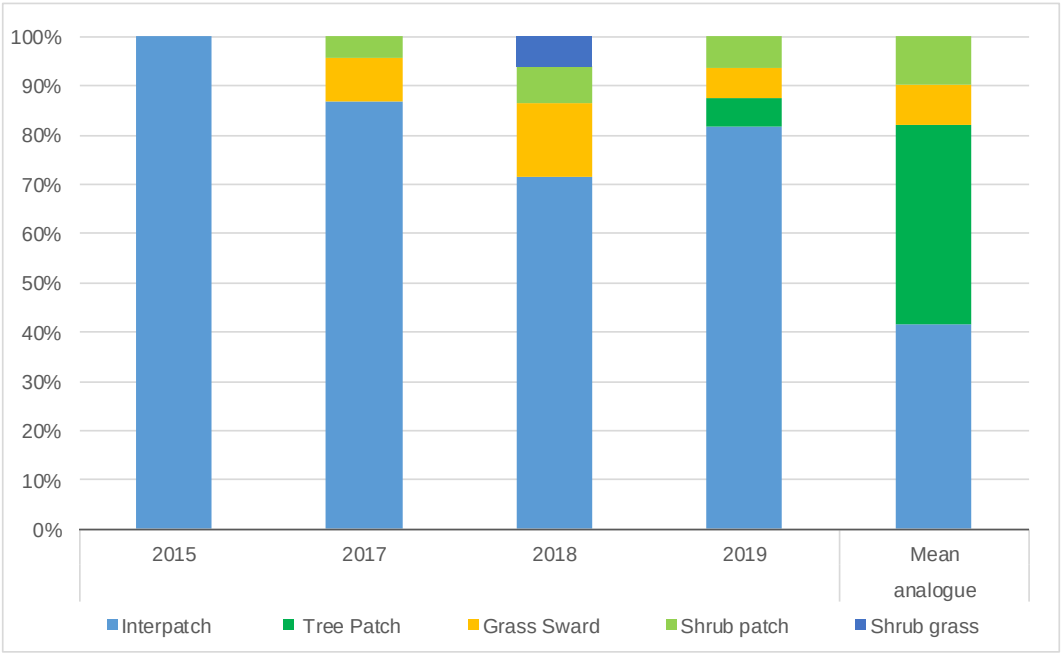

Figure 18. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANODO RT 10.

Table 7. Summary of the landscape organisation data for KANODO analogue and KANODO RT 10 rehabilitation site 2015-2019.

Site Type	No. of patch zones per 10m	Total patch area (m²)	Average inter-patch length (m)	Landscape Organisational Index
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.6**
KANODO_RT10 Rehabilitation 2015	0	0	20	0
KANODO_RT10 Rehabilitation 2017	5.3	1.7	1.64	0.13
KANODO_RT10 Rehabilitation 2018	5.3	2.3	1.36	0.29
KANODO_RT10 Rehabilitation 2019	6.4	3.3	1.28	0.18

4.3.8 KANODO RT 11

KANODO RT 11 was similar to KANODO RT 10 in having a higher patchiness (i.e. a higher number of patches of less area) compared with analogue values (Table 8). The soil surface values continue to trend towards mean analogue values (Figure 19). Interpatch cover remained similar to that recorded in 2018, with shrub and grass cover variable (Figure 20).

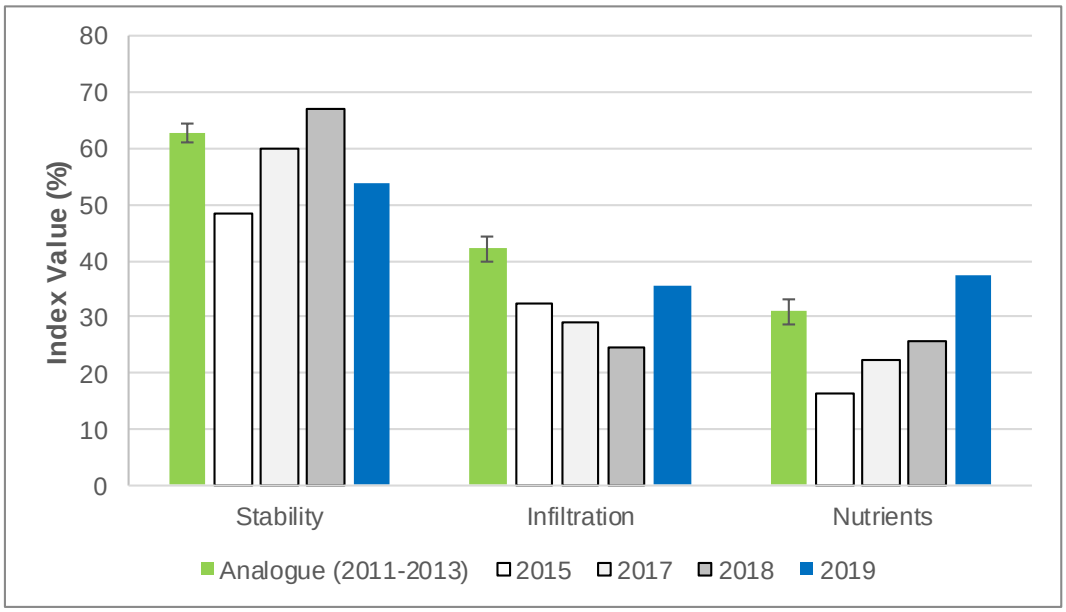

Figure 19. Landscape function indices change (2015-2019) for KANODO R T11 with respect to mean analogue site values (2011-2013).

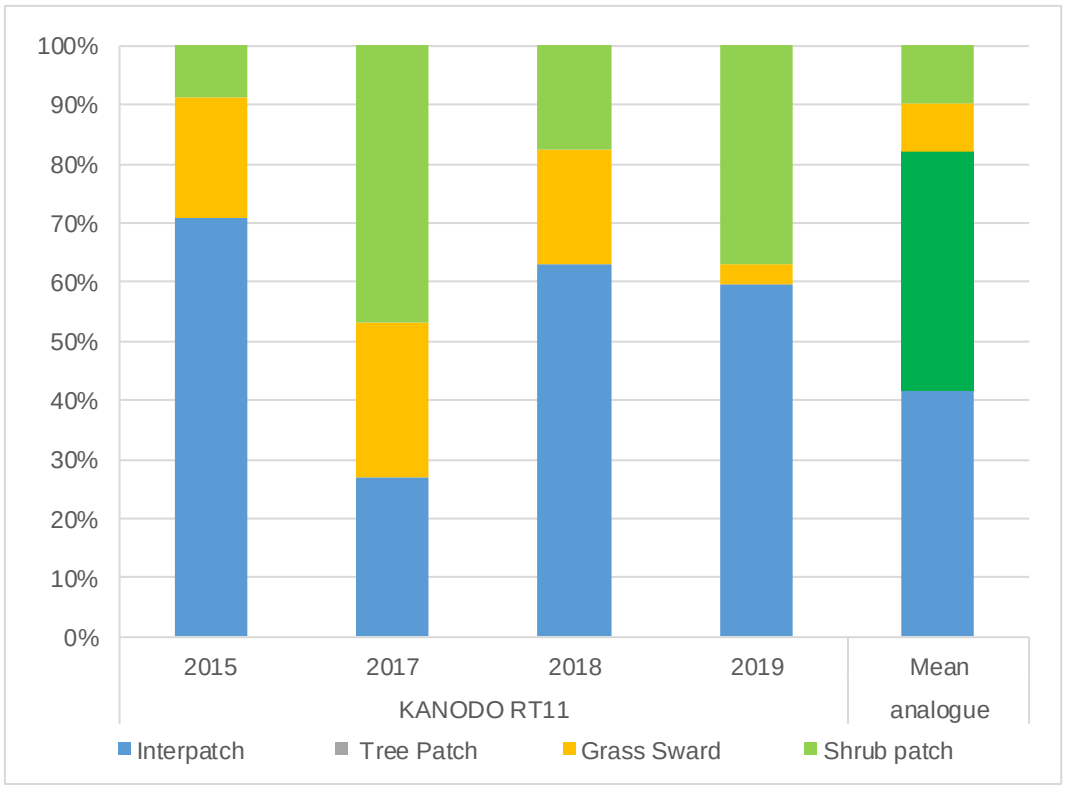

Figure 20. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANODO RT 11.

Table 8. Summary of the landscape organisation data for KANODO analogue and KANODO RT 11 rehabilitation site 2015-2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.6**
KANODO_RT11 Rehabilitation 2015	3	1.9	2.4	0.3
KANODO_RT11 Rehabilitation 2017	4.4	70	0.61	0.73
KANODO_RT11 Rehabilitation 2018	6.4	12.7	0.99	0.37
KANODO_RT11 Rehabilitation 2019	6.2	44.4	0.87	0.46

4.3.9 KANODO RT 12

KANODO RT 12 displayed similar soil surface trends to RT 10 and RT 11, except that infiltration continued to decrease (Figure 21). Interpatch cover increased substantially from 2018 levels with a commensurate decrease in shrub cover (Figure 22).

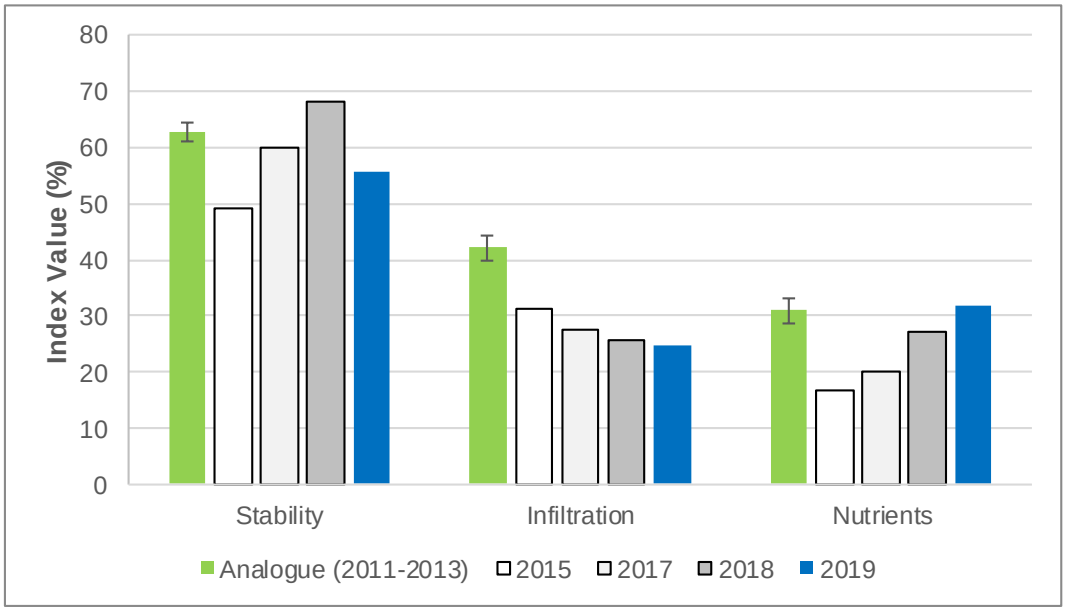

Figure 21. Landscape function indices change (2015-2019) for KANODO RT 12 with respect to mean analogue site values (2011-2013).

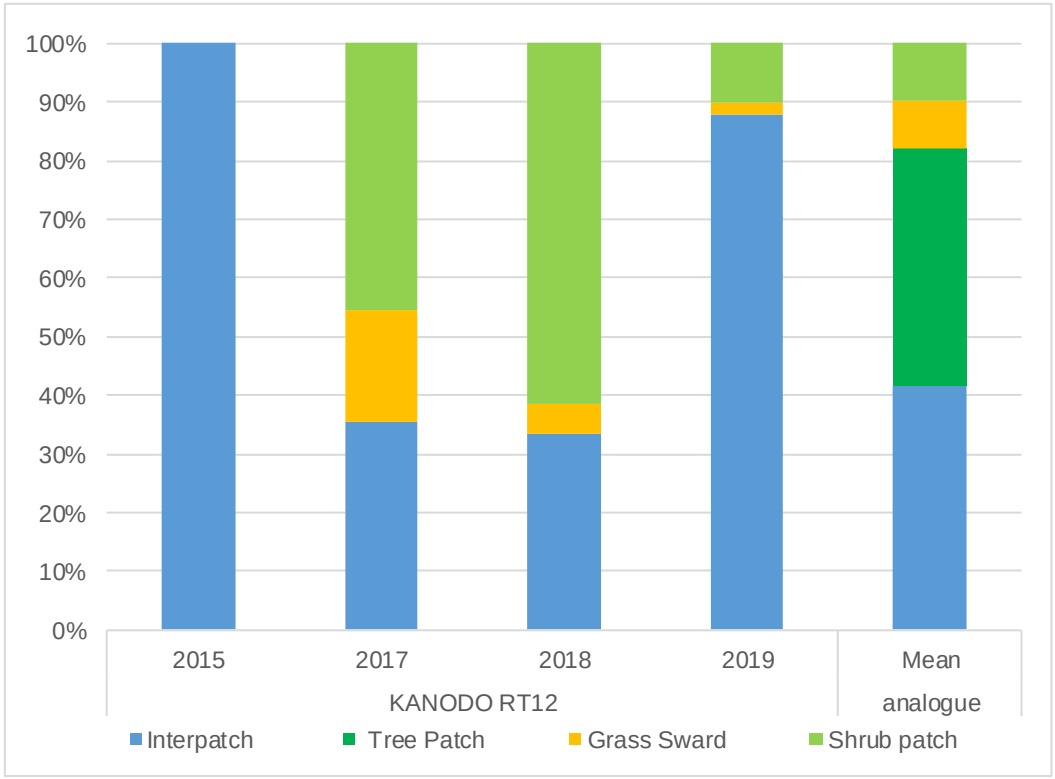

Figure 22. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANODO RT 12 (2015-2019).

