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Cover photo

Eucalyptus dwyeri (Dwyer's Red Gum) saplings.

Executive summary

The 2020 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 compare 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 the 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 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 Biodiversity Offset Management Plan 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 been undertaken during spring and this year was undertaken from the 13th - 15th October.

2018 Conservation Agreement

In 2018, a Conservation Agreement was made 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 throughout the spring after above average rainfall throughout the year. 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 Conservation Agreement 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 Parkes Airport is 599 mm, however, there have been extreme seasonal conditions with below average rainfall being recorded in 2015 and 2017, while in 2016, widespread flooding was experienced around Parkes. In 2017, very low rainfall activity occurred throughout most of the year, with the extremely dry conditions continuing into 2018 with a total of only 328 mm recorded for the entire year. Drought conditions continued into 2019, with only 212 mm being received up to the end of October compared to an expected average of 484 mm, and a total of only 230 mm was recorded for the year. In 2020 above average rainfall was experienced throughout most of the year, with exceptionally high rainfall being recorded in April with 155mm received. There was a total of 752 mm recorded up until end of October, compared to the expected long-term mean of 550mm 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 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. This year the improved seasonal conditions resulted in increased levels of ground cover in most sites and while there was an increase in perennial plants cover in numerous sites, most areas were dominated by annual plants and many were exotic species.

In several of the grassland sites, deep ripping had been undertaken in preparation for the planting of tubestock in spring 2020 and created 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.

There was little overall difference in the total ecological of the functional between the Grey Box or Red Gum monitoring sites, despite the lack of a perennial overstorey in the derived grasslands. The most functional site this year was the [low quality] Red Gum woodland DWoodLQ, followed by one each of the Red Gum and Grey Woodland reference site (DWood1 and GBWood3). The least functional sites tended to be the Red Gum derived grassland sites, with one site DReveg2 having a decrease in function as a result of disturbance caused by deep ripping.

There continued to be 8 - 23 mature trees (>5cm dbh) recorded in the three Grey Box woodland reference sites equating to a density of 200 - 575 stems per hectare sites. There were seven trees in the White Box site and 28 trees in the Ironbark woodland. The trees were typically in moderate health but there were 20 - 30% of the population that were in a state of advanced dieback and in GBWood3, WBWood1and Ironwood1 there continued to be some (dead) stags. Reproductive structures such as buds, flowers or fruits were only recorded in two Grey Box reference sites and in the White Box and Ironbark woodlands this season. There continued to be an absence

of mistletoe however hollows suitable as nesting sites (>10cm) were noted in WBWood1, GBWood1 and GBWood3.

This year a decline in mature tree densities was recorded in two of the Dwyer's Red Gum woodland reference sites, where there were now 8-23 live individuals equating to a density of 200-575 stems per hectare. There continued to be nine trees in DWoodLQ and this year there were four eucalypt saplings >5cm dbh recorded in DReveg1 as naturally regenerated seedlings have significantly grown. The health of the trees in the reference sites has further declined as a result of the drought with 22-60% of individuals being in moderate health and 6-22% were in a state of advanced dieback. There was an increase in the number (dead) stags where 20-68% of the population were now dead. All three reference sites had at least some individuals bearing reproductive structures such as buds, flowers or fruit. A small percentage of individuals in DWood1 and DWood2 contained hollows suitable for nesting sites (>10 cm), and mistletoe was recorded in DWood3 this year. In DWoodLQ, all trees were typically in medium health but there was an increase in the number with advanced dieback, with some bearing mature fruit. The eucalypt saplings in DReveg1 were all considered to be healthy but may have had some insect damage.

There continued to be an absence of trees and mature shrubs (>5cm dbh) in most of the derived grassland areas, however some regenerating eucalypt seedlings were recorded in low densities in DReveg1. There was also natural regeneration of a variety of species scattered throughout the native pasture areas, including small pockets of *Acacia spectabilis* (Mudgee Wattle) and a variety of other native shrubs were observed around the remnant fringes this year. In some areas there has also been significant regeneration of *E. dwyeri* with stems densities estimated to be ~18,700 stems per hectare, and *Callitris endlicheri* (Black Cypress Pine) regeneration was also common. In the larger grassland areas however, there were occasional volunteer shrubs and tree seedlings, and revegetation activities had not yet been completed in all areas at the time of monitoring. In the monitoring site GBReveg3, there were nine shrubs and juvenile trees as a result of the recent planting of tubestock, where there was a 69% survival rate at the time of monitoring.

This year, floristic diversity has significantly increased across all monitoring sites as a result of the above average rainfall and while native species were more diverse than exotics species, all sites except Ironwood were dominated by a higher proportion of exotic annuals this year in comparison to the reference sites.

The results of the soil analyses indicate that the soils associated with the Grey Box and Red Gum woodlands and derived native grasslands are naturally slightly to very strongly acidic and low in organic matter, phosphorous and nitrate. 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. Previous analyses have demonstrated there were 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 2020. 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 Red Gum woodland monitoring sites against primary completion performance indicators in 2020.

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
Perf	ormance indicators are quantifi	ed by the range of values obtained fro	m replicated reference site	s						2020					1
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	рН	pH (*5.6 - 7.3)	5.6	5.3	5.8	5.3	6.5	5.6	6.3	5.8	5.9	5.7	5.0
			Organic Matter	% (*>4.5)	3.5	3.8	2.7	5.5	3.3	5.0	3.3	2.0	2.3	3.3	4.7
			Phosphorous	ppm (*50)	4.2	7.2	3.4	7.2	8.7	6.1	5.5	6.7	5.1	4.8	4.8
Phase 4: Ecosystem & Land use Establishment	Landscape Function Analysis (LFA): Landform as it was designed to do stability and organisation	Landform is stable and performing as it was designed to do	LFA Stability	%	71.5	69.9	77.8	71.0	76.6	71.0	72.6	72.7	75.0	65.1	67.5
			LFA Landscape organisation	%	100	86	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		species/area	2	3	1	1	1	0	4	0	0	6	5
			Diversity of shrubs and juvenile trees	% population	100	100	100	100	100	0	100	0	0	100	100
			Exotic species richness	<no. area<="" td=""><td>19</td><td>14</td><td>17</td><td>22</td><td>20</td><td>9</td><td>22</td><td>20</td><td>24</td><td>21</td><td>6</td></no.>	19	14	17	22	20	9	22	20	24	21	6

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
	Vegetation density	Vegetation contains a density of species comparable to that of the local remnant vegetation	Density of shrubs and juvenile trees	No./area	8	3	1	8	1	0	9	0	0	7	76
	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	0	0	4	4
			Shrubs	No./area	1	2	0	0	0	0	2	0	0	3	2
			Herbs	No./area	29	25	28	43	33	27	30	32	38	43	30
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	%	41.5	31.1	48.1	58.1	48.6	40.7	43.9	43.5	44	51.8	49.7
			LFA Nutrient recycling	%	40.9	31.6	46.4	58.1	48.7	41.8	42	43	45.1	51.5	47.8
	Protective ground cover	Ground layer contains protective ground cover and habitat structure comparable with the local remnant vegetation	Perennial plant cover (< 0.5m)	%	16	25	64	7	21	40.5	31.5	46.5	30.5	16.5	9.5
			Total Ground Cover	%	98	80.5	100	100	98.5	97	100	96	99	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	%	58.2	80.4	64.2	67.2	38.5	77.5	52.1	54.3	34	43.8	92.6

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
	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	1	1	1	6	1	0	9	0	0	5	45
			shrubs and juvenile trees 1.5 - 2m in height	No./area	2	0	0	0	0	0	0	0	0	0	1
	Ecosystem structure	The vegetation is developing in structure and complexity comparable to that of the local remnant	Foliage cover 0.5 - 2 m	% cover	0	0	0	0	0	0	0	0	2	2	0
	vegetation	Foliage cover >6m	% cover	0	0	0	35	0	0	0	0	0	52	40	
	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 density	Vegetation contains a density of maturing tree and shrubs species comparable to that of the local remnant vegetation	Tree density	No./area	4	0	0	9	0	0	0	0	0	8	40
	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	88	70
			Healthy trees	% population	100	0	0	0	0	0	0	0	0	25	3
			Flowers/fruit: Trees	% population	0	0	0	11.1	0	0	0	0	0	38	10

Conclusion

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.

The derived grassland revegetation sites presently did not meet many completion targets related to diversity and density of tree and shrub species. While there are areas where natural regeneration is occurring, there has been limited regeneration occurring within the larger clearings and selected grassland monitoring sites. Most of the derived grassland sites also contained a high dominance of exotic annual species and were weedier than the 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.

In the remnant woodland sites, there has typically been a decline in tree health and increasing numbers of stags in most sites as a result of prolonged drought, especially in the Red Gum sites. While the shrub populations have also suffered, numerous young tree and shrub seedlings were observed in some of the woodland areas after the improved seasonal conditions. It is anticipated that naturally regenerating seedlings will benefit from the reduction in 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 this year. The aim is to increase biodiversity and habitat values through the removal of livestock grazing to allow natural regeneration, supplemented with direct seeding and tubestock planting. These activities aim to assist in the development of woodland communities that are similar to the local remnant woodlands, with the performance of the revegetation activities being compared to their comparative ecological performance indicators in the medium to longer term. It must be noted that the reference sites at Kokoda are typically degraded and of low quality which subsequently have provided low benchmarks for some performance targets. In the Grey Box woodlands reference sites in particular, there was limited abundance and diversity of the grassy understorey and there were limited shrubs. Subsequently the revegetation activities undertaken have included a range of other local species associated with the respective community types.

While floristic diversity targets were often met, the revegetation sites tended to be dominated by exotic annual species, which are likely to decline in the medium to longer-term as perennial plants including trees and shrubs become more abundant. Most weeds observed were limited to common annual agricultural weeds which have become quite dominant this year as a result of the drought, combined with years of overgrazing. Extensive disturbance and herbivory by macropods and goats has therefore become an important management issue.

NPM have 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. Strategic grazing is likely to be a critical management strategy in the longer-term which will be required 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.

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. Most orchids are only identifiable during a limited time period during suitable conditions during spring and/or autumn, depending on the species. As a result of the dry conditions experienced throughout most of 2017 - 2019, none of these orchid populations have been observed to be flowering, thus emphasising the need to map and refer to their known

locations. This year a few of these orchid species were sighted again but they occurred in lower diversity and densities.

Other potential management issues may be related to high density *E. dwyeri* and *Callitris endlicheri* regeneration which was observed to be occurring within and adjacent to woodland areas where mature trees were present. The increase in competition from high density stands such as these are likely to suppress the herbaceous understorey as they become more established, thereby adversely affecting 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, property maintenance and bushfire management. Regular inspections should be undertaken with slashing and/or strategic grazing management implemented on a as needed basis. This year the recently upgraded access tracks around and throughout the steeper areas of woodland have suffered from erosion, with severe rilling noted in numerous areas, including one of the main drainage lines. In addition, high mortality of Callitris saplings has resulted in many individuals falling over, with many having fallen over the main access tracks. Fallen trees require removal and some parts of the tracks require amelioration where erosion has become severe.

