Northparkes Mines

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2022/23 Annual Compliance Report

EPBC Approval 2013/6788

Freshwater turtle *native wildlife at Northparkes Mines 2022.*

CMOC | Northparkes

Pre-clearing Assessment-Step Change and Infill Extension Project

Infill Extension and E31 Areas

Northparkes Mines

2 August 2022

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1. Introduction

GHD Pty Ltd (GHD) was engaged by Northparkes Mines (NPM) to complete biodiversity pre-clearance surveys of the E31 and Infill Extension areas located at the Northparkes Mines facility, Goonumbla, NSW.

These surveys were completed as part of the:

– Northparkes Mines Step Change Project. Where biodiversity pre-clearance surveys are a condition of approval for the project and outlined in the EPBC Approval 2013/6788; and

– Northparkes Infill Extension Project. Where biodiversity pre-clearance surveys were completed as due diligence works as part of best practice guidelines for the North Parkes Mine.

This report presents the results of the pre-clearance assessments and provides recommendations to prevent or minimise potential impacts to ecology resulting from the clearing works.

1.1 Limitations

This report: has been prepared by GHD for Northparkes Mines and may only be used and relied on by Northparkes Mines for the purpose agreed between GHD and Northparkes Mines as set out in section 1 of this report.

GHD otherwise disclaims responsibility to any person other than Northparkes Mines arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

2. Site Information

The 'site' comprises two areas, identified as the E31 and Infill Extension clearance areas within Northparkes Mines, Goonumbla, as shown on Figure 1 below.

Figure 1 ***E31 and Infill Extension areas (shown with yellow hatching) within the Northparkes Mines site (shown with a red border)***

2.1 E31

The E31 open cut pit area is approximately 2.3 ha, approximately 1.5 ha (65%) is proposed to be cleared. Vegetation in E31 is mapped as Plant Community type (PCT) 56 Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW. Canopy species within the E31 area consisted of *Eucalyptus populnea* (Poplar Box) and *Callitris glaucophylla* (White Cypurus Pine). E31 is a patch of remnant vegetation surrounded by cleared paddock. Another larger patch of similar vegetation is located approximately 220 m east.

Photo 1 ***View of E31 (facing east) prior to clearing***

2.2 Infill Extension

The Infill TSF Extension proposed clearance area is approximately 5.3 ha. Vegetation is mapped as PCT 76 Western Grey Box tall grassy woodland on alluvial loam and clay soils in the NSW South Western Slopes and Riverina Bioregions. Canopy species within the Infill Extension area consisted almost exclusively of *Eucalyptus microcarpa* (Grey Box). The Infill Extension area comprises a mix of remnant vegetation and of vegetation planted by Northparkes Mines in the 1990s.

Photo 2 *View of vegetation within the northernmost Infill Extension area (facing east) prior to clearing*

3. Methods

The purpose of pre-clearing surveys was to assess woodland proposed for removal for signs of resident fauna and potential fauna habitat. In particular pre-clearing surveys targeted threatened species and any habitat critical to them from within vegetation proposed for removal.

The pre-clearing inspection was completed by two GHD Ecologists on 15 June 2022, and included the following:

- Identification and recording of any potential fauna habitat present within the clearing boundary, including but limited to:
  - nests;
  - hollow bearing trees (including Diameter at Breast Height (DBH));
  - large logs, rock piles and woody debris;
  - heath, sedges and soaks/swamps;
  - dense understorey shrubs;
  - burrows below groundcover vegetation, runways and other established fauna routes;
  - evidence of fresh scat; and
  - other habitat features for local fauna as determined by the ecologist.
- Recording of locations using a handheld GPS and details of identified potential habitat;
- Assessment for the presence of threatened flora and fauna species by thorough visual inspection of potential habitat features;
- Consideration of habitat present, and the likelihood of identified habitat to support threatened species likely to occur in the disturbance area; and
- The identification and location recording of any prevalent weed species identified on site.

Habitat features and existing weed species recorded during the site pre-clearing assessment are provided in Tables 1 and 2, Section 4.

4. Results

4.1 E31

Various ecologically valuable habitat features were identified during the E31 pre-clearing site assessment.

Nine trees with a DBH ranging between 50 cm and 90 cm contained small to medium-sized hollows (5 m to 20 cm diameter). A mud nest was observed in a White Cyprus Pine tree (ID.019), with down feathers observed on the opening of a 5cm-10 cm hollow on a Poplar Box (ID.004). Honeybees were also observed in a low 5 cm hollow in this tree.

Five stags with multiple small (<5 cm) to large (~30 cm) hollows were reported in the clearance area of E31. One stag (ID. 008) contained a straw and feather nest containing six large eggs (likely Australian Wood Duck eggs). Although no birds were observed at the nest, it is noted that it was in use as the clutch had grown to eight eggs two days after the initial observation (i.e. on the 18th June), as observed by Northparkes Mines Ecology staff.

Four medium to large fallen logs (up to 70 cm DBH) were identified within the area that may provide habitat for fauna. The logs identified were partially rotted, with some that contained multiple hollows that could provide potential shelter for fauna such as reptile and small mammal species.

No further habitat features were identified.

All observed habitat features were photographed and locations recorded with a handheld GPS for future re-identification during clearing surveys. The results of the survey are provided in Table 1 below. Selected, representative photographs are provided below. Each feature location is also provided below in Figure 2. It is noted that Features 1, 2 and 3 are located outside of the proposed clearance boundary, but have been included due to the proximity to the clearance area and the potential for disturbance.

Table 1. Habitat features observed in the proposed E31 clearance area. Co-ordinates are in GDA94, Zone 55

Feature ID	Feature Type	Species Name	Notes	Eastings	Northings
001	Logs	-	Large with hollows.	600145	6355717
002	Stag	-	To be retained. 2 x 5-10cm hollows.	600136	6355697
003	Tree	*Eucalyptus populnea*	DBH 80-90cm. 5-10cm hollow.	600149	6355683
004	Tree	*Eucalyptus populnea*	5-10cm hollows. Down feather on hollow opening. Low 5cm hollow with honeybees present.	600158	6355704
005	Stag		Low hollows on dead limbs (2 x 5-10cm).	600166	6355717
006	Tree	*Eucalyptus populnea*	Small hollow that may not be deep.	600166	6355712
007	Log	-	DBH 60-70cm.	600193	6355689
008	Stag	-	Large 20-30cm opening. Small opening 5-10cm. Six large eggs.	600200	6355699

Feature ID	Feature Type	Species Name	Notes	Eastings	Northings
009	Tree	*Eucalyptus populnea*	May have hollows. Multi-stemmed tree. DBH 50-60cm	600210	6355670
010	Stag		Large 20-30cm hollow in dead limb.	600223	6355689
011	Tree	*Eucalyptus populnea*	5-10cm hollow. DBH 60-70cm.	600197	6355710
012	Tree	*Eucalyptus populnea*	2 x 5-10cm hollows in spouts. DBH 70-80cm.	600172	6355736
013	Tree	*Eucalyptus populnea*	5-10cm hollow in spout. DBH 70-80cm.	600181	6355736
014	Stag	-	<5cm hollow. DBH 40-50cm.	600192	6355750
015	Stag	-	2 x 5-10cm hollows. 2 x <5cm hollows.	600203	6355739
016	Log	-	Fallen log.	600223	6355724
017	Tree	*Eucalyptus populnea*	10-20cm hollow.	600226	6355691
018	Log	-	Fallen log.	600229	6355692
019	Tree	*Callitris glaucophylla*	Mud nest	600225	6355785

Identified exotic species and listed weeds

While no Weeds of National Significance were identified, Capeweed (*Arctotheca calendula*), Spear thistle (*Cirsium vulgare*), Flaxleaf fleabane (*Conyza bonariensis*), Barley (*Hordeum sp.*), Common peppergrass (*Lepidium africanum*), Annual ryegrass (*Lolium rigidum*), Horehound (*Marrubium vulgare*), Sheep sorrel (*Rumex acetosella*), Wild Sage (*Salvia verbenaca*), Blackberry nightshade (*Solanum nigrum*) and Dutch clover (*Trifolium repens*) were reported in the E31 clearance area. Care should be taken to reduce the risk of weeds spreading in the area.

Incidental fauna sightings

Incidental fauna sightings/observations reported in the E31 area during pre-clearing is provided in Table 2 below.

Table 2 Fauna reported in E31

Species Name	Common Name	Observation Type
Aquila audax	Wedge-tailed Eagle	Observed
Chenonetta jubata	Australian Wood Duck	Observed
Cracticus nigrogularis	Pied Butcherbird	Observed
Elanus axillaris	Black-shouldered Kite	Observed
Eolophus roseicapilla	Galah	Observed
Grallina cyanoleuca	Magpie Lark	Observed
Manorina melanocephala	Noisy Miner	Observed
Platycercus eximius	Eastern Rosella	Observed
Polytelis swainsonii	Superb Parrot	Heard

Species Name	Common Name	Observation Type
Saxicola chrysorrhoa	Yellow-rumped Thornbill	Observed
Struthidea cinerea	Apostle Bird	Observed

Figure 2 ***E31 proposed clearance area (outlined in yellow) and observed habitat features (shown as red dots)***

Photo 2. Stag with large hollow and nest (feature ID 008)

4.2 Infill Extension

Various ecologically valuable habitat features were identified during the Infill Extension pre-clearing site assessment.

Thirty trees with DBH's ranging between 40 cm to 120 cm each contained small to medium (<5 cm to 20 cm diameter) hollows. A 10 cm-20 cm hollow in a Grey Box (ID.020) showed signs of grass parrot use with a grass parrot observed sitting in another large Grey Box (ID.023) with a DBH of ~100 cm and at least two 5 cm-10 cm hollows.

A stick nest was observed in a Grey Box (ID.030) with a very small nest of unknown composition identified in a Turpentine Bush (ID.042). A larger nest, potentially suitable for a Australian Raven / Australian Magpie / Pied Currawong) was observed at height in a Grey Box (ID.047) with three small to medium stick nests observed in an adjacent Grey Box (ID.048).

No stags or fallen logs were identified within the area that may provide habitat for fauna.

No further habitat features were identified.

All observed habitat features were photographed and locations recorded with a handheld GPS for future re-identification during clearing surveys. The results of the survey are provided in Table 2 below. Selected, representative photographs are provided below. Each feature location is also provided below in Figure 3.

Table 2. Habitat features observed in the proposed Infill Extension clearance area. Co-ordinates are in GDA94, Zone 55

Feature ID	Feature Type	Species Name	Notes	Eastings	Northings
020	Tree	*Eucalyptus microcarpa*	DBH 60-70cm. 10-20cm hollow with signs of bird use.	598684	6357932
021	Tree	*Eucalyptus microcarpa*	DBH 60-70cm. 10-20cm hollow in dead limb.	598683	6357952
022	Tree	*Eucalyptus microcarpa*	DBH 100cm. Possible hollow in fork.	598686	6357954
023	Tree	*Eucalyptus microcarpa*	DBH 100cm. 2 x 5-10cm hollow. Grass Parrot observed.	598647	6357967
024	Tree	*Eucalyptus microcarpa*	DBH 100cm. 5-10cm hollow in sprout. Possible hollow in fork.	598621	6357948
025	Tree	*Eucalyptus microcarpa*	DBH 50-60cm. 2 x <5cm hollows. 1 x 5-10cm hollow.	598563	6357956
026	Tree	*Eucalyptus microcarpa*	DBH 80-90cm. 5-10cm hollow in dead sprout.	598558	6357953
027	Tree	*Eucalyptus microcarpa*	DBH 30-40cm. <5cm hollow in dead sprout.	598535	6357959
028	Tree	*Eucalyptus microcarpa*	DBH 40-50cm.	598579	6357962
029	Tree	*Eucalyptus microcarpa*	5-10cm hollow in trunk that is suitable for parrots.	598570	6357959
030	Tree	*Eucalyptus microcarpa*	DBH 40-50cm. Stick nest present.	598581	6357986

Feature ID	Feature Type	Species Name	Notes	Eastings	Northings
031	Tree	*Eucalyptus microcarpa*	Hollow stem. DBH 10-20cm. 5-10cm hollow.	598546	6357991
032	Tree	*Eucalyptus microcarpa*	DBH 10-20cm. 1 x 5-10cm hollow.	598519	6357975
033	Tree	*Eucalyptus microcarpa*	DBH 40-50cm. 1 x 5-10cm hollow.	598507	6357963
034	Tree	*Eucalyptus microcarpa*	DBH 70-80cm. 1 x 5-10cm hollow in dead stem.	598639	6358014
035	Tree	*Eucalyptus microcarpa*	DBH 60-70cm. 1 x 10-20cm hollow.	598646	6358021
036	Tree	*Eucalyptus microcarpa*	DBH 40-50cm. 2 x 5-10cm hollow in limb.	598677	6358015
037	Tree	*Eucalyptus microcarpa*	DBH 50-60cm. 5-10cm hollow.	598701	6358008
038	Tree	*Eucalyptus microcarpa*	DBH 80-90cm. 1 x 10-20cm hollow. 1 x 5-10cm hollow.	598779	6358003
039	Tree	*Eucalyptus microcarpa*	DBH 20-30cm. 5-10cm hollow.	598758.146	6357979
040	Tree	*Eucalyptus microcarpa*	DBH 100cm. 5-10cm hollow.	598794	6357996
041	Tree	*Eucalyptus microcarpa*	DBH 90-100cm. 1 x 10-20cm hollow. 1 x 5-10cm hollow.	598843	6357962
042	Nest	*Eremophila sturtii*	Tiny nest in Turpentine Bush.	598848	6357995
043	Tree	*Eucalyptus microcarpa*	DBH 80-90cm. 1 x 10-20cm hollow. 1 x 5-10cm hollow.	598858	6357990
044	Tree	*Eucalyptus microcarpa*	DBH 70-80cm. 1 x 10-20cm.	598859	6357987
045	Tree	*Eucalyptus microcarpa*	DBH 70-80cm. 5-10cm hollow in sprout.	598910	6357972
046	Tree	*Eucalyptus microcarpa*	DBH 110-120cm. 2 x <5cm hollows. 2 x 5-10cm hollows.	598889	6357899
047	Tree	*Eucalyptus microcarpa*	DBH 50-60cm. Possible raptor or raven nest.	598854	6357978
048	Tree	*Eucalyptus microcarpa*	DBH 100cm. 3 x stick nests.	598817	6357916
049	Tree	*Eucalyptus microcarpa*	DBH 50-60cm. 5-10cm hollow.	598799	6357922
050	Tree	*Eucalyptus microcarpa*	DBH 60cm. 5-10cm hollow in trunk.	598799	6357928

Identified exotic species and listed weeds

While no Weeds of National Significance were identified, Carex (*Carex sp.),* Spear Thistle (*Cirsium vulgare*), St John's Wort (*Hypericum perforatum*), Catsear (*Hypochaeris radicata*), Common peppergrass *(Lepidium* *africanum*), Lily flower (*Lilium sp*.) Sheep sorrel (*Rumex acetosella* and Dutch clover (*Trifolium repens*) were reported in the Infill extension clearance area. Care should be taken to reduce the risk of weeds spreading in the area.

Incidental fauna sightings

Incidental fauna sightings/observations reported in the infill extension area during pre-clearing is provided in Table 4 below.

Table 4 Fauna reported in the Infill Extension area

Species Name	Common Name	Observation Type
Aquila audax	Wedge-tailed Eagle	Observed
Chenonetta jubata	Australian Wood Duck	Observed
Cracticus nigrogularis	Pied Butcherbird	Observed
Elanus axillaris	Black-shouldered Kite	Observed
Eolophus roseicapilla	Galah	Observed
Grallina cyanoleuca	Magpie Lark	Observed
Manorina melanocephala	Noisy Miner	Observed
Platycercus eximius	Eastern Rosella	Observed
Polytelis swainsonii	Superb Parrot	Heard
Saxicola chrysorrhoa	Yellow-rumped Thornbill	Observed
Struthidea cinerea	Apostle Bird	Observed

Figure 3. Infill Extension proposed clearance area (outlined in yellow) and observed habitat features (shown as red dots)

Photo 3 *Infill Extension (Grey Box woodland)*

5. Discussion and Conclusion

The pre-clearing inspections identified a number of existing and potential fauna habitats, including nests with eggs, and hollows with signs of use (i.e. wear and feathers around the hollow entrance). The habitat features identified on site and recorded within this document will be re-identified on site during the supervised clearing process. These habitat features would be monitored on site during clearing to determine the presence of, and mitigate the risk to, fauna during clearing activities within the site.

The E31 area provides a moderate to high habitat value given that it is a remnant stand of Poplar Box woodland with multiple large hollows, and given its observed use by fauna (e.g. birds foraging within trees, and nests recorded in trees). While isolated, this stand occurs within 220m of a larger stand of woodland, and may provide ‘stepping stone’ habitat for some fauna species including birds.

One hollow-bearing tree (Feature ID 008) within the E31 area, was recorded as containing six large eggs. The installation of a motion camera targeting the nest for the following two consecutive days, recorded an increase in clutch size to eight, the clutch being brooded inconsistently and the avian species using the nest unable to be identified. Based on the characteristics of the nest and the size, shape and colour of the eggs, the clutch size, and time of year in which the eggs were laid, it was determined that it was likely to come from the Australian Wood Duck (with adults also recorded in the E31 area). As such, the clutch is unlikely to belong to any threatened species likely to occur in the area (i.e Barking Owl), and as the clutch is not currently being brooded consistently, the removal of the eggs and nest during clearing as planned is not likely to injure any adult fauna.

The Infill Extension area comprises a mix of both planted vegetation and remnant Grey Box woodland. Given the high number of hollows and potential hollows, this area also provides a medium to high habitat potential for fauna species. However, it is noted that, while containing some remnant vegetation, the vegetation patch does not comprise intact native vegetation, additionally (and as with the E31 area), suitable alternative habitat for fauna is available nearby.

Threatened species and habitat identified during pre-clearing surveys are to be managed as per the Northparkes Flora and Fauna Management Plan and Northparkes Site Disturbance Standard Operating Procedures.

A post-clearance report should be completed following the removal of habitat features.

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Post-Clearing Report – Step Change and Infill Extension Project

Infill Extension and E31 Areas

Northparkes Mines

2 August 2022

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Project name	Northparkes E44 Rocklands Biodiversity Assessment
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1. Introduction

GHD Pty Ltd (GHD) was engaged by Northparkes Mines (NPM) to complete biodiversity pre-clearance surveys and clearing supervision of the E31 and Infill Extension areas located at the Northparkes Mines facility, Goonumbla, NSW.

These surveys were completed as part of the:

- Northparkes Mines Step Change Project. Where biodiversity pre-clearance surveys and clearing supervision are a condition of approval for the project and outlined in the EPBC Approval 2013/6788; and
- Northparkes Infill Extension Project. Where biodiversity pre-clearance surveys and clearing supervision were completed as due diligence works as part of best practice guidelines for the North Parkes Mine.

All clearing supervision was undertaken by a qualified fauna ecologist. The process was conducted with reference to the Northparkes Flora and Fauna Management Plan and Northparkes Site Disturbance Standard Operating Procedures and, where applicable, the recommendations of the Pre-clearing Survey Report[1].

This report presents the observations made during clearance, and any assessments and provides recommendations to prevent or minimise potential impacts to biodiversity values resulting from the clearing works.

1.1 Limitations

This report: has been prepared by GHD for Northparkes Mines and may only be used and relied on by Northparkes Mines for the purpose agreed between GHD and Northparkes Mines as set out in section 1 of this report.

GHD otherwise disclaims responsibility to any person other than Northparkes Mines arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

[1] GHD (2022) *Pre-clearing Assessment, Infill Extension and E31 Areas* (ref.12551921)

2. Background

3. Site Description

The 'site' comprises two areas, identified as the E31 and Infill Extension clearance areas within Northparkes Mines, Goonumbla, as shown on Figure 1 below.

Figure 1 *E31 and Infill Extension areas (shown with yellow hatching) within the Northparkes Mines site (shown with a red border)*

3.1 E31

The E31 area is approximately 2.3 ha, of which, approximately 1.5 ha was cleared. Vegetation in E31 is mapped as Plant Community type (PCT) 56 Poplar Box - Belah woodland on clay-loam soils on alluvial plains of north-central NSW. Canopy species within the E31 area consisted of *Eucalyptus populnea* (Poplar Box) and *Callitris glaucophylla* (White Cypress Pine).

3.2 Infill Extension

The Infill Extension clearance area is approximately 5.3 ha. Vegetation is mapped as PCT 76 Western Grey Box tall grassy woodland on alluvial loam and clay soils in the NSW South Western Slopes and Riverina Bioregions.

Canopy species within the Infill Extension area consisted almost exclusively of *Eucalyptus microcarpa* (Grey Box). The Infill Extension area comprises four areas of vegetation planted by Northparkes Mines in the 1990s.

4. Method

4.1 Pre-clearing assessment and habitat identification

As mentioned in Section 1, a pre-clearance assessment was completed for the areas prior to clearance, as reported in GHD (2022) *Pre-clearance Surveys, E31 and Infill Extension Areas* (ref. 12551921 – GHD, 2022). However, an additional area with the Infill Extension area (shown in the below Figure 2) was not previously assessed. A pre-clearance survey was completed this additional area in conjunction with clearing supervision.

Figure 2 ***Infill Extension area showing the area previously assessed in GHD (2022) (shown in teal) and the additional area assessed during clearing works (shown in magenta)***

The aim of the pre-clearance inspection was to identify habitat features and fauna that were likely to inhabit within, and adjacent to the impact area, including nests, hollows, logs and burrows. Signs of use including animal tracks and fresh scat was also recorded. A list of the pre-clearance habitat features, and observations made during clearance activities, are provided in Tables 1 and 2 (Section 5).

4.2 Vegetation clearing

All habitat features identified during the pre-clearing survey and those identified during clearance supervision were cleared under the supervision of a qualified GHD ecologist on 20 and 21 June 2022. Trees were felled as per the Northparkes tree- felling procedure as outlined below:

- All felling of trees with significant habitat features **requires supervision by a qualified ecologist**, with a WIRES representative either present or on stand-by during clearing works
- All trees assessed to have potential significant habitat features has been marked in the field with pink spray paint
- Prior to the heavy machinery approaching the marked tree, a brief visual inspection of the tree will be undertaken by the ecologist
- All staff on foot will vacate into an area that is (1) safe from heavy vehicle interactions and; (2) where positive communications with the heavy vehicle operator is possible
- Once visual inspection is complete and no immediate ecological issues are identified, the heavy machinery will approach the marked tree and **shake the tree** for **a minimum of thirty seconds**
- The heavy machinery will **wait a minimum of 30 seconds** to allow fauna to leave tree. If it is evident that fauna have not left tree, this process (shake then wait) should be repeated.
- Once the ecologist has signaled that the tree is ready to be felled, the heavy machinery operator is to **lower the marked tree as gently as possible**
- The heavy machinery operator is to park up and signal that it is safe for the NPM staff on foot to inspect the tree. The ecologist will inspect the felled tree for any fauna.
  - Capture of displaced fauna by suitably qualified persons
  - If any injured fauna are discovered, a WIRES representative or veterinary will be contacted for consultation.
- Felled trees will be rolled so that the number of hollows blocked against the ground are minimized
- All felled trees to remain in place overnight to allow any unidentified fauna to escape
- Heavy machinery is to move onto next marked tree

The clearing of habitat resources commenced with an initial site walkover by GHD to identify any potential resident fauna still utilising the site. Clearing of habitat resources was conducted in a two-step process which involved initial disturbance of the habitat prior to clearing. This included tapping the habitat resources, followed by rolling the logs over, which were then inspected by the supervising ecologist before complete removal from the site. Habitat resources were relocated to the edge of the site to be relocated to a suitable location.

At the completion of clearing activities on the site the site ecologist conducted a final site examination to identify any potentially injured or deceased fauna.

5. Results

5.1 Vegetation removal and habitat clearance

Habitat clearing was completed under GHD ecologist supervision on 20 and 21 June 2022. The weather was sunny and mild, with temperatures of approximately 18 degrees celsius during the day, based on weather station data nearest to the site (i.e Parkes Airport - BoM[2]). West/north-westerly wind of approximately 17 km/h was

[2] BoM Parkes Airport Weather Station Data **June 2022**

experienced during clearing surveys. The supervision was completed up to one week following the pre-clearing surveys and targeted habitat features identified in the surveys (as reported in GHD, 2022).

Habitat resources were relocated to the edge of the site to be relocated to an adjacent location. Hollows of a suitable size for superb parrots were identified, in order to be salvaged by Northparkes environmental staff for later use within areas of nearby woodland.

The Australian Wood Duck nest located in E31 (site feature no.008 as referenced in GHD, 2022) was unable to remain in-situ due to the location of the tree. However, no ducks were present on the nest and the eggs were not being incubated, therefore the nest was not salvaged prior to the removal of the stag.

5.1.1 E31

Habitat features and observations for E31 are provided in Table 1, with site features shown on Figure 3.

Table 1. Habitat Features observed in the E31 clearance area. Co-ordinates are in GDA94, Zone 55

Feature ID	Feature Type	Species Name	Notes	Eastings	Northings
001	Tree	-	Tree retained	600145	6355717
002	Stag	-	Stag retained 2 x 5-10cm hollows.	600136	6355697
003	Tree	*Eucalyptus populnea*	Tree retained DBH 80-90cm. 5-10cm hollow.	600149	6355683
004	**Tree**	***Eucalyptus populnea***	**Tree removed** **5-10cm hollows.** **Down feather on hollow opening.** **Low 5cm hollow with honeybees present.**	**600158**	**6355704**
005	Stag	*Eucalyptus populnea*	Stag removed Low hollows on dead limbs (2 x 5-10cm).	600166	6355717
006	Tree	-	Tree removed No signs of fauna use	600166	6355712
007	Log	-	Log removed No signs of fauna use	600193	6355689
008	Stag	-	Stag removed Large 20-30cm hollow. Small 5-10cm hollow. Large eggs recorded (likely Australian Wood Duck).	600200	6355699
009	Tree	*Eucalyptus populnea*	Tree removed 10-20cm hollow. No depth in fork. ~5cm deep. No evidence of fauna use	600210	6355670
010	Stag	*Eucalyptus populnea*	Stag removed 10-15cm wide hollow in dead stem. Very deep >2m.	600223	6355689
011	Tree	*Eucalyptus populnea*	Tree removed 5-10cm hollow. Full with water.	600197	6355710

Feature ID	Feature Type	Species Name	Notes	Eastings	Northings
012	Tree	*Eucalyptus populnea*	Tree removed 5-10cm hollow on limb. No depth.	600172	6355736
013	Tree	-	Tree removed Insufficient depth for a hollow	600181	6355736
014	Stag	-	Stag removed All hollows rotted. No fauna signs.	600192	6355750
015	**Stag**	**-**	**Stag removed** **Microbat spp. flew out following tapping**	**600203**	**6355739**
016	Log	-	Log removed	600223	6355724
017	Tree	*Eucalyptus populnea*	Tree removed No suitable hollows	600226	6355691
018	Log	-	Log removed No signs of fauna use	600229	6355692
019	Tree	*Callitris glaucophylla*	Tree removed Mud nest – No signs of fauna/not an active nest	600225	6355785
051	**Tree**	**-**	**Tree retained** **1 x 10cm opening.** **Bees present.**	**600153**	**6355700**
052	Tree	-	Tree removed 1 x 5cm hollow. Shallow depth ~ 10cm.	600183	6355669
053	Stag	-	Stag removed Hollow 60cm deep. 5-10cm opening.	600153	6355745

Notes: Rows in bold indicate fauna recorded within habitat resources on-site

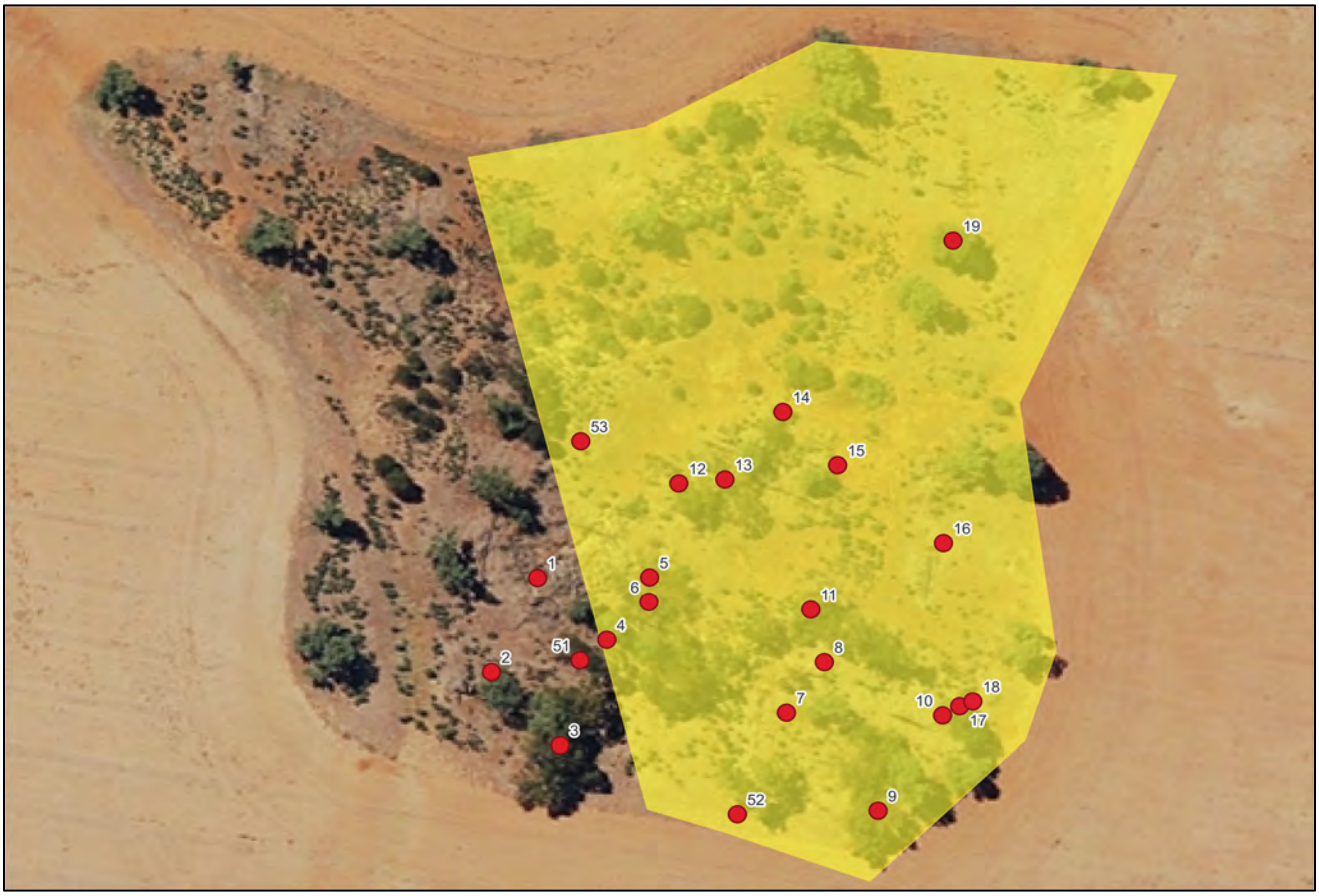

Figure 3. E31 cleared area (shown in yellow) with habitat features (shown as red dots)

5.1.2 Infill Extension

Habitat features and observations for the Infill Extension area is provided in Table 2, with site features shown on Figure 4.

Table 2. Habitat features observed in the Infill Extension clearance area. Co-ordinates are in GDA94, Zone 55

Feature ID	Feature Type	Species Name	Notes	Eastings	Northings
020	Tree	*Eucalyptus microcarpa*	Tree removed No suitable hollows. No signs of fauna use	598684	6357932
021	Tree	*Eucalyptus microcarpa*	Tree removed No suitable hollows. No signs of fauna use	598683	6357952
022	Tree	*Eucalyptus microcarpa*	Tree removed No suitable hollows. No signs of fauna use	598686	6357954
023	**Tree**	***Eucalyptus microcarpa***	**Tree removed** **Eastern Rosella recorded perching in tree prior to clearing.** **2 x 5-10cm hollows (deep chamber).** **2 x <5cm hollows (deep chamber).**	**598647**	**6357967**

Feature ID	Feature Type	Species Name	Notes	Eastings	Northings
			2 x 5-10cm hollows in dead sprout (no signs of fauna use).		
024	Tree	*Eucalyptus microcarpa*	Tree removed 5cm hollow with wide chamber. Old bee hive present.	598621	6357948
025	Tree	*Eucalyptus microcarpa*	Tree removed No suitable hollows. No signs of fauna use	598563	6357956
026	Tree	*Eucalyptus microcarpa*	Tree removed Depth of small hollow insufficient	598558	6357953
027	Tree	*Eucalyptus microcarpa*	Tree removed No suitable hollows. No signs of fauna use	598535	6357959
028	Tree	*Eucalyptus microcarpa*	Tree removed No suitable hollows. No signs of fauna use	598579	6357962
029	Tree	*Eucalyptus microcarpa*	Tree removed Depth of small hollow insufficient	598570	6357959
030	Tree	*Eucalyptus microcarpa*	Tree removed No suitable hollows. No signs of fauna use	598581	6357986
031	Tree	*Eucalyptus microcarpa*	Tree removed 2 x holloe spouts. Rotting and white ants present.	598546	6357991
032	Tree	*Eucalyptus microcarpa*	Tree removed 5-10cm hollow with 30-40cm deep chamber.	598519	6357975
033	Tree	*Eucalyptus microcarpa*	Tree removed No suitable hollows. No signs of fauna use	598507	6357963
034	Tree	*Eucalyptus microcarpa*	Tree removed No suitable hollows. No signs of fauna use	598639	6358014
035	Tree	*Eucalyptus microcarpa*	Tree removed Hole in bottom of tree 5 x good holes in stem. 10cm wide & 10cm deep (good hollow). ~3 x <5cm hollows. Old nest present.	598646	6358021
036	Tree	*Eucalyptus microcarpa*	Tree removed Depth of small hollow insufficient	598677	6358015
037	Tree	*Eucalyptus microcarpa*	Tree removed No suitable hollows. No signs of fauna use	598701	6358008
038	Tree	*Eucalyptus microcarpa*	Tree removed	598779	6358003

Feature ID	Feature Type	Species Name	Notes	Eastings	Northings
039	Tree	*Eucalyptus microcarpa*	Tree removed No suitable hollows. No signs of fauna use	598758.146	6357979
040	Tree	*Eucalyptus microcarpa*	Tree removed No suitable hollows. No signs of fauna use	598794	6357996
041	Tree	*Eucalyptus microcarpa*	Tree removed 2 x <5cm hollows. Falling sign. Not deep. No signs of fauna use	598843	6357962
042	**Nest**	***Eremophila sturtii***	**Tree retained** **Brushtail Possum present.**	**598848**	**6357995**
043	**Tree**	***Eucalyptus microcarpa***	**Tree removed** **Brushtail Possum present.** **10-15cm hollow opening.**	**598858**	**6357990**
044	Tree	*Eucalyptus microcarpa*	Tree removed Nest in the tree. No fauna present	598859	6357987
045	Tree	*Eucalyptus microcarpa*	Tree retained Adjacent tree had possum in split trunk.	598910	6357972
046	Tree	*Eucalyptus microcarpa*	Tree removed 2 x 5-10cm hollows. 10-20cm hollow. <5cm hollow. Brushtail Possum uninjured in adjacent tree.	598889	6357899
047	Tree	*Eucalyptus microcarpa*	Tree removed No suitable hollows observed	598854	6357978
048	Tree	*Eucalyptus microcarpa*	Tree retained	598817	6357916
049	Tree	*Eucalyptus microcarpa*	Tree retained	598799	6357922
050	Tree	*Eucalyptus microcarpa*	Tree retained	598799	6357928
054	Stag	-	Tree removed 5-10cm hollow. Insufficient depth. No signs of fauna use	598869	6357969
055	Stag		Tree removed 10-20cm hollow. 5-10cm hollow. No signs of fauna present	598831	6357976
056	Tree	*Eucalyptus microcarpa*	Tree removed 5-10cm opening with chamber. Some possum fur present. No fauna present	598722	6357957
057	Tree	-	Tree retained 1 x 5-10cm hollow with 1m chamber (NFS). 1 x 10-20cm hollow with 1-2m chamber (good hollows.	598938	6357980

Feature ID	Feature Type	Species Name	Notes	Eastings	Northings
			1 x 5-10cm hollow. 1 x <5cm hollow.		
058	Tree	-	Tree removed Hollow in small fork.	598722	6358006
059	Tree	-	Tree removed Hollow salvaged. 5-10cm opening. 2m deep.	598725	6358011
060	Tree	-	Tree removed No signs of fauna present	598587	6357963
061	Tree	-	Tree removed Hollow sitting in water.	598545	6357960

Notes: Rows in bold indicate fauna recorded within habitat resources on-site

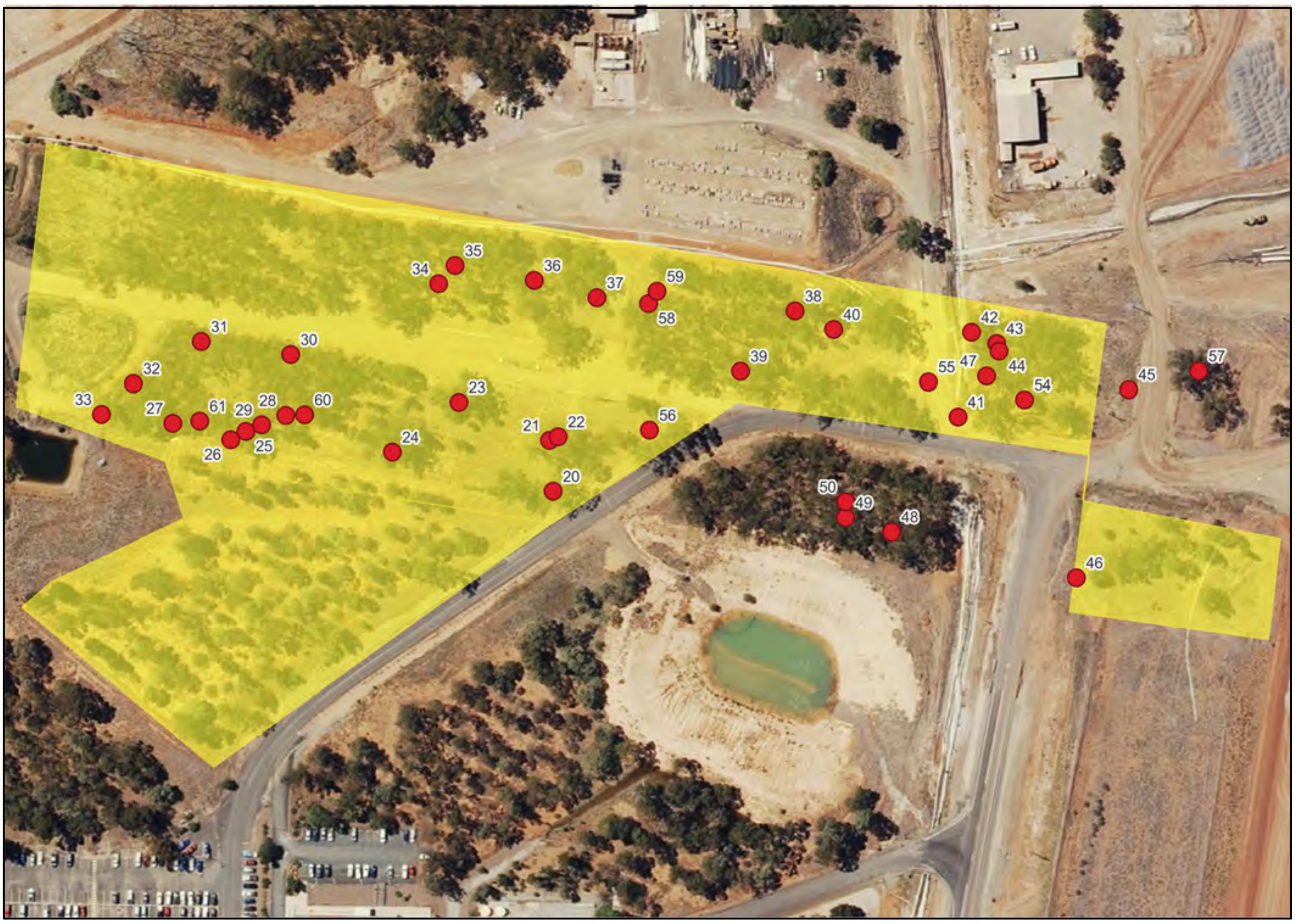

Figure 4 Infill Extension cleared area (shown in yellow) with habitat features (shown as red dots)

5.2 Incidental fauna sightings

Fauna sightings associated with the clearance activities are discussed in Tables 1 and 2 above. Incidental fauna observations made during the works (inclusive of pre-clearance [as reported in GHD, 2022] and clearance supervision) are provided in Table 3 below.

Table 3 Incidental fauna sightings

Area	Class	Species Name	Common Name	Observation Type
E31	Bird	*Aquila audax*	Wedge-tailed Eagle	Observed
	Bird	*Chenonetta jubata*	Australian Wood Duck	Observed
	Bird	*Cracticus nigrogularis*	Pied Butcherbird	Observed
	Bird	*Elanus axillaris*	Black-shouldered Kite	Observed
	Bird	*Eolophus roseicapilla*	Galah	Observed
	Bird	*Grallina cyanoleuca*	Magpie Lark	Observed
	Bird	*Manorina melanocephala*	Noisy Miner	Observed
	Bird	*Platycercus eximius*	Eastern Rosella	Observed
	Bird	*Polytelis swainsonii*	Superb Parrot	Heard
	Bird	*Saxicola chrysorrhoa*	Yellow-rumped Thornbill	Observed
	Bird	*Struthidea cinerea*	Apostle Bird	Observed
Infill Extension	Bird	*Corvus coronoides*	Australian Raven	Heard
	Bird	*Falco cenchroides*	Nankeen Kestrel	Observed
	Bird	*Gymnorhina tibicen*	Australian Magpie	Observed
	Bird	*Hirundo neoxena*	Welcome Swallow	Observed
	Bird	*Manorina melanocephala*	Noisy Miner	Observed
	Bird	*Platycercus eximius*	Eastern Rosella	Observed
	Bird	*Psephotus haematonotus*	Red-rumped Parrot	Observed
	Bird	*Smicrornis brevirostris*	Weebill	Observed
	Frog	*Crinia paransignifera*	Plains Froglet	Heard
	Mammal	*Lepus europaeus*	Brown Hare	Observed
	Mammal	*Macropus sp.*	Kangaroo	Observed
	Mammal	*Tachyglossus aculeatus*	Echidna	Diggings

5.3 Fauna injury or death

No native fauna was captured, injured or found deceased during or after site clearing at either the E31 or Infill Extension areas.

Northparkes Mines
A century of mining together

January 2023

Nest Box Inspections

Juvenile Major Mitchell parrot utilising a nest box at west Beechmore.

1. INTRODUCTION

1.1 Background

During April 2017 Northparkes developed and implemented a Habitat Augmentation Works Report, which included the installation of a total of 78 nest boxes, targeting five different animal species, in the farms and offset areas. An annual inspection in January 2023 was undertaken to determine both the condition of the nest boxes and if there was any evidence of nesting birds utilising the boxes.

2. RESULTS

The results of the inspection are provided in Table 1 below.

West Beechmore has a of total 10 nest boxes installed. From the inspection, seven boxes had signs of chewing from birds. Four boxes were in poor conditions due two having their fronts broken in, one having been moved around and tipping, and the last one having been knocked to the ground.

Middle Beechmore has a total of 9 nest boxes installed. From the inspection, seven boxes had signs of chewing from birds, and one of the boxes side doors have come open.

Brians Billabong has a total of 27 nest boxes installed. From the inspection, fifteen boxes had signs of chewing from birds, one nest box has become home to a beehive. Nine nest boxes were in poor condition with a combination of sides missing or broken and boxes being turned and unstable.

Escourt Offset has a total of 12 nest boxes installed. From the inspection, six nest boxes had been chewed by birds. Three nest boxes were in poor condition due to one entrance being chewed away and enlarged, and two having been knocked to the ground.

The Kokoda Offset area has a total of 20 nest boxes installed. From the inspection, nineteen nest boxes had been chewed by birds, one nest box has become home to a beehive. Only two were found to be in poor condition one having been knocked to the ground and the other having tipped over and been wedged into the tree facing up.

Table 1. Results of nest box inspection

Region	ID	Easting	Northing	Nest box direction facing	Tree type	Condition (Good, Average, Poor)	Comments
West Beechmore	SU01	594412	6356271	SW	GREY	Average	Chewing around entrance Front Bowing out
West Beechmore	SU02	594412	6356271	E	GREY	Average	Chewing around entrance
West Beechmore	SU03	594404	6356274	S	GREY	Average	Scratching all over
West Beechmore	SU04	594404	6356274	NE	GREY	Poor	Chewing around entrance Sections of front have fallen away
West Beechmore	SU05	594381	6356281	N	GREY	Average	Chewing around entrance
West Beechmore	SU06	594381	6356281	SE	GREY	Poor	Chewing around entrance

							Unstable and tilting
West Beechmore	SU07	594358	6356301	W	GREY	Average	Facing other way Unstable and tilting
West Beechmore	G08	594358	6356301	W	GREY	Average	Chewing around entrance
West Beechmore	SU09	594367	6356297	NW	GREY	Poor	Front broken in
West Beechmore	B10	594367	6356297	NE	GREY	Poor	Whole nest box knocked down
Middle Beechmore	SU11	595627	6356058	NW	GREY	Average	Chewing around entrance
Middle Beechmore	SU12	595627	6356058	W	GREY	Average	Chewing around entrance
Middle Beechmore	SU13	595628	6356068	W	GREY	Poor	Scratching all over Side missing
Middle Beechmore	SU14	595628	6356068	N	GREY	Average	Chewing around entrance Facing W
Middle Beechmore	SU15	595641	6356051	N	GREY	Average	Chewing around entrance Tilting
Middle Beechmore	SU16	595641	6356051	E	GREY	Good	Chewing around entrance
Middle Beechmore	SU17	595649	6356055	NE	GREY	Average	Facing E
Middle Beechmore	SU18	595670	6356057	S	GREY	Good	Chewing around entrance
Middle Beechmore	SU19	595670	6356057	NE	GREY	Average	Scratching all over
Brians Billabong	SU20	596301	6355932	S	GREY	Average	Chewing around entrance
Brians Billabong	SU21	596301	6355932	SE	GREY	Good	Condition is good however bees have taken over nest box
Brians Billabong	SU22	596298	6355934	W	GREY	Average	Chewing around entrance
Brians Billabong	SU23	596284	6355934	S	GREY	Average	Chewing around entrance
Brians Billabong	SU24	596286	6355925	S	GREY	Average	Chewing around entrance
Brians Billabong	SU25	596286	6355925	E	GREY	Average	Chewing around entrance Facing N
Brians Billabong	SU26	596294	6355922	N	GREY	Average	Chewing around entrance
Brians Billabong	SU27	596294	6355922	N	GREY	Good	
Brians Billabong	SU28	596340	6355920	S	RED RIVER	Average	Chewing around entrance
Brians Billabong	SU29	596340	6355920	N/W	RED RIVER	Poor	Side missing
Brians Billabong	SU30	596340	6355920	E	RED RIVER	Average	

Brians Billabong	SU31	596340	6355920	N	RED RIVER	Poor	Side missing
Brians Billabong	SU32	596361	6355917	NE	RED RIVER	Average	Chewing around entrance
Brians Billabong	SU33	596361	6355917	W	RED RIVER	Average	Front bowing
Brians Billabong	SU34	596361	6355917	E	RED RIVER	Poor	Side and roof missing
Brians Billabong	SU35	596361	6355917	W	RED RIVER	Average	Chewing around entrance Facing N
Brians Billabong	SU36	596370	6355891	E	RED RIVER	Average	Chewing around entrance
Brians Billabong	SU37	596370	6355891	N/W	RED RIVER	Average	Chewing around entrance
Brians Billabong	SU38	596378	635588	N/W	RED RIVER	Poor	Facing N
Brians Billabong	SU39	596378	635588	N	RED RIVER	Poor	Side missing
Brians Billabong	SU40	596363	6355879	E	RED RIVER	Poor	Facing N
Brians Billabong	SU41	596363	6355879	SW	RED RIVER	Average	Chewing around entrance
Brians Billabong	SU42	596363	6355879	NW	RED RIVER	Average	Facing upwards
Brians Billabong	SU43	596369	6355872	S	RED RIVER	Poor	Chewing around entrance Facing W
Brians Billabong	SU44	596369	6355872	S/W	RED RIVER	Poor	Chewing around entrance Facing W
Brians Billabong	SU45	596365	6355860	E	RED RIVER	Poor	Missing side
Brians Billabong	SU46	596365	6355860	S	RED RIVER	Average	Chewing around entrance
Escourt Offset	SU47	599037	6361366	N	GREY	Average	Chewing around entrance
Escourt Offset	SU48	599047	6361368	N	YELLOW	Poor	Front entrance chewed at and enlarged
Escourt Offset	SU49	599097	6361366	E	YELLOW	Good	
Escourt Offset	G50	599097	6361366	SW	YELLOW	Poor	Missing
Escourt Offset	SU51	599110	6361392	N	YELLOW	Average	Chewing around entrance
Escourt Offset	SU52	599110	6361392	S	YELLOW	Average	Facing upwards
Escourt Offset	SU53	599121	6361466	E	YELLOW	Average	
Escourt Offset	SU54	599121	6361466	S	YELLOW	Average	Chewing around entrance
Escourt Offset	G55	599074	6361478	W	YELLOW	Average	Chewing around entrance
Escourt Offset	B56	599074	6361478	S	YELLOW	Poor	Whole nest box knocked down
Escourt Offset	P57	599084	6361502	SW	YELLOW	Good	
Escourt Offset	SU58	599084	6361502	SW	YELLOW	Average	Chewing around entrance

Kokoda Offset	SP59	635511	6317793	W	MUGGA	Good	Chewing around entrance
Kokoda Offset	SU60	635511	6317793	N	MUGGA	Average	Chewing around entrance
Kokoda Offset	P61	635511	6317793	E	MUGGA	Average	Chewing around entrance
Kokoda Offset	SU62	635557	6317829	W	GREY	Poor	Knocked to the ground
Kokoda Offset	B63	635557	6317829	W	GREY	Good	Chewing around entrance
Kokoda Offset	SU64	635618	6317952	E	RED RIVER	Poor	Chewing around entrance Fallen and wedged in tree
Kokoda Offset	SU65	635618	6317952	NE	RED RIVER	Average	Chewing around entrance
Kokoda Offset	SU66	636651	6318441	NE	MUGGA	Average	Chewing around entrance
Kokoda Offset	SU67	636651	6318441	N	MUGGA	Average	Chewing around entrance
Kokoda Offset	SU68	636570	6318458	E	MUGGA	Good	Chewing around entrance
Kokoda Offset	SU69	636570	6318458	NE	MUGGA	Average	Chewing around entrance
Kokoda Offset	SU70	636742	6318411	S	MUGGA	Average	Chewing around entrance
Kokoda Offset	SU71	636742	6318411	E	MUGGA	Average	Chewing around entrance
Kokoda Offset	SP72	636742	6318411	N	MUGGA	Average	Chewing around entrance
Kokoda Offset	SU73	636233	6318576	NE	GREY	Average	Chewing around entrance Bees have taken over
Kokoda Offset	SU74	636233	6318576	S	GREY	Average	Chewing around entrance
Kokoda Offset	SU75	636224	6318591	N/E	RED RIVER	Average	Chewing around entrance
Kokoda Offset	SU76	636224	6318591	SE	RED RIVER	Average	Chewing around entrance
Kokoda Offset	SP77	636148	6318625	W	GREY	Average	Chewing around entrance
Kokoda Offset	SU78	636148	6318625	N	GREY	Good	Chewing around entrance

Table 2 identifies that from the 78 installed nest boxes, 3 were found to have no signs of disturbance, 54 had been chewed by animals, potentially Gallahs and Cockatoos, 2 have been taken over by bees, 8 need some maintenance work, and 4 will need replacing.

Approximately 10% of boxes require maintenance work or are to be replaced. Northparkes will aim to replace/repair nest boxes during the next habitat augmentation program. Habitat augmentation will be undertaken in the surrounding areas as a means of providing compensatory habitat relative to that disturbed by the proposed action.

Table 2. Condition of nest boxes since installation in 2017.

Condition	Number of Nest boxes 2017	Number of Nest boxes 2018	Number of Nest boxes 2019	Number of Nest boxes 2022
Perfect condition with little to no evidence of animal activity	42	41	13	3
Evidence of chewing by birds	27	23	43	54
Occupied	2	0	0	0
Side Door Open/poor condition	7	13	21	19
Destroyed	0	1	1	4
Total	78	78	78	78

The next nest box inspection is scheduled for H2 2023.

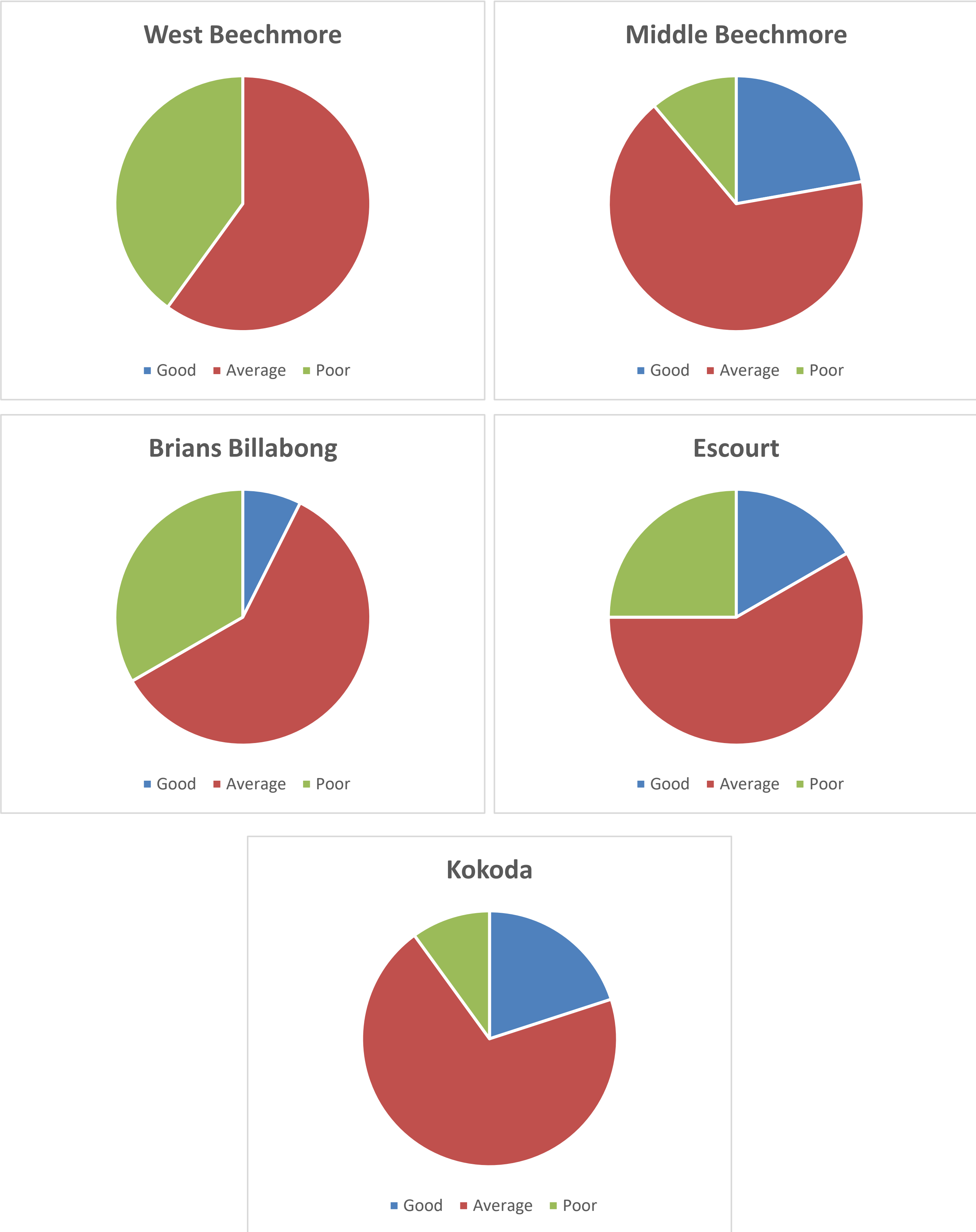

Figure 1. Percentage of nest box condition per location.

2022
Kokoda
Biodiversity Offset Area
Ecological Monitoring
Report

for
Northparkes Mines

Prepared by DnA Environmental

December 2022

Disclaimer

This is a report of work carried out by DnA Environmental, under contract and on behalf of China Molybdenum Co. Ltd (CMOC) Pty Ltd as agent severally for and on behalf of the Northparkes Joint Venture and has been prepared according to the brief provided by the client. The information contained herein is complete and correct to the best of my knowledge. The representations, statements, opinions and advice, expressed or implied in this report are produced in good faith but on the basis that DnA Environmental are not liable (whether by reason of negligence, lack of care or otherwise) to any person for any damage or loss whatsoever which has occurred or may occur in relation to that person taking or not taking (as the case may be) action in respect of any or all of the content.

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Executive summary

The 2022 Kokoda Offset Area (KOA) ecological monitoring report was prepared by DnA Environmental on behalf of Northparkes Mines (NPM) as part of the Biodiversity Offset Strategy and associated Biodiversity Offset Management Plan (BOMP). The BOMP provides a framework for the implementation of ecological management actions, regeneration strategies, controls and monitoring programs for the Kokoda Offset Site.

This ecological monitoring report describes the monitoring methodology and presents the results of the monitoring program first established in 2015. The primary objective of the monitoring program is to assess the progress of natural regeneration and revegetation areas by comparing a range of ecological performance targets or completion criteria against less disturbed areas of remnant woodland (reference sites) that are representative of the desired woodland community as described in the BOMP.

The Kokoda Offset Site is 350 hectares and is located in the Mandagery locality of the Central West Slopes of NSW, approximately 52 kilometres south-east of the Northparkes mine. Historically the property has been partially cleared and grazed by sheep and cattle, however, will now remain free from domestic livestock grazing. Vegetation surveys undertaken by Umwelt in 2014 indicated the property is comprised of ten different vegetation communities consisting of derived grasslands and a variety of different woodland communities which vary according to soil type, topography and historical land practices.

The Umwelt surveys indicated there are approximately 96 ha of *Eucalyptus microcarpa* (Grey Box) Derived Native Grasslands (DNG) Endangered Ecological Community (EEC). As part of the BOMP these DNG areas will be regenerated to their original *E. microcarpa* grassy woodland community. The remaining 15 ha area of grasslands are thought to have been dominated by *Eucalyptus dwyeri* (Dwyer's Red Gum) – *E. microcarpa* (Grey Box) – *E. sideroxylon* (Mugga Ironbark) – *Callitris endlicheri* (Black Cypress Pine) community, and these will also be regenerated to the original woodland structure. There is also a very small area (2.2 ha) of *E. albens* (White Box) grassy woodland EEC. All areas of remnant woodland within the Kokoda Offset Area will be managed to improve wildlife habitat and biodiversity outcomes.

In 2014 Umwelt implemented the first ecological surveys and established 16, 20 x 20m monitoring sites across a range of vegetation communities and management zones at the KOA. The results of these surveys are provided in Umwelt (2014b). In 2015, DnA Environmental was engaged to review the monitoring program and establish a comprehensive range of ecological data which will fulfil the monitoring and reporting requirements of the BOMP. The monitoring program aimed to establish clearly defined, repeatable and consistent methodologies for monitoring changes in various aspects of ecosystem function, succession and long-term sustainability. Part of this process includes:

- Selecting a range of woodland reference sites that would be suitable benchmarks for the regenerating /revegetated woodland communities;
- Obtaining a range of completion performance indicators from these woodland reference sites;
- Comparing the progress and ecosystem function of the regenerating/revegetation areas;
- Identify positive recovery trends or indications of ecosystem failure; and
- Provide recommendations to improve the monitoring program and revegetation process.

In 2015, 17, 20 x 20m permanent monitoring sites were established across the range of vegetation communities which included:

- Three Grey Box Grassy woodland reference sites (GBWood1 - GBWood3);
- Five DNG sites which will be revegetated back to Grey Box Grassy woodland (GBReveg1 – GBReveg5);
- Three Dwyer's Red Gum (DRG) – Grey Box – Mugga Ironbark – Black Cypress woodland reference sites (DWood1 - DWood3);

- Three DNG which will be revegetated back to the Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress woodland community (DReveg1 – DReveg3);
- One White Box Grassy Woodland EEC, CEEC (WBWood1);
- One Grey Box – Ironbark woodland (IronWood1); and
- One Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest which was mapped as low quality woodland (DWoodLQ).

The monitoring sites were established by Umwelt in 2014 and these sites were used, where appropriate, to maintain consistency. The monitoring methodology adopted at Kokoda is consistent with that used in the NPM rehabilitation monitoring program and the Estcourt Offset Area ecological monitoring program. The monitoring programs are compliant and consistent with a range of approval conditions, specifically the Biodiversity Offset Strategy and associated BOMP and ESG3 Mining Operations Plan (MOP) guidelines. The monitoring methodology includes a combination of Landscape Function Analyses (LFA), accredited soil analyses and various measurements of ecosystem diversity and habitat values adapted from the Biometric Manual.

At Kokoda, a range of Key Performance Indicators (KPI's) were quantified by ecological data obtained from replicated reference sites which were representative of the Grey Box Woodland EEC and Dwyer's Red Gum woodland. All performance indicators are quantified by range values measured from these reference sites which form *upper* and *lower* KPI targets. The same ecological performance indicators are also measured in the regeneration/revegetation sites, and these should equal or exceed these values or at least demonstrate an increasing trend.

These Key Performance Indicators have been further separated into "*Primary performance indicators*" and "*Secondary performance indicators"*. Primary performance indicators are those chosen as completion criteria targets and have been identified as those that will satisfy requirements identified within the BOMP. The range values of each ecological performance indicator are adapted annually to reflect seasonal conditions and disturbance events. The results of the monitoring program have been broken down into the relevant rehabilitation phases as described in the ESG3 MOP guidelines and include:

- Landform establishment and stability;
- Growth medium development;
- Ecosystem and land use establishment; and
- Ecosystem and land use sustainability.

The annual vegetation monitoring has always been undertaken during spring and this year was undertaken from the 17 - 19th October and due to extensive rainfall, was completed on 26th October.

2018 Conservation Agreement

In 2018, a Voluntary Conservation Agreement (VCA) was executed with the Minister administering the National Parks and Wildlife Act 1974 to satisfy commitments to secure a biodiversity offset relating to the Northparkes Mine Step Change project. Under the Agreement, NPM is required to undertake a monitoring program as per Annexure B and D of the Conservation Agreement for a minimum period of 10 years of the Conservation Agreement. As per Annexure C, a revegetation program is also to be implemented, with the revegetation activities being postponed in 2018 and 2019 due to the prolonged drought.

In 2020, the external exclusion fence was completed and revegetation activities were undertaken during spring 2020 and during 2021 after above average rainfall. Revegetation involved the deep ripping and the planting of tubestock which were protected by variously sized tree guards. Subsequently, additional monitoring of the existing monitoring sites was required as part of the VCA with the Biodiversity Conservation Trust (BCT), including additional photo-point monitoring and the completion of the BCT monitoring form specified in Annexure D. These completed forms have been provided in additional sections of this report.

Summary of results

The average annual rainfall at Mandagery is 674 mm, however there have been extreme seasonal conditions with drought conditions experienced during 2017 – 2019, followed by three consecutive years of above average rainfall. In addition to these extremes in annual rainfall activity, the monthly averages indicate there has also been high seasonal variability and erratic rainfall activity since monitoring began.

In 2020 above average rainfall was experienced throughout most of the year. January, February and March 2021 had very good rainfall, but almost no rainfall was recorded in April and it was limited in May. In the next few months preceding the monitoring event rainfall was slightly higher than the expected averages. The total rainfall recorded up to the end of October 2021 was 711 mm, with 912 mm being recorded for the year.

Above average rainfall continued into 2022 for the third consecutive year, with heavy rains again causing widespread flooding across the region. While above average rainfall occurred in most months this year, there was limited rain in February and June. This year there was 1036 mm of rain recorded to the end of October which was much higher than the long-term expected average of 547 mm for the same period.

The Grey Box and Red Gum woodland reference sites were typically characterised by having a mature tree canopy and well developed, decomposing leaf litter layer with a sparse cover of native perennial forbs and grasses. The White Box, Ironbark and [low quality] Dwyer's Red Gum woodland sites were similar in structure, however low shrubs were more common in the Ironbark woodland and one of the Red Gum sites (DWood3).

The Grey Box and Red Gum derived grassland revegetation sites presently existed as degraded grassland and were structurally different to the woodland reference sites. They did however typically have good ground cover comprised of a combination of annual and perennial plants and cryptogams and in favourable seasons such as this, annual plants are abundant. During 2018 – 2019, there was limited live ground cover and often the integrity of the litter and cryptogam layers had declined as a result of overgrazing during the drought, but typically good ground cover was maintained. Since 2020 the improved seasonal conditions resulted in increased levels of ground cover in most sites and while there has been an increase in perennial plants cover in numerous sites, most grassland areas continued to be dominated by exotic annual plants, however native sedges and reeds have also been quite abundant during the wet seasons.

In several of the grassland sites, deep ripping had been undertaken in preparation for the planting of tubestock in spring 2020, creating deep troughs. While ripping removed some ground cover and exposed some areas of bare soil, the deep troughs created additional surface roughness and an additional capacity of the area to retain any mobilised resources, in most cases. Over the past two years, many of the rip lines were filled to the top with water and the ground was saturated with water, with numerous seedlings starting to appear water stressed.

There was little overall difference in total ecological functional between the Grey Box or Red Gum monitoring sites, despite the lack of a perennial overstorey in the derived grassland revegetation areas. In more wooded areas there tended to be high canopy cover, scattered perennial shrubs and ground covers and deep litter layers, while the open grasslands had a high cover of litter and annual and perennial plants. The most functional sites this year were the Red Gum reference site DWood1 and the Red Gum [low quality] woodland DWoodLQ, followed by the White Box Woodland. All of the other monitoring sites were more functional than DWood3, a Red Gum reference site, except DReveg2 which had been disturbed by deep ripping as a result of the ground preparation required for the planting of tubestock.

Tree densities ranged from 8 – 22 live mature trees (>5cm dbh) in both the Grey Box and Dwyer's Red Gum woodland reference sites equating to a density of 200 – 550 stems per hectare. The average dbh recorded in the Grey Box reference sites ranged from 19 – 35 cm, while the average dbh in the Red Gum reference sites was 12 – 24 cm. Most individuals were in moderate health, however many continued to be affected by the drought and were stressed. While one Grey Box reference sites had some dead individuals, much higher mortalities were recorded in the Dwyer's Red Gum woodland where 20 – 67% had died. Mature trees were also recorded in various states of health in the White Bix and Ironbark woodlands, however no trees or mature shrubs were yet present in the derived native grassland revegetation sites, except there were now nine volunteer *E. dwyeri* saplings in DReveg1 with dbhs ranging from 5 – 21 cm.

In the Grey Box woodland reference sites there were typically low densities of shrubs and juvenile trees (<5cm dbh), while in the Red Gum woodland there was much higher variation and there were significantly higher densities in some sites. There has been a decline in shrub populations across most woodland monitoring locations as a result of the drought, however increasing densities have typically been recorded in all woodland reference sites, including the White Box and Ironbark sites due to improved seasonal conditions triggering natural regeneration events since 2020.

In the derived grassland sites, there was some limited natural regeneration and/or tubestock had been planted, with low densities being recorded in most, but not all sites. Despite the planting program there has also been a simultaneous increase in shrub and juvenile tree density and diversity targets due to natural regeneration which has also been occurring in the reference sites. Subsequently, numerous sites were unable to meet shrub and juvenile tree density and diversity targets this year.

Total floristic diversity recorded within the 20 x 20 m monitoring sites have been highly variable between the sites, as well between the monitoring years. The drought experienced during 2017 – 2019 resulted in a declining trend, however rainfall prior to the monitoring event had stimulated a flush of plant growth in the revegetation areas which saw a minor increase in diversity in 2019. In 2020, floristic diversity has significantly increased across all monitoring sites as a result of the above average rainfall, with the diversity in the reference sites being similar to or exceeding that recorded in 2016. In 2021 and 2022 there has been a further increase in total floristic diversity in most, but not all monitoring sites.

While native species were more diverse than exotics species in most sites, there has also been an increase in the diversity of exotic species in all woodland revegetation sites. The White Box and Ironbark woodlands and all Grey Box revegetation monitoring sites had an acceptable diversity of exotics species compared to the reference sites this year, however all Red Gum revegetation sites including DWoodLQ had a higher diversity of exotics compared to the reference sites.

Most of the live plant cover in the Grey Box woodland reference sites has been provided by native species however increased exotic annual plant cover has resulted in a decline in the percent cover provided by native species in 2016, and since the drought ended in 2020 there has been a declining trend. This year native plant cover declined in all three reference sites and provided 68 - 81% of the live plant cover. There has also been a declining trend in the White Box and Ironbark woodlands they continue to have a native plant cover abundance comparable to the reference sites. In the derived grasslands, there continued to be an abundance of exotic plant cover and while native plant cover has also declined across all monitoring sites and provided 27 – 54% of the live plant cover on average this year and were weedier than desired.

In the Red Gum reference sites native plants tended to occur in higher abundance than in the Grey Box reference sites, but there have been similar changes in diversity and abundance over the seasons. This year there was also an increase in exotic plant cover, with native plants providing 79 - 95 % of the live plant cover. There have also been similar trends in DWoodLQ and all three revegetation areas, where exotic species were more dominant in most areas, with native plants providing 47 - 58% cover this year.

The results of the soil analyses indicate that the soils associated with the Grey Box and Red Gum woodlands and derived native grasslands can be naturally strongly acidic and are typically low in phosphorous and nitrate and in the derived grassland areas, they were usually low in organic matter. They tended to have a low cation exchange capacity and are non-saline and while most had an Exchangeable Sodium Percentage (ESP) below the sodic threshold, the soils may have a tendency to be sodic. The results of the soil analyses have also demonstrated there were also high levels of iron in many sites including the various woodland reference sites, suggesting these are typical of the local area.

Performance of the Kokoda monitoring sites against primary completion performance indicators

The table below provides a performance summary of the Kokoda monitoring sites against a selection of primary completion performance indicators obtained from their relevant reference sites in 2022. The selection of criteria has been presented in order of rehabilitation phases according to the ESG3 MOP guidelines. The range values of the ecological performance targets are amended annually. Revegetation sites meeting or exceeding the range values of their representative target community type have been identified with a coloured box and have therefore been deemed to meet these primary completion performance targets this year. Hashed coloured boxes associated with soil condition indicate they may be outside of the reference target ranges, but within acceptable agricultural limits.

Performance of the Grey Box, White Box, Ironbark and **Dwyer's** Red Gum woodland monitoring sites against primary completion performance indicators in 2022.

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Unit of measurement (*desirable)	DReveg 1	DReveg 2	DReveg 3	DWoodLQ	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
Performance indicators are quantified by the range of values obtained from replicated reference sites					2022	2022	2022	2022	2022	2022	2022	2022	2022	2022	2022
Phase 2: Landform establishment and stability	Landform slope, gradient	Landform suitable for final land use and generally compatible with surrounding topography	Slope	< Degrees (18°)	4	3	4	3	5	4	3	4	3	3	4
	Active erosion	Areas of active erosion are limited	No. Rills/Gullies	No.	0	0	0	0	0	0	0	0	0	0	0
Phase 3: Growth medium development	Soil chemical, physical properties and amelioration	Soil properties are suitable for the establishment and maintenance of selected vegetation species	pH	pH (*5.6 - 7.3)	5.7	5.4	6.0	5.5	6.4	5.5	6.2	5.7	6.0	6.5	5.2
			Organic Matter	% (*>4.5)	2.9	2.8	3.5	5.7	2.6	4.4	3.8	3.1	3.3	4.8	4.6
			Phosphorous	ppm (*50)	3.6	4.6	3.9	7.9	3.6	3.9	4.6	1.6	3.6	4.9	2.6
Phase 4: Ecosystem & Land use Establishment	Landscape Function Analysis (LFA): Landform stability and organisation	Landform is stable and performing as it was designed to do	LFA Stability	%	74.0	76.6	76.5	70.3	75.5	74.5	74.9	76.0	75.5	72.5	71.0
			LFA Landscape organisation	%	100	96	100	100	100	100	100	99	100	100	100
	Vegetation diversity	Vegetation contains a diversity of species comparable to that of the local remnant vegetation	Diversity of shrubs and juvenile trees	species/area	2	7	1	3	1	0	6	6	1	9	9

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Unit of measurement (*desirable)	DReveg 1	DReveg 2	DReveg 3	DWoodLQ	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
				% endemic	100	100	100	100	100	0	100	100	100	100	100
			Exotic species richness	<No./area	15	17	26	23	24	15	21	19	24	23	5
	Shrubs and juvenile tree (<5cm dbh) density	Vegetation contains a density of shrubs and juvenile trees (<5cm dbh) comparable to the local remnant vegetation	Total density of endemic shrubs and/or juvenile trees	No./area	6	11	1	23	1	0	12	7	4	23	112
	Ecosystem composition	The vegetation is comprised by a range of growth forms comparable to that of the local remnant vegetation	Trees	No./area	1	1	1	2	1	0	2	3	1	4	5
			Shrubs	No./area	1	8	0	2	0	0	4	3	0	6	5
			Herbs	No./area	19	34	33	39	32	27	27	28	32	49	25
Phase 5: Ecosystem & Land use Sustainability	Landscape Function Analysis (LFA): Landform function and ecological performance	Landform is ecologically functional and performing as it was designed to do	LFA Infiltration	%	45.6	34.5	51.5	56.1	48.2	42.9	47.9	44.8	47.1	53.2	49.6
			LFA Nutrient recycling	%	46.2	37.8	50.1	55.5	48.7	45.1	47.9	44.0	47.4	52	48.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Unit of measurement (*desirable)	DReveg 1	DReveg 2	DReveg 3	DWoodLQ	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
	Protective ground cover	Ground layer contains protective ground cover and habitat structure comparable with the local remnant vegetation	Perennial plant cover (< 0.5m)	%	20	26	7	9.5	32	6.5	18	17.5	22	38	13
			Total Ground Cover	%	91	91	100	99	100	98.5	98.5	98	100	99	98
	Native ground cover abundance	Native ground cover abundance is comparable to that of the local remnant vegetation	Percent ground cover provided by native vegetation <0.5m tall	%	50.5	57.6	47.4	47.8	27	41.9	49.1	35.4	53.7	68.7	87.2
	Ecosystem growth and natural recruitment	The vegetation is maturing and/or natural recruitment is occurring at rates similar to those of the local remnant vegetation	shrubs and juvenile trees 0 - 0.5m in height	No./area	4	5	0	11	0	0	2	1	2	12	50
			shrubs and juvenile trees 1.5 - 2m in height	No./area	0	0	0	0	0	0	1	1	0	0	5
	Ecosystem structure	The vegetation is developing in structure and complexity comparable to that of the local remnant vegetation	Foliage cover 0.5 - 2 m	% cover	2	0	0	0	0	0	0	0	0	0	0
			Foliage cover >6m	% cover	0	0	0	20	0	0	0	0	0	43	12.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Unit of measurement (*desirable)	DReveg 1	DReveg 2	DReveg 3	DWoodLQ	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
	Tree diversity	Vegetation contains a diversity of maturing tree and shrubs species comparable to that of the local remnant vegetation	Tree diversity	%	100	0	0	100	0	0	0	0	0	100	100
	Tree and mature shrub (>5cm dbh) density	Vegetation contains a density of maturing tree and shrubs (>5cm dbh) species comparable to the local remnant vegetation	Total tree and mature shrub density	No./area	9	0	0	9	0	0	0	0	0	7	27
	Ecosystem health	The vegetation is in a condition comparable to that of the local remnant vegetation.	Live trees	% population	100	0	0	100	0	0	0	0	0	87.5	73
			Healthy trees	% population	100	0	0	0	0	0	0	0	0	12.5	0
			Flowers/fruit: Trees	% population	11	0	0	78	0	0	0	0	0	12.5	11

Discussion

The extreme seasonal conditions experienced over the past few years combined with simultaneous changes in total grazing pressure has had a significant impact on the composition and diversity of the vegetation at Kokoda, with these being reflected in the range of ecological monitoring data.

In the remnant woodland sites, there has been a decline in tree health and increasing numbers of stags in most sites since 2020 as a result of prolonged drought. This has been more pronounced in the Dwyer's Red Gum woodlands on top of the rocky range, however this has opened up the canopy and has resulted in the regeneration of a range of native species since 2020 which were previously supressed by the dense Callitris regrowth. Many naturally regenerating tree and shrub seedlings have also been observed around the property and within monitoring sites as a result of the improved seasonal conditions, in combination with the reduction in ground cover and weed competition after the drought and feral animals as a result of the exclusion fencing and targeted control programs.

The revegetation activities in the derived grassland areas as described in the BOMP and VCA have been undertaken during spring in 2020, with additional planting (and re-planting) undertaken during 2021. Despite the planting activities, the derived grassland revegetation sites presently did not meet many completion targets related to diversity and density of juvenile tree and shrub species, largely due to the simultaneous increase in seedlings in their respective reference sites. Other primary ecological attributes which fell short of meeting completion performance targets tended to be associated with the limited structural complexity and population condition associated with mature woodlands, which would be expected to develop over time.

The derived grassland revegetation sites tended to be dominated by exotic annual species and were weedier than desired, however these are likely to decline in the medium to longer-term as perennial plants including trees and shrubs become more abundant. In addition, most exotic species observed were limited to common annual agricultural grasses and weeds which are associated with the long agricultural history and many are naturalised components of the local pastures. Strategic livestock grazing may be required in the longer-term to manipulate the herbaceous understorey and to maintain biodiversity, encourage tree and shrub regeneration and to reduce fuel loads as part of the integrated and adaptive management strategy for the Kokoda Offset Area.

Previously there have been significant populations of wild goats and Eastern Grey Kangaroos which had been causing overgrazing throughout the property, particularly during the drought. As part of the VCA, NPM completed the construction of an exclusion fence around most of the boundary around the Kokoda property in 2020 and have and will continue to implement a series of pest control events. This year, no goats and only small numbers of Eastern Grey Kangaroos were observed during the vegetation surveys. There was however evidence of feral pig damage near one of the monitoring sites. Extensive disturbance and herbivory by macropods, goats (and pigs?) have and will require ongoing management.

No priority weed species of the Central Tablelands LLS were recorded in the range of monitoring sites or were noted in abundance, however ongoing surveillance for weeds such as *Nassella trichotoma* (Serrated Tussock), *Rubus fruticosus* (Blackberry) and *Hypericum perforatum* (St John's Wort) should be carried out, as conditions have been most favourable over the past few years with extensive infestations being recorded across the region this year.

In 2015 and 2016 several species of terrestrial ground orchids were observed at various locations around the property. As part of the management of the Kokoda property, the location of these populations should be considered when undertaking revegetation, weed control, track upgrades and strategic grazing. None of these orchid populations were observed during the drought only a few of these orchid species were sighted again in 2021 – 2021 but they occurred in lower diversity and densities. In addition, those previously recorded along some of the access tracks in the bushland areas were not observed at all, possibly due to the widening of the access tracks. While orchid sightings have not been formally undertaken, some species were observed in greater numbers and nine different orchid species were recorded in the monitoring sites this year, along with several others as opportunistic sightings.

Other potential management issues may be related to high density *E. dwyeri* and *Callitris endlicheri* regeneration which may adversely affect floristic and biodiversity targets in the medium to longer term. Declining ground cover and increasing erosion may also occur, particularly as pests and feral animals cause increased disturbances and tracks as they seek shade and shelter within the developing wooded areas. Regular inspection will dictate the need for further management of these regrowth areas.

Safe and easy access should always be maintained around main access tracks and boundary fences to facilitate monitoring, weed control, property maintenance and bushfire management. Regular inspections should be undertaken with slashing and/or strategic grazing management implemented on an as needed basis. In addition, high Callitris mortalities have occurred as a result of the drought, with many access tracks and/or fences having the potential to be obstructed or requiring repair as dead stags are likely to continue to fall over during high wind events. Fallen trees require removal and some parts of the tracks require amelioration where erosion has become severe.

Conclusion

The results of the monitoring program have indicated that the improved seasonal conditions combined with a reduction in feral animal disturbance has resulted in an improvement in ecological function and floristic diversity in the range of monitoring sites, especially since the drought during 2017 - 2019. Improved management and the implementation of the revegetation program during 2020 – 2021 are also likely to increase the area of the various woodland communities occurring at the Kokoda Offset area, thus increasing the capacity of the existing derived grasslands to meet a wider range of woodland habitat performance indicators the medium to longer-term. Although there have been some mortalities and low densities being recorded in some of the monitoring locations it should be unnecessary to undertake replanting or infill planting. It will be important to allow the tubestock adequate space and take into consideration the requirement for open clearings for future regeneration requirements and to maintain a patchy open grassy woodland habitat.

Since 2020, many native species have also been regenerating and spreading out from existing rocky outcrops situated throughout the open pasture areas and after the extensive tree planting during 2020 – 2021, many tubestock have grown and tree guards have been removed. Species composition and diversity are also strongly correlated with seasonal conditions and disturbance history and in many situations and with sympathetic management, many ecological targets are likely to be met without further intervention in the medium to longer-term.

Despite shortfalls in meeting numerous ecological performance indicators, completion criteria targets also need to consider that their respective reference sites and therefore revegetation targets, have been obtained from regrowth woodlands that have also been subjected to a long agricultural and disturbance history. For example, higher stem densities do not necessarily translate into sustainable (grassy) woodland communities and the rigid use of some performance indicators may need to be revised.

Regular and ongoing monitoring of the performance of the revegetation program and other ongoing management activities will also assist with the implementation of future management strategies that may be required to complete long-term targets of the BOMP and VCA.

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1 Introduction: 2022 Kokoda Offset Area Ecological Monitoring Report

The 2022 Kokoda Offset Area (KOA) ecological monitoring report is a result of work carried out by DnA Environmental on behalf of Northparkes Mines (NPM) as part of the Biodiversity Offset Strategy. A Biodiversity Offset Management Plan (BOMP) has been prepared to guide the ongoing management of the Kokoda Offset Area for biodiversity conservation and enhancement purposes (Umwelt 2014a). The BOMP was prepared in accordance with the NSW Project Approval requirements (PA11_0060) and Commonwealth Project Approval (EPBC 2013/6788) requirements issued for the NPM Step Change Project and provides a framework for the implementation of ecological management actions, regeneration strategies, controls and monitoring programs for the Kokoda Offset Site.

This ecological monitoring report describes the ecological monitoring methodology and presents the results of the annual ecological monitoring program first established in 2015. The primary objective of the annual monitoring program is to assess the progress of natural regeneration and/or active revegetation areas by comparing a selection of ecological targets or completion criteria against less disturbed areas of remnant vegetation (reference sites) that are representative of the desired vegetation assemblage as described in the BOMP.

2 Kokoda Offset Area

2.1 Land use

The Kokoda Offset Site is located in the Mandagery locality of the Central West Slopes of NSW, approximately 52 kilometres south-east of the Northparkes mine. The property is 350 hectares in size and is comprised of native grasslands to the north of the property with regrowth eucalypt woodland on the steeper slopes and ridges in the southern part of the property. Historically the property has been grazed by sheep and cattle, but the property will remain free from domestic livestock grazing (Umwelt 2014).

2.2 Vegetation communities

Vegetation surveys undertaken by Umwelt (2014b) indicate there are ten different vegetation communities consisting of derived grasslands and a variety of different woodlands communities which vary according to soil type, topography and historical land practices (Table 2-1). The remaining 2.5ha is associated with farm infrastructure including farm dams and access tracks.

The Umwelt surveys indicated there are approximately 96 ha of Derived Native Grasslands (DNG) once thought to have been *Eucalyptus microcarpa* (Grey Box) Grassy Woodland which conform to the Biodiversity Conservation (BC) Act listed *Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions* EEC and the EPBC Act listed *Grey Box (Grassy Woodlands and Derived Native Grasslands of South-eastern Australia* EEC. As part of the BOMP these DNG areas will be regenerated to their original Grey Box Grassy woodland community (Umwelt 2014).

The remaining 15 ha area of DNG are thought to have been dominated by *Eucalyptus dwyeri* (Dwyer's Red Gum) – *E. microcarpa* (Grey Box) – *E. sideroxylon* (Mugga Ironbark) – *Callitris endlicheri* (Black Cypress Pine) community, and these will also be regenerated to the original woodland structure as part of the BOMP (Umwelt 2014).

There is a very small area (2.2 ha) of *E. albens* (White Box) Grassy Woodland which conforms to the BC Act listed *E. albens* (White Box) – *E. melliodora* (Yellow Box) – *E. blakelyi* (Blakely's Red Gum) Woodland EEC and the EPBC Act listed *E. albens* (White Box) – *E. melliodora* (Yellow Box) – *E. blakelyi* (Blakely's Red Gum) Grassy Woodland and Derived Native Grassland CEEC. All areas of remnant woodland within the Kokoda Offset Area will be managed to improve wildlife habitat and biodiversity outcomes (Umwelt 2014). The distribution of the various vegetation communities as mapped by Umwelt (2014) is provided in Figure 2-1.

Table 2-1. Vegetation communities occurring at the Kokoda Offset Area (Umwelt 2014b).

Vegetation Community	BC Act Status	EPBC Act Status	Vegetation within Kokoda Offset Site (ha)
Grey Box Grassy Woodland	EEC	EEC	13
Grey Box Grassy DNG	EEC	EEC	96
White Box Grassy Woodland	EEC	CEEC	2.2
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest			150
Rocky Rise Shrubby Woodland			26

Vegetation Community	BC Act Status	EPBC Act Status	Vegetation within Kokoda Offset Site (ha)
Grey Box – Ironbark Woodland			25
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine DNG			15
Dwyer's Red Gum Creek line Woodland			9.4
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Woodland Low Quality			8.6
Mugga Ironbark Woodland			1.9
Farm Tracks and Dams – Disturbed Land			2.5
Total			350

2.3 Threatened Species

2.3.1 Flora

No threatened flora species were recorded by Umwelt (2014) in the Kokoda Offset Area.

2.3.2 Fauna

Twelve threatened fauna species were recorded in the Kokoda Offset Site by Umwelt (2014b) and are listed in Table 2-2. The grey-crowned babbler, brown treecreeper and the superb parrot were the most commonly recorded threatened fauna species across the Kokoda Offset Area (Umwelt 2014b). The grey-crowned babbler and the brown treecreeper are both sedentary birds and will utilise the site across all seasons whereas the superb parrot is a seasonally nomadic species which will largely utilise the Kokoda Offset Site for foraging during spring and summer. Given the array of varied habitats within the site, there is a high potential that other threatened fauna species may occur within the Kokoda Offset Area.

Table 2-2. Threatened fauna species recorded at Kokoda (Umwelt 2014b)

Common Name	Scientific Name	Status		No. of Individuals/ Locations
		BC Act	EPBC Act	
Glossy black-cockatoo	*Calyptorhynchus lathami*	V		2/1
Superb parrot	*Polytelis swainsonii*	V	V	162/23
Little lorikeet	*Glossopsitta pusilla*	V		25/2
Brown treecreeper (eastern subspecies)	*Climacteris picumnus victoriae*	V		18/10
Speckled warbler	*Chthonicola saggitatus*	V		13/9
Hooded robin (south-eastern form)	*Melanodryas cucullata*	V		1/1
Grey-crowned babbler (eastern subspecies)	*Pomatostomus temporalis*	V		95/20
Varied sittella	*Daphoenositta chrysoptera*	V		2/2
Diamond firetail	*Stagonopleura guttata*	V		8/3
Eastern bentwing-bat	*Miniopterus schreibersii oceanensis*	V		-/2
Little pied bat	*Chalinolobus picatus*	V		-/2
Yellow-bellied sheath tail-bat	*Saccolaimus flaviventris*	V		-/2

2.4 Management zones

The KOA has been further delineated according to the condition of the vegetation and their recovery potential. A conceptual plan of the different management areas according to potential regenerative capacity and active revegetation management requirements is given in Figure 2-2 (Umwelt 2014a). Management zones 1 to 5 are DNG communities that occur on the lower slopes in the northern section of the property. These areas will each receive varying levels of management. The long-term goal for each of these zones, including zone 6, is to return them to their former woodland community structure (Table 2-3).

Table 2-3. Management Zones at the Kokoda Offset Area. (Umwelt 2014a).

Management Zone	Vegetation Type	Objective	Total Area (ha)
1	Grey Box Grassy Woodland – DNG – Active Revegetation	Restore to woodland	36.3
2	Grey Box Grassy Woodland – DNG – Potential Regeneration	Restore to woodland	21.3
3	Grey Box Grassy Woodland – DNG – Natural Regeneration	Restore to woodland	38.4
4	Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine DNG Active Regeneration	Restore to woodland	1
5	Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine DNG Natural Regeneration	Restore to woodland	13.8
6	Disturbed – Potential Regeneration	Restore to woodland	1.3
7	All Remnant Woodland and Forest	Conserve and maintain	238
		Total	350

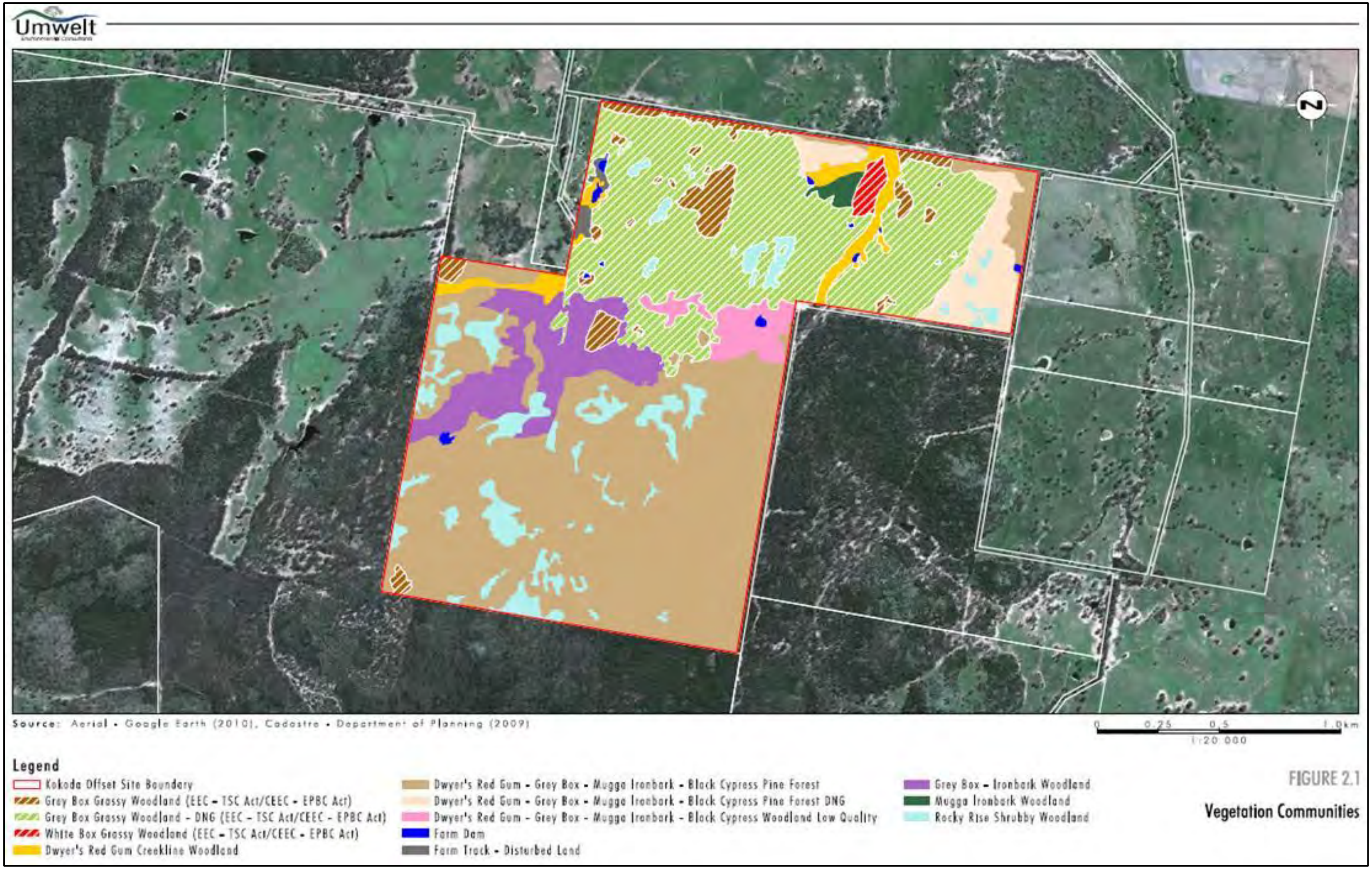


Figure 2-1. Distribution of the various vegetation communities within the Kokoda Offset Area (Umwelt 2014a)

Figure 2-2. Conceptual plan of the different management areas according to potential regenerative capacity and active revegetation management requirements (Umwelt 2014a).