Table 9. Summary of the landscape organisation data for KANODO analogue and KANODO RT 12 rehabilitation site 2015-2018.

Site Type	No. of patch zones per 10m	Total patch area (m²)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.6**
KANODO_RT12 Rehabilitation 2015	0	0	20	0
KANODO_RT12 Rehabilitation 2017	4.1	45.9	0.87	0.65
KANODO_RT12 Rehabilitation 2018	4.7	32.2	0.78	0.67
KANODO_RT12 Rehabilitation 2019	4.8	4.6	1.16	0.17

4.3.10 KANODO RT 13

KANODO RT 13 showed a decrease in all soil surface index values (compared with 2018) with stability moving back to slightly below analogue values (Figure 23). Similar to the other RT sites, interpatch cover increased as shrub cover reduced, possibly due to the drier conditions in this harsh environment (Figure 24).

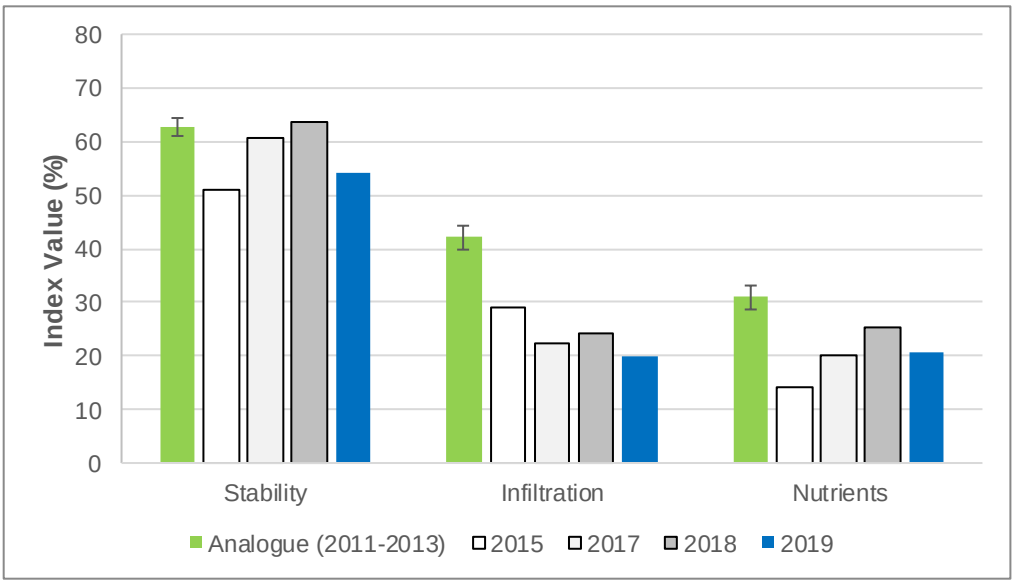

Figure 23. Landscape function indices change (2015-2019) for KANODO RT 13 with respect to mean analogue site values (2011-2013).

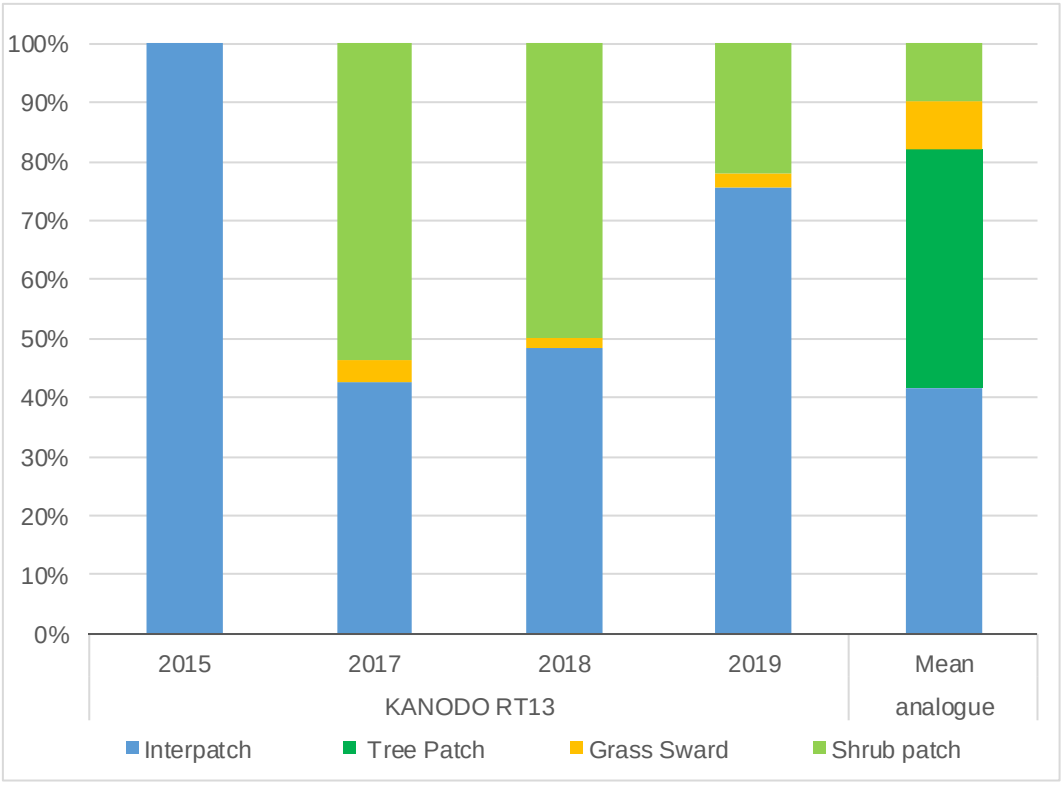

Figure 24. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANODO RT 13.

Table 10. Summary of the landscape organisation data for KANODO analogue and KANODO RT 13 rehabilitation site 2015-2019.

Site Type	No. of patch zones per 10m	Total patch area (m²)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.6**
KANODO_RT13 Rehabilitation 2015	0	0	15	0
KANODO_RT13 Rehabilitation 2017	4.6	45.1	0.9	0.59
KANODO_RT13 Rehabilitation 2018	4.2	57.8	1.15	0.52
KANODO_RT13 Rehabilitation 2019	4.6	5.6	1.64	0.24

4.3.11 KANODO RT 14

KANODO RT 14 showed similar results to KANODO RT 13 (see Table 11, Figure 25) with increasing interpatch cover and decreasing shrub cover evident (Figure 26).

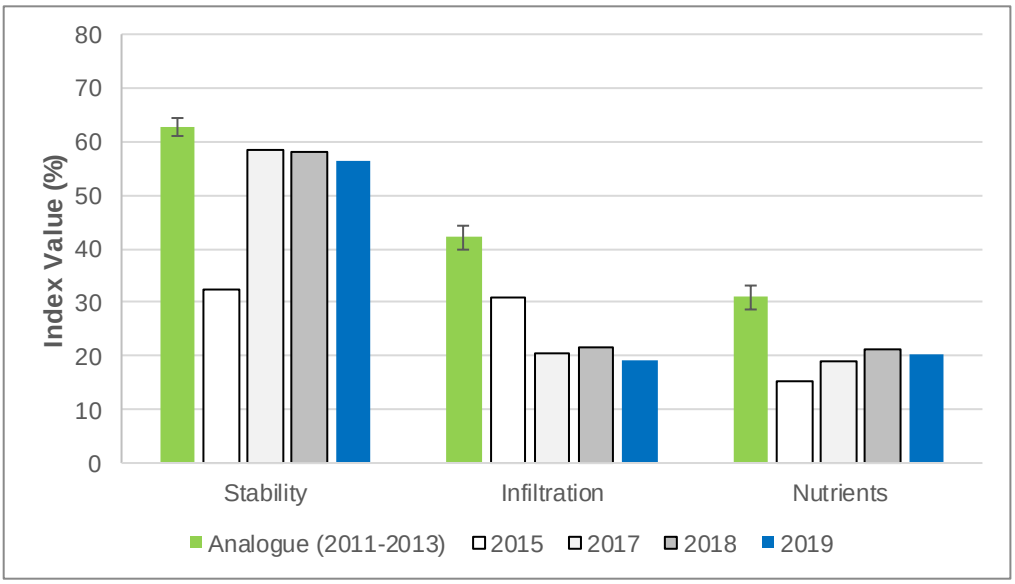

Figure 25. Landscape function indices change (2015-2019) for KANODO RT 14 with respect to mean analogue site values (2011-2013).

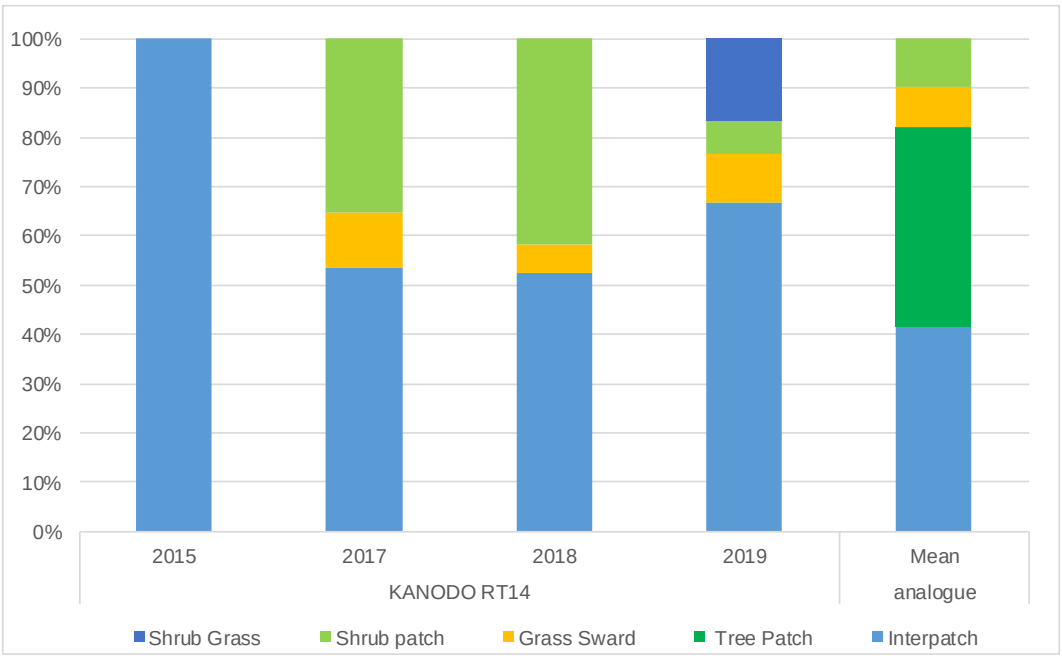

Figure 26. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANODO RT 14.

Table 11. Summary of the landscape organisation data for KANODO analogue and KANODO RT 14 rehabilitation site 2015-2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.6**
KANODO_RT14 Rehabilitation 2015	0	0	15	0
KANODO_RT14 Rehabilitation 2017	5	22.6	1.31	0.47
KANODO_RT14 Rehabilitation 2018	4.5	24.4	1.17	0.47
KANODO_RT14 Rehabilitation 2019	8.1	12.3	0.82	0.33

4.3.12 KANODO RT 15

KANODO RT 15 displayed an increase across all three soil surface indicators in comparison to 2018 (Figure 27). Trough zone cover reduced in 2019, indicating reduced weathering of the surface is occurring as litter increases (Figure 28). Patchiness remained much higher than analogue values with over 9 patches observed per 10m, a slight decrease from 2018 (Table 12).

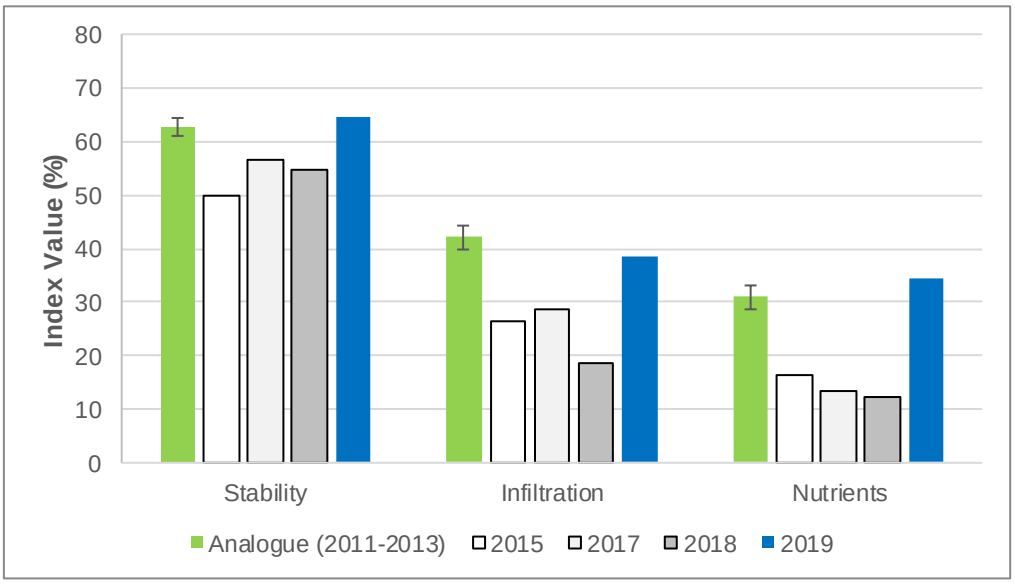

Figure 27. Landscape function indices change (2015-2019) for KANODO RT 15 with respect to mean analogue site values (2011-2013).