The improved seasonal conditions and reduction in feral animal disturbance is likely to see an improved rate of recovery of the woodland occurring at the Kokoda Offset area. Regular and ongoing monitoring of the performance of the revegetation activities undertaken in 2020 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: 2020 Kokoda Offset Area Ecological Monitoring Report

The 2020 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 compare 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 TSC 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 TSC 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	TSC Act	EPBC Act	Vegetation within Kokoda Offset Site (ha)
	Status	Status	
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	TSC Act	EPBC Act	Vegetation within Kokoda Offset Site (ha)
	Status	Status	
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	St	atus	No. of Individuals/
		TSC Act	EPBC Act	Locations
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 Restore to woodland Regeneration			
3	Grey Box Grassy Woodland – DNG – Natural Restore to woodland Regeneration			
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	
1		Total	350	

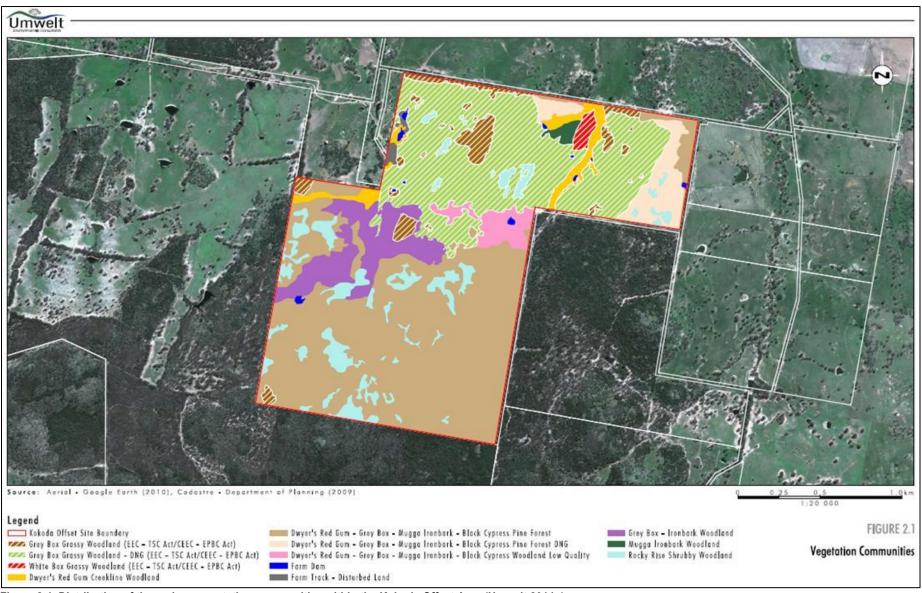


Figure 2-1. Distribution of the various vegetation communities within the Kokoda Offset Area (Umwelt 2014a)

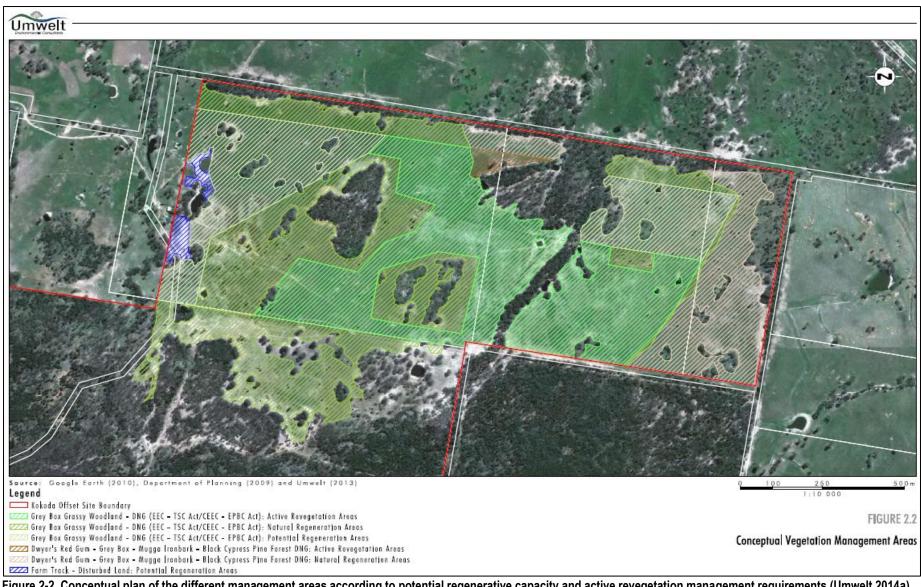


Figure 2-2. Conceptual plan of the different management areas according to potential regenerative capacity and active revegetation management requirements (Umwelt 2014a).

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 (2104a) 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 occurred 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 Kokoda Offset Site;
- 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 both *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 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 13 - 15th October.

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".

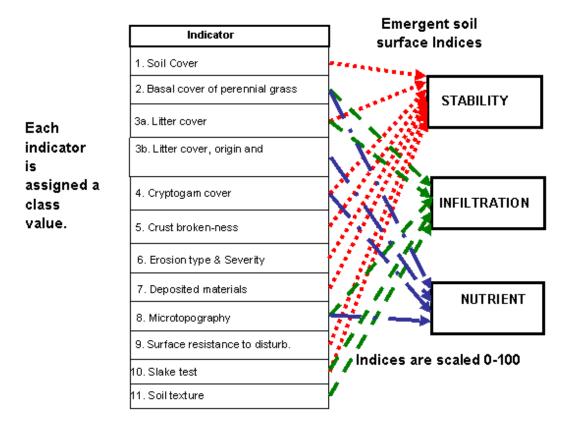
In the second stage, called "soil surface condition" (SSC) assessment, it is possible to assess and monitor soil quality using simple indicators including:

- 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:
 - o dead leaf litter;
 - o annual plants
 - o perennial plants
 - cryptogams;
 - o logs; and
 - o 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 must face 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.

5 2018 Voluntary Conservation Agreement (VCA)

In 2018, a Conservation Agreement was made 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 are 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 were 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.

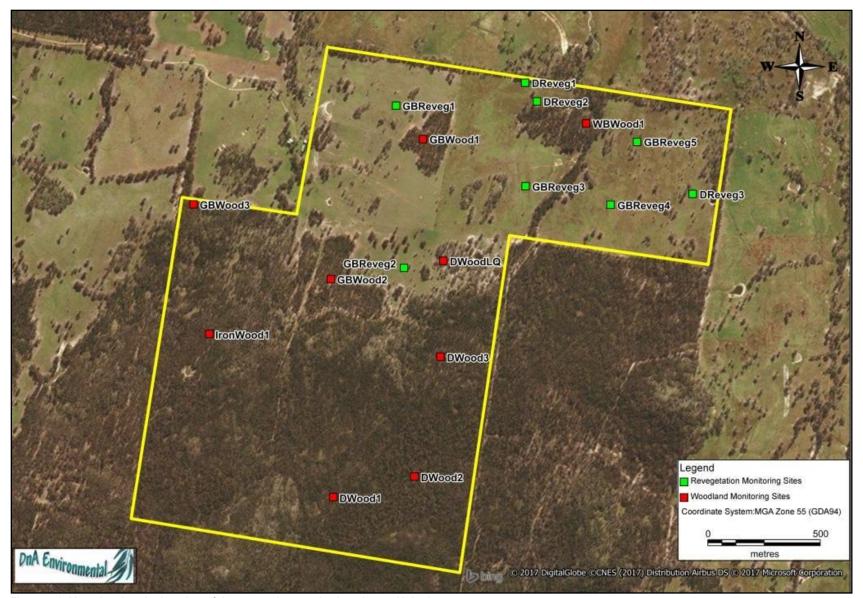


Figure 6-1. Map showing the location of the vegetation monitoring sites at Kokoda.

7 Rainfall

The average annual rainfall at Parkes Airport is 599 mm (BoM 2020), however there have been extreme seasonal conditions with below average annual rainfall being recorded since 2015 except in 2016. In 2016, widespread flooding was experienced with a total annual rainfall of 833 mm being recorded (Figure 7-1).

Despite these extremes in annual rainfall activity, the monthly averages indicate there has also been high seasonal variability and erratic rainfall activity over the past few years (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 occurred except for March where 195 mm of rainfall was recorded. Rainfall remained well below the expected monthly averages for most of the year, however there was above average monthly rainfall in November and December boosting the annual rainfall to 562 mm for the year. Extremely dry conditions returned in 2018 and only 189 mm was received up until the end of the monitoring period in October, with a total of only 328 mm recorded for the entire year. Drought conditions continued into 2019, with only 212 mm being received up to the end of October compared to an expected average of 484 mm, and a total of only 230 mm was recorded for the year.

In 2020 above average rainfall was experienced throughout most of the year, with exceptionally high rainfall being recorded in April with 155mm, and a total of 752mm being recorded up until end of October, compared to the expected long-term mean of 550 mm for the same period.

The extreme seasonal conditions experienced over the past six 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. This year, above average rainfall has resulted in a flush of annual plant growth over significant parts of the landscape.

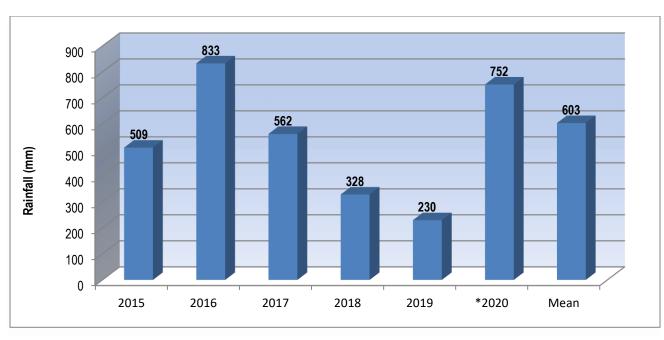


Figure 7-1. Total annual rainfall recorded at Parkes Airport 2015 to the end of October 2020 (*) compared to the long-term mean (BoM 2020).