2.5 Biodiversity Management targets

There are a range of biodiversity management targets which will be required to be met as part of the approval conditions. These have been determined by Umwelt (2014a) as short, medium and long-term targets with these being provided below. Specific performance indicators and completion criteria will be used to track the recovery of the woodlands and effectiveness of the proposed management strategies as described in the BOMP.

2.5.1 Short-term objectives

The short term (3 year) biodiversity management targets for the management of the Kokoda Offset Site are to:

- establish signage throughout the Kokoda Offset Site;
- remove stock-grazing activities from the Kokoda Offset Site;
- establish a monitoring program to assess the success of ongoing management and improvement strategies, in particular focusing on the regeneration potential of Grey Box Grassy Woodland DNG areas; and
- commence establishment of Grey Box Grassy Woodland in areas of DNG through assisted natural regeneration principles;
    - include a range of flora species from each vegetation strata represented in the target community (such as trees, shrubs, and ground cover forbs and grasses), even if only as seedlings/juvenile plants initially, as determined through monitoring of selected reference sites in the target community within the Kokoda Offset Site;
    - contain a flora species assemblage trending towards the target communities (i.e. Grey Box Grassy Woodland EEC or Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest) as determined through monitoring of selected reference sites in the target community within the Kokoda Offset Site;
    - support no more than 20 per cent foliage cover of perennial weed species (as a total of all strata, based on monitoring plot data); and
    - support no more than 20 per cent bare ground as part of the ground layer.
- effectively manage weed and pest species;
- implement weed monitoring at 6, 12, 18 and 24 months to assess if weed species are out competing native species once grazing pressure has been removed. Adaptive management practices will be adopted to control weed species as necessary;
- from year 2 onwards, initiate active revegetation methods to establish Grey Box Grassy Woodland in areas of low recovery potential DNG as deemed required through the results of monitoring in years 1 and 2;
- manage the remnant woodland areas to maintain similar or increasing flora and fauna species diversity;
- establish an appropriate long-term conservation mechanism; and
- demonstrate that accurate records are being maintained substantiating all activities and monitoring associated with the BOMP.

2.5.2 Medium-term objectives

The preliminary medium term (6, 10 and 15 years) biodiversity management targets for the Kokoda Offset Site are to:

- effectively monitor, control and reduce weed and pest species populations;
- monitor and document collective trend towards an increase in native flora and fauna species diversity;

- monitor and document DNG areas trending toward woodland communities, containing native species commensurate with those of the target woodland communities.

2.5.3 Long-term objectives

The preliminary long-term (i.e. 20 years) biodiversity management targets for the Kokoda Offset Site are to:

- effectively control and reduce weed and pest species populations;
- increase the overall native flora and fauna species diversity compared to conditions during baseline assessments;
- improve the habitat values of the remnant woodland communities in the Kokoda Offset Site compared to conditions during baseline assessments;
- successfully establish an additional 96 hectares of Grey Box Grassy Woodland EEC in areas of existing DNG and demonstrate that the regenerated communities are representative of local reference sites in remnant Grey Box Grassy Woodland EEC.
- regenerate/revegetate management areas contain a minimum of 50 per cent of the native flora species diversity recorded from reference sites in the target community within the Kokoda Offset Site;
- regenerate/revegetate management areas support a vegetation structure that is similar to that recorded for reference sites in the target community within the Kokoda Offset Site;
- demonstrate that second generation trees are present within regeneration/revegetation areas;
- identify that more than 75 per cent of trees are healthy and growing as indicated by long-term monitoring;
- ensure that weed species do not dominate any vegetation stratum (i.e. weed species comprise less than 10 per cent of any vegetation stratum);
- ongoing monitoring of soil stability, including implementation of erosion and sediment controls to management significant erosions concerns, as required; and
- regenerate/revegetate areas linked to existing woodland remnants to establish vegetation corridors within the broader landscape and manage excessive edge effects.

2.6 BOMP Ecological Monitoring Program

The Kokoda Offset Area will be subject to an ongoing monitoring program to measure the success of management and restoration strategies in meeting the approval conditions, management targets and performance indicators in a timely manner. The monitoring program will incorporate annual systematic monitoring as well as biannual (twice yearly) inspections as indicated in the BOMP (Umwelt 2014a). Primary monitoring objectives as indicated in the BOMP (Umwelt 2014a) include;

- identify any potential loss of biodiversity values over the entire Kokoda Offset Site;
- document the ecological characteristics of remnant woodland vegetation to establish a baseline for developing accurate closure criteria for the regeneration of DNG;
- assess the recovery of DNG areas;
- assess and map the presence of threats such as significant populations of pest fauna species or weed infestations; and
- identify the need for additional or corrective management measures to achieve the performance indicators and completion criteria.

2.7 Ecological monitoring timing and schedules

According to the BOMP the ecological monitoring will be annual for the first five years, then every three years for the following 15 years (Umwelt 2014a). The first ecological monitoring surveys were completed in Winter and Spring 2014 (Umwelt 2014b). Where possible subsequent monitoring events should occur in the same season. Preferential ecological monitoring surveys should be undertaken in spring or autumn as there tends to be a lower diversity of species detectable in the more extreme weather conditions of winter and summer seasons (except where specific seasons are required for targeted bird surveys).

3 BOMP Ecological monitoring surveys

It was proposed in the BOMP that the monitoring program should incorporate techniques that:

- are relatively simple to measure, can be replicated with limited subjectivity, and are reproducible;
- adopt the SMART principles (specific, measurable, achievable, realistic and timely);
- are targeted towards recording information that provides a good indication of the status of the biodiversity values of the KOA;
- allow for floristic composition and structure to be monitored over time using basic statistical analysis;
- allow for comparison to reference (control) sites; and
- are cost effective.

3.1 2014 vegetation surveys

In 2014 Umwelt implemented the first vegetation surveys and established 16, 20 x 20m monitoring sites across the range of vegetation communities and management zones at the KOA. The results of these surveys are provided in Umwelt (2014b).

3.2 2015 vegetation surveys

3.2.1 Review

In 2015, DnA Environmental was engaged to review the monitoring program and establish a comprehensive range of ecological data which will fulfil the monitoring and reporting requirements of the BOMP. The monitoring programs aim to establish clearly defined, repeatable and consistent methodologies for monitoring changes in various aspects of ecosystem function, succession and long-term sustainability. Part of this process included:

- Establishing a range of relevant reference sites to compare and track the progress and inherent ecosystem function of rehabilitation areas;
- Selecting a range of suitable reference sites that reflect the desired final land use, biodiversity targets, historical disturbances and local community expectations; and
- Undertaking a monitoring program that provides simple but informative and reliable information that indicates positive recovery trends or rapid detection of rehabilitation failure.

3.2.2 Ecological performance indicators

At Kokoda, a range of Key Performance Indicators (KPI's) were quantified by data obtained from replicated reference sites which were representative of the Grey Box Woodland EEC and Dwyer's Red Gum woodland. All ecological performance indicators are quantified by range values measured from these reference sites which form *upper* and *lower* KPI targets. The same ecological performance indicators are also measured in the revegetation/rehabilitation sites, and these should equal or exceed these values or at least demonstrate an increasing trend.

These Key Performance Indicators have been further separated into "*Primary performance indicators*" and "*Secondary performance indicators"*. Primary performance indicators are those chosen as essential completion criteria targets and have been identified as those that will satisfy requirements identified within the BOMP. The range values of each ecological performance indicator are adapted annually to reflect seasonal conditions and disturbance events. Secondary performance indicators are those that would be desirable to achieve but do not necessarily have a direct effect on consent conditions or meeting biodiversity targets.

The monitoring sites were established by Umwelt in 2014 and these sites were used, where appropriate, to maintain consistency. The monitoring methodology adopted at Kokoda is consistent with that used in the NPM rehabilitation monitoring program (DnA Environmental 2010 – 2014a; 2018a, 2020a) and the Estcourt Offset Area ecological monitoring program (DnA Environmental 2010 – 2014a; 2019b, 2020b). The annual vegetation monitoring has been undertaken during spring and this year was undertaken from the 17 - 19th October and due to extensive rainfall, was completed on the 26th of October.

Field work and associated reports have been undertaken by Dr Donna Johnston and Andrew Johnston from DnA Environmental. In 2021 and 2022, field surveys were undertaken by Andrew Johnston (DnA Environmental) and Ray Mjadwesch (Mjadwesch Environmental Service Support).

4 Vegetation monitoring methodologies

The vegetation monitoring methodologies include a combination of Landscape Function Analyses (CSIRO Tongway & Hindley 1996), accredited soil analyses and various measurements of ecosystem diversity and habitat values using an adaptation of methodologies derived from the Biometric Manual 3.1 (DECCW 2011) and these have been described in more detail below.

4.1 Landscape Function Analyses

The LFA is a methodology used to assess key indicators of ecosystem function including landscape organisation and soil surface condition as measure of how well the landscape retains and uses vital resources. It was developed by CSIRO scientists Tongway and Hindley (Tongway 1994, Tongway and Hindley 1995, 1996, 2003, 2004). The indicators used quantify the utilisation of the vital landscape resources of water, topsoil, organic matter and perennial vegetation in space and time. Additional information and data spreadsheets are freely available on the internet.

The LFA methodology collects data at two "nested" spatial scales.

1. At coarse scale, landscape organisation is characterised. Patches and interpatches, indicators of resource regulation, are mapped at the 0.5 to 100 m scale from a gradient-oriented transect (making sense of landscape heterogeneity); and
2. At fine scale, soil surface assessment (soil "quality") examines the status of surface processes at about the 1-m scale, with rapidly assessed indicators on the patches and interpatches identified at coarse scale.

At each scale, parameters are calculated that reflect several aspects of landscape function. In the first stage, we identify and record the patches and interpatches along a line oriented directly down slope. Sometimes there are several different types of each patch/interpatch which provides a measure of heterogeneity or "landscape organisation".

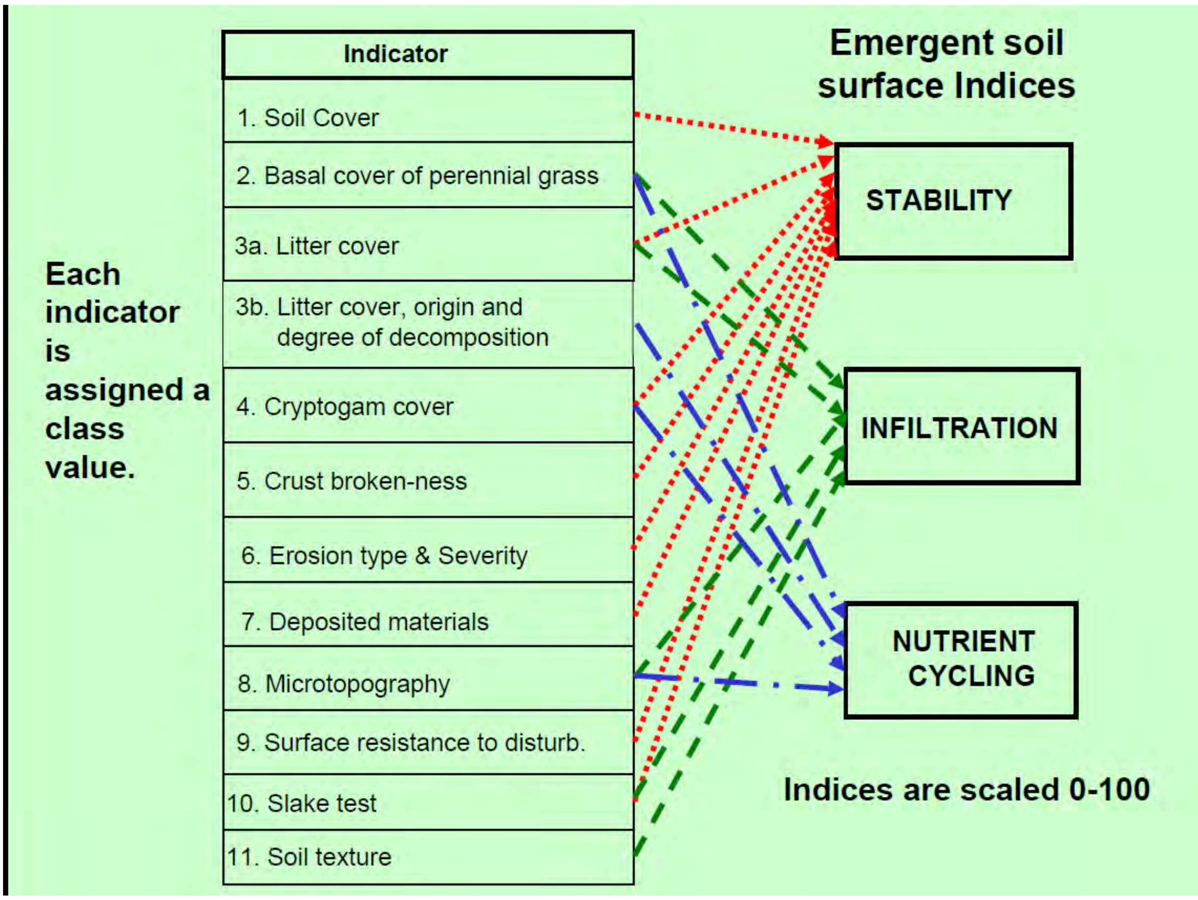
In the second stage, called "**soil surface condition" (SSC)** assessment, it is possible to assess and monitor soil quality using simple indicators including:

- Rain splash protection;
- Perennial vegetation cover;
- Litter;
    - Percent litter cover;
    - Origin of the litter;
    - Extent of decomposition;
- Cryptogam cover;
- Crust Brokenness;
- Soil Erosion Type and Severity;
- Deposited Materials;
- Soil Surface Roughness;
- Surface Nature (resistance to disturbance);
- Slake Test; and
- Soil Surface Texture.

These 11 features are compiled and calculated into three indices of soil quality:

1. Stability (that is, resistance to accelerated erosion),

2. Infiltration (the rate soil absorbs water) and
3. Nutrient Cycling (the way plant litter and roots decompose and become available for use by other plants).



4.2 Soil analyses

Soil samples are undertaken using standard soil sampling techniques within the monitoring quadrat. At least 12 samples are taken at each site and bulked together. Soil samples are sent to Southern Cross University at their National Association of Testing Authorities (NATA) accredited laboratory for analysis. Soil analyses consist of assessing the parameters, pH, Electrical Conductivity (EC), available calcium (Ca), magnesium (Mg), potassium (K), nitrate nitrogen (N), sulphur (S), organic matter (OM), exchangeable Sodium (Na), Ca, Mg, K, hydrogen (H), cation exchange capacity, available and extractable phosphorus (P), micronutrients zinc (Zn), manganese (Mn), Iron (Fe), copper (Cu), boron (B), silicon (Si), aluminium (Al), molybdenum (Mo), Cobalt (Co) and selenium (Se) and total carbon. A report with analysis and desirable levels recommended in the agricultural industry is provided by the laboratory. Exchangeable Sodium Percentages were calculated as a measure of sodicity or dispersion.

Since 2017, a “Basic agricultural soil analyses” have been undertaken as previous soil results indicated that all sites at Kokoda did not have any heavy metal contaminants, other than high iron levels which were typical of the local area as demonstrated in the various woodland reference sites.

4.3 Monitoring structural diversity, floristic and other biodiversity attributes

In addition to LFA, assessments of various biodiversity components must also be made to monitor changes in particular plants and groups of plants through the various successional phases and to document and/or identify critical changes or management actions required.

Some simple and rapid procedures for making these assessments were developed by CSIRO scientists (Gibbons 2002, Gibbons *et al* 2008). They were developed for assessing habitat quality across a range of vegetation types in the southern NSW Murray-Darling Basin which formed the basis of the Biometric Model used in the Property Vegetation Planning Process (DECCW 2011). Some adaptations have been made to reduce monitoring effort where possible, and to incorporate aspects of newly formed revegetation sites or sites in the early stages of recovery. For example, some habitat features such as the detailed measuring and assessment of decomposition of the logs and branches has been omitted, whilst the understorey assessment included planted tubestock, direct seeding as well as natural recruitment and naturally occurring shrubs.

The rapid ecological assessment provides quantitative data that measures changes in:

- Ground cover diversity and abundance in five repeated 1 x 1m sub-plots every 4m (20m transect) using Braun-Blanquet method;
- Ground cover composition and habitat characteristics including % cover in 10 repeated 1 m lengths every 2m (20m transect) provided by:
  - dead leaf litter;
  - annual plants
  - perennial plants
  - cryptogams;
  - logs; and
  - rocks.
- Vegetation structure and projected foliage cover at 0 – 0.5 and increasing 2m height increments to >6.0m height in 10 repeated 1 m lengths every 2m (20m transect);
- Floristic diversity and growth forms in 20 x 20m quadrat;
- Shrub and juvenile tree density and diversity in 20 x 20m quadrat;
- Tree and mature shrub density, diversity and health condition in 20 x 20m quadrat; and
- Other habitat attributes such as the presence of hollows, fire scars, mistletoe and the production of buds, flowers and fruit in 20 x 20m quadrat.

4.3.1 The permanent monitoring quadrats

The permanent monitoring quadrats are 20 x 20m and original transects established by Umwelt were utilised where possible. The 20m LFA transect always faces down slope and this same transect has also been used as the vegetation transect, in most cases. In all but one site (DWood1) the left side of the monitoring plot forms both the LFA and vegetation transect with the remaining plot occurring to the right.

Four marker pegs were used to mark out the permanent transect position (using Umwelt marker posts where possible) and these are situated at each corner of the 20 x 20m square plot. GPS readings are taken to ensure quadrats can be relocated over time. Permanent photo-points are also established at various marker pegs of the quadrat to record changes in these attributes over time.

4.4 Limitations

4.4.1 Suitable reference sites

All remnant vegetation within the Kokoda Offset Area and subsequent reference sites have been subjected to some form of disturbance, in particular clearing, over grazing, erosion and "woody weed invasion". The long-term historical disturbance associated with agriculture (and mining) is evident across the region, therefore, the woodland reference sites were considered to be in a degraded and modified state, but quite typical of those communities in the context of the local environment.

4.4.2 Plant identification

In some cases, there may have been a lack of critical features and/or reproductive structures (due to heavy grazing or browsing, new germinants etc) that may be required for the positive identification of some plant genera, and therefore some species may have only been identified to the genera level. Where species names have been changed and/or updated and/or plants may have been previously misidentified, corrections according to PlantNet have been applied where possible. In most cases these occurrences are unlikely to have an impact on the meeting of completion targets.

4.5 Amendments

4.5.1 KPI table inclusions

This year, inclusions were made to the KPI tables regarding tree and mature shrub density (> 5 cm dbh) and shrub and juvenile tree density (< 5cm dbh) targets. These included segregating the population(s) into:

- Density of eucalypts;
- Density of acacias;
- Density of other endemic shrubs;
- Density of exotic/non endemics; and
- Percentage of eucalypts.

5 2018 Voluntary Conservation Agreement (VCA)

In 2018, a Voluntary Conservation Agreement (VCA) was executed with the Minister administering the National Parks and Wildlife Act 1974 to satisfy commitments to secure a biodiversity offset relating to the Northparkes Mine Step Change project. Under the Agreement, NPM is required to undertake a monitoring program as per Annexure B and D of the Conservation Agreement for a minimum period of 10 years of the Conservation Agreement dated 9th February 2018. As per Annexure C, a revegetation program is also to be implemented, with this postponed in 2018 and 2019 due to the ongoing drought. In 2020, the external exclusion fence was completed, and revegetation activities were undertaken throughout the spring. This involved the deep ripping and the planting of tubestock which were protected by variously sized tree guards.

5.1 Additional monitoring requirements of the VCA

Subsequently, additional monitoring of the existing monitoring sites are required as part of the Conservation Agreement with BCT including additional photo-point monitoring, and the completion of the BCT monitoring form specified in Annexure D. The results also need to be compared to baseline (November 2016) and benchmark quadrat data (Table 2 (not 5)), Annexure D.

Please note that there were a few errors within the Conservation Agreement relating specifically to:

1. Table 5, Annexure D as referred to in the Conservation Agreement is in fact presented as Table 2, Annexure D;
2. In Table 2, Annexure D, the Biometric vegetation type should be LA151: Western Grey Box - Cypress Pine Shrubby Woodland on stony foot slopes in the NSW South Western Slopes Bioregion and Riverina Bioregion. This community LA151 is consistently referred to throughout the Conservation Agreement and is *not* Biometric Vegetation Type LA154 as stated in the header of Table 2, Annexure D within the Conservation Agreement;
3. The benchmark data presented within Table 2, Annexure D is consistent for LA151, except for an error in the Maximum value for Native Ground Cover Other (NGCO) which should be 20, not 10 as presented in Table 2 within the Conservation Agreement;
4. The benchmark data presented within Table 2, Annexure D is consistent with those associated with LA166, not LA165. Subsequently the data presented in the Table 2 within the Conservation Agreement is incorrect. Correct values associated with LA165 have since been applied within this monitoring report.

A discussion of the changes, results, condition and effectiveness of management actions implemented or required continue to be provided in the “Kokoda Annual Vegetation Monitoring Report”. Data and trends in data since monitoring began in 2015 continue to be utilised so the historical series of data since NPM took ownership are not lost and continue to fulfil requirements of the BOMP. Changes in performance indicators are also required as part of the new Conservation Agreement.

6 Kokoda vegetation monitoring sites

A preliminary evaluation of the location of the sites established by Umwelt in 2014 via digital mapping suggested that not all main vegetation communities occurring and mapped at Kokoda by Umwelt were represented. In addition, there appeared to be more sites in the cleared DNGs than necessary to fulfil minimum quadrat numbers according to DEC guidelines (2012). Subsequently sites established by Umwelt in 2014 were retained where possible, however in some cases the sites were not required, were not in suitable condition for use as a reference site or new sites were established in unrepresented vegetation communities.

Since 2015, 17 permanent monitoring sites have been monitored at Kokoda by DnA Environmental and included three Grey Box Grassy woodland reference sites and five Grey Box Grassy woodland DNG sites which will be regenerated back to Grey Box Grassy woodland according to the BOMP (Umwelt 2014 Table 6-1).

There were three Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress woodland reference sites and three Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress woodland DNG which will be regenerated back to the Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress woodland community (Umwelt 2014). There was also one site established in each of represented examples of White Box Grassy Woodland CEEC, Grey Box – Ironbark woodland (dominated by Ironbark) and a Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest which was originally mapped by Umwelt as low quality woodland (Umwelt 2014).

These 17 sites continue to be monitored as part of the annual monitoring program, and as of 2019 according to the additional monitoring requirements of the BCT Conservation Agreement.

Table 6-1. The number of permanent monitoring sites established in each of the vegetation communities.

Community type as per Umwelt 2014	Biometric Vegetation Type as per VCA (2018)	PCT	Size (ha)	Site description	Sites established (DnA 2015)
Grey Box Grassy woodland DNG (EEC)	Western Grey Box Cypress Pine Shrubby Woodland on stony foot slopes in the NSW South Western Slopes Bioregion and Riverina Bioregion	LA151	96	Probable active rehabilitation area	GBReveg1 GBReveg2 GBReveg3 GBReveg4 GBReveg5
Grey Box Grassy woodland EEC	Western Grey Box Cypress Pine Shrubby Woodland on stony foot slopes in the NSW South Western Slopes Bioregion and Riverina Bioregion	LA151	13	reference site	GBWood1 GBWood2 GBWood3
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine DNG	Mugga Ironbark Black Cypress Pine Woodland on Hillslopes and Ridges of the Central Lachlan Region of NSW Western Slopes Bioregion	LA165	15	Probable active rehabilitation area	DReveg1 DReveg2 DReveg3
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest	Mugga Ironbark Black Cypress Pine Woodland on Hillslopes and Ridges of the Central Lachlan Region of NSW Western Slopes Bioregion	LA165	150	reference site	DWood1 DWood2 DWood3
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest	Mugga Ironbark - Black Cypress Pine Woodland on Hillslopes and Ridges of the Central Lachlan Region of NSW Western Slopes Bioregion	LA165	8.6	Low quality [Umwelt]	DWoodLQ
White Box Grassy Woodland CEEC	White Box – White Cypress Pine – Western Grey Box shrub/grass/forb Woodland of the of NSW Western Slopes Bioregion	LA218	2.2	CEEC	WBWood1

Community type as per Umwelt 2014	Biometric Vegetation Type as per VCA (2018)	PCT	Size (ha)	Site description	Sites established (DnA 2015)
Grey Box – Ironbark woodland	Mugga Ironbark Black Cypress Pine Woodland on Hillslopes and Ridges of the Central Lachlan Region of NSW Western Slopes Bioregion	LA151	25	Non EEC	IronWood1
Dwyer's Red Gum creek-line woodland	Mugga Ironbark Black Cypress Pine Woodland on Hillslopes and Ridges of the Central Lachlan Region of NSW Western Slopes Bioregion	LA165	9.4	Non EEC – narrow linear	0
Rocky Rise Shrubby woodland	Mugga Ironbark Black Cypress Pine Woodland on Hillslopes and Ridges of the Central Lachlan Region of NSW Western Slopes Bioregion	LA165	26	Non EEC – Numerous small pockets	0
Total No. monitoring Sites					17

6.1 Monitoring site descriptions and locations

GPS co-ordinates (GDA94), aspects and slopes of the ecological monitoring sites remain unchanged and are provided in Appendix 1. The map showing the locations of the monitoring sites is shown in Figure 6-1.

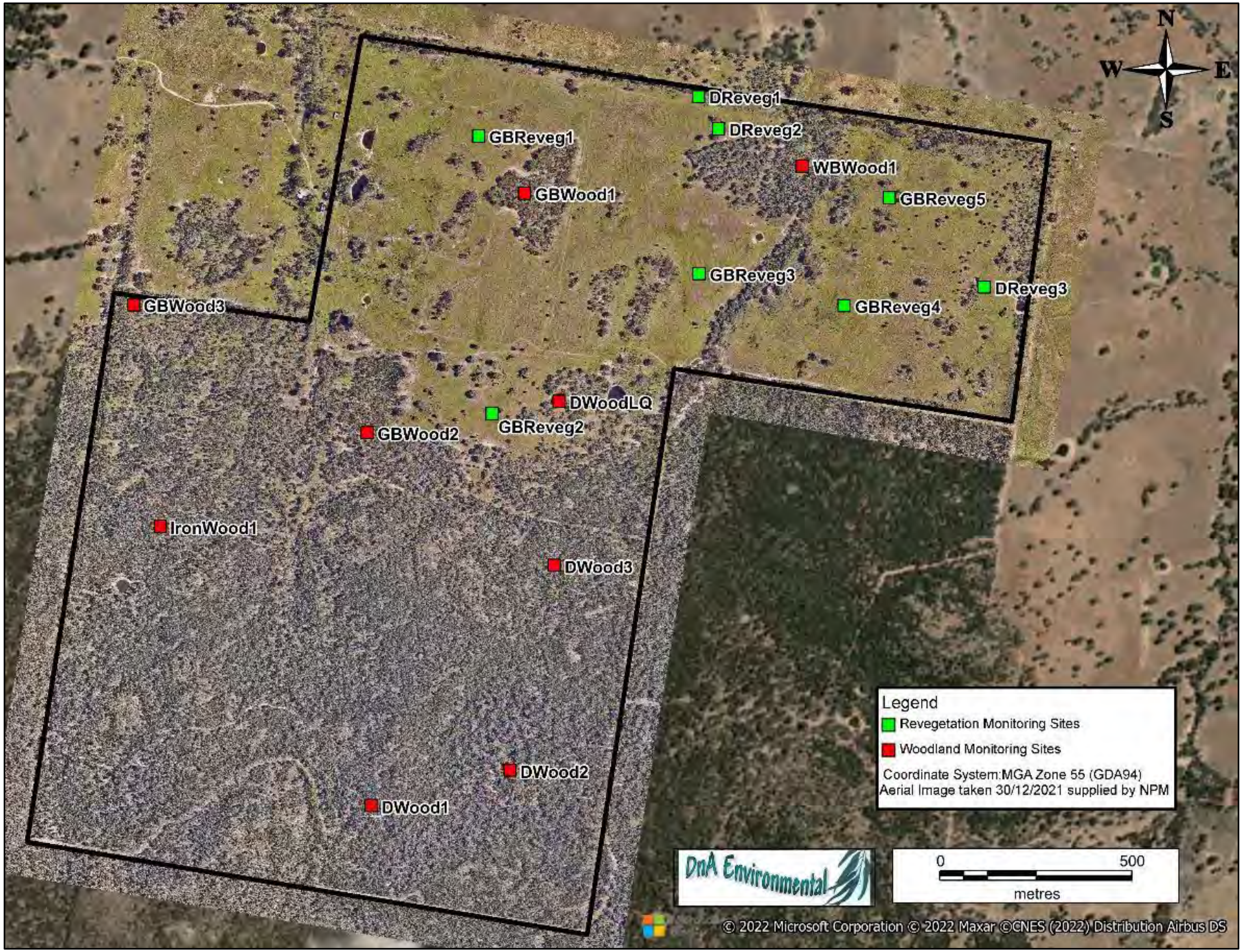


Figure 6-1. Map showing the location of the vegetation monitoring sites at Kokoda.

7 Rainfall

The average annual rainfall at Mandagery (Rawene) is 674 mm (BoM 2022), however there have been extreme seasonal conditions with drought conditions experienced during 2017 – 2019, followed by three consecutive years of above average rainfall (Figure 7-1).

In addition to these extremes in annual rainfall activity, the monthly averages indicate there has also been high seasonal variability and erratic rainfall activity since monitoring began (Figure 7-2). 2015 was a dry rainfall year with limited rainfall occurring between February and March 2015. Above average rainfall was then experienced in April, July and August which stimulated a flush of annual plant growth during the 2015 monitoring period. April 2016 marked the beginning of a long period of above average monthly rainfall, with record breaking rains falling from April through to October causing widespread flooding.

In 2017, very low rainfall activity typically occurred throughout the year and except in March where 195 mm of rainfall was recorded. In November and December however above average monthly rainfall was recorded which boosted the annual rainfall to 626 mm for the year. Extremely dry conditions returned in 2018 and only 242 mm was received up until the end of the monitoring period in October, with a total of only 403 mm recorded for the entire year. Drought conditions continued into 2019, with only 274 mm being received up to the end of October compared to an expected average of 547mm, and a total of only 299 mm was recorded for the year.

The ongoing drought was finally broken in 2020 with above average rainfall being experienced throughout most of the year up until August, with exceptionally high rainfall of 173 mm being recorded in April. Despite below average rainfall during September there was a total of 889 mm being recorded up until end of October, compared to the expected long-term mean of 547 mm for the same period. January, February and March 2021 had very good rainfall, but almost no rainfall was recorded in April and it was limited in May. In the next few months preceding the monitoring event rainfall was higher than the expected averages. The total rainfall recorded up to the end of October 2021 was 711 mm, with 912 mm being recorded for the year.

Above average rainfall continued into 2022 for the third consecutive year, with heavy rains again causing widespread flooding across the region. While above average rainfall occurred in most months this year, there was limited rain in February and June. This year there was 1036 mm of rain recorded to the end of October which was much higher than the long-term expected average of 547 mm for the same period.

The extreme seasonal conditions experienced over the past eight years have had a significant impact on the composition and diversity of the vegetation communities at Kokoda. Prolonged dry conditions tend to result in increased grazing pressure by macropods and goats with the outcomes being reflected within the range of monitoring data. Over the last three years, more favourable seasonal conditions has promoted the germination, growth and abundance of the vegetation over significant parts of the landscape.

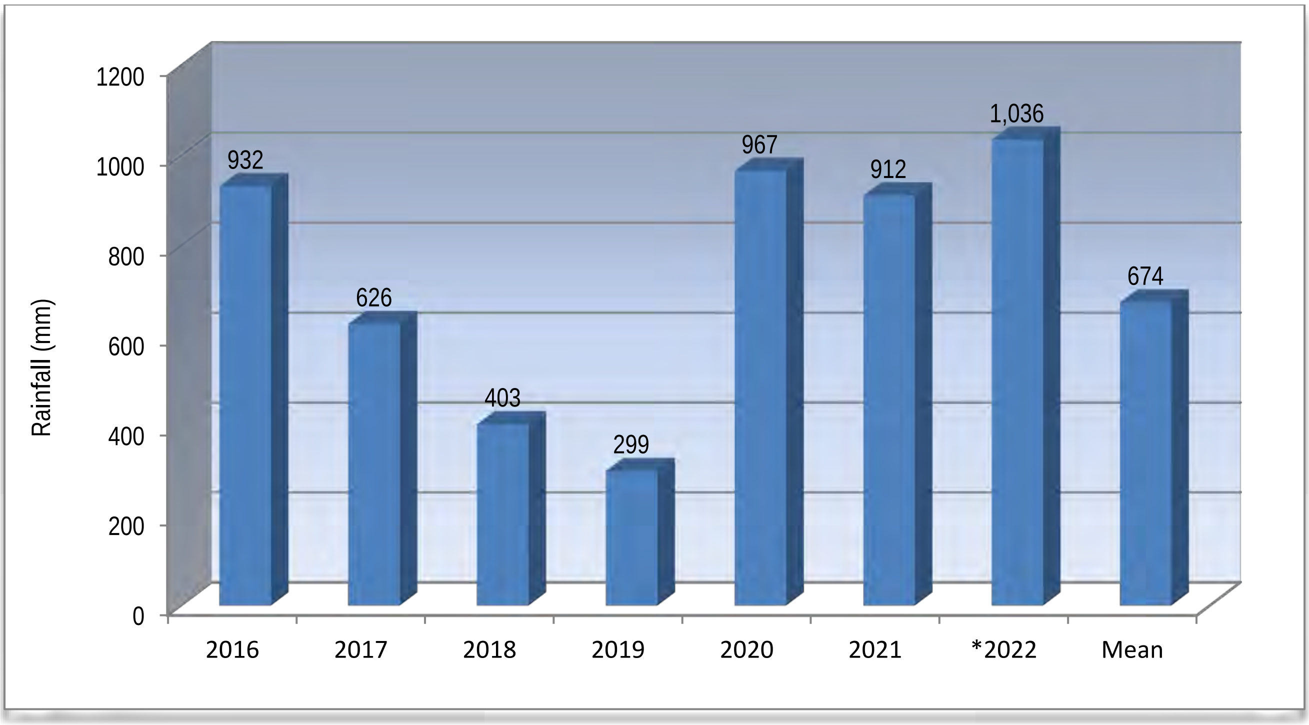


Figure 7-1. Total annual rainfall recorded at Mandagery (Rawene) from 2016 to the end of October 2022 (*) compared to the long-term mean (BoM 2022).

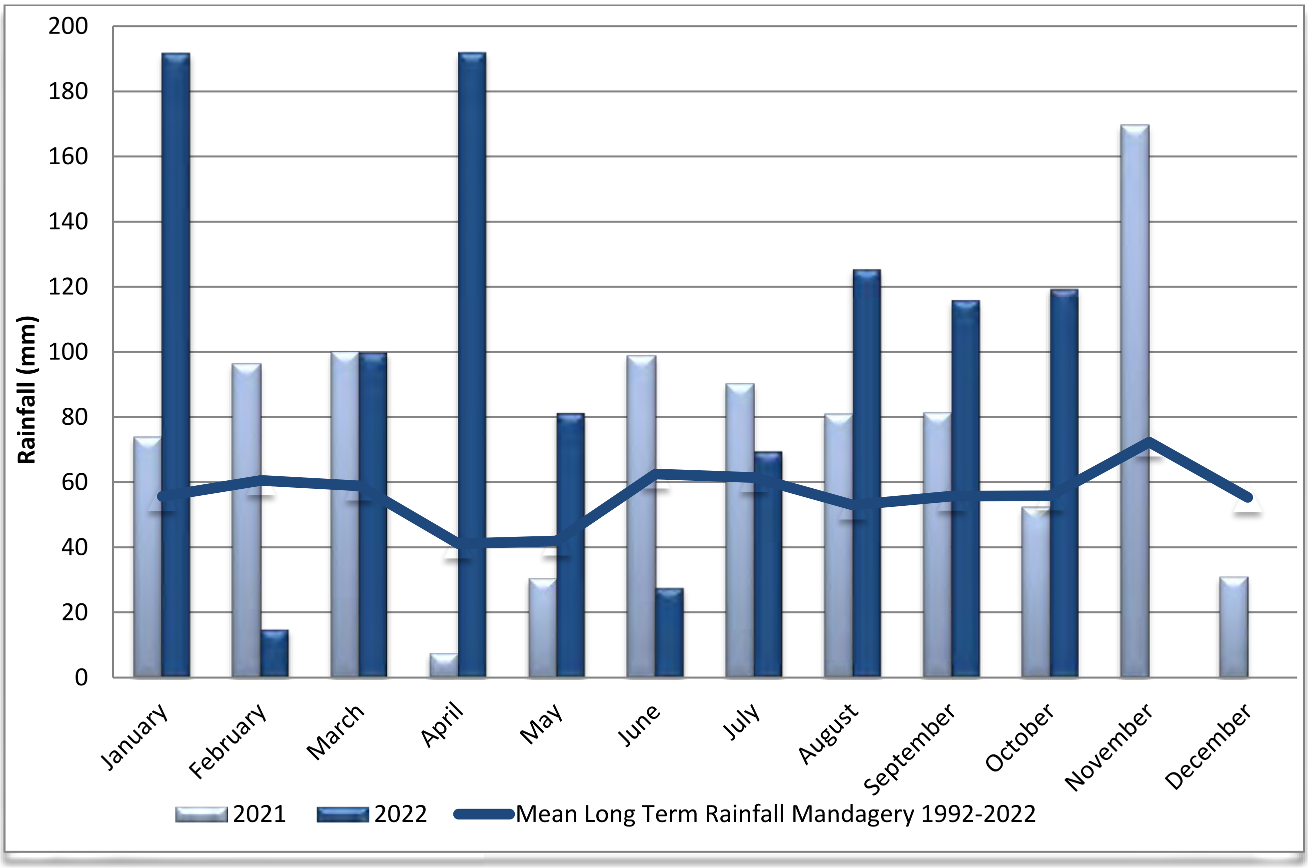


Figure 7-2. Monthly rainfall recorded at Mandagery January 2021 to the end of October 2022 compared to the long-term monthly averages recorded at Mandagery (Rawene) (BoM 2022).

8 Results: Grey Box Woodland monitoring sites

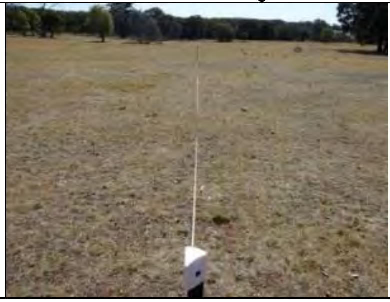
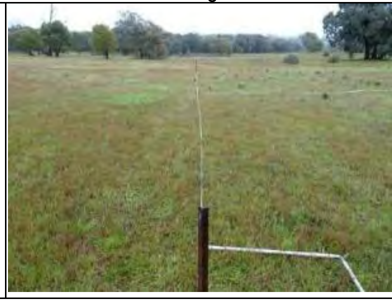
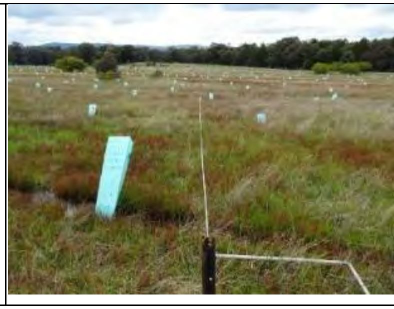
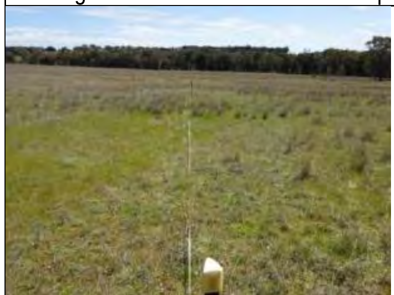
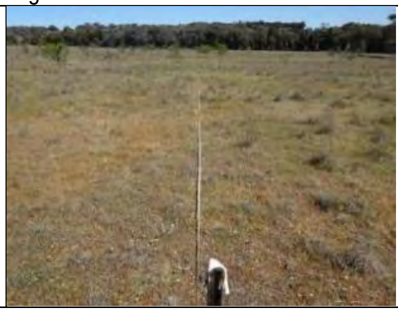
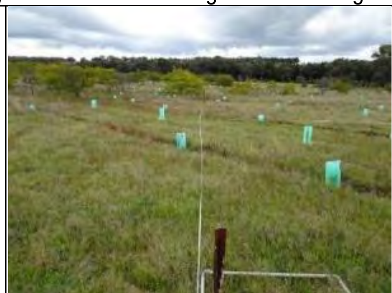
This section provides the results of the monitoring within the Grey Box monitoring sites and demonstrates ecological trends and performance of the revegetation sites against a selection of ecological performance indicators. This section has also included the White Box grassy woodland and Grey Box - Ironbark woodland.

8.1 Photo-points

General descriptions of the Grey Box Grassy Woodland monitoring sites established at Kokoda including photographs taken along the vegetation transect are provided in Table 8-1. Please note that in some years photographs have been omitted in order to present increasing quantities of photographic data. Please refer to the relevant reports if required.

Table 8-1. General site descriptions and permanent photo -points of the Grey Box woodland monitoring sites at Kokoda.

<table>
<tr><th>2015</th><th>2017</th><th>2019</th><th>2021</th><th>2022</th></tr>
<tr><td colspan="5">GBReveg1: Degraded native pasture dominated by the exotic annuals Trifolium angustifolium (Narrow-leaf Clover) and Vulpia muralis (Rats-tail Fescue). The site was however relatively diverse and maintained relatively good ground cover. The natives Bothriochloa macra Red-leg Grass and Rytidosperma spp. (Wallaby Grass) were also very common. In 2018, the pastures were heavily grazed causing the deterioration of the litter and cryptogam layers and species diversity was low. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover. Since 2020, above average rainfall resulted in a flush of plant growth and exotic annuals and native sedges and reeds were abundant.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th>2015</th><th>2017</th><th>2019</th><th>2021</th><th>2022</th></tr>
<tr><td colspan="5">GBReveg2: Degraded native pasture dominated by the exotic annuals Aira cupaniana (Silvery Hairgrass) and Vulpia muralis (Rats-tail Fescue) with large patches of Parentucellia latifolia (Red Bartsia). In 2018, the pastures were heavily grazed causing the deterioration of the litter and cryptogam layers and species diversity was low. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover. Since 2020, above average rainfall resulted in a flush of plant growth and exotic annuals and native sedges and reeds were abundant.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">GBReveg3: Native pasture dominated by Bothriochloa macra and the exotic annuals Aira cupaniana, Hypochaeris glabra (Smooth Catsear) with patches of Vulpia muralis. In 2018, the pastures were heavily grazed causing the deterioration of the litter and cryptogam layers and species diversity was low. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover. The area had been deep ripped and planted to tubestock just prior to monitoring in 2020. Since 2020, above average rainfall resulted in a flush of plant growth and exotic annuals and native sedges and reeds were abundant. In 2022, there were 12 seedlings but the tree guards had been removed.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">GBReveg4: Degraded native pasture dominated by Bothriochloa macra, but the exotic annuals Vulpia muralis (Rats-tail Fescue), Hypochaeris glabra (Smooth Catsear) and Aira cupaniana were also abundant. Mosses and cryptogam were scattered throughout. In 2018, the pastures were heavily grazed causing the deterioration of the litter and cryptogam layers and species diversity was low. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover. In 2020 the area had been deep ripped and was due to be planted to tubestock. Since 2020, above average rainfall resulted in a flush of plant growth and exotic annuals and native sedges and reeds were abundant. In 2022, there were 7 seedlings but the tree guards had been removed.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
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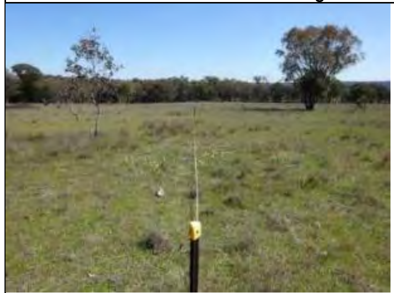
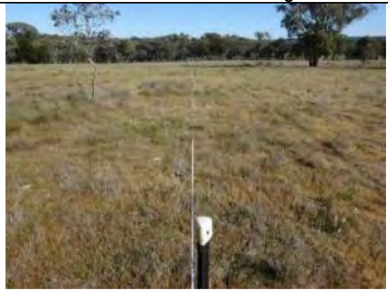
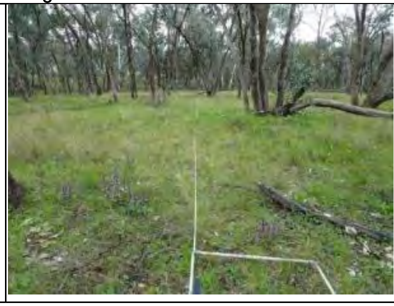
<tr><th>2015</th><th>2017</th><th>2019</th><th>2021</th><th>2022</th></tr>
<tr><td colspan="5">GBReveg5: Degraded native pasture dominated by Bothriochloa macra, but the exotic annuals Vulpia muralis (Rats-tail Fescue), Hypochaeris glabra (Smooth Catsear) and Aira cupaniana were also abundant. In 2018, the pastures were heavily grazed causing the deterioration of the litter and cryptogam layers and species diversity was low. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover. Since 2020, above average rainfall resulted in a flush of plant growth and exotic annuals and native sedges and reeds were abundant.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">WBWood1: High quality open regrowth woodland dominated by E. albens (White Box) with some scattered mature E. blakelyi (Blakely's Red Gum) and Callitris endlicheri. In 2015, Several species of ground orchids were found. In 2018 there continued to be deep litter layer however species diversity was low. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover. Since 2020, above average rainfall resulted in a flush of plant growth and there was a high diversity of herbs and grasses.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">IronWood1: Moderate density regrowth woodland dominated by E. sideroxylon (Mugga Ironbark) with scattered E. microcarpa, E. albens, E. dwyeri and Callitris endlicheri. There were scattered mature trees and a moderate density of younger saplings. There were scattered individuals of Brachyloma daphnoides (Daphne Heath). In 2018 there continued to be deep litter layer however species diversity was low. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover. Since 2020, above average rainfall resulted in a flush of plant growth and there has been a lot of natural tree and shrub regeneration and a high diversity of herbs.</td></tr>
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<table>
<tr><th>2015</th><th>2017</th><th>2019</th><th>2021</th><th>2022</th></tr>
<tr><td colspan="5">GBWood1: Very degraded regrowth woodland dominated by E. microcarpa with some scattered Callitris endlicheri. There were some large old regrowth trees however there were limited shrubs or tree regeneration. There were some dead stags and fallen branches. In 2018, there continued to be deep litter layer however species diversity was low. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover. Since 2020, above average rainfall resulted in an increase in plant growth, with native herbs and exotic annuals scattered throughout.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">GBWood2: Degraded regrowth woodland dominated by E. microcarpa with some scattered E. sideroxylon. There was a moderate density of regrowth trees and some limited but recent recruitment of volunteer shrubs. There were some dead stags and fallen branches were common across the site. There was a high cover of dead leaf litter with a sparse cover of native ground cover species. In 2018, numerous shrubs had died however there continued to be litter layer however species diversity was low. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover. Since 2020, above average rainfall resulted in an increase in plant growth, with native herbs and exotic annuals scattered throughout.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">GBWood3: Degraded regrowth woodland dominated by E. microcarpa with some scattered E. sideroxylon. There was a moderate density of regrowth trees and some limited but recent recruitment of volunteer shrubs. There were no dead stags, but some fallen branches occurred across the site. There was a high cover of dead leaf litter with a sparse cover of native ground cover species. In 2018, there continued to be deep litter layer however species diversity was low. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover. Since 2020, above average rainfall resulted in an increase in plant growth, with native herbs and exotic annuals being scattered throughout.</td></tr>
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8.2 Landscape Function Analyses

8.2.1 Landscape Organisation

A patch is an area within an ecosystem where resources such as soil and litter tend to accumulate, while areas where resources are mobilised and transported away are referred to as interpatches. Landscape Organisation Indices (LOI) are calculated by the length of the patches divided by the length of the transect to provide an index or percent of the transect which is occupied by functional patch areas (Tongway and Hindley 2004).

The three Grey Box woodland reference sites were characterised by having a mature tree canopy and a well-developed, decomposing leaf litter layer and a sparse cover of native perennial forbs and grasses. Despite the improved conditions the continued disturbance and heavy grazing pressure has resulted in some bare patches in all three woodland sites resulting in a marginal decline in patch areas in previous years. This year ground cover had improved in two sites however continued disturbance was recorded in GBWood01, with the resultant Landscape Organisation target being 84 - 100% this year (Figure 8-1).

The White Box and Ironbark woodlands were also characterised with having a mature tree canopy and a well-developed leaf litter layer. In the White Box woodland, native grass and forb cover was low during the drought conditions 2017 - 2019, while in the Ironbark woodland there continued to be scattered low shrubs. Since 2020, both sites had improved levels of ground cover and both continued to have high functional patch areas and LO's of 100%.

While the Grey Box revegetation sites presently exist as degraded grasslands and are structurally different to the woodland reference sites, they typically had good ground cover comprised of a combination of annual and perennial plants and cryptogams. During 2017 - 2019 there was limited live ground cover and often the integrity of the litter and cryptogam layers had declined. In GBReveg3 and GBReveg4 deep ripping had been undertaken in preparation for the planting of tubestock in spring 2020 which created deep troughs. While ripping removed some ground covers and exposed some areas of bare soil, the deep troughs created additional surface roughness and an additional capacity of the area to retain any mobilised resources in most cases. Since 2020 there has been high levels of ground cover in most site and this year the grassland revegetation sites had 99 - 100% functional patch areas (Figure 8-1). In GBReveg 3, the rip lines were filled to the top with water and the ground was saturated with water, as were many of the rip lines across the area during the last two years of above average rainfall, with numerous seedlings starting to appear water stressed.

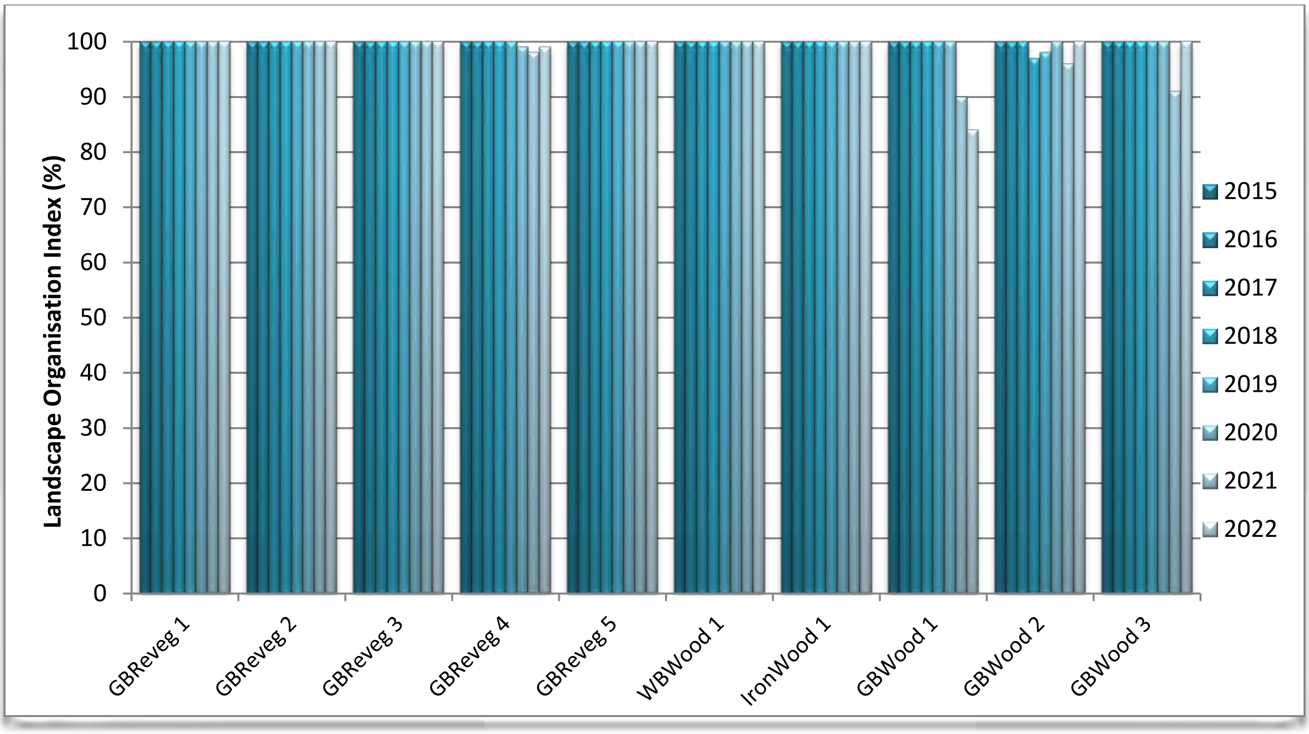


Figure 8-1. Landscape Organisation Indices recorded in the Grey Box woodland monitoring sites.

8.2.2 Soil surface assessments

8.2.2.1 Stability

The stability of the reference sites was largely provided by the perennial tree cover, moderately deep litter layers and sandy clay loam soils which were very stable. In 2019 there was a further reduction in live plant cover in the understorey and there continued to be a lot of litter mobilised and deposited across these sites. In 2020 there were increased levels of ground cover and an increase in stability was recorded at all three sites, while a minor reduction was recorded in 2021. This year, stability indices have increased in all sites with LFA stability indices 63.9 – 68.5 being recorded in the reference sites.

In the White Box and Ironbark woodlands, stability indices tended to follow similar trends and this year increased stability was also recorded and with stability indices of 72.5 and 71.0, continuing to be more stable than the Grey Box woodland reference sites (Figure 8-2). In the Grey Box grassland revegetation sites, stability indices have slightly decreased in all sites except GBReveg2 and ranged from a low of 74.5 in GBReveg2 to a high of 76.0 in GBReveg4, thus all revegetation areas continued to be more stable than the Grey Box reference sites.

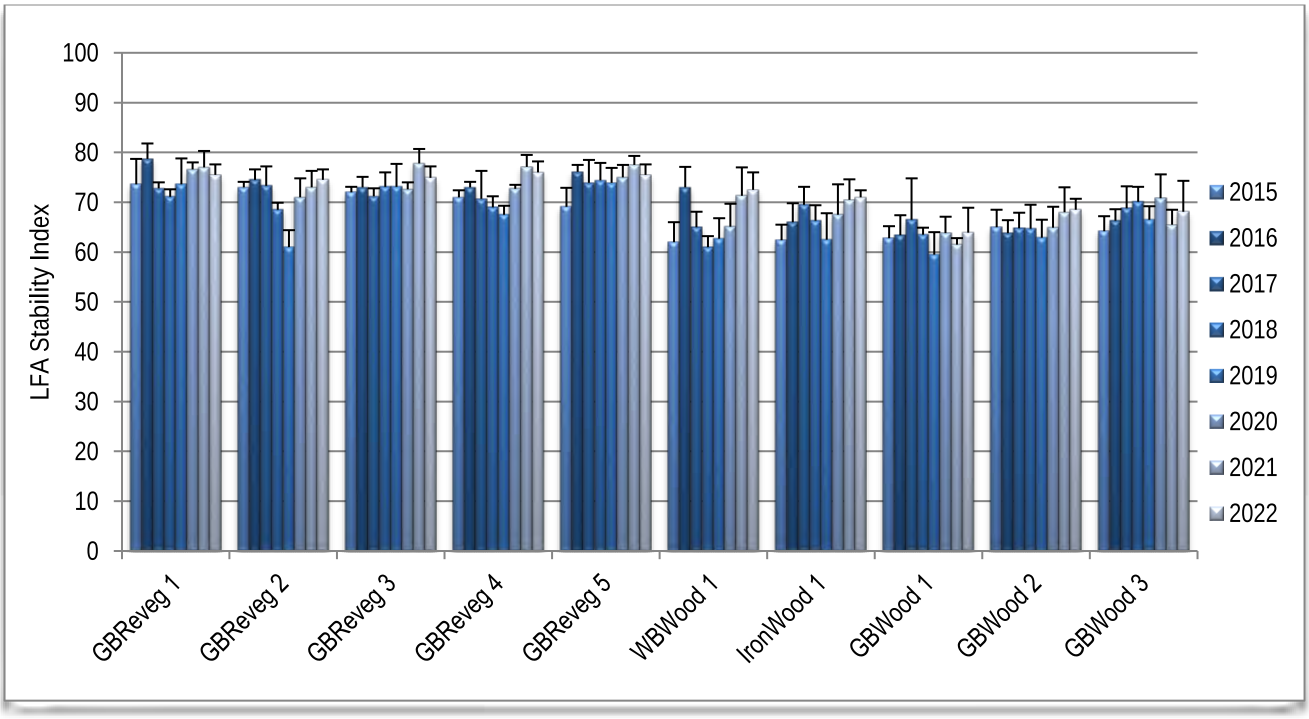


Figure 8-2. LFA stability indices recorded in the Grey Box woodland monitoring sites.

8.2.2.2 Infiltration

There continued to be a well-developed and decomposing litter layer that had often formed a rich spongy humus layer. During 2017 - 2019 however, increased usage by wildlife has increased surface crusting in some areas, and despite the improved seasonal conditions, there was a marginal decrease in infiltration in two reference sites again this year, with the reference sites providing an infiltration range of 46.9 – 52.0 (Figure 8-3). While a negligible decrease was recorded in the White Box woodland with an index of 53.2, an increase in infiltration capacity was recorded in Ironbark woodland, with an infiltration index of 49.6.

In comparison to the reference sites the grassland revegetation sites tended to have an undeveloped litter layer and a hard surface crust which reduces the infiltration capacity of moisture to enter the soil profile. Previously they often had increased cover of perennial ground covers however overgrazing may have caused these to decline in some areas. This year infiltration capacity has slightly decreased in all except GBReveg2, due to the decline in perennial plant covers and perhaps due to the continued waterlogging, with infiltration indices ranging from a low of 42.9 (GBReveg1) to a high of 48.2 (GBReveg1). This year revegetation sites GBReveg1, GBReveg3 and GBReveg5 had an infiltration capacity that was comparable to the woodland reference sites.

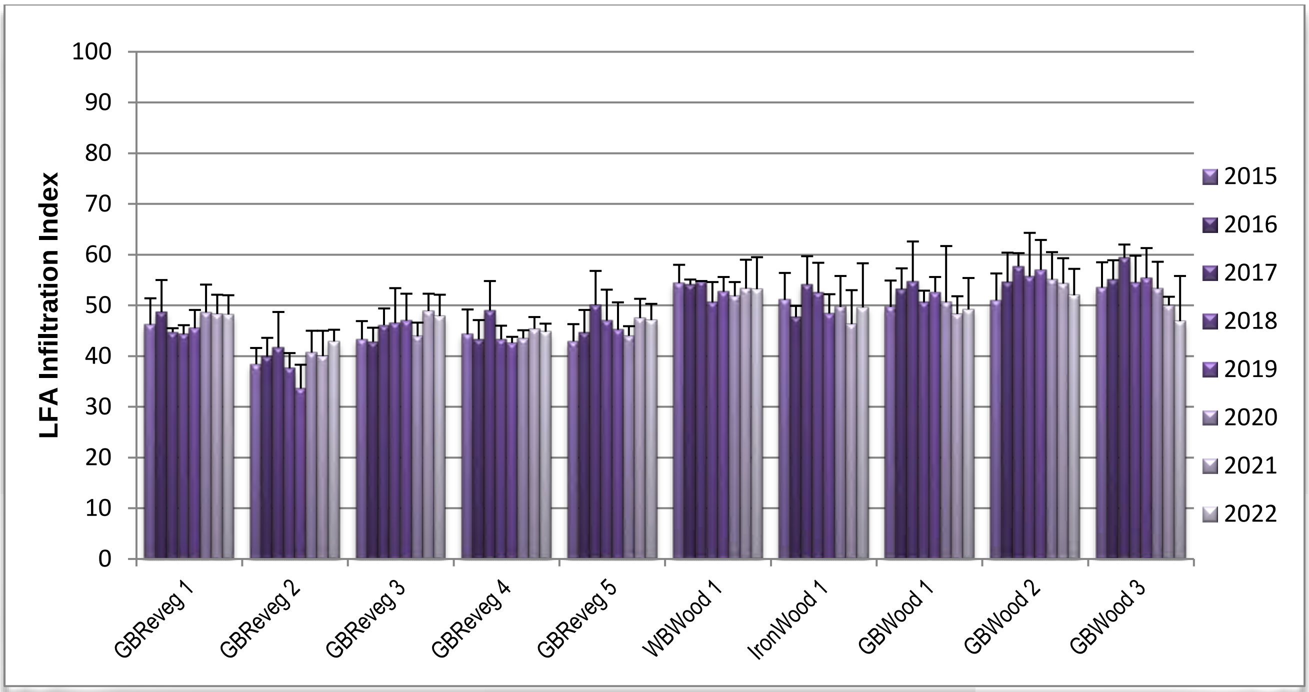


Figure 8-3. LFA infiltration indices recorded in the Grey Box woodland monitoring sites.

8.2.2.3 Nutrient recycling

The nutrient recycling capacity is influenced by the degree of perennial plant cover and accumulation and decomposition of the litter layers, which is in turn influenced by the degree of soil compaction and soil surface crusting. During the drought, increased usage by wildlife has increased surface crusting in some areas, and despite the improved seasonal conditions there was a marginal decrease in infiltration in two reference sites again this year, with the reference sites providing an nutrient recycling range of 44.8 – 49.2 (Figure 8-4). Only minor changes were recorded in the White Box and Ironbark woodlands with infiltration indices of 52.0 and 48.5 respectively.

In the Grey Box grassland revegetation sites, there were only a few scattered juvenile trees or shrubs in some sites. The litter and humus layers were less developed than the reference sites, but cryptogams were often abundant. Previously, heavy grazing during the drought caused a deterioration of grassy understorey and cryptogamic layer, causing a decline in nutrient recycling capacity in most areas. Since 2020 there has been an increase in annual plant and litter cover and there was a significant increase in perennial plant cover in all sites last year. This year, perennial plant cover has decline however typically there has been a marginal increase in nutrient recycling capacity except in GBReveg4 and GBReveg5. All sites except GBReveg4 had a nutrient recycling capacity comparable to the reference sites this year, with indices ranging from a low of 44.0 in GBReveg4 to a high of 48.7 in GBReveg1.

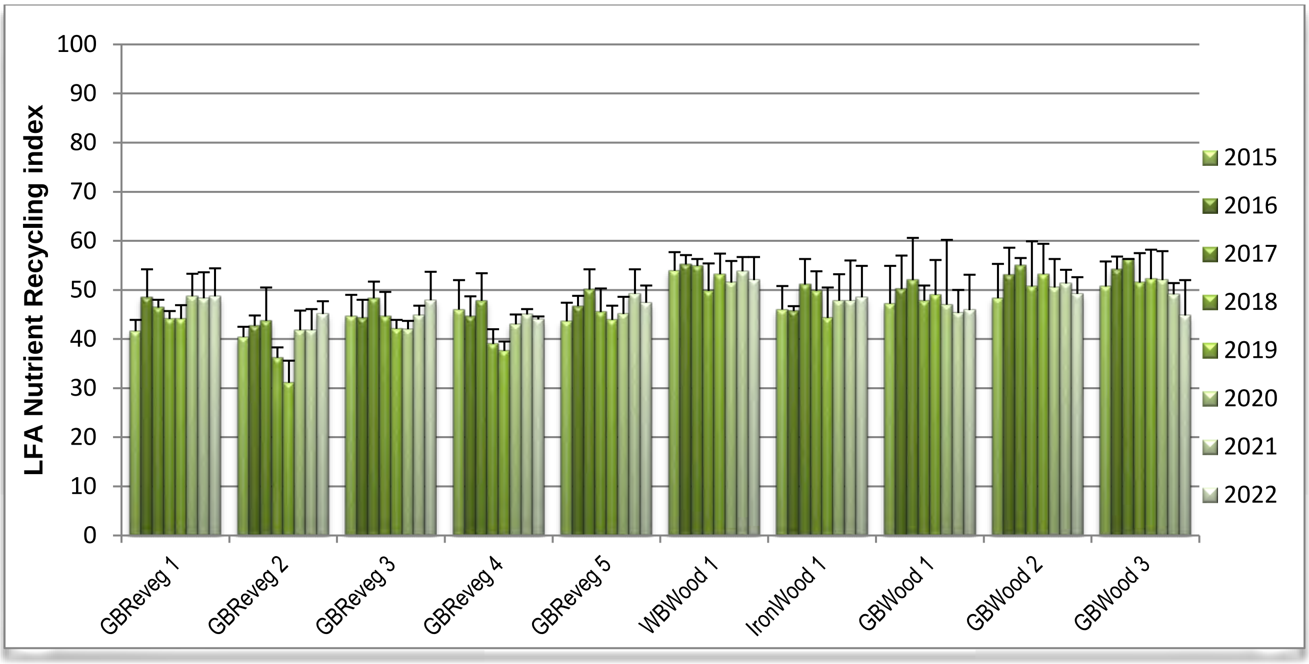


Figure 8-4. LFA nutrient recycling indices recorded in the Grey Box woodland monitoring sites.

8.2.3 Most functional sites

The sum of the LFA stability, infiltration and nutrient recycling components provide an indication of the most functional to least functional monitoring sites recorded this year and is provided in Figure 8-5. The maximum score possible is 300. There continued to be little overall difference in the total ecological functional between most of the monitoring sites, and this year the White Box Woodland site WBWood1 continued to be the most ecologically functional site with a total score of 178. There was little difference in scores in sites GBReveg1, GBReveg3, GBReveg5, GBWood2 and IronWood1 with scores of 172 - 169. GBReveg4 and GBReveg4 had a sum of scores which were slightly higher than the two reference sites GBWood3 and GBWood1 which had scores of 160 and 159 respectively. Examples of the various combinations of ground covers which are important to overall ecosystem function have been provided in Table 8-2.

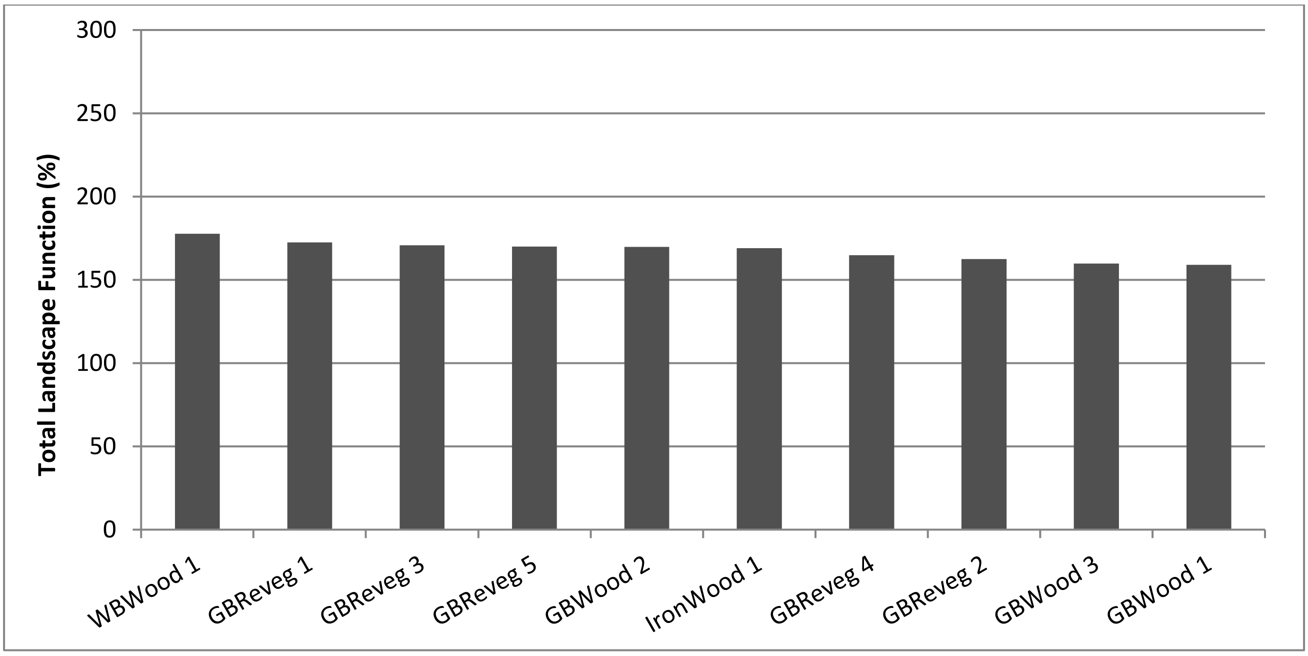
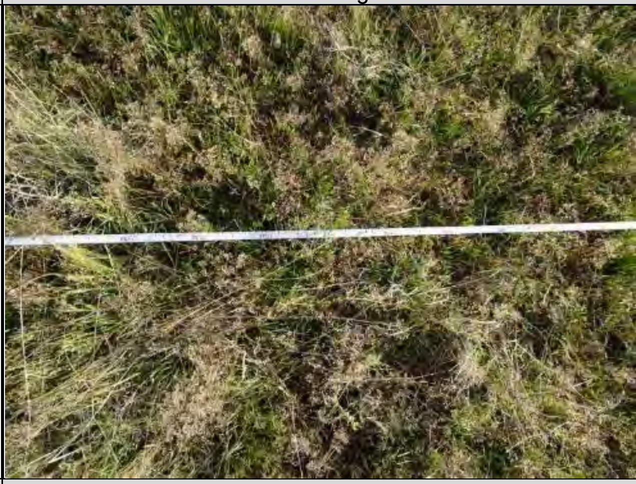


Figure 8-5. Sum of the LFA stability, infiltration and nutrient recycling components indicating the most functional to least functional monitoring site recorded in 2022.

Table 8-2. Examples of the different ground covers in the Kokoda Grey Box monitoring sites in 2022.

GBReveg1	GBReveg2
	
GBReveg3	GBReveg4
	
GBReveg5	WBWood1
	

IronWood1	GBWood1
	
GBWood2	GBWood3
	

8.3 *Trees and mature shrubs*

8.3.1 Population density

Mature trees and shrubs with a stem diameter >5cm dbh were recorded in the three Grey Box woodland reference sites as well as the White Box and Ironbark woodland sites. There was no change in tree density in two of the reference sites however one had died in GBWood02 where population densities were 8 – 22 this year, equating to a density of 200 – 550 stems per hectare (Figure 8-6). In WBWood1 and Ironwood1 one individual had died at both sites in 2019, probably as a result of the ongoing drought and two additional individuals have died in IronWood1 in 2021. One sapling had grown in IronWood1 where seven individuals were recorded in the White Box site and there were 27 in the Ironbark woodland. No trees or mature shrubs were yet present in the derived GBReveg native grassland sites.

8.3.2 Diameter at breast height

The average dbh recorded in the Grey Box reference sites ranged from 19 – 35 cm with the minimum dbh being 6 cm and the maximum dbh was 58 cm (Table 8-3). In the White Box woodland, the average dbh was 31 cm with a maximum dbh of 42cm, while in the Ironbark woodland the average dbh was 18 with a maximum of 50 cm. The relatively small trunk diameters indicate the trees are relatively young and indicative of their regrowth status.

8.3.3 Condition

The trees and mature shrubs in the Grey Box woodland monitoring sites were typically in moderate health but there were 10 – 38% of the population that were in a state of advanced dieback and 19% of the population had died in GBWood3, with many previous stags having now fallen over. In WBWood1 and Ironwood1 most individuals were also in moderate health however 38 - 41% were in a state of advanced dieback and 13 – 27% of the population were [dead] stags. Reproductive structures such as buds, flowers or fruits continue to be recorded in two reference sites and in the White Box and Ironbark woodlands. There continued to be an absence of mistletoe however hollows suitable as nesting sites (>10cm) were noted in WBWood1, Ironwood1, GBWood1 and GBWood3.

8.3.4 Species composition

The Grey Box reference sites were dominated by *Eucalyptus microcarpa* (Grey Box) however a single mature *Acacia implexa* (Hickory) was also recorded in GBWood2, while a single *E. sideroxylon* (Mugga Ironbark) was recorded in GBWood2 and GBWood3. The White Box woodland was dominated by *E. albens* but a *Callitris endlicheri* and *E. blakelyi* were also present. The Ironbark woodland was dominated by *E. sideroxylon* and contained numerous individuals of *E. albens* and *E. dealbata,* and there was one *Callitris endlicheri.*

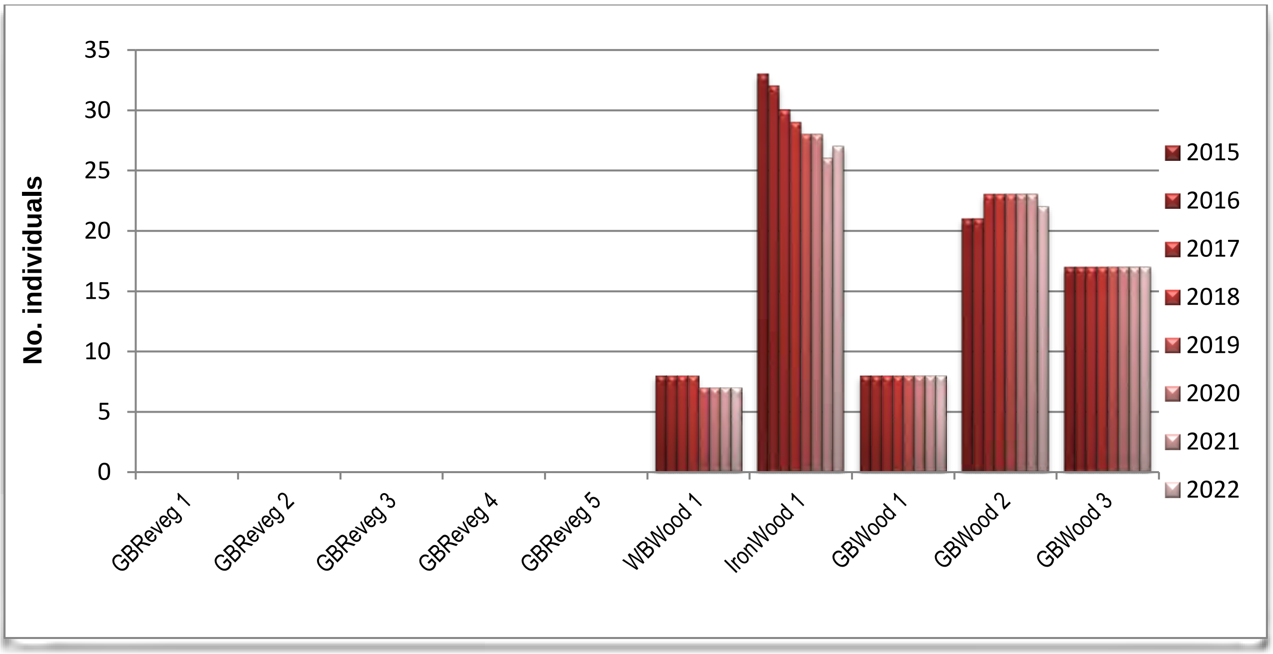


Figure 8-6. Tree and mature shrub densities (>5cm dbh) in the Kokoda Grey Box woodland monitoring sites.

Table 8-3. Trunk diameters and condition of the trees and mature shrubs in the woodland monitoring sites in 2022.

Site Name	No species	Average dbh (cm)	Max dbh (cm)	Min dbh (cm)	Total trees	No. with multiple limbs	% Live trees	% Healthy	% Medium Health	% Advanced Dieback	% Dead	% Mistletoe	% Flowers / fruit	%. Trees with hollows
GBReveg 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GBReveg 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GBReveg 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GBReveg 4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GBReveg 5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WBWood 1	3	31	42	18	8	4	88	13	63	38	13	0	13	25

Site Name	No species	Average dbh (cm)	Max dbh (cm)	Min dbh (cm)	Total trees	No. with multiple limbs	% Live trees	% Healthy	% Medium Health	% Advanced Dieback	% Dead	% Mistletoe	% Flowers / fruit	%. Trees with hollows
IronWood 1	4	18	50	6	37	3	73	0	32	41	27	0	11	3
GBWood 1	1	35	58	13	8	0	100	0	63	38	0	0	0	50
GBWood 2	3	19	33	8	22	4	100	27	55	18	0	0	23	0
GBWood 3	2	24	55	6	21	9	81	19	52	10	19	0	19	10

8.4 Shrubs and juvenile trees

8.4.1 Population density

In the woodland reference sites, there was some variability in the densities of shrubs and juvenile trees between the sites, with slightly more individuals in all sites with 6 – 44 individuals being recorded this year (Figure 8-7), equating to a maximum density of 150 - 1100 stems per hectare. In the White Box woodland there were two more individuals as a result of natural regeneration with a total of 23 individuals. In the Ironbark woodland there was a significant decrease in shrubs in 2020 as a result of the drought and since then there has been increasing densities with 112 individuals this year. In the derived grassland sites, there was some limited natural regeneration, with one volunteer *Callitris endlicheri* (Black Cypress Pine) seedling continued to be recorded in GBReveg1. In GBReveg3 there were 14 shrubs and juvenile trees planted in 2020 - 2021. In GBReveg4 there were seven seedlings as a result of the planting program, while in GBReveg5 there were four volunteer *E. dwyeri* seedlings.

8.4.2 Height class

In the reference sites, most individuals were less than 1.0 m in height but there were two individuals >2.0 m tall in GBWood2 and GBWood3. In WBWood1 and IronWood1 most were also less than 1.0 m in height, with the vast majority being <0.5 m (Table 8-4). In the GBReveg sites all individuals were less than 2.0m tall.

8.4.3 Species diversity

In the woodland reference sites, there were 2 - 6 species of shrubs and juvenile trees with the range of species including juvenile *E. microcarpa, Callitris endlicheri* (Black Cypress Pine), *Acacia implexa* (Hickory)*, A. paradoxa* (Kangaroo Thorn), *Cassinia laevis* (Cough Bush) and/or *Cassinia sifton* [arcuata] (Sifton Bush). Seedlings of *Brachychiton populneus* (Kurrajong), *Brachyloma daphnoides* (Daphne Heath) and Solanum aviculare (Kangaroo Apple) may also have been present.

In the White Box woodland there were nine different species including two acacias, two eucalypt seedlings and *Brachychiton populneus, Brachyloma daphnoides, Callitris endlicheri*, *Dodonaea viscosa* subsp. *cuneata* (Wedge-leaf Hopbush) seedlings. This year there were also seedlings of *Ozothamnus diosmifolius* (Pill Flower) and *Indigofera adesmiifolia* (Native Indigo). In the Ironbark woodland, there were now nine species which continued to be dominated by *Brachyloma daphnoides* with scattered seedlings of *Callitris endlicheri* and three eucalypt species. There were also occasional juveniles of *Cassinia laevis, E albens* and one *Brachychiton populneus* seedling. This year there was also one *Exocarpos cupressiformis* (Native Cherry) seedling.

One volunteer *Callitris endlicheri* seedling 0.5 – 1.0m tall continued to be recorded in GBReveg1. In GBReveg3, GBReveg4 and GBReveg5 there was a combination of *Eucalyptus microcarpa*, *E. sideroxylon*, *E. dwyeri, Acacia decora* (Western Golden Wattle), *A. implexa* (Hickory), *Acacia spectabilis,* and *Dodonaea viscosa* subsp. *angustifolia* tubestock seedlings as a result of the planting/replanting program. Some of the *E. dwyeri, Allocasuarina verticillata* and *Acacia spectabilis* seedlings were volunteer species. No shrubs or juvenile trees were recorded in GBReveg2.

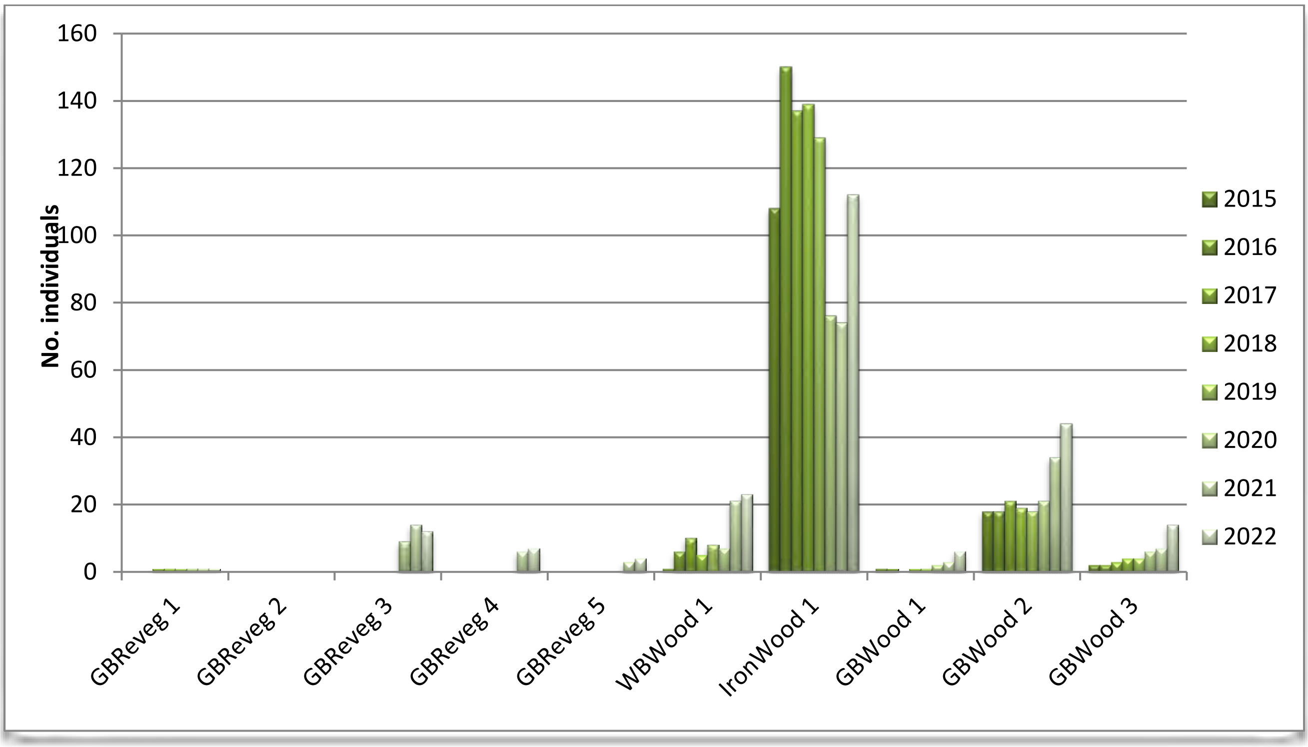


Figure 8-7. Total shrubs and juvenile trees recorded in the Grey Box monitoring sites.

Table 8-4 Number of individuals represented in each height class across the range of monitoring sites.

Site Name	0-0.5m	0.5-1.0m	1.0-1.5m	1.5-2.0m	>2.0m	Total	No. species	% Endemic
GBReveg 1	0	1	0	0	0	1	1	100
GBReveg 2	0	0	0	0	0	0	0	0
GBReveg 3	2	4	5	1	0	12	6	100
GBReveg 4	1	4	1	1	0	7	6	100
GBReveg 5	2	2	0	0	0	4	1	100
WBWood 1	12	9	2	0	0	23	9	100
IronWood 1	50	46	9	5	2	112	9	100
GBWood 1	4	1	0	1	0	6	2	100
GBWood 2	15	12	10	6	1	44	6	100
GBWood 3	8	4	0	1	1	14	6	100

8.5 Total ground Cover

Total ground cover is a combination of leaf litter, annual plants, cryptogams, rocks, logs and live perennial plants (<0.5 m in height). The drought combined with increased grazing pressure during 2017 – 2019 typically resulted in a reduction in live plant and litter cover across the range of monitoring sites. In 2020, seasonal conditions improved, however the woodland reference site GBWood1 continued to suffer from the effects of the drought and ongoing disturbance by animals to provide a target range of 84.0 – 97.0% (Figure 8-8). Since 2020, total ground cover has also improved in the White Box woodlands and all revegetation sites with ground covers ranging from 98 - 100% this year.

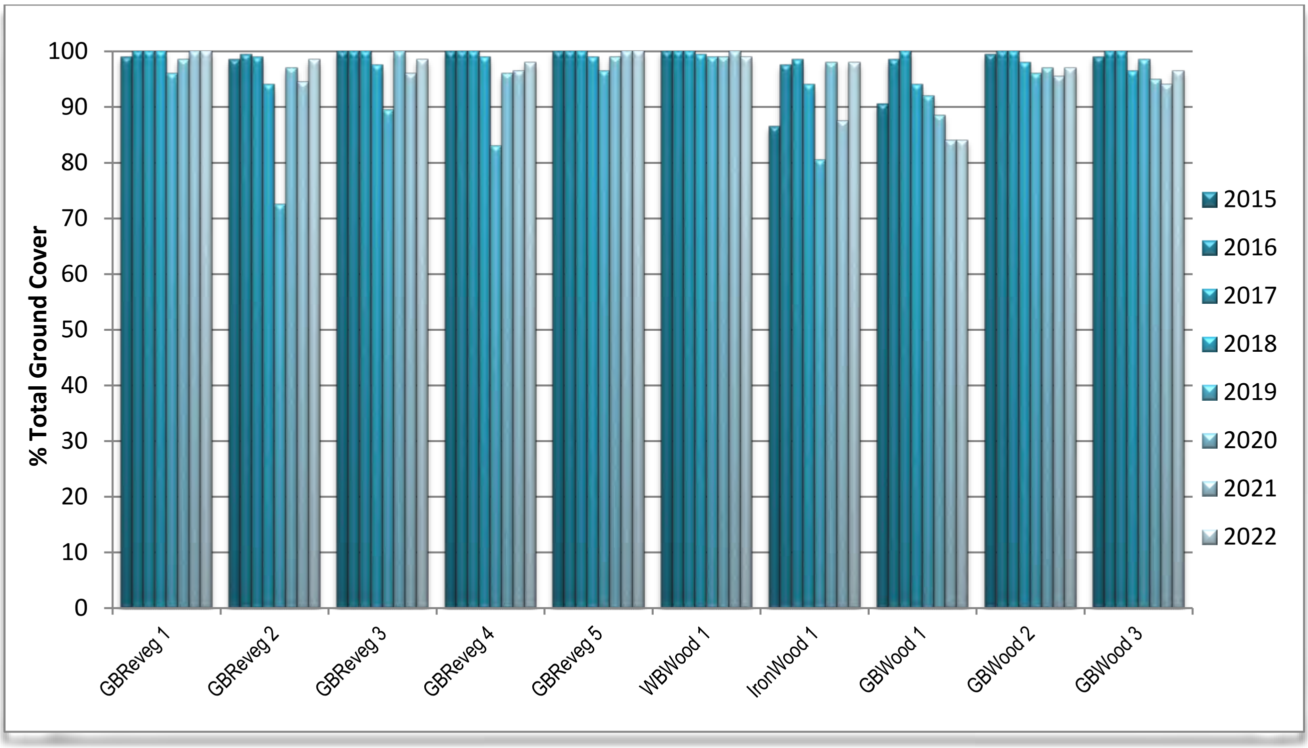


Figure 8-8. Total ground cover recorded in the Grey Box woodland monitoring sites.

8.6 Structural composition

The ground cover composition and structure of the Grey Box monitoring sites are provided in Figure 8-9. In the reference sites, the most dominant form of ground cover continued to be provided by dead leaf litter which was largely derived from fallen eucalypt leaves and twigs and provided 55 - 68% ground cover this year. As a result of the good seasonal conditions there has been a further increase in perennial plant covers, especially in GBWood2 and GBWood3, with the target range being 6 – 23.5%. There continued to be scattered annual weeds in two sites, which provided up to 8.5 - 17% ground cover. There continued to be a small contribution of cover (1 – 5%) provided by fallen branches.

In the White Box woodland site, perennial plant cover was quite abundant but had declined to provide 38% of the ground cover this year. There was a simultaneous reduction increase in litter and annual plant cover which provided 47.5% and 12.5% of the total cover respectively. There was a small contribution of cover provided by fallen branches and there was a minor bare patch. The Ironbark woodland was structurally very similar to the reference sites, where leaf litter was the most dominant ground cover and provided 59% cover. There has been a slight decrease in perennial plant cover with 12% cover, while there continued to be 12% cover provided annual plants. Cryptogams and logs provided 10% and 4% respectively and there was a minor bare patch.

In the derived grassland revegetation sites, perennial plant cover was highly variable and had declined across all sites with 6.5 - 32% cover. There was a significant increase in annual plants with 19.5 – 49.5% and dead leaf litter ranged from 11.5 – 61% cover. Cryptogams were not recorded in sites with a dense vegetative cover but 1% continued to be recorded in GBReveg4 and GBReveg5.

The reference sites were also characterised by having a mature canopy cover which exceeded 6.0 m in height with low hanging branches also providing occasional projected cover in the lower height classes. The White Box and Ironbark woodlands had a similar overstorey structure. Presently there is no vertical structure > 0.5 m in height in the derived grassland revegetation areas.

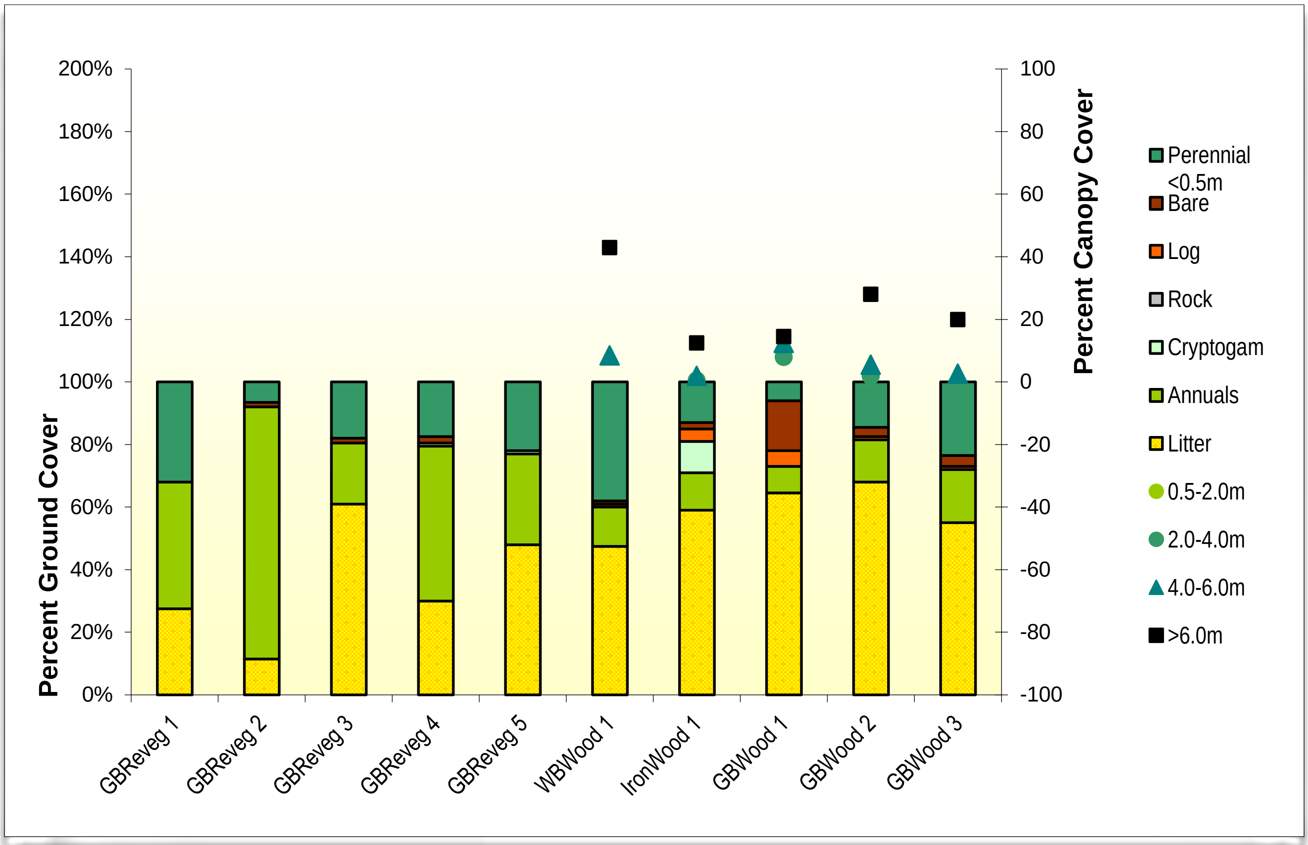


Figure 8-9. Average percent ground cover and projected foliage cover recorded in the Grey Box monitoring sites in 2022.

8.7 Floristic Diversity

Total floristic diversity recorded within the 20 x 20 m Grey Box woodland reference sites has been highly variable between the sites, as well and between the monitoring years (Figure 8-10). The dry conditions experienced during 2017 – 2019 resulted in a declining trend in diversity since 2016 in most sites, however rainfall prior to the monitoring event had stimulated a flush of plant growth in the revegetation areas which saw a minor increase in diversity in 2019. In 2020, floristic diversity has significantly increased across all monitoring sites as a result of the above average rainfall, with the diversity in the reference sites being similar to that recorded in 2016. In 2021 and 2022 there was a further increase in total floristic diversity in most, but not all monitoring sites. This year 53 – 59 species recorded in the reference sites.

While native species were more diverse than exotics species in most sites, there was 29 – 43 native species in the reference sites (Figure 8-11) and 16 - 24 exotic species this year (Figure 8-12). In the White Box and Ironbark woodlands, floristic diversity remained high with 78 and 48 species respectively, of which 23 and 5 were exotic species respectively. In the derived grassland sites, there were species, with there being 39 – 46 species of which 16 – 32 were natives and 15 – 24 were exotics. All sites had an acceptable diversity of exotics species compared to the reference sites this year.