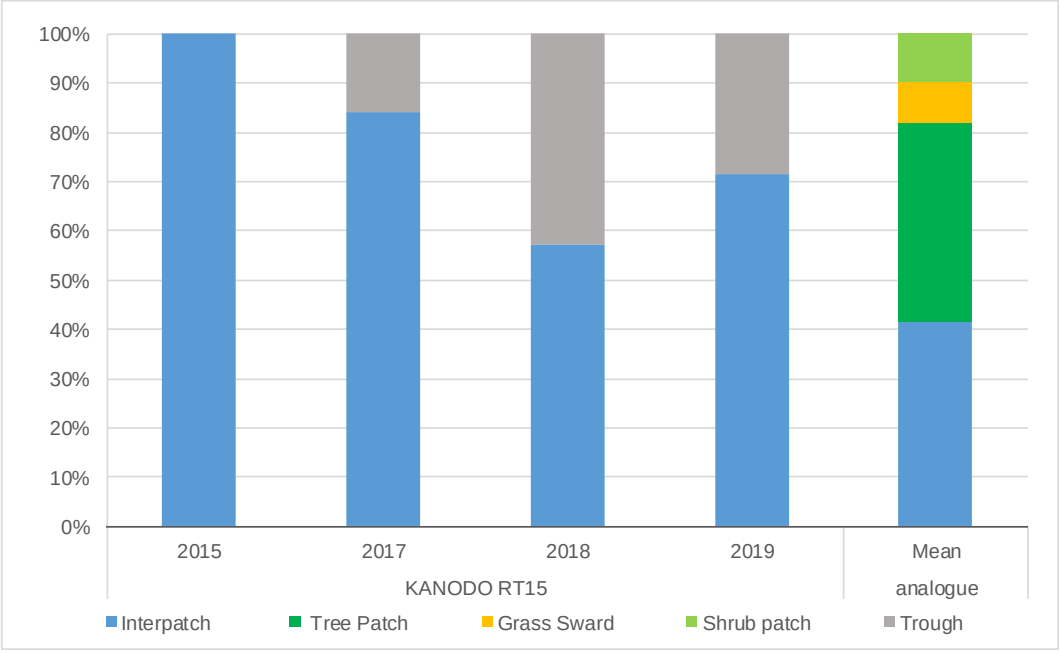

Figure 28. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANODO RT 15.

Table 12. Summary of the landscape organisation data for KANODO analogue and KANODO RT 15 rehabilitation site 2015-2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.6**
KANODO_RT15 Rehabilitation 2015	0	0	20	0
KANODO_RT15 Rehabilitation 2017	10.1	15.1	0.83	0.16
KANODO_RT15 Rehabilitation 2018	12.3	41.6	0.47	0.43
KANODO_RT15 Rehabilitation 2019	9.0	27.8	0.79	0.28

4.3.13 KANODO RT 16

A small decrease in stability was observed at this site, with substantial increases in infiltration and nutrient cycling indices evident (Figure 29). The interpatch transect proportion decreased as grass cover continues to increase at the site (Figure 30) as the vegetation matures and grass tussock size increases. Landscape organisation continues to trend towards analogue values (Table 13).

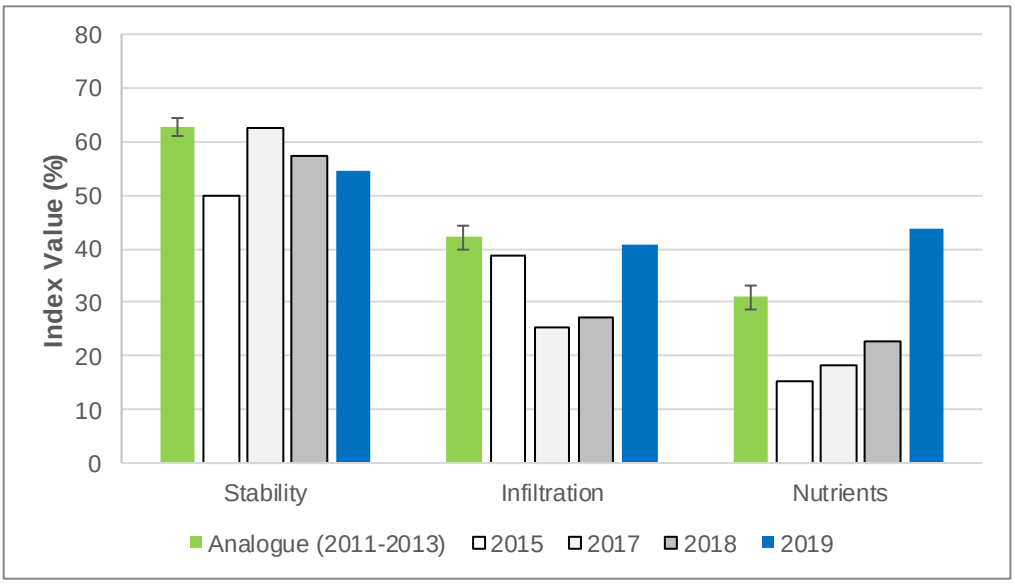

Figure 29. Landscape function indices change (2015-2019) for KANODO RT 16 with respect to mean analogue site values (2011-2013).

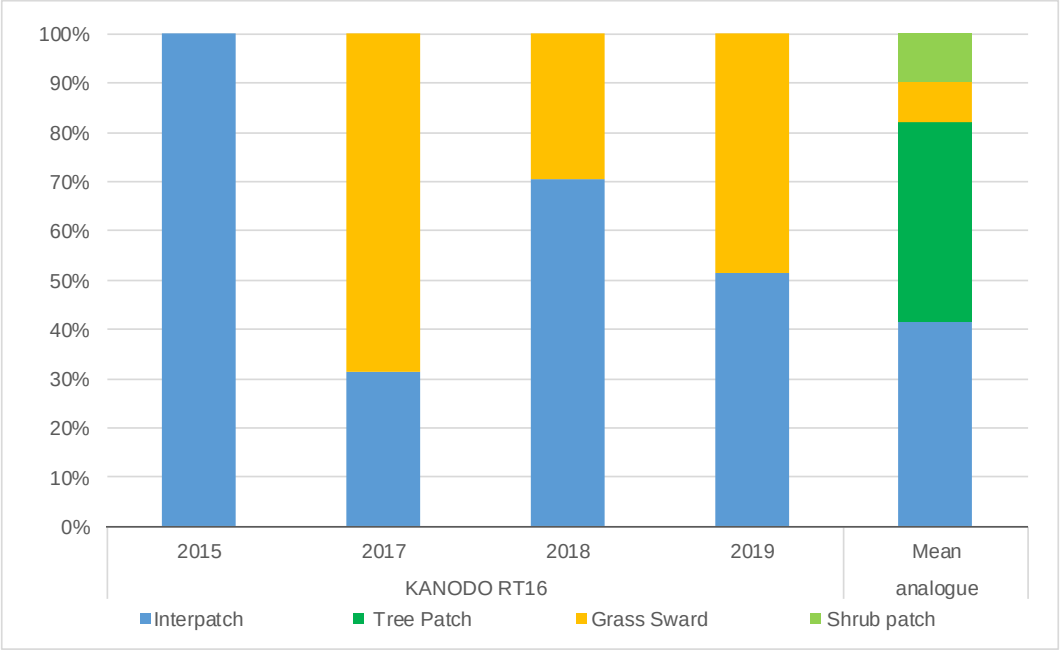

Figure 30. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANODO RT 16.

Table 13. Summary of the landscape organisation data for KANODO analogue and KANODO RT 16 rehabilitation site 2015-2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.6**
KANODO_RT16 Rehabilitation 2015	0	0	20	0
KANODO_RT16 Rehabilitation 2017	0.8	194.1	3.70	0.69
KANODO_RT16 Rehabilitation 2018	9.5	75.8	0.74	0.29
KANODO_RT16 Rehabilitation 2019	10.8	33.5	0.45	0.49

4.3.14 KANODO RT 17

The shrub patch zone which emerged in 2018 was much reduced in cover in 2019 (Figure 32), while soil stability indicators remained close to or approaching analogue values (Figure 31). Nutrient cycling and infiltration both increased substantially compared with 2018 observations, most likely due to dead and decaying organic material (e.g. plant litter) also resulting in the increased inter-patch cover seen in 2019 (Figure 32).

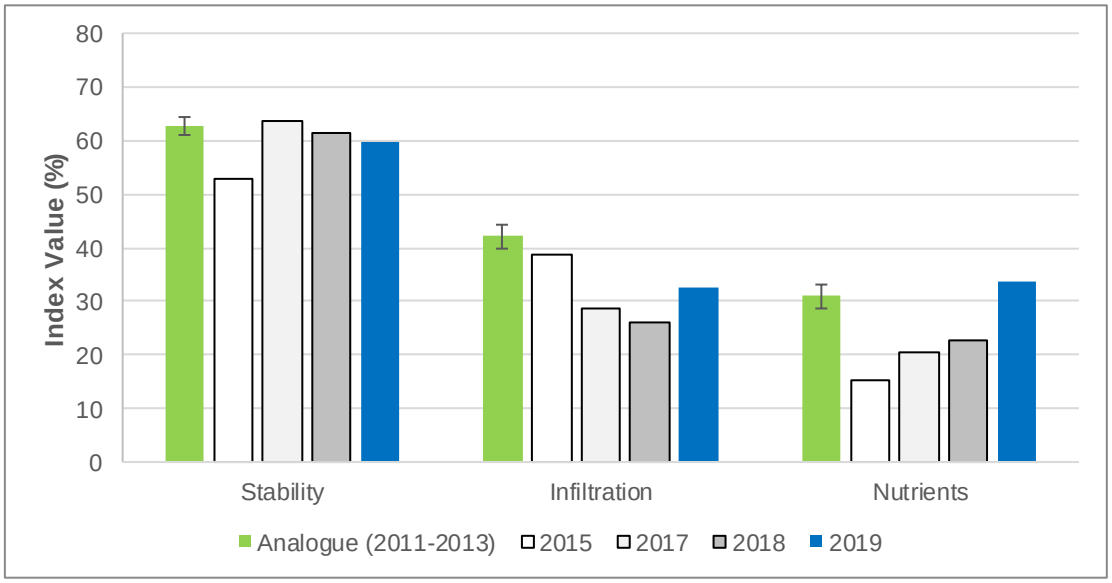

Figure 31. Landscape function indices change (2015-2019) for KANODO RT 17 with respect to mean analogue site values (2011-2013).

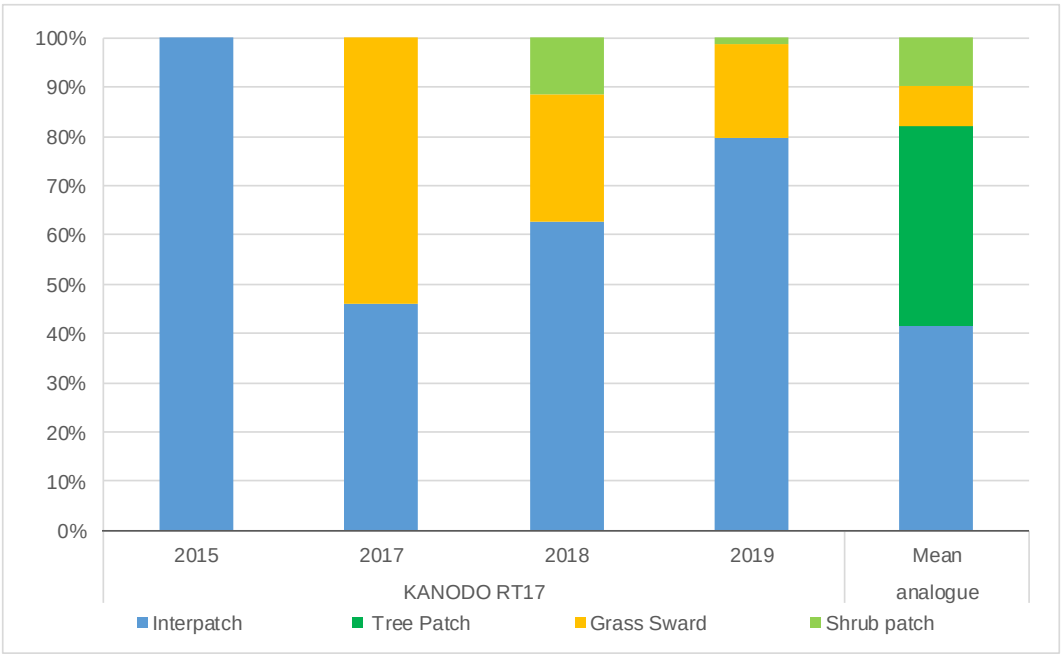

Figure 32. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANODO RT 17.

Table 14. Summary of the landscape organisation data for KANODO analogue and KANODO RT 17 rehabilitation site 2015-2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.6**
KANODO_RT17 Rehabilitation 2015	0	0	20	0
KANODO_RT17 Rehabilitation 2017	4.7	102.9	1.06	0.54
KANODO_RT17 Rehabilitation 2018	6.6	5.2	1.05	0.37
KANODO_RT17 Rehabilitation 2019	9.3	1.1	0.86	0.20

4.3.15 KANODO RT 18, 19, 20, 21.

These sites are all similar in terms of their location and restoration histories and as such all display similar trajectories towards analogue values for soil surface values (Figures 33 - 36) as a dense tussock grass sward develops.

The transect proportion for these sites is of little relevance (and are therefore not presented) because they display a single uniform cover throughout the length of the transect. All sites also have very low patch length and high patch area values (Tables 15 - 18).

From a visual perspective, there is an obvious increase in grass tussock size, spread of chenopod groundcovers and early stages of *Acacia* / shrub emergence. A gradual transition is expected within these communities as overstorey components begin to develop (see photo points at Appendix 3).