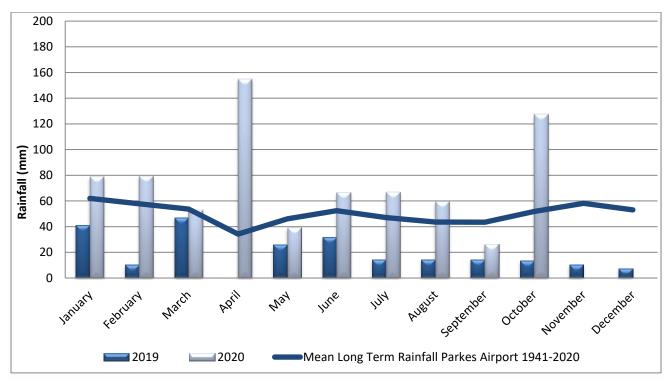


Figure 7-2. Monthly rainfall recorded at Parkes January 2019 to the end of October 2020 compared to the long-term monthly averages recorded at Parkes Airport (BoM 2020).

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 years 2016 and 2018 have been omitted in order to present increasing quantities of photographic data.

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

2015	2017	2019	2020
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			
	itives Bothriochloa macra Red-leg Grass and Rytio		
	am layers and species diversity was low. In 2019, t		razing has caused the further deterioration of the
ground cover. In 2020, above average rainfall resulted in a flush of plant growth and exotic annual were abundant.			
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2015 2017 2019 2020

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. In 2020, above average rainfall resulted in a flush of plant growth and exotic annuals were abundant.



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. In 2020, above average rainfall resulted in a flush of plant growth and exotic annuals were abundant. The area had been deep ripped and planted to tubestock just prior to monitoring.



2015 2017 2019 2020

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, above average rainfall resulted in a flush of plant growth and exotic annuals were abundant. The area had been deep ripped and was due to be planted to tubestock.



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. In 2020, above average rainfall resulted in a flush of plant growth and exotic annual were abundant.









2015 2017 2019 2020

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. In 2020, above average rainfall resulted in a flush of plant growth, with native herbs being abundant and exotic annuals scattered throughout.





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. In 2020, above average rainfall resulted in a flush of plant growth, with native herbs being abundant and exotic annuals scattered throughout.









2015 2017 2019 2020

GBWood1: Very degraded regrowth woodland dominated *by E. microcarpa* with some scattered *Callitris endlicheri*. There were some large old regrowth trees, pockets of older regrowth but there was no young regeneration and there were no shrubs. 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. In 2020, above average rainfall resulted in an increase in plant growth, with native herbs and exotic annuals scattered throughout.









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. In 2020, above average rainfall resulted in an increase in plant growth, with native herbs and exotic annuals scattered throughout.











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 dry conditions and increased levels of disturbance and heavy grazing pressure last year the woodland reference sites maintained high functional patch area, and this year all sites had a Landscape Organisation of 100% due to the good seasonal conditions and increased levels of ground cover (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 in the last few years, native grass and forb cover was low, while in the Ironbark woodland there continued to be scattered low shrubs. This year both sites had improved levels of ground cover and continued to have high functional patch areas and LO's of 100%.

While the Grey Box revegetation sites presently existed as degraded grasslands and were structurally different to the woodland reference sites, they typically had good ground cover comprised of a combination of annual and perennial plants and cryptogams. Over the last two years there has been 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 and 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. This year there were also increased levels of ground cover in most sites, and all grassland revegetation sites maintained 100% functional patch areas and continued to score LO's of 100% (Figure 8-1).

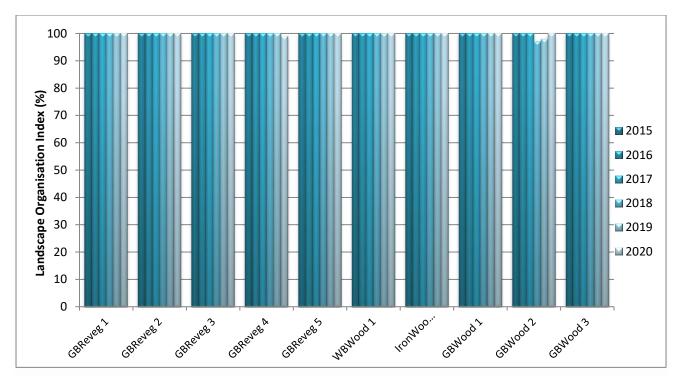


Figure 8-1. Landscape Organisation Indices recorded in the Grey Box woodland monitoring sites.

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. Last year 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. This year there were increased levels of ground cover and an increase in stability was recorded at all three sites with LFA stability indices of 63.8 - 70.8.

In the White Box and Ironbark woodlands, stability indices has also increased in both sites and with indices of 65.1 and 67.5 respectively, they continued to have an ecological stability that was similar to the Grey Box woodland reference sites (Figure 8-2). In the Grey Box grassland revegetation sites, the stability increased in all sites except GBReveg3 which had some exposed areas of soils as a result of deep. Stability indices ranged from a low of 71.0 in GBReveg2 to a high of 76.6 in GBReveg1, thus all revegetation areas continued to more stable than the Grey Box reference sites.

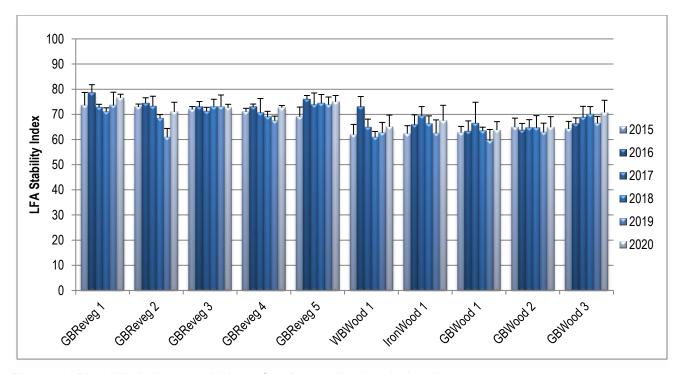


Figure 8-2. LFA stability indices recorded in the Grey Box woodland monitoring sites.

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. Over the past few years 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 this year, with the reference sites providing an infiltration range of 50.6 - 55.1 (Figure 8-3). Similar changes were recorded in the White Box and Ironbark woodlands with infiltration indices of 51.8 and 49.7 respectively.

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 increased in GBReveg1, GBReveg2 and GBReveg5 but was slightly lower in the remaining sites. This year infiltration indices ranged from a low of 40.7 (GBReveg2) to a high of 44.0 (GBReveg5), but all revegetation sites continued to have a lower infiltration capacity than the reference sites.

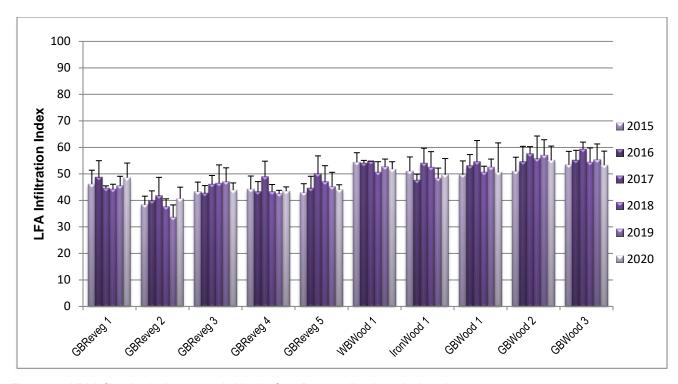


Figure 8-3. LFA infiltration indices recorded in the Grey Box woodland monitoring sites.

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. Over the past few years 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 this year, with the reference sites providing a nutrient recycling range of 47.0 - 52.0 (Figure 8-4). Similar changes were recorded in the White Box and Ironbark woodlands with infiltration indices of 51.5 and 47.8 respectively.

In the Grey Box grassland revegetation sites, there were only a few scattered juvenile trees or shrubs in some sites and the litter and humus layers was less developed than the reference sites, but cryptogams were usually abundant. Previously, heavy grazing caused a deterioration of grassy understorey and cryptogamic layer, causing a decline in nutrient recycling capacity in most areas. This year there was however a significant increase in annual plant (litter) cover and there may have been an increase in perennial plant cover in some sites, with little change or increased nutrient recycling capacity being recorded in all revegetation sites. Nutrient recycling indices ranged from a low of 41.8 in GBReveg2 to a high of 48.7 in GBReveg1.

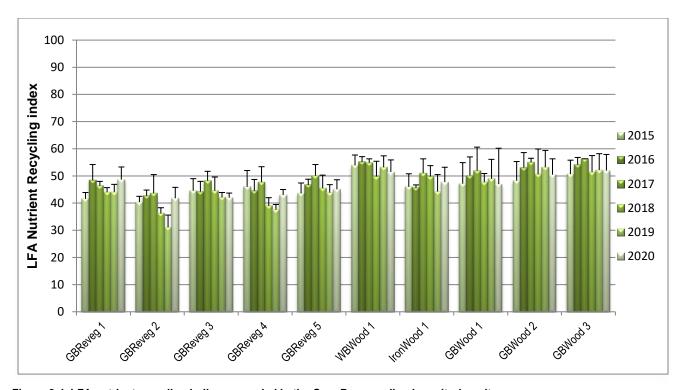


Figure 8-4. LFA nutrient recycling indices recorded in the Grey Box woodland monitoring sites.

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 was little overall difference in the total ecological of the functional between the monitoring sites, however GBWood3 continued to be the most ecologically functional site with a total score of 176. This year, GBReveg1 was only slightly lower in function despite the lack of perennial overstorey with a total sum of scores of 174, followed by the reference site GBWood2 with 171. The White Box woodland scored 168, while the Ironbark woodland scored 165, and the revegetation site GBReveg5 with 164 was slightly more functional than GBWood1 with a total function of 161. The remaining sites GBReveg4 and GBReveg3 were less functional than the reference sites but were similar to each other a total sum of scores of 159, while GBReveg2 was slightly lower with 154.

Examples of the various combinations of ground covers which are critical to overall ecosystem function have been provided in Table 8-2.

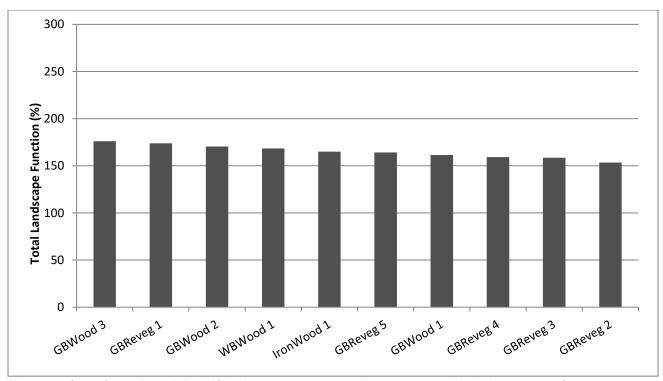


Figure 8-5. Sum of the LFA stability, infiltration and nutrient recycling components indicating the most functional to least functional monitoring site recorded in 2020.

Table 8-2. Examples of the different ground covers in the Kokoda Grey Box monitoring sites in 2020.