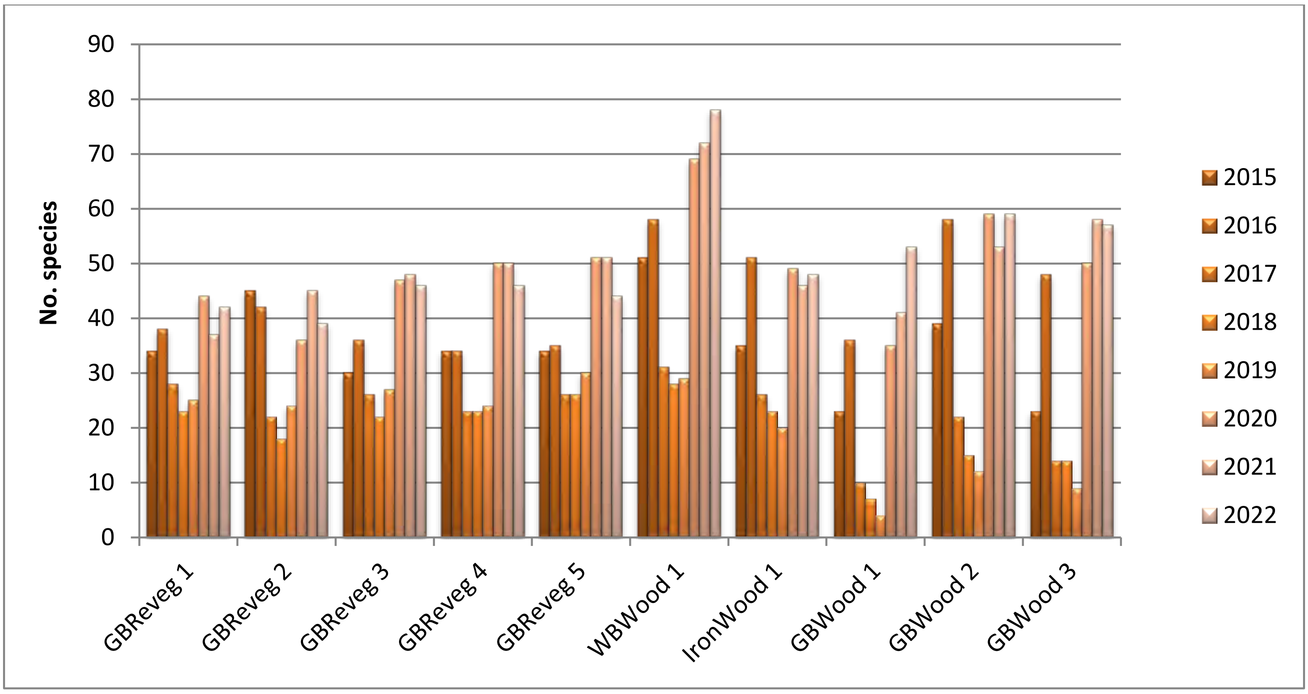


Figure 8-10. Total species diversity recorded in the Grey Box monitoring sites.

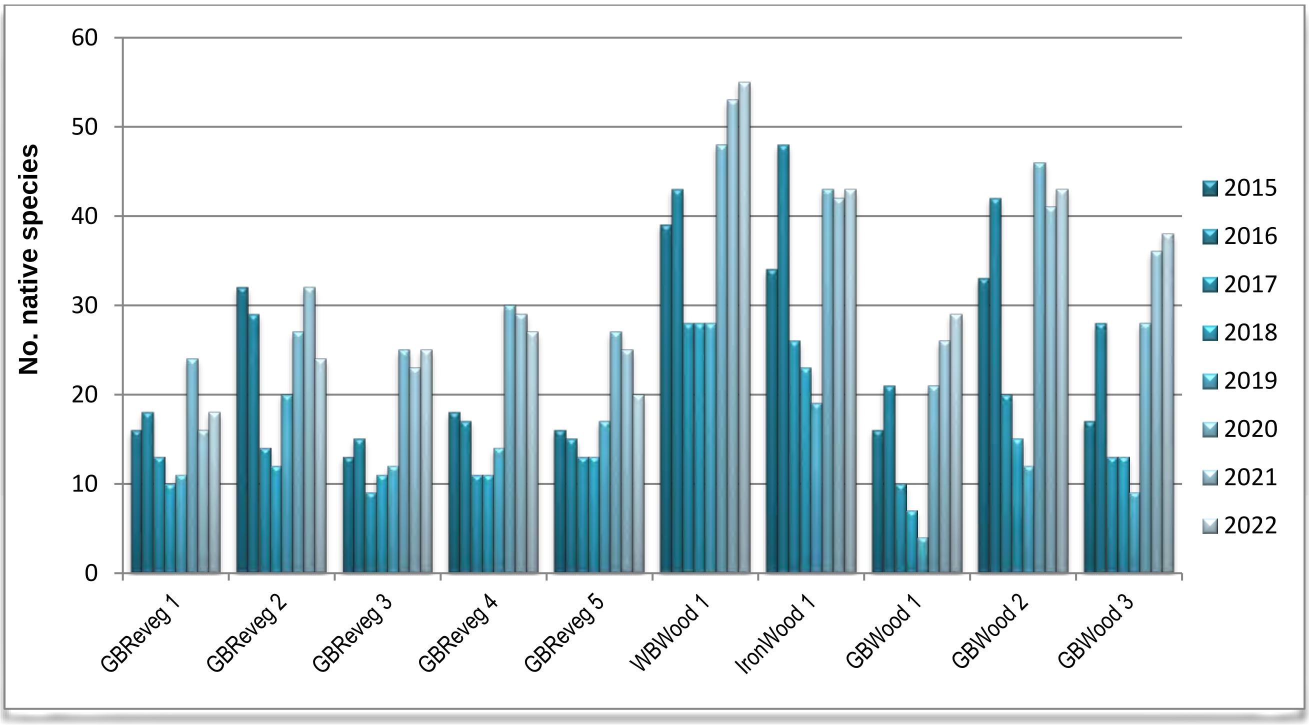


Figure 8-11. Total native species diversity recorded in the Grey Box monitoring sites.

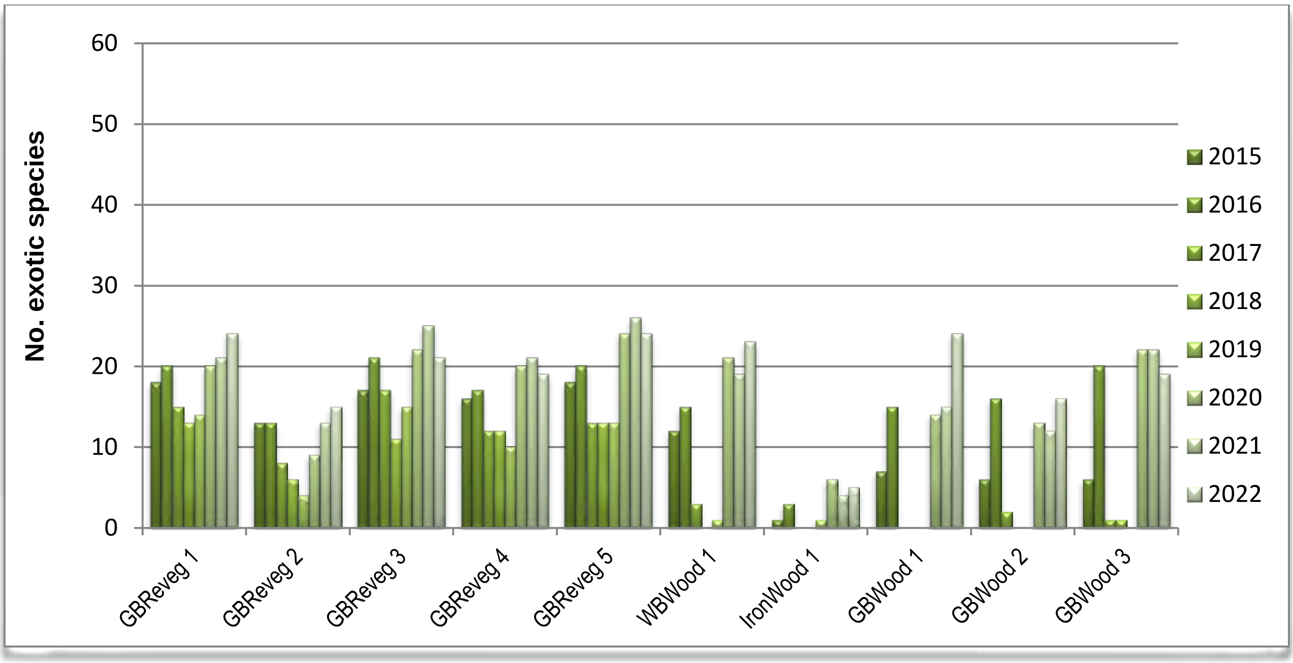


Figure 8-12. Total exotic species recorded in the Grey Box monitoring sites.

8.7.1 Percent endemic ground cover

The percent endemic ground cover is an ecological indicator used to provide some measure of the cover abundance of the live native vegetation along the vegetation transect and therefore indicates the level of weediness at the monitoring sites. While it is only estimation the percent cover of endemic ground cover species has been derived by the following equation.

Percent cover endemic species = sum of the five Braun- Blanquet scores for native species / (sum of the five Braun- Blanquet scores of exotic species + native species) x 100

Most of the live plant cover in the Grey Box woodland reference sites has been provided by native species however increased exotic annual plant cover has resulted in a decline in the percent cover provided by native species in 2016, and since 2020 there has been a declining trend. This year native plant cover declined in all three reference sites and provided 68 - 81% of the live plant cover (Figure 8-13).

In WBWood1 and Ironbark1 there was a significant increase in native plant cover in 2021 however these have also declined to 69% and 87% native plant cover respectively, but these remained comparable to the reference sites this year (Figure 8-13). In the derived grasslands, there continued to be an abundance of exotic plant cover, with native plant cover declining across all monitoring sites and provided 27 – 54% of the live plant cover on average this year. This year all grassland revegetation sites continued to have a higher abundance of exotic plant cover than the reference sites.

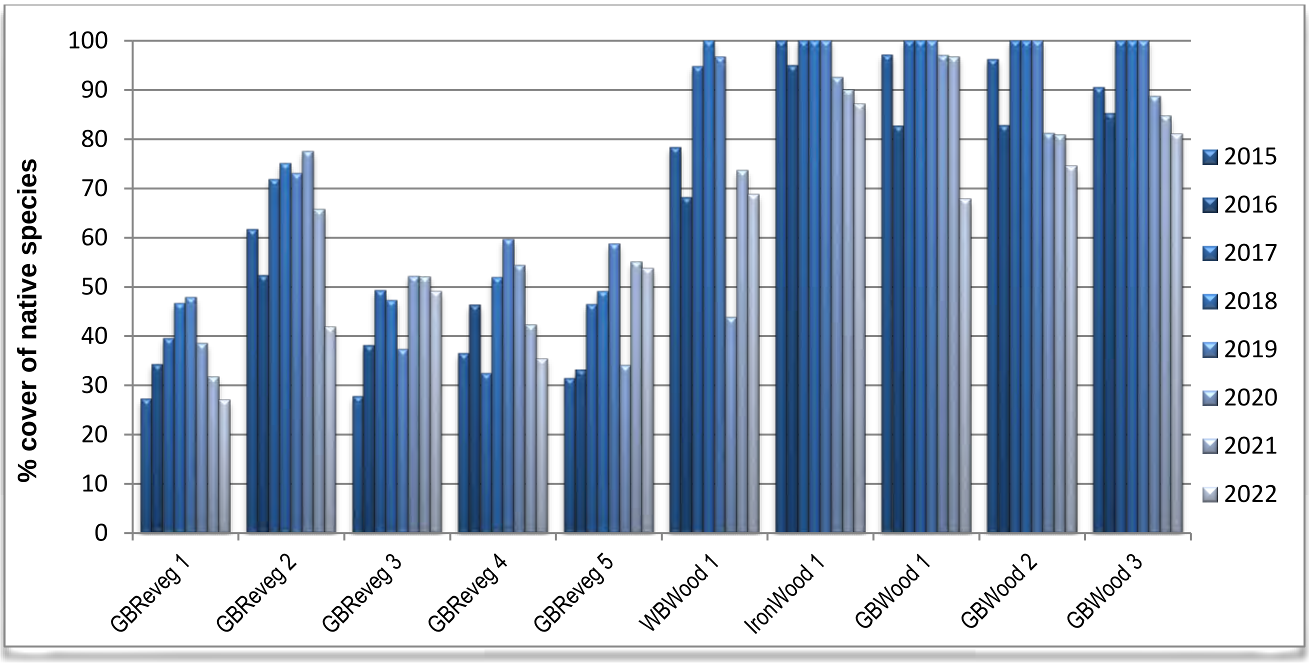


Figure 8-13. Percent endemic ground cover recorded in the Grey Box monitoring sites.

8.8 *Vegetation composition*

The composition of the vegetation as categorised by seven different growth forms is given in Figure 8-14. In the Grey Box woodland reference sites, herbs continued to provide the most diversity with 35 – 41 species, followed by 5 – 11 species of grass and 2 – 4 shrubs. There were also 2 - 3 reeds and two reed species and a fern was recorded in two sites. The White Box and Ironbark woodlands have previously had a similar range of growth forms, and often these were more diverse compared to the reference sites. This year there was a significant increase in herb diversity due to an increased diversity of exotic species, with IronWood1 being the only other site with a matching herb diversity with 49 herb species. The remaining sites typically had an adequate composition of the other growth forms, except there continued to be an absence of shrubs from GBReveg1, GBReveg2 and GBReveg5.

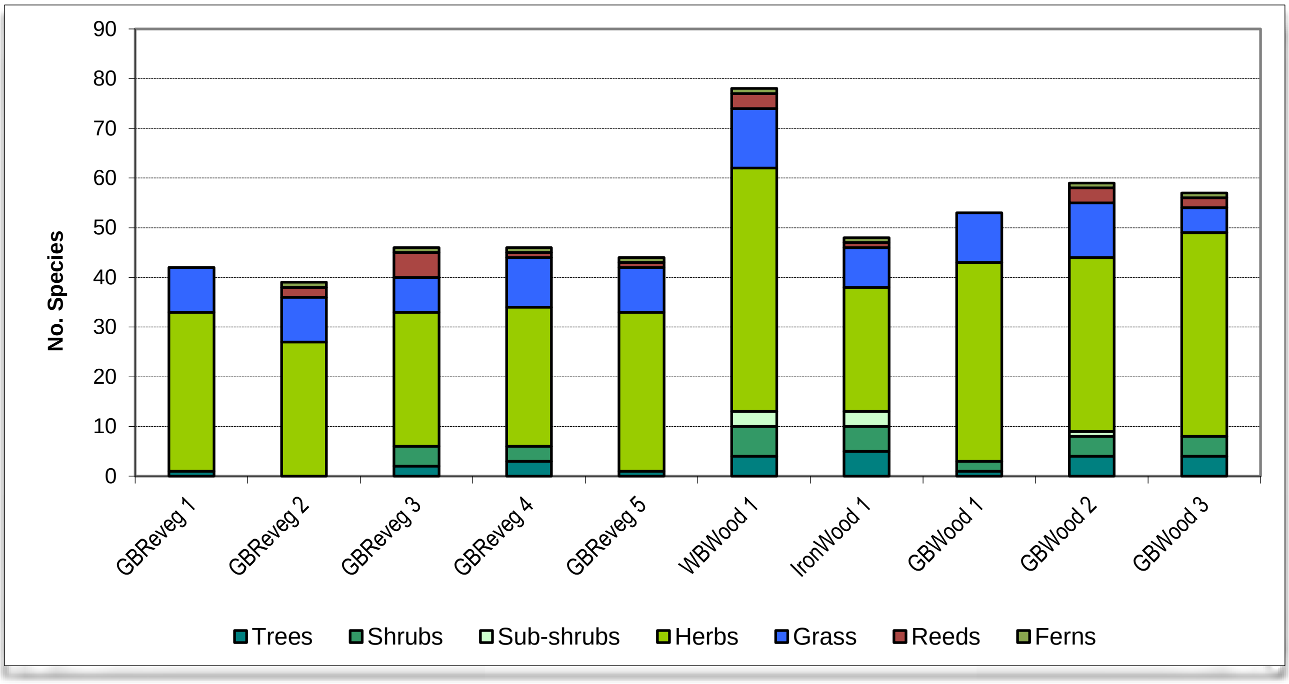


Figure 8-14. Composition of the vegetation recorded in the Grey Box monitoring sites in 2022.

8.9 Most common species

The most common species, those that were recorded in at least six of the seven revegetation sites are provided in Table 8-5. There was a variety of common exotic species such as *Hypochaeris glabra* (Smooth Catsear), *Vulpia muralis* (Rats-tail Fescue), *Aira cupaniana* (Silvery Hairgrass), *Briza minor* (Shivery Grass), *Conyza bonariensis* (Fleabane), *Hypochaeris radicata* (Flatweed), *Lysimachia [Anagallis] arvensis* (Scarlet Pimpernel), *Parentucellia latifolia* (Red Bartsia) and *Trifolium subterraneum* (Subterraneum Clover), with most being annual species.

Native species common to most sites included *Aristida ramosa* (Threeawn Grass), *Haloragis heterophylla* (Rough Raspwort), *Microtis unifolia* (Common Onion Orchid), *Calotis lappulacea* (Yellow Burr Daisy), *Cheilanthes sieberi* subsp*. sieberi* (Rock Fern), *Hypericum gramineum* (Small St. John's Wort) and *Schoenus apogon* (Common Bog Rush). Many of the common species were also recorded in one or more of the reference sites, except *Microtis unifolia*. A comprehensive list of species recorded in all monitoring sites has been included in Appendix 2.

Table 8-5. The most common species recorded in the Grey Box monitoring sites in 2022.

exotic	Scientific Name	Common Name	Habit	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	Total	GBWood1	GBWood2	GBWood3
	Aristida ramosa	Threeawn Grass	g	1	1	1	1	1	1	1	7		1	
	Haloragis heterophylla	Rough Raspwort	h	1	1	1	1	1	1	1	7		1	
*	*Hypochaeris glabra*	Smooth Catsear	h	1	1	1	1	1	1	1	7	1	1	1
	Microtis unifolia	Common Onion Orchid	h	1	1	1	1	1	1	1	7			
*	*Vulpia muralis*	Rats-tail Fescue	g	1	1	1	1	1	1	1	7	1	1	1
*	*Aira cupaniana*	Silvery Hairgrass	g	1	1	1	1	1	1		6	1	1	
*	*Briza minor*	Shivery Grass	g	1	1	1	1	1	1		6	1	1	
	Calotis lappulacea	Yellow Burr Daisy	h	1	1	1	1	1	1		6	1	1	1
	Cheilanthes sieberi	Rock Fern	f		1	1	1	1	1	1	6		1	1
*	*Conyza bonariensis*	Fleabane	h	1		1	1	1	1	1	6	1		1
	Hypericum gramineum	Small St. John's Wort	h	1	1	1	1		1	1	6		1	
*	*Hypochaeris radicata*	Flatweed	h	1	1	1	1	1		1	6	1	1	1
*	*Lysimachia [Anagallis] arvensis*	Scarlet Pimpernel	h	1	1	1	1	1	1		6	1	1	1
*	*Parentucellia latifolia*	Red Bartsia	h	1	1	1	1	1	1		6	1	1	1
	Schoenus apogon	Common Bog Rush	r		1	1	1	1	1	1	6		1	
*	*Trifolium subterraneum*	Subterraneum Clover	h	1	1	1	1	1	1		6		1	

Note: “1” denotes the presence of that species and is not a measure of cover abundance
Key to habit legend: t = tree; s = shrub; ss =sub-shrub; h = herb; g = grass, r = reed; v = vine; f = fern; p = parasite

8.10 Most abundant species

The most abundant species recorded in each of the Grey Box monitoring sites this year are provided in Table 8-6. The most abundant species were those that collectively summed to a Braun-Blanquet total of 10 or more from the five replicated sub-plots along the vegetation transect. The maximum score that can be obtained by an individual species is 30.

The exotic annual grasses *Aira cupaniana* (Silvery Hairgrass*)*, *Briza minor* (Shivery Grass) and *Vulpia muralis* (Rats-tail Fescue) continued to be abundant in one or more of the grassland revegetation areas, as were the native grass *Bothriochloa macra* (Red-leg Grass) and small native sedge *Schoenus apogon* (Common Bog Rush). Other species that were relatively abundant included *Bromus hordeaceus* (Soft Brome), *Trifolium subterraneum* (Subterraneum Clover) and *Parentucellia latifolia* (Red Bartsia), with the native *Haloragis heterophylla* (Rough Raspwort) being relatively abundant in GBReveg5.

In WBWood1 the natives *Austrostipa scabra* (Speargrass) and *Hydrocotyle laxiflora* (Stinking Pennywort) provided the most ground cover, while in IronWood1, *Xerochrysum bracteatum* (Golden Everlasting) and seedlings of *Brachyloma daphnoides* (Daphne Heath) were the most abundant this year. Despite the high floristic diversity in the reference sites, no species was in sufficient abundance to meet the minimum criteria in GBWood1 again this year. *Schoenus apogon* was the most abundant in GBWood2 and *Austrostipa scabra* and *Microlaena stipoides* (Weeping Rice-grass) were the most abundant species in GBWood3 and these provided only relatively low cover scores.

Table 8-6. The most abundant species recorded in the Grey Box monitoring sites in 2022.

Scientific Name	Common Name	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	GBWood1	GBWood2	GBWood3
**Aira cupaniana*	Silvery Hairgrass	10	15		15						
**Bromus hordeaceus*	Soft Brome	10									
**Trifolium subterraneum*	Subterraneum Clover	12									
**Vulpia muralis*	Rats-tail Fescue	14			14	10					
Bothriochloa macra	Red-leg Grass	12		14	11	13					
**Briza minor*	Shivery Grass		10		13						
* *Parentucellia latifolia*	Red Bartsia		13								
Schoenus apogon	Common Bog Rush		13	14						11	
Haloragis heterophylla	Rough Raspwort					13					
Austrostipa scabra	Speargrass						11				11
Hydrocotyle laxiflora	Stinking Pennywort						12				
Brachyloma daphnoides	Daphne Heath							12			
Xerochrysum bracteatum	Golden Everlasting							10			
Microlaena stipoides	Weeping Rice-grass										11

* Denotes exotic species.

8.11 Soil analyses

This section summarises the changes of several important soil characteristics over time. The full results of the soil analyses for the Grey Box monitoring sites in 2022 are provided in Appendix 3.

8.11.1 pH

Figure 8-15 shows the pH recorded in the Grey Box monitoring sites compared to the “desirable” range in medium or clay loam soils as prescribed by the agricultural industry for growing introduced pastures and crops. There was minimal change in the soil pH range recorded in the woodland reference sites and they continued to remain lower than desirable agricultural ranges. With soil pH ranging from 5.1 – 5.5 the soils were strongly acidic (Bruce & Rayment 1982). The soils in IronWood1 were also strongly acidic with a pH of 5.2 and this year so was GBReveg2 with pH 5.5. The soils in the remaining sites and the White Box woodland ranged from 5.7 – 6.4 and were slightly to moderately acidic, but they remained within desirable agricultural guidelines.

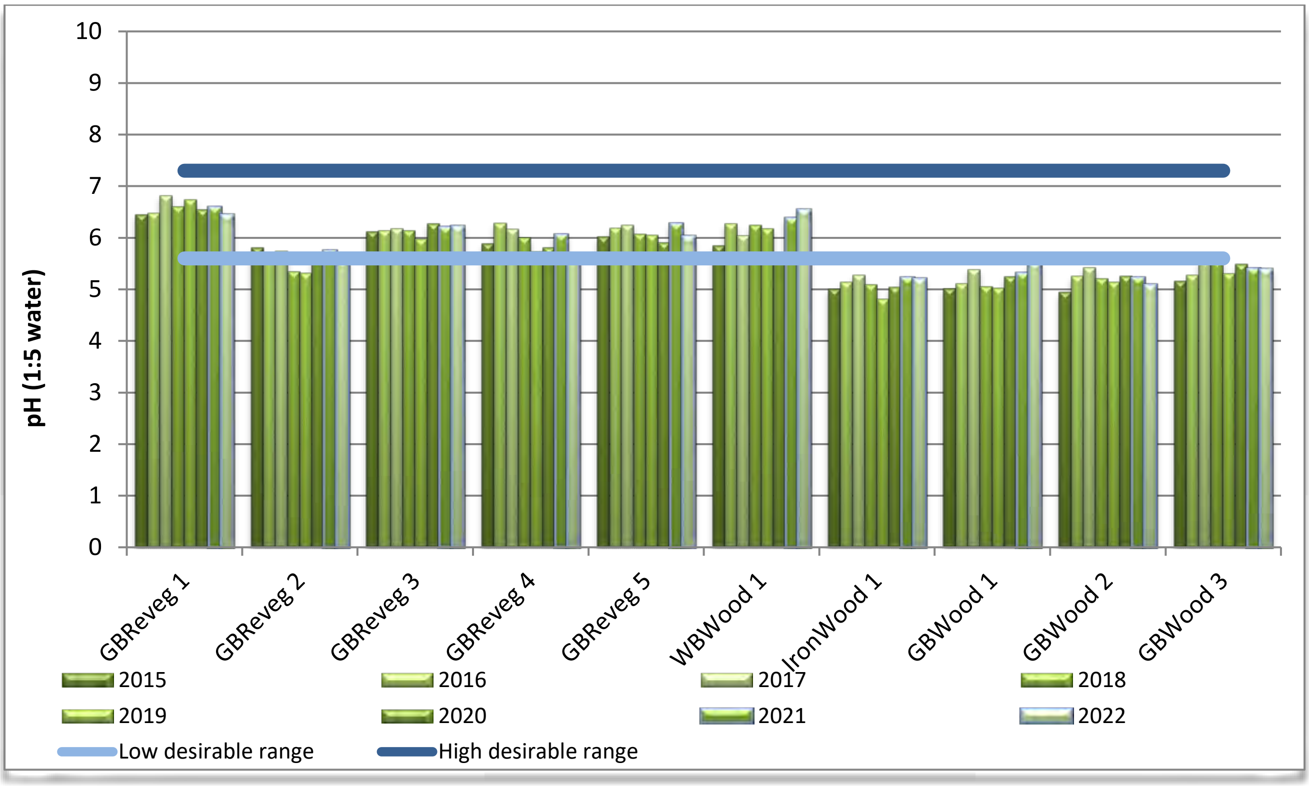


Figure 8-15. Soil pH recorded in the Grey Box monitoring sites compared to the desirable agricultural range.

8.11.2 Conductivity

Figure 8-16 shows the Electrical Conductivity (EC) recorded in the Grey Box monitoring sites compared to the “desirable” range in medium or clay loam soils as prescribed by the agricultural industry for growing introduced pastures and crops. The EC recorded across the range of sites was well below the agricultural threshold indicating there are very low levels of soluble salts in the soil profile and that they are non-saline. The highest EC readings were recorded in the reference sites which ranged from 0.047 – 0.054 dS/m. In the remaining sites, EC ranged from a low of 0.025 dS/m in GBReveg1 and GBReveg4 to a high of 0.048 dS/m in WBWood1.

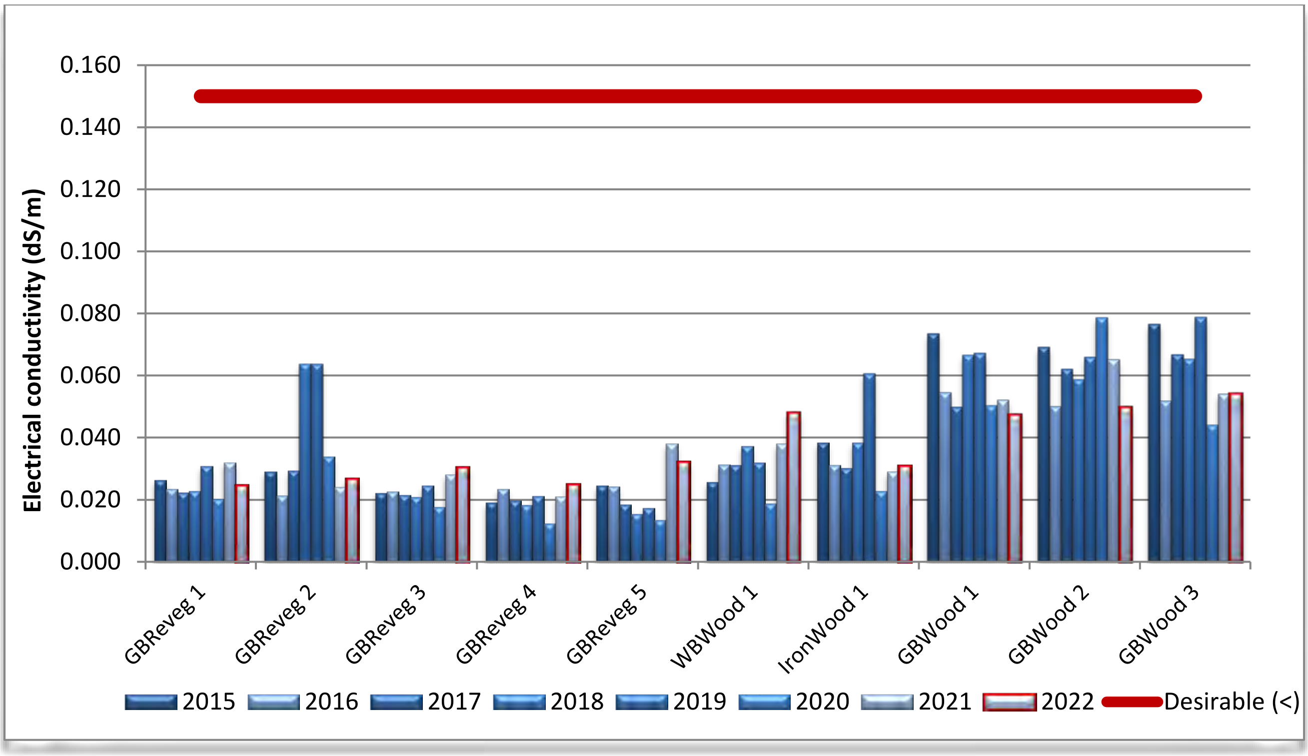


Figure 8-16. Electrical Conductivity recorded in the Grey Box monitoring sites compared to the desirable agricultural levels.

8.11.3 Organic Matter

In the Grey Box woodland reference sites Organic Matter (OM) levels were at or higher than desirable agricultural threshold of 4.5%, with OM concentrations ranging from 6.4 – 8.4% (Figure 8-17). At IronWood1 and WBWood1 OM was at adequate levels with 4.6 and 4.8 respectively, while in the remaining grassland sites OM was low and ranged from 2.6 – 4.4%.

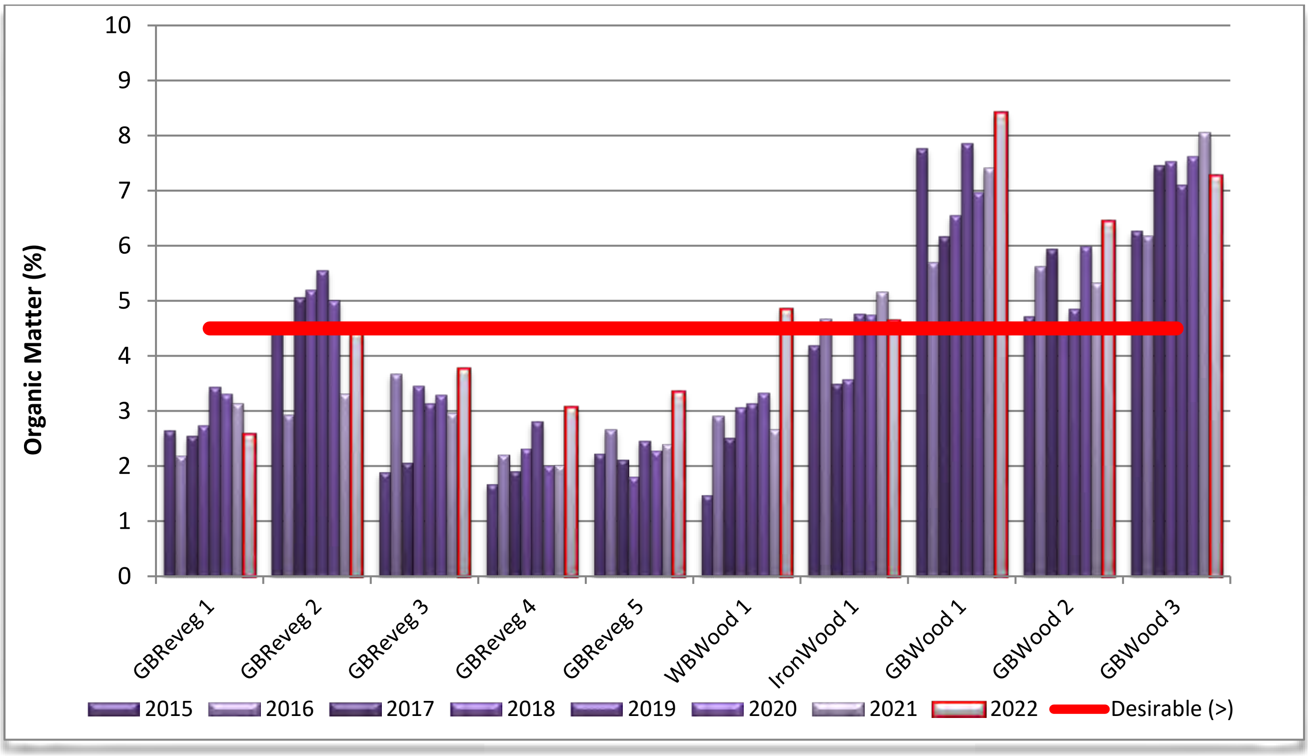


Figure 8-17. OM concentrations recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

8.11.4 Phosphorous

Phosphorous levels continued to be lower than the agricultural standards across all Grey Box monitoring sites and this year there tended to be a marginal decrease in P across most sites. Despite being very low in the woodland reference sites, they remained the highest with a P range of 4 – 17 mg/kg this year. P concentrations were also very low in the remaining sites, however P ranged from 3 – 5 mg/kg and were comparable to the reference sites in GBReveg3 and WBWood1 this year (Figure 8-18).

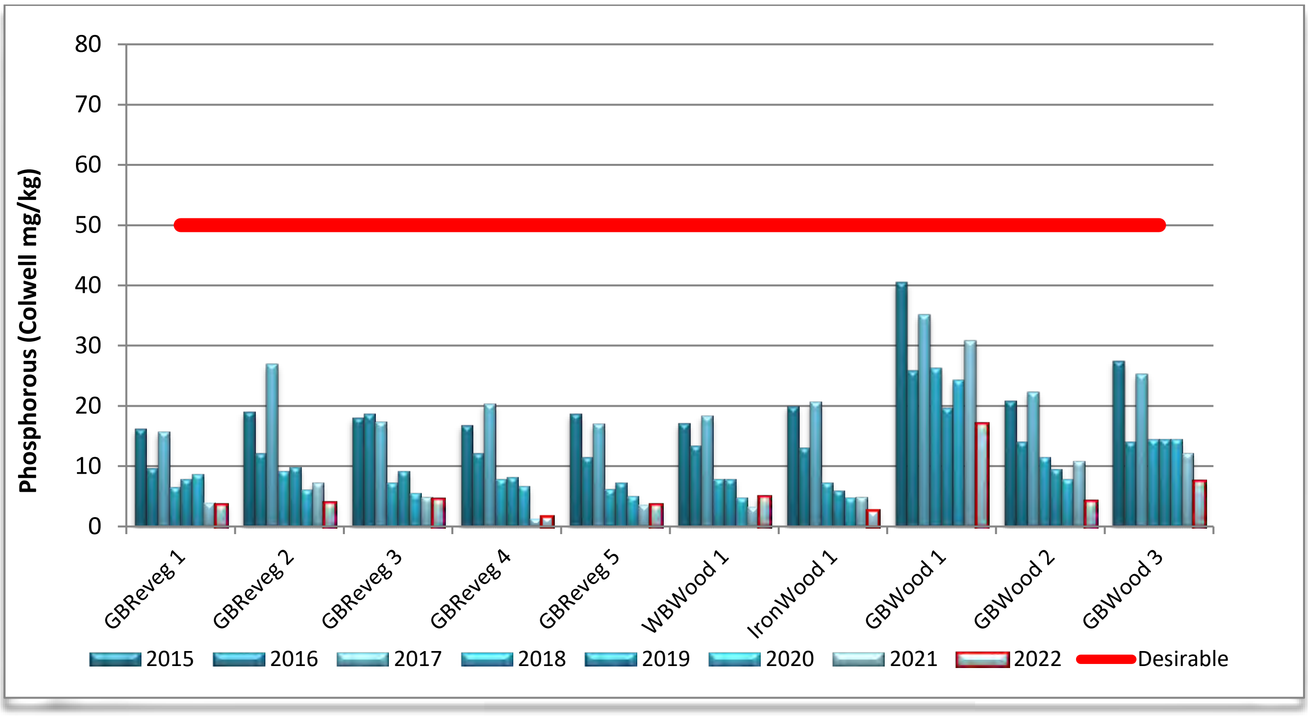


Figure 8-18. Phosphorous concentrations recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

8.11.5 Nitrate

Nitrate levels were lower than the agricultural standards across all Grey Box monitoring sites and there continued to be little differences between most sites. This year N has declined in most sites and in the reference sites N ranged from 1.5 – 3.2 mg/kg (Figure 8-19). In the remaining sites N ranged from 0.6 – 4.0 mg/kg, with sites GBReveg5 and WBWood1 having concentrations similar to or higher than the reference sites.

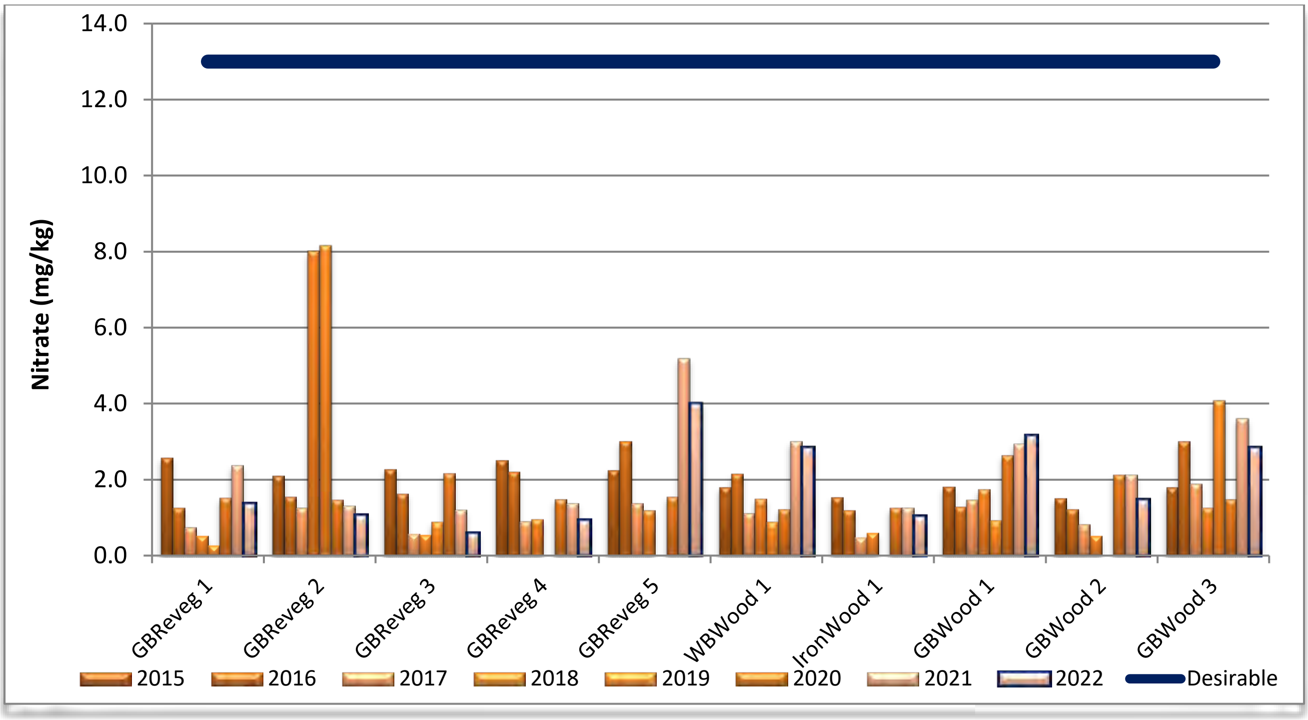


Figure 8-19. Nitrate concentrations recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

8.11.6 Cation Exchange Capacity

Cation Exchange Capacity (CEC) is the capacity of the soil to hold the major cations (calcium, magnesium, sodium and potassium) and is also a measure of the potential fertility of the soil. All the Grey Box monitoring sites had a low CEC and in the reference sites CEC ranged from 4.8 – 9.7 cmol/kg (Figure 8-20). Site WBWood1 had a CEC which was similar to the reference sites with 10.3 cmol/kg. The remaining sites had a low CEC that ranged from 3.3 cmol/kg (GBReveg4) to 5.6 cmol/kg (GBReveg3).

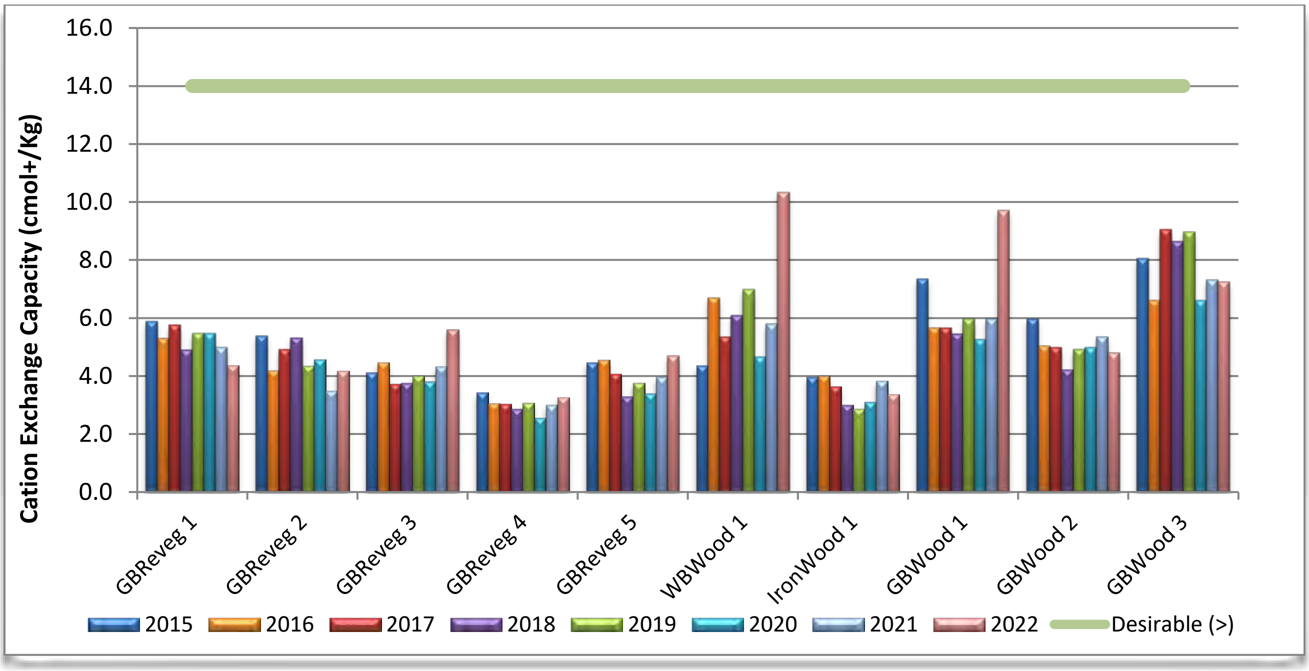


Figure 8-20. Cation Exchange Capacity recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

8.11.7 Exchangeable Sodium Percentage

Sodicity refers to a significant proportion of sodium in the soil compared to other cations with soil considered to be sodic when there is sufficient sodium to interfere with its structural stability which often interferes with plant growth. Sodic soils tend to suffer from poor soil structure including hard soil, hardpans, surface crusting and rain pooling on the surface, which can affect water infiltration, drainage, plant growth, cultivation and site accessibility. ESP recorded in the woodland reference sites was highly variable and has slightly increased across most sites this year. In the reference sites, ESP remained within non sodic levels and ranged from 0.7 – 4.1% (Figure 8-21). ESP in the remaining sites ranged from 0.4 – 3.5% and despite being higher than the local reference sites, all sites had an ESP lower than the 5% threshold and were also non sodic (Isbell 1996).

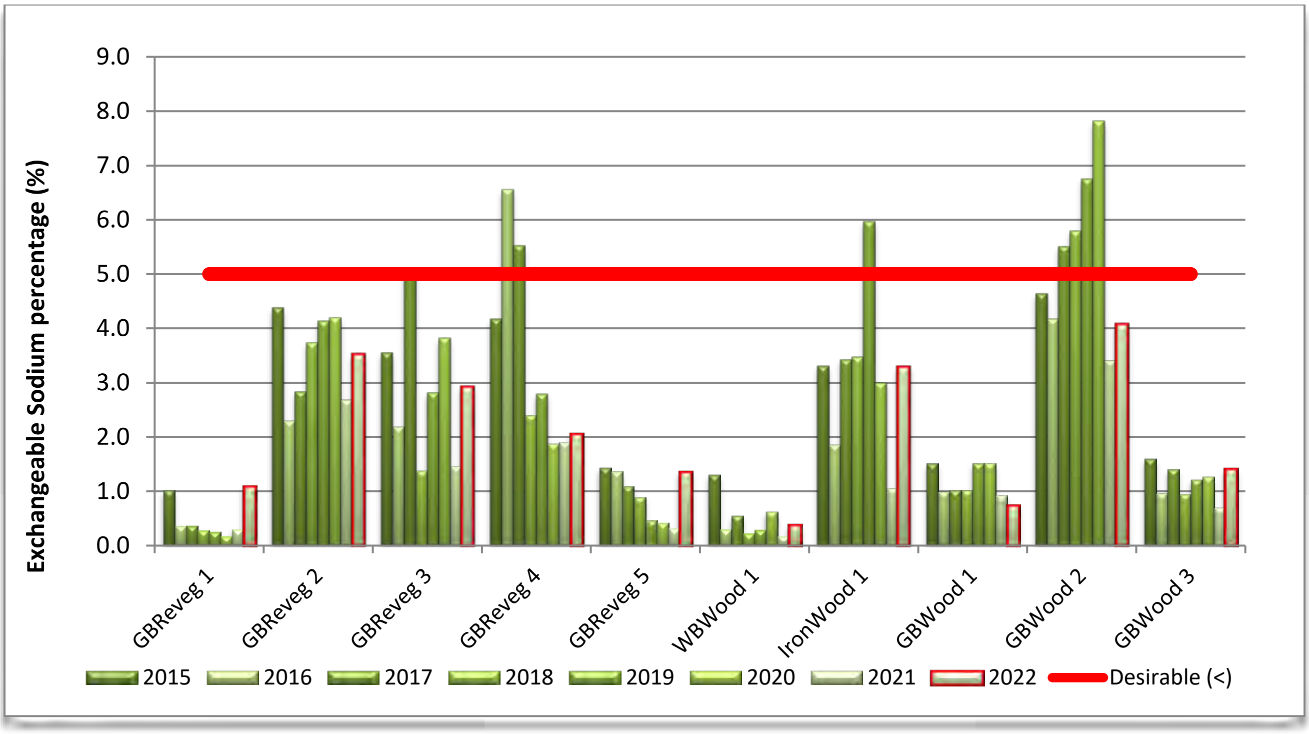


Figure 8-21. ESP recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

8.12 Grey Box woodland site performance towards meeting woodland completion criteria targets

Table 8-7 indicates the performance of the Kokoda Grey Box monitoring sites against a selection of proposed Completion Performance Indicators during the 2022 monitoring period. The selection of criteria has been presented in order of ecosystem successional processes, beginning with landform establishment and stability (orange) and ending with indicators of ecosystem and land use sustainability (blue). The range values are amended annually.

Monitoring sites meeting or exceeding the range values of the Grey Box woodland reference sites have been identified with a shaded colour box and have therefore been deemed to meet completion criteria targets. In the case of "growth medium development," upper and lower soil property indicators are also based on results obtained from the respective reference sites sampled in 2022. In some cases, the site may not fall within ranges based on these data but may be within "desirable" levels as prescribed by the agricultural industry. If this scenario occurs, the rehabilitation site has been identified using a striped shaded box to indicate that it falls within "desirable" ranges but does not fall within specified completion criteria targets using the adopted methodology.

Table 8-7. Performance of the Grey Box monitoring sites against the Primary and Secondary Performance Indicators in 2022.

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2022		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
Performance indicators are quantified by the range of values obtained from replicated reference sites							2022	2022	2022	Lower	Upper	2022	2022	2022	2022	2022	2022	2022
Phase 2: Landform establishment and stability	Landform slope, gradient	Landform suitable for final land use and generally compatible with surrounding topography	Slope	Landform is generally compatible within the context of the local topography.		< Degrees (18°)	2	3	1	1	3	5	4	3	4	3	3	4
	Active erosion	Areas of active erosion are limited	No. Rills/Gullies	Number of gullies or rills >0.3m in width or depth in a 50m transect are limited and stabilising		No.	0	0	0	0	0	0	0	0	0	0	0	0
			Cross-sectional area of rills		Provides an assessment of the extent of soil loss due to gully and rill erosion and that it is limited and/or is stabilising	m2	0	0	0	0	0	0	0	0	0	0	0	0
Phase 3: Growth medium development	Soil chemical, physical properties	Soil properties are suitable for the establishment and	pH	pH is typical of that of the surrounding landscape or falls within desirable ranges provided by the agricultural industry		pH (*5.6 - 7.3)	5.5	5.1	5.4	5.1	5.5	6.4	5.5	6.2	5.7	6.0	6.5	5.2

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2022		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
	and amelioration	maintenance of selected vegetation species	EC		Electrical Conductivity is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	< dS/m (*<0.150)	0.047	0.050	0.054	0.047	0.054	0.025	0.027	0.030	0.025	0.032	0.048	0.031
			Organic Matter	Organic Carbon levels are typical of that of the surrounding landscape, increasing or fall within desirable ranges provided by the agricultural industry		% (*>4.5)	8.4	6.4	7.3	6.4	8.4	2.6	4.4	3.8	3.1	3.3	4.8	4.6
			Phosphorous	Available Phosphorus is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		ppm (*50)	17.1	4.3	7.5	4.3	17.1	3.6	3.9	4.6	1.6	3.6	4.9	2.6
			Nitrate		Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	ppm (*>12.5)	3.2	1.5	2.9	1.5	3.2	1.4	1.1	0.6	0.9	4.0	2.9	1.1
			CEC		Cation Exchange Capacity is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	Cmol+/kg (*>14)	9.7	4.8	7.2	4.8	9.7	4.4	4.2	5.6	3.3	4.7	10.3	3.4
			ESP		Exchangeable Sodium Percentage (a measure of sodicity) is typical of the surrounding landscape or is less than the 5% threshold for sodicity	% (*<5)	0.7	4.1	1.4	0.7	4.1	1.1	3.5	2.9	2.1	1.4	0.4	3.3

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2022		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
Phase 4: Ecosystem & Land use Establishment	Landscape Function Analysis (LFA): Landform stability and organisation	Landform is stable and performing as it was designed to do	LFA Stability	The LFA stability index provides an indication of the sites stability and is comparable to or trending towards that of the local remnant vegetation		%	63.9	68.5	68.1	63.9	68.5	75.5	74.5	74.9	76.0	75.5	72.5	71.0
			LFA Landscape organisation	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and is comparable to that of the local remnant vegetation		%	84	100	100	84	100	100	100	100	99	100	100	100
	Vegetation diversity	Vegetation contains a diversity of species comparable to that of the local remnant vegetation	Diversity of shrubs and juvenile trees	The diversity of shrubs and juvenile trees with a stem diameter < 5cm is comparable to that of the local remnant vegetation.		species/ area	2	6	6	2	6	1	0	6	6	1	9	9
				The percentage of shrubs and juvenile trees with a stem diameter < 5cm dbh which are local endemic species and these percentages are comparable to the local remnant vegetation		% endemic	100	100	100	100	100	100	0	100	100	100	100	100
			Total species richness		The total number of live plant species provides an indication of the floristic diversity of the site and is comparable to the local remnant vegetation	No./area	53	59	57	53	59	42	39	46	46	44	78	48
			Native species richness		The total number of live native plant species provides an indication of the native plant diversity of the site and that it is greater than or comparable to the local remnant vegetation	>No./area	29	43	38	29	43	18	24	25	27	20	55	43

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2022		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
			Exotic species richness	The total number of live exotic plant species provides an indication of the exotic plant diversity of the site and that it is less than or comparable to the local remnant vegetation		<No./area	24	16	19	16	24	24	15	21	19	24	23	5
	Shrubs and juvenile tree (<5cm dbh) density	Vegetation contains a density of shrubs and juvenile trees (<5cm dbh) comparable to the local remnant vegetation	Total density of shrubs or juvenile trees		The total density of shrubs or juvenile trees with a stem diameter < 5cm is comparable to the local remnant vegetation	No./area	6	44	14	6	44	1	0	12	7	4	23	112
			Density of eucalypts	The density of eucalypts is comparable to the local remnant vegetation		No./area	1	0	1	0	1	0	0	5	3	4	1	4
			Density of acacias	The density of acacias is comparable to the local remnant vegetation		No./area	0	34	2	0	34	0	0	6	2	0	10	2
			Density of other endemic shrubs	The density of other endemic shrubs is comparable to the local remnant vegetation		No./area	5	10	11	5	11	1	0	1	2	0	12	106
			Density of exotic / non endemic species	The density of exotic / non endemic species is comparable to the local remnant vegetation		<No./area	0	0	0	0	0	0	0	0	0	0	0	0
			The percentage of eucalypts	The percentage of eucalypts is comparable to the local remnant vegetation		% population	17	0	7	0	17	0	0	42	43	100	4	4
			Total density of endemic shrubs and/or juvenile trees	The total density of endemic shrubs and/or juvenile trees (< 5cm) is comparable to the local remnant vegetation		No./area	6	44	14	6	44	1	0	12	7	4	23	112
	Ecosystem composition	The vegetation is comprised by a range of growth forms comparable to that of the local	Trees	The number of tree species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	1	4	4	1	4	1	0	2	3	1	4	5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2022		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
		remnant vegetation	Shrubs	The number of shrub species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	2	4	4	2	4	0	0	4	3	0	6	5
			Sub-shrubs		The number of sub-shrub species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	1	0	0	1	0	0	0	0	0	3	3
			Herbs	The number of herbs or forb species comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	40	35	41	35	41	32	27	27	28	32	49	25
			Grasses		The number of grass species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	10	11	5	5	11	9	9	7	10	9	12	8
			Reeds		The number of reed, sedge or rush species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	3	2	0	3	0	2	5	1	1	3	1
			Ferns		The number of ferns comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	1	1	0	1	0	1	1	1	1	1	1
			Vines		The number of vines or climbing species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	0	0	0	0	0	0	0	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2022		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
			Parasite		The number of parasite species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	0	0	0	0	0	0	0	0	0	0	0
Phase 5: Ecosystem & Land use Sustainability	Landscape Function Analysis (LFA): Landform function and ecological performance	Landform is ecologically functional and performing as it was designed to do	LFA Infiltration	LFA infiltration index provides an indication of the sites infiltration capacity and is comparable to or trending towards that of the local remnant vegetation		%	49.2	52.0	46.9	46.9	52.0	48.2	42.9	47.9	44.8	47.1	53.2	49.6
			LFA Nutrient recycling	LFA nutrient recycling index provides an indication of the sites ability to recycle nutrient and is comparable to or trending towards that of the local remnant vegetation		%	45.9	49.2	44.8	44.8	49.2	48.7	45.1	47.9	44.0	47.4	52	48.5
	Protective ground cover	Ground layer contains protective ground cover and habitat structure comparable with the local remnant vegetation	Litter cover		Percent ground cover provided by dead plant material is comparable to that of the local remnant vegetation	%	64.5	68.0	55.0	55	68	27.5	11.5	61	30	48	47.5	59
			Annual plants		Percent ground cover provided by live annual plants is comparable to that of the local remnant vegetation	<%	8.5	13.5	17.0	8.5	17	40.5	80.5	19.5	49.5	29	12.5	12
			Cryptogam cover		Percent ground cover provided by cryptogams (e.g. mosses, lichens) is comparable to that of the local remnant vegetation	%	0	0	0	0	0	0	0	0	1	1	0	10
			Rock		Percent ground cover provided by stones or rocks (> 5cm diameter) is comparable to that of the local remnant vegetation	%	0	0	0	0	0	0	0	0	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2022		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	5	1	1	1	5	0	0	0	0	0	1	4
			Bare ground		Percentage of bare ground is less than or comparable to that of the local remnant vegetation	< %	16.0	3.0	3.5	3	16	0	1.5	1.5	2	0	1	2
			Perennial plant cover (< 0.5m)	Percent ground cover provided by live perennial vegetation (< 0.5m in height) is comparable to that of the local remnant vegetation		%	6.0	14.5	23.5	6	23.5	32	6.5	18	17.5	22	38	13
			Total Ground Cover	Total groundcover is the sum of protective ground cover components (as described above) and that it is comparable to that of the local remnant vegetation		%	84.0	97.0	96.5	84	97	100	98.5	98.5	98	100	99	98
	Ground cover diversity	Vegetation contains a diversity of species per square meter comparable to that of the local remnant vegetation	Native understorey abundance		The abundance of native species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it is has more than or an equal number of native species as the local remnant vegetation	> species/ m^2	6.0	9.8	10.2	6.0	10.2	4	5.2	5.4	5.8	7.6	12.6	8.8
			Exotic understorey abundance		The abundance of exotic species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it is has less than or an equal number of exotic species as the local remnant vegetation	< species/ m^2	2.8	4.2	2.6	2.6	4.2	10.2	6.6	7.8	9.6	7.6	7.4	1.8

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2022		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
	Native ground cover abundance	Native ground cover abundance is comparable to that of the local remnant vegetation	Percent ground cover provided by native vegetation <0.5m tall	The percent ground cover abundance of native species (<0.5m height) compared to exotic species is comparable to that of the local remnant vegetation		%	67.8	74.5	81.1	67.8	81.1	27	41.9	49.1	35.4	53.7	68.7	87.2
	Ecosystem growth and natural recruitment	The vegetation is maturing and/or natural recruitment is occurring at rates similar to those of the local remnant vegetation	shrubs and juvenile trees 0 - 0.5m in height	The number of shrubs or juvenile trees < 0.5m in height provides an indication of establishment success and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation		No./area	4	15	8	4	15	0	0	2	1	2	12	50
			shrubs and juvenile trees 0.5 - 1m in height		The number of shrubs or juvenile trees 0.5-1m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	1	12	4	1	12	1	0	4	4	2	9	46
			shrubs and juvenile trees 1 - 1.5m in height		The number of shrubs or juvenile trees 1-1.5m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	0	10	0	0	10	0	0	5	1	0	2	9

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2022		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
			shrubs and juvenile trees 1.5 - 2m in height	The number of shrubs or juvenile trees 1.5-2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation		No./area	1	6	1	1	6	0	0	1	1	0	0	5
			shrubs and juvenile trees >2m in height		The number of shrubs or juvenile trees > 2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	0	1	1	0	1	0	0	0	0	0	0	2
	Ecosystem structure	The vegetation is developing in structure and complexity comparable to that of the local remnant vegetation	Foliage cover 0.5 - 2 m	Projected foliage cover provided by perennial plants in the 0.5 - 2m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation		% cover	0	2	0	0	2	0	0	0	0	0	0	0
			Foliage cover 2 - 4m		Projected foliage cover provided by perennial plants in the 2 - 4m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation	% cover	8	2	0	0	8	0	0	0	0	0	0	0.5
			Foliage cover 4 - 6m		Projected foliage cover provided by perennial plants in the 4 -6m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation	% cover	13	6	3	2.7	12.5	0	0	0	0	0	8.5	2

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2022		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
			Foliage cover >6m	Projected foliage cover provided by perennial plants > 6m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation		% cover	15	28	20	14.5	28.0	0	0	0	0	0	43	12.5
	Tree diversity	Vegetation contains a diversity of maturing tree and shrubs species comparable to that of the local remnant vegetation	Tree diversity		The diversity of trees or shrubs with a stem diameter > 5cm is comparable to the local remnant vegetation. Species used in rehabilitation will be endemic to the local area	species/ area	1	3	2	1	3	0	0	0	0	0	3	4
				The percentage of maturing trees and shrubs with a stem diameter > 5cm dbh which are local endemic species and these percentages are comparable to the local remnant vegetation		%	100	100	100	100	100	0	0	0	0	0	100	100
	Tree and mature shrub (>5cm dbh) density	Vegetation contains a density of maturing tree and shrubs (>5cm dbh) species comparable to the local remnant vegetation	Total tree and mature shrub density	The total density of live trees and/or mature shrubs with a stem diameter > 5cm is comparable to that of the local remnant vegetation		No./area	8	22	17	8	22	0	0	0	0	0	7	27
			Density of eucalypts	The density of eucalypts with a stem diameter > 5cm is comparable to that of the local remnant vegetation		No./area	8	21	17	8	21	0	0	0	0	0	6	26
			Density of acacias	The density of acacias with a stem diameter > 5cm is comparable to the local remnant vegetation		No./area	0	1	0	0	1	0	0	0	0	0	0	0
			Density of other endemic species	The density of other endemic species with a stem diameter > 5cm is comparable to the local remnant vegetation		No./area	0	0	0	0	0	0	0	0	0	0	1	1

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2022		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
			Density of exotic / non endemic species	The density of exotic / non endemic species with a stem diameter > 5cm is comparable to the local remnant vegetation		<No./area	0	0	0	0	0	0	0	0	0	0	0	0
			Percentage of eucalypts	The percentage of eucalypts with a stem diameter > 5cm is comparable to the local remnant vegetation		% population	100.0	95.5	100.0	95	100	0	0	0	0	0	86	96
			Average dbh		Average tree diameter of the tree population provides a measure of age, (height) and growth rate and that it is trending towards the local remnant vegetation.	cm	35	19	24	19	35	0	0	0	0	0	31	18
	Ecosystem health	The vegetation is in a condition comparable to that of the local remnant vegetation.	Live trees	The percentage of the tree population which are live individuals and that the percentage is comparable to the local remnant vegetation		% population	100	100	81	81	100	0	0	0	0	0	87.5	73
			Healthy trees	The percentage of the tree population which are in healthy condition and that the percentage is comparable to the local remnant vegetation		% population	0	27	19	0	27.3	0	0	0	0	0	12.5	0
			Medium health		The percentage of the tree population which are in a medium health condition and that the percentage is comparable to the local remnant vegetation	% population	63	55	52	52.4	62.5	0	0	0	0	0	62.5	32
			Advanced dieback		The percentage of the tree population which are in a state of advanced dieback and that the percentage is comparable to the local remnant vegetation	<% population	38	18	10	9.5	37.5	0	0	0	0	0	37.5	41

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2022		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
			Dead Trees		The percentage of the tree population which are dead (stags) and that the percentage is comparable to the local remnant vegetation	% population	**0**	**0**	**19**	**0**	**19**	**0**	**0**	**0**	**0**	**0**	**12.5**	**27**
			Mistletoe		The percentage of the tree population which have mistletoe provides an indication of community health and habitat value and that the percentage is comparable to the local remnant vegetation	% population	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
			Flowers/fruit: Trees	The percentage of the tree population with reproductive structures such as buds, flowers or fruit provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources comparable to that of the local remnant vegetation		% population	**0**	**23**	**19**	**0**	**22.7**	**0**	**0**	**0**	**0**	**0**	**12.5**	**11**
			Hollows: Trees		The percentage of the tree population which have hollows provides an indication of the habitat value and that the percentage is comparable to the local remnant vegetation	% population	**50**	**0**	**10**	**0**	**50**	**0**	**0**	**0**	**0**	**0**	**25**	**3**

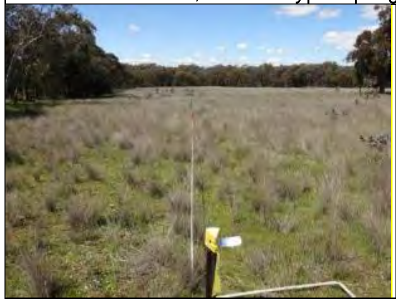
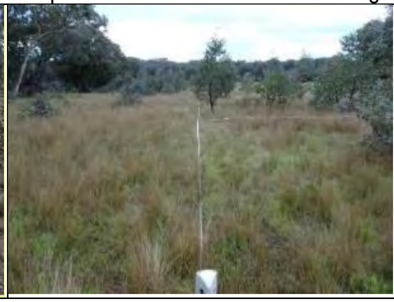
9 Results: Red Gum monitoring sites

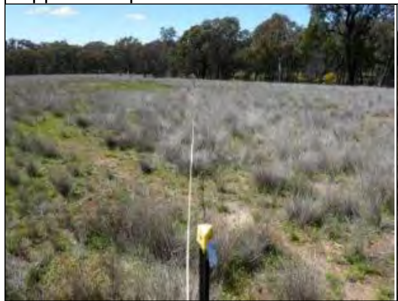
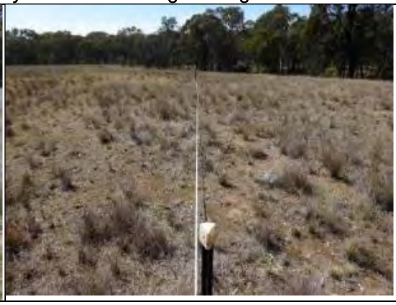
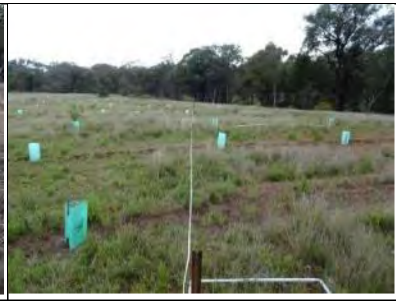
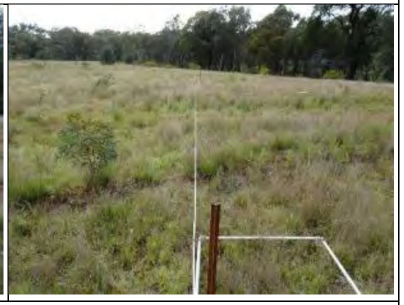
This section provides the results of the monitoring within the Red Gum monitoring sites and demonstrates ecological trends and performance of the revegetation sites against a selection of ecological performance indicators. This section has also included site DWoodLQ, a grassy woodland which was deemed to be of low quality by Umwelt in the original surveys.

9.1 Photo-points

General descriptions of the Red Gum Woodland monitoring sites established at Kokoda including photographs taken along the vegetation transect are provided Table 9-1. Please note that in some years photographs have been omitted in order to present increasing quantities of photographic data.

Table 9-1. General site descriptions and permanent photo-points of the Red Gum monitoring sites at Kokoda.

2015	2017	2019	2021	2022
DReveg1: Degraded native pasture with a moderate abundance of *Aristida racemosa* (three-awn Grass, but the exotic annuals *Hypochaeris glabra* (Smooth Catsear) and *Vulpia muralis* (Rats-tail Fescue) were also abundant. The site was relatively diverse and maintained good ground cover. Mosses and cryptogam were common and there was some scattered *E. dwyeri* regeneration 0.5 – 2.0m in height. In 2016 there was slightly more biomass and the eucalypt saplings had grown. In 2017, the grass was grazed low except for scattered stressed tussocks of Aristida and scattered annual grasses and forbs. The eucalypt saplings had grown and suffered from galls and lerps. In 2018, the remnant grass tussocks were very stressed, and the ground cover in between was grazed very low. There continued to be a lot of moss cover (dead) and the eucalypt saplings had grown. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover. Since 2020, the eucalypt saplings had grown and there was an abundance of annual ground covers. One side of the quadrat had a slashed track through it in 2021.				
				

<table>
<tr><th>2015</th><th>2017</th><th>2019</th><th>2020</th><th>2022</th></tr>
<tr><td colspan="5">DReveg2: Degraded native pasture dominated by Aristida racemosa (three-awn Grass, but the exotic annuals Hypochaeris glabra (Smooth Catsear) and Vulpia muralis (Rats-tail Fescue) were also abundant. The site was relatively diverse and maintained relatively good ground cover with mosses and cryptogam scattered throughout, however there was no tree or shrub regeneration. In 2016 there was slightly more biomass but little other change was apparent. During the drought in 2017 - 2019, the grass was grazed low except for scattered stressed tussocks of Aristida and there was a decline in cryptogam cover and bare patches were developing. In 2020, seasonal conditions had improved and since then there has been an abundance of annual ground cover. In 2020 the site had been deep ripped and planted with tubestock. This year the seedlings had grown and the tree guards had been removed.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">DReveg3: Degraded native pasture dominated by the exotic annuals Hypochaeris glabra (Smooth Catsear), Vulpia muralis (Rats-tail Fescue), Aira cupaniana (Silvery Hairgrass) and Parentucellia latifolia (Red Bartsia). The site was relatively diverse and maintained relatively good ground cover with mosses and cryptogam scattered throughout, however there was no tree or shrub regeneration. In 2016 there was slightly more biomass but little other change was apparent. During the drought in 2017 - 2019, the grass was grazed low except for scattered stressed tussocks of Aristida and there was a decline in cryptogam cover and bare patches were developing. In 2020, seasonal conditions had improved and since then there has been an abundance of annual ground cover</td></tr>
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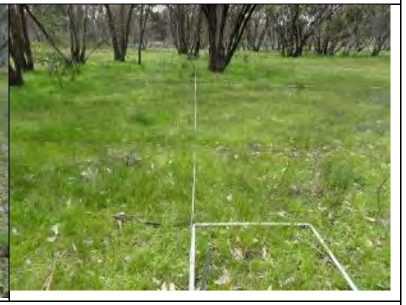
<table>
<tr><th>2015</th><th>2017</th><th>2019</th><th>2020</th><th>2022</th></tr>
<tr><td colspan="5">DWoodLQ: Open regrowth E. dwyeri woodland with occasional E. albens on the cleared grazing ecotone. The understorey was diverse but contained an abundance of annual grasses and forbs. The site maintained good ground cover with leaf litter dominant under the mature tree canopies. In 2016 there was a significant increase in live ground cover and the trees appeared healthier. In 2017, there was a good cover of eucalypt leaf litter and scattered native grasses. The majority of trees were in medium health. In 2018, the remnant grass tussocks were very stressed, and the ground cover in between was grazed very low and bare patches were starting to develop. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover. Since 2020, there has been an abundance of annual ground covers.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="5">DWood1: Regrowth E. dwyeri – Callitris endlicheri woodland with scattered E. dwyeri and E. dealbata trees and a moderate density of Callitris endlicheri saplings. Many saplings have died since the drought which has opened up the canopy. Gonocarpus tetragynus (Hill Raspwort), Cheilanthes sieberi (Rock fern) and Hypochaeris glabra (Smooth Catsear) are dominant in the understorey and there has been a good cover of leaf litter. There are many fallen branches and Cypress trunks and there is an adjacent rocky granite outcrop. There were numerous Callitris seedlings. Since 2020, there has been an increased cover of annual ground covers.</td></tr>
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2015	2017	2019	2020	2022
DWood2: Relatively open regrowth woodland of *Callitris endlicheri* and occasional *E. sideroxylon* (Mugga Ironbark). There were many Callitris stags with some having fallen down. There were scattered pockets of *Brachyloma daphnoides* (Daphne Heath) and a range of sparsely scattered native herbs however *Vulpia muralis* (Rat's Tail Fescue) was also common in pockets. There was extensive Callitris regeneration ~ 5cm in height. Coral Lichen was common throughout the larger woodland area and were present at the end of the vegetation transect. There was an extensive network of ant tunnels. In 2016 there was a significant increase in live ground cover. In 2017, there was typically a good cover of leaf litter, scattered sub-shrubs but live ground cover was limited. Occasional patches of lichens and mosses. At end of the veg transect the ground felt spongy, probably as a result of past ant activity. In 2018 there was little live ground cover and some Callitris regeneration has persisted. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover and some Callitris regeneration has persisted. Since 2020, there has been an increased cover of annual ground covers, with numerous scattered Callitris seedlings.				
				
DWood3: A grassy clearing with low density *E. dwyeri* – *Callitris endlicheri* in the bottom of the slope within a major drainage depression. There were scattered patches of *Calytrix tetragona* and a significant number of small *Callitris* and *Calytrix* seedlings. The understorey contained a wide diversity of native herbs. There was extensive sedimentation within the site as a result of extensive overland erosion from the adjacent slopes which had low ground cover. In 2016 there was a significant increase in live ground cover and the understorey shrubs were flowering. In 2017, site had been heavily grazed. Typically, good ground cover had been retained but there was limited live ground cover and the Calytrix were very stressed. The mature trees also appeared to be drought stressed, there continued to be a significant number of small *Callitris* seedlings. In 2018 there was little apparent change. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover. More shrubs had died however significant number of Callitris seedlings have persisted. Since 2020, there has been an abundance of annual ground covers and there continued to be a significant number of small *Callitris* seedlings and the *Calytrix tetragona* was flowering				
				

9.2 Landscape Function Analyses

9.2.1 Landscape Organisation

The three Red Gum woodland reference sites were characterised by having a mature tree canopy, scattered shrubs and a well-developed decomposing leaf litter layer and a sparse cover of native perennial forbs and grasses that collectively provided a highly functional patch area. During 2018 and 2019, heavy grazing and disturbance by animals resulted in a reduction in patch area in DWood3 and since 2020 it has recovered with all three sites continuing to have 100% LO this year.

The Red Gum woodland site DWoodLQ was characterised with having an open mature tree canopy, moderate cover of annual and perennial ground cover species and typically had a well-developed leaf litter layer but this was patchy. This site continued to have high functional patch area despite the drought and continued to have an LO of 100%.

The Dwyer's Red Gum grassland revegetation sites presently exist as degraded pastures and were structurally different to the woodland reference sites, however they typically had good ground cover comprised of a combination of annual and perennial plants and cryptogams. In 2018, heavy grazing and disturbance by animals also resulted in a reduction in patch area in DReveg1 in 2019 which has since recovered. Bare patches persisted in DReveg2 during 2018 and 2019, while in 2020 – 2021 deep ripping that was undertaken in preparation for the planting of tubestock in spring 2020, created deep troughs. While deep ripping removed some ground covers and exposed some areas of bare soil, the deep troughs created additional surface roughness and an additional capacity of the area to retain any mobilised resources. This year there has been a slight increase in cover with an LO of 96%. The remaining sites continued to have 100% functional patch area (Figure 9-1).

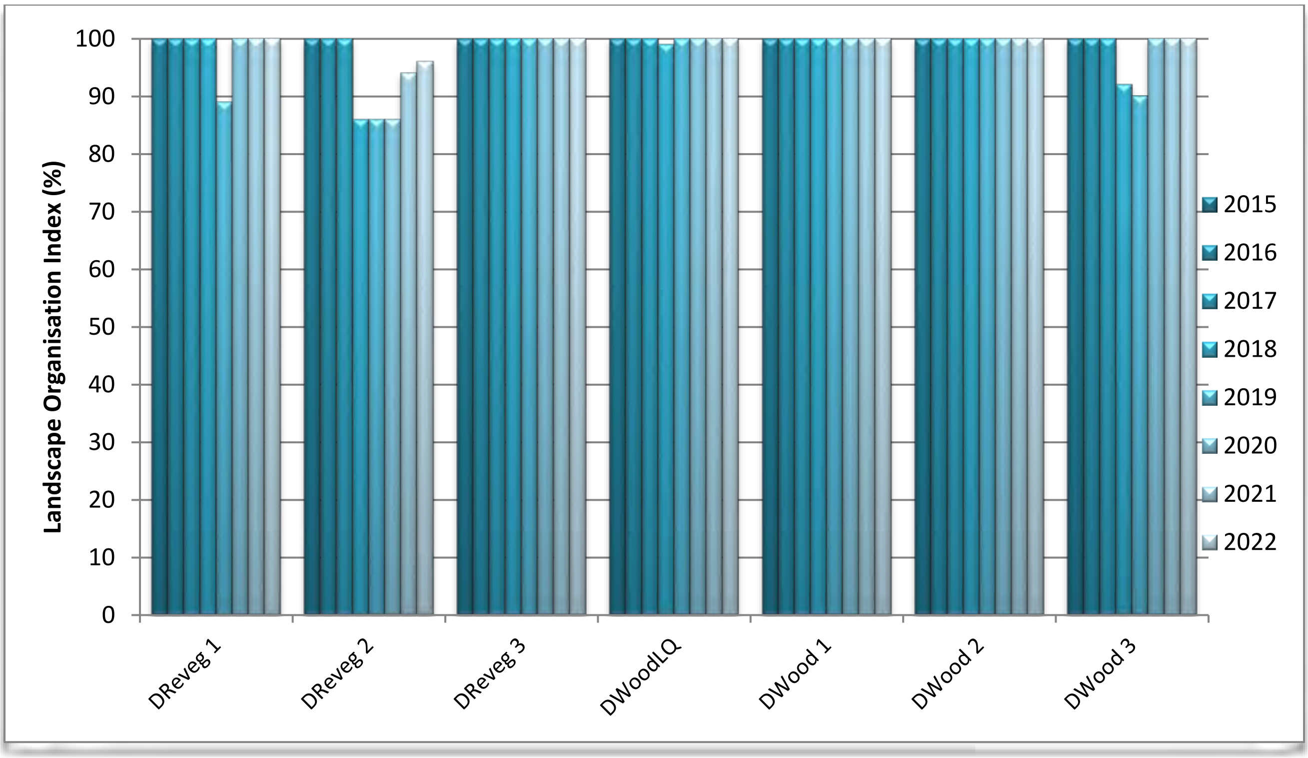

Figure 9-1. Landscape Organisation Indices recorded in the **Dwyer's Red Gum** woodland monitoring sites.

9.2.2 Soil surface assessments

9.2.2.1 Stability

LFA stability indices in the Red Gum reference sites initially demonstrated an increasing trend. During the drought in 2018 and 2019 a decrease in stability was recorded largely due to heavy grazing and disturbance by animals, with stability typically increasing in these sites since 2020. This year a slight decline was recorded in DWood3 with the resultant range being 67.0 – 77.0. Similar trends were recorded in DWoodLQ, where the stability index has also decreased to 70.3 this year and this site continued to have a stability comparable to the woodland reference sites (Figure 9-2).

In the Dwyer's Red Gum derived grasslands, stability has also marginally decreased in two sites, with indices ranging from 74.0 (DReveg1) – 76.6 (DReveg2), with all sites having a stability that continues to be comparable to the woodland reference sites this year. Despite the lack of a mature tree canopy, the high stability indices can be attributed to the higher abundance of perennial ground covers, very hard soil crusts which usually contained a significant abundance of cryptogam cover. The sandy clay soils were subjected to some slaking but there tended to be less recent evidence of erosion or deposition within these sites in comparison to the reference sites.

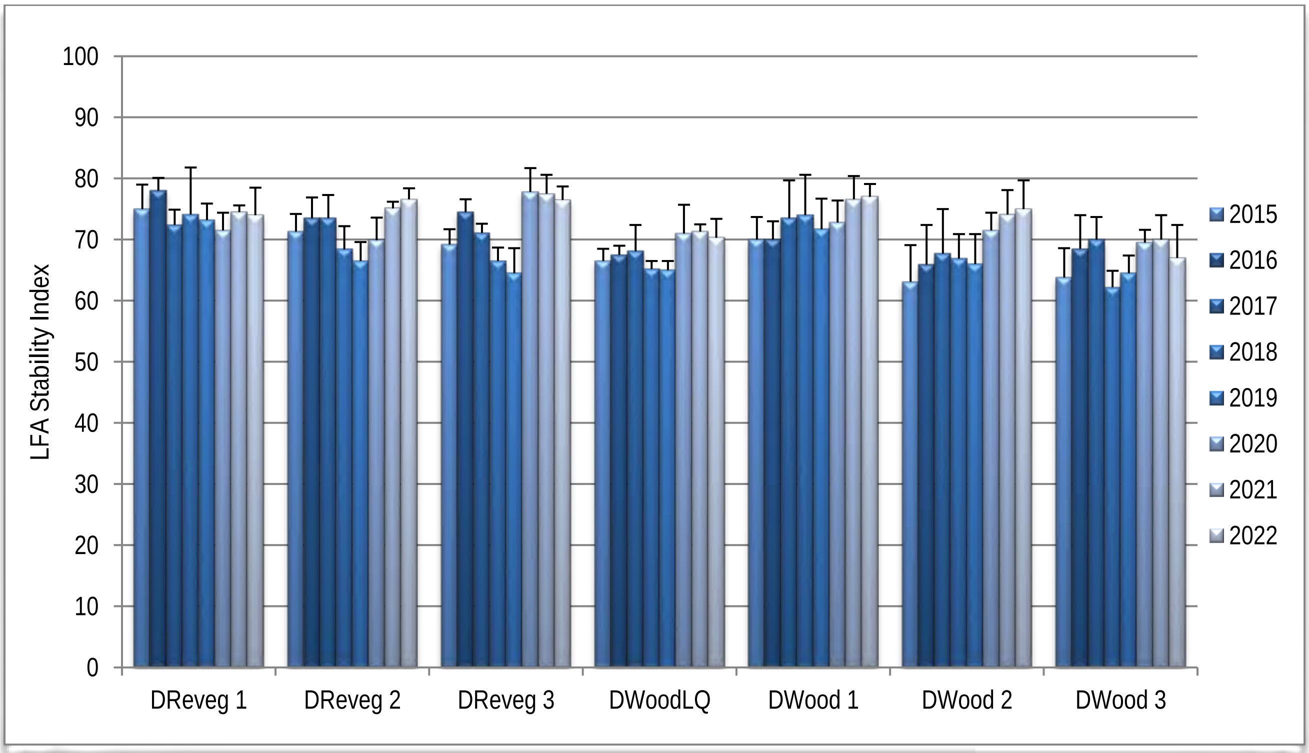

Figure 9-2. LFA stability indices recorded in the **Dwyer's Red Gum** woodland monitoring sites.

9.2.2.2 Infiltration

The infiltration capacity of the Red Gum woodland reference sites also declined during the drought however slight improvements were recorded in 2020 – 2021. This year, infiltration had marginally declined in two sites where indices ranged from 45.0 – 54.8. Negligible change in infiltration capacity has been recorded in DWoodLQ this year and it continued to have an infiltration higher than the reference sites with an index of 56.1 (Figure 9-3). Infiltration in the grassland revegetation areas were also affected by the drought, especially DReveg2, however they have since shown increasing improvement with infiltration indices of 34.5 – 51.5 being recorded this year. Site DReveg2 however, continued to have a low infiltration capacity compared to the reference sites.

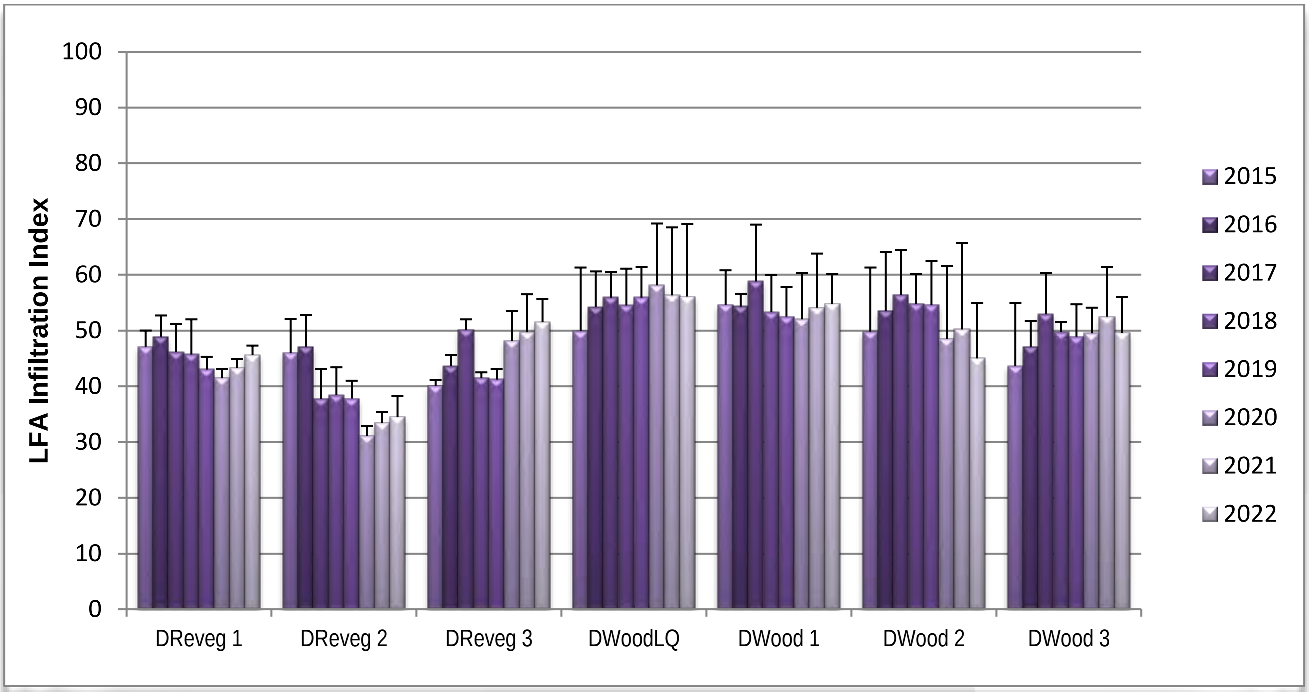

Figure 9-3. LFA infiltration indices recorded in the **Dwyer's Red Gum** woodland monitoring sites.

9.2.2.3 Nutrient recycling

The nutrient recycling capacity is influenced by the degree of perennial plant cover and accumulation and decomposition of the litter layers, which is in turn influenced by the degree of soil compaction and soil surface crusting. In the Dwyer's Red Gum woodland reference sites and DWoodLQ, there was a mature overstorey and there tended to be a low abundance of perennial ground cover but there were well developed litter layers, although the sites were very patchy. Since the drought, there has been a significant reduction in shrub and canopy covers in numerous reference sites, resulting in a reduction in the nutrient capacities of these sites with the nutrient recycling range being 41.8 – 49.7 this year. There has only been a minor reduction in nutrient recycling in DWoodLQ and this year had an index of 55.5 and continued to be higher than the reference sites (Figure 9-4).

In the Dwyer's Red Gum revegetation sites there was an increase in nutrient recycling capacity in all three sites, despite the disturbance created by deep ripping in DReveg2. This year nutrient recycling indices ranged from a low of 37.8 in DReveg2 to a high of 50.1 in DReveg3, however nutrient recycling capacity remained low in DReveg2 compared to the reference sites.

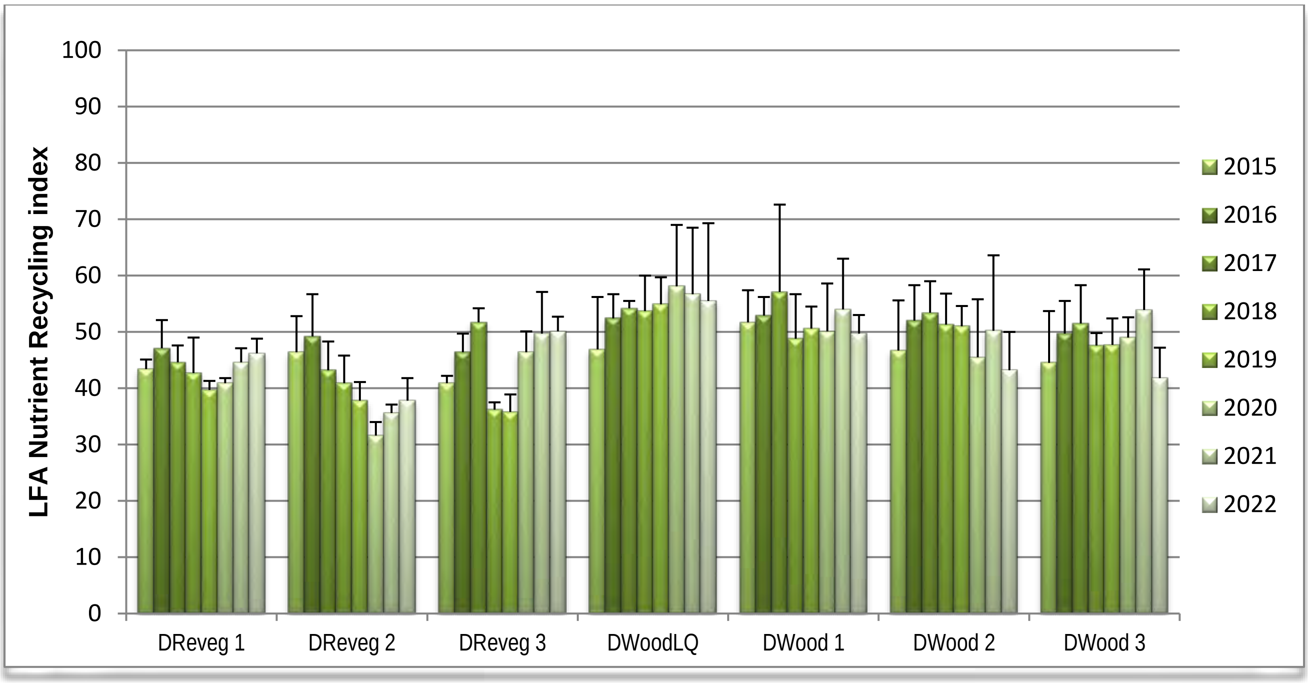

Figure 9-4. LFA nutrient recycling indices recorded in the **Dwyer's Red Gum** woodland monitoring sites.

9.2.3 Most functional sites

The sum of the LFA stability, infiltration and nutrient recycling components provide an indication of the most functional to least functional monitoring sites recorded this year and is provided in Figure 9-5. The maximum score possible is 300. This year, the Red Gum woodland DWoodLQ and the reference site DWood1 were as equally functional as each other with a sum of scores of 182, followed very closely by the derived grassland DReveg3 with a sum of scores of 178. DReveg1 was marginally higher than the reference sites DWood2 and DWood3 which had scores of 163 and 158 respectively. DReveg2 continued to be the least functional site with the score of 149. Examples of the various combinations of ground covers which are critical to overall ecosystem function have been provided in Table 9-2.

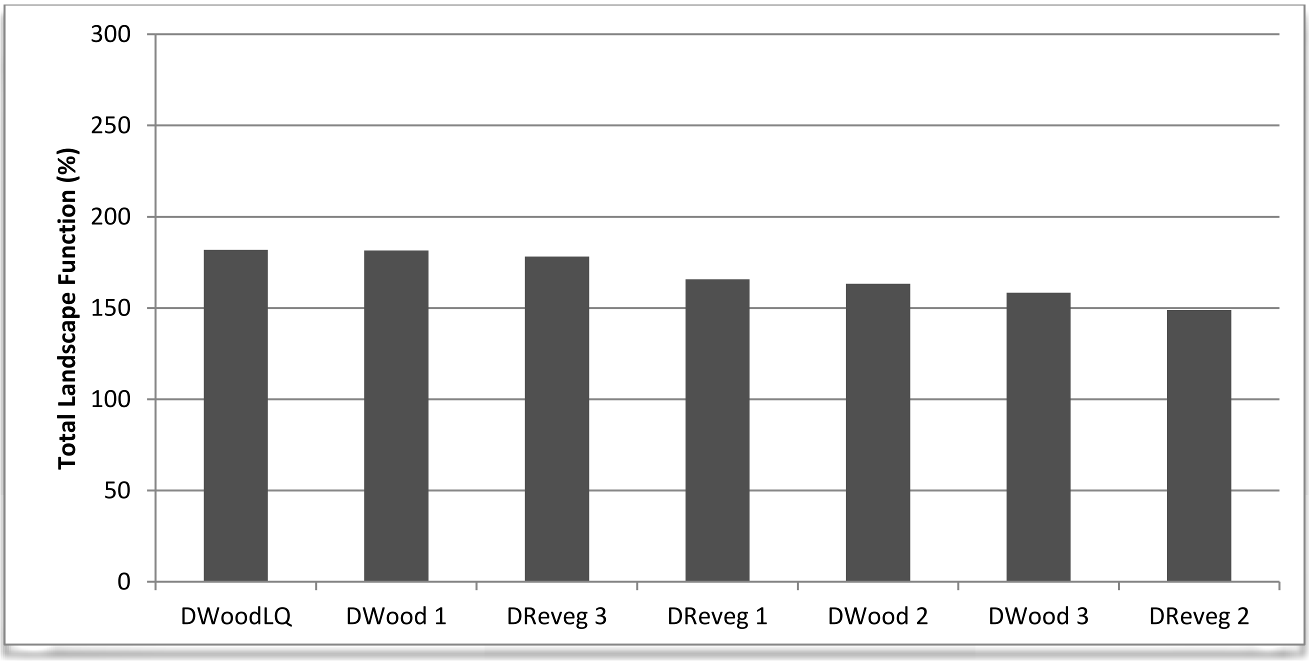

Figure 9-5. Sum of the LFA stability, infiltration and nutrient recycling components indicating the most functional to least functional monitoring site recorded in 2022.