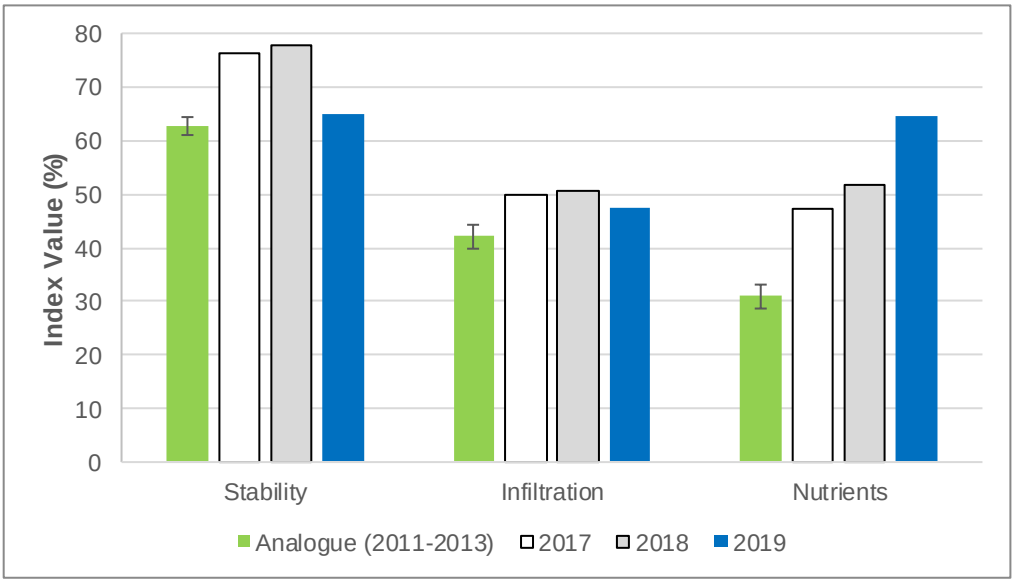

Figure 33. Landscape function indices change (2017-2019) for KANODO RT 18 with respect to mean analogue site values (2011-2013).

Table 15. Summary of the landscape organisation data for KANODO analogue and KANODO RT 18 rehabilitation site 2017-2018.

Site Type	No. of patch zones per 10m	Total patch area (m²)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.60**
KANODO_RT18 Rehabilitation 2017	0.3	125	0	1.00
KANODO_RT18 Rehabilitation 2018	0.4	125	0	1.00
KANODO_RT18 Rehabilitation 2019	0.5	95	0	1.00

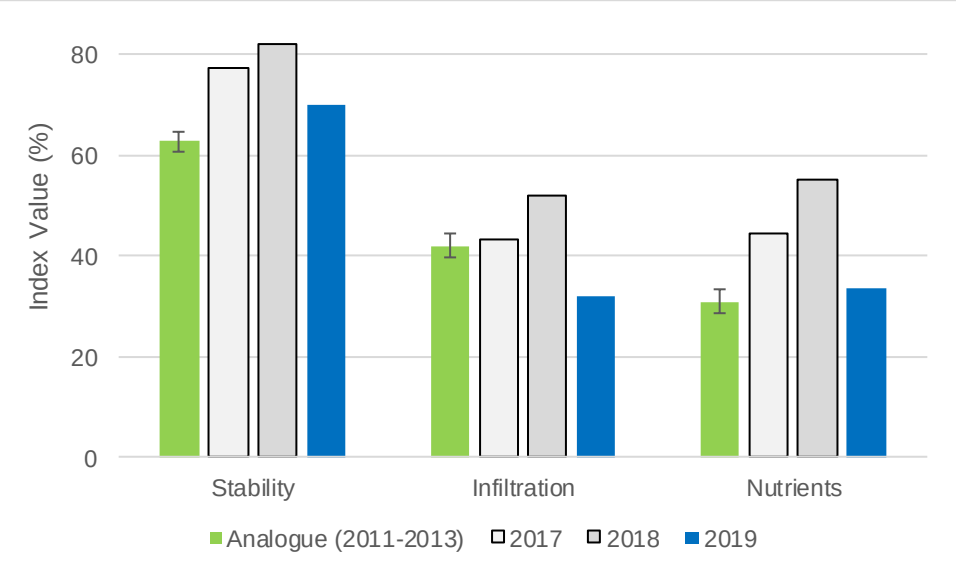

Figure 34. Landscape function indices change (2017-2019) for KANODO RT 19 with respect to mean analogue site values (2011-2013).

Table 16. Summary of the landscape organisation data for KANODO analogue and KANODO RT 19 rehabilitation site 2017-2019.

Site Type	No. of patch zones per 10m	Total patch area (m²)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.6**
KANODO_RT19 Rehabilitation 2017	0.4	125.0	0	1.00
KANODO_RT19 Rehabilitation 2018	0.4	125.0	0	1.00
KANODO_RT19 Rehabilitation 2019	0.4	125.0	0	1.00

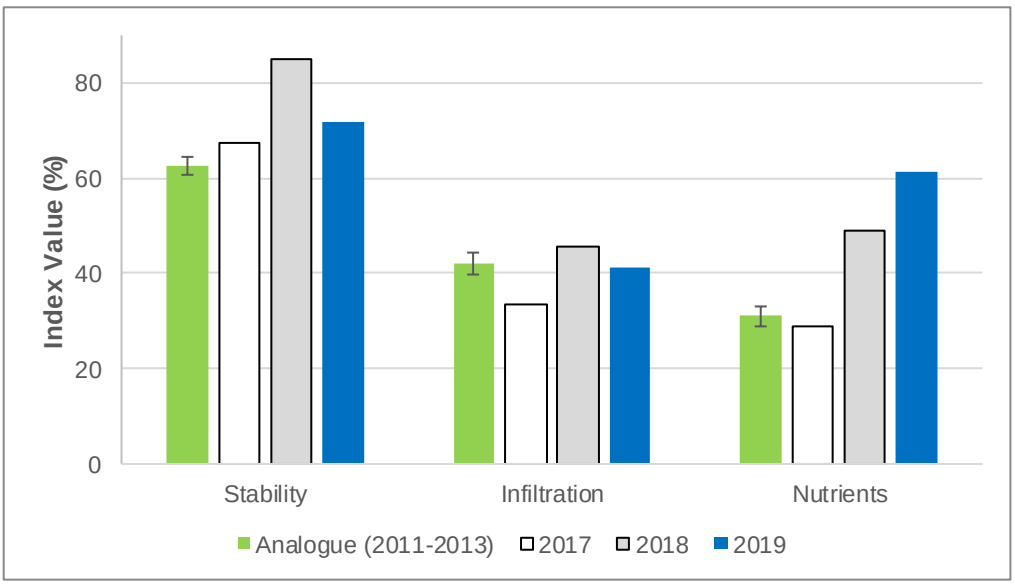

Figure 35. Landscape function indices change (2017-2019) for KANODO RT 20 with respect to mean analogue site values (2011-2013).

Table 17. Summary of the landscape organisation data for KANODO analogue and KANODO RT 20 rehabilitation site 2017-2019.

Site Type	No. of patch zones per 10m	Total patch area (m²)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.6**
KANODO_RT20 Rehabilitation 2017	0.4	125.0	0	1.00
KANODO_RT20 Rehabilitation 2018	0.4	125.0	0	1.00
KANODO_RT20 Rehabilitation 2019	0.4	125.0	0	1.00

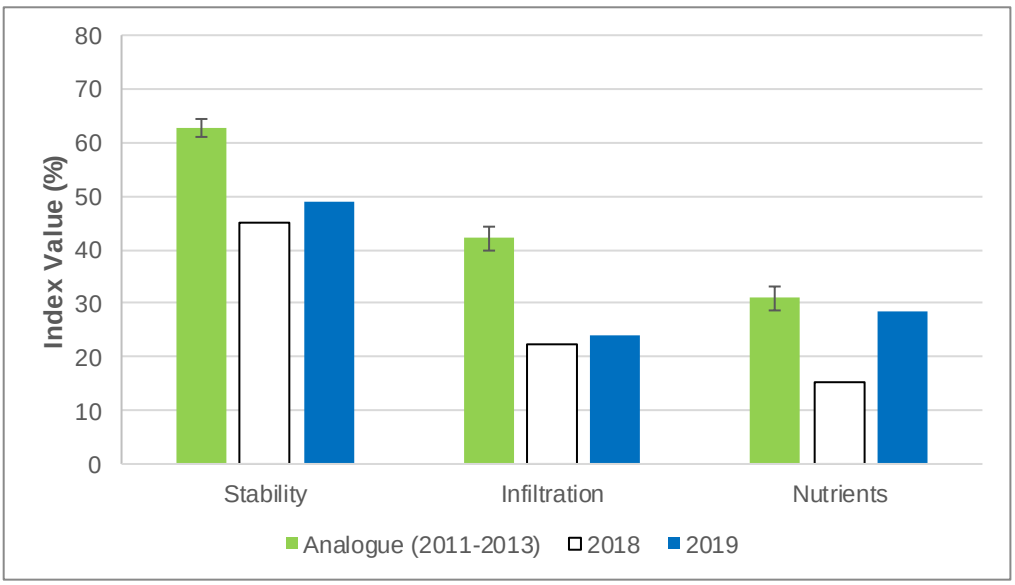

Figure 36. Landscape function indices change (2018-19) for KANODO RT 21 with respect to mean analogue site values (2011-2013).

Table 18. Summary of the landscape organisation data for KANODO analogue and KANODO RT 21 rehabilitation site 2018-19.

Site Type	No. of patch zones per 10m	Total patch area (m²)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**2.8**	**308.4**	**1.8**	**0.6**
KANODO_RT21 Rehabilitation 2018	0.4	125	1	1
KANODO_RT21 Rehabilitation 2019	2.0	124.5	0	1

4.4 *Lomandra effusa* (Scented Mat Rush) Grassland rehabilitation transects

4.4.1 KANLOM RT 01

Soil stability and infiltration are both below analogue values for this site, while nutrient levels in 2019 increased to exceed analogue values (Figure 37). Structural complexity has increased substantially from the previous years, with shrub and grass cover increasing substantially and interpatch cover decreasing proportionally (Figure 38, Appendix 3). At this early stage, landscape organisational values are trending well towards analogue values (Table 19).

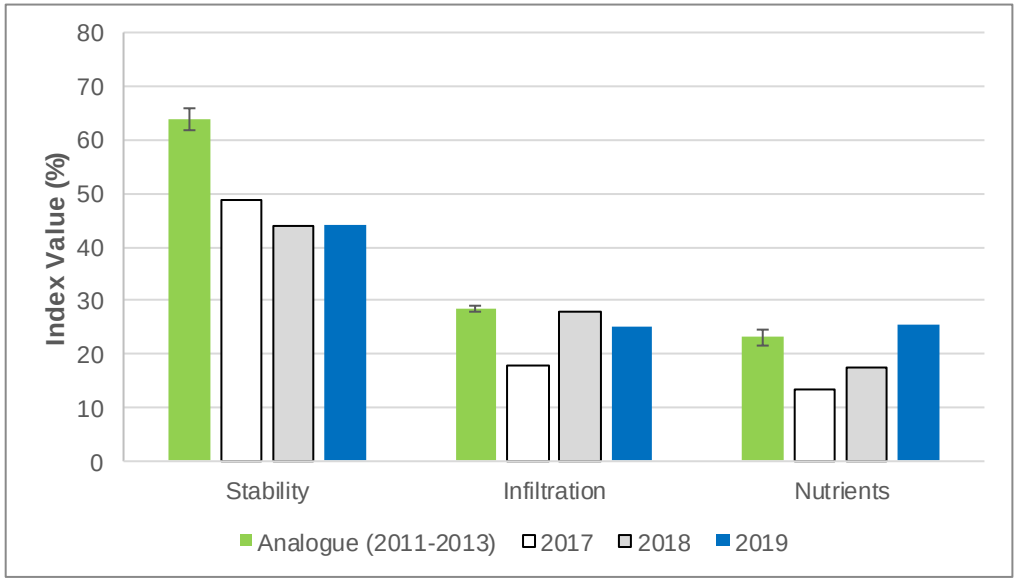

Figure 37. Landscape function indices change (2017-2019) for KANLOM RT 01 with respect to mean analogue site values (2011-2013).

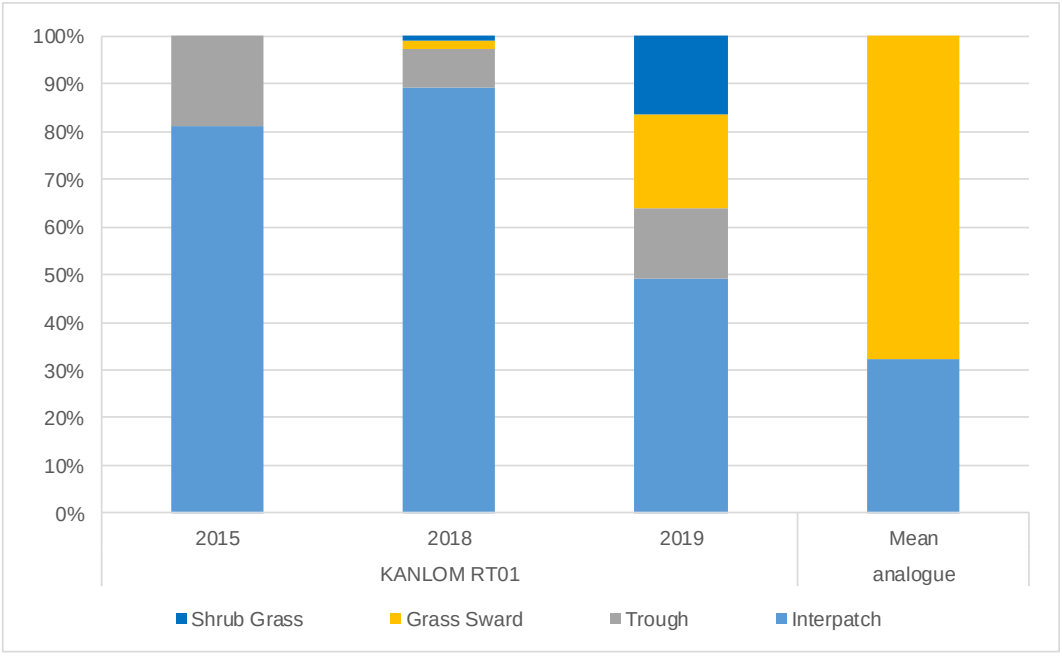

Figure 38. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANLOM RT 01.