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. In WBWood1 and Ironwood1 one individual had died at both sites in 2019, probably as a result of the ongoing drought but no changes were recorded this year. The

resultant population densities recorded in the Grey Box reference sites continued to be 8 - 23, equating to a density of 200 – 575 stems per hectare (Figure 8-6). There were seven individuals in the White Box site and 28 in the Ironbark woodland. No trees or mature shrubs were yet present in the derived native grassland sites.

8.3.2 Diameter at breast height

The average dbh recorded in the Grey Box reference sites ranged from 18 - 34 cm with the minimum dbh being 7 cm and the maximum dbh was 57 cm (Table 8-3). The relatively small trunk diameters indicate the trees are relatively young and indicative of their regrowth status. In the White Box woodland, the average dbh was 30 cm with a maximum dbh of 39cm, while in the Ironbark woodland the average dbh was 17 with a maximum of 50 cm.

8.3.3 Condition

The trees and mature shrubs in the Grey Box woodland monitoring sites were typically in moderate health but there were 20 – 30% of the population that were in a state of advanced dieback. In GBWood3, WBWood1 and Ironwood1 there continued to be some (dead) stags. Reproductive structures such as buds, flowers or fruits were only recorded in two reference sites and in the White Box and Ironbark woodlands this season. There continued to be an absence of mistletoe however hollows suitable as nesting sites (>10cm) were noted in WBWood1, 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*.

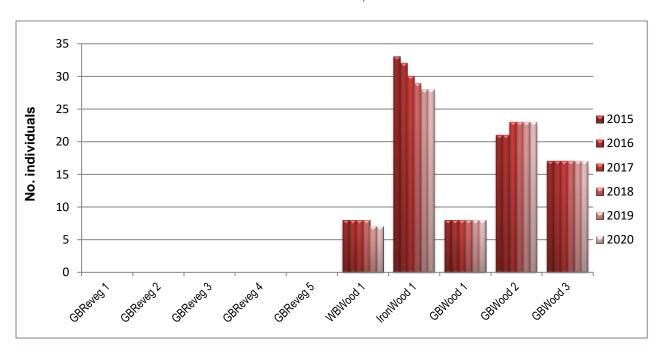


Figure 8-6. Tree and mature shrub densities (>5cm dbh) in the Kokoda Grey Box woodland monitoring sites.

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	30	39	18	8	4	88	25	50	13	13	0	38	13
IronWood 1	4	17	50	6	40	3	70	3	18	50	30	0	10	0
GBWood 1	1	34	57	13	8	0	100	0	75	25	0	0	0	50
GBWood 2	3	18	31	9	23	4	100	26	43	30	0	0	9	0
GBWood 3	2	24	53	7	20	10	85	5	60	20	15	0	10	10

Table 8-3. Trunk diameters and condition of the trees and mature shrubs in the woodland monitoring sites in 2020.

8.4 Shrubs and juvenile trees

8.4.1 Population density

In the woodland reference sites, there were slightly more shrubs and juvenile trees (Figure 8-7) with 2-21 individuals being recorded this year, equating to a maximum density of 50-525 stems per hectare. In the White Box woodland there was one less seedling with seven individuals. In the Ironbark woodland there were significantly fewer shrubs with 76 individuals being recorded. One *Callitris endlicheri* (Black Cypress Pine) seedling continued to be recorded in GBReveg1 this year. As a result of tubestock planting, there were nine shrubs and juvenile trees in GBReveg3 this year.

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 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 GBReveg3 all individuals were less than 0.5m.

8.4.3 Species diversity

In the woodland reference sites, there were 1 - 3 species of shrubs and juvenile trees with the range of species including juvenile *E. microcarpa, Acacia implexa* (Hickory), *A. paradoxa* (Kangaroo Thorn) and *Cassinia laevis* (Cough Bush). No *A. spectabilis* (Mudgee Wattle) or *Brachyloma daphnoides* (Daphne Heath) were recorded this year as they had died as a result of the drought.

In the White Box woodland there were two *A. decora* (Western Golden Wattle) and one each of *E. albens, Acacia implexa, Brachychiton populneus* (Kurrajong), *Dodonaea viscosa* subsp. *cuneata* (Wedge-leaf Hopbush) and *Callitris endlicheri* seedlings. In the Ironbark woodland, the shrubby understorey was more diverse and continued to be dominated by *Brachyloma daphnoides* with scattered *Callitris endlicheri* seedlings. There were also occasional juveniles of *Cassinia laevis, E. dealbata* and *E albens* but the *Brachychiton populneus* was not found this year. One *Callitris endlicheri* seedling continued to be recorded in GBReveg1 this year.

In GBReveg3, there were five *Eucalyptus microcarpa*, one *E. sideroxylon*, two *Acacia decora* (Western Golden Wattle) and one *Acacia implexa* (Hickory) tubestock seedlings.

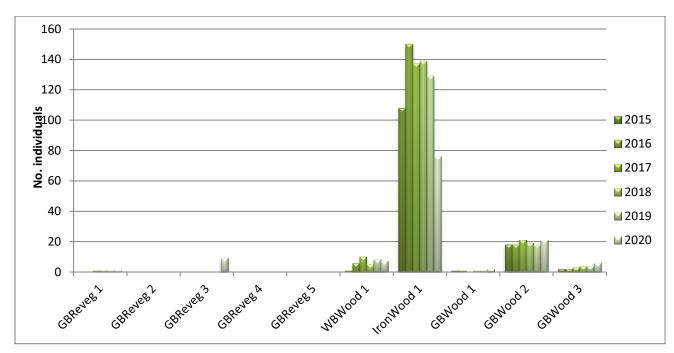


Figure 8-7. Total shrubs and juvenile trees recorded in the Grey Box monitoring sites.

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	1	0	0	0	0	1	1	100
GBReveg 2	0	0	0	0	0	0	0	0
GBReveg 3	9	0	0	0	0	9	4	100
GBReveg 4	0	0	0	0	0	0	0	0
GBReveg 5	0	0	0	0	0	0	0	0
WBWood 1	5	2	0	0	0	7	6	100
IronWood 1	45	29	1	1	0	76	5	100
GBWood 1	1	1	0	0	0	2	2	100
GBWood 2	9	11	1	0	0	21	4	100
GBWood 3	4	1	0	0	1	6	3	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 ongoing drought combined with increased grazing pressure has typically resulted in a reduction in live plant and litter cover in the woodland reference sites, and while the seasonal conditions have improved, the reference sites have continued to suffer from the effects of overgrazing and disturbance by animals to provide a target range of 88.50 – 97.0% (Figure 8-8).

Over the past two years overgrazing has also resulted in a reduction in ground cover in all pasture sites as well as both WBWood1 and IronWood1 sites. This year however total ground cover has improved in all revegetation sites as well as the White Box and Ironbark woodlands with ground covers ranging from 96 – 100%.

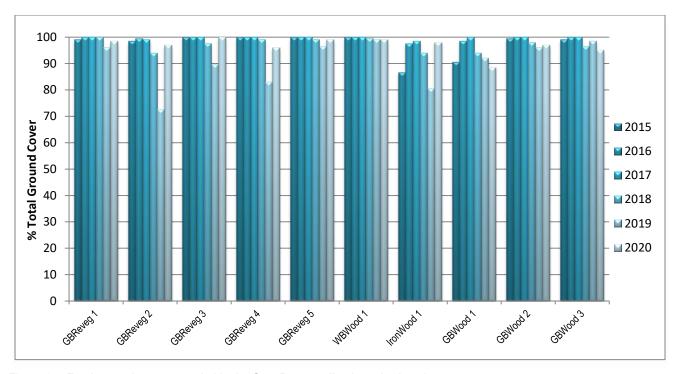


Figure 8-8. Total ground cover recorded in the Grey Box woodland monitoring sites.

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 were largely derived from fallen eucalypt leaves and twigs and provided a lower 63 - 82% ground cover this year. As a result of the improved seasonal conditions there was a simultaneous increase in annual plant cover with 0.5 - 23% cover, and a slight increase in perennial plant cover with 1 - 7% cover. There continued to be a small contribution of cover provided by fallen branches (0.5 - 5.0%) and in GBWood02, 5% cover was provided by cryptogams.

Previously the White Box woodland site was very similar in structure to the reference sites, but this year the site had become dominated by annual ground cover plants which provided 58% ground cover and there has been a significant increase in cover provided by perennial plants with 16.5% cover. The remaining cover tended to be provided by dead leaf litter and a fallen branch. The Ironbark woodland was structurally very similar to the reference sites this year, where leaf litter and annual plants were the most dominant ground cover, and cryptogams and logs provided 7% and 5% respectively, while there was 10% perennial plant cover this year.

In the derived grassland revegetation sites, annual and perennial plant cover has also significantly increased in all sites, with 41 - 64% annual plant cover and 21 - 47% perennial plant covers recorded this year. Cryptogams were recorded in low abundance in all sites and provided 2 - 7% cover, while there was 5 - 15% dead leaf litter.

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. Tall weeds provided some structure >0.5m in height in GBReveg5. Presently there is no vertical structure > 0.5 m in height in the remaining derived grassland revegetation areas.

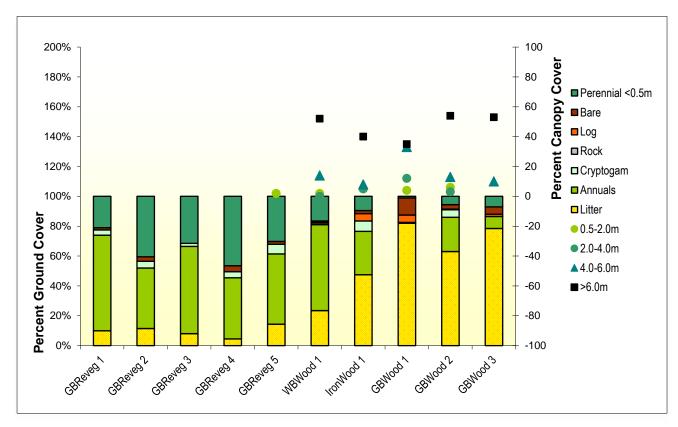


Figure 8-9. Average percent ground cover and projected foliage cover recorded in the Grey Box monitoring sites in 2020.

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. In 2016 there was a high diversity of species as a result of the wet seasonal conditions with 36 - 58 species being recorded in the reference sites, while in 2018 there were only 7 - 15 species (Figure 8-10).

The dry conditions experienced during 2017 - 2019 resulted in a declining trend in diversity since 2016 in most sites, however recent rainfall had stimulated a flush of plant growth in the revegetation areas which saw a minor increase in diversity last year. This year, floristic diversity has significantly increased across all monitoring sites as a result of the above average rainfall. There was a total of 35 - 59 species recorded in the reference sites, with the diversity being similar to that recorded in 2016. While native species were more diverse than exotics species (Figure 8-11), there were 13 - 22 were exotic species recorded this year (Figure 8-12).