Table 9-2. Examples of the different ground covers in the Kokoda Red Gum monitoring sites in 2022.

DReveg1	DReveg2
	
DReveg3	DWoodLQ
	
DWood1	DWood2
	

DWood3	DWood3(2)
	

9.3 Trees and mature shrubs

9.3.1 Population density

This year in tree densities (stem diameter >5 cm dbh) have declined in DWood2, where total populations in the reference sites were 8 – 21 live individuals, equating to a density of 200 – 525 stems per hectare (Figure 9-6). There continued to be nine trees in the DWoodLQ, and this year there were nine eucalypt saplings recorded in DReveg1 as volunteer seedlings have significantly grown. No trees or mature shrubs were present in the other two derived native grassland sites.

9.3.2 Diameter at breast height

The average dbh recorded in the Red Gum reference sites was 12 – 24 cm but ranged from 5 – 55 cm (Table 9-3), an indication of relatively young population and regrowth status. In DWoodLQ, the average dbh was 23 cm and ranged from 16 – 27 cm. In DReveg1, the saplings had grown with dbhs ranging from 5 – 21 cm.

9.3.3 Condition

The health of the trees and mature shrubs in the Red Gum woodland reference sites appear to have been affected by the ongoing drought however 52 – 63% of the population were in moderate health. There continued to be 10 – 38% with advanced dieback and this year 20 – 67% were dead stags. All three reference sites had at least some individuals bearing reproductive structures such as buds, flowers or fruit. A small percentage of individuals in DWood2 contained hollows suitable for nesting sites (>10 cm) and no mistletoe was recorded in any site year.

In DWoodLQ, all trees were in medium health and 78% were in bud. The eucalypt saplings in DReveg1 were all considered to be healthy but may have had some insect damage and one Red Gum was in bud.

9.3.4 Species composition

The Dwyer's Red Gum reference sites were dominated by *Callitris endlicheri* (Black Cypress Pine) although there may also have been scattered individuals of *Allocasuarina verticillata* (Drooping Sheoak), *E. dealbata* (Tumbledown Red Gum), *E. sideroxylon* and/or *E. albens*. The DWoodLQ woodland was dominated by *E. dwyeri* and contained one *E. albens* (White Box). The nine individuals in DReveg1 were *E. dwyeri* saplings.

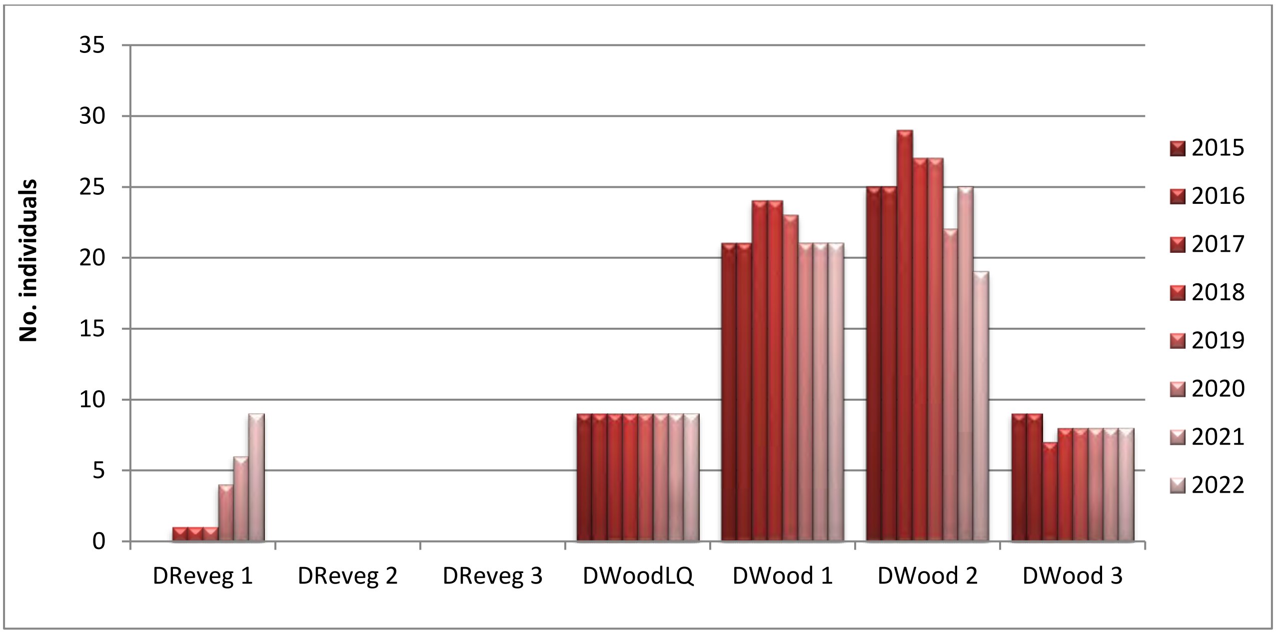

Figure 9-6. Tree and mature shrub densities (>5cm dbh) in the Kokoda Red Gum woodland monitoring sites.

Table 9-3. Trunk diameters and condition of the trees and mature shrubs in the Red Gum monitoring sites in 2022.

Site Name	No species	Average dbh (cm)	Max dbh (cm)	Min dbh (cm)	Total trees	No. with multiple limbs	% Live trees	% Healthy	% Medium Health	% Advanced Dieback	% Dead	% Mistletoe	% Flowers / fruit	%. Trees with hollows
DReveg 1	1	10	21	5	9	4	100	100	0	0	0	0	11	0
DReveg 2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DReveg 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DWoodLQ	2	23	27	16	9	6	100	0	100	0	0	0	78	0
DWood 1	3	12	29	5	63	0	33	8	22	3	67	0	13	0
DWood 2	3	18	55	5	33	1	58	3	39	15	42	0	12	3
DWood 3	3	24	32	7	10	2	80	20	50	10	20	0	70	0

9.4 Shrubs and juvenile trees

9.4.1 Population density

There was a large variation on the number of shrubs and juvenile trees (<5 cm dbh) recorded in the Red Gum reference sites, however declining densities were recorded in most sites in 2020 as a result of drought mortality. Since 2021 many more seedlings had germinated as a result of the favourable conditions and while it was difficult to count with accuracy, there was an estimated 65 – 1082 seedlings (Figure 9-7). In the revegetation areas, there were 1 – 7 seedlings due to natural regeneration and in DReveg2, six additional individuals were due to the tree planting program. In DWoodLQ, seedlings densities had increased to 23 as a result of natural regeneration.

9.4.2 Height class

In the reference sites, the vast majority of individuals were less than 0.5 m in height and all were less than 1.5m tall, except in DWood3 which has some taller individuals (Table 9-4). In DReveg1 seedlings were a range of heights and most height classes continue to be represented, while in DReveg2, DReveg3 and DWoodLQ all individuals were less than 2.0m in height.

9.4.3 Species diversity

In the woodland reference sites, there were 5 - 7 species of shrubs and juvenile trees with the most abundant species being young *Callitris endlicheri* seedlings. In 2021 there was also an abundance of *Eucalyptus dealbata* seedlings in DWood1 and DWood2. *Brachyloma daphnoides* (Daphne Heath) continued to be abundant in DWood2 and there was one *Eucalyptus sideroxylon* seedling.

There were also low occurrences of a range of other species including *Acacia doratoxylon* (Spearwood), *Calytrix tetragona* (Fringe Myrtle), *Allocasuarina verticillata* (Drooping She oak), *Cassinia laevis* (Cough Bush) and *Bossiaea buxifolia* (Box-leaved Bitter-pea). In DWood3 there was a significantly high density of *Callitris endlicheri* seedlings and *Calytrix tetragona* (Fringe Myrtle). In DWoodLQ, there were eight scattered *E. dwyeri, Acacia implexa* and two *A. lanigera* seedlings.

In DReveg1 most individuals were *E. dwyeri* saplings but two *A. decora* seedlings were also recorded. In DReveg2 there was a combination of natural and planted seedlings of *A. decora, A. implexa, A. paradoxa, Cassinia laevis, C. arcuata, Dodonaea viscosa* subsp*. cuneata* and *E. dwyeri.* It was noted that there were also individuals of *Enchylaena tomentosa* (Ruby Saltbush) and *Rytidosperma* species that had also been planted into the sites last year. In DReveg3 there continued to be one volunteer *Allocasuarina verticillata*.

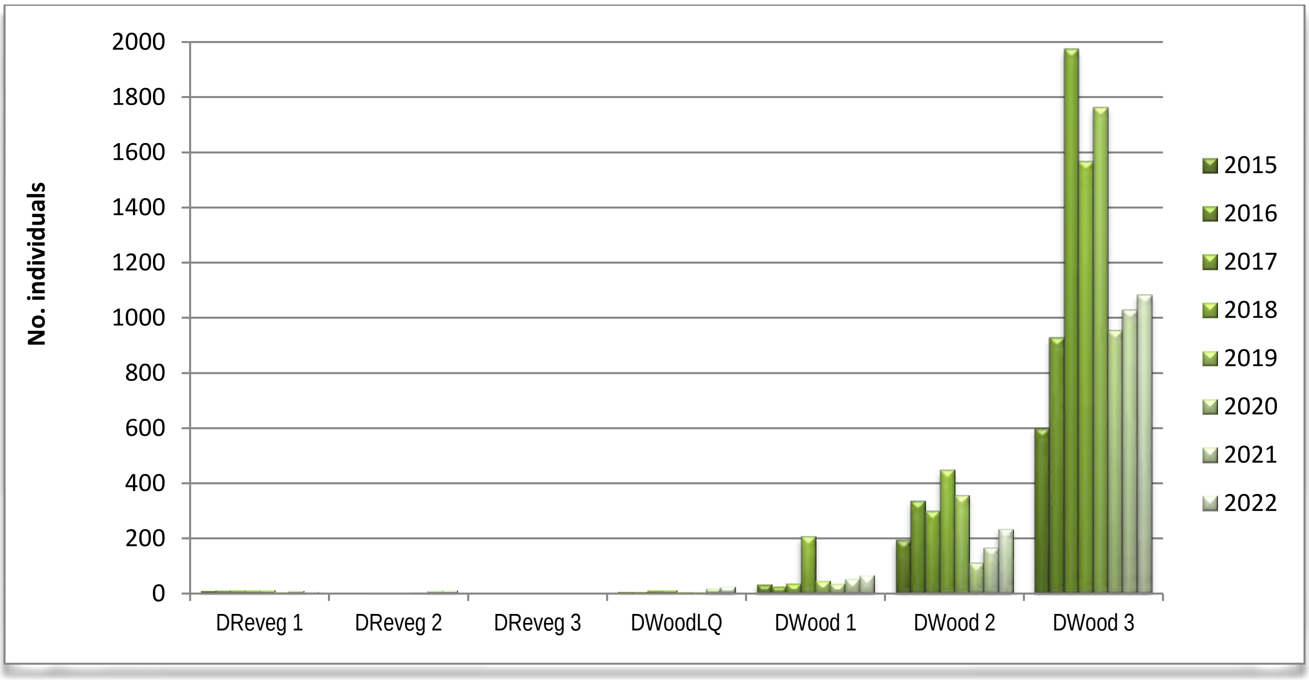

Figure 9-7. Total shrubs and juvenile trees recorded in the Red Gum monitoring sites.

Table 9-4 Number of individuals represented in each height class across the range of monitoring sites.

Site Name	0-0.5m	0.5-1.0m	1.0-1.5m	1.5-2.0m	>2.0m	Total	No. species	% Endemic
DReveg 1	4	0	1	0	1	6	2	100
DReveg 2	5	1	5	0	0	11	7	100
DReveg 3	0	0	1	0	0	1	1	100
DWoodLQ	11	10	2	0	0	23	3	100
DWood 1	62	3	0	0	0	65	5	100
DWood 2	180	48	4	0	0	232	7	100
DWood 3	490	414	130	40	8	1082	6	100

9.5 Total ground Cover

Total ground cover, which is a combination of leaf litter, annual plants, cryptogams, rocks, logs and live perennial plants (<0.5 m in height) had declined in all three reference sites as a result of the drought, heavy grazing and previously there have been extensive areas of ant nests, although these have been inactive since 2020. In 2021 increased ground cover was recorded in two reference sites however animal disturbance continued to create some bare patches in DWood2 and DWood03, with 54.5 - 100% cover being recorded in the reference sites this year (Figure 9-8). In the grassland rehabilitation areas ground cover has increased to 91 – 100% cover, while in DWoodLQ ground cover was slightly higher with 99%.

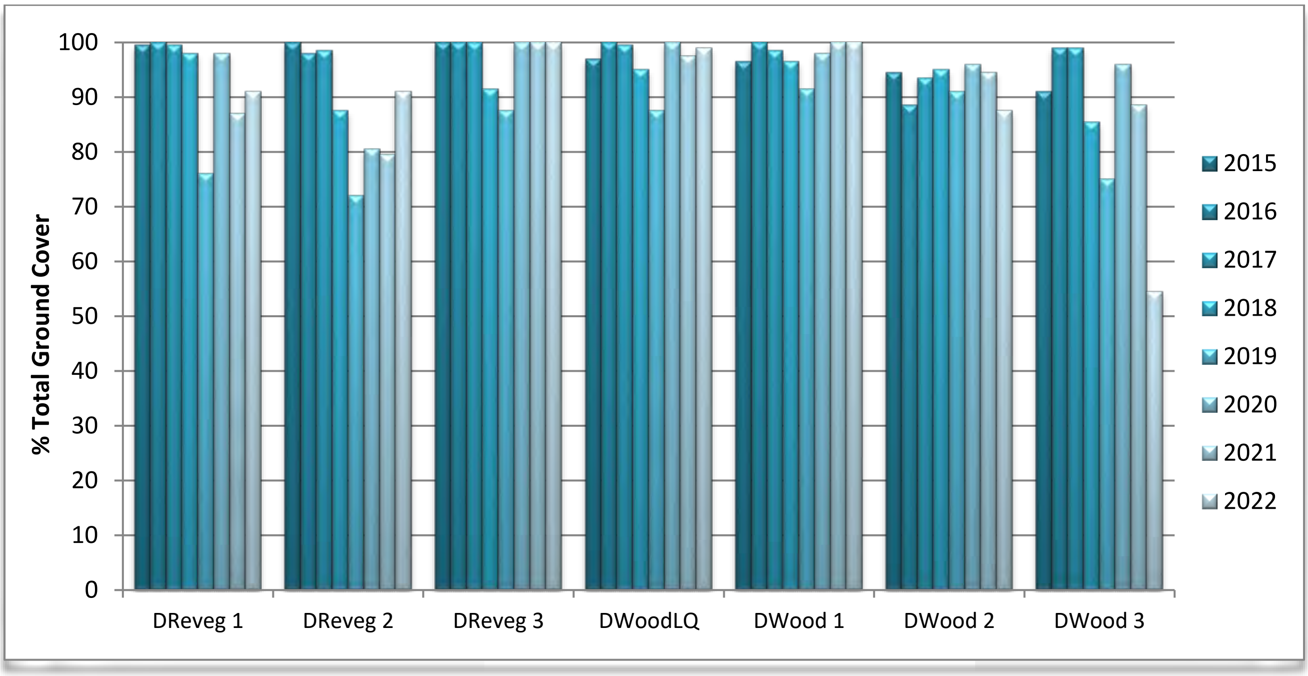

Figure 9-8. Total ground cover recorded in the Red Gum woodland monitoring sites.

9.6 Structural composition

The various combinations of the ground covers and structural compositions of the woodland sites are provided in Figure 9-9. In the Red Gum woodland reference sites, there has been a further decrease increase in perennial plant cover in DWood1 and DWood2 while a small increase was recorded in DWood3, to provide a target range of 8 – 44%. Dead leaf litter was also quite abundant in two sites and provided 11 – 37% of the total ground covers, while annual plant cover has significantly increased in DWood2 and DWood3 with a range of 3 – 36% this year. Cryptogams provided up to 9% and fallen branches provided up to 8% cover in DWood1 and DWood2. In DWood1 there was 8% cover from scattered rocks.

Previously the ground cover in DWoodLQ was very similar to DWood3 and was also dominated by dead litter, with scattered annual and perennial ground covers and pockets of cryptogams and this year had a higher total ground cover. The reference sites and DWoodLQ were also characterised by having a mature canopy cover > 6.0 m in height which provided 2 – 20% projected canopy cover, with low hanging branches and scattered shrubs also providing occasional cover in the lower height classes.

In the grassland revegetation sites, perennial plant cover has significantly increased in some sites while annual plant cover has increased in others, with 7 – 26% perennial and 20 – 44% annual cover recorded this year. There was also dead leaf litter with cover ranging from providing 21 – 60%. Cryptogams continued to be abundant in

DReveg2 and provided 24% cover. There was some low foliage cover in DReveg 1 due to a eucalypt sapling, however no foliage cover >0.5 m in height was recorded in the other two sites.

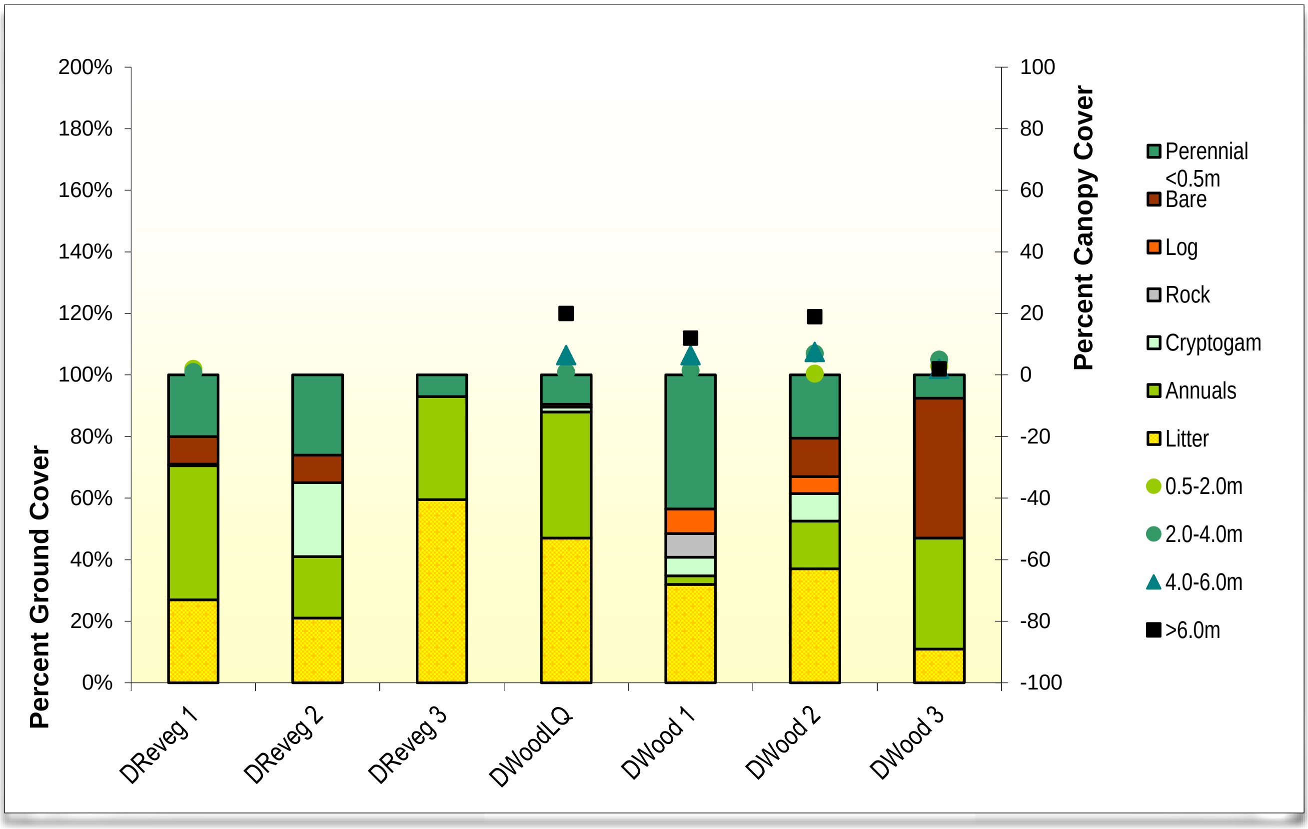

Figure 9-9. Average percent ground cover and projected foliage cover recorded in the Red Gum monitoring sites in 2022.

9.7 Floristic Diversity

Total floristic diversity recorded within the 20 x 20 m Red Gum monitoring sites has tended to change with changes in seasonal conditions with the lowest diversity being recorded during the 2017 – 2019 drought. Since 2020, species diversity has been high with a total of 43 – 52 species being recorded in the reference sites (Figure 9-10), and of these 36 – 43 were native species (Figure 9-11) and 7 – 9 were exotic (Figure 9-12).

In DWoodLQ, there were a total of 57 species, with 34 of these being native species and there was a higher diversity of exotics compared to the reference sites with 23 species. In the grassland revegetation sites, there was 32 – 56 species, with 17 – 39 of these being native species and 15 – 26 were exotics. Subsequently all revegetation sites and DWoodLQ had a higher diversity of exotics compared to the reference sites.

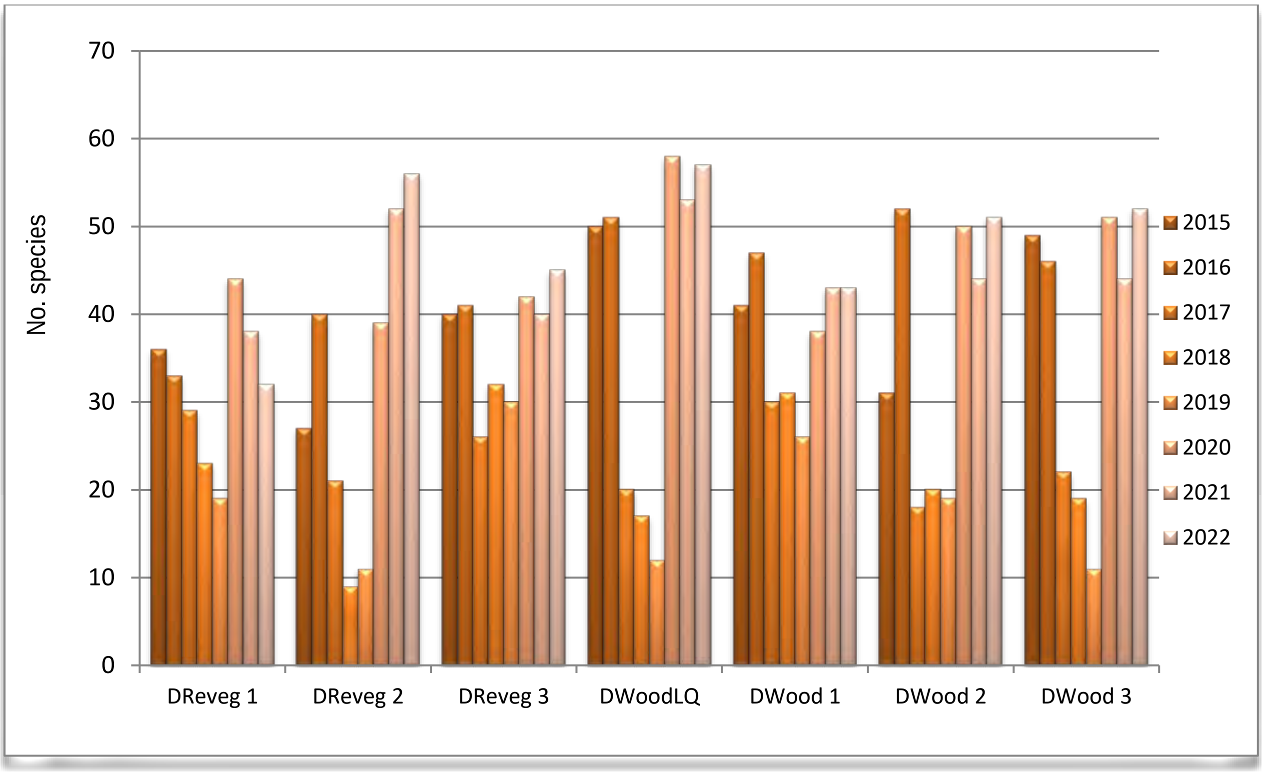

Figure 9-10. Total species diversity recorded in the Red Gum monitoring sites.

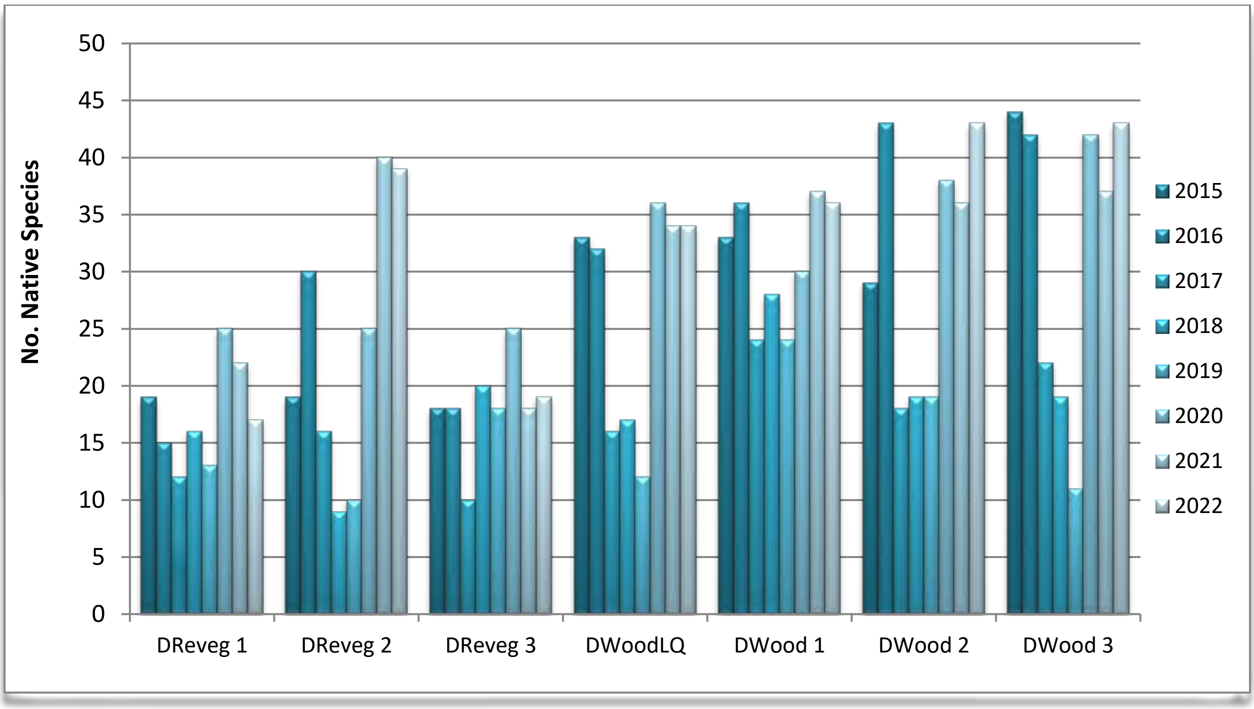

Figure 9-11. Total native species recorded in the Red Gum monitoring sites.

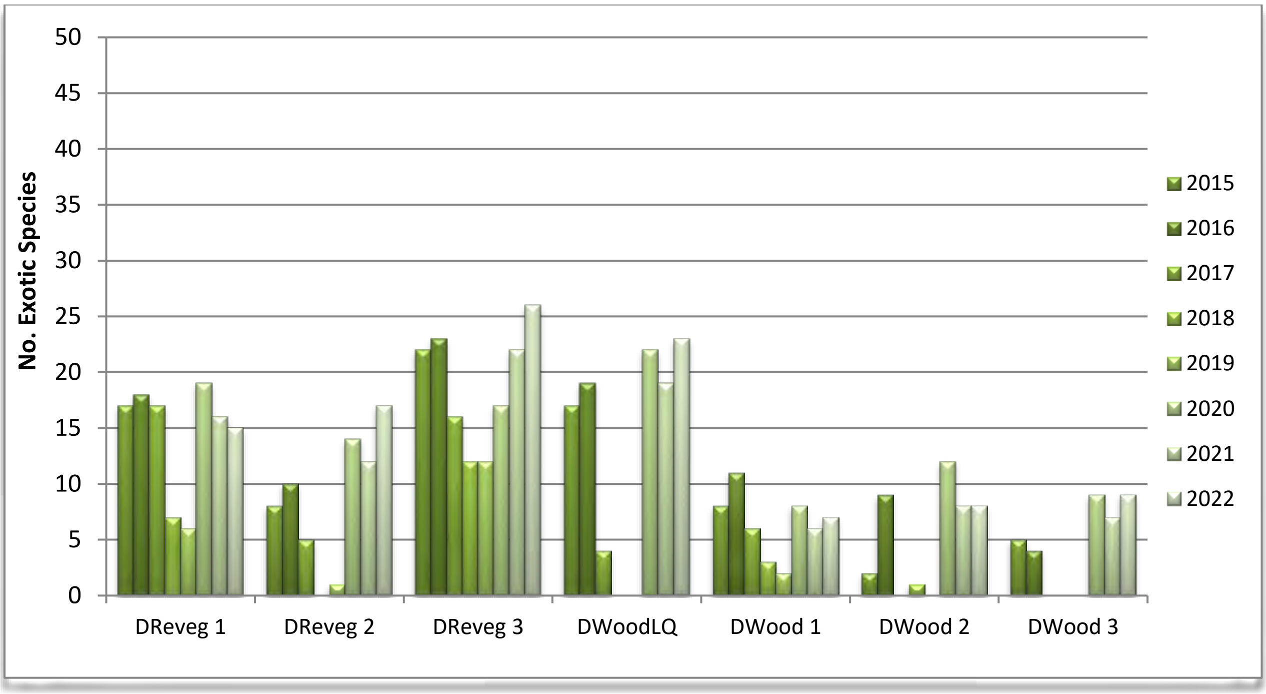

Figure 9-12. Total exotic species recorded in the Red Gum monitoring sites.

9.7.1 Percent endemic ground cover

The percent endemic ground cover is an ecological indicator used to provide some measure of the cover abundance of the live native vegetation along the vegetation transect and therefore indicates the level of weediness at the monitoring sites. While it is only estimation the percent cover of endemic ground cover species has been derived by the following equation.

Percent cover endemic species = sum of the five Braun- Blanquet scores for native species / (sum of the five Braun- Blanquet scores of exotic species + native species) x 100

During the drought, most of the live plant cover in the reference sites has been provided by native species. In 2020 however, the flush of exotic annual plant cover has tended to result in a decline in the proportion of native cover in most cases, with 79 - 95 % of the live cover being provided by native plants in the reference sites this year (Figure 9-13). There was also a declining trend in DWoodLQ this year where native plants provided 48% of the live plant cover. In the grassland revegetation sites, there has previously been a decline in native plant abundance in all three sites however native plant cover has slightly increased in DReveg3. This year native plants provided 47 - 58% cover however all sites continued to have a higher abundance of exotic species compared to the reference sites.

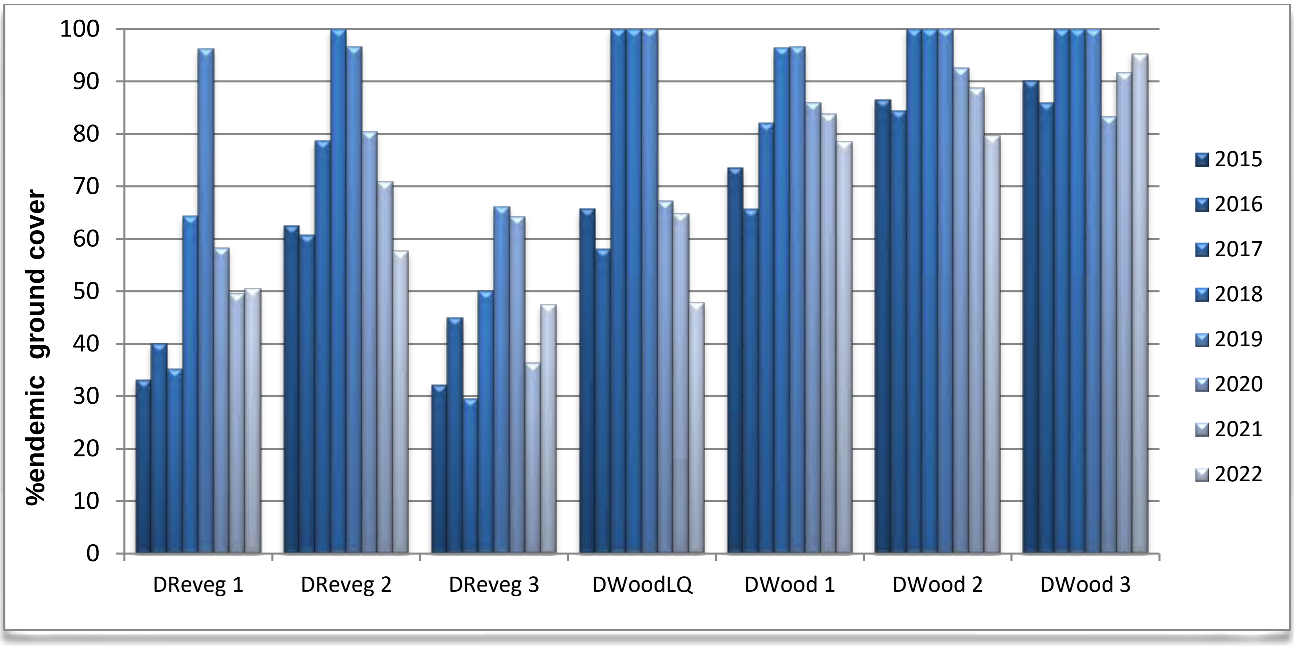

Figure 9-13. Percent endemic ground cover recorded in the Red Gum monitoring sites.

9.8 Vegetation composition

The composition of the vegetation as categorised by seven different growth forms is given in Figure 9-14. In the Red Gum woodland reference sites, herbs and grasses continued to be the most diverse plant groups with 26 - 31 herbs, followed by grasses with 6 – 7 species. There were 3 - 4 tree species, 3 – 5 shrub species and 1 - 4 sub-shrubs as well as 1 - 4 species of reed (rushes and sedges) and a fern was recorded at all three sites. DWoodLQ had a higher or similar diversity of herbs, grasses, reeds and ferns but it had a low diversity of tree, shrubs and sub – shrubs. In the grassland revegetation areas there was typically an adequate diversity of herbs, grasses, reeds and ferns however there was a low diversity of herbs and ferns in DReveg1. There was however a low diversity of trees, shrubs and sub-shrubs in these sites, with the exception of DReveg2 which had a high diversity of shrubs compared to the reference sites.

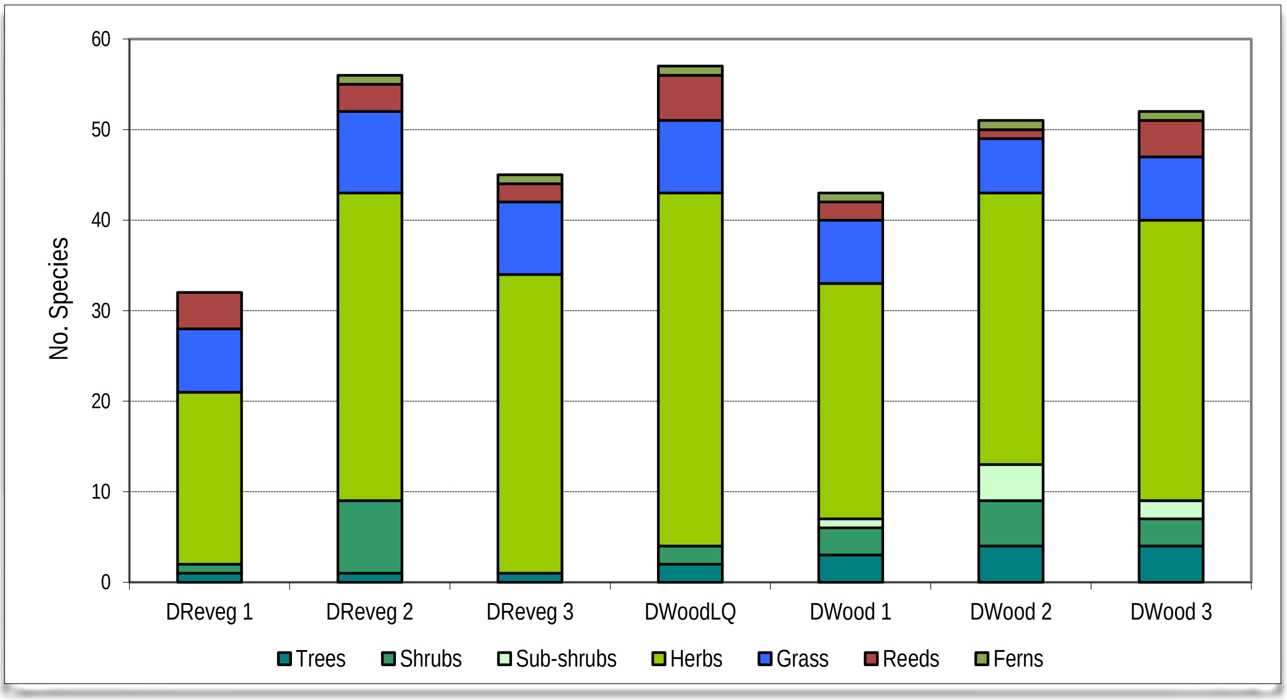

Figure 9-14. Composition of the vegetation recorded in the Red Gum monitoring sites in 2022.

9.9 Most common species

The most common species recorded in the revegetation sites is provided in Table 9-5. Native species common to all revegetation sites include *Bothriochloa macra* (Red-leg Grass), *Drosera peltata* (Pale Sundew), *Haloragis heterophylla* (Rough Raspwort), *Hypericum gramineum* (Small St. John's Wort), *Schoenus apogon* (Common Bog Rush) and *Xerochrysum bracteatum* (Golden Everlasting).

Exotic species common to all four sites included *Aira cupaniana* (Silvery Hairgrass), *Briza minor* (Shivery Grass), *Hypochaeris glabra* (Smooth Catsear), *Hypochaeris radicata* (Flatweed), *Lysimachia [Anagallis] arvensis* (Scarlet Pimpernel), *Parentucellia latifolia* (Red Bartsia) and *Vulpia muralis* (Rats-tail Fescue). All of these common species were also recorded in at least one reference site, with the exception of *Bothriochloa macra*. A comprehensive list of species recorded in all monitoring sites has been included in Appendix 2.

Table 9-5. The most common species recorded in the Red Gum monitoring sites in 2022.

exotic	Scientific Name	Common Name	Habit	DReveg1	DReveg2	DReveg3	DWoodLQ	Total	DWood1	DWood2	DWood3
*	*Aira cupaniana*	Silvery Hairgrass	g	1	1	1	1	4	1	1	1
	Bothriochloa macra	Red-leg Grass	g	1	1	1	1	4			
*	*Briza minor*	Shivery Grass	g	1	1	1	1	4	1	1	1
	Drosera peltata	Pale Sundew	h	1	1	1	1	4		1	1
	Haloragis heterophylla	Rough Raspwort	h	1	1	1	1	4		1	1
	Hypericum gramineum	Small St. John's Wort	h	1	1	1	1	4	1	1	1
*	*Hypochaeris glabra*	Smooth Catsear	h	1	1	1	1	4	1	1	1
*	*Hypochaeris radicata*	Flatweed	h	1	1	1	1	4	1	1	1
*	*Lysimachia [Anagallis] arvensis*	Scarlet Pimpernel	h	1	1	1	1	4	1		1
*	*Parentucellia latifolia*	Red Bartsia	h	1	1	1	1	4	1		1
	Schoenus apogon	Common Bog Rush	r	1	1	1	1	4	1	1	1
*	*Vulpia muralis*	Rats-tail Fescue	g	1	1	1	1	4	1	1	1
	Xerochrysum bracteatum	Golden Everlasting	h	1	1	1	1	4	1	1	1

Note: "1" denotes the presence of that species and is not a measure of cover abundance
Key to habit legend: t = tree; s = shrub; ss =sub-shrub; h = herb; g = grass, r = reed; v = vine; f = fern; p = parasite

9.10 Most abundant species

The most abundant species recorded in each of the Red Gum monitoring sites this year are provided in Table 9-6. The most abundant species were those that collectively summed to a Braun-Blanquet total of 10 or more from the five replicated sub-plots along the vegetation transect. The maximum score that can be obtained by an individual species is 30.

The sites tended to be dominated by a different composition of species across the range of sites. The grassland revegetation sites were often dominated by exotic annual grasses such as *Aira cupaniana* (Silvery Hairgrass), *Briza minor* (Shivery Grass) and *Vulpia muralis* (Rats-tail Fescue). *Hypochaeris glabra* (Smooth Catsear) had declined in abundance this year bit continued to be recorded in relatively high numbers in DReveg2.

Other species that may have occurred in localised abundance included perennial natives such as *Aristida ramosa* (Threeawn Grass), *Haloragis heterophylla (*Rough Raspwort), *Cheilanthes sieberi* subsp*. sieberi* (Rock Fern), *Gonocarpus elatus* (Hill Raspwort) and *Hypericum gramineum* (Small St. John's Wort). *Schoenus apogon* (Common Bog Rush), a small native annual sedge, was also quite abundant in numerous locations including two reference sites. In the reference sites, *Gonocarpus elatus* (Hill Raspwort) was the most abundant in DWood1 and *Haloragis heterophylla* was also in moderate abundance in DWood3.

Table 9-6. The most abundant species recorded in the Red Gum monitoring sites in 2022.

Scientific Name	Common Name	DReveg1	DReveg2	DReveg3	DWoodLQ	DWood1	DWood2	DWood3
**Aira cupaniana*	Silvery Hairgrass	14	12		11			
**Briza minor*	Shivery Grass	16		13				
Aristida ramosa	Threeawn Grass	15	15					
Haloragis heterophylla	Rough Raspwort	11						12
Schoenus apogon	Common Bog Rush	12			14		14	18
**Hypochaeris glabra*	Smooth Catsear		11				10	
Cheilanthes sieberi subsp. sieberi	Rock Fern		11					
Gonocarpus elatus	Hill Raspwort		11			17		
Hypericum gramineum	Small St. John's Wort		10					
**Vulpia muralis*	Rats-tail Fescue			10				

9.11 Soil analyses

This section summarises the changes of several important soil characteristics over time. The full results of the soil analyses for the Red Gum monitoring sites are provided in Appendix 4.

9.11.1 pH

Figure 9-15 shows the pH recorded in the Red Gum monitoring sites compared to the “desirable” range in medium or clay loam soils as prescribed by the agricultural industry for growing introduced pastures and crops. There has continued to be negligible change in the soil pH range across the sites and this year pH in the woodland reference sites remained slightly lower than or just within the threshold desirable agricultural ranges. With soil pH ranging from 5.4 – 5.8 the soils were moderately to strongly acidic (Bruce & Rayment 1982). In the remaining sites the soil pH ranged from 5.4 – 6.0 and were comparable to the Red Gum reference sites and DReveg1 and DReveg3 continued to be within the minimum desirable agricultural range.

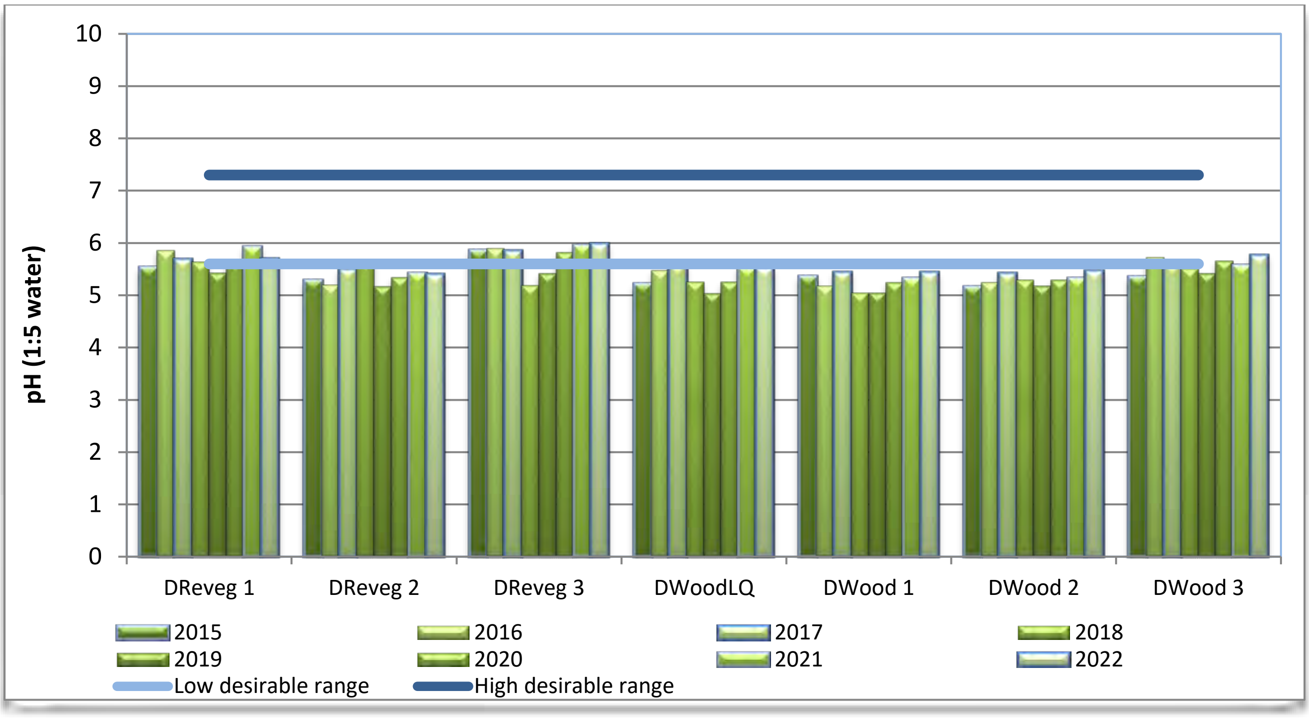

Figure 9-15. Soil pH recorded in the Red Gum monitoring sites compared to the desirable agricultural range.

9.11.2 Conductivity

Figure 9-16 shows the Electrical Conductivity (EC) recorded in the Red Gum monitoring sites compared to the "desirable" range in medium or clay loam soils as prescribed by the agricultural industry for growing introduced pastures and crops. The EC recorded across the range of sites remained well below the agricultural threshold indicating there are very low levels of soluble salts in the soil profile and that they are non-saline. The EC readings in the reference sites ranged from 0.026 – 0.036 dS/m. In the remaining sites EC ranged from a low of 0.015 dS/m in DReveg2 to a high of 0.036 dS/m in DWoodLQ.

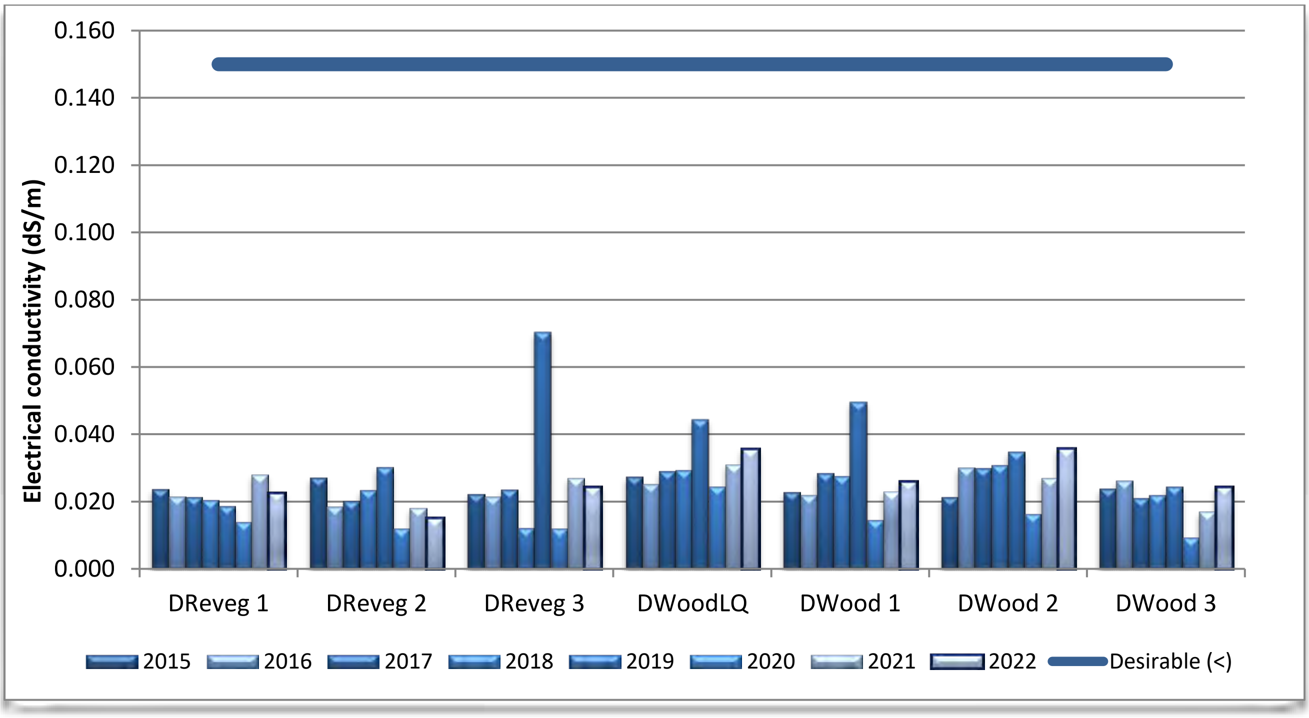

Figure 9-16. Electrical Conductivity recorded in the Red Gum monitoring sites compared to the desirable agricultural levels.

9.11.3 Organic Matter

In the Dwyer's Red Gum woodland reference sites OM levels have significantly increased and this year ranged from 4.5 – 7.9% which were similar to or exceeding the desirable agricultural threshold of 4.5% (Figure 9-17). OM in the derived grassland sites ranged from 2.8 – 3.5% and were lower than the woodland reference sites, while in DWoodLQ, OM had increased to 5.7% and remained comparable to the reference sites and above agricultural guidelines.

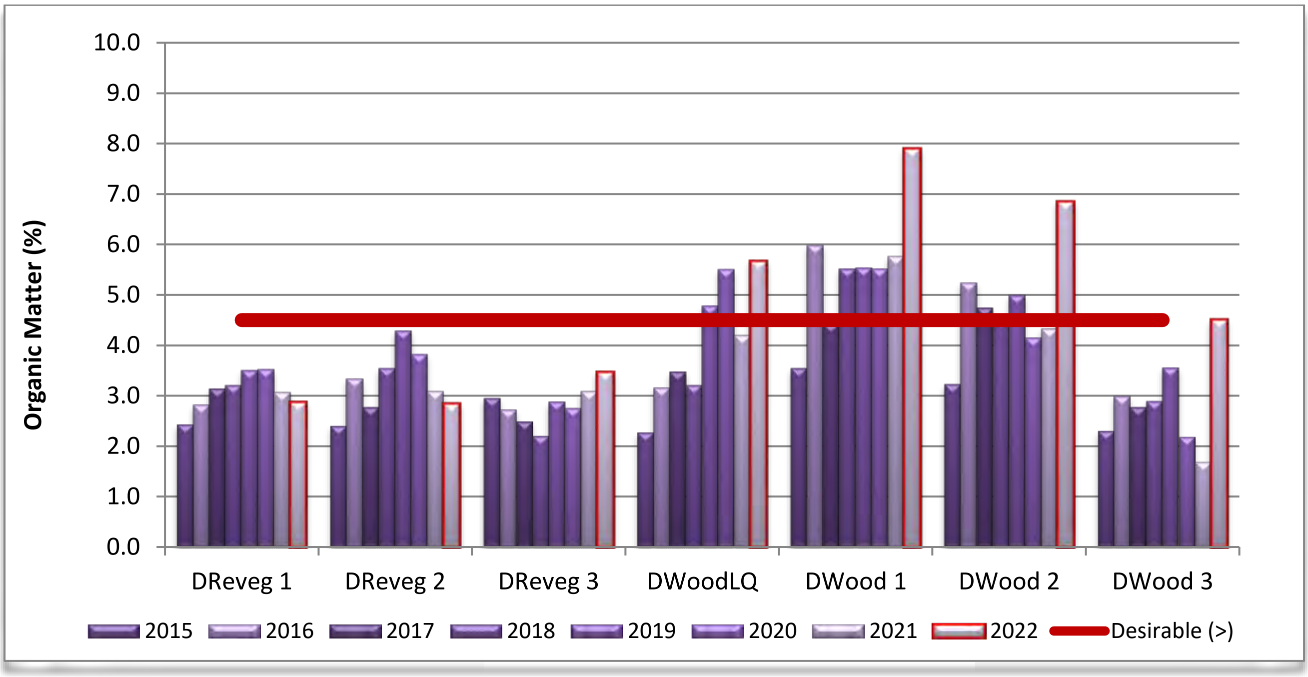

Figure 9-17. Organic Matter concentrations recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

9.11.4 Phosphorous

Phosphorous levels were lower than the agricultural standards across all Dwyer's Red Gum monitoring sites and in the woodland reference sites, P concentrations were 2 – 3 mg/kg this year. P in the remaining sites ranged from 2 – 8 mg/kg and were similar to or slightly higher than the reference sites this year (Figure 9-18).

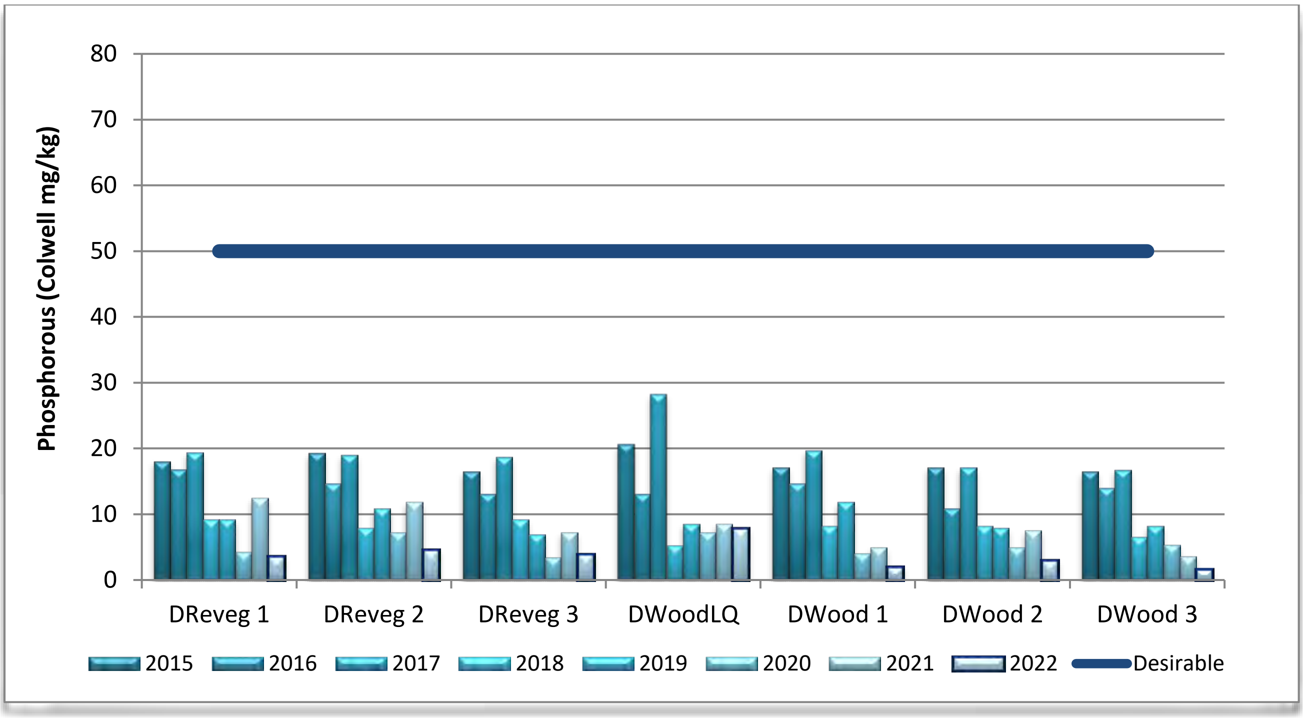

Figure 9-18. Phosphorous concentrations recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

9.11.5 Nitrate

Nitrate levels have previously been much lower than the agricultural standards across all Red Gum monitoring sites and there were little differences between the sites. This year N was 1.0 – 2.6 mg/kg in the reference sites, and in DWoodLQ had a higher N with 4.4 mg/kg. In the remaining grassland there was 0.6 mg/kg in all three sites however these were very low compared to the reference sites this year (Figure 9-19).

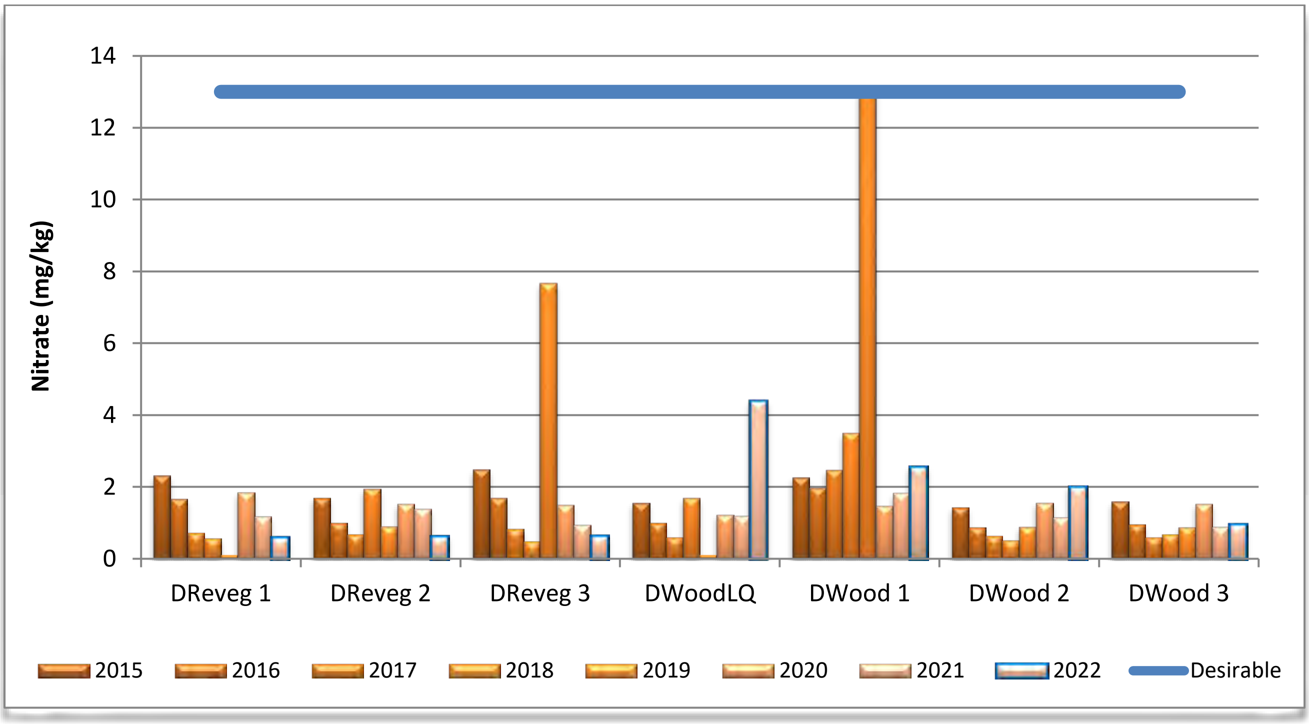

Figure 9-19. Nitrate concentrations recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

9.11.6 Cation Exchange Capacity

All of the Red Gum monitoring sites had a low CEC and in the reference sites CEC has slightly increased to 3.0 – 5.2 cmol/kg. In the remaining sites, CEC ranged from a low of 2.5 cmol/kg in DReveg3 to a high of 3.8 cmol/kg in DWoodLQ, with DWoodLQ having CEC comparable to the reference sites this year (Figure 9-20).

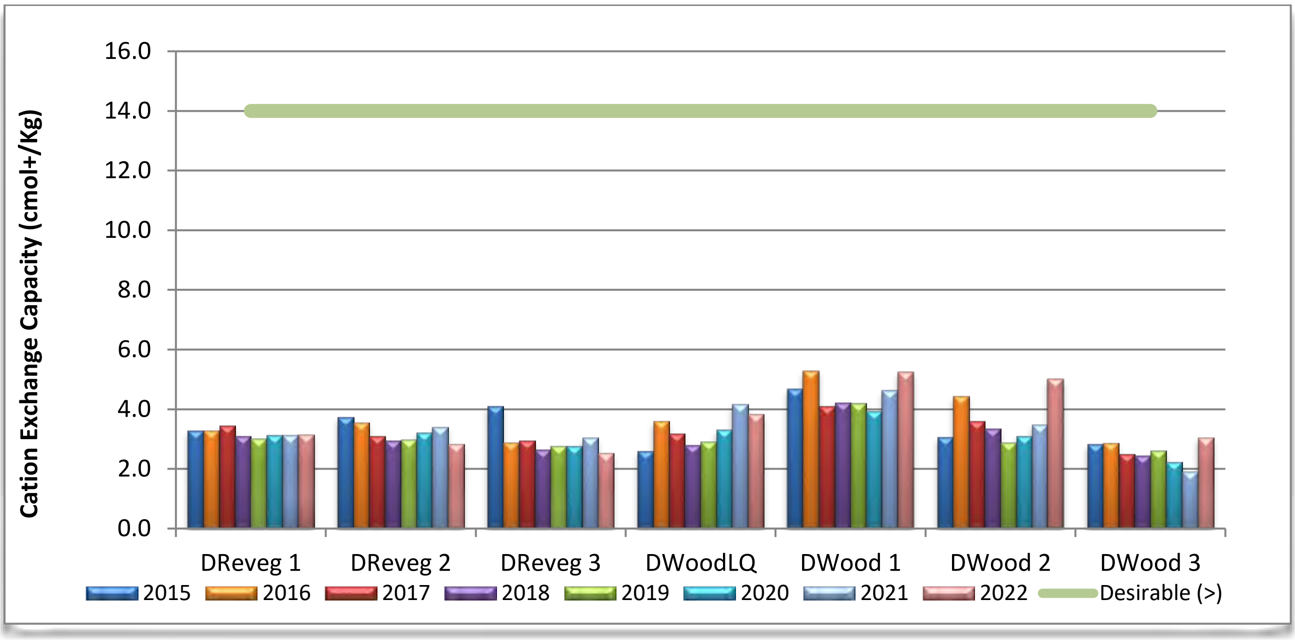

Figure 9-20. Cation Exchange Capacity recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

9.11.7 Exchangeable Sodium Percentage

ESP recorded in the woodland reference sites has been highly variable and this year has increased in all sites, with CEC ranging from 1.0 – 4.6% and these remained below the 5% threshold for sodicity (Figure 9-21). In GBReveg2, ESP was 1.8%, however in the remaining sites ESP has increased to 5.9 – 6.7% and above the sodic threshold.

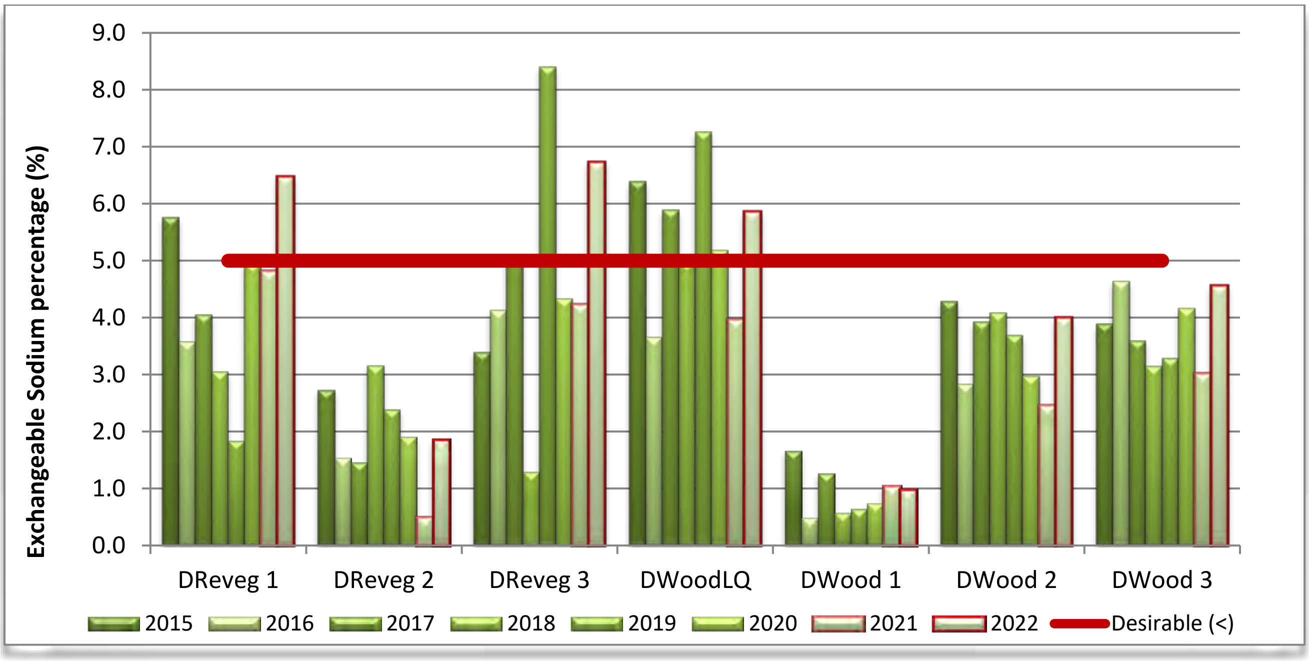

Figure 9-21. ESP recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

9.12 Red Gum: Site performance towards meeting woodland completion criteria targets

Table 9-7 indicates the performance of the Kokoda Red Gum monitoring sites against a selection of proposed Completion Performance Indicators during the 2022 monitoring period. The selection of criteria has been presented in order of ecosystem successional processes, beginning with landform establishment and stability (orange) and ending with indicators of ecosystem and land use sustainability (blue). The range values are amended annually.

Monitoring sites meeting or exceeding the range values of the Red Gum woodland reference sites have been identified with a shaded colour box and have therefore been deemed to meet completion criteria targets. In the case of "growth medium development", upper and lower soil property indicators are also based on results obtained from the respective reference sites sampled in 2022. In some cases, the site may not fall within ranges based on these data but may be within "desirable" levels as prescribed by the agricultural industry. If this scenario occurs, the rehabilitation site has been identified using a striped shaded box to indicate that it falls within "desirable" ranges but does not fall within specified completion criteria targets using the adopted methodology.

Table 9-7. Performance of the Red Gum revegetation monitoring sites against the Primary and Secondary Performance Indicators in 2022.

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2022		DReveg 1	DReveg 2	DReveg 3	DWood LQ
Performance indicators are quantified by the range of values obtained from replicated reference sites							2022	2022	2022	Lower	Upper	2022	2022	2022	2022
Phase 2: Landform establishment and stability	Landform slope, gradient	Landform suitable for final land use and generally compatible with surrounding topography	Slope	Landform is generally compatible within the context of the local topography.		< Degrees (18°)	4	3	3	3	4	4	3	4	3
	Active erosion	Areas of active erosion are limited	No. Rills/Gullies	Number of gullies or rills >0.3m in width or depth in a 50m transect are limited and stabilising		No.	0	0	0	0	0	0	0	0	0
			Cross-sectional area of rills		Provides an assessment of the extent of soil loss due to gully and rill erosion and that it is limited and/or is stabilising	m2	0	0	0	0	0	0	0	0	0
Phase 3: Growth medium development	Soil chemical, physical properties and amelioration	Soil properties are suitable for the establishment and maintenance of selected vegetation species	pH	pH is typical of that of the surrounding landscape or falls within desirable ranges provided by the agricultural industry		pH (*5.6 - 7.3)	5.4	5.5	5.8	5.4	5.8	5.7	5.4	6.0	5.5
			EC		Electrical Conductivity is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	< dS/m (*<0.150)	0.026	0.036	0.024	0.024	0.036	0.023	0.015	0.024	0.036

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2022		DReveg 1	DReveg 2	DReveg 3	DWood LQ
			Organic Matter	Organic Carbon levels are typical of that of the surrounding landscape, increasing or fall within desirable ranges provided by the agricultural industry		% (*>4.5)	7.9	6.8	4.5	4.5	7.9	2.9	2.8	3.5	5.7
			Phosphorous	Available Phosphorus is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		ppm (*50)	2.0	3.0	1.6	1.6	3.0	3.6	4.6	3.9	7.9
			Nitrate		Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	ppm (*>12.5)	2.6	2.0	1.0	1.0	2.6	0.6	0.6	0.6	4.4
			CEC		Cation Exchange Capacity is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	Cmol+/kg (*>14)	5.2	5.0	3.0	3.0	5.2	3.1	2.8	2.5	3.8
			ESP		Exchangeable Sodium Percentage (a measure of sodicity) is typical of the surrounding landscape or is less than the 5% threshold for sodicity	% (*<5)	1.0	4.0	4.6	1.0	4.6	6.5	1.8	6.7	5.9
Phase 4: Ecosystem & Land use Establishment	Landscape Function Analysis (LFA): Landform stability and organisation	Landform is stable and performing as it was designed to do	LFA Stability	The LFA stability index provides an indication of the sites stability and is comparable to or trending towards that of the local remnant vegetation		%	77.0	75.0	67.0	67.0	77.0	74.0	76.6	76.5	70.3
			LFA Landscape organisation	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and is comparable to that of the local remnant vegetation		%	100	100	100	100	100	100	96	100	100
	Vegetation diversity	Vegetation contains a diversity of species comparable	Diversity of shrubs and juvenile trees	The diversity of shrubs and juvenile trees with a stem diameter < 5cm is comparable to that of the local remnant vegetation.		species/ area	5	7	6	5	7	2	7	1	3

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2022		DReveg 1	DReveg 2	DReveg 3	DWood LQ
		to that of the local remnant vegetation		The percentage of shrubs and juvenile trees with a stem diameter < 5cm dbh which are local endemic species and these percentages are comparable to the local remnant vegetation		% endemic	100	100	100	100	100	100	100	100	100
			Total species richness		The total number of live plant species provides an indication of the floristic diversity of the site and is comparable to the local remnant vegetation	No./area	43	51	52	43	52	32	56	45	57
			Native species richness		The total number of live native plant species provides an indication of the native plant diversity of the site and that it is greater than or comparable to the local remnant vegetation	>No./area	36	43	43	36	43	17	39	19	34
			Exotic species richness	The total number of live exotic plant species provides an indication of the exotic plant diversity of the site and that it is less than or comparable to the local remnant vegetation		<No./area	7	8	9	7	9	15	17	26	23
	Shrubs and juvenile tree (<5cm dbh) density	Vegetation contains a density of shrubs and juvenile trees (<5cm dbh) comparable to the local remnant vegetation	Total density of shrubs or juvenile trees		The total density of shrubs or juvenile trees with a stem diameter < 5cm is comparable to the local remnant vegetation	No./area	65	232	1082	65	1082	6	11	1	23
			Density of eucalypts	The density of eucalypts is comparable to the local remnant vegetation		No./area	25	40	2	2	40	4	1	0	17
			Density of acacias	The density of acacias is comparable to the local remnant vegetation		No./area	4	2	0	0	4	2	6	0	6
			Density of other endemic shrubs	The density of other endemic shrubs is comparable to the local remnant vegetation		No./area	36	190	1080	36	1080	0	4	1	0
			Density of exotic / non endemic species	The density of exotic / non endemic species is comparable to the local remnant vegetation		<No./area	0	0	0	0	0	0	0	0	0
			The percentage of eucalypts	The percentage of eucalypts is comparable to the local remnant vegetation		% population	38	17	0.2	0	38	67	9	0	74

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2022		DReveg 1	DReveg 2	DReveg 3	DWood LQ
			Total density of endemic shrubs and/or juvenile trees	The total density of endemic shrubs and/or juvenile trees (< 5cm) is comparable to the local remnant vegetation		No./area	65	232	1082	65	1082	6	11	1	23
	Ecosystem composition	The vegetation is comprised by a range of growth forms comparable to that of the local remnant vegetation	Trees	The number of tree species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	3	4	4	3	4	1	1	1	2
			Shrubs	The number of shrub species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	3	5	3	3	5	1	8	0	2
			Sub-shrubs		The number of sub-shrub species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	1	4	2	1	4	0	0	0	0
			Herbs	The number of herbs or forb species comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	26	30	31	26	31	19	34	33	39
			Grasses		The number of grass species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	7	6	7	6	7	7	9	8	8
			Reeds		The number of reed, sedge or rush species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	2	1	4	1	4	4	3	2	5
			Ferns		The number of ferns comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	1	1	1	1	1	0	1	1	1
			Vines		The number of vines or climbing species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	0	0	0	0	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2022		DReveg 1	DReveg 2	DReveg 3	DWood LQ
			Parasite		The number of parasite species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	0	0	0	0	0	0	0	0
Phase 5: Ecosystem & Land use Sustainability	Landscape Function Analysis (LFA): Landform function and ecological performance	Landform is ecologically functional and performing as it was designed to do	LFA Infiltration	LFA infiltration index provides an indication of the sites infiltration capacity and is comparable to or trending towards that of the local remnant vegetation		%	54.8	45.0	49.6	45.0	54.8	45.6	34.5	51.5	56.1
			LFA Nutrient recycling	LFA nutrient recycling index provides an indication of the sites ability to recycle nutrient and is comparable to or trending towards that of the local remnant vegetation		%	49.7	43.2	41.8	41.8	49.7	46.2	37.8	50.1	55.5
	Protective ground cover	Ground layer contains protective ground cover and habitat structure comparable with the local remnant vegetation	Litter cover		Percent ground cover provided by dead plant material is comparable to that of the local remnant vegetation	%	32	37	11	11	37	27	21	59.5	47
			Annual plants		Percent ground cover provided by live annual plants is comparable to that of the local remnant vegetation	<%	3	16	36	3	36	43.5	20	33.5	41
			Cryptogam cover		Percent ground cover provided by cryptogams (e.g. mosses, lichens) is comparable to that of the local remnant vegetation	%	6	9	0	0	9	0.5	24	0	1.5
			Rock		Percent ground cover provided by stones or rocks (> 5cm diameter) is comparable to that of the local remnant vegetation	%	8	0	0	0	8	0	0	0	0
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	8	6	0	0	8	0	0	0	0
			Bare ground		Percentage of bare ground is less than or comparable to that of the local remnant vegetation	< %	0	13	46	0	46	9	9	0	1
			Perennial plant cover (< 0.5m)	Percent ground cover provided by live perennial vegetation (< 0.5m in height)		%	44	21	8	8	44	20	26	7	9.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2022		DReveg 1	DReveg 2	DReveg 3	DWood LQ
				is comparable to that of the local remnant vegetation											
			Total Ground Cover	Total groundcover is the sum of protective ground cover components (as described above) and that it is comparable to that of the local remnant vegetation		%	**100**	**88**	**55**	**55**	**100**	**91**	**91**	**100**	**99**
	Ground cover diversity	Vegetation contains a diversity of species per square meter comparable to that of the local remnant vegetation	Native understorey abundance		The abundance of native species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it is has more than or an equal number of native species as the local remnant vegetation	> species/m^2	**5**	**7**	**9**	**5**	**9**	**5**	**7.6**	**7.2**	**7.6**
			Exotic understorey abundance		The abundance of exotic species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it is has less than or an equal number of exotic species as the local remnant vegetation	< species/m^2	**2**	**2**	**1**	**1**	**2**	**5.6**	**6.2**	**7.0**	**8.8**
	Native ground cover abundance	Native ground cover abundance is comparable to that of the local remnant vegetation	Percent ground cover provided by native vegetation <0.5m tall	The percent ground cover abundance of native species (<0.5m height) compared to exotic species is comparable to that of the local remnant vegetation		%	**79**	**80**	**95**	**79**	**95**	**50.5**	**57.6**	**47.4**	**47.8**
	Ecosystem growth and natural recruitment	The vegetation is maturing and/or natural recruitment is occurring at rates similar to those of the local remnant vegetation	shrubs and juvenile trees 0 - 0.5m in height	The number of shrubs or juvenile trees < 0.5m in height provides an indication of establishment success and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation		No./area	**62**	**180**	**490**	**62**	**490**	**4**	**5**	**0**	**11**
			shrubs and juvenile trees 0.5 - 1m in height		The number of shrubs or juvenile trees 0.5-1m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that	No./area	**3**	**48**	**414**	**3**	**414**	**0**	**1**	**0**	**10**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2022		DReveg 1	DReveg 2	DReveg 3	DWood LQ
					of the local remnant vegetation										
			shrubs and juvenile trees 1 - 1.5m in height		The number of shrubs or juvenile trees 1-1.5m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	0	4	130	0	130	1	5	1	2
			shrubs and juvenile trees 1.5 - 2m in height	The number of shrubs or juvenile trees 1.5-2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation		No./area	0	0	40	0	40	0	0	0	0
			shrubs and juvenile trees >2m in height		The number of shrubs or juvenile trees > 2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	0	0	8	0	8	1	0	0	0
	Ecosystem structure	The vegetation is developing in structure and complexity comparable to that of the local remnant vegetation	Foliage cover 0.5 - 2 m	Projected foliage cover provided by perennial plants in the 0.5 - 2m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation		% cover	0	1	3	0	3	2	0	0	0
			Foliage cover 2 - 4m		Projected foliage cover provided by perennial plants in the 2 - 4m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation	% cover	2	7	5	2	7	1	0	0	1

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2022		DReveg 1	DReveg 2	DReveg 3	DWood LQ
			Foliage cover 4 - 6m		Projected foliage cover provided by perennial plants in the 4 -6m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation	% cover	7	8	2	2	8	0	0	0	6.5
			Foliage cover >6m	Projected foliage cover provided by perennial plants > 6m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation		% cover	12	19	2	2	19	0	0	0	20
	Tree diversity	Vegetation contains a diversity of maturing tree and shrubs species comparable to that of the local remnant vegetation	Tree diversity		The diversity of trees or shrubs with a stem diameter > 5cm is comparable to the local remnant vegetation. Species used in rehabilitation will be endemic to the local area	species/ area	3	3	3	3	3	1	0	0	2
				The percentage of maturing trees and shrubs with a stem diameter > 5cm dbh which are local endemic species and these percentages are comparable to the local remnant vegetation		%	100	100	100	100	100	100	0	0	100
	Tree and mature shrub (>5cm dbh) density	Vegetation contains a density of maturing tree and shrubs (>5cm dbh) species comparable to the local remnant vegetation	Total tree and mature shrub density	The total density of live trees and/or mature shrubs with a stem diameter > 5cm is comparable to that of the local remnant vegetation		No./area	21	19	8	8	21	9	0	0	9
			Density of eucalypts	The density of eucalypts with a stem diameter > 5cm is comparable to that of the local remnant vegetation		No./area	2	4	4	2	4	9	0	0	9
			Density of acacias	The density of acacias with a stem diameter > 5cm is comparable to the local remnant vegetation		No./area	0	0	0	0	0	0	0	0	0
			Density of other endemic species	The density of other endemic species with a stem diameter > 5cm is comparable to the local remnant vegetation		No./area	19	15	4	4	19	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2022		DReveg 1	DReveg 2	DReveg 3	DWood LQ
			Density of exotic / non endemic species	The density of exotic / non endemic species with a stem diameter > 5cm is comparable to the local remnant vegetation		<No./area	0	0	0	0	0	0	0	0	0
			Percentage of eucalypts	The percentage of eucalypts with a stem diameter > 5cm is comparable to the local remnant vegetation		% population	10	21	50	10	50	100	0	0	100
			Average dbh		Average tree diameter of the tree population provides a measure of age, (height) and growth rate and that it is trending towards the local remnant vegetation.	cm	12	18	24	12	24	10	0	0	23
	Ecosystem health	The vegetation is in a condition comparable to that of the local remnant vegetation.	Live trees	The percentage of the tree population which are live individuals and that the percentage is comparable to the local remnant vegetation		% population	33	58	80	33	80	100	0	0	100
			Healthy trees	The percentage of the tree population which are in healthy condition and that the percentage is comparable to the local remnant vegetation		% population	8	3	20	3	20	100	0	0	0
			Medium health		The percentage of the tree population which are in a medium health condition and that the percentage is comparable to the local remnant vegetation	% population	22	39	50	22	50	0	0	0	100
			Advanced dieback		The percentage of the tree population which are in a state of advanced dieback and that the percentage is comparable to the local remnant vegetation	<% population	3	15	10	3	15	0	0	0	0
			Dead Trees		The percentage of the tree population which are dead (stags) and that the percentage is comparable to the local remnant vegetation	% population	67	42	20	20	67	0	0	0	0
			Mistletoe		The percentage of the tree population which have mistletoe provides an indication of community health and habitat value and that the percentage is	% population	0	0	0	0	0	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2022		DReveg 1	DReveg 2	DReveg 3	DWood LQ
					comparable to the local remnant vegetation										
			Flowers/fruit : Trees	The percentage of the tree population with reproductive structures such as buds, flowers or fruit provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources comparable to that of the local remnant vegetation		% population	**13**	**12**	**70**	**12**	**70**	**11**	**0**	**0**	**78**
			Hollows: Trees		The percentage of the tree population which have hollows provides an indication of the habitat value and that the percentage is comparable to the local remnant vegetation	% population	**0**	**3**	**0**	**0**	**3**	**0**	**0**	**0**	**0**

10 Management considerations

10.1 Elevated soil results

Soils across the Kokoda Offset Area have always had particularly elevated levels of Iron, which were typically three times above or higher than the recommended agricultural guidelines of 22 mg/kg in medium clay loam soils, indicating it probably occurs in naturally high concentrations across the local area. Concentrations up to 360 mg/kg were recorded at DReveg1 this year.

10.2 Natural regeneration

Many native species were regenerating and spreading out from existing rocky outcrops situated throughout the open pasture areas (Figure 10-1). After the extensive tree planting during 2020 – 2021, many tubestock have grown and tree guards have been removed. Despite some mortalities and low densities being recorded in some of the monitoring locations it should be unnecessary to undertake replanting or infill planting. It will be important to allow the tubestock adequate space and take into consideration the requirement for open clearings for future regeneration requirements and to maintain a patchy open grassy woodland habitat.

Figure 10-1. Many native species were regenerating (left). Significant growth of existing tubestock seedlings (right)

10.3 Priority weeds

No priority weed species of the Central Tablelands LLS were recorded in the range of monitoring sites or were noted in abundance, however ongoing surveillance for weeds such as *Nassella trichotoma* (Serrated Tussock), *Rubus fruticosus* (Blackberry) and *Hypericum perforatum* (St John's Wort) should be carried out, as conditions have been most favourable over the past few years with extensive infestations being recorded across the region this year.

Most weeds observed across the Kokoda Offset Area were limited to common agricultural weeds associated with a long agricultural history and in the last few years have been quite abundant as a result of overgrazing during the drought.

10.4 Feral animals

NPM completed the construction of an exclusion fence around most of the boundary around the Kokoda property in 2020 and have and will continue to implement a series of pest control events. Previously there have been significant populations of wild goats and Eastern Grey Kangaroos which had been causing overgrazing throughout the property, particularly during the drought. As part of the VCA, NPM completed the construction of an exclusion fence around most of the boundary around the Kokoda property in 2020 and have and will continue to implement a series of pest control events. This year, no goats and only a small group of Eastern Grey Kangaroos were observed during the vegetation surveys. There was however evidence of feral pig damage near one of the monitoring sites (GBReveg4) with there being significant damage caused by the pigs foraging, digging and uprooting the vegetation.

10.5 Threatened fauna

Survey of fauna was not the focus of this study, however threatened fauna including Grey-crowned Babblers and Superb Parrot were frequently heard throughput the woodland remnants or flying over the open pastures.

10.6 Orchid observations

A map showing the locations of opportunistic sightings of orchids in 2015 and 2016 outside of the monitoring sites is provided in Figure 10-2 and Table 10-1. This year several of the known orchid populations *Calochilus robertsonii* (Purplish Beard Orchid) and *Caladenia aff. tentaculata* (Greencomb Spider Orchid) were again present, however some continue to be absent and presumed to have been destroyed. Others such as *Prasophyllum campestre* (Inland Leek Orchid) and *Diuris goonooensis* (Western Donkey Orchid) have not been observed in the WBWood1 monitoring site since 2016, possibly due to increasing competition. While orchid sightings have not been formally undertaken, some species were observed in greater numbers and nine different orchid species were recorded in the monitoring sites this year, with several others as opportunistic sightings (Appendix 2).

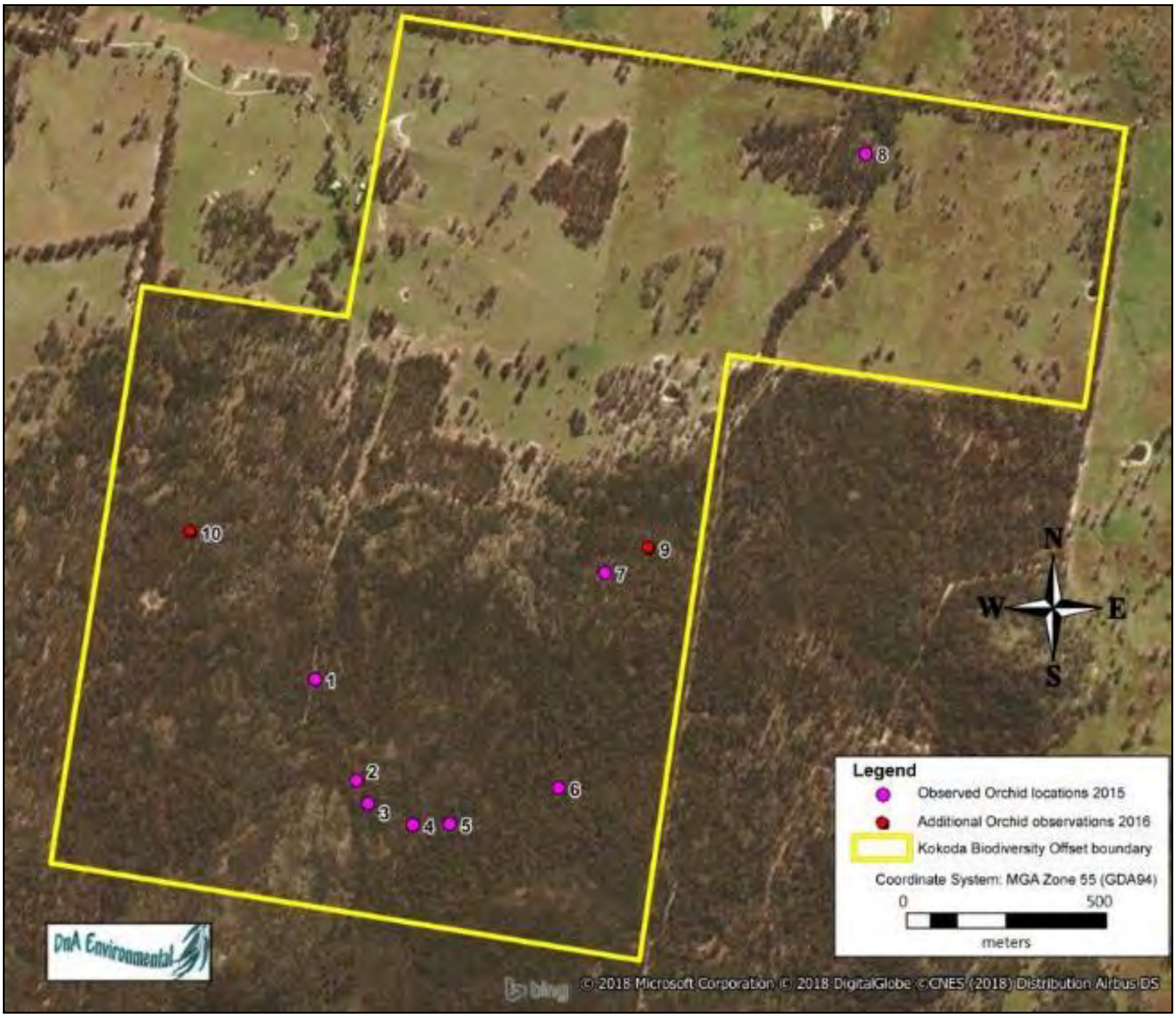

Figure 10-2. A map showing the approximate locations of orchid species sighted around the Kokoda property in 2015 - 2016.

Table 10-1. Approximate coordinates and orchid species observed at Kokoda in 2015, 2016 and 2020 – 2022 outside of the monitoring locations.

Location	Easting	Northing	Orchid Species
1	55 635441	6317088	*Caladenia aff. tentaculata* (Greencomb Spider Orchid)
2	55 635541	6316835	*Caladenia aff. tentaculata* (Greencomb Spider Orchid), *Glossodia major* (Wax-lip Orchid), *Diuris goonooensis* (Western Donkey Orchid); Figure 10-3
3	55 635568	6316778	*Caladenia aff. tentaculata* (Greencomb Spider Orchid), *Diuris goonooensis* (Western Donkey Orchid)
4	55 635679	6316724	*Glossodia major* (Wax-lip Orchid); Figure 10-4
5	55 635771	6316725	*Glossodia major* (Wax-lip Orchid)
6	55 636043	6316811	*Thelymitra spp*., *Glossodia major* (Wax-lip Orchid); *Caladenia gracilis* (Musky Caladenia)
7	55 636166	6317342	*Caladenia aff. tentaculata* (Greencomb Spider Orchid)
8	55 636830	6318372	*Prasophyllum campestre* (Inland Leek Orchid), *Caladenia carnea* (Pink Fingers), *Diuris goonooensis* (Western Donkey Orchid), *Pterostylis nana* (Dwarf Greenhood), *Caladenia aff. tentaculata* (Greencomb Spider Orchid)
9	55 636276	6317402	*Calochilus robertsonii* (Purplish Beard Orchid)
10	55 635136	6317457	*Calochilus robertsonii* (Purplish Beard Orchid), *Caladenia gracilis* (Musky Caladenia), *Thelymitra spp.*

Figure 10-3. *Calochilus robertsonii* (Purplish Beard Orchid) and *Caladenia aff. tentaculata* (Greencomb Spider Orchid).

Figure 10-4. *Glossodia major* (Wax-lip Orchid) and *Caladenia carnea* (Pink Fingers).

10.7 Other wildflower observations

Myriocephalus rhizocephalus (Woolly Heads; Figure 10-5), a small annual daisy was found on the edge of the main access track at the entrance into Kokoda in 2020 and is probably at the most eastern range of its known distribution. It is known to grow in moister areas in mallee and on sandy and clay soils; west from West Wyalong (https://plantnet.rbgsyd.nsw.gov.au/cgi-bin/NSWfl.pl?page=nswfl&lvl=sp&name=Myriocephalus~rhizocephalus).

Utricularia dichotoma (Fairy Aprons), previously mistaken as *Mimulus gracilis* (Slender Monkey-flower) and the introduced species, *Linaria pelisseriana* (Pelisser's Toadflax), were common in damp depressions / moist springs across the Kokoda property (Figure 10-6) but were not necessarily recorded in the monitoring sites. *Thysanotus patersonii* (Twining Fringe Lily) and *Drosera glanduligera* (Scarlet Sundew) were common in numerous monitoring sites (Figure 10-7). *Solanum aviculare* (Kangaroo Apple) and *Microseris lanceolata* (Yam Daisy) were also found in various locations (Figure 10-8).

Figure 10-5. *Myriocephalus rhizocephalus* (Woolly Heads) was observed in 2020.


Figure 10-6. *Utricularia dichotoma* (Fairy Aprons) and *Linaria pelisseriana* (Pelisser's Toadflax) were common on the moist depressions or springs across the Kokoda Offset Area.


Figure 10-7. *Thysanotus patersonii* (Twining Fringe Lily) and *Drosera glanduligera* (Scarlet Sundew).


Figure 10-8. *Solanum aviculare* (Kangaroo Apple) and *Microseris lanceolata* (Yam Daisy).

10.8 Site access

The upgraded access tracks around and throughout the steeper areas of bushland had suffered from erosion, with severe rilling continuing in numerous areas including one of the main drainage lines and adjacent to the firebreak on the south eastern boundary. In addition, numerous springs and waterholes made traversing the property difficult after the record-breaking rainfall over the last two years. Many springs were running, with water laying on top of the soil surface across significant areas, including on top of the rocky range in the *E. dwyeri – E. sideroxylon* communities and in ripped planting lines (Figure 10-9). In addition, high Callitris mortalities have occurred as a result of the drought, with many access tracks and/or fences having the potential to be obstructed or requiring repair as dead stags are likely to continue to fall over during high wind events.

Figure 10-9. Many springs were running, with water laying on top of the soil surface in numerous areas including on top of the rocky range (left) and in ripped planting lines (right).

11 Annexure D Voluntary Conservation Agreement

Comparison of Kokoda monitoring sites results against Benchmark data for each Biometric Vegetation Type/ Plant Community Type, October 2022 (Table 11-1, Table 11-2, Table 11-3) as per the Voluntary Conservation Agreement 2018. Please note that due to some errors in the Conservation Agreement, some corrections to the following tables have been applied, as described in Section 5.1 of this report. Field data sheets and photo-points associated with the individual sites are provided in Appendix 5.