Table 19. Summary of the landscape organisation data for KANLOM analogue and KANLOM RT 01 rehabilitation site 2017-2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**4.8**	**95.5**	**0.6**	**0.7**
KANLOM_RT01 Rehabilitation 2017	4.3	45.5	1.74	0.19
KANLOM_RT01 Rehabilitation 2018	2.8	19.3	0.81	0.11
KANLOM_RT01 Rehabilitation 2019	7.1	76.8	0.91	0.51

4.4.2 KANLOM RT 02

The current soil stability value for this site remains below the analogue, likely due to the soil physical properties within this area (Figure 39). However, values for infiltration and nutrients now exceed analogue values (Figure 39). At this point, there is still a significant difference between the transect proportion values and analogue values, including a substantial cover of shrubs, not present in analogue sites (Figure 40). Landscape organisation indices are all trending towards analogue values (Table 20).

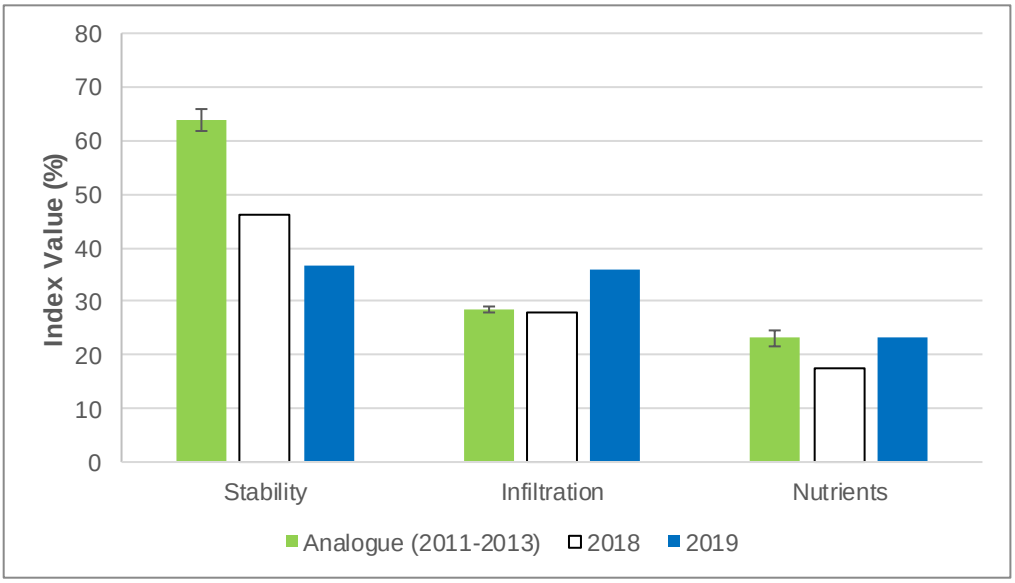

Figure 39. Landscape function indices change (2018-19) for KANLOM RT 02 with respect to mean analogue site values (2011-2013).

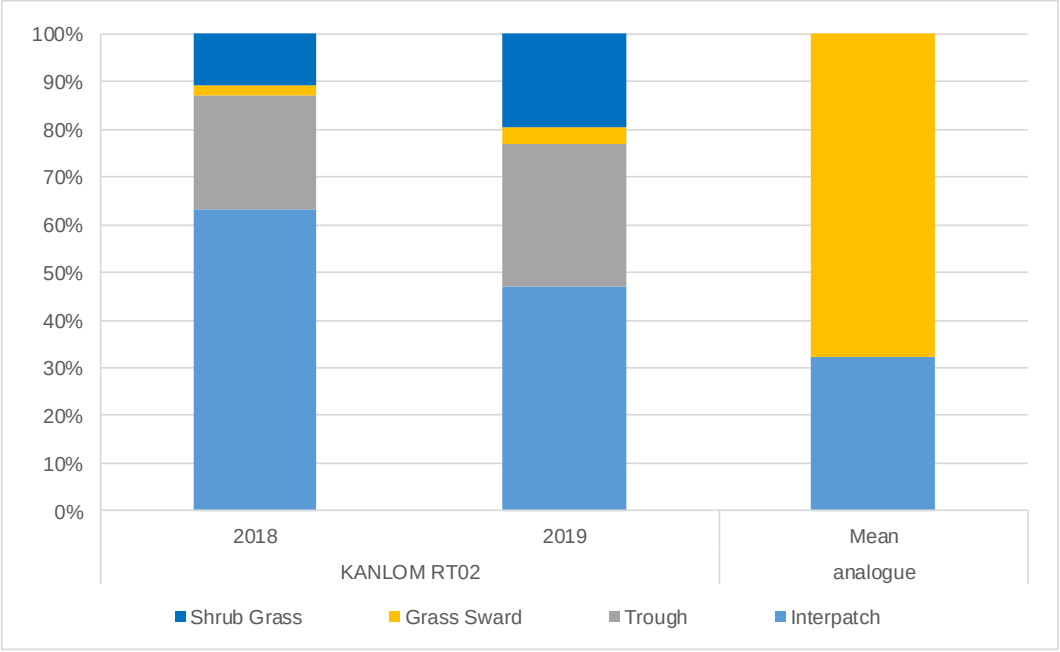

Figure 40. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANLOM RT 02.

Table 20. Summary of the landscape organisation data for KANLOM analogue and KANLOM RT 02 rehabilitation site 2018-2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**4.8**	**95.5**	**0.6**	**0.7**
KANLOM_RT01 Rehabilitation 2018	5.5	49.3	1.17	0.35
KANLOM_RT01 Rehabilitation 2019	6.0	85.9	0.99	0.53

4.5 *Acacia pycnantha* (Golden Wattle) Low Woodland transects

4.5.1 KANACA RT 01

In the third year of monitoring for this transect, the soil surface indicators are approaching or exceeding analogue values, with a slight decrease in stability compared with 2018 (Figure 41). Grass sward cover has increased commensurate with the decrease in shrub cover and the transect is approaching analogue composition and cover values (Figure 42). Patch zones are yet to stabilize as the vegetation continues to develop and transform through early successional stages (Table 21).

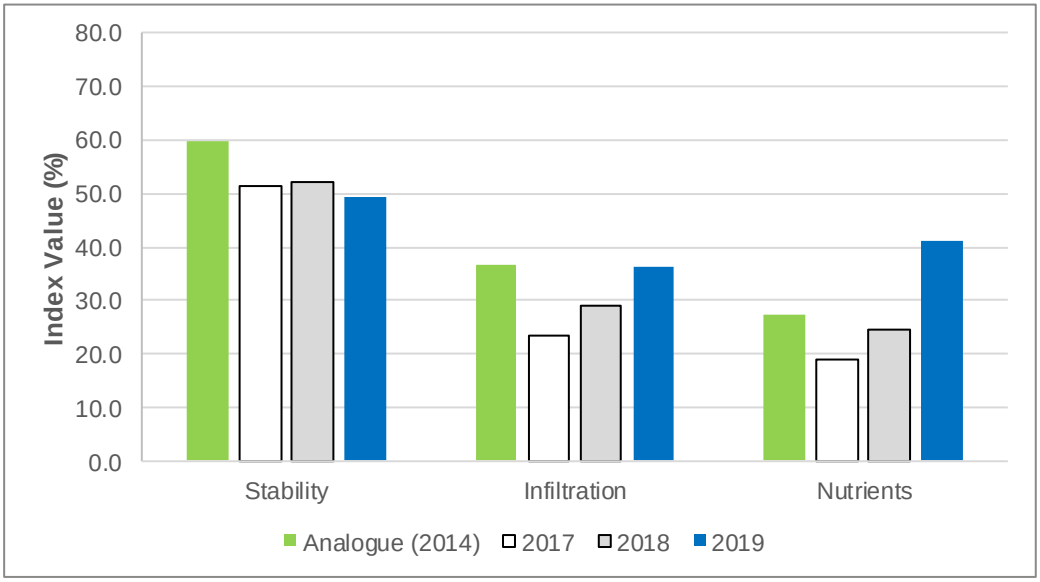

Figure 41. Landscape function indices change (2017-2019) for KANACA RT 01 with respect to mean analogue site values (2014).

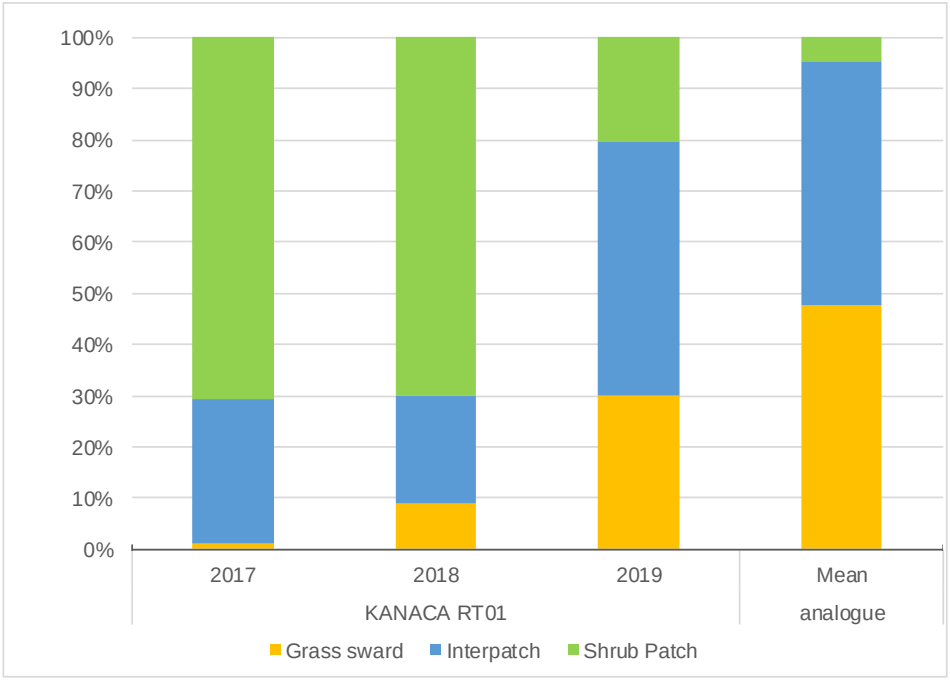

Figure 42. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANACA RT 01.

Table 21. Summary of the landscape organisation data for KANACA analogue and KANACA RT 01 rehabilitation site 2017-2019.

Site Type	No. of patch zones per 10m	Total patch area (m²)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2014	**4.7**	**141.6**	**1**	**0.7**
KANACA_RT01 Rehabilitation 2017	7.7	158.3	2.28	0.32
KANACA_RT01 Rehabilitation 2018	4.3	150.3	0.49	0.79
KANACA_RT01 Rehabilitation 2019	8.7	46.7	0.71	0.50

4.5.2 KANACA RT 02

The third year of monitoring of this patch has seen a continued increase in infiltration and nutrient cycling and a slight decrease in stability that is close to the analogue level (Figure 43). The transect cover continues to be a near monoculture of native grass species (Figure 43). Grass cover is likely to dominate in this site until overstory vegetation components (visible now in the photo point at Appendix 3) mature and compete with the grasses for limited resources. The landscape organisation value remained at 1 due to the uniform cover of grass (Table 22).

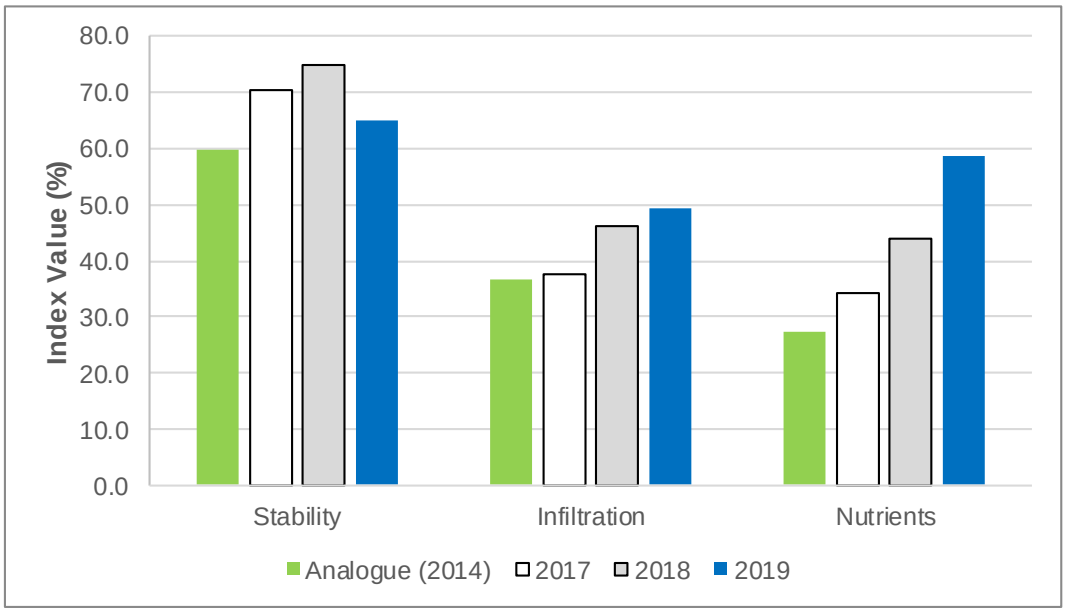

Figure 43. Landscape function indices change (2017-2019) for KANACA RT 02 with respect to mean analogue site values (2014).