In the White Box and Ironbark woodlands, floristic diversity was high with 69 and 49 species respectively, of which 21 and 6 were exotic species. In the derived grassland sites, there were 36-51 species, and while native species were more diverse than exotics, there were 9-24 exotics, with GBReveg5 having a slightly higher diversity of exotics species than the reference sites.

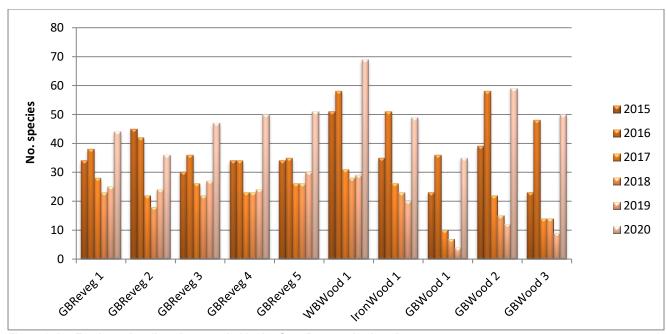


Figure 8-10. Total species diversity recorded in the Grey Box monitoring sites.

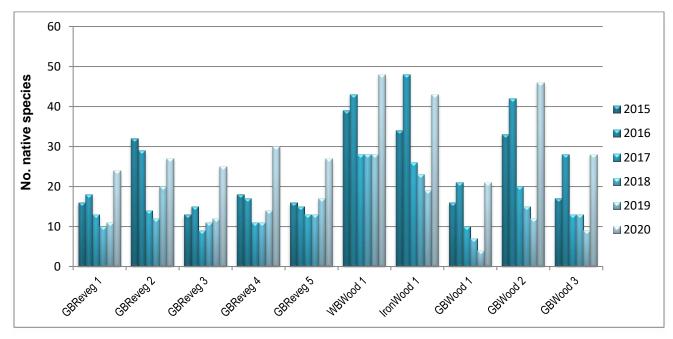


Figure 8-11. Total native species diversity recorded in the Grey Box monitoring sites.

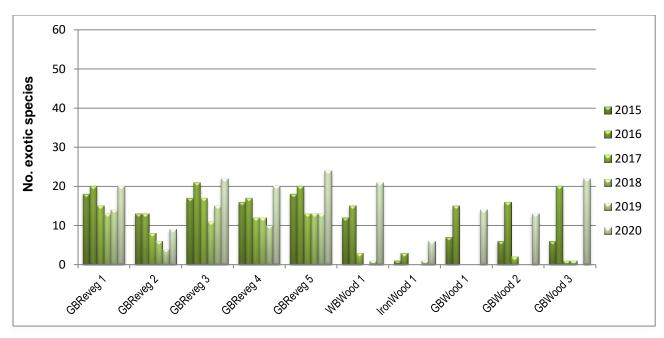


Figure 8-12. Total exotic species recorded in the Grey Box monitoring sites.

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 again in 2020. This year native plants provided 81 - 97% of the live plant cover in the woodland reference sites (Figure 8-13).

These changes were also recorded in WBWood1 and IronWood1, however there was a significant decrease in native cover over the past year, with exotic plants being more abundant than natives with 44% native plant cover this year. In Ironwood1, native plants continued to be dominant and provided 93% of the live plant cover, despite a marginal decrease (Figure 8-13).

In the derived grasslands, similar trends were often recorded however this year an increase in native plant cover was recorded in GBReveg2 and GBReveg3, while an increase in exotic plant cover was recorded in the remaining revegetation sites. While native plants were more abundant in GBReveg2 with 78% cover, there was only 39% and 34% native plant cover in GBReveg1 and GBReveg5 this year. In GBReveg3 and GBReveg4, there were similar proportion of native and exotic plant covers with 52% and 54% provided by native plants. This year all grassland revegetation sites, and the White Box woodland site were weedier than the reference sites.

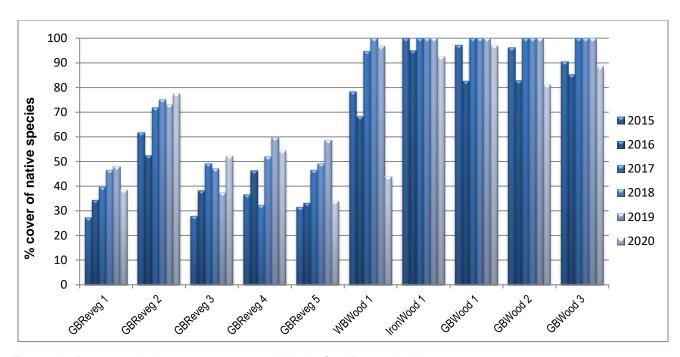


Figure 8-13. Percent endemic ground cover recorded in the Grey Box monitoring sites.

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 this year there was a significant increase in plant diversity with a high diversity of 27 – 39 herbs. There were 1 - 3 tree species, 1 – 4 shrub species and 5 – 11 grasses recorded in the sites. There were 1 – 4 reed/sedge species and a fern was recorded in one site. The White Box and Ironbark woodlands had a simar range of growth forms, and often these were more diverse compared to the reference sites. In the grassland revegetation sites there was also an adequate representation of plants in the herbaceous understorey, but several sites including GBReveg2, GBReveg4 and GBReveg5 did not contain any tree species, and shrubs were absent in four of the five grassland sites.

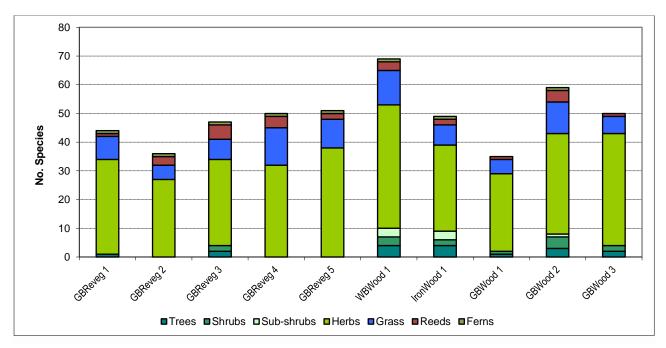


Figure 8-14. Composition of the vegetation recorded in the Grey Box monitoring sites in 2020.

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 common exotic species and included *Aira cupaniana* (Silvery Hairgrass), *Hypochaeris glabra* (Smooth Catsear), *Parentucellia latifolia* (Red Bartsia), *Arctotheca calendula* (Capeweed), *Juncus capitatus* (Capitate Rush), *Lysimachia arvensis* (Scarlet Pimpernel) and *Tolpis umbellata* (Yellow Hawkweed) and these were common to most monitoring sites, including some of the reference sites.

Native species common to most sites included *Cheilanthes sieberi* subsp. *sieberi* (Rock Fern), *Oxalis perennans* (Yellow Wood-sorrel), *Bothriochloa macra* (Red-leg Grass), *Elymus scaber* (Common Wheatgrass), *Euchiton sphaericus* (Japanese Cudweed), *Microtis unifolia* (Common Onion Orchid), *Schoenus apogon* (Common Bog Rush), *Sebaea ovata* (Yellow Centaury) and *Triptilodiscus pygmaeus* (Austral Sunray). Many of the common species were also recorded in one or more of the reference sites. 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 2020.

	o or the moor common opeon	, , , , , , , , , , , , , , , , , , , 			•9	0.1100								
exotic	Scientific Name	Common Name	Habit	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	Total	GBWood1	GBWood2	GBWood3
*	Aira cupaniana	Silvery Hairgrass	g	1	1	1	1	1	1	1	7		1	1
	Cheilanthes sieberi subsp. sieberi	Rock Fern	f	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
	Oxalis perennans	Yellow Wood-sorrel	h	1	1	1	1	1	1	1	7	1	1	1
*	Parentucellia latifolia	Red Bartsia	h	1	1	1	1	1	1	1	7			
*	Arctotheca calendula	Capeweed	h	1	1	1	1	1		1	6	1	1	1
	Bothriochloa macra	Red-leg Grass	g	1	1	1	1	1	1		6			
	Elymus scaber	Common Wheatgrass	g	1		1	1	1	1	1	6		1	
	Euchiton sphaericus	Japanese Cudweed	h	1		1	1	1	1	1	6	1	1	1
*	Juncus capitatus	Capitate Rush	r	1	1	1	1	1	1		6			
*	Lysimachia arvensis	Scarlet Pimpernel	h	1	1	1	1	1	1		6	1	1	1
	Microtis unifolia	Common Onion Orchid	h	1	1	1	1	1	1		6			
	Schoenus apogon	Common Bog Rush	r		1	1	1	1	1	1	6		1	
	Sebaea ovata	Yellow Centaury	h	1	1	1	1	1	1		6			
*	Tolpis umbellata	Yellow Hawkweed	h	1	1	1	1	1	1		6			1
	Triptilodiscus pygmaeus	Austral Sunray	h	1	1	1	1	1		1	6		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

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 *Hypochaeris glabra* (Smooth Catsear) continued to be relatively abundant in several grassland sites and had become particularly abundant in GBReveg1 and WBWood1 this year. Other annual exotics which were relatively abundant in numerous sites included *Parentucellia latifolia* (Red Bartsia), *Trifolium arvense*

(Haresfoot Clover) and *Aira cupaniana* (Silvery Hairgrass). The native perennial grasses *Bothriochloa macra* (Red-leg Grass) and *Rytidosperma racemosum* (Wallaby Grass) were also relatively abundant in some revegetation sites. *Haloragis heterophylla* (Rough Raspwort) and *Schoenus apogon* (Common Bog Rush), both moisture dependent native species were relatively abundant in some areas. The remaining species were only recorded in abundance in one of the monitoring sites.

Table 8-6. The most abundant species recorded in the Grey Box monitoring sites in 2020.

rable 6-6. The most abundant specie	33 recorded in the Orey Box i	110111101	ing on		2020.						
Scientific Name	Common Name	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	GBWood1	GBWood2	GBWood3
*Hypochaeris glabra	Smooth Catsear	17			12	12	17				
* Parentucellia latifolia	Red Bartsia	12	11								
*Trifolium arvense	Haresfoot Clover	18				11					
Bothriochloa macra	Red-leg Grass	12		13							
Rytidosperma racemosum	Wallaby Grass	10	13								
Haloragis heterophylla	Rough Raspwort		17	18	17						
Schoenus apogon	Common Bog Rush		19	18				14			
Triptilodiscus pygmaeus	Austral Sunray		10								
*Aira cupaniana	Silvery Hairgrass			10	10	15					
*Juncus capitatus	Capitate Rush			10							
*Trifolium subterraneum	Subterraneum Clover			10							
Isolepis congrua	Slender Club-sedge			10							
* Echium plantagineum	Paterson's Curse					10					
*Lysimachia arvensis	Scarlet Pimpernel						20				
*Trifolium campestre	Hop Clover						10				
Einadia nutans subsp. nutans	Climbing Saltbush								10		
Daucus glochidiatus	Australian Carrot									10	
Ranunculus sessiliflorus var.	Small-flowered										
sessiliflorus	Buttercup									10	
Arthropodium minus	Small Vanilla Lily										10

^{*} 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 2020 is 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 5.2 – 5.5 the soils were strongly acidic (Bruce & Rayment 1982). The soils in IronWood1 were also strongly to very strongly acidic with a pH of 5.0 but were slightly to moderately acidic in the remaining sites and the White Box woodland. With pH ranging from 5.6 – 6.5, the soils in these sites were within desirable agricultural ranges.