Table 11-1. Comparison of Kokoda monitoring sites results against Benchmark data for LA151.

LA151 - Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion										
		NPSR	**NOS**	**NMS**	**NGCG**	**NGCS**	**NGCO**	**EPC**	**Logs (m)**	**Hollows**
Benchmark	**min**	**30**	**8**	**3**	**3**	**3**	**3**		**46**	**2**
	max		**35**	**35**	**25**	**25**	**20**			
GBReveg1		18	0	0	34.5	0	1.1	40.5	0	0
GBReveg2		24	0	0	1.1	0	38	47.5	0	0
GBReveg3		25	0	0	35	0.7	21.5	37.5	0	0
GBReveg4		27	0	0	7	0.25	3	67.5	0	0
GBReveg5		20	0	0	10	0.1	6	52.5	0	1
GBWood1		29	20.25	0	10.25	0.25	9.75	9.25	114.5	12
GBWood2		43	20.25	0.25	5.75	6.1	16.25	9.5	47	0
GBWood3		38	23.25	0.25	30	0.35	17.5	4.25	168.5	2
Average		**28.0**	**8.0**	**0.1**	**16.7**	**1.0**	**14.1**	**33.6**	**41.25**	**1.875**

Table 11-2. Comparison of Kokoda monitoring sites results against Benchmark data for LA165.

LA165 - Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion										
		NPSR	**NOS**	**NMS**	**NGCG**	**NGCS**	**NGCO**	**EPC**	**Logs (m)**	**Hollows**
Benchmark	**min**	**30**	**8**	**3**	**3**	**3**	**3**		**46**	**2**
	max		**35**	**35**	**25**	**25**	**20**			
DReveg1		17	6.5	0	28.25	0.25	25.25	20.75	0	0
DReveg2		39	0	0	26.25	0.55	9	4.25	4	0
DReveg3		19	0	0	5.5	0.1	6.25	58	0	0
DWood1		36	12.5	1.25	6.75	0.4	35	0.5	341.5	4
DWood2		43	26	0	2	10	26	9.5	262	3
DWood3		43	16	0.5	5	19.5	29.25	0.7	73	0
DWoodLQ		34	15.5	0	0.4	0.7	37	22.5	17.5	0
IronWood1		43	21.5	2	17.5	4.75	25	0.7	111.5	1
Average		**34.3**	**12.3**	**0.5**	**11.5**	**4.5**	**24.1**	**14.6**	**101.2**	**1.0**

Table 11-3. Comparison of Kokoda monitoring sites results against Benchmark data for LA218.

LA218 - White Box - White Cypress Pine - Western Grey Box shrub/grass/forb woodland in the NSW South Western Slopes Bioregion										
		NPSR	**NOS**	**NMS**	**NGCG**	**NGCS**	**NGCO**	**EPC**	**Logs (m)**	**Hollows**
Benchmark	**min**	**23**	**8**	**1**	**15**	**3**	**3**		**66**	**0.8**
	max		**35**	**20**	**70**	**5**	**20**			
WBWood1		55	21.25	0	20.5	0.45	20.25	12.5	68	2
Average		**55.0**	**21.3**	**0.0**	**20.5**	**0.5**	**20.3**	**12.5**	**68.0**	**2.0**

12 Discussion

The extreme seasonal conditions experienced over the past few years combined with simultaneous changes in total grazing pressure has had a significant impact on the composition and diversity of the vegetation at Kokoda, with these being reflected in the range of ecological monitoring data.

In the remnant woodland sites, there has been a decline in tree health and increasing numbers of stags in most sites since 2020 as a result of prolonged drought. This has been more pronounced in the Dwyer's Red Gum woodlands on top of the rocky range, however this has opened up the canopy and has resulted in the regeneration of a range of native species since 2020 which were previously supressed by the dense Callitris regrowth. Many naturally regenerating tree and shrub seedlings have also been observed around the property and within monitoring sites as a result of the improved seasonal conditions, in combination with the reduction in ground cover and weed competition after the drought and feral animals as a result of the exclusion fencing and targeted control programs.

The revegetation activities in the derived grassland areas as described in the BOMP and VCA have been undertaken during spring in 2020, with additional planting (and re-planting) undertaken during 2021. Despite the planting activities, the derived grassland revegetation sites presently did not meet many completion targets related to diversity and density of juvenile tree and shrub species, largely due to the simultaneous increase in seedlings in their respective reference sites. Other primary ecological attributes which fell short of meeting completion performance targets tended to be associated with the limited structural complexity and population condition associated with mature woodlands, which would be expected to develop over time.

The derived grassland revegetation sites tended to be dominated by exotic annual species and were weedier than desired, however these are likely to decline in the medium to longer-term as perennial plants including trees and shrubs become more abundant. In addition, most exotic species observed were limited to common annual agricultural grasses and weeds which are associated with the long agricultural history and many are naturalised components of the local pastures. Strategic livestock grazing may be required in the longer-term to manipulate the herbaceous understorey and to maintain biodiversity, encourage tree and shrub regeneration and to reduce fuel loads as part of the integrated and adaptive management strategy for the Kokoda Offset Area.

Previously there have been significant populations of wild goats and Eastern Grey Kangaroos which had been causing overgrazing throughout the property, particularly during the drought. As part of the VCA, NPM completed the construction of an exclusion fence around most of the boundary around the Kokoda property in 2020 and have and will continue to implement a series of pest control events. This year, no goats and only small numbers of Eastern Grey Kangaroos were observed during the vegetation surveys. There was however evidence of feral pig damage near one of the monitoring sites. Extensive disturbance and herbivory by macropods, goats (and pigs?) have and will require ongoing management.

No priority weed species of the Central Tablelands LLS were recorded in the range of monitoring sites or were noted in abundance, however ongoing surveillance for weeds such as *Nassella trichotoma* (Serrated Tussock), *Rubus fruticosus* (Blackberry) and *Hypericum perforatum* (St John's Wort) should be carried out, as conditions have been most favourable over the past few years with extensive infestations being recorded across the region this year.

In 2015 and 2016 several species of terrestrial ground orchids were observed at various locations around the property. As part of the management of the Kokoda property, the location of these populations should be considered when undertaking revegetation, weed control, track upgrades and strategic grazing. None of these orchid populations were observed during the drought only a few of these orchid species were sighted again in 2021 – 2021 but they occurred in lower diversity and densities. In addition, those previously recorded along some of the access tracks in the bushland areas were not observed at all, possibly due to the widening of the access tracks. While orchid sightings have not been formally undertaken, some species were observed in greater numbers and nine different orchid species were recorded in the monitoring sites this year, along with several others as opportunistic sightings.

Other potential management issues may be related to high density *E. dwyeri* and *Callitris endlicheri* regeneration which may adversely affect floristic and biodiversity targets in the medium to longer term. Declining ground cover and increasing erosion may also occur, particularly as pests and feral animals cause increased disturbances and tracks as they seek shade and shelter within the developing wooded areas. Regular inspection will dictate the need for further management of these regrowth areas.

Safe and easy access should always be maintained around main access tracks and boundary fences to facilitate monitoring, weed control, property maintenance and bushfire management. Regular inspections should be undertaken with slashing and/or strategic grazing management implemented on an as needed basis. In addition, high Callitris mortalities have occurred as a result of the drought, with many access tracks and/or fences having the potential to be obstructed or requiring repair as dead stags are likely to continue to fall over during high wind events. Fallen trees require removal and some parts of the tracks require amelioration where erosion has become severe.

13 Conclusion

The results of the monitoring program have indicated that the improved seasonal conditions combined with a reduction in feral animal disturbance has resulted in an improvement in ecological function and floristic diversity in the range of monitoring sites, especially since the drought during 2017 - 2019. Improved management and the implementation of the revegetation program during 2020 – 2021 are also likely to increase the area of the various woodland communities occurring at the Kokoda Offset area, thus increasing the capacity of the existing derived grasslands to meet a wider range of woodland habitat performance indicators the medium to longer-term. Although there have been some mortalities and low densities being recorded in some of the monitoring locations it should be unnecessary to undertake replanting or infill planting. It will be important to allow the tubestock adequate space and take into consideration the requirement for open clearings for future regeneration requirements and to maintain a patchy open grassy woodland habitat.

Since 2020, many native species have also been regenerating and spreading out from existing rocky outcrops situated throughout the open pasture areas and after the extensive tree planting during 2020 – 2021, many tubestock have grown and tree guards have been removed. Species composition and diversity are also strongly correlated with seasonal conditions and disturbance history and in many situations and with sympathetic management, many ecological targets are likely to be met without further intervention in the medium to longer-term.

Despite shortfalls in meeting numerous ecological performance indicators, completion criteria targets also need to consider that their respective reference sites and therefore revegetation targets, have been obtained from regrowth woodlands that have also been subjected to a long agricultural and disturbance history. For example, higher stem densities do not necessarily translate into sustainable (grassy) woodland communities and the rigid use of some performance indicators may need to be revised.

Regular and ongoing monitoring of the performance of the revegetation program and other ongoing management activities will also assist with the implementation of future management strategies that may be required to complete long-term targets of the BOMP and VCA.

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Appendix 1._GPS co-ordinates, aspects and slopes of the offset monitoring sites (GDA94).

Site Reference	LFA/Veg transect Start	LFA/Veg transect Finish	Slope (°)	Bearing (°)	Right bottom marker peg	Right top marker peg
GBReveg1	55635984 6318463	55635965 6318468	5	270 W	55635991 6318478	55635971 6318484
GBReveg2	55636009 6317740	55635990 6317742	4	269 W	55636017 6317758	55635996 6317761
GBReveg3	55636556 6318096	55636575 6318102	3	53 NE	55636563 6318075	55636582 6318083
GBReveg4	55636934 6318008	55636912 6318012	4	270 W	55636939 6318026	55636919 6318031
GBReveg5	55637056 6318287	55637041 6318301	3	303 NW	55637070 6318307	55637057 6318314
WBWood1	55636830 6318372	55636817 6318388	3	325 NW	55636845 6318378	55636836 6318396
IronWood1	55635137 6317458	55635133 6317479	4	337 NW	55635156 6317464	55635147 6317481
GBWood1	55636102 6318312	55636087 6318322	2	273 W	55636111 6318331	55636097 6318337
GBWood2	55635682 6317695	55635668 6317708	3	318 NW	55635696 6317700	55635685 6317714
GBWood3	55635075 6318036	55635090 6318037	1	90 E	55635071 6318019	55635086 6318075
DReveg1	55636561 6318557	55636576 6318552	4	98 E	55636551 6318539	55636571 6318533
DReveg2	55636612 6318473	55636632 6318469	3	90 E	55636610 6318453	55636631 6318447
DReveg3	55637301 6318051	55637319 6318049	4	93 E	55637296 6318031	55637316 6318029
DWoodLQ	55636185 6317769	55636200 6317769	3	82 E	55636179 6317749	55636198 6317751
*DWood1	*55635679 6316724	*55635661 6316733	4	290 NW	*55635668 6316707	*55635652 6316715
DWood2	55636043 6316811	55636059 6316804	3	95 E	55636035 6316793	55636050 6316788
DWood3	55636166 6317342	55636176 6317357	3	27 NE	55636175 6317329	55636186 6317344

*NB: Transect along right edge, site flips to the left.

Appendix 2. List of flora species recorded in the Kokoda monitoring sites in 2022

Note: “1” denotes the presence of that species and is not a measure of cover abundance
Key to habit legend: t = tree; s = shrub; ss =sub-shrub; h = herb; g = grass, r = reed; v = vine; f = fern; p = parasite

Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Adiantaceae		*Cheilanthes sieberi*	Rock Fern	f		1	1		1	1	1	1	1	1	1	1	1		1	1	1
Anthericaceae		*Laxmannia gracilis*	Slender Wire Lily	h	1									1		1			1		
Apiaceae		*Daucus glochidiatus*	Australian Carrot	h	1	1	1	1				1	1	1		1	1		1	1	1
Araliaceae		*Hydrocotyle laxiflora*	Stinking Pennywort	h		1	1						1	1	1	1	1				1
Asparagaceae		*Arthropodium minus*	Small Vanilla Lily	h	1	1	1		1				1		1	1					
Asparagaceae		*Arthropodium strictum*	Chocolate Lily	h		1															
Asparagaceae		*Thysanotus patersonii*	Twining Fringe Lily	h		1							1	1	1		1				
Asphodelaceae		*Bulbine bulbosa*	Bulbine Lily	h									1								
Asphodelaceae		*Bulbine semibarbata*	Leek Lily	h	1	1															
Asphodelaceae		*Tricoryne elatior*	Yellow Autumn-lily	h									1			1	1		1		
Asteraceae	*	*Arctotheca calendula*	Capeweed	h		1	1			1										1	1
Asteraceae		*Calotis cuneifolia*	Purple Burr Daisy	h											1						
Asteraceae		*Calotis hispidula*	Bogan Flea	h	1																
Asteraceae		*Calotis lappulacea*	Yellow Burr Daisy	h	1	1	1	1	1	1	1	1	1				1		1		1
Asteraceae	*	*Carduus tenuiflorus*	Winged Slender Thistle	h									1								
Asteraceae	*	*Carthamus lanatus*	Saffron Thistle	h						1		1									
Asteraceae		*Cassinia laevis*	Cough Bush	s	1	1	1							1	1	1			1		
Asteraceae		*Cassinia sifton [arcuata]*	Sifton Bush	s			1												1		
Asteraceae	*	*Chondrilla juncea*	Skeleton Weed	h				1											1	1	

Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Asteraceae		*Chrysocephalum apiculatum*	Common Everlasting	h	1																
Asteraceae	*	*Cirsium vulgare*	Spear Thistle	h	1		1						1								
Asteraceae	*	*Conyza bonariensis*	Fleabane	h	1		1	1		1	1	1	1	1		1				1	
Asteraceae		*Cotula australis*	Common Cotula	h			1														
Asteraceae	*	*Cotula bipinnata*	Ferny Cotula	h	1																1
Asteraceae		*Cymbonotus lawsonianus*	Bear's Ear	h			1						1								
Asteraceae		*Euchiton sphaericus*	Japanese Cudweed	h	1	1	1						1	1		1	1		1		1
Asteraceae	*	*Gamochaeta americana*	Cudweed	h	1																
Asteraceae	*	*Hypochaeris glabra*	Smooth Catsear	h	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Asteraceae	*	*Hypochaeris radicata*	Flatweed	h	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1
Asteraceae	*	*Lactuca serriola*	Prickly Lettuce	h	1	1	1	1	1			1	1								
Asteraceae		*Microseris lanceolata*	Yam Daisy	h											1	1					
Asteraceae		*Ozothamnus diosmifolius*	Pill Flower	s									1								
Asteraceae		*Podolepis jaceoides*	Showy Copper-wire Daisy	h											1						
Asteraceae		*Pseudognaphalium luteoalbum*	Jersey Cudweed	h						1						1					1
Asteraceae		*Senecio lautus*	Fireweed	h										1							
Asteraceae		*Senecio prenanthoides*		h			1														
Asteraceae		*Senecio quadridentatus*	Cotton Fireweed	h		1	1						1							1	
Asteraceae		*Solenogyne bellioides*		h									1								
Asteraceae	*	*Soliva anthemifolia*	Dwarf Jo-Jo	h																1	1
Asteraceae	*	*Sonchus asper*	Prickly Sowthistle	h			1														
Asteraceae	*	*Sonchus oleraceus*	Milk Thistle	h	1	1	1			1		1	1	1		1	1				1
Asteraceae		*Stuartina muelleri*	Spoon Cudweed	h	1	1	1		1				1	1	1	1			1		1

Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Asteraceae	*	*Tolpis umbellata*	Yellow Hawkweed	h	1			1	1	1	1	1							1		1
Asteraceae		*Triptilodiscus pygmaeus*	Austral Sunray	h					1	1	1	1					1	1	1		
Asteraceae		*Vittadinia cuneata*	Fuzzweed	h	1	1	1		1	1	1								1		
Asteraceae		*Vittadinia gracilis*	A Fuzzweed	h	1	1	1	1	1			1									
Asteraceae		*Xerochrysum bracteatum*	Golden Everlasting	h	1	1	1	1				1	1	1	1	1	1	1	1	1	1
Boraginaceae	*	*Echium plantagineum*	Paterson's Curse	h				1			1	1							1	1	
Brassicaceae	*	*Capsella bursa-pastoris*	Shepherd's Purse	h	1																
Brassicaceae	*	*Lepidium bonariense*	Peppercress	h	1																
Brunoniaceae		*Brunonia australis*	Blue Pincushion	h											1						
Campanulaceae		*Wahlenbergia communis*	Tufted Bluebell	h	1		1		1	1		1	1			1	1		1	1	1
Campanulaceae		*Wahlenbergia gracilenta*	Annual Bluebell	h					1					1	1			1		1	
Campanulaceae		*Wahlenbergia gracilis*	Sprawling Bluebell	h						1			1			1					
Campanulaceae		*Wahlenbergia stricta*	Tall Bluebell	h											1	1	1				
Campanulaceae		*Wahlenbergia stricta subsp. alterna*	Tall Bluebell	h							1										
Caryophyllaceae	*	*Cerastium glomeratum*	Mouse-ear Chickweed	h	1		1		1				1							1	1
Caryophyllaceae	*	*Moenchia erecta*	Erect Chickweed	h		1												1		1	1
Caryophyllaceae	*	*Petrorhagia nanteuilii*	Proliferous Pink	h		1		1		1	1	1	1					1	1	1	
Caryophyllaceae	*	*Petrorhagia velutina*	Velvet Pink	h																1	
Caryophyllaceae	*	*Polycarpon tetraphyllum*	Four-leaved Allseed	h																	1
Caryophyllaceae	*	*Silene gallica*	French Catchfly	h			1	1													
Caryophyllaceae	*	*Spergularia rubra*	Sandspurry	h					1												
Caryophyllaceae	*	*Stellaria media*	Chickweed	h	1		1														

Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Casuarinaceae		*Allocasuarina verticillata*	Drooping Sheoak	t							1				1	1	1			1	
Centrolepidaceae		*Centrolepis strigosa*	Hairy Centrolepis	h																	1
Chenopodiaceae		*Einadia nutans*	Climbing Saltbush	h	1		1														
Colchicaceae		*Wurmbea dioica*	Early Nancy	h					1		1					1	1			1	1
Convolvulaceae		*Dichondra repens*	Kidney Weed	h		1											1				
Crassulaceae		*Crassula colorata*	Dense Stonecrop	h															1		
Crassulaceae		*Crassula decumbens*	Spreading Stonecrop	h	1	1	1														1
Crassulaceae		*Crassula sieberiana*	Austral Stonecrop	h	1																
Cupressaceae		*Callitris endlicheri*	Black Cypress Pine	t		1	1	1					1	1	1	1	1				
Cyperaceae	*	*Cyperus sp.*	A sedge	r						1											
Cyperaceae		*Isolepis congrua*	Slender Club-sedge	r		1				1							1	1		1	1
Cyperaceae		*Lepidosperma laterale*	Broad Sword-sedge	r											1						
Cyperaceae		*Schoenus apogon*	Common Bog Rush	r		1			1	1	1	1	1	1	1	1	1	1	1	1	1
Dilleniaceae		*Hibbertia obtusifolia*	Hoary Guinea Flower	ss									1								
Dilleniaceae		*Hibbertia riparia*	Silky Guinea Flower	ss		1							1	1		1					
Droseraceae		*Drosera glanduligera*	Scarlet Sundew	h													1		1		1
Droseraceae		*Drosera peltata*	Pale Sundew	h					1	1	1		1	1		1	1	1	1	1	1
Epacridaceae		*Astroloma humifusum*	Native Cranberry	ss										1	1	1	1				
Epacridaceae		*Brachyloma daphnoides*	Daphne Heath	s		1							1	1	1	1	1				
Epacridaceae		*Lissanthe strigosa*	Peach Heath	ss									1	1		1	1				
Euphorbiaceae		*Phyllanthus hirtellus*	Thyme Spurge	ss												1					
Euphorbiaceae		*Poranthera microphylla*	Small Poranthera	h		1	1						1		1		1				

Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Fabaceae (Faboideae)		*Bossiaea buxifolia*	Box-leaved Bitter-pea	s										1			1				
Fabaceae (Faboideae)		*Dillwynia sericea*	Parrot-Pea	s												1			1		
Fabaceae (Faboideae)		*Glycine clandestina*	Climbing Glycine	h									1								
Fabaceae (Faboideae)		*Glycine tabacina*	Variable Glycine	h								1									
Fabaceae (Faboideae)		*Indigofera adesmiifolia*	Native Indigo	s									1								
Fabaceae (Faboideae)		*Pultenaea sp.*	Bush-pea	s															1		
Fabaceae (Faboideae)	*	*Trifolium angustifolium*	Narrow-leaf Clover	h								1									
Fabaceae (Faboideae)	*	*Trifolium arvense*	Haresfoot Clover	h		1		1		1	1	1	1					1	1		1
Fabaceae (Faboideae)	*	*Trifolium campestre*	Hop Clover	h		1		1		1	1	1	1						1	1	
Fabaceae (Faboideae)	*	*Trifolium dubium*	Yellow Suckling Clover	h	1			1		1	1	1	1					1	1	1	
Fabaceae (Faboideae)	*	*Trifolium glomeratum*	Clustered Clover	h			1	1		1	1	1	1							1	
Fabaceae (Faboideae)	*	*Trifolium sp.*	A Clover	h	1																1
Fabaceae (Faboideae)	*	*Trifolium subterraneum*	Subterraneum Clover	h		1		1	1	1	1	1	1					1		1	1
Fabaceae (Mimosoideae)		*Acacia decora*	Western Golden Wattle	s						1	1		1					1	1		
Fabaceae (Mimosoideae)		*Acacia doratoxylon*	Spearwood	s											1	1					
Fabaceae (Mimosoideae)		*Acacia implexa*	Hickory	s		1	1			1			1	1					1		1

Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Fabaceae (Mimosoideae)		*Acacia lanigera*	Woolly Wattle	s																	1
Fabaceae (Mimosoideae)		*Acacia paradoxa*	Kangaroo Thorn	s		1													1		
Fabaceae (Mimosoideae)		*Acacia spectabilis*	Mudgee Wattle	s						1	1										
Gentianaceae	*	*Cicendia quadrangularis*		h															1	1	1
Gentianaceae		*Sebaea ovata*	Yellow Centaury	h				1			1		1						1		
Geraniaceae	*	*Erodium cicutarium*	Common Crowsfoot	h				1	1												
Geraniaceae		*Geranium solanderi*	Native Geranium	h									1								
Goodeniaceae		*Goodenia hederacea*	Forest Goodenia	h										1	1	1			1		
Haloragaceae		*Gonocarpus elatus*	Hill Raspwort	h		1	1				1	1	1	1	1	1	1		1		1
Haloragaceae		*Gonocarpus tetragynus*	Raspwort	h									1	1			1				
Haloragaceae		*Haloragis heterophylla*	Rough Raspwort	h		1		1	1	1	1	1	1	1		1	1	1	1	1	1
Hypericaceae		*Hypericum gramineum*	Small St. John's Wort	h		1		1	1	1	1		1	1	1	1	1	1	1	1	1
Hypoxidaceae		*Hypoxis spp.*		h																	1
Iridaceae	*	*Romulea rosea*	Onion Grass	h																1	
Iridaceae	*	*Sisyrinchium rosulatum*	Scourweed	h																1	
Juncaceae		*Juncus aridicola*	Tussock Rush	r																	1
Juncaceae		*Juncus bufonius*	Toad Rush	r			1											1			
Juncaceae	*	*Juncus capitatus*	Capitate Rush	r						1			1				1		1		1
Juncaceae		*Juncus remotiflorus*	A rush	r													1	1			1
Juncaceae		*Juncus usitatus*	A Rush	r		1	1		1	1									1		
Juncaceae		*Luzula flaccida*		r									1								
Lamiaceae		*Ajuga australis*	Australian Bugle	h									1								

Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Lamiaceae	*	*Marrubium vulgare*	Horehound	h			1														
Lamiaceae	*	*Salvia verbenaca*	Wild Sage	h				1													
Lobeliaceae		*Isotoma axillaris*	Showy Isotome	h			1														
Lomandraceae		*Lomandra multiflora*	Many-flowered Mat-rush	h	1																
Myrtaceae		*Calytrix tetragona*	Common Fringe Myrtle	s												1	1				
Myrtaceae		*Eucalyptus albens*	White Box	t									1	1			1				1
Myrtaceae		*Eucalyptus blakelyi*	Blakely's Red Gum	t									1								
Myrtaceae		*Eucalyptus dealbata*	Tumbledown Gum	t										1	1	1	1				
Myrtaceae		*Eucalyptus dwyeri*	Dwyer's Red Gum	t							1	1						1	1		1
Myrtaceae		*Eucalyptus microcarpa*	Grey Box	t	1	1	1			1	1										
Myrtaceae		*Eucalyptus sideroxylon*	Mugga Ironbark	t		1	1			1				1		1					
Onagraceae		*Epilobium billardierianum*	Willow Herb	h	1																
Ophioglossaceae		*Ophioglossum lusitanicum*	Adders Tongue	h															1		
Orchidaceae		*Caladenia aff. tentaculata*	Greencomb Spider Orchid	h									1			1	1				
Orchidaceae		*Caladenia carnea*	Pink Fingers	h										1		1					
Orchidaceae		*Caladenia gracilis*	Musky Caladenia	h										1							
Orchidaceae		*Calochilus robertsonii*	Brown-bearded Orchid, Pale Beard Orchid	h										1			1				
Orchidaceae		*Glossodia major*	Wax-lip Orchid	h										1							
Orchidaceae		*Microtis unifolia*	Common Onion Orchid	h				1	1	1	1	1	1	1	1		1	1	1	1	
Orchidaceae		*Pterostylis bicolor*	Bicolor Greenhood	h				1	1										1		
Orchidaceae		*Pterostylis nana*	Dwarf Greenhood	h											1	1					
Orchidaceae		*Thelymitra sp.*	Sun Orchid	h							1					1					

Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Orobanchaceae	*	*Orobanche minor*	Broomrape	h			1						1								
Orobanchaceae	*	*Parentucellia latifolia*	Red Bartsia	h	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1
Oxalidaceae		*Oxalis perennans*	Yellow Wood-sorrel	h	1		1	1		1					1						
Phormiaceae		*Dianella longifolia*	Blueberry Lily	h									1								
Phormiaceae		*Dianella sp.*	Flax Lilly	h							1										
Phormiaceae		*Stypandra glauca*	Nodding Blue Lily	h										1	1	1	1				1
Plantaginaceae	*	*Linaria pelisseriana*	Pelisser's Toadflax	h				1	1		1	1	1						1	1	1
Plantaginaceae		*Plantago varia*	Variable Plantain	h											1						
Plantaginaceae		*Veronica plebeia*	Trailing Speedwell	h			1									1					
Poaceae	*	*Aira cupaniana*	Silvery Hairgrass	g	1	1		1	1	1	1	1	1		1	1	1	1	1	1	1
Poaceae		*Anthosachne [Elymus] scabra*	Common Wheatgrass	g							1	1									
Poaceae		*Aristida ramosa*	Threeawn Grass	g		1		1	1	1	1	1	1	1			1	1	1		1
Poaceae		*Austrostipa scabra*	Speargrass	g	1	1	1	1	1		1		1	1	1		1		1		
Poaceae		*Bothriochloa macra*	Red-leg Grass	g	1	1		1		1	1	1	1					1	1	1	1
Poaceae		*Bothriochloa sp.*	Redgrass	g												1					
Poaceae	*	*Briza maxima*	Quaking Grass	g												1					
Poaceae	*	*Briza minor*	Shivery Grass	g	1	1		1	1	1	1	1	1		1	1	1	1	1	1	1
Poaceae	*	*Bromus hordeaceus*	Soft Brome	g				1		1	1	1						1			
Poaceae	*	*Bromus molliformis*	Soft Brome	g																1	
Poaceae	*	*Bromus rubens*	Red Brome	g								1									
Poaceae	*	*Catapodium rigidum*	Rigid Fescue	g	1																
Poaceae		*Dichelachne micrantha*	Shorthair Plumegrass	g		1							1	1	1						
Poaceae		*Echinopogon ovatus*	Forest Hedgehog Grass	g		1							1	1							

Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Poaceae		*Eragrostis brownii*	Brown's Lovegrass	g					1										1	1	
Poaceae	*	*Hordeum leporinum*	Barley Grass	g	1								1								
Poaceae	*	*Lolium rigidum*	Wimmera Ryegrass	g	1	1							1					1			
Poaceae		*Microlaena stipoides*	Weeping Rice-grass	g	1	1	1						1				1				1
Poaceae		*Panicum sp.*	A Panic	g															1		
Poaceae		*Paspalidium sp.*		g										1	1						
Poaceae	*	*Poa bulbosa*	Bulbous Poa	g					1												1
Poaceae		*Rytidosperma erianthum*	Hill Wallaby Grass	g		1	1		1										1		
Poaceae		*Rytidosperma fulvum*	Wallaby Grass	g							1		1	1	1	1	1				1
Poaceae		*Rytidosperma racemosum*	Wallaby Grass	g	1		1	1						1						1	
Poaceae		*Sporobolus creber*	Western Rat's-tail Grass	g				1	1	1	1	1								1	
Poaceae	*	*Vulpia muralis*	Rats-tail Fescue	g	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Polygonaceae	*	*Rumex acetosella*	Sheep Sorrel	h							1							1		1	
Polygonaceae		*Rumex brownii*	Swamp Dock	h	1	1	1	1	1			1	1					1			1
Primulaceae	*	*Lysimachia [Anagallis] arvensis*	Scarlet Pimpernel	h	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1
Ranunculaceae		*Ranunculus sessiliflorus var. sessiliflorus*	Small-flowered Buttercup	h	1	1	1						1		1	1	1				1
Rubiaceae		*Galium gaudichaudii*	Rough Bedstraw	h	1	1		1	1	1		1	1				1			1	
Rubiaceae		*Opercularia sp.*	Stinkweed	h		1															
Rubiaceae		*Pomax umbellata*	Pomax	h											1						
Santalaceae		*Exocarpos cupressiformis*	Native Cherry	s										1							
Sapindaceae		*Dodonaea viscosa subsp. angustifolia*	Giant Hopbush	s						1											
Sapindaceae		*Dodonaea viscosa subsp. angustissima*	Narrow-leaf Hopbush	s							1										

Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Sapindaceae		*Dodonaea viscosa subsp. cuneata*	Wedge-leaf Hopbush	s									1						1		
Scrophulariaceae		*Limosella australis*		h													1	1			1
Scrophulariaceae	*	*Verbascum virgatum*	Twiggy Mullein	h			1	1				1									
Solanaceae		*Solanum aviculare*	Kangaroo Apple	s	1		1														
Solanaceae	*	*Solanum nigrum*	Blackberry Nightshade	h	1		1														1
Stackhousiaceae		*Stackhousia monogyna*	Creamy Candles	h								1	1								
Sterculiaceae		*Brachychiton populneus*	Kurrajong	t		1	1						1	1							

Appendix 3. ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT: Grey Box Woodland Sites Kokoda Offset Area 2021

Soil samples supplied by DnA Environmental on 31/10/2022 - Lab Job No. N4133

		Site	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	GBWood1	GBWood2	GBWood3	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
Parameter		Method reference	N4133/4	N4133/5	N4133/6	N4133/7	N4133/8	N4133/15	N4133/16	N4133/12	N4133/13	N4133/14	Indicative guidelines - refer to Notes 6 and 8			
Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	495	285	469	241	377	924	176	520	185	411	*1150*	*750*	*375*	*175*
Soluble Magnesium (mg/kg)			63	80	102	84	92	162	50	204	94	206	*160*	*105*	*60*	*25*
Soluble Potassium (mg/kg)			86	85	83	87	105	115	67	132	72	119	*113*	*75*	*60*	*50*
Soluble Phosphorus (mg/kg)			1.3	<1	1.5	1.1	1.5	2.5	<1	2.4	1.1	1.6	*15*	*12*	*10*	*5.0*
Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	1.8	1.9	1.8	1.8	1.8	2.3	3.0	12	3.1	4.9	*45 note 8*	*30 note 8*	*24 note 8*	*20 note 8*
		**Rayment & Lyons 2011 - 9B2 (Colwell)	3.6	3.9	4.6	1.6	3.6	4.9	2.6	17	4.3	7.5	*80*	*50*	*45*	*35*
		**Inhouse S3A (Bray 2)	2.7	3.7	3.0	2.5	2.6	3.6	3.2	17	4.3	7.3	*90 note 8*	*60 note 8*	*48 note 8*	*40 note 8*
Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	1.4	1.1	0.60	0.94	4.0	2.9	1.1	3.2	1.5	2.9	*15*	*13*	*10*	*10*
Ammonium Nitrogen (mg/kg N)			4.8	5.2	4.4	6.3	6.7	8.0	11	5.0	7.4	12	*20*	*18*	*15*	*12*
Sulfur (mg/kg S)			4.9	5.2	5.5	5.6	5.5	6.8	5.9	9.5	7.3	11	*10.0*	*8.0*	*8.0*	*7.0*
pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.44	5.54	6.21	5.65	6.02	6.53	5.20	5.51	5.08	5.38	*6.5*	*6.5*	*6.3*	*6.3*
Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.025	0.027	0.030	0.025	0.032	0.048	0.031	0.047	0.050	0.054	*0.200*	*0.150*	*0.120*	*0.100*
Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	2.6	4.4	3.8	3.1	3.3	4.8	4.6	8.4	6.4	7.3	*> 5.5*	*>4 .5*	*> 3.5*	*> 2.5*
Exchangeable Calcium	($cmol_+$/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	3.4	2.3	3.8	1.7	3.0	8.1	1.6	6.1	2.0	3.9	*15.6*	*10.8*	*5.0*	*1.9*
	(kg/ha)		1,516	1,020	1,728	784	1,368	3,617	736	2,733	888	1,748	*7000*	*4816*	*2240*	*840*

		Site	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	GBWood1	GBWood2	GBWood3	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
	(mg/kg)		677	455	771	350	611	1,615	328	1,220	396	780	*3125*	*2150*	*1000*	*375*
Exchangeable Magnesium	(cmol$_{+}$/kg)		0.55	0.81	1.1	0.81	0.95	1.7	0.56	2.6	1.1	2.4	*2.4*	*1.7*	*1.2*	*0.60*
	(kg/ha)		150	221	291	221	259	468	152	721	298	640	*650*	*448*	*325*	*168*
	(mg/kg)		67	99	130	99	116	209	68	322	133	286	*290*	*200*	*145*	*75*
Exchangeable Potassium	(cmol$_{+}$/kg)		0.35	0.41	0.40	0.40	0.54	0.49	0.33	0.74	0.38	0.57	*0.60*	*0.50*	*0.40*	*0.30*
	(kg/ha)		303	362	355	353	471	432	293	649	337	501	*526*	*426*	*336*	*224*
	(mg/kg)		135	162	158	158	210	193	131	290	150	224	*235*	*190*	*150*	*100*
Exchangeable Sodium	(cmol$_{+}$/kg)		<0.065	0.15	0.16	0.07	<0.065	<0.065	0.11	0.07	0.20	0.10	*0.3*	*0.26*	*0.22*	*0.11*
	(kg/ha)		<33	76	84	35	<33	<33	57	36	101	52	*155*	*134*	*113*	*57*
	(mg/kg)		<15	34	37	15	<15	<15	25	16	45	23	*69*	*60*	*51*	*25*
Exchangeable Aluminium	(cmol$_{+}$/kg)	**Inhouse S37 (KCl)	0.01	0.49	0.03	0.18	0.03	0.01	0.70	0.09	1.1	0.25	*0.6*	*0.5*	*0.4*	*0.2*
	(kg/ha)		2.4	99	5.9	37	5.2	3.0	140	18	231	51	*121*	*101*	*73*	*30*
	(mg/kg)		1.1	44	2.6	16	2.3	1.3	63	8.0	103	23	*54*	*45*	*32*	*14*
Exchangeable Hydrogen	(cmol$_{+}$/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.04	0.04	0.06	0.05	0.07	<0.01	0.03	0.06	<0.01	0.07	*0.6*	*0.5*	*0.4*	*0.2*
	(kg/ha)		<1	<1	1.5	1.2	1.5	<1	<1	1.4	<1	1.5	*13*	*11*	*8*	*3*
	(mg/kg)		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	*6*	*5*	*4*	*2*
Effective Cation Exchange Capacity (ECEC) (cmol$_{+}$/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol$_{+}$/kg)	4.4	4.2	5.6	3.3	4.7	10	3.4	9.7	4.8	7.2	*20.1*	*14.3*	*7.8*	*3.3*
Calcium (%)		**Base Saturation Calculations - Cation cmol$_{+}$/kg / ECEC x 100	77	54	69	53	65	78	49	63	41	54	*77.6*	*75.7*	*65.6*	*57.4*
Magnesium (%)			13	19	19	25	20	17	17	27	23	32	*11.9*	*11.9*	*15.7*	*18.1*

	Site	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	GBWood1	GBWood2	GBWood3	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
Potassium (%)		7.9	9.9	7.3	12	11	4.8	9.9	7.6	8.0	7.9	*3.0*	*3.5*	*5.2*	*9.1*
Sodium - ESP (%)		1.1	3.5	2.9	2.1	1.4	0.37	3.3	0.73	4.1	1.4	*1.5*	*1.8*	*2.9*	*3.3*
Aluminium (%)		0.27	12	0.52	5.6	0.55	0.14	21	0.92	24	3.5	*6.0*	*7.1*	*10.5*	*12.1*
Hydrogen (%)		0.87	1.0	1.2	1.7	1.4	0.00	0.98	0.65	0.00	0.91				
Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium ($cmol_+$/kg)	6.1	2.8	3.6	2.1	3.2	4.7	2.9	2.3	1.8	1.7	*6.5*	*6.4*	*4.2*	*3.2*
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	0.83	0.67	0.77	0.76	0.99	0.53	<0.5	1.6	0.70	0.93	*6.0*	*5.0*	*4.0*	*3.0*
Manganese (mg/kg)		8.4	14	15	11	23	18	37	25	62	23	*25*	*22*	*18*	*15*
Iron (mg/kg)		69	203	185	155	104	72	167	201	269	256	*25*	*22*	*18*	*15*
Copper (mg/kg)		0.30	0.19	0.34	0.26	0.32	0.22	0.14	0.40	0.23	0.30	*2.4*	*2.0*	*1.6*	*1.2*
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.16	0.45	0.34	0.23	0.24	0.66	0.45	0.76	0.63	1.1	*2.0*	*1.7*	*1.4*	*1.0*
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	15	26	28	20	25	22	16	26	28	28	*50*	*45*	*40*	*35*
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	1.5	2.5	2.2	1.8	1.9	2.8	2.7	4.8	3.7	4.2	*> 3.1*	*> 2.6*	*> 2.0*	*> 1.4*
Total Nitrogen (%)		0.11	0.14	0.15	0.13	0.16	0.17	0.14	0.28	0.17	0.23	*> 0.30*	*> 0.25*	*> 0.20*	*> 0.15*
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	14	18	14	13	12	16	19	17	21	18	*10–12*	*10–12*	*10–12*	*10–12*
Basic Texture	**Inhouse S65	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay	Clay	..	..	..	..
Basic Colour		Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	..	..	..	..
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	16	17	19	16	21	31	20	30	32	35	..	..	..	..

Appendix 4. ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT: Dwyer's Red Gum Sites Kokoda Offset Area 2021

Soil samples supplied by DnA Environmental on 31/10/2022 - Lab Job No. N4133

Parameter	Method reference	DReveg1	DReveg2	DReveg3	DWoodLQ	DWood1	DWood2	DWood3	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
	Site	N4133/1	N4133/2	N4133/3	N4133/17	N4133/9	N4133/10	N4133/11	Indicative guidelines - refer to Notes 6 and 8			
Soluble Calcium (mg/kg)	**Inhouse S10 - Morgan 1	215	172	173	223	432	259	195	*1150*	*750*	*375*	*175*
Soluble Magnesium (mg/kg)		62	33	52	92	54	119	67	*160*	*105*	*60*	*25*
Soluble Potassium (mg/kg)		46	62	57	61	62	65	46	*113*	*75*	*60*	*50*
Soluble Phosphorus (mg/kg)		<1	<1	<1	<1	<1	<1	<1	*15*	*12*	*10*	*5.0*
Phosphorus (mg/kg P)	**Rayment & Lyons 2011 - 9E2 (Bray 1)	1.6	5.2	1.9	1.9	1.9	2.0	2.5	*45 note 8*	*30 note 8*	*24 note 8*	*20 note 8*
	**Rayment & Lyons 2011 - 9B2 (Colwell)	3.6	4.6	3.9	7.9	2.0	3.0	1.6	*80*	*50*	*45*	*35*
	**Inhouse S3A (Bray 2)	4.0	9.1	4.4	3.6	2.7	2.7	2.9	*90 note 8*	*60 note 8*	*48 note 8*	*40 note 8*
Nitrate Nitrogen (mg/kg N)	**Inhouse S37 (KCl)	0.60	0.63	0.63	4.4	2.6	2.0	0.95	*15*	*13*	*10*	*10*
Ammonium Nitrogen (mg/kg N)		4.8	4.0	11	6.9	6.9	5.4	5.9	*20*	*18*	*15*	*12*
Sulfur (mg/kg S)		4.4	5.4	3.4	6.5	8.8	7.3	6.8	*10.0*	*8.0*	*8.0*	*7.0*
pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	5.69	5.40	5.98	5.52	5.43	5.46	5.76	*6.5*	*6.5*	*6.3*	*6.3*
Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.023	0.015	0.024	0.036	0.026	0.036	0.024	*0.200*	*0.150*	*0.120*	*0.100*
Estimated Organic Matter (% OM)	**Calculation: Total Carbon x 1.75	2.9	2.8	3.5	5.7	7.9	6.8	4.5	*> 5.5*	*>4 .5*	*> 3.5*	*> 2.5*

			Site	DReveg1	DReveg2	DReveg3	DWoodLQ	DWood1	DWood2	DWood3	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
	Exchangeable Calcium	(cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	1.5	1.3	1.2	1.9	3.7	2.4	1.7	*15.6*	*10.8*	*5.0*	*1.9*
		(kg/ha)		685	599	559	837	1,666	1,093	748	*7000*	*4816*	*2240*	*840*
		(mg/kg)		306	267	249	373	744	488	334	*3125*	*2150*	*1000*	*375*
	Exchangeable Magnesium	(cmol+/kg)		0.64	0.34	0.53	0.91	0.60	1.3	0.69	*2.4*	*1.7*	*1.2*	*0.60*
		(kg/ha)		175	92	145	247	164	348	189	*650*	*448*	*325*	*168*
		(mg/kg)		78	41	65	110	73	155	84	*290*	*200*	*145*	*75*
	Exchangeable Potassium	(cmol+/kg)		0.24	0.29	0.27	0.28	0.37	0.35	0.23	*0.60*	*0.50*	*0.40*	*0.30*
		(kg/ha)		213	258	239	248	326	306	204	*526*	*426*	*336*	*224*
		(mg/kg)		95	115	107	111	146	137	91	*235*	*190*	*150*	*100*
	Exchangeable Sodium	(cmol+/kg)		0.20	<0.065	0.17	0.23	<0.065	0.20	0.14	*0.3*	*0.26*	*0.22*	*0.11*
		(kg/ha)		105	<33	88	116	<33	103	71	*155*	*134*	*113*	*57*
		(mg/kg)		47	<15	39	52	<15	46	32	*69*	*60*	*51*	*25*
	Exchangeable Aluminium	(cmol+/kg)	**Inhouse S37 (KCl)	0.48	0.80	0.23	0.53	0.44	0.72	0.22	*0.6*	*0.5*	*0.4*	*0.2*
		(kg/ha)		98	161	46	107	88	144	45	*121*	*101*	*73*	*30*
		(mg/kg)		44	72	21	48	39	64	20	*54*	*45*	*32*	*14*
	Exchangeable Hydrogen	(cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.05	<0.01	0.07	0.03	0.06	0.03	0.09	*0.6*	*0.5*	*0.4*	*0.2*
		(kg/ha)		1.1	<1	1.7	<1	1.3	<1	2.1	*13*	*11*	*8*	*3*
		(mg/kg)		<1	<1	<1	<1	<1	<1	<1	*6*	*5*	*4*	*2*
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	3.1	2.8	2.5	3.8	5.2	5.0	3.0	*20.1*	*14.3*	*7.8*	*3.3*

	Site	DReveg1	DReveg2	DReveg3	DWoodLQ	DWood1	DWood2	DWood3	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
Calcium (%)	**Base Saturation Calculations - Cation $cmol_+/kg$ / ECEC x 100	48	47	49	48	71	49	55	*77.6*	*75.7*	*65.6*	*57.4*
Magnesium (%)		20	12	21	24	11	25	23	*11.9*	*11.9*	*15.7*	*18.1*
Potassium (%)		7.7	10	11	7.4	7.1	7.0	7.6	*3.0*	*3.5*	*5.2*	*9.1*
Sodium - ESP (%)		6.5	1.8	6.7	5.9	0.98	4.0	4.6	*1.5*	*1.8*	*2.9*	*3.3*
Aluminium (%)		15	28	9.1	14	8.3	14	7.3	*6.0*	*7.1*	*10.5*	*12.1*
Hydrogen (%)		1.5	0.00	3.0	0.79	1.1	0.65	3.1				
Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium ($cmol_+/kg$)	2.4	3.9	2.3	2.1	6.2	1.9	2.4	*6.5*	*6.4*	*4.2*	*3.2*
Zinc (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	0.69	<0.5	0.83	1.1	<0.5	<0.5	0.69	*6.0*	*5.0*	*4.0*	*3.0*
Manganese (mg/kg)		12	4.7	16	25	28	46	36	*25*	*22*	*18*	*15*
Iron (mg/kg)		360	122	344	283	98	233	237	*25*	*22*	*18*	*15*
Copper (mg/kg)		0.41	0.13	0.34	0.18	0.22	0.13	0.24	*2.4*	*2.0*	*1.6*	*1.2*
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.31	<0.1	0.27	0.56	0.80	0.75	0.48	*2.0*	*1.7*	*1.4*	*1.0*
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	28	12	21	21	13	18	20	*50*	*45*	*40*	*35*
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	1.6	1.6	2.0	3.2	4.5	3.9	2.6	*> 3.1*	*> 2.6*	*> 2.0*	*> 1.4*
Total Nitrogen (%)		0.11	0.09	0.14	0.21	0.20	0.15	0.13	*> 0.30*	*> 0.25*	*> 0.20*	*> 0.15*
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	15	18	14	16	22	26	19	*10–12*	*10–12*	*10–12*	*10–12*
Basic Texture	**Inhouse S65	Clay	Clay	Clay	Clay	Clay	Clay	Clay	..	..	..	..
Basic Colour		Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	..	..	..	..
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	14	9.6	16	23	17	23	16	..	..	..	..

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.*CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
   Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 $cmol_+/kg$ = 230 mg/kg Sodium, 390 mg/kg Potassium,
    122 mg/kg Magnesium, 200 mg/kg Calcium
11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
14. Analysis conducted between sample arrival date and reporting date.
15. This report is not to be reproduced except in full. Results only relate to the item tested.
16. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer SCU.edu.au/eal/t&cs).
17. This report was issued on 11/11/2022.

Quality Checked: Kris Saville
Agricultural Co-Ordinator

KS

Appendix 5. 2022 Annexure D: Completed BAM field monitoring forms and photo-points

Monitoring Data Sheet			
Monitoring Point Number	GBReveg1	Date	18/10/22
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 635978E, 6318477N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:	0		
Midstorey:	0		
Groundcover(grass):	34.5		
Groundcover (shrub):	0		
Groundcover (other):	1.1		
Native species richness:	18		
Proportion of canopy species regenerating	0.5		
Exotic cover	40.5		
Number of trees with hollows	0		
Total length of fallen logs	0		

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			One *Callitris endlicheri* volunteer
Threatened species sightings			Superb Parrots over head
Fire event/fuel			Low - moderate
Weeds			Annual exotics are dominant
Pest animals			Limited
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points GBReveg1 55 635978E, 6318477N

North	West
	
South	**East**
	

Monitoring Data Sheet			
Monitoring Point Number	GBReveg2	Date	18/10/22
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636002E, 6317748N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:			0
Midstorey:			0
Groundcover(grass):			1.1
Groundcover (shrub):			0
Groundcover (other):			38
Native species richness:			24
Proportion of canopy species regenerating			0
Exotic cover			47.5
Number of trees with hollows			0
Total length of fallen logs			0

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Nil
Threatened species sightings			Grey Crowned Babblers and Superb Parrots heard nearby
Fire event/fuel			Low
Weeds			Annual exotics
Pest animals			limited
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points GBReveg2 55 636002E, 6317748N

North	West
	
South	**East**
	

Monitoring Data Sheet			
Monitoring Point Number	GBReveg3	Date	19/10/22
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636570E, 6318095N		

2. Floristic BioMetric attributes	
Native cover	
Overstorey:	0
Midstorey:	0
Groundcover(grass):	35
Groundcover (shrub):	0.7
Groundcover (other):	21.5
Native species richness:	25
Proportion of canopy species regenerating	1
Exotic cover	37.5
Number of trees with hollows	0
Total length of fallen logs	0

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Tubestock planted in October 2020, replanted 2021.
Threatened species sightings			Grey Crowned Babblers heard nearby
Fire event/fuel			Low -moderate
Weeds			Exotic Annuals
Pest animals			Limited
Visitor impact/vehicles			Nil
Rubbish dumping			nil

Photo Points GBReveg3 55 636570E, 6318095N

North	West
	
South	**East**
	

Monitoring Data Sheet			
Monitoring Point Number	GBReveg4	Date	26/10/22
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636926E, 6318020N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:	0		
Midstorey:	0		
Groundcover(grass):	7		
Groundcover (shrub):	0.25		
Groundcover (other):	3		
Native species richness:	27		
Proportion of canopy species regenerating	1		
Exotic cover	67.5		
Number of trees with hollows	0		
Total length of fallen logs	0		

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Tubestock planted 2021?, Natural regen of *A. spectabilis* and *A. decora* occurring in site.
Threatened species sightings			Nil
Fire event/fuel			Low - moderate
Weeds			Exotic Annuals
Pest animals			low
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points GBReveg4 55 636926E, 6318020N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	GBReveg5	Date	26/10/22
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 637055E, 6318301N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:	0		
Midstorey:	0		
Groundcover(grass):	10		
Groundcover (shrub):	0.1		
Groundcover (other):	6		
Native species richness:	20		
Proportion of canopy species regenerating	0.33		
Exotic cover	52.5		
Number of trees with hollows	1		
Total length of fallen logs	0		

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			3 *Eucalyptus dwyeri* seedlings
Threatened species sightings			Nil, patch of *Stackhousia monogyna*
Fire event/fuel			Low - moderate
Weeds			Exotic Annuals
Pest animals			low
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points GBReveg5 55 637055E, 6318301N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	WBWood1	Date	19/10/22
Vegetation Community	LA218 White Box - White Cypress Pine - Western Grey Box shrub/grass/forb woodland in the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636833E, 6318381N		

2. Floristic BioMetric attributes	
Native cover	
Overstorey:	21.25
Midstorey:	0
Groundcover(grass):	20.5
Groundcover (shrub):	0.45
Groundcover (other):	20.25
Native species richness:	55
Proportion of canopy species regenerating	0.5
Exotic cover	12.5
Number of trees with hollows	2
Total length of fallen logs	68

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Limited eucalypt and scattered shrub regeneration
Threatened species sightings			7 *Caladenia tentaculata*, high diversity of native wildflowers. Grey Crowned Babblers
Fire event/fuel			Low- moderate
Weeds			low
Pest animals			low
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points WBWood1 55 636833E, 6318381N

North	West
	
South	**East**
	

Monitoring Data Sheet				
Monitoring Point Number	IronWood1		Date	17/10/22
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion			
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 635146E, 6317472N			
2. Floristic BioMetric attributes				
Native cover				
Overstorey:			21.5	
Midstorey:			2	
Groundcover(grass):			17.5	
Groundcover (shrub):			4.75	
Groundcover (other):			25	
Native species richness:			43	
Proportion of canopy species regenerating			0.66	
Exotic cover			0.7	
Number of trees with hollows			1	
Total length of fallen logs			111.5	

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Scattered *Callitris endlicheri,* various low shrubs including *Brachyloma daphnoides, limited eucalypt regeneration. Xerochrysum bracteantha* abundant.
Threatened species sightings			Species of interest include *Caladenia carnea, Caladenia gracilis, Calochilus robertsonii*
Fire event/fuel			Moderate
Weeds			Scattered annual exotics
Pest animals			Limited
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points IronWood1 55 635146E, 6317472N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	GBWood1	Date	18/10/22
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636101E, 6318236N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:			20.25
Midstorey:			0
Groundcover(grass):			10.25
Groundcover (shrub):			0.25
Groundcover (other):			9.75
Native species richness:			29
Proportion of canopy species regenerating			1
Exotic cover			9.25
Number of trees with hollows			12
Total length of fallen logs			114.5

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Limited *E. microcarpa* regeneration, one *Cassinia laevis*, one *A. implexa seedling*
Threatened species sightings			Superb Parrots over head
Fire event/fuel			Low
Weeds			Limited
Pest animals			Kangaroo camps
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points: GBWood1 55 636101E, 6318236N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	GBWood2	Date	18/10/22
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 635682E, 6317708N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:			20.25
Midstorey:			0.25
Groundcover(grass):			5.75
Groundcover (shrub):			6.1
Groundcover (other):			16.25
Native species richness:			43
Proportion of canopy species regenerating			0.5
Exotic cover			9.5
Number of trees with hollows			0
Total length of fallen logs			47
3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Scattered *Acacia paradoxa* and *A. implexa* regeneration, one each of *Eucalyptus microcarpa*, *Brachychiton, Cassinia* and *Brachyloma* seedlings
Threatened species sightings			Superb Parrots over head
Fire event/fuel			Low
Weeds			Nil
Pest animals			Hare
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points: GBWood2 55 635682E, 6317708N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	GBWood3	Date	19/10/22
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 635080E, 6318033 N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:	23.25		
Midstorey:	0.25		
Groundcover(grass):	30		
Groundcover (shrub):	0.35		
Groundcover (other):	17.5		
Native species richness:	38		
Proportion of canopy species regenerating	0.5		
Exotic cover	4.25		
Number of trees with hollows	2		
Total length of fallen logs	168.5		

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Limited *Eucalyptus microcarpa* and scattered shrub regeneration
Threatened species sightings			Grey Crowned Babblers heard nearby
Fire event/fuel			Low
Weeds			Low
Pest animals			Limited – new boundary fence installed in 2020
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points GBWood3 55 635080E, 6318033 N

North	West
	
South	**East**
	

Monitoring Data Sheet			
Monitoring Point Number	DReveg1	Date	19/10/2022
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636561E, 6318547N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:	6.5		
Midstorey:	0		
Groundcover(grass):	28.25		
Groundcover (shrub):	0.25		
Groundcover (other):	25.25		
Native species richness:	17		
Proportion of canopy species regenerating	100		
Exotic cover	20.75		
Number of trees with hollows	0		
Total length of fallen logs	0		

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Scattered *Eucalyptus dwyeri,* occasional *A. decora*
Threatened species sightings			Superb Parrots overhead
Fire event/fuel			low
Weeds			Exotic Annuals – *Hypochaeris glabra*
Pest animals			Low
Visitor impact/vehicles			Deep ripping for planting, slashed track
Rubbish dumping			Nil

Photo Points DReveg1 55 636561E, 6318547N

North	West
	
South	**East**
	

Monitoring Data Sheet			
Monitoring Point Number	DReveg2	Date	29/10/2022
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636623E, 6318461N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:	0		
Midstorey:	0		
Groundcover(grass):	26.25		
Groundcover (shrub):	0.55		
Groundcover (other):	9		
Native species richness:	39		
Proportion of canopy species regenerating	1		
Exotic cover	4.25		
Number of trees with hollows	0		
Total length of fallen logs	4		

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Natural regeneration of *Acacia decora* and *Eucalyptus dwyeri, Callitris, Cassinia.* Other trees and shrubs planted as tubestock in 2021
Threatened species sightings			Nil
Fire event/fuel			Low
Weeds			Annual exotics
Pest animals			Low
Visitor impact/vehicles			Rip lines for planting
Rubbish dumping			Nil

Photo Points DReveg2 55 636623E, 6318461N

North	West
	
South	**East**
	

Monitoring Data Sheet			
Monitoring Point Number	DReveg3	Date	26/10/2022
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 637305E, 6318039N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:	0		
Midstorey:	0		
Groundcover(grass):	5.5		
Groundcover (shrub):	0.1		
Groundcover (other):	6.25		
Native species richness:	19		
Proportion of canopy species regenerating	0		
Exotic cover	58		
Number of trees with hollows	0		
Total length of fallen logs	0		

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			One *Allocasuarina verticillata, E. dwyeri* saplings and other shrubs on rocky knoll
Threatened species sightings			Babblers nearby
Fire event/fuel			Low - Moderate
Weeds			Annual exotic weeds
Pest animals			Limited
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points DReveg3 55 637305E, 6318039N

North	West
	
South	**East**
	

Monitoring Data Sheet			
Monitoring Point Number	DWoodLQ	Date	18/10/2022
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636191E, 6317757N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:		15.5	
Midstorey:		0	
Groundcover(grass):		0.4	
Groundcover (shrub):		0.7	
Groundcover (other):		37	
Native species richness:		34	
Proportion of canopy species regenerating		0.5	
Exotic cover		22.5	
Number of trees with hollows		0	
Total length of fallen logs		17.5	

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			*Eucalyptus dwyeri* (extensive in wider area), occasional shrub seedling
Threatened species sightings			Superb Parrots nearby.
Fire event/fuel			Low
Weeds			Annual exotics
Pest animals			Low
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points DWoodLQ 55 636191E, 6317757N

North	West
	
South	**East**
	

Monitoring Data Sheet			
Monitoring Point Number	DWood1	Date	17/10/2022
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 635665E, 6316756N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:	12.5		
Midstorey:	1.25		
Groundcover(grass):	6.75		
Groundcover (shrub):	0.4		
Groundcover (other):	35		
Native species richness:	36		
Proportion of canopy species regenerating	0.55		
Exotic cover	0.5		
Number of trees with hollows	4		
Total length of fallen logs	341.5		

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Numerous scattered *Callitris endlicheri, E. dealbata* seedlings,
Threatened species sightings			Nil
Fire event/fuel			Low - moderate
Weeds			low
Pest animals			low
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points DWood1 55 635665E, 6316756N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	DWood2	Date	17/10/2022
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636044E, 6316797N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:			26
Midstorey:			0
Groundcover(grass):			2
Groundcover (shrub):			10
Groundcover (other):			26
Native species richness:			43
Proportion of canopy species regenerating			1.0
Exotic cover			9.5
Number of trees with hollows			3
Total length of fallen logs			262
3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			*Callitris endlicheri, E. dealbata and E. sideroxylon* seedlings and scattered shrub regeneration
Threatened species sightings			Nil
Fire event/fuel			Low – moderate – lots of fallen timber
Weeds			Low – *Hypochaeris glabra*, annual grasses
Pest animals			Low
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points DWood2 55 636044E, 6316797N

North	West
	
South	**East**
	

Monitoring Data Sheet			
Monitoring Point Number	DWood3	Date	25/10/2022
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 6361176E, 6317341N		

2. Floristic BioMetric attributes	
Native cover	
Overstorey:	16
Midstorey:	0.5
Groundcover(grass):	5
Groundcover (shrub):	19.5
Groundcover (other):	29.25
Native species richness:	43
Proportion of canopy species regenerating	0.66
Exotic cover	0.7
Number of trees with hollows	0
Total length of fallen logs	73

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Extensive *Callitris endlicheri regeneration,* limited *E. dealbata* seedlings, *Calytrix tetragona* abundant
Threatened species sightings			Species of interest *Calochilus robertsonii*
Fire event/fuel			Low-moderate
Weeds			*Hypochaeris glabra*, annual grasses
Pest animals			Low
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points DWood3 55 6361176E, 6317341N

North	West
	
South	East
	

LWQ3006 – North Parkes Mine Kokoda Revegetation Project

Abstract

Using post revegetation surveys and condition assessments provide the information and guidance for the ongoing maintenance and regeneration by Northparkes Mine of the Kokoda Offset Property.

The collection and storage of corflute tree guards and their accompanying hardwood stakes ensure the minimisation of plastic debris polluting the offset and preserve them for reuse in the future.

A Skillset Landworks team assessed the 16013 planted sites in July and August 2022. Plant condition was assessed using a point index system.
Overall survival rate across the site is 81.72%.
The cell with the highest survival rate was T1 with 96.3%. The lowest scoring cell is M4, with 64.68%.

The largest negative impact on plants across all cells was waterlogging and site inundation. Many inundated plants showed symptoms of hypoxia, yellowed, stunted and drooping leaves. Heavy fungal infestation was observed on some *Eucalyptus spp* individuals and a majority of *Brachychiton populneus.*

The revegetation survey results indicate the Kokoda offset is seeing a high rate of successful plant establishment as well as displaying a vigorous natural regeneration from the existing seedbank and the resilient remnant bush.

Methods.

Species present were allocated a code for efficient recording, table#1. Eucalypts were grouped and surveyed as undifferentiated. Dodonaea spp and Einadia spp were also grouped. The assessor walked each ripline and radioed the code back for each plant to a scribe as they went. Each code contained species, condition and impact upon the individual plant if it's condition was less than healthy. The phonetic alphabet was used to minimise confusion. Results were written into paper forms which were collated at the end of each day.

Discussion.

M4 showed the lowest success rate due to waterlogging. 35% of plants were absent or showed evidence of Hypoxia/ stress brought about by waterlogging due to their position in the discharge zone of the higher water table and the retention of water by the deep riplines. Potentially, smaller seedlings may have succumbed to submergence.

T1 was situated in a well-drained site and as such had the highest rate of survival at 96.3%.
8 sites/ 1.7%, were recorded as affected by waterlogging.

Very few instances of grazed plantings were recorded. Ample grasses available to herbivores and low numbers of kangaroos on site have greatly reduced grazing pressure.

Observations

Acacia spp were generally hardy across the sites. Established wild specimens were thriving and flowering in inundated areas.

Austrodanthonia spp were suffering a build-up of dead leaves and material within the guards due to the protection of the guard against grazing, wind and other external influences. Excess shade from this material was seen to be shading out green material below and causing senescence. The removal of the guards will allow natural processes to occur and the Austrodanthonia to continue growing.

Dodonaea spp were vigorous outside chronically inundated sites

Einadia spp did not tolerate wet sites but was seen growing vigorously in well drained areas.

Enchylaena tomentosa appeared on the higher cells only.

Chrysocephalum apiculatum were visibly stressed in wet sites and vigorous in better drained and elevated sites.

Brachychiton populneus showed widespread incidences of fungal parasitism, dark areas of mildew on leaves and chlorophyll loss, across most wet sites.

Cassinia arcuata had varied reactions to inundation but were generally growing better in well-drained soil.

Dianella revoluta and *Lomandra spp* tolerated wet conditions where they were established.

Bursaria spinosa is usually tolerant of damp sites but juvenile plants were seen having trouble establishing in inundated conditions.

Eucalyptus spp generally showed vigorous growth except where excessive water retarded their establishment through hypoxia and enabling fungal infection.

Allocasuarina luehmannii / verticillata. Both species generally occur in rocky, well drained sites but were seen to be mostly successful across the site.

Hardenbergia violacea was vigorous on well drained sites.

Juncus spp were found growing in guards occasionally, it is not clear whether they were planted or naturally occurring. They grew well in all conditions.

Melaleuca spp were encountered only a few times in the field. They may have grown from seed in planted tubestock.

Conclusion.

With an overall success rate of 81.72% the planting at Kokoda can be deemed a success. Despite continued heavy rain a solid series of plant communities have been established and will continue to do so as the weather warms.
Continued monitoring, weed suppression where required and infill planting if necessary will see Kokoda Offset restored.

Tables

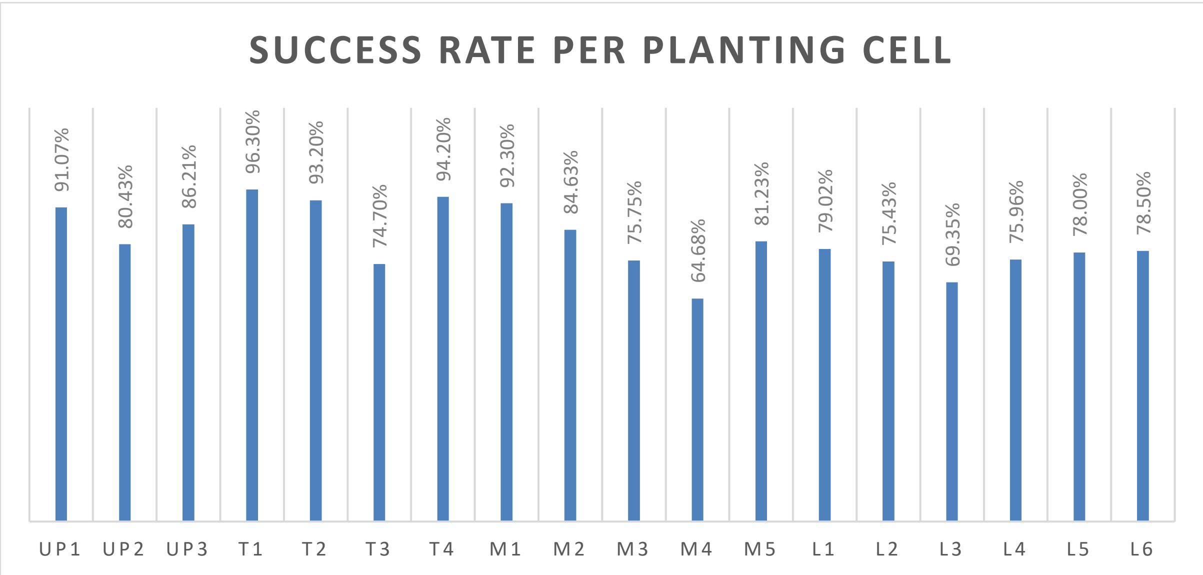
Table 1
Species List

Acacia decora	Ac d
Acacia doratoxylon	Ac do
Acacia hakeoides	Ac h
Acacia implexa	Ac i
Acacia lanigera	Ac l
Acacia paradoxa	Ac p
Acacia spectabilis	Ac s
Cassinia arcuata	C
Chrysocephalum apiculatum	Chr
Dodonea spp	D
Einadia hastata, Einadia nutans	Ein
Bursaria spinosa	B
Enchylaena tomentosa	Enc
Eucalyptus spp	E
Allocasuarina leuhmannii	Allo l
Allocasuarina verticillata	Allo v
Brachychiton populneus	Bp
Lomandra spp	L
Dianella spp	Di
Austrodanthonia spp	Aus
Hardenbergia violacea	Hv
Juncus spp	J

Table 2
Condition and Impacts Table

3	Specimen healthy
2	Specimen under stress but showing vigour
1	Specimen suffering under impact
0	Specimen completely dead or missing
B	Plant browsed or damaged by Animal interaction.
F	Frost damage.
W	Waterlogging or inundation stress.
D	Dehydration.
N	Nutrient deficiency.
I	Insect damage from feeding including defoliation, leaf skeletonising and excessive gall formation on juvenile plant, causing retarded growth.
P	Parasitism by fungus.

Table 3
Success Rate



Acacia spectabilis growing vigorously out through a large tree guard

Flooded site with plant, guard and mat missing through probable negative browsing interaction.

Typical inundated ripline site in Planting Cell M4


Typically stressed *Brachychiton populneus*


Heavily browsed *Allocasuarina verticillata*

Typical inundated site with missing plant

Einadia hastata growing well in well drained position, Cell M5

Einadia hastata conforming to guard shape after removal.

2022 Pine Donkey Orchid Surveys

for
Northparkes Mines
CMOC Mining Services Pty Limited
December 2022

Prepared by DnA Environmental

Disclaimer

This is a report of work carried out by DnA Environmental, under contract and on behalf of China Molybdenum Co. Ltd (CMOC) Pty Ltd as agent severally for and on behalf of the Northparkes Joint Venture and has been prepared according to the brief provided by the client. The information contained herein is complete and correct to the best of my knowledge. The representations, statements, opinions and advice, expressed or implied in this report are for the benefit of the Client only. The Content is produced in good faith but on the basis that DnA Environmental are not liable (whether by reason of negligence, lack of care or otherwise) to any person for any damage or loss whatsoever which has occurred or may occur in relation to that person taking or not taking (as the case may be) action in respect of any or all of the Content.

Signed: 

Dr Donna Johnston
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PhD, BAppSc (Hons) MEIANZ

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Acknowledgements

This report was prepared by Dr Donna Johnston and Andrew Johnston from DnA Environmental. Field work and associated reports have typically been undertaken by Dr Donna Johnston and Andrew Johnston from DnA Environmental. Since 2021, field surveys have been undertaken by Andrew Johnston (DnA Environmental) and Ray Mjadwesch (Mjadwesch Environmental Service Support). Reports continue to be prepared by Dr Donna Johnston and Andrew Johnston.

Executive summary

The Northparkes copper-gold mine is located in central western New South Wales (NSW) approximately 27 kilometres north north-west of the town of Parkes. Ecological surveys undertaken in 2011 and 2012 as part of the Environmental Assessment for an extension of the Project, identified the Pine Donkey Orchid (*Diuris tricolor*) (PDO), a threatened terrestrial herb species listed as vulnerable under the *Biodiversity Conservation Act 2016* on the mine site. The Northparkes Mine Extension Project was approved in 2014 with the management of the Pine Donkey Orchid populations being included in the approval conditions. Targeted baseline surveys of the two known populations at Limestone Forest E48 subsidence zone and TSR along Adavale Lane north of the ML have been undertaken in spring since 2014. This report has been produced to comply with the approval conditions, as well as to fulfil the requirements outlined in the Northparkes Biodiversity Offset Management Plan (BOMP) and Species Management Plan for the Pine Donkey Orchid.

The monitoring requirements specified within the BOMP included;

- The location of all individuals are to be recorded using a handheld GPS and a total count is to be provided for each population;
- Monitoring of ground cover abundance and flora species composition using permanent five × five metre floristic plots;
- Weed monitoring via walking meandering transects through both populations, and where required weed control; and
- Annual fence inspections.

Field work and associated reports have typically been undertaken by Dr Donna Johnston (PhD, BAppSc (Hons), MEIANZ) and Andrew Johnston (BAppSc) from DnA Environmental. Since 2021, field surveys have been undertaken by Andrew Johnston (DnA Environmental) and Ray Mjadwesch (Mjadwesch Environmental Service Support; BAppSc; MEIANZ). In 2016 however, the surveys were undertaken by Vivien Howard (MEnvPl, BSc) from Niche Environment and Heritage.

The average annual rainfall at Parkes Airport is 618 mm however, there have been extreme seasonal conditions with drought conditions experienced during 2017 – 2019, followed by three consecutive years of above average rainfall which caused widespread flooding across the region. In addition to these extremes in annual rainfall activity, the monthly averages indicate there has also been high seasonal variability and erratic rainfall activity since monitoring began. While above average rainfall occurred in most months this year, there was limited rain in February and June. This year there was 880mm of rain recorded to the end of October which was much higher than the long-term expected average of 500 mm for the same period.

Livestock grazing is prohibited at NPM and the TSR on Adavale is intermittently grazed by travelling stock but has not been grazed since 2018. During 2017 – 2019 the ongoing drought conditions and simultaneous increase in grazing and disturbances by resident macropods resulted in a significant decline in the condition and diversity of the herbaceous understorey, and in 2019 there was limited live ground cover and no orchids were recorded at either location.

As a result of the improved rainfall conditions since 2020, there has been significant increases in ground cover and floristic diversity. Exotic annuals were however also abundant especially in 2020, with the increased growth of the vegetation making locating the orchids more difficult. Nonetheless, there were a total of 770 individuals located at Limestone Forest in 2020, with additional individuals located outside of the exclusion fence. In 2021, seasonal conditions continued to be favourable and with a lower of height and abundance of weeds, the conditions for locating orchids had significantly improved and population densities increased to 973, with many individuals growing in close proximity to each other or in tight clumps.

Above average rainfall continued into 2022, and while ground cover was abundant it was typically 20 – 30 cm tall and there were significantly fewer weeds. For the period from 2014 - 2022, the highest total population count was

recorded this year with a total of 2271 orchids, of which 1491 orchids recorded in the Limestone Forest, and 780 individuals at Adavale Lane, which was slightly fewer than 2021. Since 2020, additional individuals have been located outside of the exclusion fence namely to the east, with a small number also being recorded to the west. This year 194 individuals were located outside the exclusion fence.

After the long drought period, annual weeds were prolific throughout the PDO survey areas in 2020, with *Echium plantagineum* (Paterson's Curse) being especially tall and dense beneath mature tree canopies and throughout the woodland areas. Few orchids if any were found within these weedy areas, but visibility was poor due to the long dense undergrowth. A small number of individuals were found in these areas, but they were usually weak and spindly due to the high competition levels, and few orchids were found despite extended searches in previous known locations. In the more open clearings, annual weeds especially several different species of Trifolium (Clovers) were usually abundant. Orchids could often be found in patches of *Trifolium arvense* (Haresfoot Clover), which is a weaker annual herb and therefore *T. arvense* did not appear to have a significant impact on the orchids at this stage. The orchids however were not typically found growing amongst the larger, more dense leafy growth of *Trifolium subterraneum* (Subterraneum Clover) or areas where other plant covers were high.

In the Limestone Forest sites there has been a significant increase in the cover provided by perennial ground covers and increased levels of dead litter, with there being a simultaneous decrease in live annual plant cover and an overall reduction in exotic annual weeds. Annual ground covers however continued to be relatively abundant in LFPDO1 and LFPDO2 where they provided 20 – 31% cover this year, while only 6% annual plant cover was recorded in LFPDO3.

At Adavale Lane, after the drought had broken in 2020, the ground cover was almost entirely dominated by annual plants in ALPDO1 and ALPDO3 while in ALPDO2, dead leaf litter was most dominant. In 2021 there tended to be an increase perennial ground covers, however they were in slightly less abundance this year and provided 16 – 38% of the total ground cover. Dead leaf litter continued to be dominant in ALPD03 and provided 74% cover, while annual plants continued to be quite abundant in ALPDO1 with 52% cover.

At Limestone Forest during the drought, there were only 4 -9 species recorded in the plots in 2019, however there has been a significant increase in floristic diversity across all three sites since then. This year there has been an increase in ground cover growth resulting in a further decline in total species diversity in two monitoring plots, including a reduction in the diversity of native and exotic species, probably due to the higher levels of competition. In LFPDO3, there was also a decline in native diversity, however there was an increased diversity of exotic species. This year there were 17 – 26 species recorded in the 5 x 5 monitoring quadrats, with 30 – 41% of these being exotic species.

At Adavale Lane during the drought, there were only 2 - 3 species recorded in the plots in 2019, however there has been a significant increase in floristic diversity across all three sites since then. This year there was a minor increase in exotic species diversity in two plots while a minor decrease was recorded in ALPDO3, where 30 – 32 species were recorded in the 5 x 5m monitoring quadrats, where 23 – 48% species were exotic.

Native species recorded in all three Limestone Forest sites included the native grass *Aristida jerichoensis var. jerichoensis* (Jericho Wiregrass), while there were a range of other annual and perennial herbs such as *Bulbine bulbosa* (Bulbine Lily), *Cheilanthes sieberi* subsp. *sieberi* (Rock Fern) and *Chrysocephalum apiculatum* (Common Everlasting). This year two native orchids including *Diuris tricolor* (Pine Donkey Orchid) and *Pterostylis bicolor* (Bicolor Greenhood) were also located in all three plots. Four exotic species were also common to all sites and included *Sonchus oleraceus* (Milk Thistle), *Trifolium arvense* (Haresfoot Clover), *Trifolium subterraneum* (Subterraneum Clover) and *Vulpia muralis* (Rats-tail Fescue).

At Adavale Lane, the exotic annuals have significantly declined in abundance, however *Trifolium repens* (White Clover) continued to be abundant in ALPDO1 along with natives *Cheilanthes sieberi* and *Vittadinia cuneata* (Fuzzweed). Native grasses *Anthosachne [Elymus] scabra* provided the most cover in ALPDO2, while *Dichondra repens* and *Panicum effusum* (Hairy Panic) provided the most cover in ALPDO3.

Swainsona sericea is listed under the NSW Biodiversity Conservation Act as a vulnerable species and has been recorded in the Limestone Forest exclusion site. Since 2020 a small population of *Prasophyllum campestre,* another species of orchid was also growing in the Limestone Forest. While it is not a listed species, its presence in the site for the first time in 2020 is of interest. Since 2021, the abundance of *Swainsona sericea* and *Prasophyllum campestre* appeared to have increased with the improved seasonal conditions.

This year there continued to be range of common exotic species that have become widely naturalised throughout the surrounding agricultural areas, and the Limestone Forest and Adavale Lane areas. While a variety of *Trifolium* species continue to be quite abundant, more undesirable weeds such as *Echium plantagineum* and *Arctotheca calendula* were in limited abundance compared to previous years and were largely restricted to small pockets of higher disturbance such as old stockcamps and/or areas where kangaroos frequently camp.

Conclusion

The orchid population densities, ground cover abundance and floristic diversity at Limestone Forest E48 area and Adavale Lane appear to be inherently implicated with the changes in seasonal conditions which is also compounded with changes in grazing pressure by resident macropods. The unfenced roadside population at Adavale Lane may also be periodically impacted by travelling stock. Population densities of *Diuris tricolor* have been the lowest when rainfall was limited prior to and during the emergence period (August – September) such as in 2019, while population densities were highest during 2016 and 2020 - 2022 which had above average rainfall throughout most of year. Subsequently the density in the orchid populations have been highly variable during the monitoring period, with populations having increased since monitoring began in 2014, with the highest population counts being recorded this year.

Management of increasing levels of vegetative cover including native perennial ground covers and dead litter cover has been a desirable result after the long disturbance history and drought. High competition levels of these and/or annual ground covers in the future will however probably be necessary in order to manage ground cover biomass, which may have the potential to cause a decline in orchid population numbers. These could be managed in part by careful and considered macropod grazing and/or herbicide application. While macropod numbers are not easily managed in the Adavale Lane area, they could be readily manipulated in the Limestone area exclusion area by leaving the access gate open during late winter – very early spring before PDOs emerge, and again late summer -autumn after the orchids have died off below ground level.

At Adavale Lane, the level of undesirable annual weeds has significantly declined since 2020, however problematic areas could be targeted by a carefully designed and implemented herbicide regime, when orchids are dormant underground. Resident macropods and/or travelling livestock may also assist in reducing the grassy biomass. The current distribution and density of undesirable weeds are unlikely to present a threat to any of the orchid populations and no further management in the short-term is considered necessary at this time.

Continued monitoring of the orchid populations, ground cover species and their abundance combined with managed grazing levels will assist in the ongoing management requirements of the PDO populations, and these also be determined by the changes in seasonal conditions.

Ongoing observations for potential management intervention such as woody weed control, reduction in biomass, exotic species invasion and vertebrate pest management (as per current BOMP requirements) would also be required. *Swainsona sericea* and *Prasophyllum campestre* and the range of other native woodland species that also occur in the conservation areas would also benefit from the strategic management interventions that are implemented.

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1 Introduction: 2022 Pine Donkey Orchid surveys

The Northparkes copper-gold mine is located in central western New South Wales (NSW) approximately 27 kilometres north north-west of the town of Parkes. It is a joint venture between China Molybdenum Co. Ltd (CMOC) (80%) and the Sumitomo Group (20%), with CMOC as managers of the mine. Northparkes produces ore from the mine at a rate of approximately 6.5 – 7.5 million tonnes per annum. Northparkes consists of underground operations accessing several copper sulphide porphyry ore bodies. In addition, Northparkes farms the bulk of its 6,115 ha landholding including much of the 2,456 ha of land within its three existing mining leases.

1.1 Project Background

The Northparkes Mine Extension Project (formerly known as the Northparkes Mines Step Change Project) (the Project) was approved with conditions under the *Environmental Planning and Assessment Act 1979* (NSW) DC11_0060) and the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth of Australia) EPBC 2013/6788) in 2014. Key elements of the Project included:

- continued underground block cave mining in two existing ore bodies;
- the development of an additional underground block cave mine, under one of the existing open cut pits;
- additional campaign open cut mining in existing mine leases;
- augmenting approved Tailings Storage facilities (TSFs); moving the existing access road;
- construction of the new TSF (Rosedale); and
- extending the life of the mine by seven years to 2032.

Ecological surveys undertaken in 2011 and 2012 as part of the Environmental Assessment for the Project identified the pine donkey orchid (*Diuris tricolor*) (PDO), a threatened terrestrial herb species listed as vulnerable under the Biodiversity Conservation Act 2016, on the mine site. Since then, targeted surveys for the pine donkey orchid have been undertaken in response to comments from the Office of Environment and Heritage (OEH). Targeted surveys of the two known populations at E48 subsidence zone and Adavale Lane have been undertaken in spring since 2014, with the current report presenting the results of the surveys in 2015 – 2022.

1.2 Scope and purpose

Targeted pine donkey orchid surveys were first conducted at and around Northparkes Mine in 2013. As such, conditions relating directly to the management of the pine donkey orchid populations are included in the Development Consent conditions for the Project (DC11_0060) as outlined in Table 1-1.

As per the condition, Northparkes has produced a Biodiversity Management Plan (referred to the as Biodiversity Offset Management Plan (BOMP: CMOC 2014)) for the project. Following comments from the Office of Environment and Heritage (OEH), a Species Management Plan (CMOC 2015a) for the Pine Donkey Orchid was produced to specifically manage potential impacts on the populations of this species at Northparkes.

The current document has been produced to comply with the above conditions, as well as to fulfil the requirements outlined in the Northparkes BOMP and Species Management Plan for the Pine Donkey Orchid.

Table 1-1. Development Consent conditions relating to the management of the pine donkey orchid

Schedule	Condition number	Condition
3	24	The Proponent shall actively manage and main the populations of Pine Donkey Orchid located to the north of the project area (near Adavale Lane) and near the E48 subsidence zone.
3	29	The Proponent shall prepare and implement a Biodiversity Management Plan for the project to the satisfaction of the Secretary. This plan must: (d) Include a detailed description of the measures that would be implemented for: - Managing and maintaining the populations of Pine Donkey Orchid located to the north of the project area (near Adavale Lane) and near the E48 subsidence zone.

Figure 1-1. *Diuris tricolor* (Pine Donkey Orchid).

1.3 Survey teams

Surveys for the Environmental Assessment undertaken in 2013 in 2014 were completed by Umwelt.

In 2015 (CMOC 2015b) and 2017 – 2022 (DnA Environmental 2017 - 2022), field surveys as described in this report were undertaken Dr Donna Johnston (PhD, BAppSc (Hons), MEIANZ) and Andrew Johnston (BAppSc), DnA Environmental ecologists. In 2015 field assistance was provided by Roisin Feeney (Northparkes Environment Advisor- Ecology (MSc, BSc (Hons 1), BA). In 2018, additional field assistance was provided by Michael Thomas, Nathan Jones and Donna Shaw (Northparkes Environmental Department). In 2019 additional field assistance was again provided by Michael Thomas. In 2021 and 2022, field surveys were undertaken by Andrew Johnston (DnA Environmental) and Ray Mjadwesch (BAppSc; MEIANZ) of Mjadwesch Environmental Service Support.

In 2016 (CMOC 2016), the surveys were undertaken by Vivien Howard (MEnvPl, BSc) from Niche Environment and Heritage and Roisin Feeney (Northparkes Environment Advisor- Ecology (MSc, BSc (Hons1), BA)).

1.4 Survey timing

In 2013, the surveys were undertaken between 25 - 26th September by two Umwelt ecologists. In 2014, the surveys were conducted on 11th and 14th November, with many of the orchids having withered due to the later timing and onset of hot dry conditions.

In 2015 the surveys were also not undertaken at the optimum timing, with the onset of hot dry conditions resulting in most if not all individuals having lost their petals and were withered right back. This made identifying individuals difficult, particularly in Adavale Land (AL) where there was a higher ground cover abundance of other species which obscured vision. The surveys were undertaken on 20th and 21st October 2015.

In 2016, the Pine Donkey Orchid surveys were undertaken much earlier in the month to better coincide with the flowering season of this species. Surveys were undertaken over two days, including 4th and 5th October 2016. In 2017, the surveys were also undertaken on the 4th and 5th October while in 2018, the surveys were conducted between 2 – 3rd October.

In 2019 and 2020, the Pine Donkey Orchid populations were regularly monitored by NPM staff for flowering individuals from late September to early October. In 2019, prolonged drought conditions resulted in the absence of any flowering individuals being located, however the ground cover surveys were conducted on 10th October. In 2020, the surveys were undertaken during 24 – 25th and 28th September, while in 2021 the surveys were undertaken during 28 – 29th September and due to wet weather were completed on 5th October.

This year the Pine Donkey Orchid populations were regularly monitored by NPM staff for flowering individuals, with monitoring being conducted from the 2nd to the 4th of October.

2 Methodology

Since 2013, the Pine Donkey Orchid surveys have been undertaken in the two known locations including the E48 subsidence zone near Limestone Forest (LF) and Adavale lane (AL). Since 2015 provisions were also made for the inclusion of species composition and cover abundance data in order to fulfil monitoring requirements according to the latest revision of the Biodiversity Offset Management Plan (BOMP, Umwelt 2014). The monitoring requirements specified within the BOMP included:

- Annual orchid monitoring during flowering period: Annual seasonal monitoring during the flowering period (September to October) to assess the ongoing status of the population will be undertaken. The location of all individuals are to be recorded using a handheld GPS and a total count is to be provided for each population.
- Ground cover monitoring: Monitoring of ground cover abundance and flora species composition using permanent five × five metre floristic plots will be undertaken. Three five × five metre floristic plots will be established at the Adavale Lane population and another three at the E48 population. The plots will be positioned to measure the species composition and cover abundance of ground covers in the population areas.
- Weed monitoring: Weed monitoring via walking meandering transects through both populations, and where required weed control. All weed control actions will be undertaken outside the flowering period of the species.
- Annual fence inspections

2.1 Orchid population distribution

Individual orchids occurring within the Limestone Forest population were located using 5m wide stratified and systematic bands within the exclusion areas using 50m measuring tapes to delineate these bands where possible. These transects were slowly traversed and when individuals were located, red marker flags were inserted adjacent to each individual (Figure 2-1). At every individual orchid, or sometimes a group of orchids, GPS recordings were taken with each being recorded onto a log sheet. When more than one individual occurred within a 1m radius, GPS coordinates recorded them as a group. These data were recorded and uploaded to create a spreadsheet and location map of individuals occurring in each population.

In 2020 and 2021, an expanded search outside the exclusion fences was also undertaken outside the exclusion fence at Limestone Forest and in the Adavale Lane populations. The method of systematically traversing the population areas in 5m bands was undertaken and focussed on the less weedy open clearings areas and preferred habitat.

Figure 2-1. Individual orchids and/or clumps were marked with red marker flags.

2.2 Permanent ground cover monitoring quadrats

Three 5 x 5m permanent monitoring quadrats were also first established within each of the two known populations at Limestone Forest (LF) and Adavale Lane (AL) in 2015. The monitoring plot was aligned in a northerly direction with the vegetation transect situated on the western side of the quadrat. Marker pegs were established in each corner so that they can be readily re-established at each annual monitoring event. The monitoring methodology was adapted from the Biometric Manual 3.1 (DECCW 2011). Within each of the 5 x 5m quadrats, the floristic diversity and cover abundance of individual species using Braun-Blanquet methodology occurring within five (5) replicated 1 x 1 m subplots undertaken along a permanent vegetation transect. Total floristic diversity was also recorded by searching systematically in increasing sized sub-plots, these being 1x1, 1x2, 2x2 and 5x5m areas. The ground cover monitoring data sheets are provided in previous PDO monitoring reports, including DnA Environmental (2019).

A map showing the locations and monitoring quadrats of the two PDO populations is given in Figure 2-2. GPS coordinates of the LF and AL orchid monitoring quadrats are provided in Table 2-1. Sites were established in areas where the PDO were recorded by Umwelt in 2014. However due to the hot dry conditions in 2015 when permanent quadrats were first established, not all sites may have contained PDO individuals.

Figure 2-2. Map showing the locations and monitoring quadrats in the two PDO populations.

Table 2-1. GPS coordinates of the LF and AL PDO monitoring quadrats.

Site	Start Easting	Start Northing	End Easting	End Northing
LFPDO1	55 598592	6356209	55 598593	6356212
LFPDO2	55 598613	6356266	55 598613	6356271
LFPDO3	55 598661	6356273	55 598663	6356280
ALPDO1	55 598625	6360341	55 598629	6360341
ALPDO2	55 598730	6360314	55 598735	6360317
ALPDO3	55 598903	6360505	55 598910	6360506

3 Results

3.1 Rainfall

The average annual rainfall at Parkes Airport AWS is 618 mm (BoM 2022), however there have been extreme seasonal conditions with below average annual rainfall being recorded since 2015 at NPM, except in 2016 and 2020 - 2022 (Figure 3-1).

In addition to these extremes in annual rainfall activity, the monthly averages indicate there has also been high seasonal variability and erratic rainfall activity since monitoring began (Figure 3-2). 2015 was a dry rainfall year with limited rainfall occurring between February and March 2015. Above average rainfall was then experienced in April, July and August which stimulated a flush of annual plant growth during the 2015 monitoring period. April 2016 marked the beginning of a long period of above average monthly rainfall, with record breaking rains falling from April through to October causing widespread flooding. In this nine-month period, 605 mm was recorded, with expected averages also being recorded in November and December. In 2016, a total annual rainfall of 772 mm was recorded on site.

In 2017, very low rainfall activity occurred except for March where 159 mm of rainfall was recorded. Rainfall remained well below the expected monthly averages for most of the year, with a total of 448 mm being recorded for the year. Extremely dry conditions extended in 2018 and these included the key growing seasons in autumn and spring where very limited rainfall fell. Up until November 2018, only 151 mm was received compared to an expected average of 479 mm, with a total of 275 mm recorded for the year.

Drought conditions continued into 2019, with only 189 mm being received up to the end of October, with 47 mm of this being received in January. Below monthly averages were recorded for the year to the end of October and were particularly low prior to the annual flowering event expected in spring. January 2020 marked the end of the prolonged drought conditions with above average monthly rainfall being recorded for most months up until August. Except for October where 115mm was recorded, rainfall was below the average for the remainder of the year but the total rainfall was 796 mm and above the annual average.

These drier conditions extended into January 2021, with good rainfall occurring in February to March, but almost no rainfall was recorded in April, and it was limited in May. In the next few months preceding the orchid surveys rainfall was slightly higher than the expected averages. The total rainfall recorded up to the end of October 2021 was 518 mm which was slightly higher than the expected average of 497 mm for the same period, and there was 741 mm recorded for the year.

Despite limited rain in February and June, above average rainfall continued into 2022 for the third consecutive year, with heavy rains again causing widespread flooding across the region. This year there was 880mm of rain recorded to the end of October which was much higher than the long-term expected average of 500 mm for the same period.

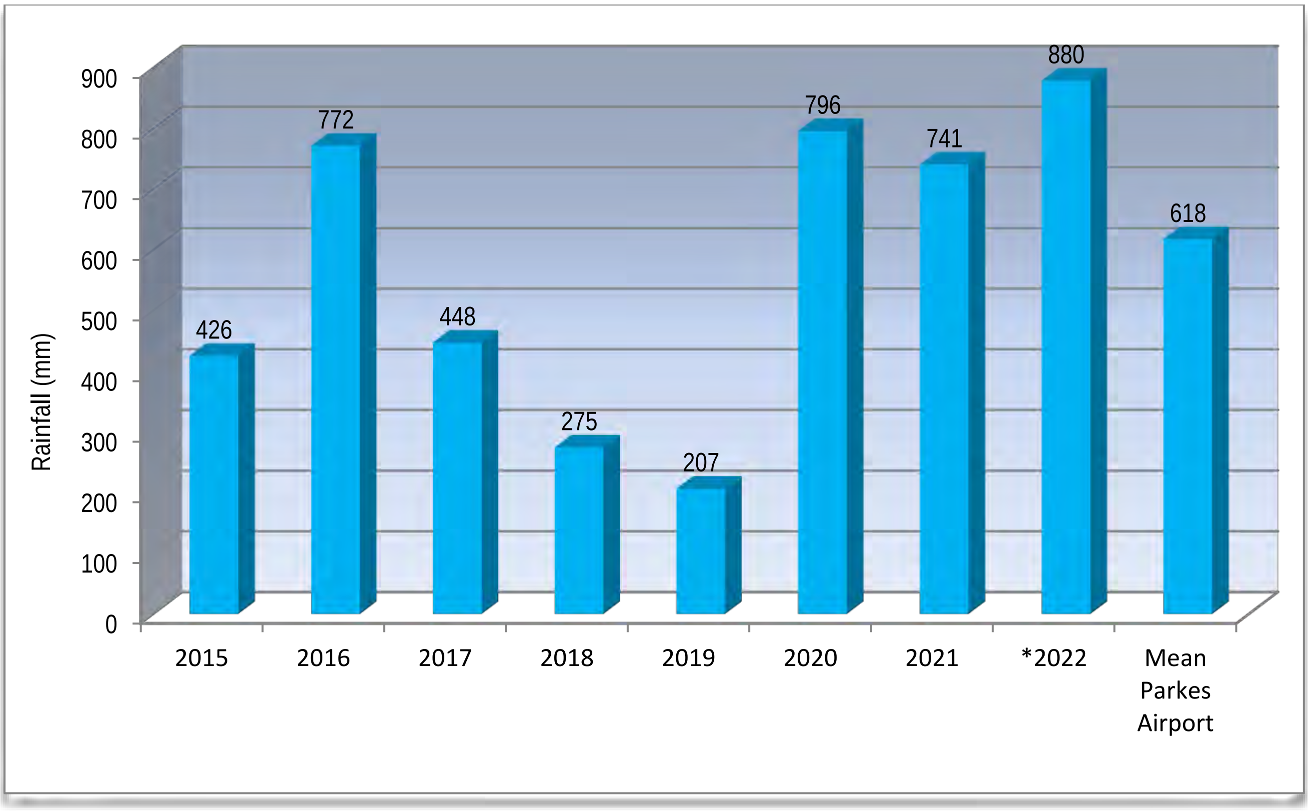


Figure 3-1. Total annual rainfall recorded at NPM January 2015 to the end of October 2022 compared to the long-term averages recorded at Parkes Airport) (BoM 2022).