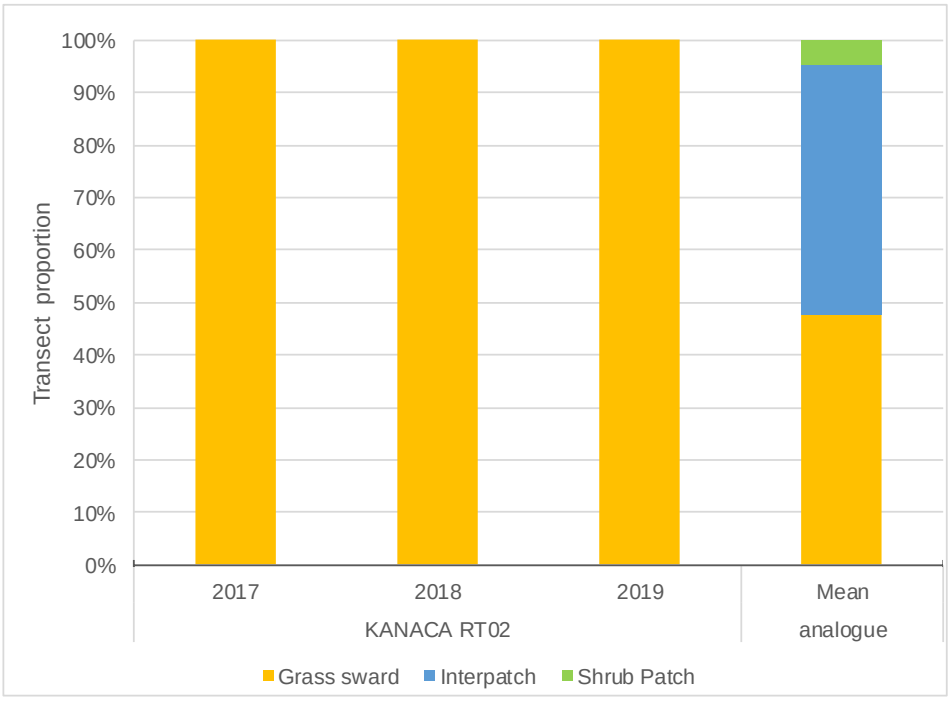

Figure 44. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANACA RT 02.

Table 22. Summary of the landscape organisation data for KANACA analogue and KANACA RT 02 rehabilitation site 2017-2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2014	**4.7**	**141.6**	**1**	**0.70**
KANACA_RT02 Rehabilitation 2017	**1**	**125**	**0**	**1.00**
KANACA_RT02 Rehabilitation 2018	**0.4**	**125**	**0**	**1.00**
KANACA_RT02 Rehabilitation 2019	**0.4**	**125**	**0**	**1.00**

4.5.3 KANACA RT 03

The second monitoring year for KANACA RT 03 showed similar results to 2018 for landscape function indices, with stability, infiltration and nutrients all remaining below analogue levels (Figure 45). Grass sward dominated the transect cover for both monitoring years, with a small trough area also present in both years (Figure 46). Patch area and number of patches was very low as expected in a newly restored patch (Table 23).

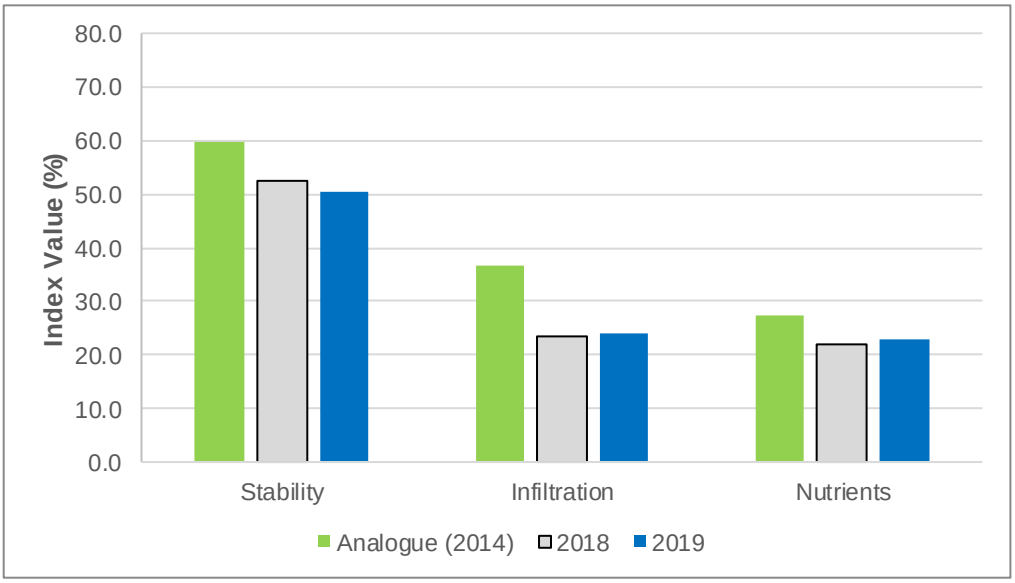

Figure 45. Landscape function indices change (2018-19) for KANACA RT 03 with respect to mean analogue site values (2014).

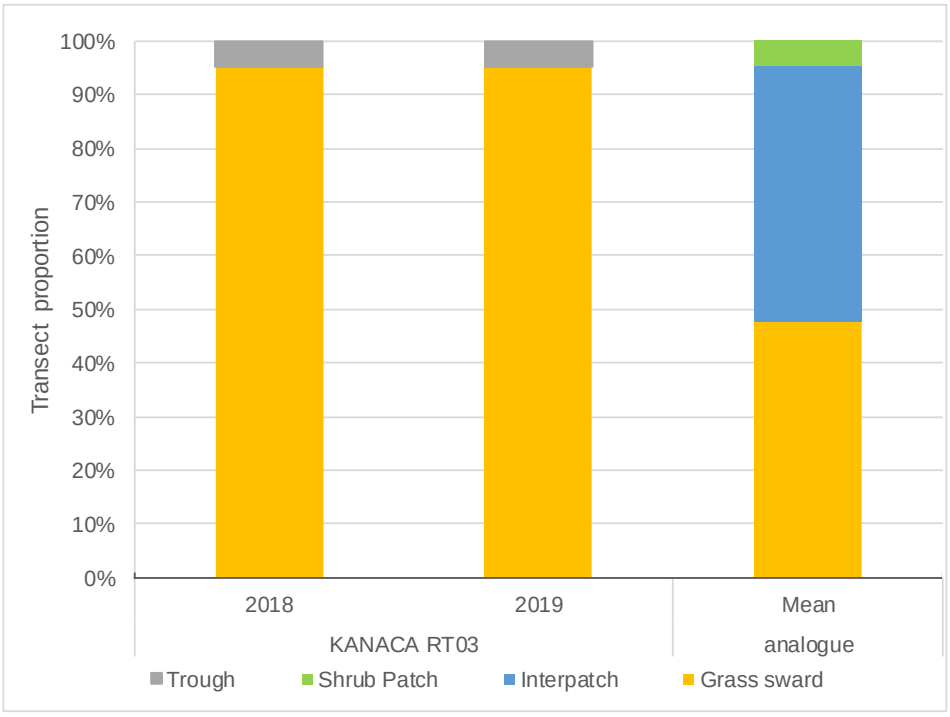

Figure 46. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANACA RT 03.

Table 23. Summary of the landscape organisation data for KANACA analogue and KANACART03 rehabilitation site 2018-19.

Site Type	No. of patch zones per 10m	Total patch area (m²)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2014	**4.7**	**141.6**	**1**	**0.7**
KANACA_RT03 Rehabilitation 2018	**0.3**	**0.48**	**14.3**	**0.05**
KANACA_RT03 Rehabilitation 2019	**1.0**	**173**	**0**	**1**

4.6 Grass Laydown area rehabilitation transect

4.6.1 KANGRA RT 01

The permanent grass laydown area established in 2012 now has a good cover of *Chloris truncata* (Windmill Grass) which was the original species planted. The trend of increasing functional attributes has continued in 2019 for infiltration and nutrient cycling, with the latter now above the mean analogue value.

The proportion of grass sward has gradually increased at this site since it was established in 2013, but decreased slightly in 2019 towards analogue site levels (Figure 47). Landscape organisation indices remain variable as patch number and area totals move towards a more stable state in the absence of significant disturbance (Table 24).

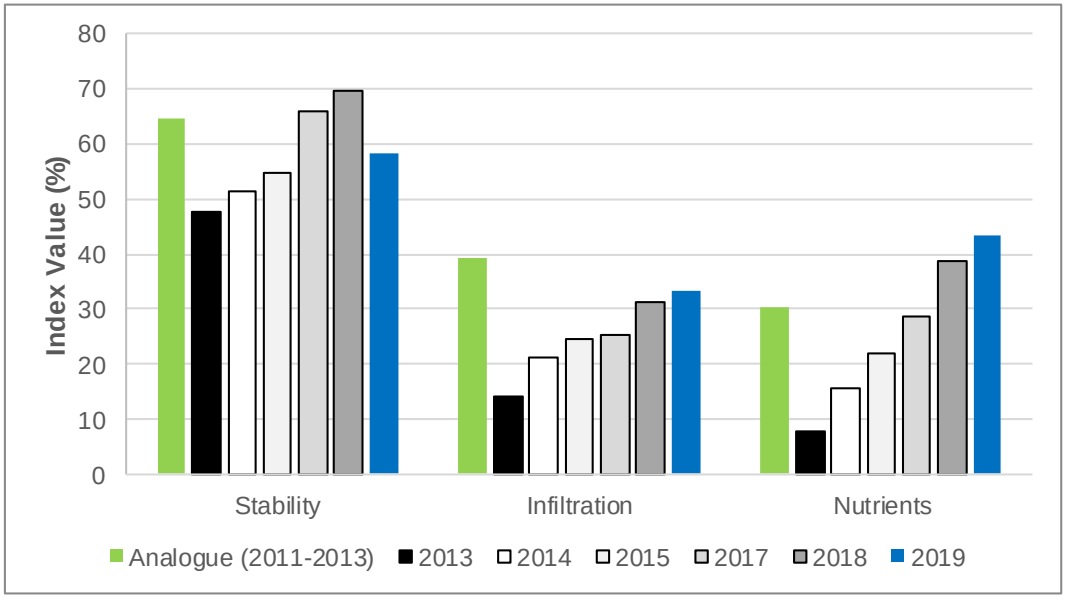

Figure 47 Landscape function indices change (2013-2019) for KANGRA RT 01 with respect to mean analogue site values (2011-2013).

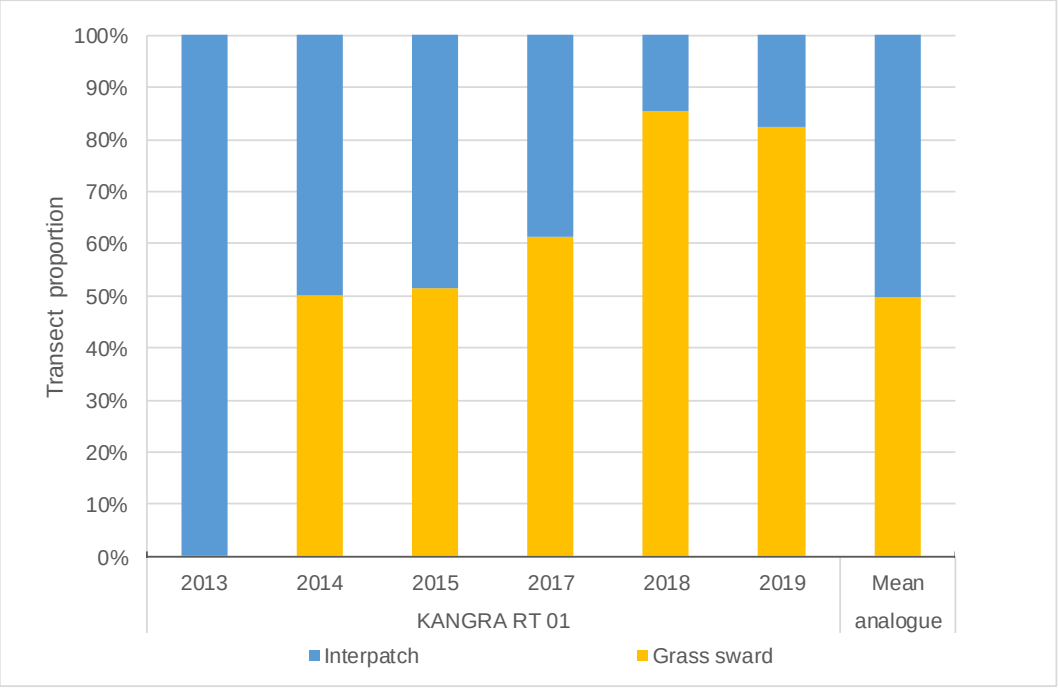

Figure 48. Percentage cover of each of the Surface Soil Assessment zones recorded at site KANGRA RT 01.

Table 24. Summary of the landscape organisation data for KANGRA analogue and KANGRA RT 01 rehabilitation site 2013-2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index*
Analogue 2011 -13	**4.7**	**179.1**	**0.5**	**0.74**
KANGRA1 Rehabilitation 2013	0	100	10	0
KANGRA1 Rehabilitation 2014	5	64.6	1.12	0.53
KANGRA1 Rehabilitation 2015	3	278.4	1.62	0.52
KANGRA1 Rehabilitation 2017	3.3	142.5	1.29	0.61
KANGRA1 Rehabilitation 2018	1.3	211.8	1.51	0.85
KANGRA1 Rehabilitation 2019	2.6	204.3	0.78	0.82

4.7 Grassy hillslope analogue sites

This section presents initial results for the four new LFA grassland monitoring sites established in 2019. These sites (KANGRA 10-13) were established as analogue sites on hill slopes with different aspects (see photopoints at Appendix 3), representative of hills in the surrounding landscape against which to measure future rehabilitation activities.

4.7.1 KANGRA 10-13

Soil surface indicators were generally similar across all four sites with noticeably lower stability for KANGRA 13 compared with the other three sites (Figure 49). All of these sites were dominated by grass sward cover with small rocky areas also present in all transects and small sedgeland patches present in KANGRA 11 (Figure 50).