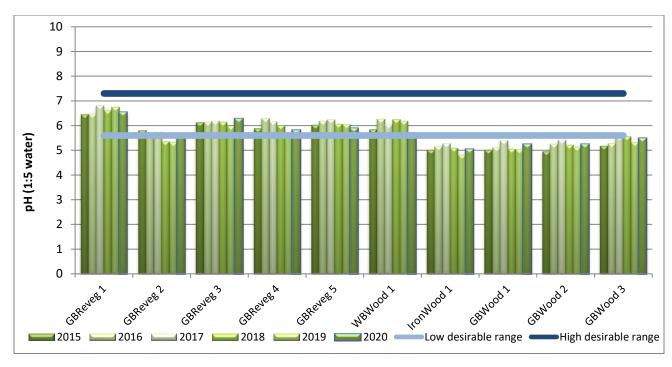


Figure 8-15. Soil pH recorded in the Grey Box monitoring sites compared to the desirable agricultural range.

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 0.050 – 0.079 dS/m. In the remaining sites EC ranged from a low of 0.012 dS/m in GBReveg4 to a high of 0.034 dS/m in GBReveg2.

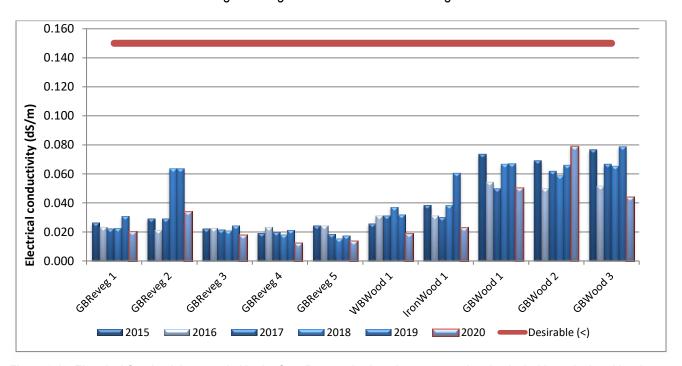


Figure 8-16. Electrical Conductivity recorded in the Grey Box monitoring sites compared to the desirable agricultural levels.

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 6.0 - 7.6% (Figure 8-17). At GBReveg2, there was 5.0% OM while at IronWood1 OM was 4.7% with these being slightly higher than desirable agricultural range. OM in the remaining sites remained lower than the Grey Box woodlands and ranged from a low of 2.0% in GBReveg4 to a high of 3.3% in GBReveg1, GBReveg3 and WBWood01.

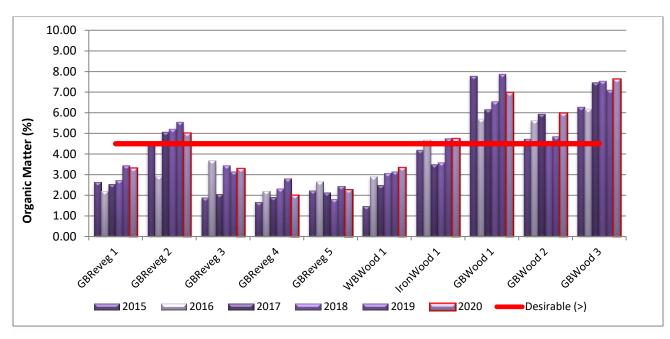


Figure 8-17. Organic Matter concentrations recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

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 all most sites. They remained the highest within the woodland reference sites which had a P range of 8-24 mg/kg this year. P concentrations were similar in GBReveg1 with 9 mg/kg, while in the remaining revegetation sites, P was lower and ranged from 5-7 mg/kg (Figure 8-18).

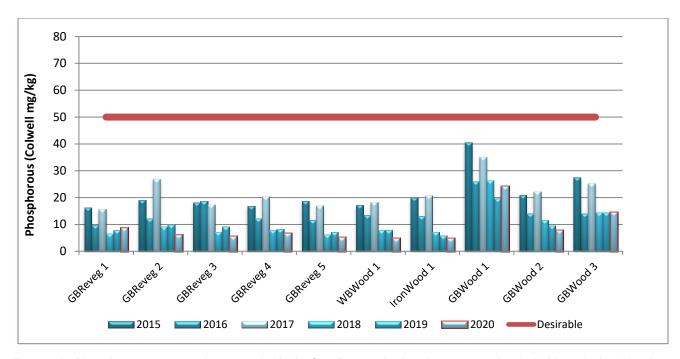


Figure 8-18. Phosphorous concentrations recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

8.11.5 Nitrate

Nitrate levels were lower than the agricultural standards across all Grey Box monitoring sites. There continued to be little differences between most sites and limited change appears to have occurred, with the exception of the small spike in GBReveg2 in 2018 and 2019. In the reference sites N ranged from 1.5 -2.6 mg/kg, with GBReveg3 having a similar N of 2.2 mg/kg. The remaining sites had low N concentrations ranging from 1.2 – 1.6 mg/kg (Figure 8-19).

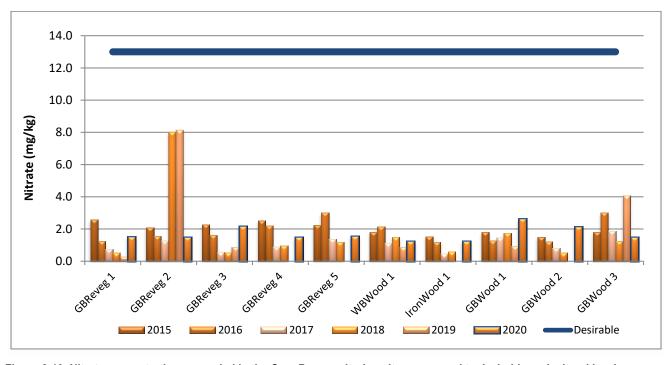


Figure 8-19. Nitrate concentrations recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

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 5.3 – 6.6 cmol/kg (Figure 8-20). Site GBReveg1 had a CEC which was similar to the reference sites with 5.5 cmol/kg. The remaining sites had a low CEC that ranged from 2.6 cmol/kg (GBReveg4) to 4.7 cmol/kg (WBWood01).

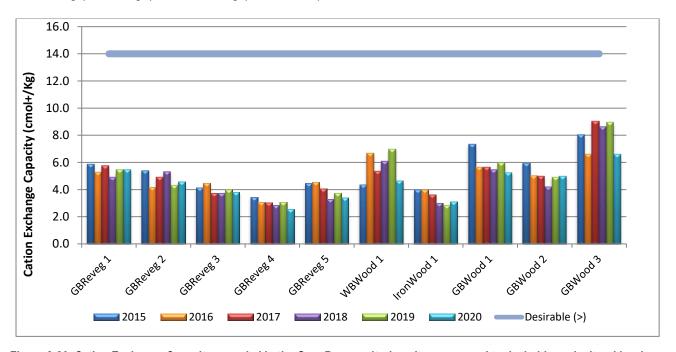


Figure 8-20. Cation Exchange Capacity recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

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 ranged from 1.3 - 7.8% (Figure 8-21), with the soils in GBWood02 being sodic. This ESP also continued to be variable across the remaining sites, however all sites had an ESP lower than the 5% threshold and were non sodic (Isbell 1996). ESP ranged from 0.2 (GBReveg1) -4.2% (GBReveg2).

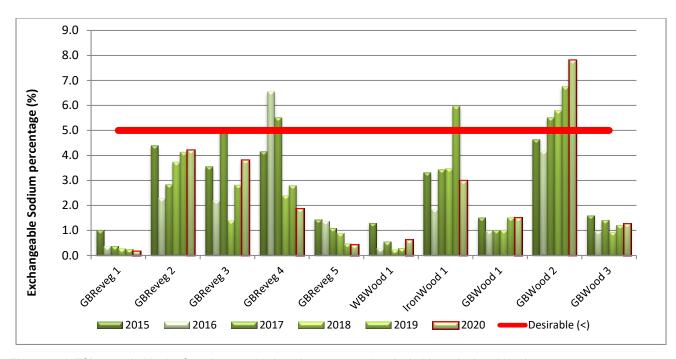


Figure 8-21. ESP recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

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 2020 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 <u>shaded</u> 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 2020. 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 <u>striped shaded</u> 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 2020.

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performanc e Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable	GBWood1	GBWood2	GBWood3	Wood		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
Per	formance indica	tors are quantific	ed by the range	of values obtained from r	replicated reference sites	•	2020	2020	2020	Lower	Upper		•		2020			
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.		C 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 and amelioration	Soil properties are suitable for the establishmen t and maintenance	рН	pH is typical of that of the surrounding landscape or falls within desirable ranges provided by the agricultural industry		pH (*5.6 - 7.3)	5.2	5.3	5.5	5.2	5.5	6.5	5.6	6.3	5.8	5.9	5.7	5.0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performanc e Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable	GBWood1	GBWood2	GBWood3	Wood	Box dland ystem 2020	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
		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)	0.05	0.07 9	0.04	0.04	0.07 9	0.02	0.03	0.01 8	0.01	0.01 3	0.01 9	0.02
			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)	7.0	6.0	7.6	6.0	7.6	3.3	5.0	3.3	2.0	2.3	3.3	4.7
			Phosphorous	Available Phosphorus is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		ppm (*50)	24.3	7.8	14.5	7.8	24.3	8.7	6.1	5.5	6.7	5.1	4.8	4.8
			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	2.1	1.5	1.5	2.6	1.5	1.5	2.2	1.5	1.6	1.2	1.3
			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)	5.3	5.0	6.6	5.0	6.6	5.5	4.6	3.8	2.6	3.4	4.7	3.1
			ESP		Exchangeable Sodium Percentage (a measure of sodicity) is typical of the surrounding landscape or is less than the 5% threshold for sodicity	% (*<5)	1.5	7.8	1.3	1.3	7.8	0.2	4.2	3.8	1.9	0.4	0.6	3.0
Phase 4: Ecosystem & Land use Establishmen t	Landscape Function Analysis (LFA): Landform stability and	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		%	63.8	64.9	70.8	63.8	70.8	76.6	71.0	72.6	72.7	75.0	65.1	67.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performanc e Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable	GBWood1	GBWood2	GBWood3	Wood	Box dland ystem 2020	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
	organisatio n			of the local remnant vegetation														
			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	100	100	99	100	100	100
	Vegetation diversity	Vegetation contains a diversity of species comparable to that of the local remnant vegetation	Diversity of	The diversity of shrubs and juvenile trees with a stem diameter < 5cm is comparable to that of the local remnant vegetation.		species/ar ea	2	4	3	2	4	1	0	4	0	0	6	5
			shrubs and juvenile trees	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		% populatio n	100	100	100	100	100	100	0	100	0	0	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	35	59	50	35	59	44	36	47	50	51	69	49
			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	>No./area	21	46	28	21	46	24	27	25	30	27	48	43