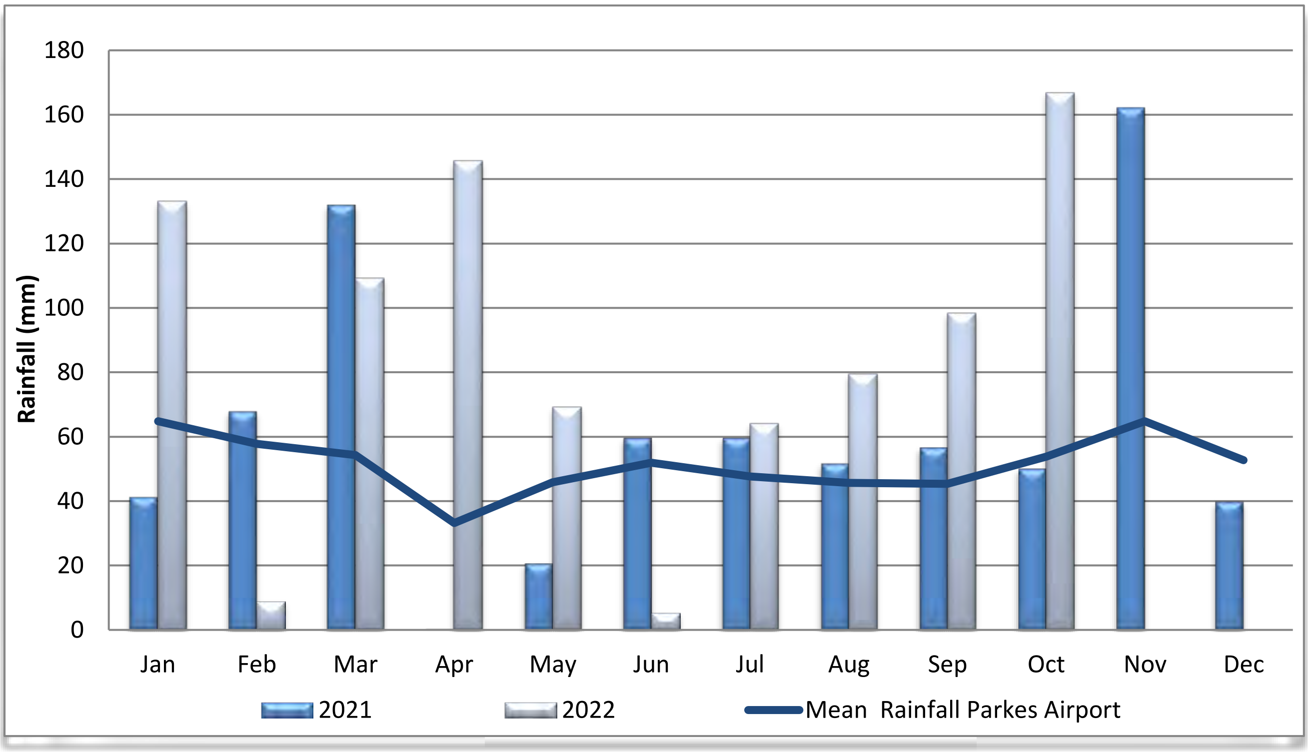


Figure 3-2. Monthly rainfall recorded at NPM January 2019 to the end of October 2022 compared to the long-term monthly averages recorded at Parkes Airport (BoM 2022).

3.2 PDO population densities

The density of *Diuris tricolor* individuals recorded at the two populations have varied significantly over the years, with the seasonal conditions and survey timing having a significant impact on the orchid populations, ground cover abundance and ease of identification. In 2017, exceptionally dry conditions resulted in individuals being stunted with most being 10 - 15cm in height. Some individuals had finished flowering, while others were in bud. In 2018, very dry conditions persisted throughout the year. There was however 31 mm and 29 mm of rain during August and September which promoted the emergence of the Pine Donkey Orchids. The combination of dry conditions and slightly earlier surveying resulted in individuals that were also very small and many were still in bud. In 2019, no individuals were recorded at all as a result of the continued dry conditions and increased grazing pressure by macropods.

The increased growth of the grassy vegetation in 2020 year made locating the orchids more difficult. In the Limestone Forest, the PDOs were growing amongst several other species with yellow flowers and there were large patches of *Echium plantagineum* (Patterson's Curse) in the Callitris woodland areas. In Adavale Lane, the abundance of exotic annual ground covers, including tall dense thickets of *Echium plantagineum* made locating individuals particularly hard, if not impossible. On the northern side of the road *Echium plantagineum* was often taller than the surveyors!

In 2021, seasonal conditions continued to be favourable and, with a lower of height and abundance of weeds, the conditions for locating orchids had significantly improved since 2020. The ongoing seasonal conditions resulted in an increased orchid population, with many individuals growing in close proximity to each other or in tight clumps. Above average rainfall continued into 2022, and while ground cover was abundant it was typically 20 – 30 cm tall and there were significantly fewer weeds, especially at Adavale Lane.

The distribution of individuals found in each of the known populations in 2015 - 2022 is provided in Figure 3-4 and Figure 3-5. Since 2020, additional individuals have been located outside of the exclusion fence, namely to the east, with a small number also being recorded to the west in 2018 and 2020 - 2022. This year 194 individuals were located outside the exclusion fence.

For the period from 2014 - 2022, the highest population counts were recorded this year with total of 2271 orchids, where 1491 orchids were recorded in Limestone Forest, while there were slightly fewer at Adavale Lane with 780 individuals. In 2019, the ongoing drought combined with intensive grazing pressure resulted in no individuals at all being recorded in that year (Table 3-1, Figure 3-3).

Table 3-1. Population densities of *Diuris tricolor* (Pine Donkey Orchid).

Population	2014	2015	2016	2017	2018	2019	2020	2021	2022
Limestone Forest	69	143	485	37	494	0	770	973	1491
Adavale Lane	130	38	603	37	52	0	180	859	780
Total	199	181	1088	74	546	0	950	1832	2271

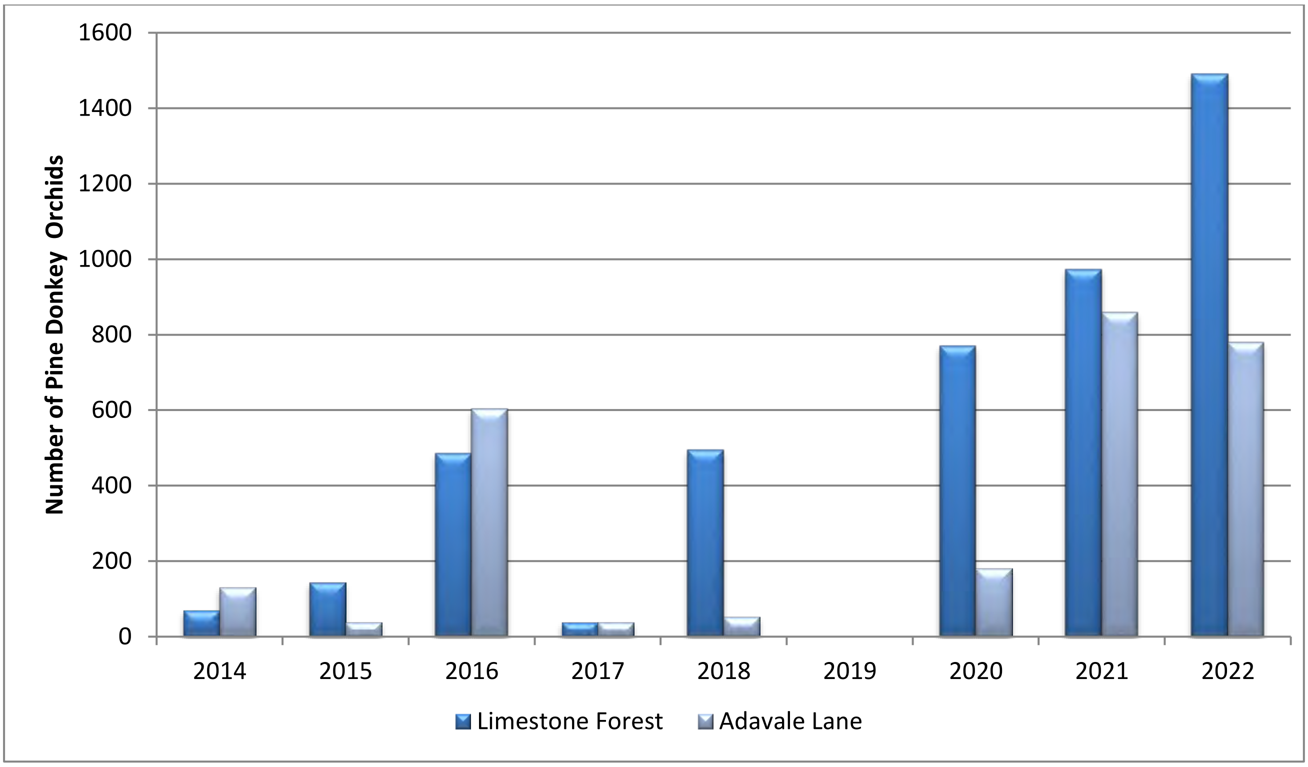


Figure 3-3. Number of Pine Donkey Orchids found in each population since 2014.

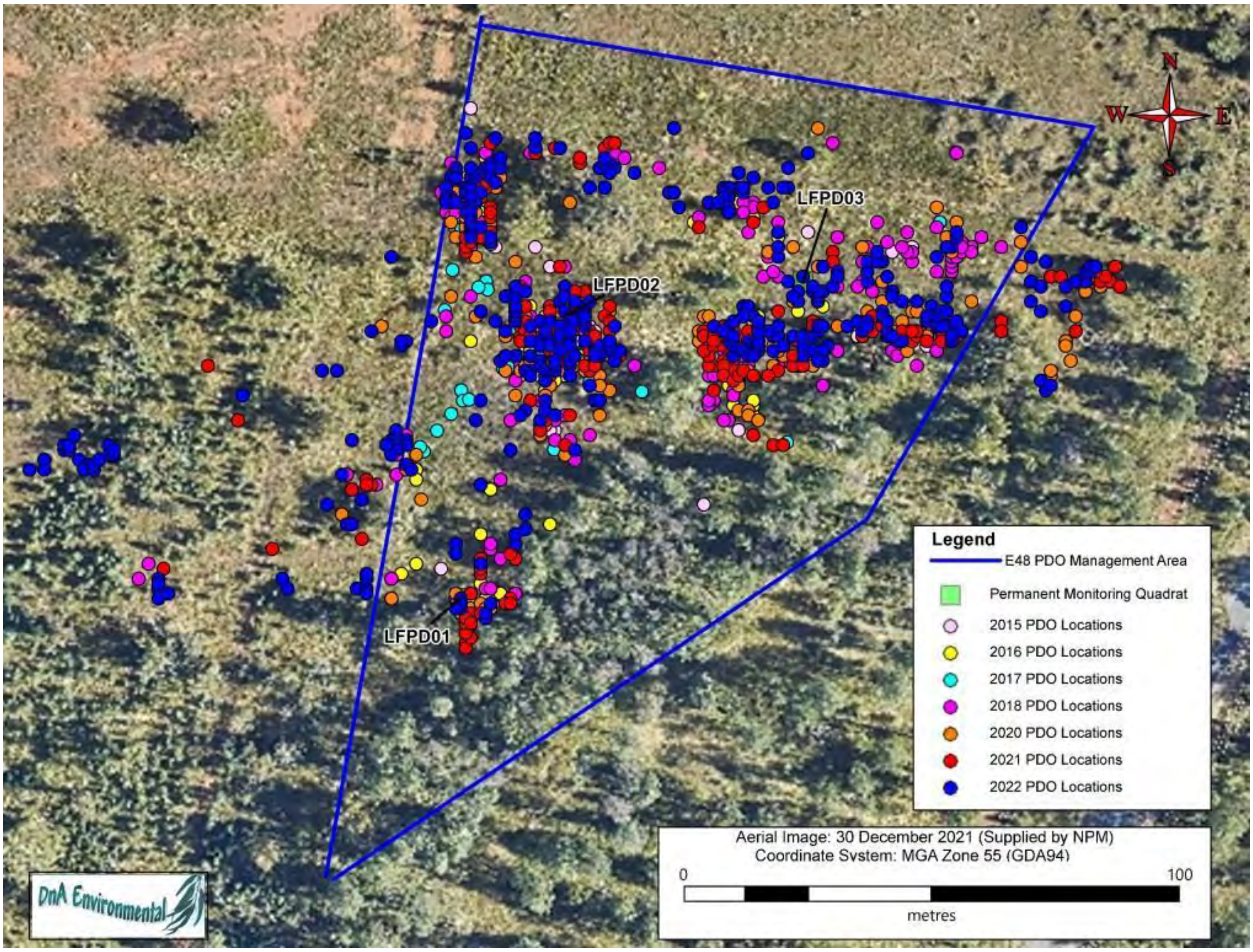


Figure 3-4. Distribution of the *Diuris tricolor* at Limestone Forest 2015 – 2022.

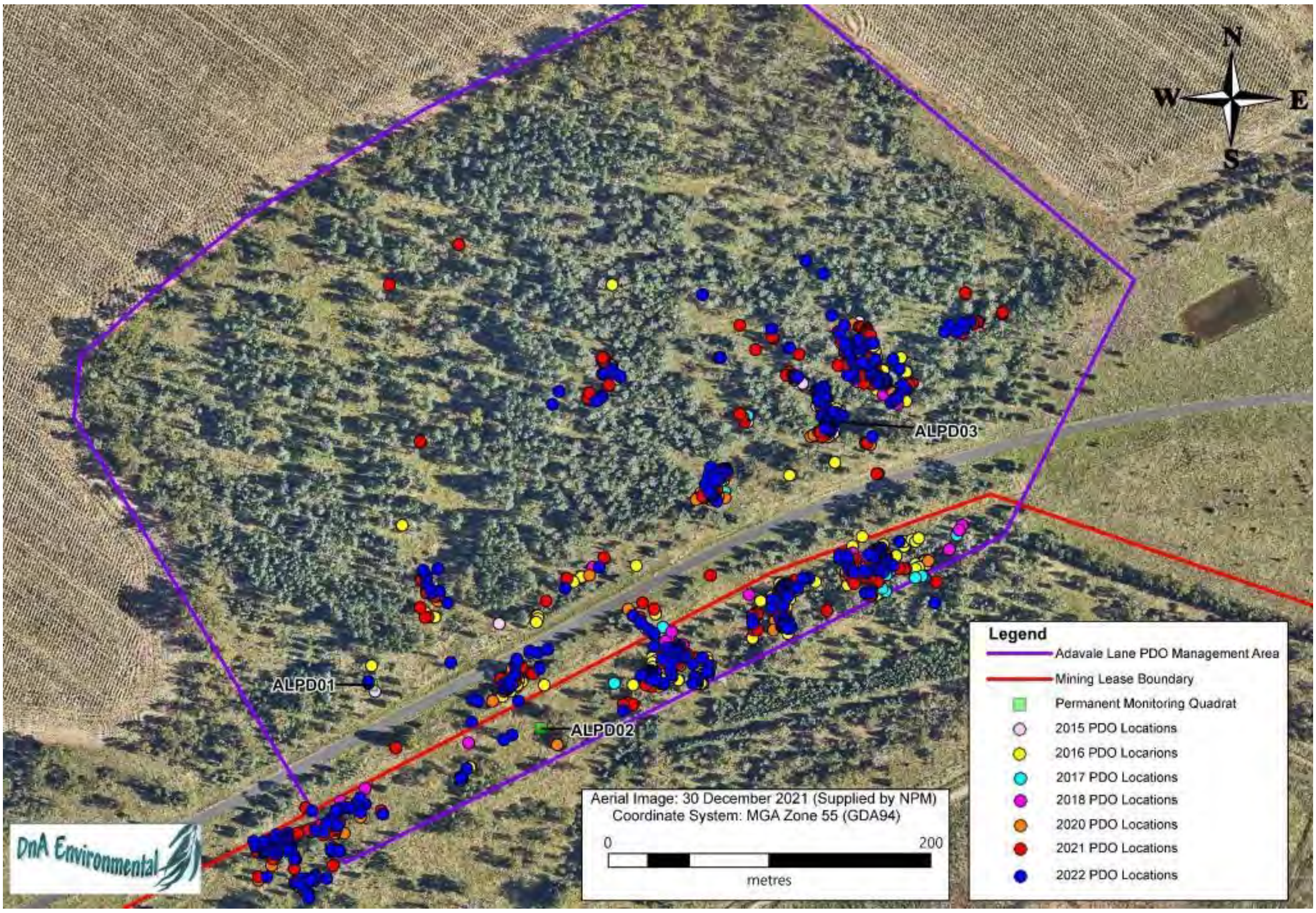


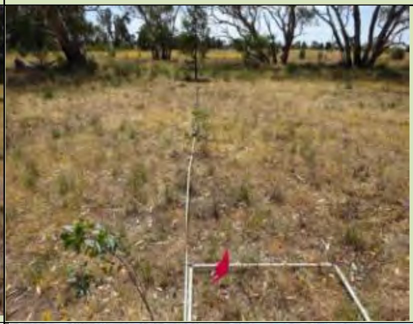
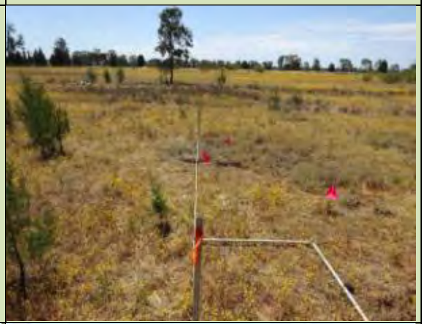
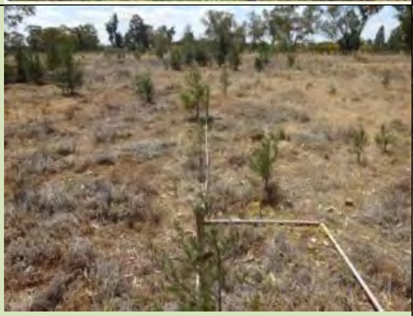
Figure 3-5. Distribution of the *Diuris tricolor* at Adavale Lane 2015 – 2022.

3.3 Photo-points

Permanent photo-points along the vegetation transects within the Limestone Forest (Table 3-2) and Adavale Lane (Table 3-5) have been taken every year since 2015 to illustrate changes occurring in the vegetation communities. Note the *Callitris* regeneration in the Limestone Forest was selectively removed in 2018.

In 2016, site photographs and subsequent data taken in LFPD02 and LFPD03 were named incorrectly by Niche Environment and Heritage in their report that year. Photo-points and vegetation transects may also have not been established along the same transects in 2016, and as result some differences may have been incurred for this reason.

Table 3-2. Photo-points at the three permanent monitoring quadrats established at Limestone Forest during 2015 – 2022.

Year	LFPDO1	LFPDO2	LFPDO3
2015			
2016			
2017			
2018			
2019			

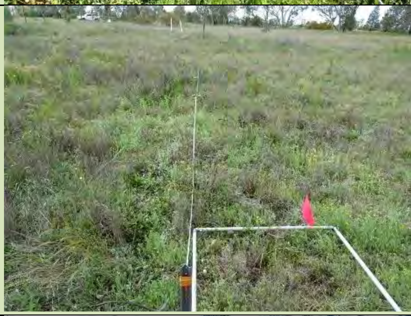
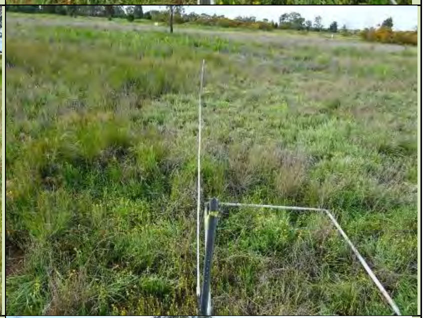
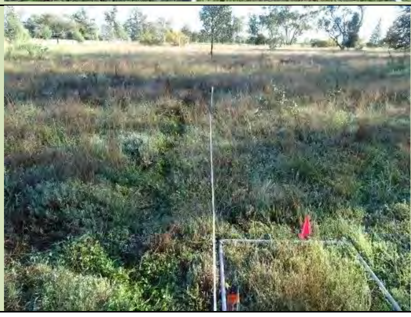
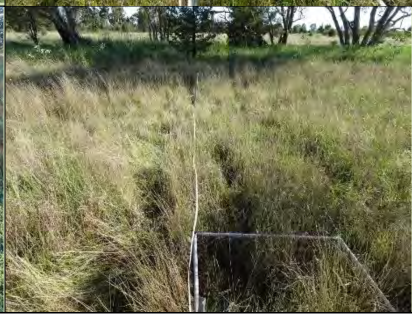
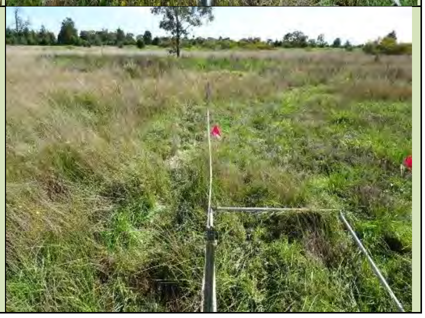
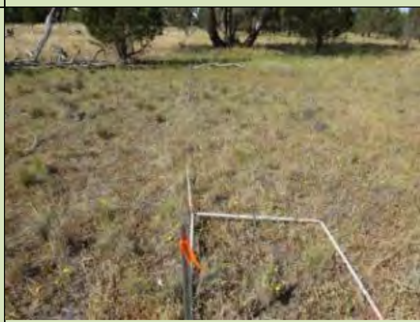
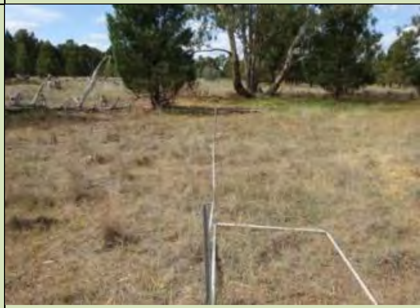
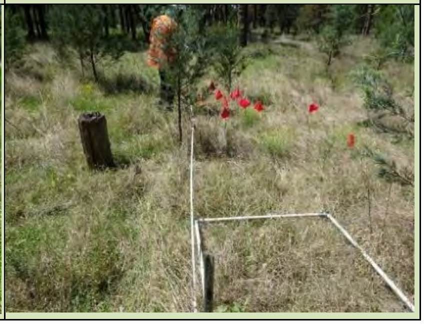
Year	LFPDO1	LFPDO2	LFPDO3
2020			
2021			
2022			

Table 3-3. Photo-points at the three permanent monitoring quadrats established at Adavale Lane during 2015 – 2022.

Year	ALDO1	ALPDO2	ALPDO3
2015			
2016			

Year	ALDO1	ALPDO2	ALPDO3
2017			
2018			
2019			
2020			
2021			

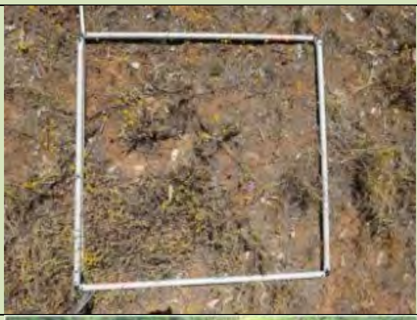
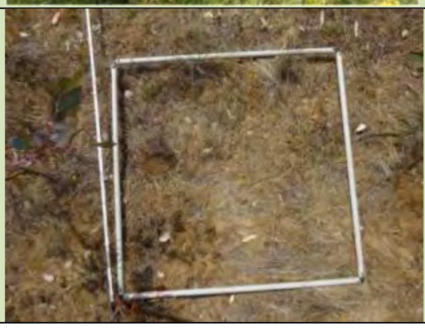
Year	ALDO1	ALPDO2	ALPDO3
2022			

3.4 Ground cover monitoring results

3.4.1 Permanent photo-points

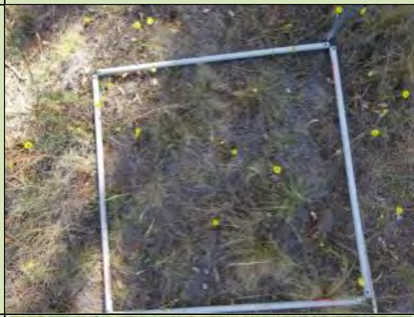
Photo-points of the ground cover in the Limestone Forest (Table 3-4) and Adavale Lane (Table 3-5) monitoring sites have been taken every year since 2015. The photographs clearly illustrate the profound effect that the seasonal conditions and the level of disturbance by animals have had on the ground cover in the various locations. Changes in ground cover abundance and composition have also had an impact of the *Diuris tricolor* populations as evidenced by the fluctuations in population densities.

Table 3-4. Permanent photo-points of the ground cover composition in the Limestone Forest monitoring quadrats.

Year	LFPDO1	LFPDO2	LFPDO3
2015			
2016			
2017			

Year	LFPDO1	LFPDO2	LFPDO3
2018			
2019			
2020			
2021			
2022			

Table 3-5.Permanent photo-points of the ground cover composition in the Adavale Lane monitoring quadrats.

Year	ALPDO1	ALPDO2	ALPDO3
2015			
2016			
2017			
2018			
2019			

Year	ALPDO1	ALPDO2	ALPDO3
2020			
2021			
2022			

3.4.2 Total Ground Cover

Total ground cover, which is a combination of leaf litter, annual plants, cryptogams, rocks, logs and live perennial plants (<0.5m in height) recorded in the Limestone Forest (LF) and Adavale Lane (AL) PDO sites are provided in Figure 3-6 and Figure 3-7. Since 2020 there has been high levels of ground cover at both population sites and 100% ground cover recorded at all monitoring locations this year.

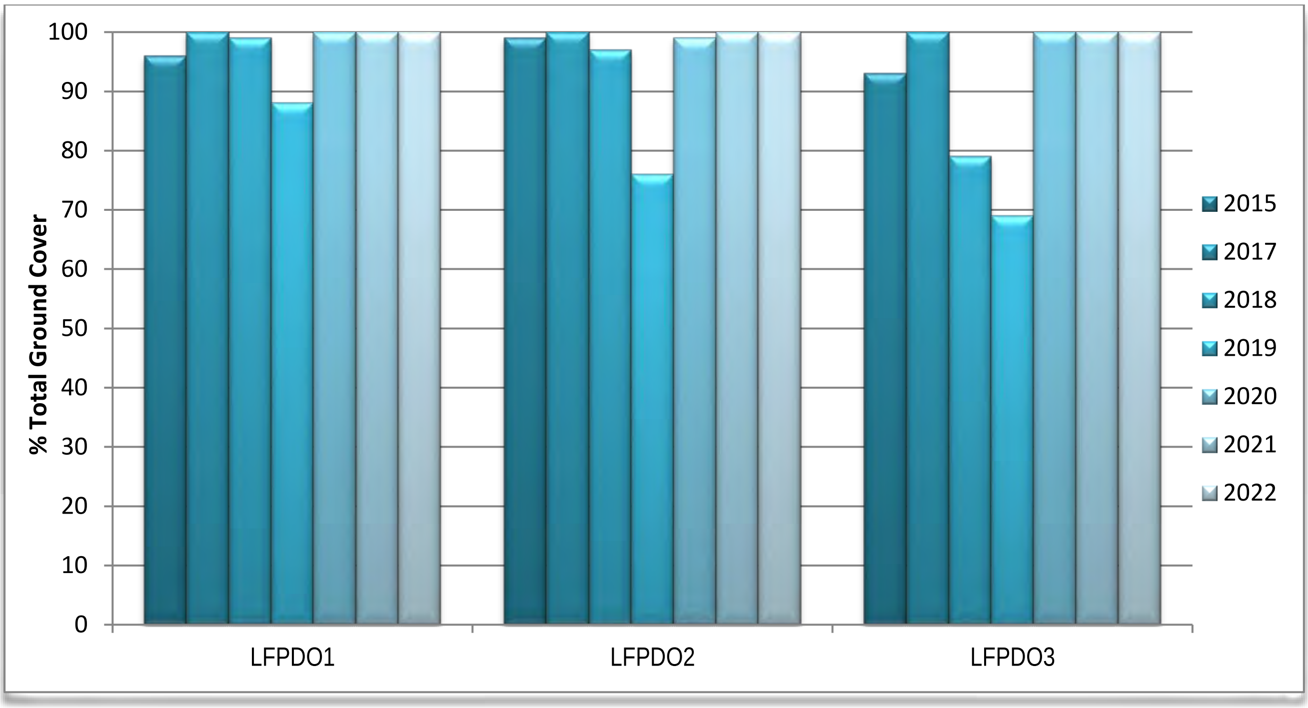


Figure 3-6. Total ground cover recorded in the LF PDO monitoring sites.

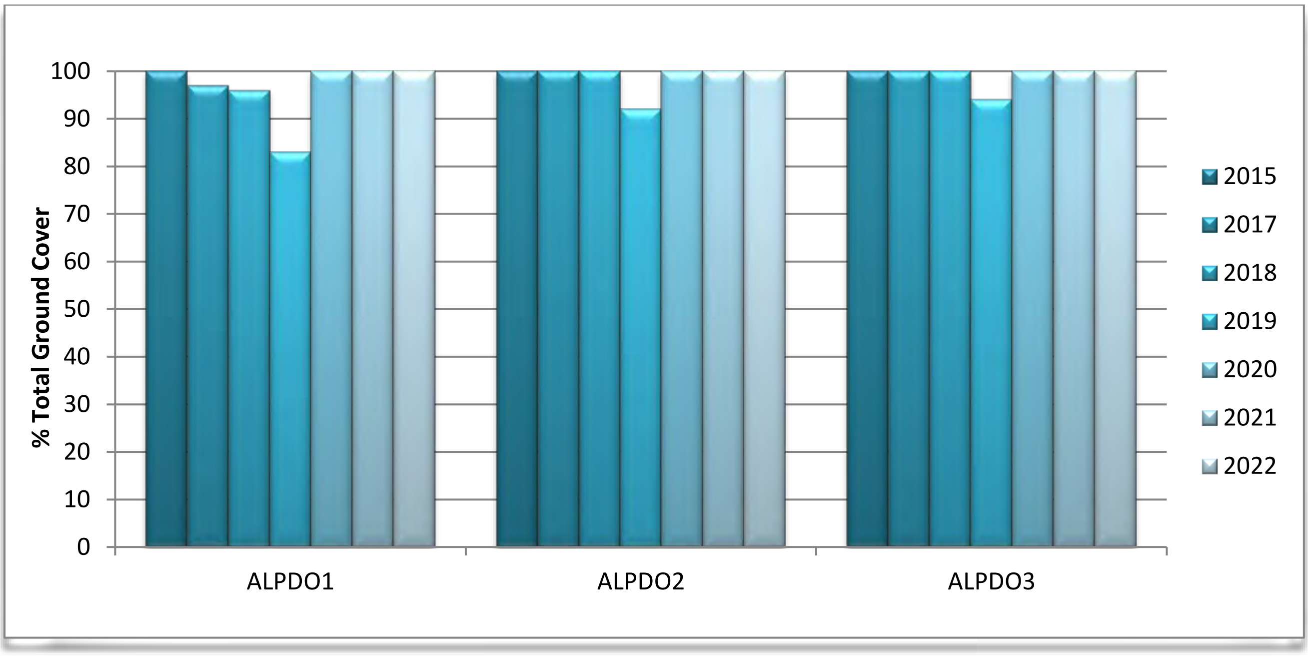


Figure 3-7. Total ground cover recorded in the AL PDO monitoring sites.

3.4.3 Structural composition

The various combinations of the ground covers and structural compositions of the Limestone Forest (LF) and Adavale Lane (AL) PDO sites this year are provided in Figure 3-8 and Figure 3-9.

In the LF sites, there has been a further increase in the cover provided by perennial ground cover in two plots and this year there was 61 – 79% perennial ground cover. There was a simultaneous decrease in dead litter and live annual plant cover, however annual ground covers continued to be relatively abundant in LFPDO1 and LFPDO2 where they provided 20 – 31% cover. There was only 6% annual plant cover in LFPDO3.

After the drought in 2020 the ground cover was almost entirely dominated by annual plants in ALPDO1 and ALPDO3, while in ALPDO2 dead leaf litter was most dominant. There has tended to be an increase in perennial ground covers until 2021, however they were in slightly less abundance and provided 16 – 38% of the total ground cover this year. Dead leaf litter continued to be dominant in ALPDO2 and ALPD03 and provided 50% and 74% cover respectively, while annual plants continued to be quite abundant in ALPDO1 with 52% cover. A small percentage of cryptogam cover was recorded in ALPDO2 this year and a young *Callitris glaucophylla* sapling continued to provide some vertical cover 0.5 – 2.0 m in height in ALPDO3.

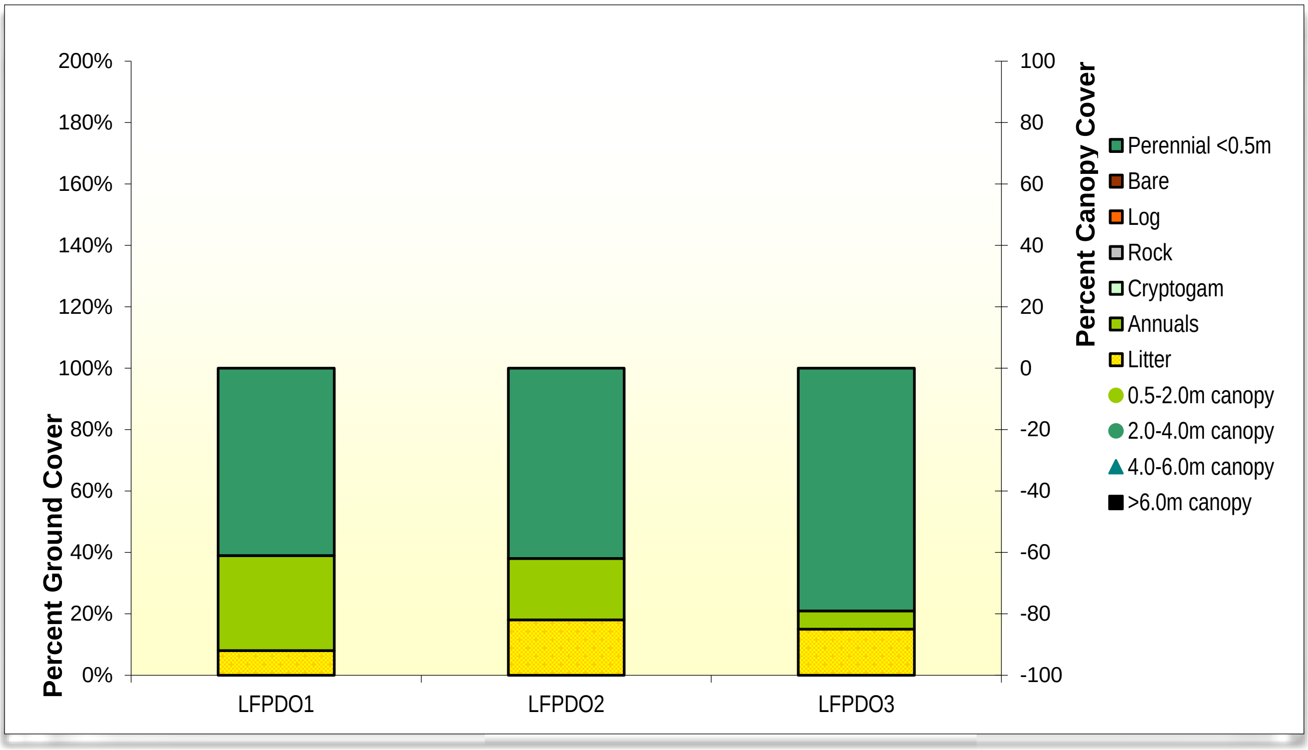


Figure 3-8. Average percent ground cover and projected foliage cover recorded in the LF PDO monitoring sites in 2022.

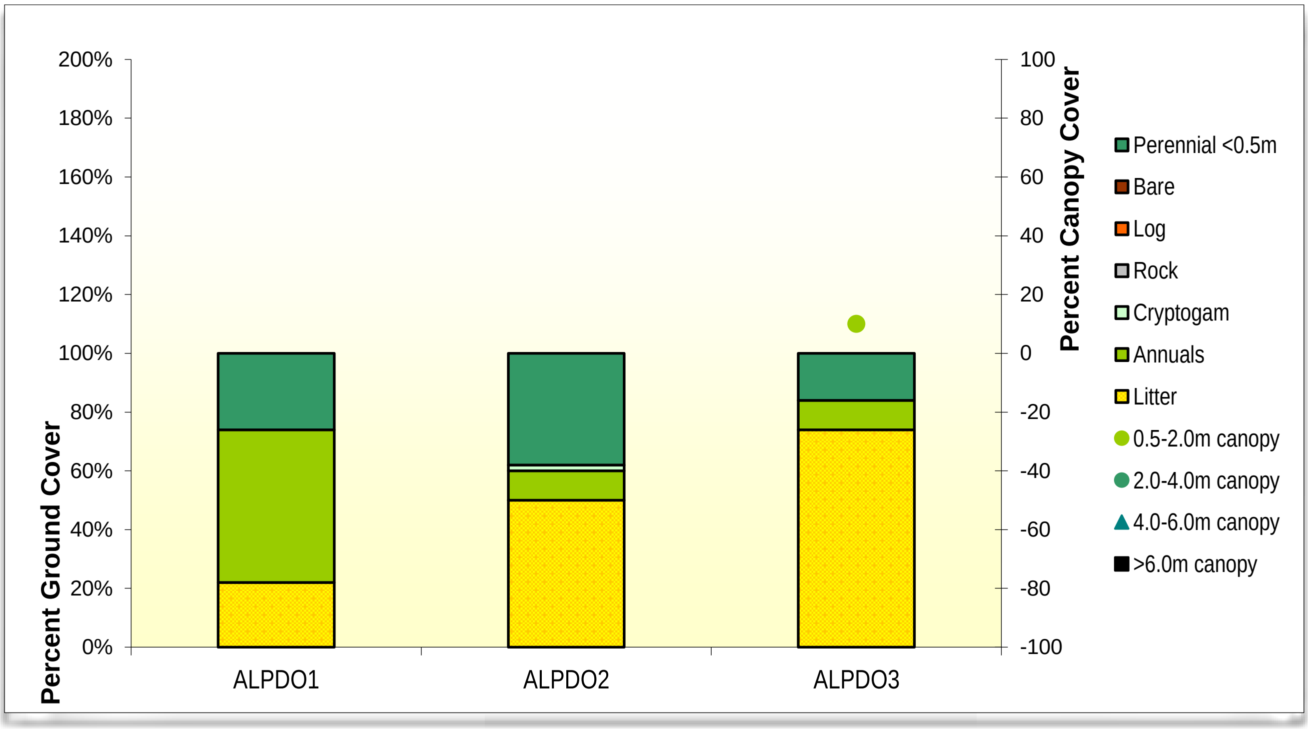


Figure 3-9. Average percent ground cover and projected foliage cover recorded in the AL PDO monitoring sites in 2022.

3.4.4 Floristic diversity

3.4.4.1 Limestone Forest

The total number of live plant species recorded in the 5 x 5m monitoring plots in Limestone Forest 2015 – 2022 is provided in Figure 3-10, where the total diversity of species was 15 – 18 per 5 x 5m monitoring plot . Very dry conditions were experienced during 2017 – 2019 resulting in the lowest diversity of species that have been recorded, with only 2 – 3 species.

Since the break of the drought in 2020, floristic diversity significantly increased to 28 – 32 species, however this also resulted in an increase in exotic species (Figure 3-11). In 2021, there was a slightly lower diversity of species with 22 – 26 species and while there were fewer exotic species in two sites. There were also fewer native species and there was an increased diversity of exotic species in LFPDO2. The favourable seasonal conditions also promoted the growth and abundance of numerous native species including *Diuris tricolor* and a range of other species with similar habitat traits such as *Arthropodium fimbriatum [Dichopogon fimbriatus]* (Nodding Chocolate Lily), *Bulbine bulbosa* (Bulbine Lily) and *Prasophyllum campestre* (Inland Leek Orchid).

In 2022, there was an increase in ground cover growth and higher levels of competition resulting in a further decline in total species diversity in two plots, however diversity increased in LFPDO3 due to an increased diversity of exotic species. This year there were 17 – 26 species recorded in the 5 x 5 monitoring quadrats, with 6 – 10 or 30 – 41% of these being exotic species.

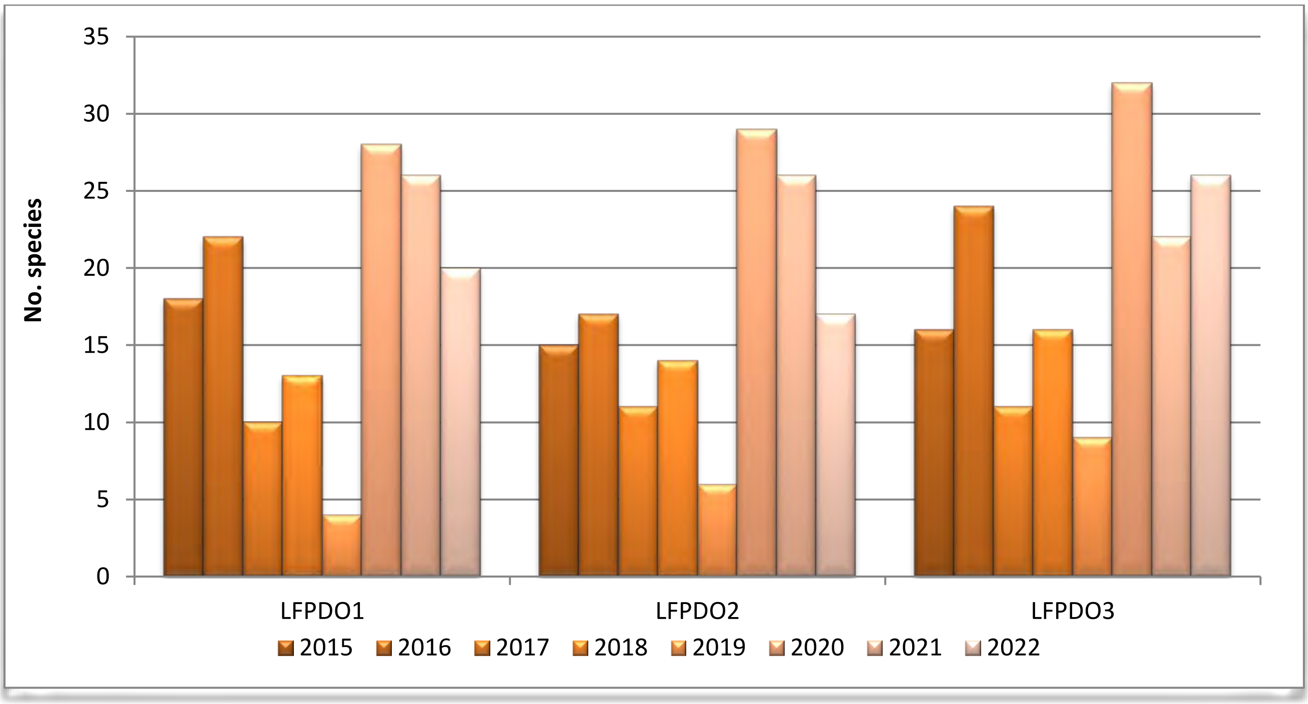


Figure 3-10. Total species diversity recorded in the LFPDO monitoring sites.

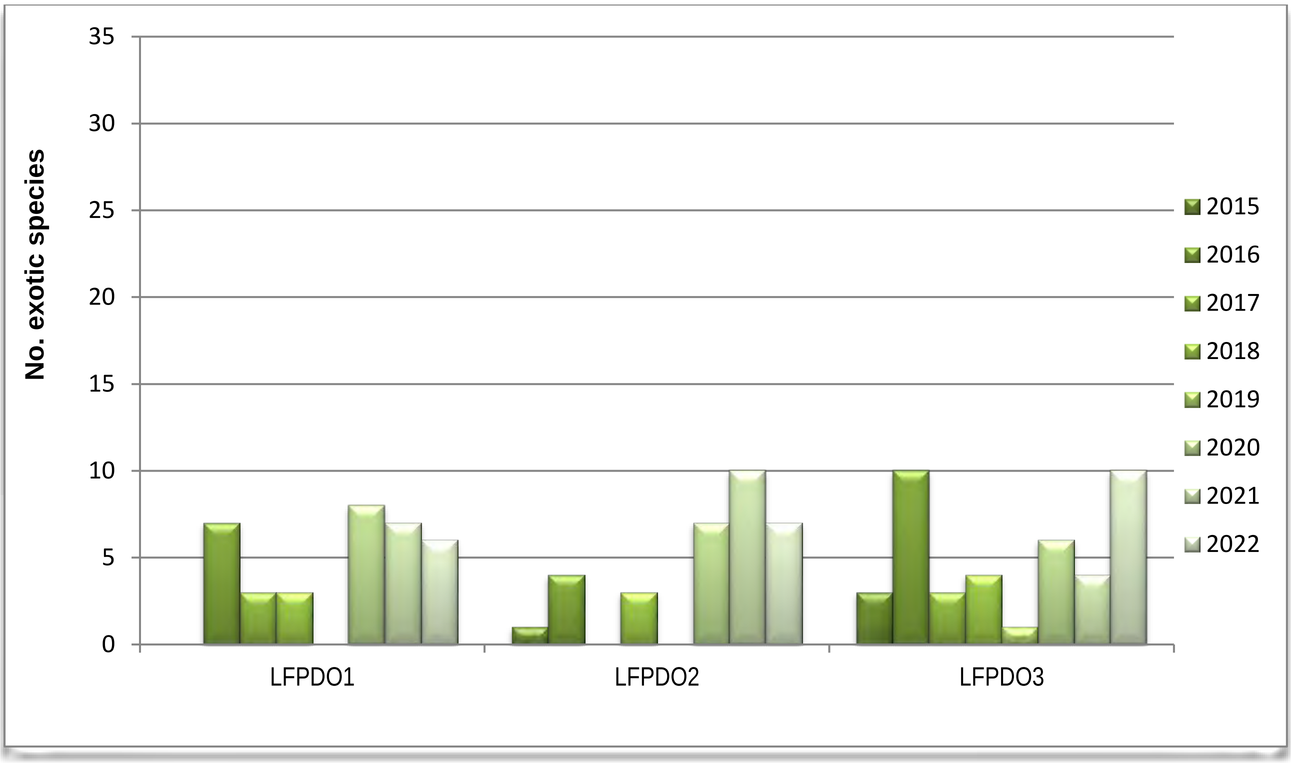


Figure 3-11. Exotic species diversity recorded in the LFPDO monitoring sites.

3.4.4.2 Adavale Lane

The total number of live plant species recorded in the three 5x5m monitoring plots at Adavale Lane 2015 – 2022 are provided in Figure 3-12. At Adavale Lane, floristic diversity has been variable within and between the three monitoring plots. In 2015 when monitoring first began there were 22 – 25 species in the monitoring plots, of which 6 – 11 (27 – 44%) were exotic species.

Since then, there has typically been a declining trend in diversity including a simultaneous decline in the diversity of exotic annual species (i.e. weeds) due to the enhanced growth of persisting perennial species such as native grasses as a result of the reduction in disturbance such as grazing. The drought conditions 2017 – 2019 however had the most significant impact on the diversity and composition of the grassy ground covers, and ALPDO1 was also subjected to very heavy grazing by travelling stock during this time.

A total of only 2 – 3 native species was recorded in the three plots and no exotic species were recorded in any site in 2019. In 2020, drought conditions were finally broken and above average rainfall in 2020 and 2021 resulted in an increase in floristic diversity across all sites, however there was also an increased diversity of exotic species in two sites. This year there were 30 – 32 species recorded in the 5 x 5m monitoring quadrats, where 7 – 15 (23 – 48%) species were exotic.

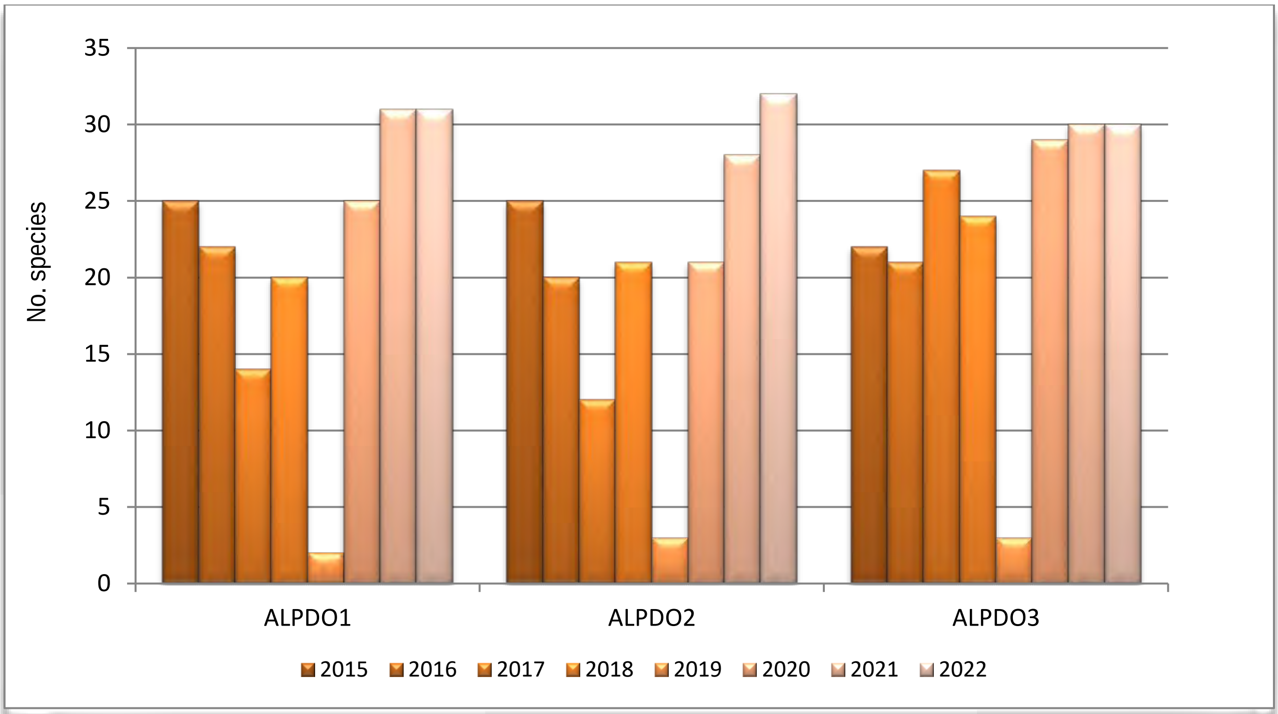


Figure 3-12. Total species diversity recorded in the ALPDO monitoring sites.

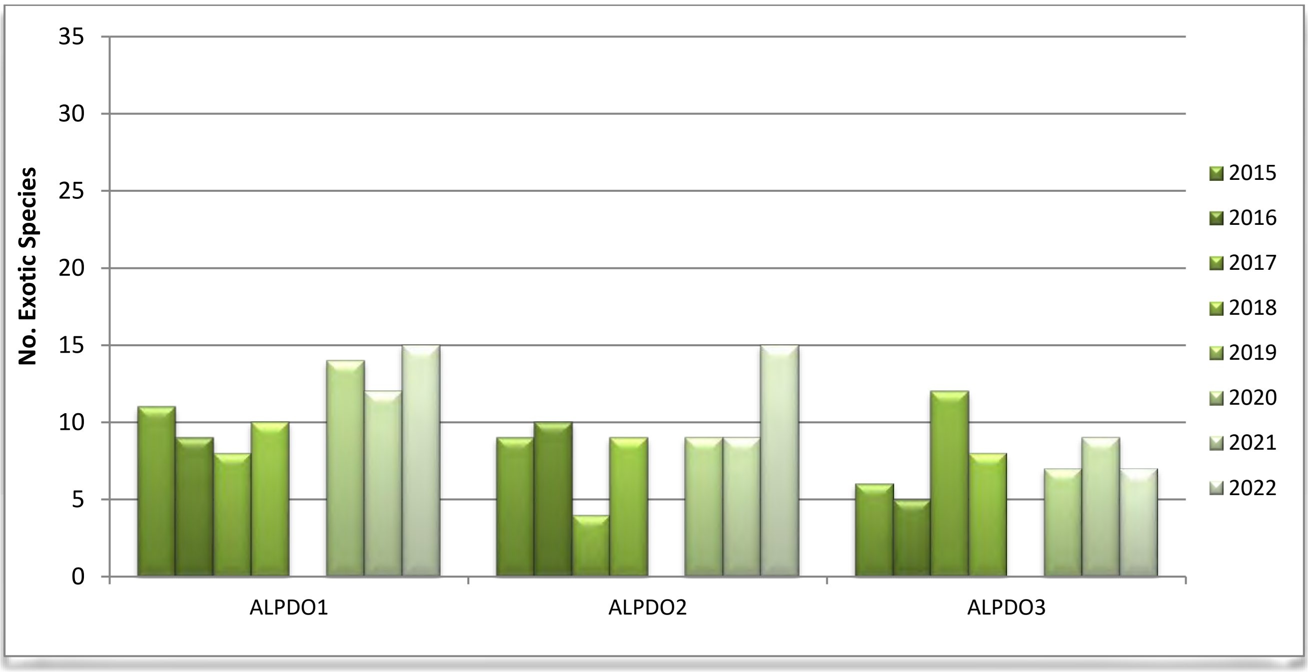


Figure 3-13. Exotic species diversity recorded in the ALPDO monitoring sites.

3.4.5 Average species diversity/m²

Overall, ground cover diversity was typically higher in the AL populations but they also tended to contain a higher diversity of weeds. In the LF sites the average number of native species per m^2 has declined from 7.8 – 8.2 to 5.2 - 6.2/m^2, while the average diversity of exotic species has increased from 1.2 – 3.8 to 3.2 – 4.0/m^2 (Table 3-6). In the AL populations, the diversity of native species per m^2 has increased to 5.6 – 8.6 on average, with there also being an increase in exotic species with 3.0 – 8.0 exotic species/m^2 this year.

Table 3-6. The average number of native and exotic species /m2 in each monitoring plot in 2022.

Site Name	Native species/m2	Exotic species/m2	Total species/m2
LFPDO1	6.2	3.2	9.4
LFPDO2	5.2	4.0	9.2
LFPDO3	5.8	3.8	9.6
ALPDO1	5.6	8.0	13.6
ALPDO2	8.6	4.4	13.0
ALPDO3	8.2	3.0	11.2

3.4.6 Pine Donkey orchid densities in the quadrats

The density of PDO's found in the 5x5m monitoring plots have varied over the years with none being recorded in the small monitoring plots in 2017 or 2019, while none were recorded anywhere at all in 2019 at the height of the drought. This year there were 2 – 4 orchids in the Limestone Forest plots and 0 – 17 at Adavale Lane (Figure 3-14).

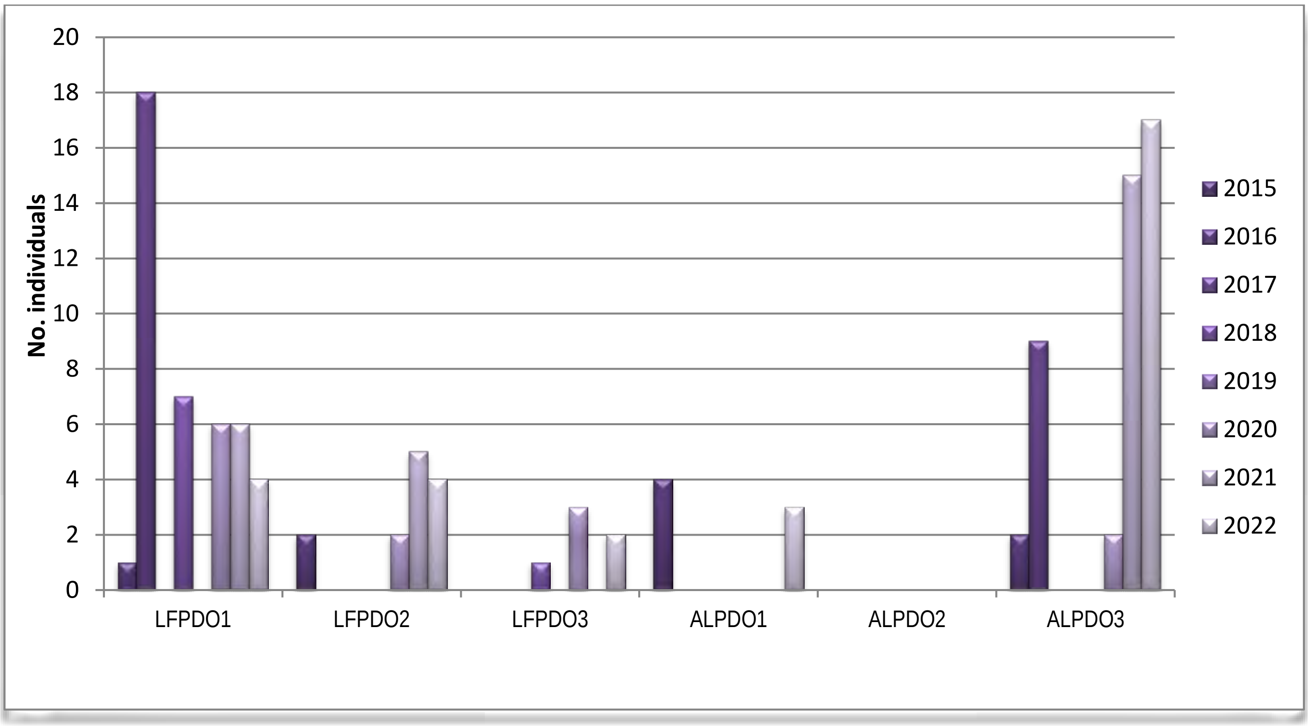


Figure 3-14. Density of PDO's found in the 5x5m monitoring plots

3.4.7 Tree and shrub seedling densities in the quadrats

The density of *Callitris glaucophylla* (White Cypress Pine) and *E. dwyeri* (Dwyer's Red Gum) seedlings and/or saplings have also been monitored over the years. In 2015 when monitoring first began, there were scattered *Callitris* seedlings in all LF plots while in LFPDO2, seven *E. dwyeri* seedlings/saplings were also recorded with two individuals exceeding 2m in height. In ALPDO1 there was one large *Callitris* sapling and in ALPDO3 there were four *C. glaucophylla* seedlings (Figure 3-15).

In 2018, no *Callitris* seedlings/saplings were recorded as a result of the selective removal program in the Limestone Forest exclosure area, while *E. dwyeri* saplings were retained in LFPDO2. After the drought in 2020 some new *E. dwyeri* regeneration was observed at Limestone Forest. During 2020 – 2021 *E. dwyeri* seedlings were recorded in two LF plots and this year there was a significant increase in *E. dwyeri* seedlings <1.0m tall.

There continued to be one large *Callitris* individual in ALPDO1 (22 cm dbh), while four *Callitris* seedlings < 2.0m tall continued to be recorded in ALPDO3.

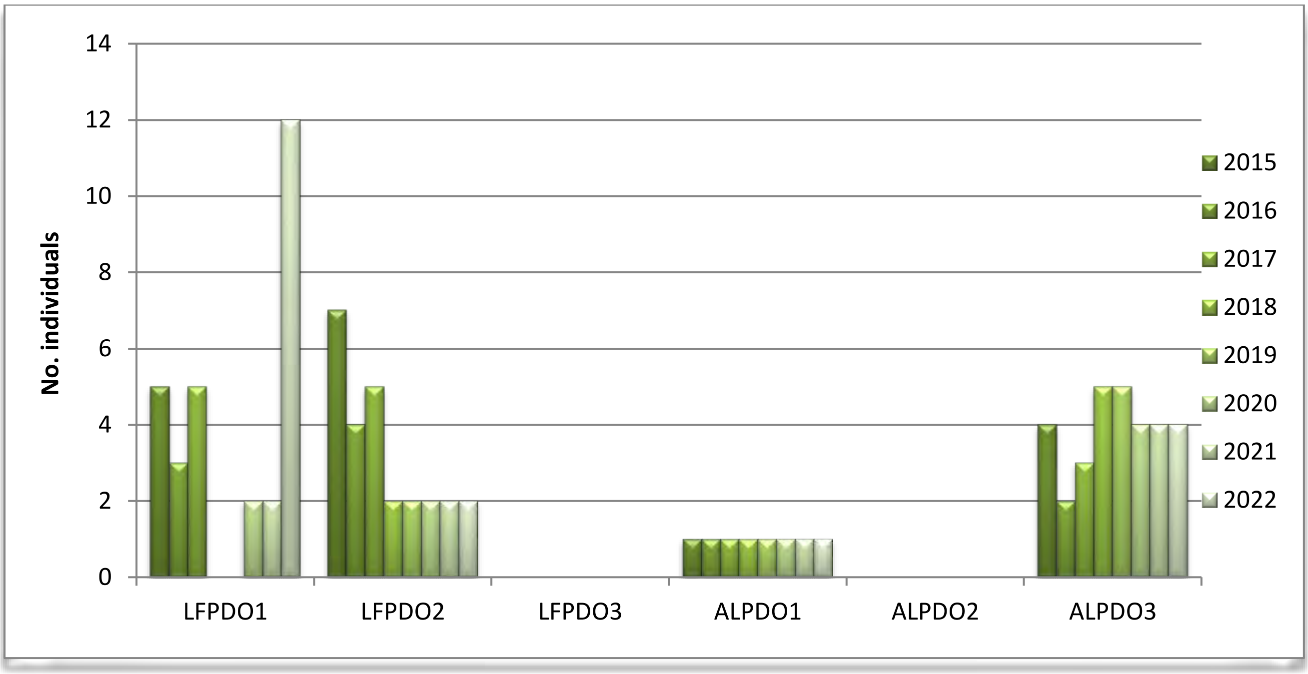


Figure 3-15. Density of tree and shrub seedlings recorded in the 5 x5 m monitoring plots.

3.4.8 Percent native ground cover

The percent native ground cover is an ecological indicator used to provide some measure of the cover abundance of the live native vegetation along the vegetation transect and therefore indicates the level of weediness at the monitoring sites. While it is only an estimation, the percent cover of endemic ground cover species has been derived by the following equation:

Percent cover endemic species = sum of the five Braun- Blanquet scores for native species / (sum of the five Braun- Blanquet scores of exotic species + native species) x 100.

In agricultural areas, the percentage of live native plant cover often tends to increase during drier seasonal conditions as growth of many exotic annual species cannot be sustained, thus leaving the hardier native perennial ground cover to provide most of the live ground cover. In more favourable seasonal conditions, the opposite can often occur.

There has been high variability in the proportion of ground cover provided by native species between the two PDO populations, with the higher percentage of native cover typically being recorded in the LF population. In 2019 however the drought conditions resulted in only the hardiest native perennial ground covers to persist and almost all surviving plants were native. Since the drought was broken in 2020 there has been a significant plant growth resulting in a high abundance of exotic (annual) species, subsequently reducing the proportion of native ground covers. Despite a further decline in native plant cover in Limestone Forest, native plants continued to be more abundant than exotics, where native plants provided 63 – 67% cover across the sites (Figure 3-16).

In Adavale Lane, the percent live native plant cover also tended to increase during the drought, however in 2020 there was a significant increase in exotic plant growth resulting in a reduction in cover provided by native plants. Similarly to Limestone Forest, native plant cover increased last year but has slightly declined this year with native plants providing 46 - 74% cover this year.

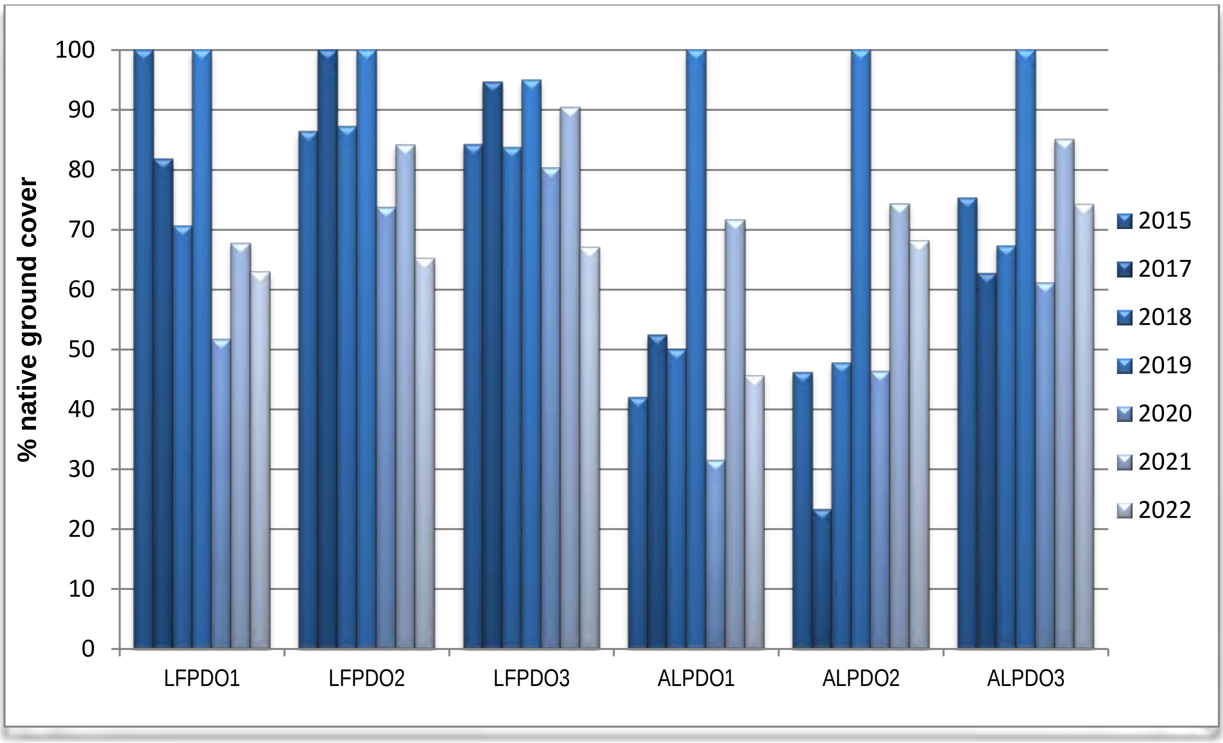


Figure 3-16. Percent endemic ground cover recorded in the PDO monitoring sites.

3.4.9 Common species recorded at Limestone Forest

Table 3-7 provides a list of species that were recorded in all three monitoring plots this year, with 10 species recorded in all three Limestone Forest monitoring sites. Native species recorded in all sites included the native grass *Aristida jerichoensis var. jerichoensis* (Jericho Wiregrass), while there were a range of other native herbs such as *Bulbine bulbosa* (Bulbine Lily), *Cheilanthes sieberi* subsp. *sieberi* (Rock Fern) and *Chrysocephalum apiculatum* (Common Everlasting). This year two native orchids including *Diuris tricolor* (Pine Donkey Orchid) and *Pterostylis bicolor* (Bicolor Greenhood) were also located in all three plots.

This year four exotic species were common to all sites and included *Sonchus oleraceus* (Milk Thistle), *Trifolium arvense* (Haresfoot Clover), *Trifolium subterraneum* (Subterraneum Clover) and *Vulpia muralis* (Rats-tail Fescue). A comprehensive list of species recorded in the PDO monitoring sites in 2022 has been provided in Appendix 1.

Table 3-7. Common species recorded in the Limestone Forest population in 2022.

Family	exotic	Scientific Name	Common Name	Habit
Poaceae		*Aristida jerichoensis var. jerichoensis*	Jericho Wiregrass	g
Asphodelaceae		*Bulbine bulbosa*	Bulbine Lily	h
Adiantaceae		*Cheilanthes sieberi*	Rock Fern	f
Asteraceae		*Chrysocephalum apiculatum*	Common Everlasting	h
Orchidaceae		*Diuris tricolor*	Pine Donkey Orchid	h
Orchidaceae		*Pterostylis bicolor*	Bicolor Greenhood	h
Asteraceae	*	*Sonchus oleraceus*	Milk Thistle	h
Fabaceae (Faboideae)	*	*Trifolium arvense*	Haresfoot Clover	h
Fabaceae (Faboideae)	*	*Trifolium subterraneum*	Subterraneum Clover	h
Poaceae	*	*Vulpia muralis*	Rats-tail Fescue	g

Key to habit legend: t = tree; s = shrub; ss =sub-shrub; h = herb; g = grass, r = reed; v = vine; f = fern; p = parasite

3.4.10 Common species recorded at Adavale Lane

This year 15 species were recorded in all three Adavale Lane monitoring plots (Table 3-8).

Common native ground covers were *Arthropodium fimbriatum [Dichopogon fimbriatus]* (Nodding Chocolate Lily), *Bulbine bulbosa* (Bulbine Lily), *Calotis lappulacea* (Yellow Burr Daisy), *Cheilanthes sieberi* subsp. *sieberi* (Rock Fern), *Dichondra repens* (Kidney Weed), *Sida corrugata* (Corrugated Sida) and *Vittadinia cuneata* (Fuzzweed) which were common to all three sites. The most common native grasses were *Anthosachne [Elymus] scabra* (Common Wheatgrass) and *Panicum effusum* (Hairy Panic).

There were also five exotic species *Lactuca serriola* (Prickly Lettuce), *Sonchus oleraceus* (Milk Thistle), *Trifolium arvense* (Haresfoot Clover) and *Trifolium glomeratum* (Clustered Clover) recorded in the three sites. A comprehensive list of species recorded in the PDO monitoring sites in 2022 has been provided in Appendix 1.

Table 3-8. Common species recorded in the Adavale Lane population in 2022.

Family	exotic	Scientific Name	Common Name	Habit
Poaceae		*Anthosachne [Elymus] scabra*	Common Wheatgrass	g
Asparagaceae		*Arthropodium fimbriatum*	Nodding Chocolate Lily	h
Poaceae		*Austrostipa scabra*	Speargrass	g
Asphodelaceae		*Bulbine bulbosa*	Bulbine Lily	h
Asteraceae		*Calotis lappulacea*	Yellow Burr Daisy	h
Adiantaceae		*Cheilanthes sieberi*	Rock Fern	f
Convolvulaceae		*Dichondra repens*	Kidney Weed	h
Asteraceae	*	*Lactuca serriola*	Prickly Lettuce	h
Poaceae		*Panicum effusum*	Hairy Panic	g
Caryophyllaceae	*	*Petrorhagia nanteuilii*	Proliferous Pink	h
Malvaceae		*Sida corrugata*	Corrugated Sida	h
Asteraceae	*	*Sonchus oleraceus*	Milk Thistle	h
Fabaceae (Faboideae)	*	*Trifolium arvense*	Haresfoot Clover	h
Fabaceae (Faboideae)	*	*Trifolium glomeratum*	Clustered Clover	h
Asteraceae		*Vittadinia cuneata*	Fuzzweed	h

Key to habit legend: t = tree; s = shrub; ss =sub-shrub; h = herb; g = grass, r = reed; v = vine; f = fern; p = parasite

3.5 Most abundant species

The most abundant species recorded in each of the PDO monitoring sites this year are provided in Table 3-9. The most abundant species were those that collectively summed to a Braun-Blanquet total of 10 or more from the five replicated sub-plots along the vegetation transect. The maximum score that can be obtained by an individual species is 30.

In the Limestone Forest survey area, the native perennials *Aristida jerichoensis var. jerichoensis* (Jericho Wiregrass) and *Chrysocephalum apiculatum* (Common Everlasting) continued to be relatively abundant in all sites, and the exotic annual *Trifolium subterraneum* (Subterraneum Clover) was abundant in patches. In LFPDO2 and LFPDO3 *Bulbine bulbosa* (Bulbine Lily) were also quite abundant while *Cheilanthes sieberi subsp. sieberi* (Rock Fern) was also abundant in LFPDO2.

At Adavale Lane, the exotic annuals have significantly declined in abundance this year, however *Trifolium repens* (White Clover) continued to be abundant in ALPDO1 along with natives *Cheilanthes sieberi* and *Vittadinia cuneata* (Fuzzweed). Native grasses *Anthosachne [Elymus] scabra* provided the most cover in ALPDO2, while *Dichondra* *repens* and *Panicum effusum* (Hairy Panic) provided the most cover in ALPDO3. The cover of abundance of individual species recorded in each monitoring plot has been provided in Appendix 2.

Table 3-9. The most abundant species recorded in the PDO monitoring sites in 2022.

Exotic	Scientific Name	Common Name	Habit	LFPDO1	LFPDO2	LFPDO3	ALPDO1	ALPDO2	ALPDO3
*	*Trifolium subterraneum*	Subterraneum Clover	h	19		14			
	Aristida jerichoensis var. jerichoensis	Jericho Wiregrass	g	12	16	10			
	Chrysocephalum apiculatum	Common Everlasting	h	17	10	22			
	Bulbine bulbosa	Bulbine Lily	h		11	11			
	Cheilanthes sieberi subsp. sieberi	Rock Fern	f		15		11		
*	*Trifolium repens*	White Clover	h				13		
	Vittadinia cuneata	Fuzzweed	h				14		
	Anthosachne [Elymus] scabra	Common Wheatgrass	g					12	
	Dichondra repens	Kidney Weed	h						14
	Panicum effusum	Hairy Panic	g						10

3.6 Threatened species

Swainsona sericea (Silky Swainsona) was recorded in the Limestone Forest area and identification was confirmed by the National Herbarium of NSW in 2015. *Swainsona sericea* is listed under the NSW Biodiversity Conservation Act as vulnerable. Since 2020 a small population of *Prasophyllum campestre,* another species of orchid was also growing in the Limestone Forest. While it is not a listed species, its presence in the site for the first time in 2020 is of interest. Since 2021, the abundance of *Swainsona sericea* and *Prasophyllum campestre* appears to have increased with the improved seasonal conditions.

Figure 3-17. *Swainsona sericea* (left) and *Prasophyllum campestre* *(right) in the Limestone Forest PDO exclusion site. *Photo: A. Johnston, R. Mjadwesch.

3.7 Weeds

Meandering transects are undertaken to locate orchids as well as to identify any weeds which may have the potential to impact on the orchid populations. Previously a range of annual exotic herbs and grasses were frequently found throughout the survey areas, with most being common agricultural weeds that have become naturalised in the local area. Areas that were particularly dominated by annual weeds such as *Echium plantagineum* (Paterson's Curse) and *Sisymbrium irio* (London Rocket) were typically under tree canopies as a result of old stock camps developed under previous grazing regimes.

During the drought, annual weeds typically occurred in limited abundance, however in 2020 when rainfall conditions improved, annual exotics such as *Trifolium subterraneum* (Subterraneum Clover) had become quite dominant through the Limestone Forest PDO monitoring sites. In Adavale Lane several species of Trifolium were abundant, especially *Trifolium arvense* (Haresfoot Clover). Increased grazing and disturbance by wildlife (i.e. macropods) in both the Limestone Forest and Adavale Lane, also resulted in the understorey of the Callitris dominated woodlands to become dominated by *Echium plantagineum,* which was often 1.5 - 2.0m tall in 2020 (Figure 3-18). *Arctotheca calendula* (Capeweed) was also abundant in patches throughout the Limestone Forest area. In 2021, the seasonal conditions continued to be favourable and increasing competition of the more desirable species, there was a reduction in the abundance and growth rates of exotic annual weeds.

This year there continued to be a range of common exotic species in the Limestone Forest and Adavale Lane areas that have become widely naturalised throughout the surrounding agricultural areas. The most abundant of these have been described in Section 3.5, with many of these being a variety of *Trifolium* species which continue to be quite abundant. The more undesirable weeds such as *Echium plantagineum*, *Arctotheca calendula* and *Cirsium vulgare* were in limited abundance compared to previous years and were largely restricted to small pockets of higher disturbance such as old stockcamps and/or areas where kangaroos frequently camp (Figure 3-19).

Figure 3-18. In 2020 the understorey of the Callitris woodlands were dominated by 1.5 - 2.0m *Echium plantagineum* in both the Limestone Forest and Adavale Lane PDO surveys areas

Figure 3-19. This year, undesirable weeds were less abundant in both the Limestone Forest and Adavale Lane PDO surveys areas.

3.8 Fence inspections

The exclusion fence around the Limestone Forest population previously appeared to be in good working order, with little to no evidence of overgrazing by macropods. In 2019, the ongoing drought resulted in macropods breaching the exclusion fence as fodder became more and more limited. As a result, the height of the exclusion fence was increased in an attempt to prevent macropods from entering the protected area. In 2020, the exclusion fence was replaced by a larger stronger fence and there has been no evidence of grazing by macropods since then.

The fences at AL appear to be adequate to prevent grazing from travelling livestock from the wider conservation areas. The narrow roadside verges included in the Adavale Lane population are intermittently grazed by travelling stock. In 2019 heavy grazing and disturbance by macropods continued to be evident in the roadside verges as well as the larger wooded conservation area to the north of Adavale Lane. Since 2020, there has been little evidence of grazing by livestock.

4 Conclusion

The orchid population densities, ground cover abundance and floristic diversity at Limestone Forest E48 area and Adavale Lane appear to be inherently implicated with the changes in seasonal conditions which is also compounded with changes in grazing pressure by resident macropods. The unfenced roadside population at Adavale Lane may also be periodically impacted by travelling stock. Population densities of *Diuris tricolor* have been the lowest when rainfall was limited prior to and during the emergence period (August – September) such as in 2019, while population densities were highest during 2016 and 2020 - 2022 which had above average rainfall throughout most of year. Subsequently the density in the orchid populations have been highly variable during the monitoring period, with populations having increased since monitoring began in 2014, with the highest population counts being recorded this year.

Management of increasing levels of vegetative cover including native perennial ground covers and dead litter cover has been a desirable result after the long disturbance history and drought. High competition levels of these and/or annual ground covers in the future will however probably be necessary in order to manage ground cover biomass, which may have the potential to cause a decline in orchid population numbers. These could be managed in part by careful and considered macropod grazing and/or herbicide application. While macropod numbers are not easily managed in the Adavale Lane area, they could be readily manipulated in the Limestone area exclusion area by leaving the access gate open during late winter – very early spring before PDOs emerge, and again late summer -autumn after the orchids have died off below ground level.

At Adavale Lane, the level of undesirable annual weeds has significantly declined since 2020, however problematic areas could be targeted by a carefully designed and implemented herbicide regime, when orchids are dormant underground. Resident macropods and/or travelling livestock may also assist in reducing the grassy biomass. The current distribution and density of undesirable weeds are unlikely to present a threat to any of the orchid populations and no further management in the short-term is considered necessary at this time.

Continued monitoring of the orchid populations, ground cover species and their abundance combined with managed grazing levels will assist in the ongoing management requirements of the PDO populations, and these also be determined by the changes in seasonal conditions.

Ongoing observations for potential management intervention such as woody weed control, reduction in biomass, exotic species invasion and vertebrate pest management (as per current BOMP requirements) would also be required. *Swainsona sericea* and *Prasophyllum campestre* and the range of other native woodland species that also occur in the conservation areas would also benefit from the strategic management interventions that are implemented.