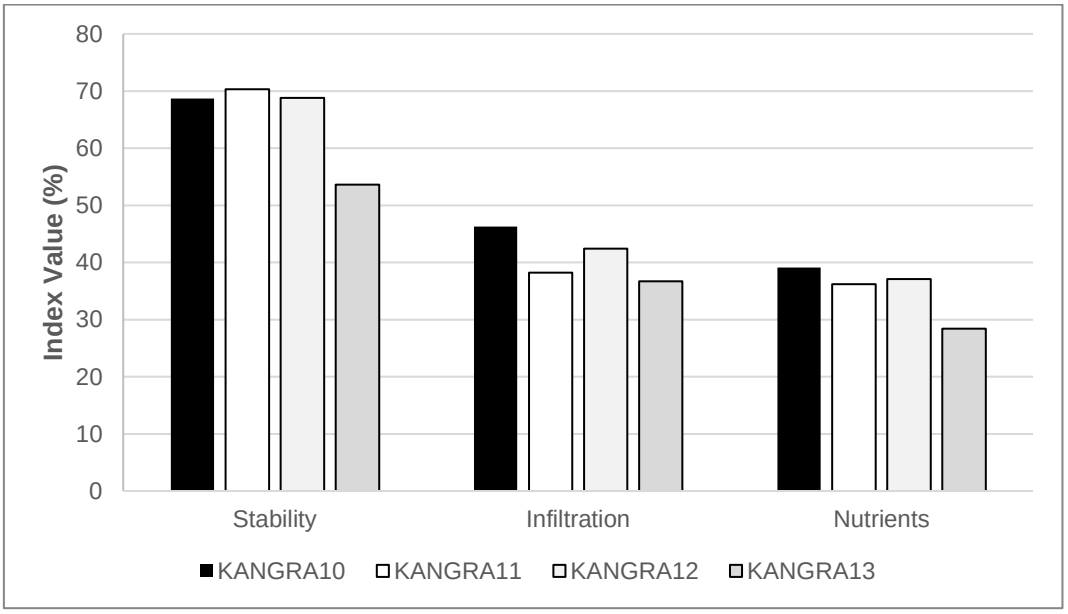

Figure 49. Landscape function analysis indices for the four newly established sites KANGRA 10-13.

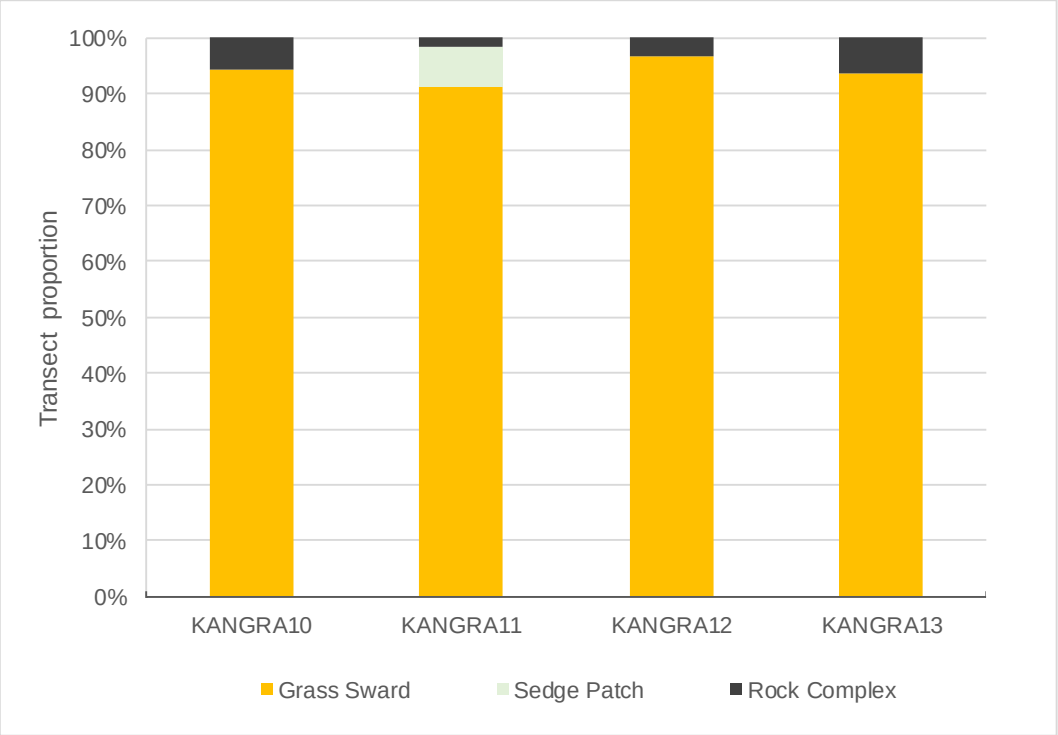

Figure 50. Percentage cover of each of the Surface Soil Assessment zones recorded at sites KANGRA 10-13.

Table 25. Summary of the landscape organisation data for new sites KANGRA 10-13 establlished in 2019.

Site Type	No. of patch zones per 10m	Total patch area (m^2)	Average inter-patch length (m)	Landscape Organisational Index*
KANGRA 10 2019	2.8	190.6	0	1.00
KANGRA 11 2019	5.2	183.4	0	1.00
KANGRA 12 2019	3.0	232.8	0	1.00
KANGRA 13 2019	3.0	240	0	1.00

5 DISCUSSION AND RECOMMENDATIONS

In general, the LFA indicators have shown positive rehabilitation trends over the life of the Kanmantoo monitoring program (2011-2019). Rehabilitation plots have typically reached a level of 'self-sustaining communities', relative to analogue sites, after a period of only 3-4 years.

For areas with the topsoil removed and works undertaken on the WRL which is subjected to bank and trough contour ripping, all indicators show that since inception of rehabilitation works, LFA function indices all achieve or exceed analogue values in the first few years. Sites where no treatment has occurred show below analogue values and downward trends in functional indices.

Based on the initial success rates of restoration activities across the Kanmantoo Mine Area, it is likely that ongoing works will result in similar functional trends as those observed using LFA to date. This includes initial low values, followed by a rebound period whereby plant cover produces high stability, infiltration and nutrient cycling values before stabilising back to analogue values.

The LFA sites monitored at Kanmantoo allow for sufficient data from which to detect trends in functional landscape-based attributes. Qualitative observations of rehabilitation success (i.e. field observations and photopoints) are supported by long-term quantitative LFA results.

Non-functional ecological vegetation attributes such as plant species richness (and whether species are native or exotic) are currently not recorded as part of the LFA monitoring program, limiting the ability of the program to determine the success of species of interest used in revegetation and seeding mixes. Species composition and germination success should be considered as part of ongoing monitoring to provide information on how species respond to specific restoration methods, thus informing future rehabilitation activities. Such information would also be useful for assessing: 1) overall trends in plant species abundance and diversity; and 2) impacts on vegetation from threats such as total grazing pressure.

Ongoing monitoring should continue to adapt in order to maximise the efficiency and effectiveness of detecting changes in LFA monitoring sites. Ongoing annual review and adaptation of the monitoring program is recommended, altering factors such as frequency of assessment, indicators measured and sampling locations.

6 REFERENCES

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7 APPENDICES

Appendix 1. Summary of LFA sites monitored and monitoring frequency 2011-2019.

Site name	Site type*	2011	2012	2013	2014	2015	2017	2018	2019	Easting	Northing
KANSTI 4	RH				P	P				319376	6115483
KANODORT20	RH						P	P	P	318732	6115394
KANODO RT21	RH							P	P	318482	6114090
KANODO RT19	RH						P	P	P	319062	6115176
KANODO RT18	RH						P	P	P	318988	6115623
KANODO RT17	RH					P	P	P	P	317308	6115933
KANODO RT16	RH					P	P	P	P	317324	6115923
KANODO RT15	RH					P	P	P	P	317348	6115912
KANODO RT14	RH					P	P	P	P	316941	6116079
KANODO RT13	RH					P	P	P	P	316974	6116086
KANODO RT12	RH					P	P	P	P	317006	6116086
KANODO RT11	RH					P	P	P	P	317021	6116090
KANODO RT10	RH					P	P	P	P	317051	6116090
KANODO RT07	RH					P	P	P	P	317131	6116083
KANODO 9	RH				P	P	P	P	P	317807	6114076
KANODO 8	RH				P	P	P	P	P	316735	6116444
KANODO 7	RH				P	P	P	P		319201	6115552
KANODO 6	RH	P	P	P	P	P	P	P	P	316537	6116233
KANODO 4	RH	P	P	P	P	P	P	P	P	316754	6116204
KANODO 5	RH	P	P	P	P	P	P	P	P	316751	6116127
KANLOM RT02	RH							P	P	318368	6114430
KANLOM RT01	RH						P	P	P	317786	6114369
KANLOM 8	RH				P	P				319346	6114276
KANLOM 7	RH				P	P				319071	6114078
KANLOM 6	RH				P	P				318438	6114177

KANLOM 5	RH				P	P				**318697**	**6114345**
KANLOM 4	RH				P	P				**319429**	**6115476**
KANGRA RT01	RH			P	P	P	P	P	P	**319155**	**6114300**
KANACA RT03	RH							P	P	**318361**	**6114074**
KANACA RT02	RH						P	P	P	**318818**	**6115697**
KANACA RT01	RH						P	P	P	**318482**	**6114758**
KANACA 4	AN				P					**318536**	**6114302**
KANACA 3	AN				P	P				**319538**	**6115467**
KANLOM1	AN	P	P	P						**317961**	**6114064**
KANLOM2	AN	P	P	P						**317963**	**6114040**
KANLOM3	AN	P	P	P						**317931**	**6114051**
KANODO1	AN	P	P	P						**317515**	**6115604**
KANODO2	AN	P	P	P						**317528**	**6115551**
KANODO3	AN	P	P	P						**318229**	**6115760**
KANSTI1	AN	P	P	P						**318063**	**6114321**
KANSTI2	AN	P	P	P						**318008**	**6114283**
KANSTI3	AN	P	P	P						**318130**	**6115752**
KANGRA2	RH			P						**319163**	**6114317**
KANGRA3	RH			P						**319180**	**6114339**
KANACA1	AN				P					**318326**	**6115281**
KANACA2	AN				P					**318347**	**6115328**
KANGRA 10	AN								P	**316490**	**6114929**
KANGRA 11	AN								P	**316343**	**6114870**
KANGRA 12	AN								P	**317408**	**6114149**
KANGRA 13	AN								P	**317382**	**6114100**

Appendix 2. Landscape Function Analysis (LFA) results summary 2011 – 2019.

Zones	Stability (%)								Infiltration (%)								Nutrients (%)							
	2011	2012	2013	2014	2015	2017	2018	2019	2011	2012	2013	2014	2015	2017	2018	2019	2011	2012	2013	2014	2015	2017	2018	2019
KANODO	61.2	60.5	66.3	-	-	-	-	-	37.5	44.3	44.4	-	-	-	-	-	26.8	31.7	34.5	-	-	-	-	-
KANODO4	68.9	60.5	67	65.9	61.5	63.8	56.4	60.6	52.5	54.1	56.1	56.8	62.7	40.3	42.8	38.1	46.2	38.7	48.2	46.9	48.5	30.3	36.2	30.8
KANODO5	69.8	63.6	64.2	61.3	58.9	63.8	65.1	59.7	55.5	54	60	54.2	48.9	42.3	37.9	33.5	48	39.1	47.3	39.7	30.2	30.9	30.7	27.4
KANODO6	66.9	61.3	65.2	63.8	58.8	65.2	61.7	61.1	54.4	55.3	56.1	56.9	55.6	41.4	38	48	46.5	39.6	44.6	45.8	42	31.1	29.1	35.8
KANODO8				48.7	49.5	59.1	62.9	64.3				26	20	21.9	22.3	23.4				16.67	13.26	17.1	17.9	26.2
KANODO9				48.5	61.7	74	72.2	65.9				21.2	31.2	27.1	31.7	34.6				15.8	22.8	30.4	33.5	55.2
KANODO RT_07					53	63.7	71	61.5					30.9	35.9	33.6	36.7					16.3	25.1	38.2	40.5
KANODO RT_10					51	57.6	60.9	49.4					28.1	23.8	18.3	25.4					12.6	14.3	16.4	22.9
KANODO RT_11					48.3	59.9	6.9	53.7					32.3	29.1	24.7	35.4					16.3	22.5	25.8	37.3
KANODO RT_12					49	60.1	68.1	55.5					31.2	27.6	25.6	24.7					16.7	20.1	27.2	32
KANODO RT_13					51	60.7	63.6	54.2					29.1	22.3	24.4	19.9					14	20	25.4	20.5
KANODO RT_14					32.2	58.6	58.2	56.4					30.9	20.6	21.4	19.3					15.4	18.8	21.3	20.3
KANODO RT_15					50	56.5	54.7	64.7					26.3	28.6	18.5	38.5					16.3	13.4	12.1	34.5
KANODO RT_16					50	62.6	57.2	54.6					38.6	25.3	27.3	40.6					15.4	18.3	22.8	43.7
KANODO RT_17					52.8	63.5	61.3	59.7					38.6	28.5	25.9	32.4					15.4	20.3	22.8	33.8
KANODO RT_18						76.5	78	64.8						49.9	50.8	47.4						47.4	51.6	64.6
KANODO RT_19						77.5	82	69.9						43.5	52.2	32						44.6	55.3	33.5
KANODO RT_20						67.5	85	71.8						33.6	45.6	41.4						28.8	48.8	61.5
KANODO RT_21							45	49.1							22.5	24.1							15.1	28.4
KANLOM	62.5	61.5	67.7						27.1	29.4	29						21.6	21.9	26.2					
KANLOM RT01						48.9	42.9	44						18	30.4	25.2						13.2	16.7	25.5
KANLOM RT02							46.1	36.8							28	36							17.5	23.1
KANACA_RT01						51.4	52	49.3						23.6	29.2	36.2						19	24.6	41
KANACA_RT02						70.5	75	64.8						37.7	46.1	49.3						34.4	44.1	58.5
KANACA_RT03							52.4	50.5							23.6	24							21.9	22.9
KANGRA RT01	-	-	47.5	51.5	54.7	65.9	69.5	58.1	-	-	14	21.4	24.6	25.3	31.4	33.2	-	-	7.7	15.8	21.8	28.7	38.6	43.3
KANGRA10								68.7								46.3								39.1
KANGRA11								70.3								38.2								36.2
KANGRA12								68.8								42.4								37.1
KANGRA13								53.6								36.7								28.4