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performanc e Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable	GBWood1	GBWood2	GBWood3	Wood	Box dland ystem 2020	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
					comparable to the local remnant vegetation													
			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<="" td=""><td>14</td><td>13</td><td>22</td><td>13</td><td>22</td><td>20</td><td>9</td><td>22</td><td>20</td><td>24</td><td>21</td><td>6</td></no.>	14	13	22	13	22	20	9	22	20	24	21	6
	Vegetation density	Vegetation contains a density of species comparable to that of the local remnant vegetation	Density of shrubs and juvenile trees	The density of shrubs or juvenile trees with a stem diameter < 5cm is comparable to that of the local remnant vegetation		No./area	2	21	6	2	21	1	0	9	0	0	7	76
	Ecosystem composition	The vegetation is comprised by a range of growth forms comparable to that of the	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	3	2	1	3	1	0	2	0	0	4	4
		local 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	1	4	2	1	4	0	0	2	0	0	3	2
			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		No./area	27	35	39	27	39	33	27	30	32	38	43	30

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performanc e Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable	GBWood1	GBWood2	GBWood3	Wood	Box dland ystem 2020	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
				of the local remnant vegetation														
			Grasses		The number of grass species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	5	11	6	5	11	8	5	7	13	10	12	7
			Reeds		The number of reed, sedge or rush species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	1	4	1	1	4	1	3	5	4	2	3	2
			Fems		The number of ferns comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	1	0	0	1	1	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
			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	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		%	50.6	55.1	53.3	50.6	55.1	48.6	40.7	43.9	43.5	44	51.8	49.7

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performanc e Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable	GBWood1	GBWood2	GBWood3	Wood	Box dland ystem 2020	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
	performanc e		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		%	47.0	50.5	52.0	47.0	52.0	48.7	41.8	42	43	45.1	51.5	47.8
	Protective ground cover	Ground layer contains protective ground cover and habitat	Litter cover		Percent ground cover provided by dead plant material is comparable to that of the local remnant vegetation	%	82.0	63.0	78.5	63.0	82.0	10	11.5	8	4.5	14.5	23.5	47.5
		structure comparable with the local remnant vegetation	Annual plants		Percent ground cover provided by live annual plants is comparable to that of the local remnant vegetation	<%	0.5	23.0	8.0	0.5	23.0	64	40.5	58.5	41	47.5	57.5	29
			Cryptogam cover		Percent ground cover provided by cryptogams (e.g. mosses, lichens) is comparable to that of the local remnant vegetation	%	0.0	5.0	0.0	0.0	5.0	3.5	4.5	2	4	6.5	0.5	7
			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	0	0	0	0	0
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	5.0	0.5	1.5	0.5	5.0	0	0	0	0	0	1	5
			Bare ground		Percentage of bare ground is less than or comparable to that of the local remnant vegetation	< %	11.5	3.0	5.0	3.0	11.5	1.5	3	0	4	2	1	2
			Perennial plant cover (< 0.5m)	Percent ground cover provided by live perennial vegetation (< 0.5m in height) is		%	1.0	5.5	7.0	1.0	7.0	21	40.5	31.5	46.5	30.5	16.5	9.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performanc e Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable	GBWood1	GBWood2	GBWood3	ecosy	Box dland ystem 2020	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
				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		%	88.5	97.0	95.0	88.5	97.0	98.5	97	100	96	99	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	5.0	10.6	7.2	5.0	10.6	7.6	9.6	7.6	7.6	6.4	9.6	10.4
			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	0.2	2.6	1.0	0.2	2.6	8	3.8	10.8	7.4	12.2	7.4	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		%	97	81	89	81.2	97.0	38.5	77.5	52.1	54.3	34	43.8	92.6

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performanc e Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable	GBWood1	GBWood2	GBWood3	Wood	Box dland ystem 2020	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
	Ecosystem growth and natural recruitment	The vegetation is maturing and/or natural recruitment is occurring at rates similar to those of the local remnant	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	1	9	4	1	9	1	0	9	0	0	5	45
		vegetation	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	11	1	1	11	0	O	0	0	0	2	29
			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	1	0	0	1	0	0	0	0	0	0	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	0	0	0	0	0	0	0	0	0	0	0	1

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performanc e Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable	GBWood1	GBWood2	GBWood3	Wood	Box dland ystem 2020	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
			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	1	0	1	0	0	0	0	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	4	6	0	0	6	0	0	0	0	2	2	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	12	3	0	0	12	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	33	13	10	10	33	0	0	0	0	0	14	8
			Foliage cover >6m	Projected foliage cover provided by perennial plants > 6m vertical height stratum indicates the		% cover	35	54	53	35	54	0	0	0	0	0	52	40

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performanc e Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable	GBWood1	GBWood2	GBWood3	Grey Wood ecosy range	/stem	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
				community structure is comparable to that of the local remnant vegetation														
	Tree diversity Tree density	Vegetation contains a diversity of maturing tree and shrubs species comparable to that of the local remnant vegetation			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/ar ea	1	3	2	1	3	0	0	0	0	0	3	4
			Tree diversity	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
		Vegetation contains a density of maturing tree and shrubs species comparable to that of the local remnant vegetation	Tree density	The density of shrubs or trees with a stem diameter > 5cm is comparable to that of the local remnant vegetation		No./area	8	23	20	8	23	0	0	0	0	0	8	40
			Average dbh		Average tree diameter of the tree population provides a measure of age, (height) and growth rate and that it is trending towards that of the local remnant vegetation.	cm	34	18	24	18	34	0	0	0	0	0	30	17
	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	V	% populatio n	100	100	85	85	100	0	0	0	0	0	88	70

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performanc e Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable	GBWood1	GBWood2	GBWood3	Grey Wood ecosy range	dland /stem	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
			Healthy trees	The percentage of the tree population which are in healthy condition and that the percentage is comparable to the local remnant vegetation		% populatio n	0	26	5	0	26	0	0	0	0	0	25	3
			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	% populatio n	75	43	60	43	75	0	0	0	0	0	50	18
			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	<% populatio n	25	30	20	20	30	0	0	0	0	0	13	50
			Dead Trees		The percentage of the tree population which are dead (stags), and that the percentage is comparable to the local remnant vegetation	% populatio n	0	0	15	0	15	0	0	0	0	0	13	30
			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	% populatio n	0	0	0	0	0	0	0	0	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performanc e Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable	GBWood1	GBWood2	GBWood3	Wood	Box dland ystem 2020	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
			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		% populatio n	0	9	10	0	10	0	0	0	0	0	38	10
			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	% populatio n	50	0	10	0	50	0	0	0	0	0	13	0

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 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.

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

	2015	2017	2019	2020
			Grass, but the exotic annuals Hypochaeris glabra	
Fescue)	were also abundant. The site was relative	ely diverse and maintained good ground cover. Mo	sses and cryptogam were common and there was s	some scattered <i>E. dwyeri</i> regeneration 0.5 – 2.0m
			the grass was grazed low except for scattered str	
			remnant grass tussocks were very stressed, and t	
			ne site continued to be very dry and heavy grazing h	has caused the further deterioration of the ground
cover. Ir	n 2020, the eucalypt saplings had grown	and there was an abundance of annual ground cov	rers.	
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2015 2017 2019 2020

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. Mosses and cryptogam were scattered throughout. Presently there was no tree or shrub regeneration. In 2016 there was slightly more biomass but little other change was apparent. In 2017, the grass was grazed low except for scattered stressed tussocks of Aristida leaving limited ground cover apart from litter and cryptogams and some small bare patches have developed. There was evidence of rabbits (scratchings). In 2018, the remnant grass tussocks were very stressed, and the ground cover in between was grazed very low. There was a decline in cryptogam cover and bare patches were developing. There continued to be a lot of moss cover (dead) and a lot of macropod/rabbit scat had accumulated. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover. In 2020, there was an abundance of annual ground covers. The site had been deep ripped in preparation for tubestock planting during the spring.



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 however relatively diverse and maintained relatively good ground cover. Mosses and cryptogam were scattered throughout. Presently there was no tree or shrub regeneration. In 2016 there was slightly more biomass, but little other change was apparent. In 2017, the grass was grazed low except for scattered stressed tussocks of Aristida but good ground cover has been maintained. 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. In 2020, there was an abundance of annual ground covers.



2015 2017 2019 2020

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. In 2020, there was an abundance of annual ground covers.



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 recently died probably over the prolonged summer 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 is a god 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. In 2016 there was little apparent change. In 2017, there was typically a good cover of leaf litter and scattered native grasses and perennial forbs with these being stressed. The trees appeared healthy. More mature Callitris have died with more also having fallen over. In 2018 the site had opened up with remaining trees appearing to be healthy. 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. In 2020, there was an increased cover of annual ground covers.



2015 2017 2019 2020

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. In 2020, there was an increased cover of annual ground covers, with scattered small 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 s of Callitris seedlings have persisted. In 2020, there was an abundance of annual ground covers and while many shrubs had died, there continued to be a significant number of small *Callitris* seedlings.









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 and a well-developed decomposing leaf litter layer and a sparse cover of native perennial forbs and grasses and collectively provided a highly functional patch area. Over the previous two years, heavy grazing and disturbance by animals resulted in a reduction in patch area in DWood3, but this site has recovered with all three sites having 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 year this site continued to have high functional patch area and an LO of 100%, and there was an increase in plant covers.

While the Dwyer's Red Gum grassland revegetation sites presently existed as degraded pastures and were structurally different to the woodland reference sites, they typically had good ground cover comprised of a combination of annual and perennial plants and cryptogams. Last year, heavy grazing and disturbance by animals also resulted in a reduction in patch area in DReveg1 which has also recovered, however no change was recorded in DReveg2 with 86% LO. In DReveg2, deep ripping that was undertaken in preparation for the planting of tubestock in spring 2020, created deep troughs, and 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. Subsequently, all sites except DReveg2 had 100% functional patch area (Figure 9-1).