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Appendix 1. Species recorded in the PDO monitoring sites in 2022

Note "1" denotes the presence of that species and is not a measure of cover abundance
Key to habit legend: t = tree; s = shrub; ss =sub-shrub; h = herb; g = grass, r = reed; v = vine; f = fern; p = parasite

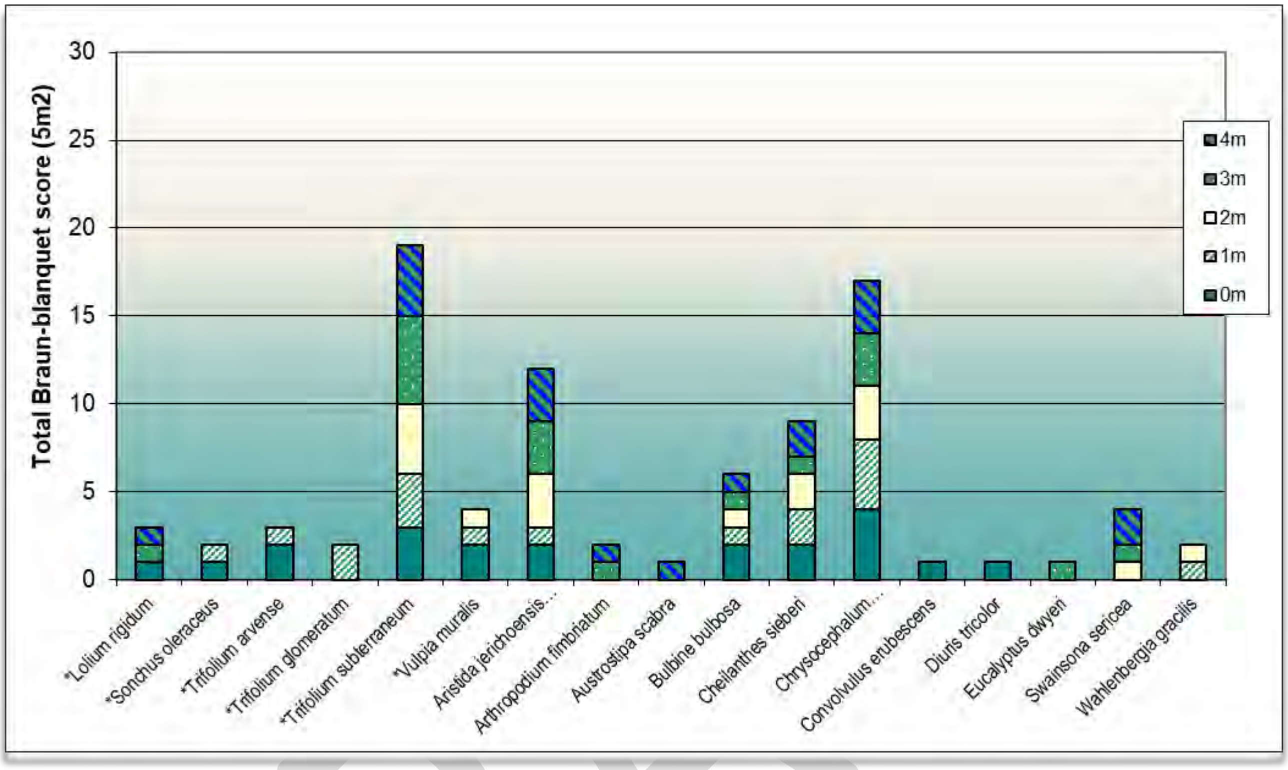
Family	exotic	Scientific Name	Common Name	Habit	LFPDO1	LFPDO2	LFPDO3	ALPDO1	ALPDO2	ALPDO3	Total
Adiantaceae		*Cheilanthes sieberi*	Rock Fern	f	1	1	1	1	1	1	6
Anthericaceae		*Tricoryne elatior*	Yellow Autumn-lily	h			1				1
Apiaceae		*Daucus glochidiatus*	Australian Carrot	h			1			1	2
Asparagaceae		*Arthropodium fimbriatum*	Nodding Chocolate Lily	h	1	1		1	1	1	5
Asphodelaceae		*Bulbine bulbosa*	Bulbine Lily	h	1	1	1	1	1	1	6
Asteraceae		*Calotis cuneifolia*	Purple Burr Daisy	h				1		1	2
Asteraceae		*Calotis lappulacea*	Yellow Burr Daisy	h			1	1	1	1	4
Asteraceae		*Chrysocephalum apiculatum*	Common Everlasting	h	1	1	1			1	4
Asteraceae		*Cymbonotus lawsonianus*	Bear's Ear	h					1		1
Asteraceae	*	*Hypochaeris glabra*	Smooth Catsear	h		1	1	1	1		4
Asteraceae	*	*Hypochaeris radicata*	Flatweed	h		1	1				2
Asteraceae	*	*Lactuca serriola*	Prickly Lettuce	h			1	1	1	1	4
Asteraceae		*Senecio quadridentatus*	Cotton Fireweed	h					1		1
Asteraceae	*	*Sonchus oleraceus*	Milk Thistle	h	1	1	1	1	1	1	6
Asteraceae		*Triptilodiscus pygmaeus*	Austral Sunray	h			1				1
Asteraceae		*Vittadinia cuneata*	Fuzzweed	h				1	1	1	3
Asteraceae		*Vittadinia gracilis*	A Fuzzweed	h				1	1		2
Asteraceae		*Xerochrysum bracteatum*	Golden Everlasting	h						1	1
Boraginaceae		*Cynoglossum australe*	Australian Hounds Tounge	h						1	1
Boraginaceae	*	*Echium plantagineum*	Paterson's Curse	h					1		1
Campanulaceae		*Wahlenbergia communis*	Tufted Bluebell	h						1	1
Campanulaceae		*Wahlenbergia gracilis*	Sprawling Bluebell	h	1		1	1	1		4
Campanulaceae		*Wahlenbergia luteola*	Australian Bluebell	h					1	1	2
Campanulaceae		*Wahlenbergia stricta*	Tall Bluebell	h					1	1	2

Family	exotic	Scientific Name	Common Name	Habit	LFPDO1	LFPDO2	LFPDO3	ALPDO1	ALPDO2	ALPDO3	Total
Caryophyllaceae	*	*Cerastium glomeratum*	Mouse-ear Chickweed	h					1		1
Caryophyllaceae	*	*Petrorhagia nanteuilii*	Proliferous Pink	h			1	1	1	1	4
Chenopodiaceae		*Einadia nutans*	Climbing Saltbush	h						1	1
Convolvulaceae		*Convolvulus erubescens*	Australian Bindweed	h	1	1			1		3
Convolvulaceae		*Dichondra repens*	Kidney Weed	h				1	1	1	3
Cupressaceae		*Callitris glaucophylla*	White Cypress Pine	t				1		1	2
Fabaceae (Faboideae)		*Glycine tabacina*	Variable Glycine	h						1	1
Fabaceae (Faboideae)	*	*Medicago polymorpha*	Burr Medic	h					1		1
Fabaceae (Faboideae)		*Swainsona sericea*	Silky Swainsona	h	1						1
Fabaceae (Faboideae)	*	*Trifolium angustifolium*	Narrow-leaf Clover	h				1	1		2
Fabaceae (Faboideae)	*	*Trifolium arvense*	Haresfoot Clover	h	1	1	1	1	1	1	6
Fabaceae (Faboideae)	*	*Trifolium campestre*	Hop Clover	h				1	1		2
Fabaceae (Faboideae)	*	*Trifolium dubium*	Yellow Suckling Clover	h				1	1		2
Fabaceae (Faboideae)	*	*Trifolium glomeratum*	Clustered Clover	h	1		1	1	1	1	5
Fabaceae (Faboideae)	*	*Trifolium repens*	White Clover	h				1			1
Fabaceae (Faboideae)	*	*Trifolium subterraneum*	Subterraneum Clover	h	1	1	1				3
Gentaniaceae	*	*Centaurium erythraea*	Common Centaury	h						1	1
Goodeniaceae		*Velleia paradoxa*	Spur Velleia	h	1		1			1	3
Lamiaceae	*	*Salvia verbenaca*	Wild Sage	h				1			1
Malvaceae		*Sida corrugata*	Corrugated Sida	h				1	1	1	3
Myrtaceae		*Eucalyptus dwyeri*	Dwyer's Red Gum	t	1	1					2
Orchidaceae		*Diuris tricolor*	Pine Donkey Orchid	h	1	1	1	1		1	5
Orchidaceae		*Microtis unifolia*	Common Onion Orchid	h			1				1
Orchidaceae		*Pterostylis bicolor*	Bicolor Greenhood	h	1	1	1				3
Oxalidaceae		*Oxalis perennans*	Yellow Wood-sorrel	h			1	1	1		3
Poaceae	*	*Aira cupaniana*	Silvery Hairgrass	g		1	1				2
Poaceae		*Anthosachne [Elymus] scabra*	Common Wheatgrass	g		1		1	1	1	4
Poaceae		*Aristida jerichoensis var. jerichoensis*	Jericho Wiregrass	g	1	1	1				3
Poaceae		*Austrostipa scabra*	Speargrass	g	1		1	1	1	1	5
Poaceae	*	*Avena fatua*	Wild Oats	g				1	1		2

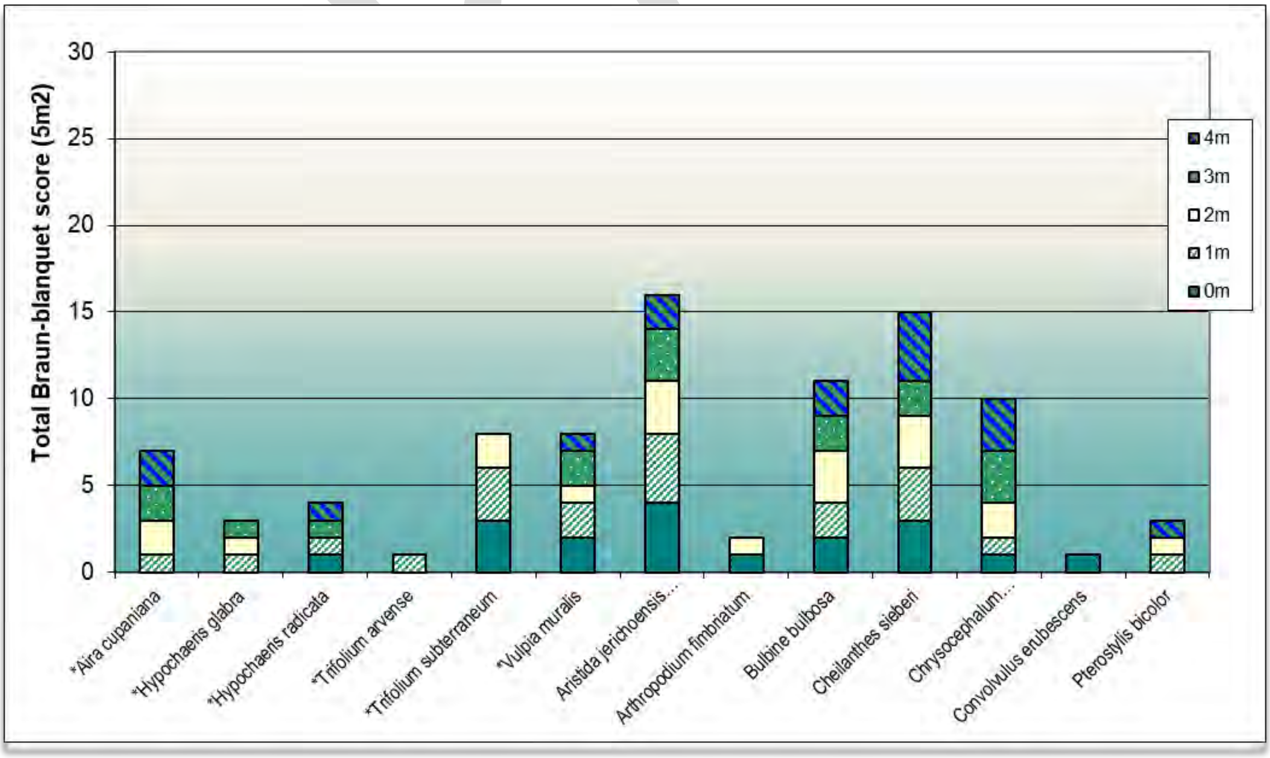
Family	exotic	Scientific Name	Common Name	Habit	LFPDO1	LFPDO2	LFPDO3	ALPDO1	ALPDO2	ALPDO3	Total
Poaceae	*	*Bromus hordeaceus*	Soft Brome	g				1		1	2
Poaceae	*	*Lolium rigidum*	Wimmera Ryegrass	g	1			1			2
Poaceae		*Panicum effusum*	Hairy Panic	g	1		1	1	1	1	5
Poaceae	*	*Vulpia muralis*	Rats-tail Fescue	g	1	1	1	1	1		5
Primulaceae	*	*Lysimachia [Anagallis] arvensis*	Scarlet Pimpernel	h					1		1
					20	17	26	31	33	30	

Appendix 2: Species cover abundance in individual 5x5m monitoring plots in 2022

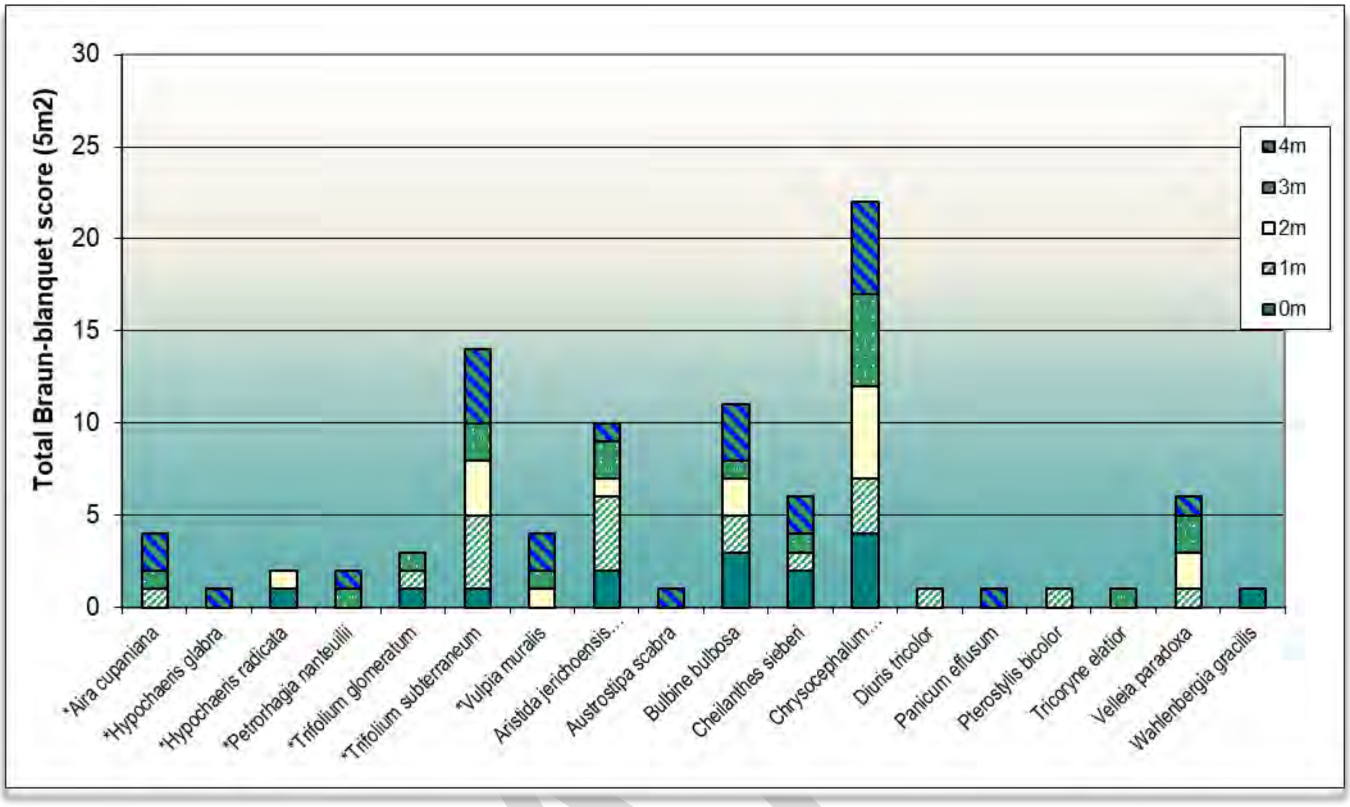
LFPDO1



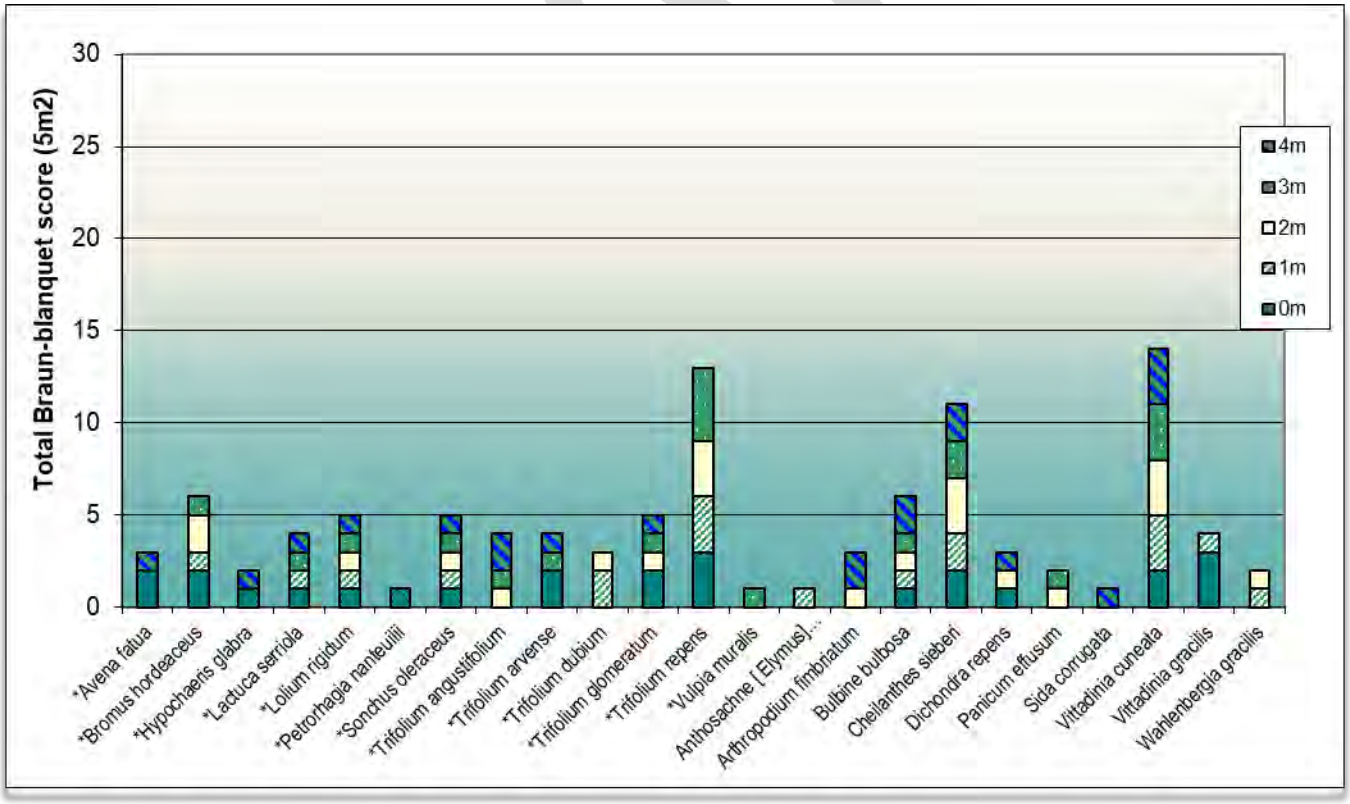
LFPDO2



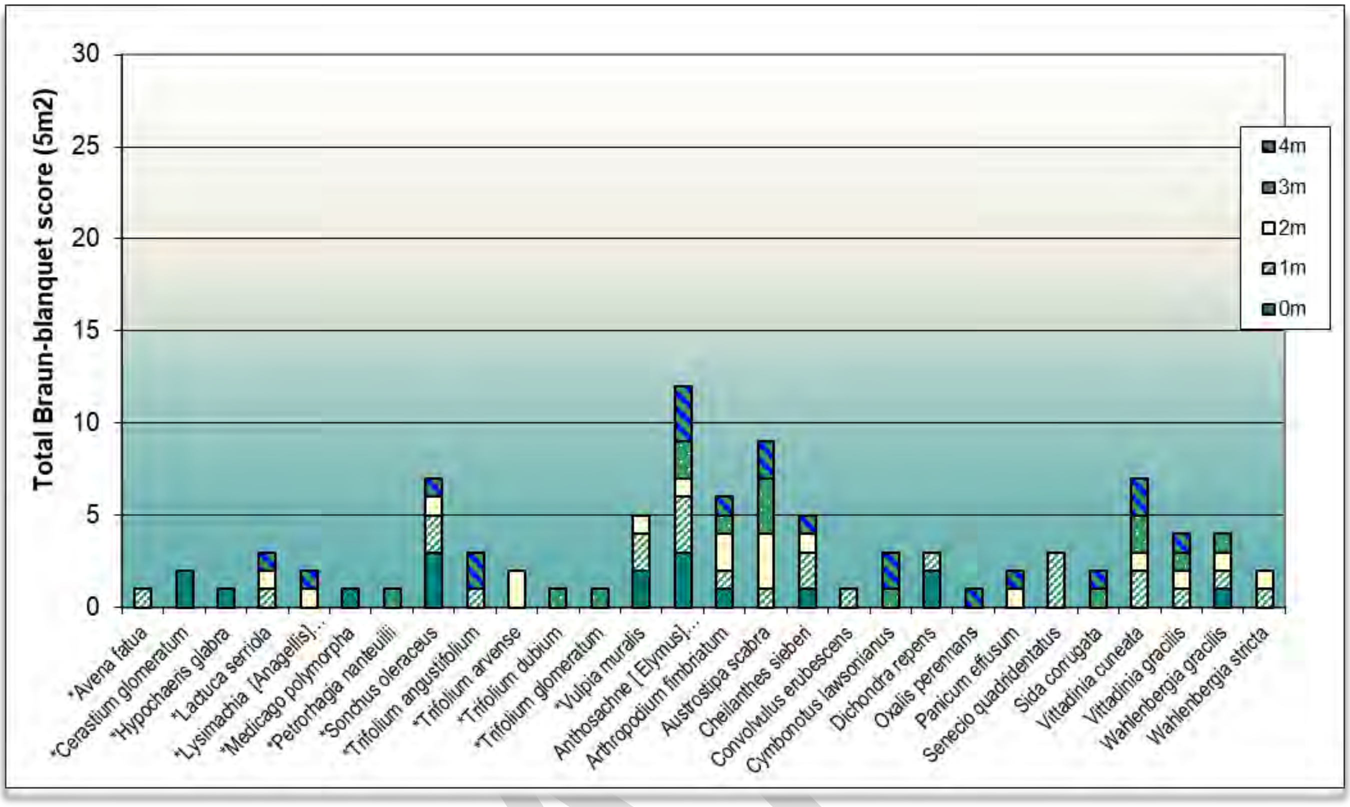
LFPDO3



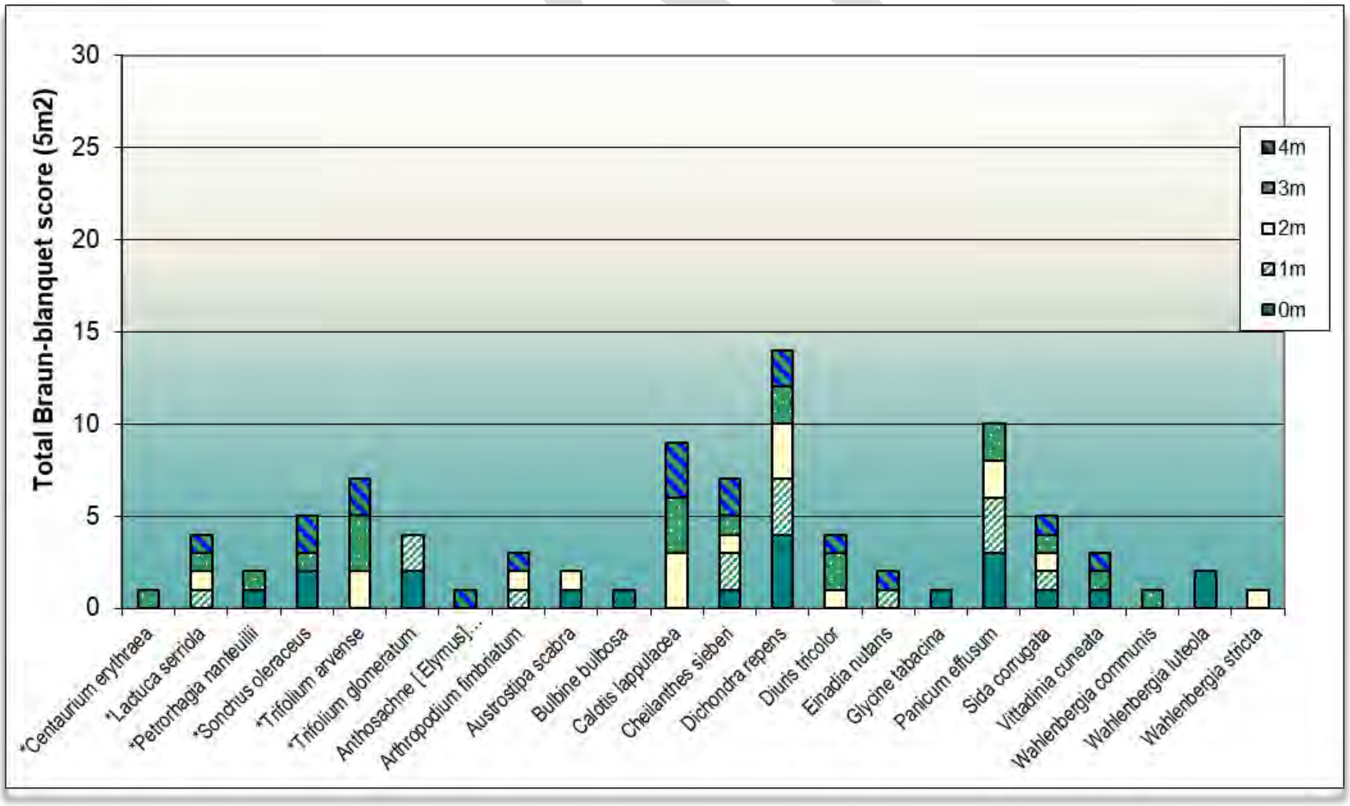
ALPDO1



ALPDO2



ALPDO3



Kokoda offset site

2022 Bird and kangaroo survey report

Northparkes Mines

16 December 2022

→ **The Power of Commitment**

Project name		Kokoda bird surveys 2022				
Document title		Kokoda offset site | 2022 Bird and kangaroo survey report				
Project number		12587149				
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Status Code	Revision	Author	Reviewer		Approved for issue		
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1. Introduction

The Northparkes copper and gold mine (Northparkes) is located approximately 27 km north-west of Parkes, New South Wales (NSW). Northparkes is a joint venture between China Molybdenum Co. Ltd (CMOC) and the Sumitomo Group, with CMOC as managers of the mine. In 2021, Northparkes processed 6.84 million tonnes of ore, and metal recovery was 69.1% gold and 82.8% copper.

Northparkes consists of underground operations accessing several copper sulphide porphyry ore bodies. In addition, Northparkes farms over 6000 hectares (ha) of farming country including land within its four existing mining leases.

1.1 Project background

The Northparkes Mines Step Change Project (the Project) was approved with conditions under the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) (DA11_0060) and Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (2013/6788) in 2014. Key elements of the Project included:

– Continued underground block cave mining in two existing ore bodies
– The development of an additional underground block cave mine, under one of the existing open cut pits
– Additional campaign open cut mining in existing mine leases
– Augmenting approved Tailings Storage Facilities (TSFs); moving the existing access road; construction of the new TSF (Rosedale)
– Extending the life of the mine by seven years to 2032

As part of the Step Change Project approval conditions, residual impacts resulting from the Project required biodiversity offsetting. To fulfil this requirement, Northparkes secured the Kokoda Offset Area (Kokoda), a 350 ha site located in the Mandagery locality of the Central West Slopes of NSW.

A Biodiversity Offset Management Plan (BOMP) was prepared in 2014 (Umwelt 2014), which guides the short, medium and long-term conservation and management actions at Kokoda. The BOMP was prepared in accordance with the NSW Development Consent (DA11_0060) and Commonwealth Project Approval (EPBC 2013/6788) requirements and provides a framework for the implementation of ecological management actions, regeneration strategies, controls and monitoring programs at Kokoda.

1.2 Purpose of this report

During ecological surveys for the Step Change Project Environmental Assessment, two threatened fauna species were observed within the Project area:

– Superb Parrot (*Polytelis swainsonii*) (vulnerable – NSW *Biodiversity Conservation Act 2016* (BC Act) and EPBC Act)
– Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*) (vulnerable - BC Act).

Suitable habitat for the following Matters of National Environmental Significance (MNES) was identified within the Mine Extension Project area:

– Swift Parrot (*Lathamus discolour*) (endangered – BC Act and critically endangered – EPBC Act)
– Regent Honeyeater (*Anthochaera phrygia*) (critically endangered – BC Act and EPBC Act).

This report outlines the results of the winter and spring 2022 bird surveys undertaken at Kokoda, to fulfil the requirements outlined in the BOMP.

In 2022, ‘Winter’ surveys were undertaken in July and ‘Spring’ surveys were undertaken in October to be generally consistent with periods of surveys undertaken between 2014 to 2021. In 2020 the October surveys were delayed until November due to heavy rainfall on the proposed survey days in October.

In addition to the bird survey in the winter period, in 2017 the NSW Office of Environment and Heritage (OEH) (now the NSW Department of Planning and Environment (DPE)) requested, during the revision of the BOMP, that a survey be conducted of kangaroo numbers in the derived native grasslands of the Kokoda Offset Area. Kangaroo surveys have been conducted each year since 2017 and were conducted again in the 2022 survey period.

The Project Approval and BOMP did not provide a preferred methodology for the kangaroo survey and one was developed for the 2017 surveys which has since been repeated for the 2018 to 2022 surveys.

1.3 Scope and limitations

This report has been prepared by GHD for Northparkes Mines and may only be used and relied on by Northparkes Mines for the purpose agreed between GHD and Northparkes Mines as set out in section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Northparkes Mines arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (refer section 1.4 of this report). GHD disclaims liability arising from any of the assumptions being incorrect.

1.4 Assumptions

Although the Project Approvals were issued under the NSW *Threatened Species Conservation Act 1995* (TSC Act), on the 25 August 2017, this act was repealed and replaced with the NSW *Biodiversity Conservation Act 2016* (BC Act). All state listed threatened species formerly listed under the TSC Act are now listed under the BC Act. Any reference to state listed species from here on, should refer to the BC Act rather than the TSC Act.

All survey locations are the same as those completed in the previous bird monitoring years. GHD assumes that these locations and habitat types remain consistent based on the location data provided by Northparkes.

2. Existing environment

The Kokoda Offset Area is a 350 ha site located in the Mandagery locality of the Central West Slopes of NSW. Kokoda is located within the Cabonne Council area which is known for its agriculture, mining, ballooning, food and wine industries.

Prior to purchase by Northparkes, Kokoda was a hobby farm, with the areas of grassy woodland used for sheep grazing and large patches of remnant vegetation occurring in the southern section of the property. Kokoda was strategically selected as it is located along a north-south vegetation corridor, connecting remnant woodland and forest vegetation along the ridges and hills from north of Eugowra in the south to east of Narromine in the north. This vegetation corridor includes Goobang National Park, the largest conserved remnant patch of woodland and forest vegetation in the Central West region of NSW.

2.1 Weather conditions

The 2022 weather conditions during bird and kangaroo surveys are detailed in Table 1. Climate data is taken from the Parkes Airport weather station (65068) (BoM 2022), as this is the nearest weather station in the locality. The proposal site is located about 27 km north-west of Parkes (and the weather station). Although the rainfall results from Parkes were low (see Table 1) there was heavy rainfall overnight during the winter survey period.

Table 1 Weather conditions (BoM 2022)

Date	Survey type	Max. temperature (°C)	Min. temperature (°C)	Rainfall (mm)
Winter surveys				
18/07/2022	Kangaroo counts	11.4	3.8	0
19/07/2022	Bird surveys	14.4	-2.9	0
19/07/2022	Kangaroo counts	14.4	-2.9	0
20/07/2022	Bird surveys	Not recorded		
Spring surveys				
17/10/2022	Kangaroo counts	21.3	4.2	0
18/10/2022	Bird surveys	22.7	10.7	0
18/10/2022	Kangaroo counts	22.7	10.7	0
19/10/2022	Bird surveys	21.5	13.9	0.2

From 2017, when surveys commenced at the Kokoda site, until 2019, the region experienced severe drought conditions. These conditions subsided in 2020, where the mean average of rainfall of 637.8 millimetres (mm) was surpassed over the next three years and including 2022 where it was already above the rainfall average prior to conducting spring surveys. Rainfall patterns across the years of survey are as follows:

– 2017 recorded 561.6 mm
– 2018 recorded 328.4 mm
– 2019 recorded 229.8 mm
– 2020 recorded 870.2 mm
– 2021 recorded 857.2 mm
– 2022 recorded 686.8 mm until 21 October 2022.

There was a large increase in rainfall in 2020 compared to the 2018 and 2019 totals, which has been sustained through 2021 and 2022. The 2020, 2021 and 2022 total rainfall are well above the average annual rainfall of the Parkes area, which is 636 mm per year. Total rainfall for 2022 is not yet known, with more rainfall predicted throughout November and December.

2.2 Personnel

Field surveys described in the report were undertaken by Mal Weerakoon (GHD Ecologist) and accompanied by Donna Shaw, Northparkes Mines. Mal replaces Leigh Maloney, who had previously completed all site surveys and technical review of the reporting from 2017 until 2021 for the Kokoda Offset Area. Mal is familiar with the local avian fauna due to his ongoing biodiversity work within the E44 and Rocklands areas of Northparkes Mines.

3. Method

3.1 Desktop and literature review

A desktop review of relevant literature, ecological databases and reports was completed before conducting the site visit in order to identify the existing avian biodiversity values within the Kokoda Offset Area (Table 2 and Appendix A).

Table 2 Desktop and literature review resources

Source	Data	Description of source	Search area
Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) Protected Matters Search Tool (PMST)	Information on species and communities listed under the EPBC Act	This search tool does not produce species records, it uses data on species and communities listed under the EPBC Act to produce indicative distribution maps, which are used to inform the likelihood of species presence within an area.	10 km buffer around a rough polygon of the property.
NSW BioNet (2022)	Government-held information about plants and animals in NSW	This search tool provides records from a variety of sources, including from members of the public and scientific surveys.	Search criteria: Licensed Report of all Valid Records of Threatened (Listed under BC Act), Commonwealth listed, protected, CAMBA listed, JAMBA listed or ROKAMBA listed, exotic listed or native listed birds (class:aves) in selected area (North: -33.22 West: 148.40 East: 148.50 South: -33.32) returned a total of 696 records and 121 species including 11 threatened species.
Birds Australia (BA) (2022)	Bird data only	Generates a list of species within a drawn polygon. No date or location information provided with records.	Birds listed for a polygon covering the Kokoda property and a roughly 10 km radius.
Northparkes Mines winter and spring bird survey 2015 to 2021 reports	Reports the desktop and field survey results from the ecological surveys undertaken at Kokoda from 2015 to 2021	Surveys and reporting undertaken by GHD senior ecologist in 2017 and 2021 and by Northparkes Mines environment team in 2015 and 2016.	Bird species recorded during targeted bird surveys at Kokoda from 2015 to 2021.
Northparkes Mines Ecological Monitoring Baseline Survey – Winter and Spring 2014 (Umwelt 2014)	Reports the desktop and field survey results from ecological surveys undertaken at Kokoda in 2014	Surveys and reporting undertaken by Umwelt.	Bird species recorded during targeted bird surveys at Kokoda in 2014 (Umwelt 2014).

3.2 Field surveys

Winter bird surveys at Kokoda were designed to target the Regent Honeyeater and Swift Parrot. Spring bird surveys were designed to target the Superb Parrot and eastern subspecies of the Grey-crowned Babbler. The recommended survey methods for these species are outlined below in Table 3 as outlined in the Survey Guidelines for Australia's Threatened Birds (DEWHA 2010) (excluding the Grey-crowned Babbler which is only listed under the BC Act).

Table 3 Recommended survey method for threatened species

Species	Recommended survey methods (DEWHA 2010)
Winter targeted species	
Regent Honeyeater (*Anthochaera Phrygia*)	Area searches in suitable habitat, preferably in the morning but other times may also be appropriate. Detection by call is possible when birds are most vocal (outside the breeding season). Otherwise, detection is by sighting. Targeted searches of woodland patches with heavily flowering trees is useful, especially around water points such as dams and creek lines. Also check among flocks of other blossom nomads such as lorikeets and other honeyeaters. Broadcast surveys immediately before and during the breeding season may also be useful.
Swift Parrot (*Lathamus discolor*)	Area searches or transect surveys of suitable habitat, preferably in the early morning and afternoon when birds are most active and vocal. Detection by sighting or call. Slow-moving vehicle transects also effective in expansive areas, detecting loud, distinctive 'clinking' call that can be heard over noise of engine. Targeted surveys of patches of heavily flowering eucalypts may be useful. Timing: surveys on the mainland should be conducted between March and July.
Spring targeted surveys	
Superb Parrot (*Polytelis swainsonii*)	Area searches or transect surveys of suitable habitat, preferably in the early morning (sunrise to 10 am) and evening (4 pm to sunset). Morning surveys may be of greater value as the species' movements is more coordinated at this time. Detection by sighting or call, usually of flying birds. Vehicle-based transects appropriate in areas where most habitat is restricted to roadside remnants. Survey effort will need to be increased outside the breeding season, as dispersal makes the species more difficult to detect.
Grey-crowned Babbler (eastern subspecies) (*Pomatostomus temporalis temporalis*)	None given. However, the following methods for passerines, including babblers in general, is listed in DEWHA 2010. Diurnal area searches or transect-point surveys in areas of favoured habitat in and around the study area. Detection mostly by sighting and calls, though ravens, swallows and bowerbirds may be detected by nests or bowers.

3.2.1 Winter surveys

As outlined in the BOMP, the winter bird monitoring consists of:

– 'Site based diurnal winter bird surveys for Regent Honeyeater and Swift Parrot. As a minimum two 20-minute bird surveys will be undertaken at six reference sites (consistent with flora monitoring where possible). Winter bird surveys will be undertaken at derived native grassland (DNG) regeneration sites once the regenerating canopy species reach a minimum height of four meters.'

– Native plantings were undertaken at sites SP1, SP6 and SP7 in the winter and spring of 2020. Sites SP10, SP5 and SP7 currently have no native tree regeneration, site SP1 has limited regeneration mostly comprising Acacia spp. and site S6 has moderate regeneration of eucalypt spp. At the time of the 2022 winter survey period the canopy species present at all of the DNG regeneration sites had not reached the minimum height of four meters, and as such no additional surveys were undertaken here.

– Targeted bird surveys were undertaken at the six existing winter bird survey sites (Figure 1). Surveys consisted of two, two-hectare area searches for 20 minutes in suitable habitat at each winter survey site. All bird surveys were undertaken by one ecologist. During targeted bird surveys, all birds seen (using binoculars) or heard (using diagnostic calls) were recorded. Targeted bird surveys were undertaken at each survey site twice, in the early morning when birds are most active and vocal to maximise detectability. Any opportunistic bird species identified during surveys were also recorded.

– Consistent with surveys in winter 2014 to 2021, as the regeneration areas do not meet the height requirements for monitoring at this stage, surveys were only undertaken at woodland locations within Kokoda. The six survey sites were positioned in areas of suitable habitat for both targeted species.

– All survey access was completed on foot.

3.2.2 Spring surveys

As outlined in the BOMP, the spring bird monitoring consists of:

– ‘Site based diurnal spring woodland bird surveys. As a minimum, two 20-minute bird surveys will be undertaken at six reference sites (in target woodland community remnants) and six DNG regeneration sites (consistent with flora monitoring sites where possible). Spring woodland bird surveys will be undertaken in DNG regeneration sites during all growth stages as Grey-crowned Babblers may occur in both DNG and woodland areas and Superb Parrots may forage in DNG areas.’

– Targeted bird surveys were undertaken at 11 of the existing spring bird survey sites (Figure 2). As per the recommendation in the 2017 and 2018 survey report, due to the close proximity of sites SP5, SP3 and REM4 to each other and the overlap in bird species sightings between these sites, site SP5 was moved approximately 750 meters south of its original position. Site SP3 was combined with site REM4, to avoid species overlap.

– Surveys consisted of two, two-hectare area searches for 20 minutes in suitable habitat within the Kokoda site. During targeted bird surveys, all birds seen (using binoculars) or heard (using diagnostic calls) were recorded. Targeted bird surveys were undertaken at each survey site twice, in the early morning when birds are most active and vocal to maximise detectability. Any opportunistic bird species identified during surveys were also recorded.

– All survey access was completed on foot.

Legend

Winter bird survey sites

Kokoda property boundary

Paper Size A3

0 135 270 540

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Northparkes Mine

Kokoda bird and kangaroo surveys - 2022

Job Number 12587149
Revision 0
Date 01 Nov 2022

Winter bird survey sites

Figure 1

\\ghdnet\ghd\AU\Wagga Wagga\Projects\21\12587149\GIS\Maps\Deliverables\12587149_Fig1_Kokoda2022_WinterBirdSurveySites.mxd

Suite 3, Level 1, 161-169 Baylis Street Wagga Wagga NSW 2650 Australia **T** 61 2 6923 7400 **F** 61 2 6971 9565 **E** wgamail@ghd.com **W** www.ghd.com

Data source: NSW Government (LPI): Aerial photograph - 2017, roads, waterways, National Park - 2012. Created by:pfernandes

Legend

★ Spring bird survey sites

Kokoda property boundary

Paper Size A3

0 135 270 540

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Northparkes Mine
Kokoda bird and kangaroo surveys - 2022

Job Number	12587149
Revision	0
Date	01 Nov 2022

Spring bird survey sites

Figure 2

\\ghdnet\ghd\AU\Wagga Wagga\Projects\21\12587149\GIS\Maps\Deliverables\12587149_Fig2_Kokoda2022_SpringSurveySites.mxd

Suite 3, Level 1, 161-169 Baylis Street Wagga Wagga NSW 2650 Australia **T** 61 2 6923 7400 **F** 61 2 6971 9565 **E** wgamail@ghd.com **W** www.ghd.com

Data source: NSW Government (LPI): Aerial photograph - 2017, roads, waterways, National Park - 2012. Created by:pfernandes

3.2.3 Kangaroo counts

The following statement was made in the approved BOMP at the request of DPIE:

- ‘Kangaroo monitoring will be undertaken biannually within the regenerating woodland area. Monitoring is intended to give an indication of relative presence of kangaroo populations within the regenerating area over time. If a significant increase in the kangaroo population is recorded over two consecutive monitoring periods adaptive management will be investigated. Kangaroo monitoring will commence in 2017, at which point a suitable, repeatable survey methodology will be developed and documented in the Annual Review (AR). All adaptive management actions undertaken are to be documented in the AR.’
- Numbers of kangaroos were counted by completing two walking transects from west to east (one direction) in the south and then east to west (return transect) across the DNG areas in the north of the property (Figure 3). Numbers of individuals observed along each transect were recorded. Additional fauna species were also recorded but not numbers of individual species.
- Walking transects were completed at dusk on two consecutive days in both winter and spring.

Legend

Kokoda property boundary

Kangaroo count walking transect

Paper Size A3

0 85 170 340

Meters

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Northparkes Mine
Kokoda bird and kangaroo surveys- 2022

Job Number	12587149
Revision	0
Date	01 Nov 2022

Kangaroo count transects

Figure 3

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Data source: LPI (NSW Government): Aerial imagery - 2017, waterway, locality - 2012, Created by:pfernandes

4. Results

4.1 Desktop and literature review

Fauna desktop assessments conducted for the Kokoda 2022 bird survey revealed the following:

– BioNet - A total of 121 bird species were recorded within the BioNet search area of which 11 are listed under the BC Act (see Appendix A).
– PMST - 12 threatened bird species listed under the EPBC Act were predicted to occur by the PMST within the search area, one is known to occur, seven are likely to occur and four may occur. Additionally, four bird species listed as terrestrial migratory species and six migratory wetland species under the EPBC Act were listed as likely or may occur (see Appendix A and Table 4)
– Birds Australia (BA) - A total of 74 bird species were previously recorded within the BA search area (see Appendix A).
– Baseline - A total of 59 bird species were recorded within Kokoda during baseline surveys (Umwelt 2014), including six species listed as vulnerable under the BC Act and/or EPBC Act (see Table 5)
– 2017- A total of 60 species were recorded during the 2017 winter surveys and 61 species in the spring surveys. Five species listed under the BC Act and/or EPBC Act were recorded
– 2018 - A total of 50 species were recorded during the 2018 winter surveys and 68 species in the spring surveys. Five species listed under the BC Act and/or EPBC Act were recorded.
– 2019 - A total of 55 species were recorded during the 2019 winter surveys and 68 species in the spring surveys. Four species listed under the BC Act and/or EPBC Act were recorded.
– 2020 - A total of 42 species were recorded during the 2020 winter surveys and 59 species in the spring surveys. Four species listed under the BC Act and/or EPBC Act were recorded.
– 2021 - A total of 54 species were recorded during the 2021 winter surveys and 67 species in the spring surveys. Five species listed under the BC Act and/or EPBC Act were recorded.

4.2 Targeted bird surveys

A total of 57 species were recorded during the 2022 winter surveys and 61 species in the 2022 spring surveys (with a combined species diversity of 71 species). Five BC Act and/or EPBC Act listed species have been identified across the winter and spring survey period since 2017 (Table 4).

Table 4 Threatened and migratory species recorded during 2022 Kokoda bird surveys

Species	BC Act status	EPBC Act status	Winter -site ID	Spring – site ID
Brown Treecreeper (eastern subspecies) (*Climacteris picumnis* victoriae)	V	-	W1, W2, W6	REM 2, REM 4, REM 5, S7
Diamond Firetail (*Stagonopleura guttata*)	V	-	-	-
Grey-crowned Babbler (*Pomatostomus temporalis temporalis)*	V	-	W4, incidental	REM 5, S1, S5, S7, S10, incidental
Speckled Warbler (*Chthonicola sagittate*)	V	-	W1, W2, W6	REM 1, REM 3
Superb Parrot (*Polytelis swainsonii*)	V	V	W5, incidental	REM 4, S1, S6 S7, S10, incidental

The Grey-crowned Babbler, Superb Parrot and Speckled Warbler were recorded during both the spring and winter surveys on multiple occasions throughout the Kokoda site. The Grey-crowned Babbler and Speckled Warbler were recorded at multiple survey sites during both the spring and winter survey period. The Diamond Firetail was not recorded during 2022, and is unlikely to regularly occur within the Kokoda Offset site during the year.

Threatened species records appear generally consistent with previous years records. Typically, Superb Parrots, Brown Treecreepers, Grey-crowned Babblers and Speckled Warblers are recorded consistently at the site over the two survey periods.

A full list of bird species recorded during 2022 surveys is provided in Appendix B.

4.2.1 Comparison of years and species diversity

A comparative analysis of the species observed between different survey periods and years is shown in Table 5. A slightly higher number of species are recorded during the spring survey periods compared with winter periods over all five years. This is likely to be a function of the greater number of survey sites and microhabitats present in the spring than winter (11 in spring versus six in winter), rather than more species occurring in spring. Further to this, comparative analysis of species diversity at each survey site across all survey years was conducted for both winter (Figure 4) and spring (Figure 5) results. This demonstrates species diversity trends at specific survey points across the project site since 2017. Species diversity was generally consistent between 2017 and 2020 prior to the drought with a slight increase in diversity between 2021 and 2022 due to increased rainfall.

The most commonly recorded threatened species across all survey years is the Grey-crowned Babbler. The Superb Parrot and Speckled Warblers were also recorded a number of times in both the winter and spring survey periods on multiple occasions.

Table 5 Bird diversity across survey periods

Survey period	Number of bird species	Number of threatened bird species	Threatened species
Baseline	59	6	Brown Treecreeper, Grey-crowned Babbler, Hooded Robin, Little Lorikeet, Speckled Warbler and Superb Parrot
Winter 2015	42	2	Brown Treecreeper and Grey-crowned Babbler
Spring 2015	53	3	Diamond Firetail, Grey-crowned Babbler and Superb Parrot
Winter 2016	41	1	Grey-crowned Babbler
Spring 2016	51	2	Grey-crowned Babbler and Superb Parrot
Winter 2017	52 (+ 8 from x3 spring survey sites)	5	Grey-crowned Babbler, Speckled Warbler, Superb Parrot, Flame Robin and Satin Flycatcher (migratory)
Spring 2017	68	3	Grey-crowned Babbler, Speckled Warbler and Superb Parrot
Winter 2018	50	7	Superb Parrot, Diamond Firetail, Flame Robin, Speckled Warbler, Brown Treecreeper, Grey-crowned Babbler, Little Lorikeet
Spring 2018	61	3 (+1 migratory)	Grey-crowned Babbler, Superb Parrot, Speckled Warbler, Satin Flycatcher (Migratory)
Winter 2019	55	5	Grey-crowned Babbler, Dusky Woodswallow, Diamond Firetail, Superb Parrot, Speckled Warbler
Spring 2019	66	4	Grey-crowned Babbler, Diamond Firetail, Speckled Warbler, Superb Parrot
Winter 2020	42	3	Grey-crowned Babbler, Brown Treecreeper, Speckled Warbler
Spring 2020	59	3	Grey-crowned Babbler, Superb Parrot, Speckled Warbler
Winter 2021	54	4	Diamond Firetail, Grey-crowned Babbler, Superb Parrot Speckled Warbler
Spring 2021	67	4	Grey-crowned Babbler, Superb Parrot, Brown Treecreeper, Speckled Warbler
Winter 2022	57	4	Grey-crowned Babbler, Superb Parrot, Speckled Warbler, Brown Treecreeper
Spring 2022	61	4	Grey-crowned Babbler, Superb Parrot, Brown Treecreeper, Speckled Warbler

Figure 4: Winter surveys species diversity over survey years

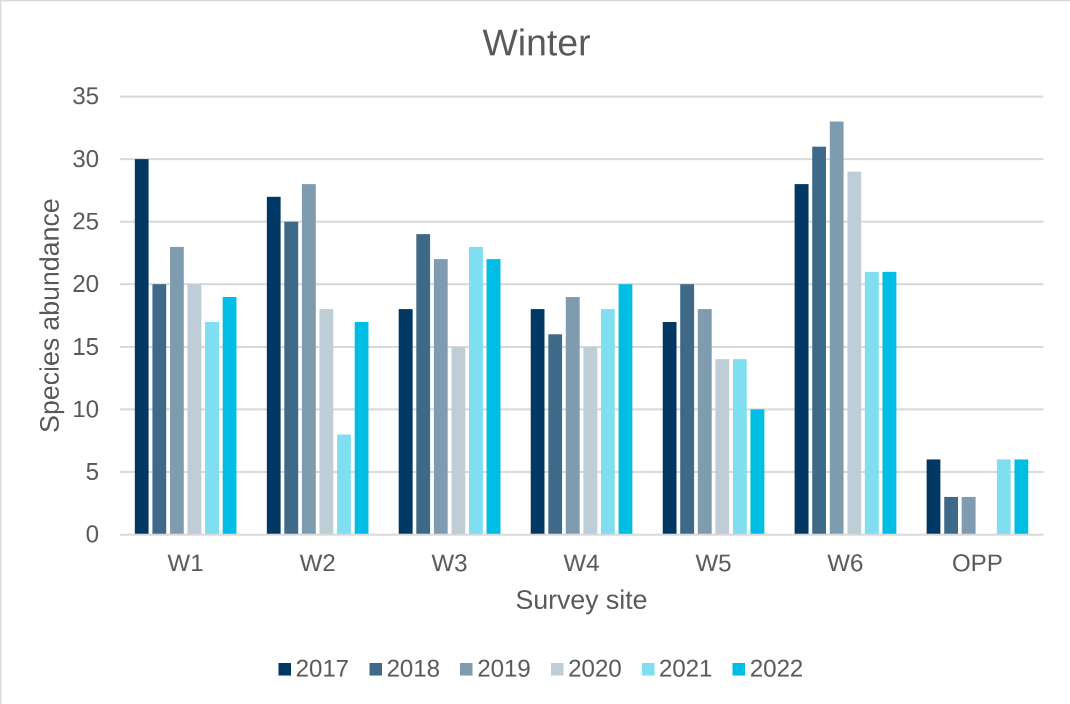
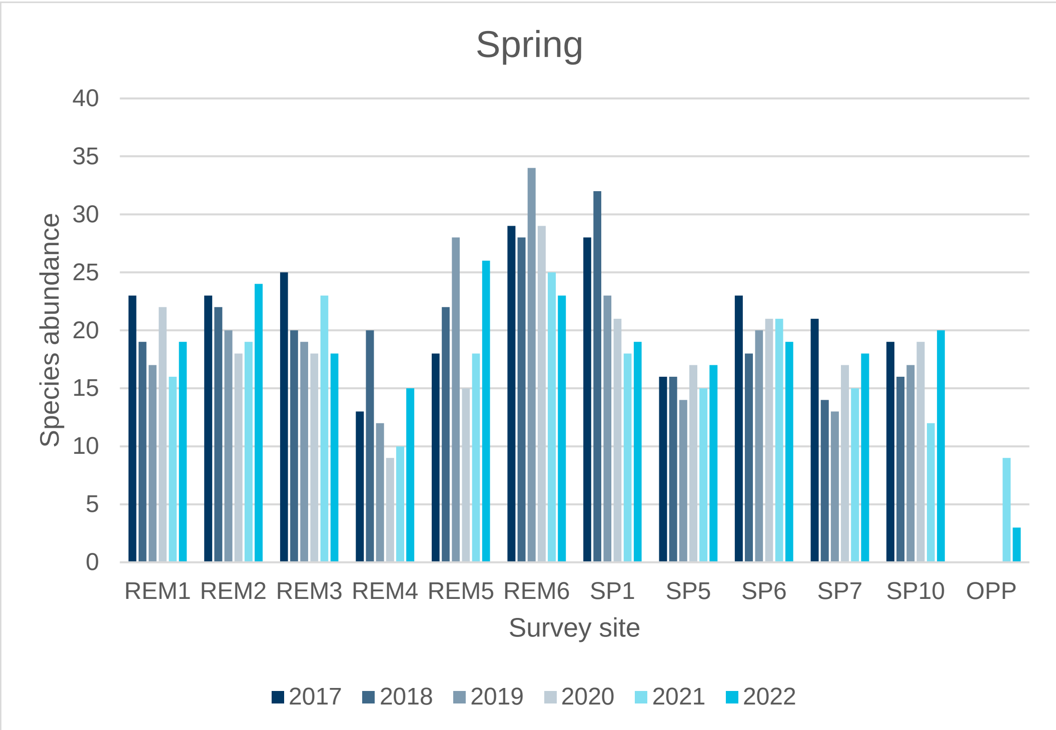


Figure 5: Spring surveys species diversity over survey years



4.3 Kangaroo population monitoring

Kangaroo counts were previously undertaken during spring and winter of 2017–2021. Data collected during these survey periods has been used as a baseline for monitoring kangaroo populations on site. Kangaroos were mostly recorded grazing on top of ridges on either side of a tributary of Sandy Creek, located running north to south in the eastern portion of the offset site.

The 2022 kangaroo surveys recorded 186 individuals during the winter surveys and 419 individuals during the spring surveys (Table 6). Ongoing site management of tree planting, monitoring of vegetation plots and disturbance of other vehicles (quad bike) during the winter and spring surveys had the potential to cause variance in the numbers as kangaroos would not have been actively grazing where human disturbance was present. However, counts of kangaroos between the survey rounds in 2022 were similar (difference being two individuals in winter and 25 individuals in spring). With comparison to 2021, kangaroo numbers only varied by nine individuals across winter and 15 individuals over spring (see Figure ***6***).

The construction of kangaroo exclusion fencing around the Kokoda site commenced in late 2019 and was completed in early 2020 before the first kangaroo count survey was conducted (with its completion denoted by the black line in Figure ***6***). The decrease in kangaroo abundance on site by 64.8% from 2019 to 2020 may be attributed to the construction of the exclusion fencing.

A slight increase in kangaroo abundance is noted over the spring 2022 survey period compared with the spring 2021 period, but is unlikely to be attributed to abiotic factors.

Kangaroo count results during 2022 surveys can be observed in Table 6, with trends over the five-year surveying period shown in Figure ***6***. Eastern Grey Kangaroo (*Macropus giganteus*) accounted for the majority of kangaroos counted, however a small number of Swamp Wallaby (*Wallabia bicolor*) was also observed.

Table 6 ***Kangaroo population numbers 2022***

Date	Total
Winter	
18 July 2022	92
19 July 2022	94
Winter total	**186**
Spring	
17 October 2022	197
18 October 2022	222
Spring total	**419**

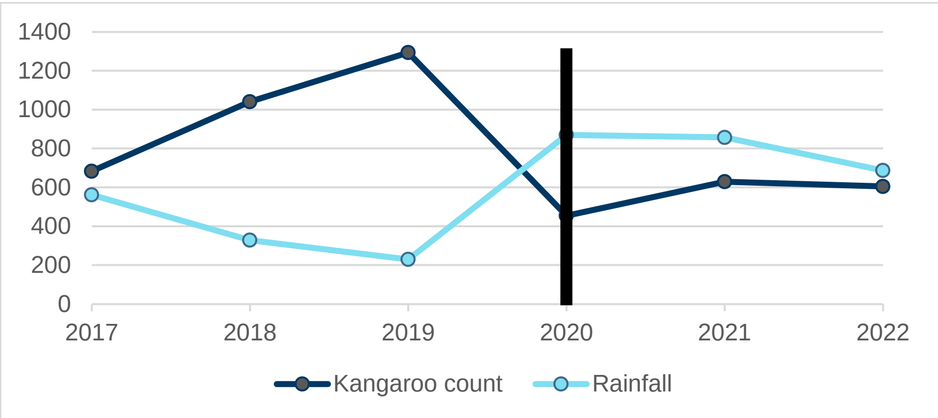


Figure** 6**: Kangaroo abundance verse rainfall at the Kokoda site

5. Discussion and recommendations

Northparkes have developed an Excel based spreadsheet to enable the winter and spring bird survey data to be entered into each year. This has created an efficient way in which to review species recorded, numbers and locations of individuals as more data is collected each year. The spreadsheet will continue to be utilised in the future surveys to monitor species composition at each site and across seasons and years.

In addition, GHD has developed a spreadsheet to compare bird diversity and kangaroo data on site. This data will be used to present trends in species sightings at survey locations for birds recorded, and to document population trends for kangaroo counts.

5.1 Winter bird surveys

The six winter bird survey sites have been selected based on the target species of Swift Parrot and Regent Honeyeater. These species rely on heavily flowering Box-Ironbark eucalypt forests for their seasonal movements to feeding areas.

In 2020 and 2021, the Parkes area experienced much higher rainfall than previous drought years, and higher than average rainfall for the year. As such, the previous low abundance of flowering eucalyptus and acacias, as influenced by the drought (including Mugga Ironbark (*Eucalyptus sideroxylon*)) in the area was not experienced in 2022. Acacia and eucalypt species were flowering but not abundantly during the site during surveys. As Mugga Ironbark was not observed to be flowering abundantly in the surrounding area, surveying was limited to the six originally selected winter bird survey sites, and the additional three sites surveyed in 2017 were disregarded. Given the suitable habitat that occurs in these additional three sites for the target species, in a suitable year they should continue to be surveyed in future winter surveys.

There is some natural regeneration of canopy species occurring at two of the DNG sites (SP1 and SP6). At both sites, regeneration of canopy species is still less than four metres and these grassland sites are unlikely to require surveys in the winter period in 2023. There is no canopy regeneration at SP10, SP5 or SP7 and these would not be needed to be added to the winter survey schedule in 2023.

5.2 Spring bird surveys

The 11 spring survey sites were surveyed twice in 2022. As per the recommendation in the 2017 report, survey site SP5 was again moved approximately 750 meters south of its previous position, and S3 was removed entirely as a survey site (see Figure 2). Given the mobile nature of bird species and the fact that this isolated, small remnant woodland consists only of canopy and groundcover stratum, it was discovered during the 2017 survey periods that there was considerable overlap between the bird species recorded at these two sites. Based on this, future surveys would benefit from combining these two survey sites into one survey site. This should continue for the 2023 survey period.

Between 51 and 67 different bird species (noting a baseline of 59 species) have been recorded during spring surveys over the last 8 years since 2014. The species composition recorded during Spring 2022 (61 species) occurs within this range and shows that bird diversity at the site has not changed since baseline.

5.3 Kangaroo population

Since the commencement of kangaroo surveys in 2017, monitoring results up until 2019 indicated that kangaroo numbers in the Derived Native Grassland (DNG) area were increasing. Kangaroo abundance in the DNG increased substantially between 2017 and 2019.

As per the statement made in the approved BOMP at the request of OEH: ‘If a significant increase in the kangaroo population is recorded over two consecutive monitoring periods adaptive management will be investigated’.

Due to a significant increase in kangaroo numbers from 2017 to 2019, Northparkes has sought to manage kangaroo numbers on site via the installation of kangaroo exclusion fencing. The commencement of installation began in late 2019 and was completed in early 2020 before the first survey period in spring. Management measures for kangaroos are particularly important given the recent planting of trees in regeneration areas SP1, SP6 and SP7 in early 2020.

Following low rainfall between 2017 and 2019, the Parkes area of NSW experienced drought conditions, which may have contributed to increased grazing pressures in nearby woodland and agricultural land, leading to a concentration of kangaroo species at the Kokoda Offset Area, where grazing by domestic stock does not occur. Between 2020 and 2022, the Parkes area experienced higher than average rainfall that has likely increased the availability of feed resources in the locality. In conjunction with the exclusion fencing this may have contributed to the general decrease in kangaroos on site since 2019.

In 2022, an increase in kangaroo numbers within the site was observed between the winter and spring monitoring period. A kangaroo cull may be required if kangaroo counts increase significantly again following 2023 monitoring surveys, to reduce kangaroo numbers within the site.

It is recommended that the method outlined in this report for the kangaroo count should continue to be followed for future monitoring.

5.4 Additional measures

No additional management recommendations, other than those outlined in the Northparkes BOMP, are required at this stage.

6. References

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DotE, 2013, Matters of national environmental significance: Significant impact guidelines 1.1, *Environment Protection and Biodiversity Conservation Act 1999*. Commonwealth Department of the Environment, Canberra.

DCCEEW, 2022a, Protected Matters Search Tool. Commonwealth Department of Climate Change, Energy, the Environment and Water, online database, accessed July 2022, URL: **http://www.environment.gov.au/erin/ert/epbc/index.html**.

DCCEEW, 2022b, Species Profile and Threats Database. Commonwealth Department of Climate Change, Energy, the Environment and Water, online database, accessed July 2022, URL: **http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl**

DEWHA, 2010, Survey guidelines for Australian's threatened birds. Guidelines for detecting birds listed as threatened under the *Environment Protection and Biodiversity Conservation Act 1999*. **https://www.dcceew.gov.au/sites/default/files/documents/survey-guidelines-birds-april-2017.pdf**

DPE 2022a, *BioNet Atlas of NSW*. NSW Department of Planning and Environment, Licensed data obtained July 2022.

DPE, 2022b, *NSW threatened species profiles*. NSW Department of Planning and Environment, online database, accessed July 2022, URL: **http://www.environment.nsw.gov.au/threatenedspecies/**

Umwelt (2014). Biodiversity Offset Management Plan: Kokoda Offset Area for Northparkes Mine. Revised 22nd September 2015

Appendix A

Desktop searches

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 21-Jul-2022

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	4
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	3
Listed Threatened Species:	26
Listed Migratory Species:	11

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	18
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	None
EPBC Act Referrals:	1
Key Ecological Features (Marine):	None
Biologically Important Areas:	None
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar Wetlands) [Resource Information]

Ramsar Site Name	Proximity
Banrock station wetland complex	700 - 800km upstream from Ramsar site
Hattah-kulkyne lakes	500 - 600km upstream from Ramsar site
Riverland	600 - 700km upstream from Ramsar site
The coorong, and lakes alexandrina and albert wetland	800 - 900km upstream from Ramsar site

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.
Status of Vulnerable, Disallowed and Ineligible are not MNES under the EPBC Act.

Community Name	Threatened Category	Presence Text
Grey Box (Eucalyptus microcarpa) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia	Endangered	Community may occur within area
Poplar Box Grassy Woodland on Alluvial Plains	Endangered	Community may occur within area
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	Community may occur within area

Listed Threatened Species [Resource Information]

Status of Conservation Dependent and Extinct are not MNES under the EPBC Act.
Number is the current name ID.

Scientific Name	Threatened Category	Presence Text
BIRD		

Scientific Name	Threatened Category	Presence Text
Anthochaera phrygia Regent Honeyeater [82338]	Critically Endangered	Foraging, feeding or related behaviour likely to occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Callocephalon fimbriatum Gang-gang Cockatoo [768]	Endangered	Species or species habitat may occur within area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat likely to occur within area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat likely to occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat likely to occur within area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Polytelis swainsonii Superb Parrot [738]	Vulnerable	Species or species habitat known to occur within area

Scientific Name	Threatened Category	Presence Text
Rostratula australis		
Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
FISH		
Macquaria australasica		
Macquarie Perch [66632]	Endangered	Species or species habitat may occur within area
FROG		
Crinia sloanei		
Sloane's Froglet [59151]	Endangered	Species or species habitat may occur within area
MAMMAL		
Chalinolobus dwyeri		
Large-eared Pied Bat, Large Pied Bat [183]	Vulnerable	Species or species habitat may occur within area
Dasyurus maculatus maculatus (SE mainland population)		
Spot-tailed Quoll, Spotted-tail Quoll, Tiger Quoll (southeastern mainland population) [75184]	Endangered	Species or species habitat may occur within area
Nyctophilus corbeni		
Corben's Long-eared Bat, South-eastern Long-eared Bat [83395]	Vulnerable	Species or species habitat likely to occur within area
Phascolarctos cinereus (combined populations of Qld, NSW and the ACT)		
Koala (combined populations of Queensland, New South Wales and the Australian Capital Territory) [85104]	Endangered	Species or species habitat likely to occur within area
Pteropus poliocephalus		
Grey-headed Flying-fox [186]	Vulnerable	Foraging, feeding or related behaviour may occur within area
PLANT		
Austrostipa wakoolica		
[66623]	Endangered	Species or species habitat may occur within area
Lepidium aschersonii		
Spiny Pepper-cress [10976]	Vulnerable	Species or species habitat may occur within area

Scientific Name	Threatened Category	Presence Text
Prasophyllum petilum		
Tarengo Leek Orchid [55144]	Endangered	Species or species habitat may occur within area
Prasophyllum sp. Wybong (C.Phelps ORG 5269)		
a leek-orchid [81964]	Critically Endangered	Species or species habitat may occur within area
Swainsona recta		
Small Purple-pea, Mountain Swainson-pea, Small Purple Pea [7580]	Endangered	Species or species habitat may occur within area
Vincetoxicum forsteri listed as Tylophora linearis		
[92384]	Endangered	Species or species habitat may occur within area
REPTILE		
Aprasia parapulchella		
Pink-tailed Worm-lizard, Pink-tailed Legless Lizard [1665]	Vulnerable	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Hirundapus caudacutus		
White-throated Needletail [682]	Vulnerable	Species or species habitat likely to occur within area
Motacilla flava		
Yellow Wagtail [644]		Species or species habitat may occur within area
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat may occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat may occur within area
Migratory Wetlands Species		

Scientific Name	Threatened Category	Presence Text
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Resource Information]

Scientific Name	Threatened Category	Presence Text
Bird		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area
Bubulcus ibis as Ardea ibis Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area
Chalcites osculans as Chrysococcyx osculans Black-eared Cuckoo [83425]		Species or species habitat likely to occur within area overfly marine area
Gallinago hardwickii Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area overfly marine area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat may occur within area
Hirundapus caudacutus White-throated Needletail [682]	Vulnerable	Species or species habitat likely to occur within area overfly marine area
Lathamus discolor Swift Parrot [744]	Critically Endangered	Species or species habitat likely to occur within area overfly marine area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area
Motacilla flava Yellow Wagtail [644]		Species or species habitat may occur within area overfly marine area

Scientific Name	Threatened Category	Presence Text
Myiagra cyanoleuca		
Satin Flycatcher [612]		Species or species habitat may occur within area overfly marine area
Neophema chrysostoma		
Blue-winged Parrot [726]		Species or species habitat may occur within area overfly marine area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Rhipidura rufifrons		
Rufous Fantail [592]		Species or species habitat may occur within area overfly marine area
Rostratula australis as Rostratula benghalensis (sensu lato)		
Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area overfly marine area

Extra Information

EPBC Act Referrals [Resource Information]

Title of referral	Reference	Referral Outcome	Assessment Status
Not controlled action			
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Data from the BioNet Atlas website, which holds records from a number of custodians. The data are only indicative and cannot be considered a comprehensive inventory, and may contain errors and omissions. Species listed under the Sensitive Species Data Policy may have their locations denatured (^ rounded to 0.1°C; ^^ rounded to 0.01°C. Copyright the State of NSW through the Department of Planning, Industry and Environment. Search criteria : Licensed Report of all Valid Records of Threatened (listed on BC Act 2016) ,Commonwealth listed ,Protected ,CAMBA listed ,JAMBA listed ,ROKAMBA listed ,Exotic listed or Native listed Birds (Class: Aves) in selected area [North: -33.22 West: 148.40 East: 148.50 South: -33.32] returned a total of 696 records of 121 species.
Report generated on 21/07/2022 5:24 PM

Kingdom	Class	Family	Species Code	Scientific Name	Exotic	Common Name	NSW status	Comm. status	Records	Info
Animalia	Aves	Casuariidae	0001	*Dromaius novaehollandiae*		Emu	P		1	
Animalia	Aves	Anatidae	0211	*Anas gracilis*		Grey Teal	P		2	
Animalia	Aves	Anatidae	0208	*Anas superciliosa*		Pacific Black Duck	P		3	
Animalia	Aves	Anatidae	0215	*Aythya australis*		Hardhead	P		1	
Animalia	Aves	Anatidae	0202	*Chenonetta jubata*		Australian Wood Duck	P		12	
Animalia	Aves	Podicipedidae	0061	*Tachybaptus novaehollandiae*		Australasian Grebe	P		2	
Animalia	Aves	Columbidae	8843	*Geopelia placida*			P		2	
Animalia	Aves	Columbidae	9931	*Geopelia striata*		Peaceful Dove	P		7	
Animalia	Aves	Columbidae	0043	*Ocyphaps lophotes*		Crested Pigeon	P		11	
Animalia	Aves	Columbidae	0034	*Phaps chalcoptera*		Common Bronzewing	P		12	
Animalia	Aves	Aegothelidae	0317	*Aegotheles cristatus*		Australian Owlet-nightjar	P		1	
Animalia	Aves	Phalacrocoracidae	0100	*Microcarbo melanoleucos*		Little Pied Cormorant	P		2	
Animalia	Aves	Phalacrocoracidae	0099	*Phalacrocorax varius*		Pied Cormorant	P		2	
Animalia	Aves	Ardeidae	0188	*Egretta novaehollandiae*		White-faced Heron	P		6	
Animalia	Aves	Accipitridae	0224	*Aquila audax*		Wedge-tailed Eagle	P		2	
Animalia	Aves	Accipitridae	0228	*Haliastur sphenurus*		Whistling Kite	P		1	
Animalia	Aves	Falconidae	0239	*Falco berigora*		Brown Falcon	P		2	
Animalia	Aves	Falconidae	0240	*Falco cenchroides cenchroides*		Nankeen Kestrel	P		4	
Animalia	Aves	Falconidae	0235	*Falco longipennis*		Australian Hobby	P		1	
Animalia	Aves	Falconidae	0238	*Falco subniger*		Black Falcon	V,P		1	
Animalia	Aves	Rallidae	0046	*Hypotaenidia philippensis*		Buff-banded Rail	P		1	
Animalia	Aves	Charadriidae	0144	*Elseyornis melanops*		Black-fronted Dotterel	P		1	
Animalia	Aves	Charadriidae	0133	*Vanellus miles*		Masked Lapwing	P		4	
Animalia	Aves	Turnicidae	0014	*Turnix varius*		Painted Button-quail	P		1	
Animalia	Aves	Cacatuidae	0269	*Cacatua galerita*		Sulphur-crested Cockatoo	P		9	
Animalia	Aves	Cacatuidae	0271	*Cacatua sanguinea*		Little Corella	P		1	
Animalia	Aves	Cacatuidae	0273	*Eolophus roseicapilla*		Galah	P		12	
Animalia	Aves	Cacatuidae	0274	*Nymphicus hollandicus*		Cockatiel	P		4	
Animalia	Aves	Psittacidae	0281	*Alisterus scapularis*		Australian King-Parrot	P		4	
Animalia	Aves	Psittacidae	0258	*Glossopsitta concinna*		Musk Lorikeet	P		1	
Animalia	Aves	Psittacidae	0260	*Glossopsitta pusilla*		Little Lorikeet	V,P		3	
Animalia	Aves	Psittacidae	0310	*Melopsittacus undulatus*		Budgerigar	P		1	
Animalia	Aves	Psittacidae	0297	*Northiella haematogaster*		Blue Bonnet	P		3	
Animalia	Aves	Psittacidae	0282	*Platycercus elegans*		Crimson Rosella	P		1	
Animalia	Aves	Psittacidae	0288	*Platycercus eximius*		Eastern Rosella	P		11	
Animalia	Aves	Psittacidae	0277	*Polytelis swainsonii*		Superb Parrot	V,P,3	V	9	
Animalia	Aves	Psittacidae	0295	*Psephotus haematonotus*		Red-rumped Parrot	P		12	
Animalia	Aves	Psittacidae	9947	*Trichoglossus haematodus*		Rainbow Lorikeet	P		1	
Animalia	Aves	Cuculidae	0338	*Cacomantis flabelliformis*		Fan-tailed Cuckoo	P		1	
Animalia	Aves	Cuculidae	0337	*Heteroscenes pallidus*		Pallid Cuckoo	P		2	
Animalia	Aves	Tytonidae	9923	*Tyto javanica*		Eastern Barn Owl	P		1	
Animalia	Aves	Alcedinidae	0322	*Dacelo novaeguineae*		Laughing Kookaburra	P		12	
Animalia	Aves	Meropidae	0329	*Merops ornatus*		Rainbow Bee-eater	P		5	
Animalia	Aves	Climacteridae	8127	*Climacteris picumnus victoriae*		Brown Treecreeper (eastern subspecies)	V,P		5	
Animalia	Aves	Climacteridae	0558	*Cormobates leucophaea*		White-throated Treecreeper	P		13	
Animalia	Aves	Maluridae	0529	*Malurus cyaneus*		Superb Fairy-wren	P		12	
Animalia	Aves	Acanthizidae	0476	*Acanthiza apicalis*		Inland Thornbill	P		3	
Animalia	Aves	Acanthizidae	0486	*Acanthiza chrysorrhoa*		Yellow-rumped Thornbill	P		10	
Animalia	Aves	Acanthizidae	0470	*Acanthiza lineata*		Striated Thornbill	P		2	
Animalia	Aves	Acanthizidae	0471	*Acanthiza nana*		Yellow Thornbill	P		9	
Animalia	Aves	Acanthizidae	0475	*Acanthiza pusilla*		Brown Thornbill	P		7	
Animalia	Aves	Acanthizidae	0484	*Acanthiza reguloides*		Buff-rumped Thornbill	P		7	
Animalia	Aves	Acanthizidae	0481	*Acanthiza uropygialis*		Chestnut-rumped Thornbill	P		3	
Animalia	Aves	Acanthizidae	0466	*Aphelocephala leucopsis*		Southern Whiteface	P		5	
Animalia	Aves	Acanthizidae	0504	*Chthonicola sagittata*		Speckled Warbler	V,P		11	
Animalia	Aves	Acanthizidae	0463	*Gerygone fusca*		Western Gerygone	P		10	
Animalia	Aves	Acanthizidae	0498	*Hylacola pyrrhopygia*		Chestnut-rumped Heathwren	P		1	

Animalia	Aves	Acanthizidae	0465	*Smicrornis brevirostris*	Weebill	P	8	
Animalia	Aves	Pardalotidae	0565	*Pardalotus punctatus*	Spotted Pardalote	P	7	
Animalia	Aves	Pardalotidae	0976	*Pardalotus striatus*	Striated Pardalote	P	11	
Animalia	Aves	Meliphagidae	0640	*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater	P	6	
Animalia	Aves	Meliphagidae	0591	*Acanthorhynchus tenuirostris*	Eastern Spinebill	P	2	
Animalia	Aves	Meliphagidae	0638	*Anthochaera carunculata*	Red Wattlebird	P	11	
Animalia	Aves	Meliphagidae	0614	*Caligavis chrysops*	Yellow-faced Honeyeater	P	11	
Animalia	Aves	Meliphagidae	0641	*Entomyzon cyanotis*	Blue-faced Honeyeater	P	7	
Animalia	Aves	Meliphagidae	0608	*Gavicalis virescens*	Singing Honeyeater	P	2	
Animalia	Aves	Meliphagidae	0619	*Lichenostomus melanops*	Yellow-tufted Honeyeater	P	4	
Animalia	Aves	Meliphagidae	0634	*Manorina melanocephala*	Noisy Miner	P	12	
Animalia	Aves	Meliphagidae	0583	*Melithreptus brevirostris*	Brown-headed Honeyeater	P	12	
Animalia	Aves	Meliphagidae	8303	*Melithreptus gularis gularis*	Black-chinned Honeyeater (eastern subspecies)	V,P	2	
Animalia	Aves	Meliphagidae	0578	*Melithreptus lunatus*	White-naped Honeyeater	P	3	
Animalia	Aves	Meliphagidae	0617	*Nesoptilotis leucotis*	White-eared Honeyeater	P	10	
Animalia	Aves	Meliphagidae	0646	*Philemon citreogularis*	Little Friarbird	P	7	
Animalia	Aves	Meliphagidae	0645	*Philemon corniculatus*	Noisy Friarbird	P	9	
Animalia	Aves	Meliphagidae	0585	*Plectorhyncha lanceolata*	Striped Honeyeater	P	3	
Animalia	Aves	Meliphagidae	0613	*Ptilotula fusca*	Fuscous Honeyeater	P	8	
Animalia	Aves	Meliphagidae	0625	*Ptilotula penicillata*	White-plumed Honeyeater	P	9	
Animalia	Aves	Pomatostomidae	0445	*Pomatostomus superciliosus*	White-browed Babbler	P	3	
Animalia	Aves	Pomatostomidae	8388	*Pomatostomus temporalis temporalis*	Grey-crowned Babbler (eastern subspecies)	V,P	10	
Animalia	Aves	Cinclosomatidae	0436	*Cinclosoma punctatum*	Spotted Quail-thrush	P	1	
Animalia	Aves	Falcunculidae	0416	*Falcunculus frontatus frontatus*	Eastern Shrike-tit	P	2	
Animalia	Aves	Campephagidae	0423	*Coracina maxima*	Ground Cuckoo-shrike	P	4	
Animalia	Aves	Campephagidae	0424	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	P	9	
Animalia	Aves	Campephagidae	0430	*Lalage sueurii*	White-winged Triller	P	3	
Animalia	Aves	Pachycephalidae	0408	*Colluricincla harmonica*	Grey Shrike-thrush	P	12	
Animalia	Aves	Pachycephalidae	0398	*Pachycephala pectoralis*	Golden Whistler	P	6	
Animalia	Aves	Pachycephalidae	0401	*Pachycephala rufiventris*	Rufous Whistler	P	11	
Animalia	Aves	Oriolidae	0671	*Oriolus sagittatus*	Olive-backed Oriole	P	6	
Animalia	Aves	Artamidae	8519	*Artamus cyanopterus cyanopterus*	Dusky Woodswallow	V,P	4	
Animalia	Aves	Artamidae	0544	*Artamus personatus*	Masked Woodswallow	P	1	
Animalia	Aves	Artamidae	0545	*Artamus superciliosus*	White-browed Woodswallow	P	4	
Animalia	Aves	Artamidae	0700	*Cracticus nigrogularis*	Pied Butcherbird	P	12	
Animalia	Aves	Artamidae	0702	*Cracticus torquatus*	Grey Butcherbird	P	7	
Animalia	Aves	Artamidae	0705	*Gymnorhina tibicen*	Australian Magpie	P	13	
Animalia	Aves	Artamidae	0694	*Strepera graculina*	Pied Currawong	P	12	
Animalia	Aves	Rhipiduridae	0361	*Rhipidura albiscapa*	Grey Fantail	P	11	
Animalia	Aves	Rhipiduridae	0364	*Rhipidura leucophrys*	Willie Wagtail	P	13	
Animalia	Aves	Corvidae	0930	*Corvus coronoides*	Australian Raven	P	10	
Animalia	Aves	Corvidae	0954	*Corvus mellori*	Little Raven	P	5	
Animalia	Aves	Monarchidae	0415	*Grallina cyanoleuca*	Magpie-lark	P	12	
Animalia	Aves	Monarchidae	9955	*Myiagra inquieta*	Restless Flycatcher	P	9	
Animalia	Aves	Monarchidae	0365	*Myiagra rubecula*	Leaden Flycatcher	P	1	
Animalia	Aves	Corcoracidae	0693	*Corcorax melanorhamphos*	White-winged Chough	P	12	
Animalia	Aves	Corcoracidae	0675	*Struthidea cinerea*	Apostlebird	P	10	
Animalia	Aves	Petroicidae	0392	*Eopsaltria australis*	Eastern Yellow Robin	P	12	
Animalia	Aves	Petroicidae	8367	*Melanodryas cucullata cucullata*	Hooded Robin (south-eastern form)	V,P	1	
Animalia	Aves	Petroicidae	0377	*Microeca fascinans*	Jacky Winter	P	11	
Animalia	Aves	Petroicidae	0381	*Petroica goodenovii*	Red-capped Robin	P	8	
Animalia	Aves	Petroicidae	0382	*Petroica phoenicea*	Flame Robin	V,P	2	
Animalia	Aves	Locustellidae	0508	*Cincloramphus cruralis*	Brown Songlark	P	2	
Animalia	Aves	Locustellidae	0509	*Cincloramphus mathewsi*	Rufous Songlark	P	4	
Animalia	Aves	Hirundinidae	0357	*Hirundo neoxena*	Welcome Swallow	P	8	
Animalia	Aves	Hirundinidae	0359	*Petrochelidon nigricans*	Tree Martin	P	2	
Animalia	Aves	Sturnidae	0999	*Sturnus vulgaris* *	Common Starling		8	
Animalia	Aves	Zosteropidae	0574	*Zosterops lateralis*	Silvereye	P	2	
Animalia	Aves	Dicaeidae	0564	*Dicaeum hirundinaceum*	Mistletoebird	P	4	
Animalia	Aves	Estrildidae	0662	*Neochmia temporalis*	Red-browed Finch	P	1	

Animalia	Aves	Estrildidae	0652	*Stagonopleura guttata*	Diamond Firetail	V,P	6
Animalia	Aves	Estrildidae	0655	*Stizoptera bichenovii*	Double-barred Finch	P	1
Animalia	Aves	Estrildidae	0653	*Taeniopygia guttata*	Zebra Finch	P	1
Animalia	Aves	Motacillidae	0647	*Anthus novaeseelandiae*	Australian Pipit	P	3

Bird data (~10km extent)

Common Name	Scientific Name	Count	Reporting Rate
Apostlebird	*Struthidea cinerea*	3	4.76%
Australian Magpie	*Gymnorhina tibicen*	21	33.33%
Australian Raven	*Corvus coronoides*	2	3.17%
Australian Wood Duck	*Chenonetta jubata*	5	7.94%
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	4	6.35%
Black-shouldered Kite	*Elanus axillaris*	1	1.59%
Blue Bonnet	*Northiella haematogaster*	1	1.59%
Brown Thornbill	*Acanthiza pusilla*	9	14.29%
Brown Treecreeper	*Climacteris picumnus*	1	1.59%
Brown-headed Honeyeater	*Melithreptus brevirostris*	11	17.46%
Buff-rumped Thornbill	*Acanthiza reguloides*	16	25.40%
Chestnut-rumped Heathwren	*Calamanthus pyrrhopygius*	1	1.59%
Common Bronzewing	*Phaps chalcoptera*	5	7.94%
Common Starling	*Sturnus vulgaris*	3	4.76%
Crested Pigeon	*Ocyphaps lophotes*	10	15.87%
Crested Shrike-tit	*Falcunculus frontatus*	1	1.59%
Crow & Raven spp		11	17.46%
Dollarbird	*Eurystomus orientalis*	2	3.17%
Dusky Woodswallow	*Artamus cyanopterus*	1	1.59%
Eastern Rosella	*Platycercus eximius*	26	41.27%
Eastern Spinebill	*Acanthorhynchus tenuirostris*	8	12.70%
Eastern Yellow Robin	*Eopsaltria australis*	15	23.81%
Galah	*Eolophus roseicapilla*	22	34.92%
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	1	1.59%
Golden Whistler	*Pachycephala pectoralis*	8	12.70%
Grey Butcherbird	*Cracticus torquatus*	3	4.76%
Grey Fantail	*Rhipidura fuliginosa*	15	23.81%
Grey Shrike-thrush	*Colluricincla harmonica*	7	11.11%
Grey Teal	*Anas gracilis*	2	3.17%
Laughing Kookaburra	*Dacelo novaeguineae*	6	9.52%
Leaden Flycatcher	*Myiagra rubecula*	2	3.17%
Little Crow	*Corvus bennetti*	2	3.17%
Little Friarbird	*Philemon citreogularis*	1	1.59%
Little Lorikeet	*Glossopsitta pusilla*	1	1.59%
Magpie-lark	*Grallina cyanoleuca*	9	14.29%
Mistletoebird	*Dicaeum hirundinaceum*	4	6.35%
Nankeen Kestrel	*Falco cenchroides*	1	1.59%
Nankeen Night-Heron	*Nycticorax caledonicus*	1	1.59%
Noisy Friarbird	*Philemon corniculatus*	7	11.11%
Noisy Miner	*Manorina melanocephala*	19	30.16%
Olive-backed Oriole	*Oriolus sagittatus*	3	4.76%
Pacific Black Duck	*Anas superciliosa*	1	1.59%
Pallid Cuckoo	*Heteroscenes pallidus*	2	3.17%
Pied Butcherbird	*Cracticus nigrogularis*	5	7.94%
Pied Currawong	*Strepera graculina*	8	12.70%
Rainbow Bee-eater	*Merops ornatus*	1	1.59%
Red Wattlebird	*Anthochaera carunculata*	15	23.81%
Red-rumped Parrot	*Psephotus haematonotus*	2	3.17%
Rufous Whistler	*Pachycephala rufiventris*	7	11.11%
Silvereye	*Zosterops lateralis*	7	11.11%
Spotted Pardalote	*Pardalotus punctatus*	10	15.87%
Spotted Quail-thrush	*Cinclosoma punctatum*	1	1.59%
Striated Pardalote	*Pardalotus striatus*	16	25.40%
Striated Thornbill	*Acanthiza lineata*	5	7.94%
Sulphur-crested Cockatoo	*Cacatua galerita*	6	9.52%
Superb Fairy-wren	*Malurus cyaneus*	16	25.40%
Turquoise Parrot	*Neophema pulchella*	1	1.59%
Varied Sittella	*Daphoenositta chrysoptera*	2	3.17%

Common Name	Scientific Name	Count	Reporting Rate
Wedge-tailed Eagle	*Aquila audax*	3	4.76%
Weebill	*Smicrornis brevirostris*	1	1.59%
Welcome Swallow	*Hirundo neoxena*	3	4.76%
Western Gerygone	*Gerygone fusca*	1	1.59%
White-eared Honeyeater	*Nesoptilotis leucotis*	18	28.57%
White-faced Heron	*Egretta novaehollandiae*	1	1.59%
White-naped Honeyeater	*Melithreptus lunatus*	4	6.35%
White-plumed Honeyeater	*Ptilotula penicillata*	5	7.94%
White-throated Gerygone	*Gerygone olivacea*	2	3.17%
White-throated Nightjar	*Eurostopodus mystacalis*	1	1.59%
White-throated Treecreeper	*Cormobates leucophaea*	24	38.10%
White-winged Chough	*Corcorax melanorhamphos*	9	14.29%
Willie Wagtail	*Rhipidura leucophrys*	2	3.17%
Yellow Thornbill	*Acanthiza nana*	10	15.87%
Yellow-faced Honeyeater	*Caligavis chrysops*	11	17.46%
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	2	3.17%

Appendix B

Bird species list

Spring bird surveys results 2022

Scientific name	Common name	REM1	REM2	REM3	REM4	REM5	REM6	SP1	SP5	SP6	SP7	SP10	Incidental
Struthidea cinerea	Apostlebird					R			R		R		
Tachybaptus novaehollandiae	Australasian Grebe												R
Cracticus tibicen	Australian Magpie	R	R	R	R	R	R	R	R	R	R	R	
Anthus novaeseelandiae	Australian Pipit							R					
Corvus coronoides	Australian Raven			R	R	R	R	R	R	R	R		
Threskiornis molucca	Australian White Ibis												R
Chenonetta jubata	Australian Wood Duck					R					R	R	
Coracina novaehollandiae	Black-faced Cuckoo-shrike				R	R	R		R	R	R	R	
Northiella haematogaster	Blue Bonnet						R						
Entomyzon cyanotis	Blue-Faced Honeyeater					R							
Acanthiza pusilla	Brown Thornbill			R									
Climacteris picumnis	**Brown Treecreeper**		R		R	R					R		
Melithreptus brevirostris	Brown-headed Honeyeater	R	R	R			R						
Acanthiza reguloides	Buff-rumped Thornbill	R		R						R			
Phaps chalcoptera	Common Bronzewing			R								R	
Ocyphaps lophotes	Crested Pigeon		R		R	R		R				R	
Platycercus elegans	Crimson Rosella					R							
Platycercus eximius	Eastern Rosella		R	R	R	R	R	R	R	R	R	R	
Eopsaltria australis	Eastern Yellow Robin	R		R	R								
Cacomantis flabelliformis	Fan-tailed Cuckoo		R										
Eolophus roseicapillus	Galah	R	R		R		R	R	R	R	R	R	
Pachycephala pectoralis	Golden Whistler	R		R									
Cracticus torquatus	Grey Butcherbird				R						R		
Rhipidura albiscapa	Grey Fantail		R				R						
Colluricincla harmonica	Grey Shrike-thrush	R	R										
Anas gracilis	Grey Teal					R				R			

Scientific name	Common name	REM1	REM2	REM3	REM4	REM5	REM6	SP1	SP5	SP6	SP7	SP10	Incidental
Pomatostomus temporalis temporalis	**Grey-crowned Babbler (eastern subspecies)**					R		R	R		R	R	
Microeca fascinans	Jacky Winter						R						
Dacelo novaeguineae	Laughing Kookaburra	R	R		R	R	R	R	R	R	R		
Myiagra rubecula	Leaden Flycatcher		R										
Corvus mellori	Little Raven					R		R	R		R	R	
Grallina cyanoleuca	Magpie-lark		R		R	R	R	R	R	R	R	R	
Philemon corniculatus	Noisy Friarbird					R	R						
Manorina melanocephala	Noisy Miner	R	R		R	R	R	R	R	R	R	R	
Geopelia striata	Peaceful Dove							R					
Cracticus nigrogularis	Pied Butcherbird		R		R		R		R	R		R	
Strepera graculina	Pied Currawong		R								R		
Anthochaera carunculata	Red Wattlebird	R	R			R						R	
Psephotus haematonotus	Red-rumped Parrot											R	
Cincloramphus mathewsi	Rufous Songlark						R						
Pachycephala rufiventris	Rufous Whistler	R	R	R		R	R		R	R			
Chalcites lucidus	Shining Bronze-cuckoo	R	R	R			R					R	
Chthonicola sagittata	**Speckled Warbler**	R		R									
Pardalotus punctatus	Spotted Pardalote	R	R	R	R			R			R		
Sturnus vulgaris	Starling									R			
Pardalotus striatus	Striated Pardalote					R	R		R	R		R	
Cacatua galerita	Sulphur-crested Cockatoo		R									R	
Malurus cyaneus	Superb Fairy-wren					R							
Polytelis swainsonii	**Superb Parrot**				R				R	R	R	R	
Smicrornis brevirostris	Weebill		R			R	R	R		R			
Hirundo neoxena	Welcome Swallow												R
Gerygone fusca	Western Gerygone			R		R	R	R	R	R		R	
Nesoptilotis leucotis	White-eared Honeyeater			R									
Melithreptus lunatus	White-naped Honeyeater	R											

Scientific name	Common name	REM1	REM2	REM3	REM4	REM5	REM6	SP1	SP5	SP6	SP7	SP10	Incide ntal
Ptilotula penicillatus	White-plumed Honeyeater							R		R			
Cormobates leucophaea	White-throated Treecreeper	R	R	R		R	R		R				
Corcorax melanorhamphos	White-winged Chough		R	R		R					R	R	
Rhipidura leucophrys	Willie Wagtail	R	R			R	R	R		R			
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	R						R					
Acanthiza nana	Yellow Thornbill	R		R			R	R					
Total		**19**	**24**	**18**	**15**	**26**	**23**	**19**	**17**	**19**	**18**	**20**	**3**

Notes: R = recorded, Bold = threatened species

Winter bird survey results 2022

Scientific name	Common name	W1	W2	W3	W4	W5	W6	Incidental
Struthidea cinerea	Apostlebird			R	R			
Anthus novaeseelandiae	Australian Pipit							R
Cracticus tibicen	Australian Magpie	R		R	R	R	R	
Corvus coronoides	Australian Raven			R	R			
Chenonetta jubata	Australian Wood Duck	R	R		R	R		
Northiella haematogaster	Blue Bonnet							R
Melithreptus brevirostris	Brown-headed Honeyeater	R	R	R			R	
Acanthiza pusilla	Brown Thornbill			R				
Climacteris picumnus victoriae	**Brown Treecreeper (eastern subspecies)**	R	R			R	R	
Coturnix ypsilophora	Brown Quail							R
Acanthiza reguloides	Buff-rumped Thornbill		R				R	
Phaps chalcoptera	Common Bronzewing							R
Ocyphaps lophotes	Crested Pigeon				R			
Platycercus elegans	Crimson Rosella	R			R			
Platycercus eximius	Eastern Rosella			R	R	R		
Falcunculus frontatus frontatus	Eastern Shrike-tit			R				
Eopsaltria australis	Eastern Yellow Robin	R	R					
Dromaius novaehollandiae	Emu						R	
Ptilotula fuscus	Fuscous Honeyeater		R					
Eolophus roseicapillus	Galah	R	R	R	R	R	R	
Pachycephala pectoralis	Golden Whistler						R	
Cracticus torquatus	Grey Butcherbird					R		
Rhipidura albiscapa	Grey Fantail						R	
Colluricincla harmonica	Grey Shrike-thrush	R		R	R			
Pomatostomus temporalis temporalis	**Grey-crowned Babbler (eastern subspecies)**				R			
Dacelo novaeguineae	Laughing Kookaburra			R	R		R	

Scientific name	Common name	W1	W2	W3	W4	W5	W6	Incidental
Philemon citreogularis	Little Friarbird	R	R				R	
Corvus mellori	Little Raven				R			
Grallina cyanoleuca	Magpie-lark			R	R	R	R	
Philemon corniculatus	Noisy Friarbird	R			R		R	
Manorina melanocephala	Noisy Miner			R	R	R		
Geopelia striata	Peaceful Dove				R			
Cracticus nigrogularis	Pied Butcherbird				R			
Phalacrocorax varius	Pied Cormorant							R
Strepera graculina	Pied Currawong						R	
Psephotus haematonotus	Red-rumped Parrot				R			
Anthochaera carunculata	Red Wattlebird	R		R			R	
Pachycephala rufiventris	Rufous Whistler			R				
Chthonicola sagittata	**Speckled Warbler**	R	R				R	
Acanthagenys rufogularis	Spiny-cheeked Honeyeater			R				
Pardalotus punctatus	Spotted Pardalote	R	R	R			R	
Pardalotus striatus	Striated Pardalote	R	R	R	R			
Acanthiza lineata	Striated Thornbill						R	
Cacatua galerita	Sulphur-crested Cockatoo	R						
Malurus cyaneus	Superb Fairy-wren		R				R	
Polytelis swainsonii	**Superb Parrot**					R		
Aquila audax	Wedge-tailed Eagle				R			
Hirundo neoxena	Welcome Swallow							R
Gerygone fusca	Western Gerygone		R	R				
Nesoptilotis leucotis	White-eared Honeyeater						R	
Melithreptus lunatus	White-naped Honeyeater	R	R	R				
Cormobates leucophaea	White-throated Treecreeper	R	R					
Corcorax melanorhamphos	White-winged Chough			R		R		
Rhipidura leucophrys	Willie Wagtail			R			R	
Caligavis chrysops	Yellow-faced Honeyeater	R	R				R	

Scientific name	Common name	W1	W2	W3	W4	W5	W6	Incidental
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	R						
Acanthiza nana	Yellow Thornbill		R	R				
Total		**19**	**17**	**22**	**20**	**10**	**21**	**6**

Notes: R = recorded, Bold = threatened species

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Management Plan

Biodiversity Offset

Risk Statement: High

This document will be reviewed on a one yearly basis, unless a process change occurs earlier than this period. This Management Plan has been developed to comply with Condition 29 of NSW Development Consent (DC11_0060) and to comply with the Northparkes Mines Step Change Project Preliminary Documentation as conditioned under the Commonwealth Project Approval (EPBC 2013/6788).

Doc No.	Version No.	Next Review Date	Owner
PLN-0065	7.02	28/06/2023	Environment & Farms Superintendent

Revision Summary

First Issue	Issue Date	Implementation Requirements	Approved By
1	30 Nov 14	Biodiversity Management Plan prepared by Umwelt for compliance with NSW Project Condition (PA11_0060)	Environment and Farms Superintendent

Version No.	Revision Date	Summary of Revision Details	Approved By
2	22 Sep 15	Biodiversity Management Plan updated to: • Incorporate comments received from the Department of Planning and Environment • Reformatted into Northparkes document style • Renamed Biodiversity Offset Management Plan (BOMP) rather than Biodiversity Management Plan (BMP) • Removed references to Pine Donkey Orchid management from main document and included in Appendix 3 – Species Management Plan for the Pine Donkey Orchid	Environment & Farms Superintendent
3	26 Jul 16	BOMP updated to include comments from OEH. Reformatted document into new Northparkes template.	PSE Manager
4	28 Oct 16	BOMP updated to include comments from OEH, following meeting with OEH on 19 October 2016.	Environment & Farms Superintendent
5	24 Nov 16	BOMP updated following response from OEH	Environment & Farms Superintendent
6	25 Feb 20	Updated to new DCS	M Row
7	23 Jun 20	Review following submission of Annual Review. Changes made to management strategy timeframes as a result of a delayed registration of the Voluntary Conservation Agreement.	Environment & Farms Superintendent
7	2 Sep 20	Approved by Department of Planning, Industry & Environment	
7.01	Jun 21	Annual review	C Higgins
7.02	Aug 22	Annual review – no change - update logo	D Shaw

Consultation Required	Public Copy Locations
Not Applicable	Northparkes Website

Associated Documents to be Reviewed
Not Applicable

Table of Contents

1. OVERVIEW

1.1 Background

CMOC Mining Services Pty Limited (CMOC) is the manager of the Northparkes Joint Venture, an unincorporated joint venture between CMOC Mining Limited (80%); Sumitomo Metal Mining Oceania Pty Ltd (13.3%) and SC Mineral Resources (6.7%). Northparkes is a copper-gold operation in Goonumbla, situated 27 kilometres north-west of the town of Parkes.

Construction of the ore processing plant and associated facilities began in 1993. Open cut mining commenced on the E22 and E27 ore bodies in late 1993. Development of the E26 lift 1 block cave underground mine began in 1994, with full scale production commencing in 1997.

1.1.1 Mining Context

Operations at Northparkes primarily comprises underground mining from multiple ore sources that feed a processing plant with a capacity of 6.5 million tonnes per annum (Mtpa). The underground mine is accessed via a decline ramp from the surface for people and materials with ore transported to the surface via inclined conveyors and a hoisting shaft, with a nominal capacity of 7.2 Mtpa. Northparkes utilises low cost block and sub-level cave mining and exploits industry leading technology, such as semi-autonomous loaders and various cave monitoring systems.

The ore processing operation consists of four stages: crushing, grinding, flotation and thickening / filtering. In addition to producing concentrate, the ore processing team also manages tailings disposal. The concentrator was constructed in two modules. Each module consists of its own grinding circuit with a single flotation circuit, concentrate thickener and filter. After extracting the copper and gold bearing minerals, the tailings are combined in a single tailings thickener before being deposited in the active tailings storage facility.

Northparkes' copper concentrate is transported to a rail siding at Goonumbla where it is then transported by rail to Port Kembla, for shipping to overseas customers.

1.1.2 Biodiverstiy Offset

The Northparkes Mines (Northparkes) Biodiversity Offset Management Plan (BOMP) has been prepared to guide the ongoing management of the Kokoda Offset Site for biodiversity conservation and enhancement purposes. The Kokoda Offset Site has been established as a biodiversity offset for the ecological impacts of the Northparkes Mines Step Change Project (the Project). The 350 hectare Kokoda Offset Site is located in the Mandagery locality of the Central West Slopes of NSW (refer to Figure 1), approximately 52 kilometres south-east of the Project Area. In addition the BOMP incorporates the existing approved biodiversity offset management plans for the existing Limestone National Forest Offset (refer to Appendix 1) and Estcourt Tailings Storage Facility Offset (refer to Appendix 2) as established in accordance with the previous project approval (PA06_0026 as modified) at Northparkes.

The BOMP has been prepared in accordance with the NSW Development Consent (DC11_0060) requirements and Commonwealth Project Approval (EPBC 2013/6788) requirements issued for the Project and provides a framework for the implementation of ecological management actions, regeneration strategies, controls and monitoring programs for the Kokoda Offset Site.

2. SCOPE

This document applies to all activities undertaken by Northparkes including mining and exploration activities, processing of copper / gold ore resources, project development, maintenance activities, mine closure, logistics, associated service and support functions, bore fields, farming operations and products.

3. OBJECTIVES

The objective of the BOMP is to facilitate the long term conservation and enhancement of the ecological values of the Kokoda Offset Site. The BOMP broadly focuses on manging woodland for conservation and assisting derived native grassland (DNG) areas to return to woodland form of key targeted vegetation communities.

The specific objectives of the BOMP are to:

- Identify and describe the area of land that will be required to be managed in accordance with this BOMP;
- Provide clear and concise instructions for the management of the Kokoda Offset Site in accordance with the biodiversity management plan objectives;
- Provide a working schedule for the implementation of BOMP activities, including:
  - Manage remnant vegetation and fauna habitat;
  - Restore the DNG component of the Grey Box Grassy Woodland EEC to woodland community;
  - Intergrate the implementation of the biodiversity offset strategies to the greatest extent practicable with the rehabilitation of the site (where relevant); and
  - Manage and maintain the populations of Pine Donkey Orchid located to the North of the project area (near Avadale Road) and near E48 subsidence zone.
- Describe monitoring, performance evaluation and reporting procedures that are informative, practical and achievable.

4. RESPONSIBILITIES

General role responsibilities are outlined in the Health, Safety and Environment Responsibilities and Accountabilities Procedure (PRO-0080). Personnel carrying out work under this document must be familiar with and comply with it in full. The following persons have specific responsibility:

Table 1: Responsibilities

Role	Responsibility
All Personell	– ensure staff and contractors accessing the Kokoda Offset Site are informed and trained where relevant in relation to controls on activities within the Offset Sites; – receive training regarding controls on activities within the Kokoda Offset Site; – observe boundaries of the Kokoda Offset Site when undertaking work on site; and – undertake activities in the Kokoda Offset Site in line with directions from the Operations Manager and People, Safety and Environment Manager.
Environment and Farm Superintendent	– report unauthorised access by stock or vehicles to the Kokoda; and – report on any fencing or track maintenance works required to prevent stock access to the Kokoda Offset Site.
PSE Manager	– co-ordinate the day to day implementation of the BOMP, including the implementation of all management activities; – undertake biannual inspections of the Kokoda Offset Site; – analyse and collate documentation for inclusion in the Annual Review; – assess the effectiveness of the management strategies and instigate the adaptive management process as required; – ensure all internal and external reporting requirements are met; – ensure that all relevant records are effectively maintained on site; – periodically review progress against targets and performance indicators; – review this managmement plan on a three yearly basis – ensure that personnel involved in the carrying out and monitoring of the BOMP activities and values are appropriately qualified, licensed and experienced to undertake the task; – manage/control access to the Kokoda Offset Site;

Role	Responsibility
Managing Director	– ensure that sufficient time and resources are allocated to allow for the implementation of biodiversity management and monitoring strategies as outlined in the BOMP; – authorise internal and external reporting requirements as well as subsequent revisions of this BOMP; and – oversee implementation of the BOMP to ensure compliance with approval requirements.

5. DEFINITIONS

Table 2: Definitions

Key Word	Definition
BOMP	Biodiversity Offset Management Plan
CEEC	Critically Endangered Ecological Community
DNG	Derived Native Grassland
DoE	Commonwealth Department of the Environment
EEC	Endangered Ecological Community
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)
ha	Hectares
LFA	Landscape Function Analysis
OEH	NSW Office of Environment and Heritage
DoPI&E (the Department)	NSW Department of Planning, Industry and Environment
TEC	Threatened Ecological Community
BC Act	Biodiversity Conservation Act 2016 (NSW)

6. DESCRIPTION OF THE KOKODA OFFSET SITE

The following sections provide a summary of the characteristics and biodiversity values of the Kokoda Offset Site as relevant to this BOMP. Further description of the baseline condition and environment of the Kokoda Offset is provided in the Environmental Assessment and the Preliminary Documentation (Umwelt 2013a and 2013b). In addition, a description of the Limestone National Forest and Estcourt Offset area are provided in Appendix 1 and Appendix 2, respectively.

6.1 Location

The Kokoda Offset Site is strategically located along a north-south potential corridor of remnant woodland and forest vegetation that runs along ridges and hills from north of Eugowra in the south, to east of Narromine in the north. The north-south potential corridor includes Goobang National Park, the largest conserved remnant of woodland and forest vegetation in the Central West region of NSW.