Appendix 3. Annual LFA monitoring site photographs

Site: KANODO 04

2011

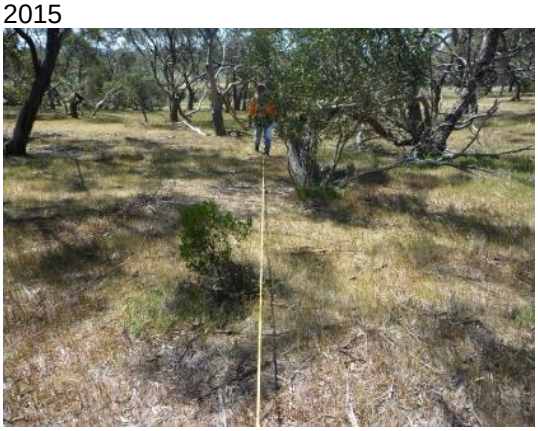
2012

2013

2014

2015

2017



2018

2019

Site: KANODO 05

2011

2012

2013

2014

2015

2017

2018

2019

Site: KANODO 06

2011

2012

2013

2014

2015

2017

2018

2019

Site: KANODO 08

2014

2015

2017

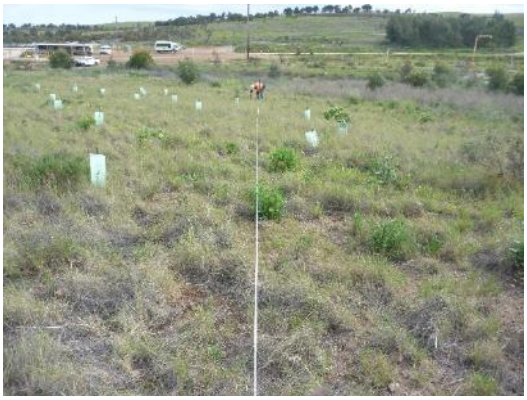
2018

2019

Site: KANODO 09

2014

2015

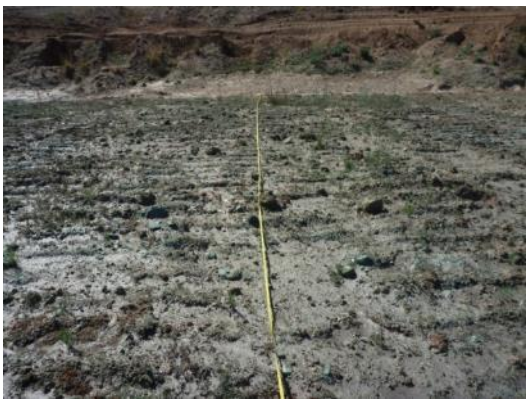


2017

2018

2019

Site: KANODO RT 07



2015

2017

2018

2019

Site: KANODO RT 10

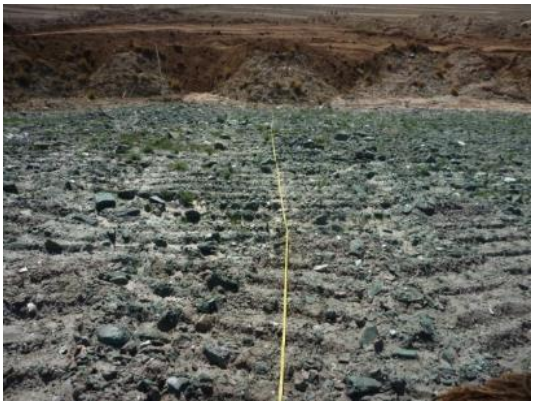
2015

2017

2018

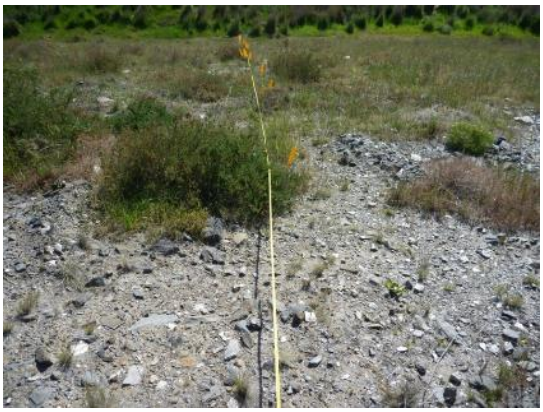
2019

Site: KANODO RT 11



2015

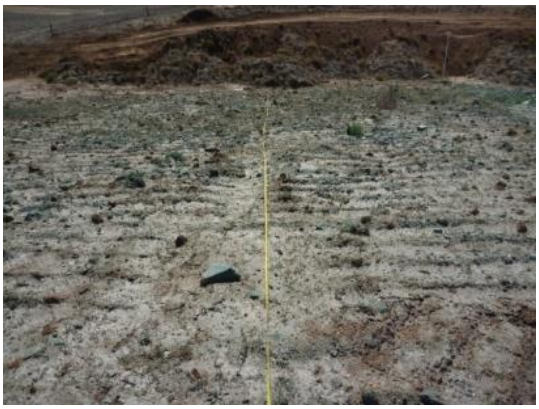
2017



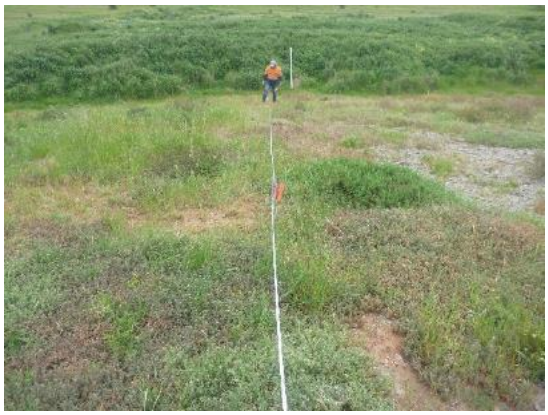
2018

2019

Site: KANODO RT 12



2015

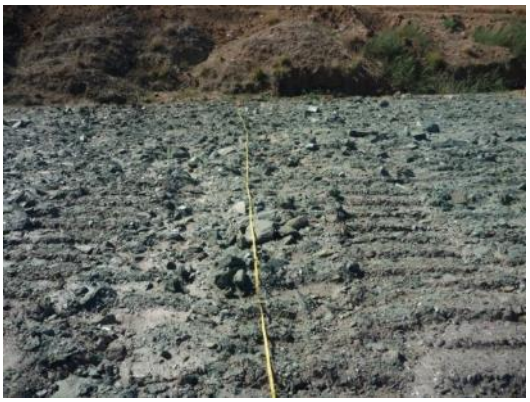


2017

2018

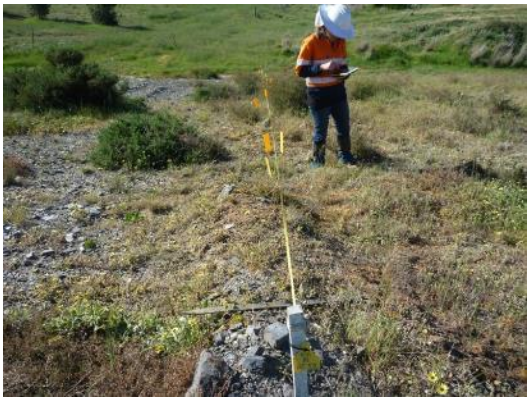
2019

Site: KANODO RT 13



2015

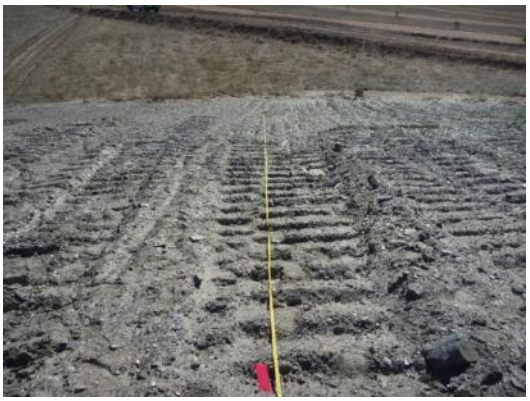
2017



2018

2019

Site: KANODO RT 14



2015

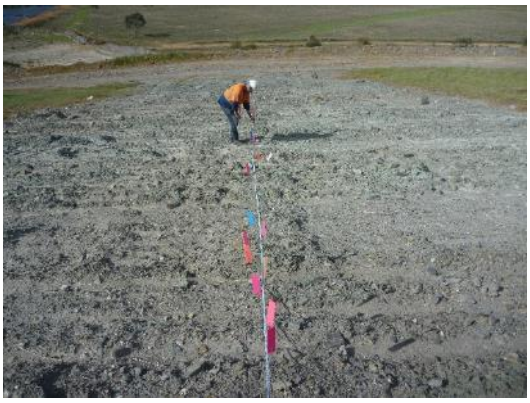
2017

2018

2019

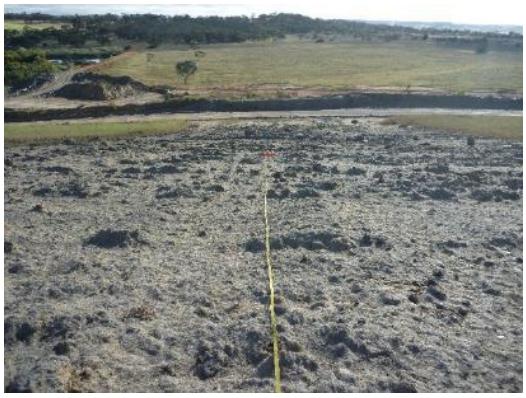
Site: KANODO RT 15

2015



2017

2018



2019

Site: KANODO RT 16

2015

2017

2018

2019

Site: KANODO RT 17

2015

2017

2018

2019

Site: KANODO RT 18

2017

2018

2019

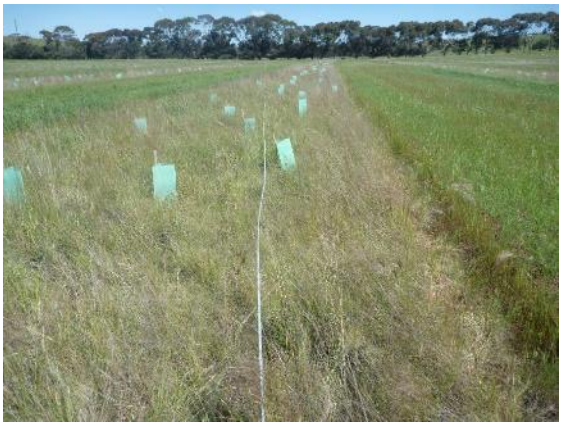
Site: KANODO RT 19

2017

2018

2019

Site: KANODO RT 20



2017

2018

2019

Site: KANODO RT 21

2018

2019

Site: KANLOM RT 01

2017

2018

2019

Site: KANLOM RT 02

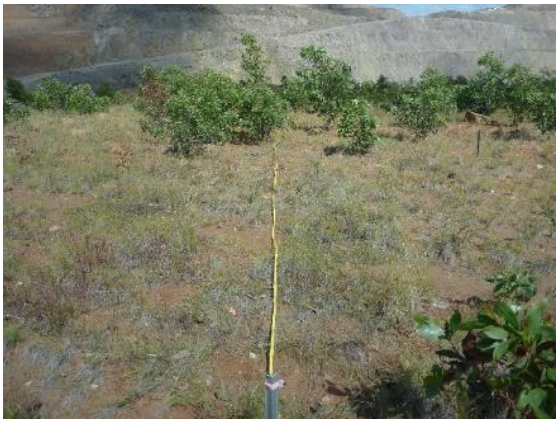
2018

2019

Site: KANACA RT 01

2017

2018



2019

Site: KANACA RT 02

2017

2018

2019

Site: KANACA RT 03

2018

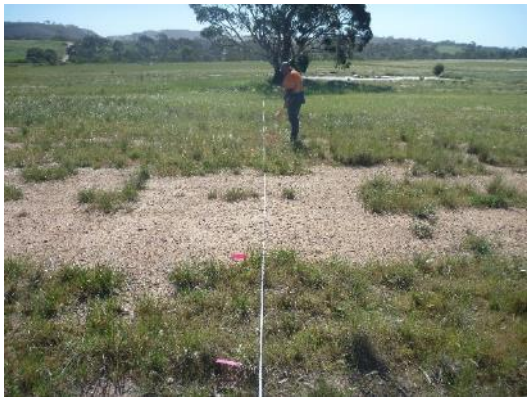
2019

Site: KANGRA RT 01

2013

2014

2015



2017

2018

2019

Site: KANGRA 10 (new analogue)

2019

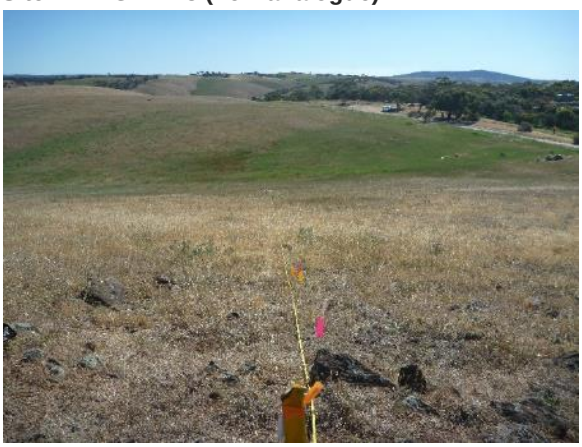
Site: KANGRA 11 (new analogue)

2019

Site: KANGRA 12 (new analogue)

2019

Site: KANGRA 13 (new analogue)



2019

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