The Kokoda Offset Site is located approximately 12 kilometres north-west of Nangar National Park, approximately 8 kilometres south of Goobang National Park, approximately 12 kilometres west of Mandagery State Forest, approximately 17 kilometres east of Cookamidgera State Forest, and approximately 20 kilometres east of Back Yamma State Forest (refer to Figure 1).

The Kokoda Offset Site comprises lower fertility soils in the northern sections, predominately cleared for grazing, and dense woodland covered slopes and ridge lines in the south of the property. Sheep and cattle grazing has been undertaken across the entire property since ecological surveys began in 2013 and is likely to have been the predominant land use for many years. Northparkes removed all stock from the Kokoda Offset Site in early 2015, following purchase of the property.

To the north of the Kokoda Offset Site, the predominant land use is agriculture, primarily cropping but also grazing. This agricultural area is largely confined to the lower and flatter areas, occurring between Goobang National Park and the southern portion of the Kokoda Offset Site.

6.2 Land tenure and conservation mechanism

The Kokoda property was purchased and secured under a Voluntary Conservation Agreement (VCA) to ensure, in perpertuity, the long-term conservation and enhancement of the offset values. Following the final sign off by the Chief Executive in February 2018, Northparkes commenced undertaking management actions in accordance with the relevant permissions and guidelines of the agreement.

6.3 Key ecological values

The Kokoda Offset Site provides conservation of 109 hectares of Grey Box Grassy Woodland EEC (including 96 hectares of DNG that will be returned to woodland form), 2.2 hectares of White Box – Yellow Box – Blakely's Red Gum Woodland EEC/CEEC, known habitat areas for the grey-crowned babbler, little lorikeet and eastern bentwing-bat and potential habitat for a number of threatened fauna species. Further details of the ecological values of the Kokoda Offset Site are provided in the following sections.

6.3.1 Vegetation communities and Threatened Ecological Communities

A total of 11 vegetation communities have been recorded in the Kokoda Offset Site, three of which are Threatened Ecological Communities (TECs). Figure 2 shows the location of the vegetation communities recorded on the Kokoda Offset Site. These vegetation communities are also listed in Table 3 below.

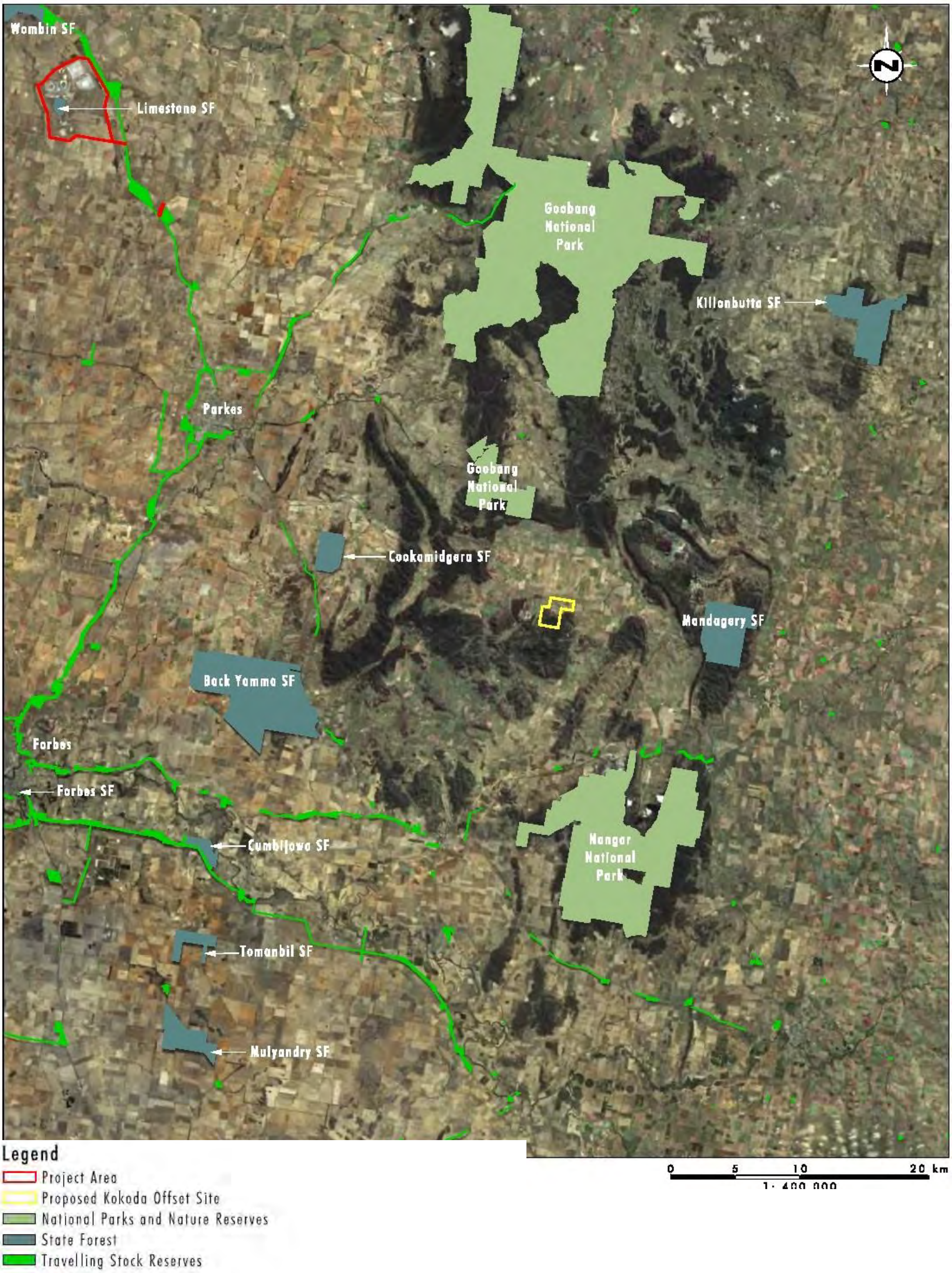


Figure 1: Location of Kokoda Biodiversity Offset

Table 3: Vegetation communities of the Kokoda Offset Site

Vegetation Community	BC Act Status	EPBC Act Status	Vegetation within Kokoda Offset Site (ha)
Grey Box Grassy Woodland	EEC	EEC	13
Grey Box Grassy DNG	EEC	EEC	96
White Box Grassy Woodland	EEC	CEEC	2.2
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest			150
Rocky Rise Shrubby Woodland			26
Grey Box – Ironbark Woodland			25
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine DNG			15
Dwyer's Red Gum Creekline Woodland			9.4
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Woodland Low Quality			8.6
Mugga Ironbark Woodland			1.9
Farm Tracks and Dams – Disturbed Land			2.5
Total			350[1]

1 = Rounding of totals applied (numbers less than 1 – 2 decimal places, numbers between 1 and 10 – 1 decimal place, and greater than 10 - no decimal places)
CEEC = Critically Endangered Ecological Community
EEC = Endangered Ecological Community
EPBC Act = Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
BC Act = NSW *Biodiversity Conservation Act 2016*
DNG = Derived Native Grassland
ha = Hectares

The 13 hectares of Grey Box Grassy Woodland and 96 hectares of Grey Box DNG on the Kokoda Offset Site conforms to the BC Act listed *Inland Grey Box Woodland in the Riverina, NSW South Western Slopes, Cobar Peneplain, Nandewar and Brigalow Belt South Bioregions* EEC and the EPBC Act listed *Grey Box (Eucalyptus microcarpa) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia* EEC.

The 2.2 hectares of White Box Grassy Woodland on the Kokoda Offset Site conforms to the BC Act listed White Box – Yellow Box – Blakely's Red Gum Woodland EEC and the EPBC Act listed White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland CEEC.

The 96 hectares of Grey Box Grassy Woodland DNG and 15 hectares of Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine DNG within the Kokoda Offset Site will be managed back to woodland form. The recovery potential of these areas was assessed resulting in the delineation of six vegetation management areas (refer to Figure 2). These management areas identify those parts of the DNG predicted to respond well to assisted natural regeneration strategies and those predicted to potentially require active management. Further detail on these vegetation management areas is included in Section 9.7.

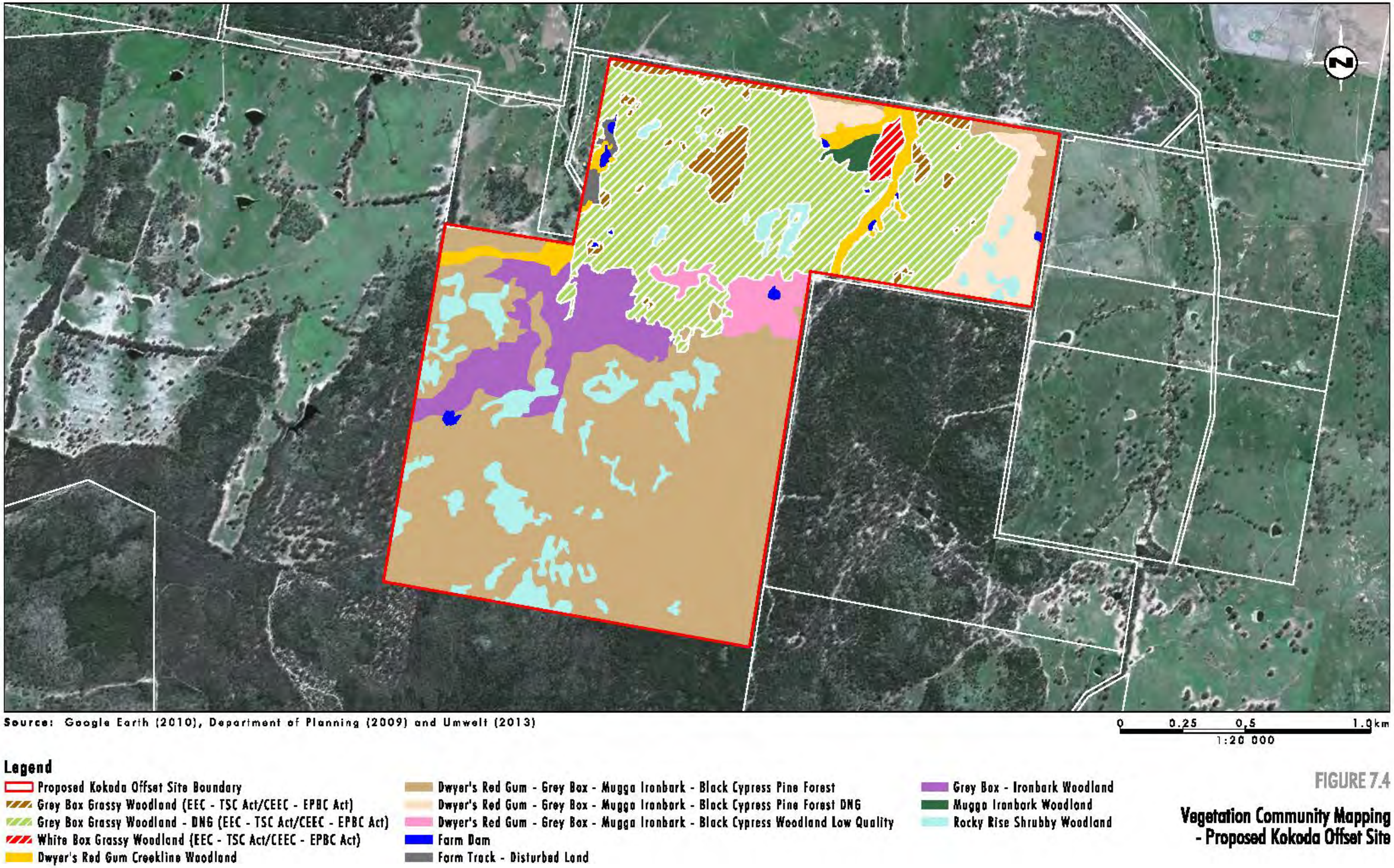


Figure 2: Vegetation communities

Figure 3: Conceptual vegetation management area with Landscape Function Analysis monitoring locations

6.3.2 Baseline Threatened Species

No threatened flora species were recorded in the Kokoda Offset Site during baseline surveys.

Twelve threatened fauna species were recorded in the Kokoda Offset Site and are listed in Table 4 below and shown on Figure 4.

Table 4: Threatened fauna species recorded within the Kokoda offset site

Common Name	Scientific Name	Status		No. of individuals/ locations
		BC Act	EPBC Act	
Glossy black-cockatoo	*Calyptorhynchus lathami*	V		2/1
Superb parrot	*Polytelis swainsonii*	V	V	162/23
Little lorikeet	*Glossopsitta pusilla*	V		25/2
Brown treecreeper (eastern subspecies)	*Climacteris picumnus victoriae*	V		18/10
Speckled warbler	*Chthonicola saggitatus*	V		13/9
Hooded robin (south-eastern form)	*Melanodryas cucullata cucullata*	V		1/1
Grey-crowned babbler (eastern subspecies)	*Pomatostomus temporalis temporalis*	V		95/20
Varied sittella	*Daphoenositta chrysoptera*	V		2/2
Diamond firetail	*Stagonopleura guttata*	V		8/3
Eastern bentwing-bat	*Miniopterus schreibersii oceanensis*	V		-/2
Little pied bat	*Chalinolobus picatus*	V		-/2
Yellow-bellied sheathtail-bat	*Saccolaimus flaviventris*	V		-/2

V = Vulnerable Species
BC Act = *Biodiversity Conservation Act 2016*
EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*

The grey-crowned babbler, brown treecreeper and the superb parrot were the most commonly recorded threatened fauna species across the Kokoda Offset Site. The grey-crowned babbler and the brown treecreeper are both sedentary birds and will utilise the site across all seasons whereas the superb parrot is a seasonally nomadic species which will largely utilise the Kokoda Offset Site for foraging during spring and summer. Given the array of varied habitats within the site, there is a high potential that other threatened fauna species may occur within the Kokoda Offset Site.

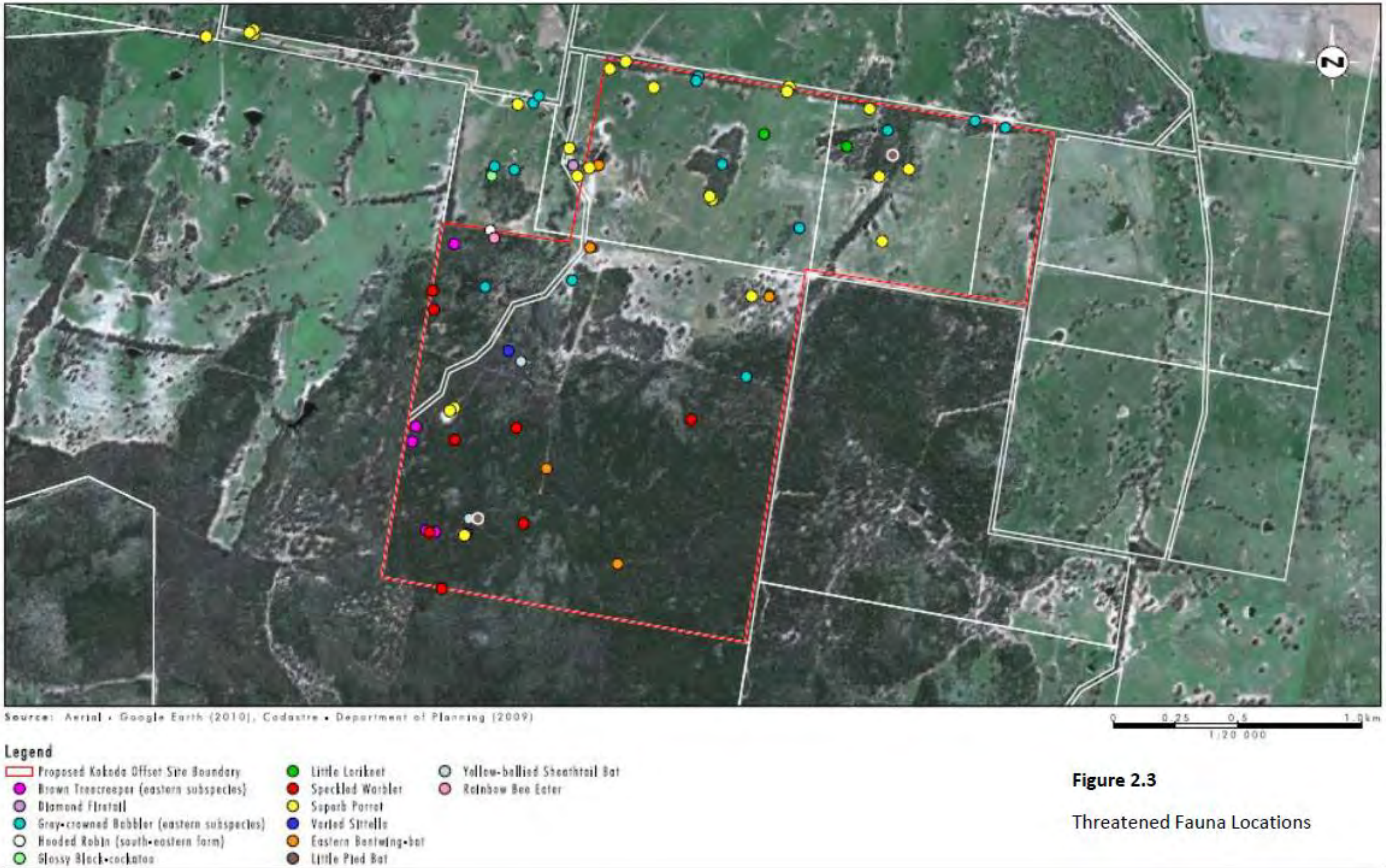


Figure 4: Threatened fauna locations

6.4 Management Zone Stratification

The Kokoda Offset Site has been stratified into seven management zones based primarily on the condition of the vegetation communities and their recovery potential. Table 5 below provides a summary of the management zones identified within the Kokoda Offset Site.

Table 5: Management Zones at the Kokoda Offset Site

Management Zone	Vegetation Type	Objective	Total Area
1	Grey Box Grassy Woodland – DNG – Active Revegetation	Restore to woodland	36.3
2	Grey Box Grassy Woodland – DNG – Potential Regeneration	Restore to woodland	21.3
3	Grey Box Grassy Woodland – DNG – Natural Regeneration	Restore to woodland	38.4
4	Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine DNG Active Regeneration	Restore to woodland	1
5	Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine DNG Natural Regeneration	Restore to woodland	13.8
6	Disturbed – Potential Regeneration	Restore to woodland	1.3
7	All Remnant Woodland and Forest	Conserve and maintain	238
		Total	350

Management zones 1 to 5 are all DNG communities that occur on the lower slopes in the northern section of the property. These areas will each receive varying levels of management, however the long term goal for each of these zones, plus zone 6, is to return them to their former woodland community structure.

7. BIODIVERSITY MANAGEMENT TARGETS

Biodiversity management targets form the basis of the BOMP. The proposed management and improvement strategies (Section 9) will enable the biodiversity management targets and conditions of the approval to be met. Specific performance indicators and completion criteria (Section 9) will be used to track the success of the BOMP in reaching these targets.

The short term (3 year) biodiversity management targets for the management of the Kokoda Offset Site are to:

- establish signage throughout the Kokoda Offset Site;
- remove stock-grazing activities from the Kokoda Offset Site by maintenance of fencing as required;
- establish a monitoring program to assess the success of ongoing management and improvement strategies, in particular focusing on the regeneration potential of Grey Box Grassy Woodland DNG areas; and
- commence establishment of Grey Box Grassy Woodland in areas of DNG through assisted natural regeneration principles;
- include a range of flora species from each vegetation strata represented in the target community (such as trees, shrubs, and ground cover forbs and grasses), even if only as seedlings/juvenile plants initially, as determined through monitoring of selected reference sites in the target community within the Kokoda Offset Site;
- contain a flora species assemblage trending towards the target communities (i.e. Grey Box Grassy Woodland EEC or Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest) as determined through monitoring of selected reference sites in the target community within the Kokoda Offset Site;
- support no more than 20 per cent foliage cover of perennial weed species (as a total of all strata, based on monitoring plot data); and
- support no more than 20 per cent bare ground as part of the ground layer.

- effectively manage weed and pest species;
- implement weed monitoring at to assess if weed species are out competing native species once grazing pressure has been removed. Adaptive management practices will be adopted to control weed species as necessary;
- from year two onwards, initiate active revegetation methods to establish Grey Box Grassy Woodland in areas of low recovery potential DNG as required through the results of monitoring in years 1 and 2;
- manage the remnant woodland areas to maintain similar or increasing flora and fauna species diversity;
- establish an appropriate long-term conservation mechanism; and
- demonstrate that accurate records are being maintained substantiating all activities and monitoring associated with the BOMP.

The preliminary medium term (6, 10 and 15 years) biodiversity management targets for the Kokoda Offset Site are to:

- effectively monitor, control and reduce weed and pest species populations;
- monitor and document collective trend towards an increase in native flora and fauna species diversity;
- monitor and document DNG areas trending toward woodland communities, containing natives species commensurate with those of the target woodland communities

The preliminary long term (i.e. 20 years) biodiversity management targets for the Kokoda Offset Site are to:

- effectively control and reduce weed and pest species populations;
- improve the overall native flora and fauna species diversity compared to conditions during baseline assessments;
- improve the habitat value of the remnant woodland communities in the Kokoda Offset Site compared to conditions during baseline assessments;
- successfully establish an additional 96 hectares of Grey Box Grassy Woodland EEC in areas of existing DNG and demonstrate that the regenerated communities are representative of local reference sites in remnant Grey Box Grassy Woodland EEC.
- regenerate/revegetate management areas contain a minimum of 50 per cent of the native flora species diversity recorded from reference sites in the target community within the Kokoda Offset Site;
- regenerate/revegetate management areas support a vegetation structure that is similar to that recorded for reference sites in the target community within the Kokoda Offset Site;
- demonstrate that second generation trees are present within regeneration/revegetation areas;
- identify that more than 75 per cent of trees are healthy and growing as indicated by long term monitoring;
- ensure that weed species do not dominate any vegetation stratum (i.e. weed species comprise less than 10 per cent of any vegetation stratum);
- ongoing monitoring of soil stability, including implementation of erosion and sediment controls to management significant erosions concerns, as required; and
- regenerate/revegetate areas linked to existing woodland remnants to establish vegetation corridors within the broader landscape and manage excessive edge effects.

8. OFFSET MONITORING PROGRAM

The Kokoda Offset Site will be subject to an ongoing monitoring program to measure the success of management and restoration strategies in meeting the approval conditions (Section 8) and performance indicators as set out in Section 9 in a timely manner. The monitoring program will incorporate annual systematic monitoring as well as biannual (twice yearly) inspections.

8.1 Monitoring Objectives

The objectives of the Kokoda Offset Site monitoring program will be to:

- identify any potential loss of biodiversity values over the entire Kokoda Offset Site;
- document the ecological characteristics of remnant woodland vegetation to establish a baseline for developing accurate closure criteria for the regeneration of DNG;
- assess the recovery of DNG areas;
- assess and map the presence of threats such as significant populations of pest fauna species or weed infestations; and
- identify the need for additional or corrective management measures to achieve the performance indicators and completion criteria.

8.2 Monitoring Timing and Schedules

Ecological monitoring will be annual for the first five years (however DNG monitoring will also be undertaken at six months – see Section 8), then every three years for the following 15 years. The first ecological monitoring survey will be completed within six months of the implementation of the BOMP, and subsequent monitoring events should occur in the same season. It is recommended that the ecological monitoring surveys be undertaken in spring or autumn as there tends to be a lower diversity of species detectable in the more extreme weather conditions of winter and summer seasons (except where specific seasons are required for targeted bird surveys).

8.3 Ecological Monitoring Techniques

The monitoring program incorporates techniques that:

a) are relatively simple to measure, can be replicated with limited subjectivity, and are reproducible;

b) adopt the SMART principles (specific, measurable, achievable, realistic and timely);

c) are targeted towards recording information that provides a good indication of the status of the biodiversity values of the Kokoda Offset Site;

d) allow for floristic composition and structure to be monitored over time using basic statistical analysis;

e) allow for comparison to reference (control) sites; and

f) are cost effective.

8.3.1 Vegetation monitoring

The ecological monitoring program for the Kokoda Offset Site will include a combination of condition assessments, floristic sampling, sapling survivorship counts and stratified quadrat sampling. Revegetation areas will be monitored by sapling survivorship counts of planted tubestock and condition assessments of surviving tubestock. Regeneration areas (DNG areas where grazing pressure from domestic stock has been removed) will be monitored via stratified and permanent quadrats. Floristic assessments will be undertaken using representative plots and standard botanical survey approaches (e.g. cover-abundance measures) to assess the floristic recovery of the DNG in comparison to the floristic composition of reference sites.

Stratified quadrats will be established in appropriate target communities within the Kokoda Offset Site. The aim of this is to provide reference sites to measure regeneration/ revegetation success against. In the event that regeneration/revegetation sites are unsuccessful in trending towards the ecological values of the reference sites, adaptive management will be undertaken, as required. This may include modifying management actions, or supplementing management actions with new or additional techniques to promote the recovery of regeneration/revegetation sites towards the values of reference sites.

Sections 9.6 (weed management) and 9.7 (regeneration of derived native grasslands) detail the individual vegetation monitoring requirements of the Kokoda Offset Site.

8.3.2 Landscape function analysis monitoring

Monitoring will include Landscape Function Analysis (LFA) techniques to assess the soil structure, stability and nutrient cycling within the DNG recovery areas. LFA is a standardised monitoring procedure that uses rapidly acquired field-assessed indicators to assess the biogeochemical functioning of landscapes (Tongway and Hindley 2004). LFA is based mainly on processes involved in surface hydrology: rainfall, infiltration, runoff, erosion, plant growth and nutrient cycling. The standard LFA methods as described by Tongway and Hindley (2004) will be followed for the survey.

A minimum of eleven LFA sites will be sampled within DNG recovery areas, five within Grey Box – Grassy Woodland EEC, three in Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest, one in Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest low quality, one in White Box Grassy Woodland CEEC and one in Grey-Box – Ironbark woodland non EEC. Suitable reference sites in remnant woodland of the target community within the Kokoda Offset Site will also be sampled. Reference sites will include a minimum of three in Grey Box – Grassy Woodland EEC and three in Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest.

8.3.3 Threatened bird monitoring

Threatened bird monitoring will be undertaken at the Kokoda Offset Site, focussing on key threatened species. The monitoring program will comprise of bird surveys of existing woodland and recovering DNG areas focusing on the presence of the threatened the grey-crowned babbler, superb parrot, swift parrot and regent honeyeater. Threatened bird monitoring will cover both the existing remnant vegetation areas as well as the recovering DNG areas, once there has been reasonable growth of canopy species (new sites will therefore be added as regeneration/revegetation areas progress). Bird monitoring will be undertaken during winter for the regent honeyeater and swift parrot (during periods when eucalypt trees are flowering) and during early spring for the superb parrot when it is most likely to be utilising the Kokoda Offset Site during local seasonal movements.

Section 9.8 details individual threatened bird monitoring requirements for the Kokoda Offset Site.

8.4 Biannual Inspections

Inspections will be undertaken biannually (twice yearly) by Northparkes environment team. During these inspections, a broad assessment of the site condition will be made and management strategies will be adapted accordingly if required.

During these inspections no systematic sampling will be undertaken, rather a broad assessment of the site condition will be made from a drive-over of the site. The inspections will aim to identify any visually obvious management concerns that require immediate attention such as new infestations of invasive weeds/pest fauna or track and fence condition. The general progress of regeneration and revegetation efforts will also be assessed during these inspections.
Key Components of Biannual Inspections:

- observe and document any weed and pest fauna infestations requiring management;
- assess the success of completed weed and pest management actions;
- assess the condition of fences, gates and access tracks, identifying areas requiring maintenance;
- document any areas of erosion, sedimentation or salinity requiring management;
- assess the progress of natural regeneration within the DNG areas; and
- inspect the condition of other infrastructure in the Kokoda Offset Site such as sheds, homesteads etc.

9. MANAGEMENT STRATEGIES, MONITORING ACTIONS, PERFORMANCE AND COMPLETION CRITERIA

The ability to report on the success of management actions relies on frequent and systematic monitoring of the Kokoda Offset Site. The monitoring program will incorporate annual comprehensive and systematic monitoring as well as biannual (twice yearly) inspections.
Ecological monitoring will be annual for the first 5 years, then every 3 years for the following 15 years. The first ecological monitoring survey will be completed within 6 months of the implementation of the BOMP, and subsequent monitoring events should occur in the same season. It is recommended that the ecological monitoring surveys be undertaken in spring or autumn as there tends to be a lower diversity of species detectable in the more extreme weather conditions of winter and summer seasons (except where specific seasons are required for targeted bird surveys).

Inspections will be undertaken biannually (twice yearly) by Northparkes environment team. During these inspections, a broad assessment of the site condition will be made, and management strategies will be adapted accordingly if required. During these inspections no systematic sampling will be undertaken; rather a broad assessment of the site condition will be made from a drive-over of the site. The inspections will aim to identify any visually obvious management concerns that require immediate attention such as new infestations of invasive weeds/pest fauna or track and fence condition.

The following management and improvement strategies have been developed for the Kokoda Offset Site to ensure that the BOMP objectives and targets are met. The strategies integrate findings and recommendations from the Northparkes Mines Step Change Project Environmental Assessment, the Preliminary Documentation report (Umwelt 2013a and 2013b) and the Northparkes Step Change Project Response to Submissions Addendum Report (Umwelt 2013c).

9.1 Access Management and Exclusion of Stock

9.1.1 Management actions

All domestic stock were removed from the Kokoda Offset Site in early 2015, within a month of the property being purchased by Northparkes.

9.1.2 Performance and completion criteria

Performance criteria and completion criteria for the access management and stock exclusion are provided in Table 6.

Table 6: Access management and exclusion of stock performance criteria and completion criteria

Action	Performance criteria	Completion criteria
Exclude stock	All stock excluded by 30 June 2015, or earlier.	Completed.

9.2 Fencing and Signage

Fencing will be used to demarcate the boundaries of the Kokoda Offset Site to exclude stock, as well as to protect from unauthorised access and disturbance. Fences will be suitably signposted to identify the purpose of the Kokoda Offset Site. Fences will be maintained to prevent stock access to the offset area.

9.2.1 Management actions

Boundary Fencing

Any new fencing (other than the boundary fences with adjoining neighbours) used within, or on the boundary of, the Kokoda Offset Site will use plain (i.e. non-barbed) wire on the upper strands, and as little barbed wire generally as possible to minimise the impact on native fauna species. As part of the ongoing monitoring program, if a restricted level of barbed wire on fencing is shown to fail to exclude stock, additional measures that pose minimal impact to native fauna will be investigated and implemented.

Removal of Redundant Fences

Where possible, redundant internal fences will be removed to allow free movement of fauna throughout the Kokoda Offset Site. Any such works would be appropriately assessed to ensure there is no adverse effect on existing vegetation and habitats.

Signage

Signs on access gates and strategic locations on boundary fencing have been erected. The signs will explain that the land is managed for conservation values and that there is restricted access to people, livestock and activities within the area.

9.2.2 Monitoring requirements

Maintenance of Fences

Boundary fence inspections will be undertaken as part of the biannual inspections by the Northparkes environment team to ensure that neighbouring stock are not able to enter the Kokoda Offset Site.

9.2.1 Performance and completion criteria

Performance and completion criteria for the fencing and signage are provided in Table 7. Trigger points for adaptive management of the fencing and signage are provided in Table 8.

Table 7: Fencing and signage performance and completion criteria

Action	Performance criteria	Completion criteria
Twice yearly boundary fence inspections by Northparkes environmental advisors	Completed twice per year	Ongoing and results included in annual reporting.
Signage inspection by Northparkes environment team	Completed twice per year	Ongoing and results included in annual reporting.

Table 8: Fencing and signage trigger points for adaptive management

Action	Trigger Point for Adaptive Management	Adaptive Management
Boundary fence inspections	Failure of fence allows humans or grazers to enter the site	Repairs undertaken as reqired
Signage inspection	Signage removed or damaged	Repair or replace signs

All adaptive management actions undertaken are to be documented.

9.3 Offset site in-perpetuity conservation

9.3.1 Management actions

The Kokoda Offset Site will be secured for in-perpetuity conservation. Northparkes has purchased the Kokoda Offset Site is currently undertaking the process of securing a Voluntary Conservation Agreement (VCA) across the Kokoda Offset Site.

9.3.2 Performance and completion criteria

Performance and completion criteria for the offset site in perpetuity are provided in Table 9.

Table 9: Offset site in-perpetuity conservation performance and completion criteria

Action	Performance criteria	Completion criteria
Purchase Kokoda Offset Site	Completed. Purchased in 2015	Completed
Establish an in perpetuity conservation mechanism across the Kokoda Offset Site	Completed on 12 June 2018	Completed

9.4 Track Maintenance

9.4.1 Management actions

Routine maintenance of tracks within the Kokoda Offset Site will be undertaken as required to make navigation through the property easier when implementing on-ground management and monitoring activities. The tracks also need to be well maintained for firefighting access if required.

9.4.2 Monitoring requirements

The condition of tracks will be assessed during biannual (twice yearly) inspections, with maintenance works undertaken as necessary.

9.4.3 Performance and completion criteria

Performance and completion criteria for the maintenance of tracks throughout the Kokoda Offset Site are provided in Table 10. Trigger points for adaptive management of the track inspections are provided in Table 11.

Table 10: Track maintenance performance and completion criteria

Action	Performance criteria	Completion criteria
Inspections of all tracks by Northparkes environment team	To be completed twice per year	Ongoing

Table 11: Track maintenance trigger points for adaptive management

Action	Trigger Point for Adaptive Management	Adaptive Management
Inspections of all tracks twice per year by Northparkes environmental advisors	Tracks blocked by fallen trees, excessively eroding or overgrown, preventing safe driving access	Repairs undertaken as required

9.5 Pest and Kangaroo Management

9.5.1 Management actions

Known feral fauna recorded within the Kokoda Offset Site are fox (*Vulpes vulpes*), rabbit (*Oryctolagus cuniculus*) and brown hare (*Lepus capensis*). These species may impact on the native fauna species through predation and competition for resources such as food, shelter, and breeding sites. Feral animals can also have a detrimental effect on regenerating areas as well as soil stability.

Pest management will comprise baiting control programs for foxes and rabbits, on an as needed basis as determined through monitoring. Where other pest species, such as cats pigs, goats, deer etc., are identified, their numbers will be monitored and control measures appropriate for the species will be included in the pest control program as needed. If monitoring identifies that pest species require control, pest management actions will be implemented in consultation with close neighbours, where possible.

9.5.2 Monitoring requirements

Feral animals (or their sign) will be opportunistically recorded during qualitative bi-annual inspections of the Kokoda Offset Site. If these records indicate the presence of a significant population of feral animals, appropriate adaptive management will be implemented. Bi-annual inspections commenced in April 2015. Data collected from this survey event will be used as the baseline data for ongoing feral animal monitoring.

Kangaroo monitoring will also be undertaken bi-annually within the regenerating woodland area. Monitoring is intended to give an indication of relative presence of kangaroo populations within the regenerating area over time. If a significant increase in the kangaroo population is recorded over two consecutive monitoring periods adaptive management will be investigated. Kangaroo monitoring will commence in 2017, at which point a suitable, repeatable survey methodology will be developed and documented in the Annual Review. All adaptive management actions undertaken are to be documented in the Annual Review.

All adaptive management actions undertaken are to be documented in the Annual Review.

9.5.3 Performance and completion criteria

Performance and completion criteria for pest management are provided in Table 12. Trigger points for adaptive management of the pest controls are provided in Table 13.

Table 12: Pest management criteria and completion criteria

Action	Performance criteria	Completion criteria
Annual opportunistic monitoring of feral animal presence during annual ecological monitoring surveys	Completed annually for the first 5 years then 3 yearly	Ongoing
Six monthly opportunistic monitoring of feral animal presence during site inspections by Northparkes environment officers	Completed every 6 months	Ongoing

Table 13: Pest control trigger points for adaptive management

Action	Trigger Point for Adaptive Management	Adaptive Management
Annual or 6 monthly surveys of the Kokoda Offset Site	Feral fauna species or signs of their presence are identified during 2 or more surveys. Or any feral species is identified during a single survey at a level (species specific) that may be impacting on biodiversity values of the Kokoda Offset Site.	Species specific management program will be developed and implemented. In the event that a species management program may increase the numbers of another pest species (e.g. fox control leading to an increase in cat numbers), both species will be targeted in the management program.

9.6 Weed Management

9.6.1 Management action

Introduced species recorded in the Kokoda Offset Site that are considered environmental weeds include Capeweed (*Arctotheca calendula*), Paterson's curse (*Echium plantagineum*), black-berry nightshade (*Solanum nigrum*), tree-of-heaven (*Ailanthus altissima*) and blackberry (*Rubus fruticosus* sp. agg.). Blackberry (*Rubus fruticosus* sp. agg.) is the only noxious weed species recorded on the Kokoda Offset Site listed in the Cabonne Local Government Area control area.

9.6.2 Monitoring requirements

Weeds will be opportunistically recorded during qualitative bi-annual inspections of the Kokoda Offset Site. If the opportunistic records indicate the presence of a significant population of weed species, appropriate adaptive management will be implemented. Bi-annual inspections commenced in April 2015. Data collected during this survey event will form the baseline data for ongoing weed monitoring. The weed control program aims to eradicate Blackberry and Tree of Heaven from thepreviously mapped locations on the property.

9.6.3 Performance and completion criteria

Performance and completion criteria for weed management are provided in Table 14. Trigger points for adaptive management of the weed controls are provided in Table 15.

Table 14: Weed management performance and completion criteria

Action	Performance criteria year 1	Performance criteria years 2 onwards	Completion criteria
Baseline weed inspection	Competed	NA	Completed
Initial weed control program	Completed	NA	Completed
Six monthly ecological monitoring of mapped weeds by Northparkes environment team	Completed twice per year	Completed twice per year	Ongoing
Weed management as required by monitoring	Undertaken as identified by monitoring	Undertaken as identified by monitoring	Ongoing

Table 15: Weed control trigger points for adaptive management

Action	Trigger Point for Adaptive Management	Adaptive Management
Annual ecological monitoring or 6 monthly surveys	Continued presence of weed plants at next survey period after treatment (e.g. 6 months after spraying).	The species specific management controls will be reviewed. The frequency of the controls may be increased or alternative control measures may be implemented
	Weed plants are identified in areas where they have not been previously identified	The weed management program will be extended to include these areas
	Patches of perennial/annual grass weeds occurring in DNG regeneration or revegetation areas (see Section 9.7)	Spot spray or dig out small clumps. Investigate potential suitability of strategic conservation grazing periodically for weed suppression. Monitor and maintain weed control.

9.7 Regeneration of Derived Native Grasslands

Areas of DNG across the Kokoda Offset Site will be managed back to areas of Grey Box Grassy Woodland EEC or Dwyer's Red Gum – Grey Box – Mugga Ironbark – black Cypress Pine Forest, consistent with the surrounding remnant vegetation.

Grey Box grassy woodlands and derived native grasslands of south-eastern Australia occurs in two forms (SEWPaC, 2012). The most common form is as a grassy woodland comprising a tree layer and an understory that must have native grasses but has a varying proportion of shrubs and herbs (SEWPaC, 2012). The derived native grassland form can occur in patches where the tree canopy and mid layer have been almost entirely removed but the native ground later remains largely intact with high flora diversity (SEWPaC, 2012). Key features of grey box grassy woodland communities include the following:

- Woodland with >50% grey box in the overstorey;
- A shrub layer that is moderately dense to absent and includes species such as Dodonaea viscosa ssp. Spatulata
- A ground layer that includes grasses, flowering plants, chenopods, leaf litter and/ or soil crusts. Common species in this layer include Rhodanthe diffusa, Goodenia pinnatifida, Einadia nutans and Crytogram soil crusts.

An initial assessment of the recovery potential for the DNG areas of the Kokoda Offset Site identified six vegetation management areas which are shown on and summarised in Table 16.

Table 16: Perliminary vegetation management areas

Vegetation Management Area	Area (ha[1])
Grey Box Grassy Woodland - DNG: Active Revegetation Areas	36
Grey Box Grassy Woodland - DNG: Natural Regeneration Areas	38
Grey Box Grassy Woodland - DNG: Potential Recovery Areas	21
Dwyer's Red Gum - Grey Box - Mugga Ironbark - Black Cypress Pine Forest DNG: Natural Regeneration Areas	14
Dwyer's Red Gum - Grey Box - Mugga Ironbark - Black Cypress Pine Forest DNG: Active Revegetation Areas	1.00
Farm Track - Disturbed Land: Potential Recovery Areas	1.32
Total	111

1 = Rounding of totals applied (numbers less than 1 – 2 decimal places, numbers between 1 and 10 – 1 decimal place, and greater than 10 - no decimal places)
DNG = Derived Native Grassland

Three types of vegetation management areas were identified:

- Natural regeneration areas which contained existing signs of regeneration and are expected to regenerate naturally once stock is removed and weeds are controlled.
- Potential regeneration areas which contained limited existing signs of regeneration or occur close to a potential seed source and may regenerate naturally once stock have been removed and weeds are controlled. After 24 months of management the level of regeneration occurring in potential regeneration areas will be assessed and such areas will either be managed for continued natural regeneration or active revegetation will be undertaken.
- Active revegetation areas contained no signs of natural regeneration and had little potential to regenerate naturally. After 24 months of management the level of regeneration occurring in active regeneration areas will be assessed and those identified with poor or no regeneration potential will be identified for active revegetation measures. Planting of tree and shrub species will be undertaken in active revegetation areas with poor or no regeneration potential.

9.7.1 Monitoring of regeneration areas

Management actions

Following the removal of domestic stock, natural regeneration management areas will be allowed to regenerate naturally for a period of 24 months. Weed monitoring will be undertaken to ensure that weed species do not out-compete native species once the grazing pressure has been removed.

At 24 months detailed monitoring of the recovery of the natural regeneration management areas will be undertaken to precisely map the recovery potential of the DNG areas to inform further detailed management actions. Those areas with high recovery potential will be allowed to continue regenerating naturally and management of high recovery potential areas will be limited to weed and pest control measures.

The key actions proposed to facilitate natural regeneration of DNG areas are:

- Stock removal: the removal of all stock grazing activities from the Kokoda Offset Site is likely to be the most important step in encouraging native species to re-establish in areas of DNG.
- Weed monitoring: in years one to three monitoring will be important in identifying key areas for weed control to ensure that native species are given the best chance of regenerating naturally. Weed monitoring will be undertaken through biannual (twice yearly) inspections and annual ecological monitoring to ensure that weed species do not out compete native species once the grazing pressure has been removed.
- Weed control: The removal of stock is likely to initially cause an influx of introduced species to establish and this will need to be managed appropriately to allow native tree and shrub species to naturally regenerate. It may be necessary to initially liberate naturally regenerating native trees and shrubs from introduced or invasive plants that are smothering their growth until they are large enough to out-compete and shade-out the invasive species.
- Pest fauna management: introduced and native fauna species have potential to threaten natural regeneration through overgrazing of new plant growth and soil disturbance. More intensive pest management may be required in assisted natural regeneration areas until a stable and resilient ecosystem is established. If it becomes a major threat to the success of natural regeneration, consideration may need to be given to other controls such as erecting temporary fencing around selected regeneration areas
- Other techniques to be implemented to trial for the regeneration of DNG areas include the use of crash grazing, slashing or controlled burning.

Monitoring requirements

As described above, for the first two years, all areas of DNG will be managed through assisted natural regeneration. After two years, detailed monitoring of the recovery of the DNG areas will be undertaken to precisely map the recovery potential of the DNG areas to inform further detailed management actions (using the vegetation management areas delineated in and Figure 3 as a guide). Those areas with high recovery potential will continue regenerating naturally and management will be limited to weed and pest control measures. Areas with low to moderate recovery potential will be managed using active revegetation techniques. Preliminary estimates of recovery potential indicate 37 hectares are likely to require active revegetation management.

DNG areas with moderate recovery potential will be targeted for low intensity revegetation works. This may include supplementary planting of canopy species (using tubestock) to supplement naturally occurring eucalypt saplings and/or other species as per recommendations of a consultant botanist and consistent with key species of Grey Box Grassy Woodland EEC or the Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest.

DNG areas with low recovery potential will be targeted for moderate to high intensity revegetation works. This may include ripping of soil and planting of tubestock species as per recommendations of a consultant botanist and consistent with the key species of the Grey Box Grassy Woodland EEC or the Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest. Tubestock will be planted at an approximate density of 400 individuals per hectare.

The selection of plant species used in the revegetation strategy is vital to the process of creating a vegetation community that is consistent both structurally and floristically with the target community, particularly in areas where the Grey Box Grassy Woodland EEC is the target. Selection of plant species used in revegetation activities should draw on the floristic results of monitoring in good condition reference sites, in consultation with a qualified and experienced botanist.

The ecological monitoring program for the Kokoda Offset Site DNG regeneration/ revegetation areas will include a combination of condition assessments, floristic sampling, sapling survivorship counts and stratified quadrat sampling. Revegetation areas will be monitored by sapling survivorship counts of planted tubestock and condition assessments of surviving tubestock. Regeneration areas (DNG areas where grazing pressure from domestic stock has been removed) will be monitored via stratified and permanent quadrats. Floristic assessments will be undertaken using representative plots and standard botanical survey approaches (e.g. cover-abundance measures) to assess the floristic recovery of the DNG in comparison to the floristic composition of reference sites.

Stratified quadrats will be established in appropriate target communities within the Kokoda Offset Site to provide reference sites to which the success of regeneration/ revegetation works can be compared. In the event that regeneration/ revegetation sites fail to trend towards the ecological values of the reference sites, adaptive management will be undertaken and management actions will be modified or supplemented with new or additional techniques to promote the recovery of regeneration/ revegetation sites towards the values of reference sites.

Monitoring will include LFA techniques to assess the soil structure, stability and nutrient cycling within the DNG recovery areas. Landscape function analysis (LFA) is a standardised monitoring procedure that uses rapidly acquired field-assessed indicators to assess the biogeochemical functioning of landscapes (Tongway and Hindley 2004). LFA is based mainly on processes involved in surface hydrology, rainfall, infiltration, runoff, erosion, plant growth and nutrient cycling. The standard LFA methods as described by Tongway and Hindley (2004) will be followed for the survey.

The proposed annual monitoring surveys comprise:

- six permanent flora plots will be established in existing remnant target woodland communities (reference sites), comprising:
    - three in Grey Box Grassy Woodland EEC; and
    - three in Dwyer's Red Gum – Grey Box – Mugga Ironbark – black Cypress Pine Forest.

Data on floristics and structure, habitat features and ecological condition will be recorded;

- eleven plots in DNG regeneration/revegetation areas, comprising:
    - five in Grey Box Grassy woodland DNG (EEC) probable active rehabilitation areas;
    - three in Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine DNG probable active rehabilitation areas;
    - one in Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest low quality;
    - one in White Box Grassy Woodland CEEC; and
    - one in Grey Box – Ironbark woodland non EEC.

Data on floristics and structure, habitat features and ecological condition will be recorded;

- sapling survivorship counts of planted tubestock and condition assessments of surviving tubestock in regeneration and revegetation areas (to start in 2015);
- permanent photo point monitoring at each monitoring site;

- a replicable stem count assessment in suitable reference (remnant woodland in target communities) and regeneration (DNG) sites for use in developing completion criteria and tracking future progress (to start in 2015); and
- LFA monitoring surveys in DNG recovery areas and reference sites in remnant woodland in target communities. A minimum of 11 LFA sites will be undertaken.

Performance and completion criteria

Performance and completion criteria for active and natural regeneration management areas are provided in Table 17. Trigger points for adaptive management of the active and natural regeneration management area methods are provided Table 18.

For performance and completion criteria for stock exclusion, weed management and pest management that apply to the regeneration and revegetation of derived native grassland areas see Section 9.1.1 (exclusion of stock), Section 9.5 (pest management) and 9.6 (weed management).

Table 17: Regeneration of derived native grasslands performance and completion criteria

Action	Baseline Surveys year 1	Performance criteria year 2 onwards	Completion criteria
Annual ecological monitoring, including LFA	Baseline ecological monitoring was completed in 2014	Completed annually for the first 5 years then 3 yearly	Ongoing

Table 18: Natural regeneration trigger points for adaptive management

Action	Trigger Point for Adaptive Management	Adaptive Management
Monitoring of DNG recovery potential at 2 years	DNG areas identified with high recovery potential	Those areas with high recovery potential will be allowed to continue regenerating naturally and management will be limited to weed and pest control measures.
	DNG areas identified with moderate recovery potential	DNG areas with moderate recovery potential will be targeted for low intensity revegetation works. This may include supplementary planting of canopy species tubestock to supplement naturally occurring eucalypt saplings and/or other species as per recommendations of a consultant botanist and consistent with the key species of the final target community.
	DNG areas identified with low recovery potential	DNG areas with low recovery potential will be targeted for moderate to high intensity revegetation works. This may include ripping of soil and planting of tubestock species as per recommendations of a consultant botanist and consistent with the key species of final target community.
Annual LFA monitoring	LFA results show a decrease of greater than 25% in soil stability, infiltration or nutrient cycling in successive years	Review current soil management practices and initiate specific control measures.
	Soil stability, infiltration and/or nutrient cycling scores of 1 or more DNG treatment types are not trending towards the values of the relevant reference sites.	Review current soil management practices and initiate specific control measures.
Ecological monitoring of DNG areas	Less than 50% success of plantings in any management area after 1 year	Investigate potential climatic or environmental reasons that may have contributed to the low success rate. Where possible develop strategies to address the climatic or environmental drivers for poor survival rates. Review current planting management practices and initiate specific management measures. Following the above investigations and development of management strategies to maximise future survival rates, replace the lost plants.

Action	Trigger Point for Adaptive Management	Adaptive Management
	Vertebrate pest species identified as limiting regeneration potential through grazing	Identify species specific pest management controls and implement specific control measures. Refer to Section 9.5 above (pest management).
	Native vertebrate species limit regeneration through grazing	Identify species specific management controls and implement species specific control measures. Consider exclusion fencing and other plant protection measures if other controls are not identified.
	Low species diversity or species diversity not consistent with target community.	Investigate presence of weed species and undertake targeted weed control where necessary (see Section 9.6) Undertake active revegetation techniques including direct seeding or tubestock planting, following appropriate ground preparation such as weed control, ripping and/or auguring.
	Low or no tree cover appearing	Plant or direct seed trees at an appropriate density using minimal disturbance.
	Tree dieback (from insect pressure, herbicide drift, water stress)	Revegetate with dense shrubs to increase diversity and attract insectivorous birds. Avoid using defoliants near woodlands when windy.
	Dense stands of colonising tree or shrub species dominate regeneration or revegetation areas	• Assess whether thinning is necessary thin manually if appropriate. • Leave if patches are small and plants are native.

9.7.2 Habitat augmentation

Habitat augmentation may be required if the regeneration areas do not meet the habitat structure benchmarks of the reference woodlands at the appropriate maturity stage. If required, nest boxes can be added to trees once that have reached a sufficient size, to accommodate a suite of fauna species that occur in the reference woodlands.
No habitat features salvaged from the impact area will be moved to the offset site as there is a risk that unknown diseases or pathogens could be transferred the approximate 50 kilometres between the sites during that process. Any fallen timber located during the track maintenance works within the offset site will be moved into the DNG regeneration areas, where practical.

Monitoring requirements

If applicable, any habitat augmentation will be monitored for its effectiveness during the annual ecological monitoring program. In the event that nest boxes are installed, an annual monitoring program will be developed which will include monitoring of occupancy rate and box condition.

Performance and completion criteria

Performance and completion criteria and trigger points for adaptive management of any habitat augmentation will be developed if required.

9.8 Threatened Bird Species Monitoring

9.8.1 Monitoring requirements

Threatened bird monitoring will be undertaken at the Kokoda Offset Site, focussing on key threatened bird species. Two threatened fauna species were recorded in the project disturbance area, the grey-crowned babbler (*Pomatostomus temporalis temporalis*) and the superb parrot (*Polytelis swainsonii*). Specific assessments of the potential for the Kokoda Offset Site to offset potential impacts on the swift parrot and regent honeyeater were a focus of the Preliminary Documentation report for the Referral to the Commonwealth Department of the Environment. Annual monitoring surveys of the Kokoda Offset Site will also include surveys for the swift parrot (*Lathamus discolor*) and regent honeyeater (*Anthochaera phrygia*).

Threatened bird monitoring will comprise bird surveys of existing woodland and recovering DNG areas focusing on the presence of threatened. Threatened bird monitoring will cover both the existing remnant vegetation areas as well as the recovering DNG areas, once there has been reasonable growth of canopy species (new sites will therefore be added as regeneration/ revegetation areas progress). Monitoring should be undertaken during winter for the regent honeyeater and swift parrot (during periods when eucalypt trees are flowering) and during early spring for the superb parrot when it is most likely to be utilising the Kokoda Offset Site during local seasonal movements. Monitoring will be undertaken for the grey-crowned babbler during both winter and spring survey periods.

The proposed monitoring surveys will comprise:

- Plot-based diurnal spring woodland bird surveys. As a minimum, two x 20 minute bird surveys will be undertaken at six reference sites (in target woodland community remnants) and five DNG regeneration sites (consistent with flora monitoring sites where possible). Each survey will cover an approximate two hectare area around the flora monitoring plots. Spring woodland bird surveys will be undertaken in DNG regeneration sites during all growth stages as grey-crowned babblers may occur in both DNG and woodland areas, and superb parrots may forage in DNG areas.
- Plot-based diurnal winter bird surveys for the regent honeyeater and swift parrot. Winter bird surveys should be undertaken in areas of flowering eucalypts across the Kokoda Offset Site. Each year a minimum of six eucalypt flowering sites should be surveyed. If no flowering eucalypts are identified during the winter survey period, the winter bird surveys will be undertaken at the six flora reference sites (in target woodland community remnants). Two 20 minute bird surveys will be undertaken at each site and cover approximately a two hectare area around the flora monitoring plots. Once DNG regeneration areas provide a four metre high canopy, winter bird surveys will also be undertaken across each of the five DNG regeneration areas.;

Opportunistic observations of the four targeted threatened bird species will be recorded during all other monitoring survey activities.

9.8.2 Performance and completion criteria

Performance and completion criteria for threatened bird surveys are provided in Table 19. Trigger points for adaptive management of the threatened bird surveys are provided in Table 20.

Table 19: Threatened bird survey performance and completion criteria

Action	Baseline Surveys year 1	Performance criteria Year 2 onwards	Completion criteria
Annual winter and spring bird surveys	Completed	To be completed annually for the first 5 years then 3 yearly	Ongoing

Table 20: Threatened bird survey trigger points for adaptive management

Action	Trigger Point for Adaptive Management	Adaptive Management
Annual winter bird surveys	No flowering eucalypts are identified during winter months.	Consider undertaking additional winter bird surveys during May or October if a large proportion of the eucalypt trees present at the Kokoda Offset Site flower during May or October.

9.9 Seed Collection

The existing woodland vegetation of the Kokoda Offset Site provides a valuable source of native seed. If active revegetation activities are required, this seed resource will be utilised where practical. The use of local provenance seed can improve the success of revegetation, while also preserving the genetic integrity of the local vegetation.

Sustainable seed collection from the Kokoda Offset Site will also be considered for use in the rehabilitation of Northparkes Areas where suitable.

9.10 Appropriate Management of Adjacent Agricultural Land

There will be ongoing consultation with adjacent land owners and/or managers to ensure they are aware of the biodiversity conservation objectives of the Kokoda Offset Site.

9.11 Erosion and Sedimentation

Owing to a high vegetation cover across most of the Kokoda Offset Site, erosion is not currently a significant management issue. Inspections of any areas of erosion concerns should be included in routine biannual inspections, targeting riparian areas and sites with limited vegetation cover.

If an area of significant erosion concern is identified, appropriate short term erosion and sediment controls will be implemented and longer term stabilisation actions such as vegetation establishment will be investigated.

9.12 Salinity

Salinity has not been identified as an issue of concern within the Kokoda Offset Site to date. Given that the site has a high vegetation cover it is not likely to become a management issue. However, any evidence suggesting the land is affected by salinity should be documented and the appropriate management and remediation strategies implemented.

9.13 Bushfire Management

A Bush Fire Management Plan for the Kokoda Offset Site (BFMP) has been prepared (refer Appendix 4). The vegetation of the Kokoda Offset Site requires appropriate bushfire management to protect life and property while providing the necessary protection to the significant ecological features of the area.

The BFMP plans for the exclusion of fire from regeneration and revegetation areas, where possible. This allows young vegetation communities to mature to a stage where they are able to withstand bushfire and regenerate naturally following a fire event. This is nominally at least 15 years, but is dependent on the success of plant establishment and the vegetation community present. The Bushfire Management Plan also considers the locations of known records of threatened species and TECs. Fire should be excluded from these areas, where possible, so that planned burn frequency and intensity does not threaten the persistence of threatened species and TECs.

The use of low intensity controlled burns to facilitate natural regeneration from the soil seed bank may need to be considered later in the project if natural recruitment levels are not sufficient. If required, an appropriate strategy will be developed in close consultation with the Rural Fire Service.

9.14 Management of Cultural Heritage Values

The Kokoda Offset Site is not subject to an Aboriginal Cultural Heritage Management Plan, however there is potential that it may contain sites of Cultural Heritage Value. As such, appropriate consideration to Cultural Heritage values will be made in regards to activities undertaken within the Kokoda Offset Site.

10. ADAPTIVE MANAGEMENT

10.1 Adaptive Management Process

Adaptive management of the BOMP will be responsive to any new and relevant data that may arise through the monitoring described in Section 8, legislative change or any other studies completed at the site. This will enable a flexible approach to management commitments, allowing ongoing feedback and refinement of the BOMP. Adaptive management will be a key mechanism to address the risks to the successful implementation of the BOMP. Adaptive management steps include regular review of the BOMP, including adaptation of targets and performance indicators, recognising potential risks to the successful implementation of the BOMP and having a frame work in place for corrective actions.

10.2 Review of BOMP

The BOMP is to undergo an internal review and revision every three years to refine and make improvements to the management strategies and to assess their performance against preliminary performance indicators and completion criteria. The three year review will look for opportunities to improve the management strategies and further develop and forecast the longer term performance indicators and completion criteria.

Amendments to the BOMP in response to adaptive management and continual improvement requirements that are consistent with the conditions of approval do not need to be submitted to relevant authorities for approval.

10.3 Assess targets and performance indicators

The performance indicators and completion criteria outlined in Section 9 are preliminary and apply to the first three years of the BOMP implementation. Due to a delayed registration of the Voluntary Conservation Agreement, commencement of management actions began in June of 2018.

A three yearly reassessment of the BOMP will be undertaken in 2021, unless a process changes earlier than this date that requires consideration. This three yearly review will reassess the targets and performance indicators and will be:

- adapted and changed as targets are met and new challenges arise;
- will be assessed and redeveloped as appropriate in response to monitoring outcomes; and
- Will be assessed for the success of the management and improvement strategies.

Modifications to the targets and performance indicators will be recorded in a revised BOMP for the Kokoda Offset Site.

10.4 Potential risks and corrective actions

There are a number of potential risks, or situations where preliminary performance indicators and completion criteria might not be achieved. The key risk of the Kokoda BOMP not succeeding relates to the return of DNG communities to woodland communities, and to the management of threats such as weeds and pests. The use of reference sites will assist in identifying whether observations from monitoring are able to be addressed by modifying management actions, or if they are due to broader conditions that can't be controlled such as climatic and seasonal factors (e.g. drought).

A list of potential situations where biodiversity conservation objectives of this BOMP may not be met is provided in Table 21 along with potential corrective actions. This list is adapted from Rawlings *et al.* (2010).

Table 21: Risks and recommended corrective action measures[1]

Potential Risks	Recommended Corrective Actions
General Management Risks	
Unauthorised stock access	• identify access points and repair fences appropriately; and • communicate with adjacent landholders to emphasise that no stock are to have access to the Kokoda Offset Site.
Infestations of noxious and environmental weeds are increasing or new species detected.	• adapt weed management program and modify strategies accordingly.
Infestations of pest animals are increasing or new species detected.	• adapt pest management program and modify strategies accordingly.
Risk to Success of Regeneration/Revegetation of DNG Areas	
No regeneration of plants, or indicator species missing	• assess fencing and ensure there is no un-authorised stock access; • control exotic weeds and pest animals to reduce competition; and • if deemed necessary, instigate active regeneration techniques including direct seeding or tubestock planting, following appropriate ground preparation.
Low species diversity or species diversity not consistent with target community.	• targeted weed control; and

Potential Risks	Recommended Corrective Actions
	• instigate active revegetation techniques including direct seeding or tubestock planting, following appropriate ground preparation such as weed control, ripping and auguring.
Low or no tree cover	• plant/ direct seed trees at appropriate rate using minimal disturbance.
Tree dieback (from insect pressure, herbicide drift, water stress)	• revegetate with dense shrubs to increase diversity and attract insectivorous birds; • avoid using defoliants near woodlands when windy; and • increase patch size through revegetation.
Patches of perennial/annual grass weeds occurring	• spot spray or dig out small clumps; • investigate suitability of strategic conservation grazing periodically for weed suppression and to stimulate native pasture; and • monitor and maintain control.
Dense stands of colonising tree or shrub species dominate regeneration or revegetation areas	• assess whether thinning is necessary; • leave if patches are small and plants are native; and • thin manually if appropriate.
Scarcity of key habitat features present in relation to reference sites	• add habitat features such as logs or branches; • control feral predators; • increase the number of vegetation layers in the patch; and • establish nest boxes for target species.

1 = Adapted from Rawlings *et al.* (2010)

11. REPORTING AND DOCUMENTATION REQUIREMENTS

11.1 Record Keeping

Northparkes will maintain accurate records substantiating all activities associated with measures taken to implement the BOMP. These records may be subject to audit by the Department or an independent auditor.

11.2 Annual Reporting

Condition 12 of the Commonwealth Project Approval states that:

> 'Within three 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, including implementation of any plans as specified in the conditions. Documentary evidence providing proof of the date of publication and non-compliance with any of the conditions of this approval must be provided to the Department at the same time as the compliance report is published. The person taking the action must also notify any non-compliance with this approval to the Department in writing within two business days of becoming aware of the non-compliance'.

Further to this, Condition 8 of the NSW Development Consent states that:

> 'the Proponent shall provide regular reporting on the environmental performance of the project on its website, in accordance with the reporting arrangements in any plans or programs approved under the conditions of this approval'.

In accordance with these conditions, within 3 months of every 12 month anniversary of the commencement of the Project, Northparkes will prepare an Annual Review which will be published on their website. In relation to the BOMP, the Annual Review will contain the following information:

1. compliance with each of the conditions of approval;
2. description of implementation of the BOMP as specified in the conditions of approval;
3. rehabilitation and management activities undertaken within the reporting period, including estimated costs;
4. results of monitoring events for the reporting period; and
5. required amendments to the management or monitoring processes as identified by the adaptive management mechanism.

Utilising the adaptive management mechanism outlined in Section 10, the results of monitoring will be utilised to inform updates to the management actions to be undertaken in the Kokoda Offset Site.

11.3 Ecological Monitoring Reporting

An ecological monitoring report will be prepared on completion of each monitoring survey. The report will include:

- a detailed description of the monitoring methods employed;
- a discussion of the results;
- an assessment as to whether the preliminary performance indicators have been met, and how the project is tracking towards the completion criteria;
- a revision of the management and improvement strategies as appropriate; and
- a revision of the preliminary performance indicators and completion criteria (if required).

12. CONSERVATION BOND AND IMPLEMENTATION COSTS

A Conservation Bond for the Kokoda Offset Site is required by DPE in accordance with Condition 28. The purpose of this bond is to cover the cost of the management of land required to be set aside as an offset area, should the mine consent holder be unable or unwilling to continue management of the land. The Conservation Bond value is based on all the activities identified in the approved BOMP and is the full cost of implementing the biodiversity offset strategy. The Conservation Bond estimate has been prepared in accordance with relevant guidelines and accepted practice to inform this process.

13. BOMP CHECKLIST AND IMPLEMENTATION SCHEDULE

A checklist summarising the Kokoda Offset Site BOMP actions required, and their schedule for implementation for the first three years is provided in Table 22. This is a snapshot of the key actions required in the first three years of implementation of the BOMP. Reference to the relevant sections of this BOMP should be made for more detail of the actions required.

Table 22: Checklist and implementation schedule for the Kokoda offset site BOMP

Actions/Targets	Timeframe
Management and Improvement Actions	
Install necessary boundary fencing and signage for the Kokoda Offset Site.	Complete.
Remove stock grazing activities from the Kokoda Offset Site.	Complete Authorised strategic conservation grazing may be adopted for ecological restoration purposes
Establish an appropriate long-term conservation mechanism for the Kokoda Offset Site.	To be agreed upon before 12 June 2018.
Lodge a conservation bond.	Complete
Routine inspection and maintenance of tracks and fences by Northparkes environmental officers.	Biannual (twice yearly) inspections. Maintenance is required throughout the life of the BOMP.
Establish an effective annual weed and pest control programs.	To be established in Year 1. Annually review and revise.
Undertake weed and pest control activities.	Commencing Year 1, concentrate efforts in DNG areas in Years 1 – 3 to assist natural regeneration.
Establish woodland vegetation in areas of derived native grassland (DNG) through assisted natural regeneration.	Implement assisted natural regeneration activities (weed and pest control, stock removal etc.) in Years 1-5. Assess progress towards performance indicators and completion criteria during the Year 3 review of the BOMP (incorporating results of inspections and monitoring). Commence active revegetation methods after Year 2 if natural regeneration is not progressing appropriately.
Active revegetation activities	Will only commence if necessary after a minimum of 2 years trial with assisted natural regeneration. The need for active revegetation will be assessed at each 3 year revision of the BOMP.
Monitoring Actions	
Establish a suitable monitoring program to assess the success of ongoing management and improvement strategies	Complete
Ecological Monitoring	Commence surveys in autumn or spring in Year 1 (baseline survey), and undertaken annually for first 5 years. Winter migratory bird monitoring to commence in winter of Year 1 (baseline survey).
General inspections across the Kokoda Offset Site by Northparkes environmental officers.	Biannually from Year 1.
Reporting and Documentation Actions	
Accurate records are being maintained substantiating all activities and monitoring relating to implementation of the BOMP.	Ongoing from Year 1.
Collate data on actions implemented and results of inspections and monitoring into the Annual Review.	Annually from Year 1.

Actions/Targets	Timeframe
Ecological Monitoring Report	Following completion of each monitoring period, within 3 months of each monitoring survey event, commencing Year 1 (baseline survey).
Update BOMP, including a revision of management actions, performance indicators and completion criteria.	Every 3 years from commencement (earlier if deemed necessary).

14. REGULATORY REQUIREMENTS

The Kokoda BOMP addresses the relevant components of schedule 3 conditions 25-29 and schedule 6 condition 3 of the NSW Development Consent (DC11_0060), and conditions 4 – 9 of the Commonwealth Approval (EPBC 2013/6788) for the Northparkes Mines Step Change Project. The details of the NSW and Commonwealth conditions and reference to where they are addressed in this BOMP are provided in Table 23 and Table 24.

Table 23: NSW Development Consent Conditions

Requirement
Schedule 3
25. The Proponent shall actively manage and maintain the populations of Pine Donkey Orchid located to the north of the project area (near Adavale Lane) and near the E48 subsidence zone. *Note: The locations of the Pine Donkey Orchid populations are shown on the figure in Appendix 6 of Consent.*
26. The Proponent shall implement the biodiversity offset strategies summarised in Table 7 below, shown conceptually in Figures 1, 2 and 3 of Appendix 7 and detailed in the table at Appendix 7, to the satisfaction of the Secretary.

Limestone National Forest Offset	*Minimum Size hectares (ha)*
Revegetate land	45.1
Sub-Total	45.1
Estcourt Tailings Storage Facility Offset	
Vegetation Community:	
Yellow Box Tall Grassy Woodland	3.3
Inland Grey Box – White Cypress Pine Tall Woodland	38.8
Derived Tussock Grasslands	23
Sub-Total	65.1
Kokoda Biodiversity Offset	
Vegetation Community:	
Grey Box Grassy Woodland EEC	13
Grey Box Grassy Woodland DNG EEC	96
White Box Grassy Woodland EEC	2.2
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest	150
Rocky Rise Shrubby Woodland	26
Grey Box – Ironbark Woodland	25
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine DNG	15
Dwyer's Red Gum Creekline Woodland	9.4
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Woodland Low Quality	8.6

Requirement

Mugga Ironbark Woodland	1.9
Farm tracks and dams (disturbed lands)	2.5
Sub-Total	350.0

Notes:

- *The The Limestone National Forest Biodiversity Offset area is marked in blue and labelled "Addition To Limestone National Forest" in Figure 1 of Appendix 7 of the Consent.*
- *The Estcourt Tailings Storage Facility Biodiversity Offset area is marked with bold black line in Figure 2 of Appendix 7 of the Consent.*
- *The Kokoda Biodiversity Offset area is marked with red line in Figure 3 of Appendix 7 of the Consent.*

The Proponent shall ensure that the Kokoda Biodiversity Offset provides suitable habitat for all the threatened fauna species confirmed and identified as being present in the disturbance areas.

Note: The threatened fauna species confirmed and identified as being present in the disturbance areas are listed in Appendix 8 of the Consent.

27. By the 30 June 2015, unless the Secretary agrees otherwise, the Proponent shall make suitable arrangements to protect the Kokoda Biodiversity Offset in perpetuity in consultation with BCD and to the satisfaction of the Secretary.

28. By 30 June 2015, unless otherwise agreed by the Secretary, the Proponent shall lodge a Conservation Bond with the Department to ensure that the biodiversity offset strategies are implemented in accordance with the performance and completion criteria of the Biodiversity Management Plan (refer to Condition 29 below). The sum of the bond shall be determined by:

(a) calculating the full cost of implementing the biodiversity offset strategy (other than land acquisition costs); and

(b) employing a suitably qualified quantity surveyor to verify the calculated costs,

to the satisfaction of the Secretary.

If the biodiversity offset strategies are completed generally in accordance with the completion criteria in the Biodiversity Management Plan to the satisfaction of the Secretary, the Secretary will release the bond.

If the biodiversity offset strategies are not completed generally in accordance with the completion criteria in the Biodiversity Management Plan, the Secretary will call in all, or part of, the conservation bond, and arrange for the satisfactory completion of the relevant works.

- Notes:
  - *This condition does not apply to the Limestone National Forest Offset;*
  - *Existing bonds which have been paid for the Estcourt Tailings Storage Facility Biodiversity Offset remain current and are satisfactory to fulfil the requirements of this condition;*
  - *Alternative funding arrangements for long-term management of the Biodiversity Offsets, such as provision of capital and management funding as agreed by BCD as part of a Biobanking Agreement or transfer to conservation reserve estate can be used to reduce the liability of the conservation and biodiversity bond, and*
  - *The sum of the bond may be reviewed in conjunction with any revision to the Biodiversity Offsets.*

Requirement
29. The Proponent shall prepare and implement a Biodiversity Management Plan for the project to the satisfaction of the Secretary. This plan must: (a) be prepared in consultation with BCD, and submitted to the Secretary for approval prior to the commencement of any development on site; (b) describe the short, medium, and long term measures that would be implemented to: • manage the remnant vegetation and fauna habitat on the biodiversity offset sites; • restore the derived native grassland component of the Grey Box Grassy Woodland EEC community within the Kokoda Biodiversity Offset to woodland community; • implement the biodiversity offset strategies; and • integrate the implementation of the biodiversity offset strategies to the greatest extent practicable with the rehabilitation of the site (where relevant); (c) include detailed performance and completion criteria for evaluating the performance of the biodiversity offset strategies, and triggering remedial action (if necessary); (d) include a detailed description of the measures that would be implemented for: • enhancing the quality of existing vegetation and fauna habitat in the biodiversity offset areas, including the derived native grassland component of the Grey Box Grassy Woodland EEC community within the Kokoda Biodiversity Offset; • creating native vegetation and fauna habitat in the biodiversity offset areas and rehabilitation area through focusing on assisted natural regeneration, targeted vegetation establishment and the introduction of naturally scarce fauna habitat features (where necessary); • managing and maintaining the populations of Pine Donkey Orchid located to the north of the project area (near Adavale Lane) and near the E48 subsidence zone (refer to Appendix 6); • collecting and propagating seed; • managing any potential conflicts between the proposed enhancement works in the biodiversity offset areas and any Aboriginal heritage values (both cultural and archaeological) in these areas; • managing salinity; • controlling weeds and feral pests; • controlling erosion; • managing grazing and agriculture on site; • controlling access; and • bushfire management; (e) include a seasonally-based program to monitor and report on the effectiveness of these measures, and progress against the detailed performance and completion criteria; (f) identify the potential risks to the successful implementation of the biodiversity offsets, and include a description of the contingency measures that would be implemented to mitigate against these risks; and (g) include details of who would be responsible for monitoring, reviewing, and implementing the plan.
Schedule 6

Requirement
3. The Proponent shall ensure that the management plans required under this approval are prepared in accordance with any relevant guidelines, and include: (a) detailed baseline data; (b) a description of: • the relevant statutory requirements (including any relevant approval, licence or lease conditions); • any relevant limits or performance measures/criteria; • the specific performance indicators that are proposed to be used to judge the performance of, or guide the implementation of, the project or any management measures; (c) a description of the measures that would be implemented to comply with the relevant statutory requirements, limits, or performance measures/criteria; (d) a program to monitor and report on the: • impacts and environmental performance of the project; • effectiveness of any management measures (see c above); (e) a contingency plan to manage any unpredicted impacts and their consequences; (f) a program to investigate and implement ways to improve the environmental performance of the project over time; (g) a protocol for managing and reporting any: • incidents; • complaints; • non-compliances with statutory requirements; and • exceedances of the impact assessment criteria and/or performance criteria; and (h) a protocol for periodic review of the plan.

Table 24: Commonwealth EPBC Act Approval Conditions

Requirement
4. To compensate for the loss of 46 hectares of GBGW and the related and additional loss of habitat for other matters of national environmental significance (Polytelis swainsonii; Lathamus discolour; Anthochaera phrygia) the person taking the action must secure the offset lands identified as the 'Kokoda Offset Site' in Section 2.3 of the Preliminary Documentation. These offset lands must be protected by a legal instrument under relevant legislation on the title prior to commencement of the action
5. The instrument referred to in Condition 4 must: (a) provide for the legal protection of the land for the duration of the impact (b) prevent any conflicting future development activities, including mining and mineral extraction; (c) c) ensure the active management of the land (in accordance with Condition 9).
6. The person taking the action must provide evidence to the Department of their compliance with Condition 4, along with offset attributes, shapefiles and textual descriptions and maps to clearly define the location and boundaries of the offset sites, prior to the commencement of the action.
7. In the event that Conditions 4 and 5 cannot be met, then the person taking the action must secure alternative offset lands to the satisfaction of the Department prior to the commencement of the action.
8. The area of land contained within the offset lands that are secured must include appropriate areas of offset lands (consistent with the Department's EPBC Act offsets policy) for each of the matters of national environmental significance that are impacted by the action, as per Section 2.4.2 and Appendix 6 of the Preliminary Documentation.

Requirement
9. The offset lands ('Kokoda Offset Site') identified in Condition 4 must be managed to improve and maintain the condition of the offset lands to the satisfaction of the Department to achieve the conservation objectives of the offset lands, including: (a) development of a suitable management plan for the offset lands which specifies conservation objectives and how they are to be achieved. The conservation objectives must be clearly set out, measurable and consistent with the conservation management intent described in Section 2.3 of the preliminary documentation. (b) implementation of all management actions and conservation measures identified in the Preliminary Documentation, including in Section 2.3 and Appendix 7, such as, weed management, pest management, stock exclusion and ecological monitoring; (c) active management of derived native grassland areas (GBGW) to allow regeneration and full recovery of these areas of GBGW ecological community over time; (d) allocation of appropriate funding to achieve the conservation objectives; (e) regular monitoring against conservation objectives and adaptive management as appropriate to achieve the conservation objectives.

14.1 Authority Consultation

Consultation with the relevant authorities including the NSW Office of Environment and Heritage (OEH) and the NSW Department of Planning and Environment (DPE) will occur throughout the implementation of this BOMP and throughout the ongoing management of the Kokoda Offset Site, as required.

Consultation with the Commonwealth Department of the Environment (DoE) has been undertaken as part of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) project approval process and will continue through the implementation of this BOMP, as required.

This BOMP was initially submitted to the Department of Planning and Environment (DPE) in November 2014. In September 2015, Northparkes received comments from the Department of Planning and Environment requesting Northparkes to amend additional information in this BOMP. Northparkes amended the BOMP and these comments are detailed in Section 16. Northparkes also received recommendations on the BOMP in December 2015 from OEH. These recommendations have been addressed in the current version of the BOMP and are detailed in the same section.

14.2 Impact Mitigation Strateies

Northparkes sought to avoid and minimise potential impacts on the ecological values of the proposed disturbance area throughout the Project planning process. This has included avoidance and minimisation of disturbance of key vegetation communities, particularly the White Box – Yellow Box – Blakely's Red Gum Woodland EEC and Grey Box Grassy Woodland EEC.

Key impact mitigation strategies in the Project Area include weed and feral animal control, general operation controls such as dust, noise, fugitive light and surface water, tree hollow replacement with nest boxes, salvage of ground habitat features (logs, boulders, etc.) for the creation of habitat features in nearby areas, a comprehensive tree felling procedure to limit impacts on hollow-dependent threatened species and the establishment of an annual ecological monitoring program.

These key impact mitigation strategies will be detailed in revision to relevant management strategies and plans. These revised strategies and plans includes the Flora and Fauna Management Plan (FFMP) and will be expanded to include areas to be impacted by the Project.

15. REFERENCE MATERIALS

Table 24: Reference Materials

Document Title	ID No. | Year
North Mining Limited, 2006. Management Plan – Site Wide – Land use. North Mining Limited.	2006
North Mining Limited, 2008. Management Plan – Site Wide – Flora and Fauna. North Mining Limited.	2010
Rawlings, K., Freudenberger, D. and Carr, D. (2010) *A Guide to Managing Box Gum Grassy Woodlands*, Department of the Environment, Water, Heritage and the Arts, Canberra	2010
Deparment of Sustainability, Environment, Water, Populations and Communities (SEWPaC) (2012). Grey Box (Eucalyptus macrocarpa) Grassy Woodlands and Derived Native Grasslands of South-Eastern Australia: A guide to the identification, assessment and management of a nationally threatened ecological community. Commonwealth of Australia. Canberra.	2012
Tongway, D J and Hindley, N L 2004. *Landscape Function Analysis: Procedures for monitoring and assessing landscapes with special reference to mine sites and rangelands.* CSIRO Sustainable Ecosystems, Canberra.	2004
Umwelt (2013a) *Environmental Assessment Northparkes Step Change Project*. Prepared by Umwelt on behalf of Northparkes Mines.	2013
Umwelt (2013b) Northparkes Mines Step Change Project Preliminary Documentation EPBC Act Referral 2013/6788. Prepared by Umwelt on behalf of Northparkes Mines.	2013
Umwelt (2013c) Northparkes Mines Step Change Project Response to Submissions Addendum Report. Prepared by Umwelt on behalf of Northparkes Mines, November 2013.	2013

16. REGULATORY COMMENTS

Biodiversity Management Plan – Updates to BOMP based on Department of Planning and Environment comments received in September 2015.

DoP comment	Comments	Status
Still appears in draft from	Document reformatted to Northparkes style for consistency with of Management Plan. Draft removed.	Complete
Appendices 1 & 2 missing	Attached Limestone National Forest Offset Area Revegetation Plan (Appendix 1) and Vegetation Management Plan (for the Estcourt Offset area) (Appendix 2)	Complete
Figures 2.3 and 2.4 missing	Figures updated to reflect the table of contents	Complete
Section 6.3 requires updating	Section 6.3 has been updated. As we are currently only in the first year on the BOMPs implementation, no results can be reported at this stage.	Complete Section 6.3
Objectives to include mention of Donkey Orchid conservation and management.	All information relating to the management of the pine donkey orchid (PDO) has been moved to Appendix 3 – Species Management Plan for the Pine Donkey Orchid (SMP for the PDO). Northparkes was requested to draft a SMP for the PDO following the submission of the BOMP to provide additional information about this particular threatened species and its management. As such, having all the information regarding the PDO in the one place provides clarity and increases readability, so that the BOMP only applies to the Kokoda offset site and all information relating to the PDO is centralised in one location.	Complete Refer Species Management Plan (Appendix 3)
Table 1. To include consent conditions for Donkey Orchid	Consent conditions relating to PDO have been included with a cross reference to Appendix 3 (SMP for the PDO).	Complete

Biodiversity Offset Management Plan- Additionally changes made to BOMP based on recommendations from the Office of Environment & Heritage in December 2015.

OEH comment	Comments	Status
1.1 Update the preliminary long term biodiversity management targets (section 3) to state: (a) "Increase the overall native flora and fauna species diversity *compared to the baseline condition*" (or something similar) (b) "Improve the habitat values of the remnant woodland communities in the *Kokoda Offset Site compared to the baseline condition*" (or something similar).	Acknowledged, change made to BOMP in Section 7.0	Complete
2.1 Remove reference to the establishment of 300 metres of new fencing in section 3	Acknowledged, changes made to BOMP in Section 3 and Section 5.2 to reflect that establishment/maintenance of fencing will be conducted as required to exclude stock from the offset area. Section 5.2 states that no new fencing is required.	Complete
2.2 The in-perpetuity conservation mechanism has not yet been finalised. Amend the status to "ongoing" or another similar description within Table 5.4.	Acknowledged, change made to BOMP in Table 5.4.	Complete
2.3 Develop an ecological burn strategy for the Kokoda offset site.	A Bush Fire Management Plan has been developed for the Kokoda Offset Site and has been included in this document (refer Appendix 4). The ecological burn strategy is included in Section 5.	Complete

OEH comment	Comments	Status
2.4 Collect and document baseline information on feral fauna and kangaroo populations. 2.5 Implement targeted monitoring of feral fauna and kangaroo numbers.	Kangaroos and feral fauna species (including foxes, hares and rabbits) occur at Kokoda. However, the number of kangaroos and feral fauna are not considered to be at a level that is detrimental to the biodiversity conservation values at the offset site. Additionally, as Kokoda is located within a predominately agricultural landscape and the boundary fences at the offset site are not kangaroo or feral proof, movement of these species, in particular kangaroos, occurs freely across property boundaries and the broader landscape. Vegetation surveys, using a Landscape Function Analysis (LFA) methodology, were undertaken across the property in 2014 and 2015. Baseline surveys conducting in 2014 were undertaken prior to the purchase of the property, while low intensity sheep grazing was still being undertaken across the property. In 2015, LFA monitoring surveys were undertaken across the property, approximately 6 months after stock had been removed. As such, both of these assessments provide baseline information on the level of grazing impacts on ground cover across the property, both with low intensity livestock grazing and after livestock grazing was removed. As stock have been excluded from the property since early 2015, the majority of ongoing grazing at the property will be from kangaroos. As Kokoda contains several ground cover species of interest, including several (not listed) orchid species, low level grazing provides an important service in terms of regulating the density of the ground cover so small herbs and forbes are able to compete and persist. However, it is acknowledged that left unregulated, kangaroo numbers, in particular, could increase over time. As such, the baseline vegetation surveys undertaken in 2014 and 2015 will be used as surrogate indictor of grazing intensity at the property. If ongoing LFA surveys indicate that ground cover has declined to levels similar to the baseline vegetation surveys, adaptive management will be initiated and an investigation into kangaroo numbers will be commenced. Additionally, feral fauna will be monitored during biannual inspections. Where feral animals are recorded, pest management options will be discussed with the near neighbours and implemented as required. Northparkes is in regular communication with the near neighbours around Kokoda, and will continue to discuss and collaborate with these neighbours on issues including kangaroo and feral animal management for the offset site.	Complete

OEH comment	Comments	Status
2.6 Consider the potential for updating the weed management actions (Table 5.9) to have a goal to eradicate tree-of-heaven and blackberry.	Northparkes internal Weed Control Program for the Kokoda Offset Site includes provisions to spray and actively manage tree-of-heaven and blackberry at the Kokoda Offset Site. However, as Kokoda occurs within an agricultural landscape with different land management practices, even if these weed species are eradiated from the property, it will be extremely difficult to ensure that these species are not reintroduced.	Complete
2.7 Amend the current trigger points for weed control (Table 14 and 15) so that they are quantifiable.	Acknowledged, change made to BOMP in Table 9.6	Complete
2.8 Information regarding the benchmark woodland sites for the derived native grassland vegetation communities should be included.	Acknowledged, change made to BOMP. Refer to Figure 2.2 for benchmark woodland sites for the derived native grassland vegetation communities.	Complete
2.9 Overlay locations of the LFA monitoring sites and the ecological monitoring sites on the vegetation management zone diagram.	Acknowledged, change made to BOMP. Figure 2.2 updated with LFA monitoring sites.	Complete
2.10 Northparkes Mines should meet with OEH after the detailed monitoring of the derived native grasslands has been completed and before the next stage of revegetation commences.	Northparkes has open communication with the OEH. Northparkes has an annual meeting regarding environmental monitoring (Annual Review), which OEH is invited to attend. Additionally, OEH is welcome to contact Northparkes at any time to arrange a meeting.	Complete

Biodiversity Offset Management Plan- Additionally changes made to BOMP based on recommendations from the Office of Environment & Heritage in August 2016.

OEH comment	Comments	Status
Targeted baseline surveys and ongoing monitoring of feral pests and kangaroo populations	Northparkes and OEH staff met on 19th October 2016 to discuss outstanding comments on the BOMP. The changes included in version 3 of the BOMP were discussed and agreed upon during this meeting.	Complete
Trigger points for weed control and eradication goals for specific weed species	Northparkes and OEH staff met on 19th October 2016 to discuss outstanding comments on the BOMP. The changes included in version 3 of the BOMP were discussed and agreed upon during this meeting.	Complete

17. ATTACHMENTS

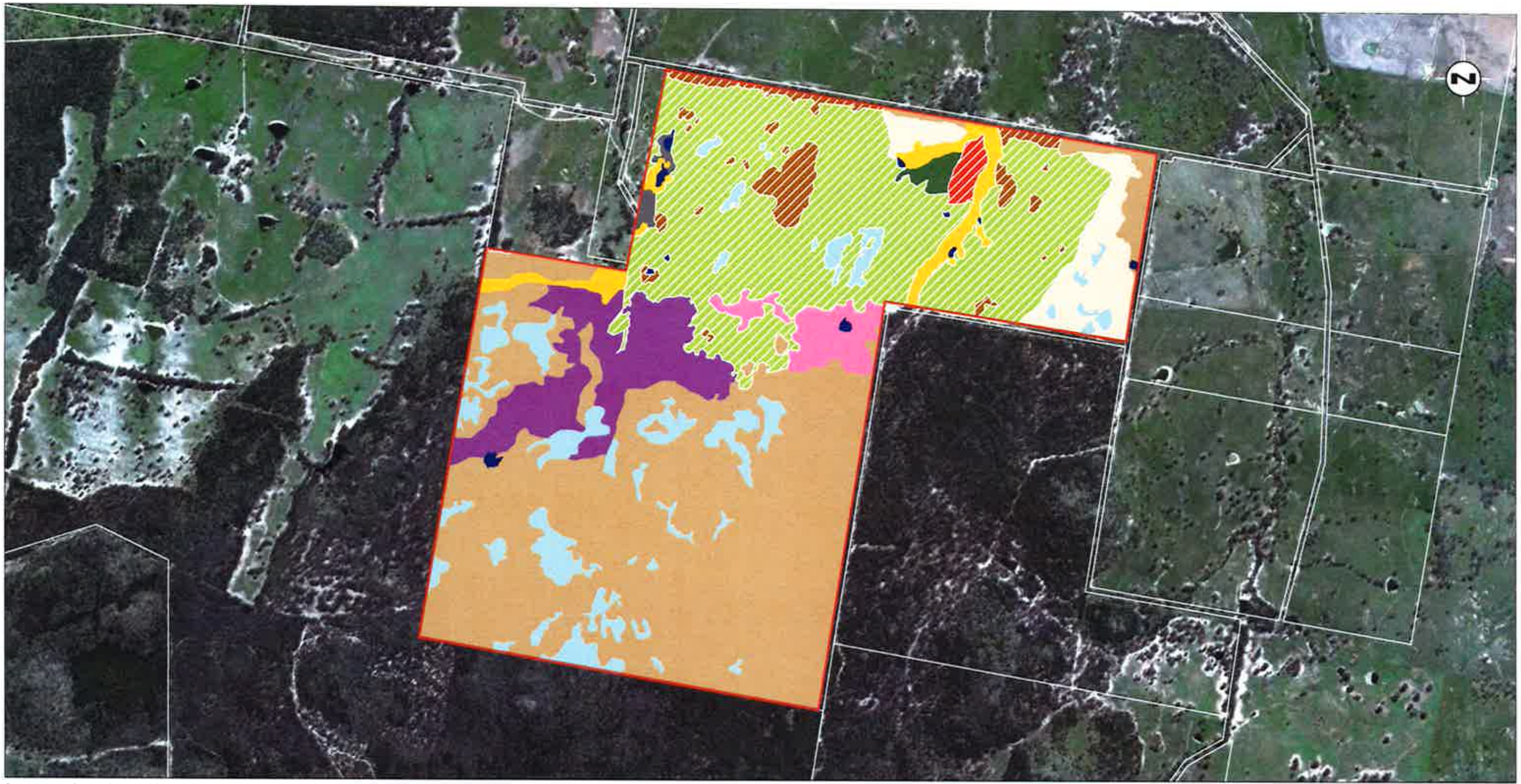
17.1 Appendix 1 Limestone National Forest Offset Area Revegetation Plan

17.2 Appendix 2 Vegetation Management Plan (for the Estcourt Offset area)

17.3 Appendix 3 Species Management Plan for the Pine Donkey Orchid

17.4 Appendix 4 Bush Fire Management Plan for the Kokoda Offset Site

Umwelt



Source: Google Earth (2010), Department of Planning (2009) and Umwelt (2013)

Legend

- Proposed Kokoda Offset Site Boundary
- Grey Box Grassy Woodland (EEC - TSC Act/CEEC - EPBC Act)
- Grey Box Grassy Woodland - DNG (EEC - TSC Act/CEEC - EPBC Act)
- White Box Grassy Woodland (EEC - TSC Act/CEEC - EPBC Act)
- Dwyer's Red Gum Creekline Woodland
- Dwyer's Red Gum - Grey Box - Mugga Ironbark - Black Cypress Pine Forest
- Dwyer's Red Gum - Grey Box - Mugga Ironbark - Black Cypress Pine Forest DNG
- Dwyer's Red Gum - Grey Box - Mugga Ironbark - Black Cypress Woodland Low Quality
- Farm Dam
- Farm Track - Disturbed Land
- Grey Box - Ironbark Woodland
- Mugga Ironbark Woodland
- Rocky Rise Shrubby Woodland

FIGURE 7.4

Vegetation Community Mapping - Proposed Kokoda Offset Site

File Name (A4): R08/2949_320.dgn
20130703 15.21

Office of Environment & Heritage

NSW GOVERNMENT

DOC18/43022

Mr Dahui Zhang
Secretary
CMOC Mining Pty Limited
Suite 24.06, Level 24, Governor Macquarie Tower
1 Farrer Place
SYDNEY NSW 2000

Dear Mr Zhang

I am pleased to advise I have signed the Kokoda Biodiversity Offset Conservation Agreement as the Minister's delegate under section 21(1) of the *National Parks and Wildlife Act 1974*.

By entering into this agreement, you are part of a wide network of people in NSW who have taken this path to protect our unique natural and cultural heritage for the benefit and enjoyment of current and future generations.

I understand that the conservation area contains habitat for a number of threatened species and protects three ecological communities including: the Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion, the White Box - White Cypress Pine - Western Grey Box shrub/grass/forb woodland in the NSW South Western Slopes Bioregion, and the Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion.

The NSW Biodiversity Conservation Trust (BCT) will register the conservation agreement on the property title. Once this is complete, the BCT will inform local council of the agreement and return a copy of the signed registered documents to you.

Thank you for entering into this partnership to secure the biodiversity values of this area in perpetuity.

If you have any questions about the agreement, please contact Mr Stuart Gold, Team Leader Landscape Conservation, Programs Branch, BCT, on 9995 6529 or at stuart.gold@bct.nsw.gov.au.

Yours sincerely

Anthony Lean
Chief Executive
9 FEBRUARY 2018

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Biodiversity Conservation Trust

COPY

Mr Dahui Zhang
Secretary
CMOC Mining Pty Limited
Suite 24.06, Level 24, Governor Macquarie Tower
1 Farrer Place
SYDNEY NSW 2000

Our ref: DOC18/383819

posted 12.6.18

Lift and peel
Sender to keep
605 34992045 098

Dear Mr Zhang

Re: Registration of Kokoda Biodiversity Offset Conservation Agreement

I am pleased to advise you that the registration of your Conservation Agreement is now complete. A copy of the signed Agreement lodged at Land Registry Services (LRS) is enclosed for your records. Also, if you have not been sent or arranged for a Conservation Area identification sign for your property, please advise us as soon as practicable and we will arrange for a sign to be sent to you.

With regard to eligibility for proportional rate exemptions under s555 of the *Local Government Act 1993*, a courtesy letter has been sent to your local Council notifying them of details relating to your Conservation Agreement. A copy of the letter is enclosed for your information.

I would like to thank you for your cooperation in working with us to finalise the Conservation Agreement.

Yours sincerely

12 June 2018

Marita Valent
Branch Support Officer
Programs Branch, Biodiversity Conservation Trust