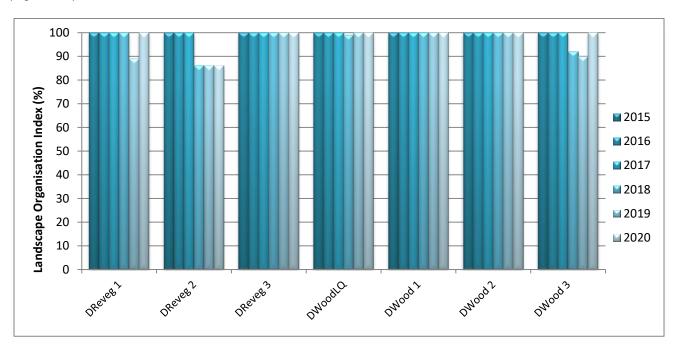


Figure 9-1. Landscape Organisation Indices recorded in the Dwyer's Red Gum woodland monitoring sites.

9.2.2 Soil surface assessments

9.2.2.1 Stability

LFA stability indices in the Red Gum reference sites were previously demonstrating an increasing trend, however in the last two years (2018 and 2019) decreasing stability was recorded in DWood1 and DWood2. This was largely due to heavy grazing and disturbance by animals which has tended to reduce the integrity of the ground cover and litter layers, thereby exposing the soils to erosion and deposition, however this trend was not observed in DWood03 where stability has been slightly increasing since 2018. This year all three reference sites have had an increase in stability with the resultant range being 69.5 – 72.8. In DWoodLQ, the stability index has also increased this year to 71.0 and therefore it had a stability that remained comparable to the woodland reference sites (Figure 9-2).

In the Dwyer's Red Gum derived native grasslands, stability has increased in DReveg2 and DReveg3 which scored indices of 69.9 and 77.8 respectively. While a marginal decline was recorded in DReveg1, all revegetation sites also had a stability that remained comparable to the woodland reference sites. 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.

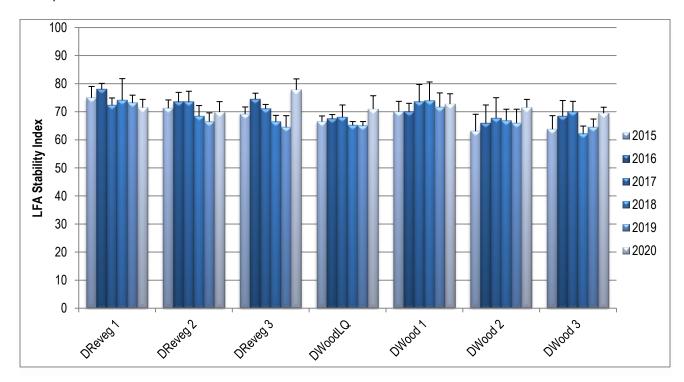


Figure 9-2. LFA stability indices recorded in the Dwyer's Red Gum woodland monitoring sites.

9.2.2.2 Infiltration

The infiltration capacity of the Red Gum woodland reference sites has continued to decrease over the past few years, as drought conditions and increased grazing resulted in the deterioration of the litter and an increased resistance of the soil crusts. This year, a further decline was recorded in DWood1 and DWood2, but a minor increase was recorded in DWood3 to provide an infiltration range of 48.5 - 52.0, but infiltration within the

individuals sites was very patchy. An increase in infiltration capacity was also recorded in DWoodLQ with this site continuing to have a higher infiltration index of 58.1 (Figure 9-3).

In the derived grassland revegetation sites, the litter layer was undeveloped and there typically was a hard surface crust which reduces the infiltration capacity of moisture to enter the soil profile, but cryptogams were often abundant. Over the past few years, the dry conditions combined with heavy grazing has resulted in a reduction in integrity of the herbaceous ground covers and litter and cryptogam layers across the area, resulting in a decline in the infiltration capacity in these sites. This year, there continued to be declining trend in DReveg1 and DReveg2 as they continue to suffer the effects of overgrazing, while in DReveg3, a significant increase was recorded. Infiltration indices ranged from 31.1 in DReveg2 to a high of 48.1 in DReveg3, therefore all revegetation sites had a low infiltration capacity compared to the reference sites again this year.

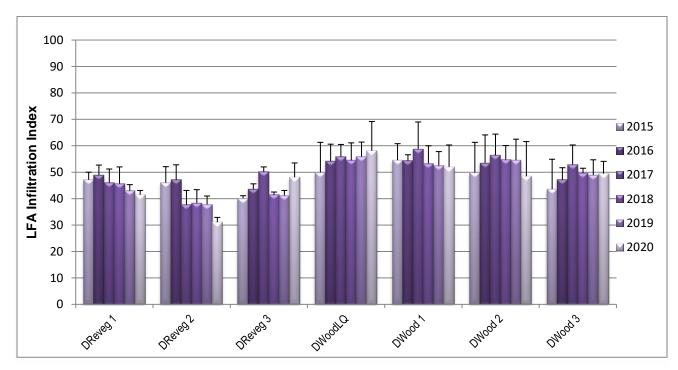


Figure 9-3. LFA infiltration indices recorded in the Dwyer's Red Gum woodland monitoring sites.

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, though the sites were patchy. The drought conditions have typically resulted in a marginal decrease in nutrient recycling capacity with this decline continuing to be recorded in DWood1 and DWood2 this year.

In the Red Gum woodland reference sites, the nutrient recycling range was 45.5 - 50.1. Nutrient recycling in DWoodLQ has continued to demonstrate and increasing trend and had an index of 58.1 this year which 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 DReveg1 and DReveg3, while a reduction was recorded in DReveg2, largely due to the disturbance created by deep ripping. This year nutrient recycling indices ranged from a low of 31.6 in DReveg2 and a high of 46.4 in DReveg3, with DReveg3 having a nutrient recycling capacity comparable to the reference sites this year.

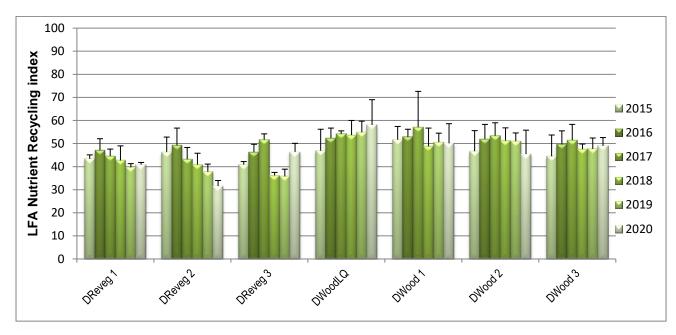


Figure 9-4. LFA nutrient recycling indices recorded in the Dwyer's Red Gum woodland monitoring sites.

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, with the [low quality] woodland (DWoodLQ) continuing to be the most ecologically functional site, followed by the Red Gum reference site DWood1 with total scores of 187 and 175 respectively. The next most functional site was DReveg3 with a sum of scores of 172, followed by DWood3 and DWood2 with total scores of 168 and 166 respectively. This was followed by the pasture revegetation site DReveg1 with154, while DReveg2 continued to be the least functional site with the score of 133, and this has decreased this year largely as a result of disturbance caused by deep ripping. Examples of the various combinations of ground covers which are critical to overall ecosystem function have been provided in Table 9-2.

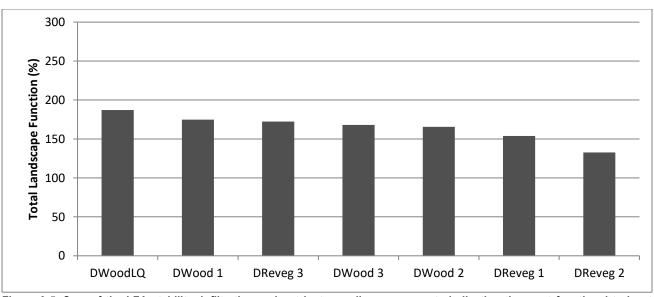
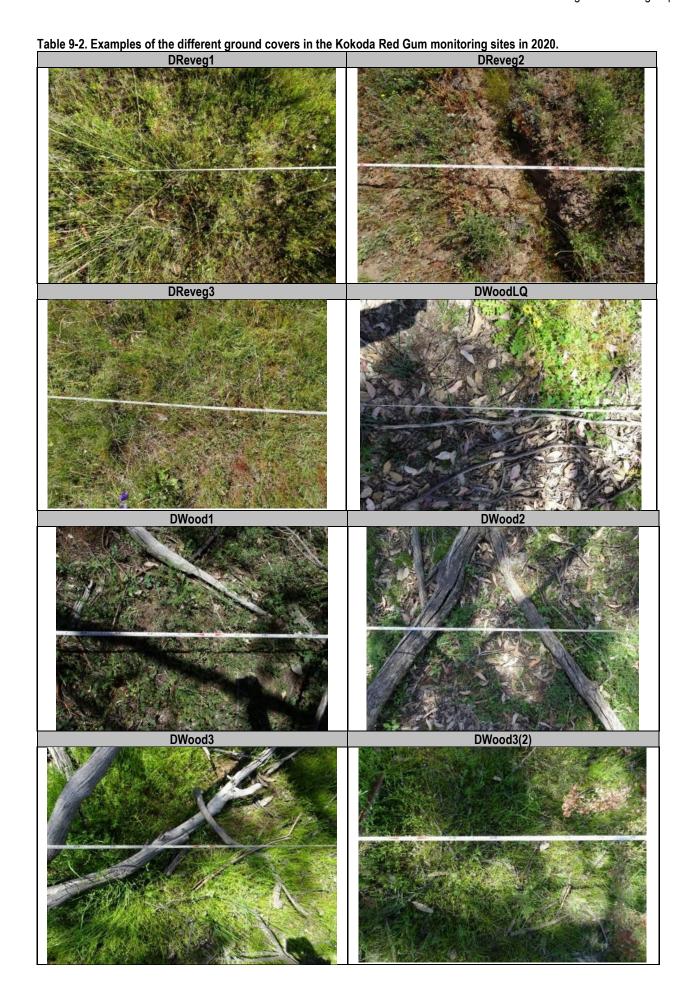


Figure 9-5. Sum of the LFA stability, infiltration and nutrient recycling components indicating the most functional to least functional monitoring site recorded in 2020.



9.3 Trees and mature shrubs

9.3.1 Population density

This year a decline in tree densities with a stem diameter >5 cm dbh was recorded in two of the Red Gum woodland reference sites. There were live tree densities of 8 – 23 live individuals, equating to a density of 200 – 575 stems per hectare (Figure 9-6). There continued to be nine trees in the DWoodLQ and this year there were four eucalypt saplings recorded in DReveg1 as 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 - 23 cm but ranged from 5 - 50 cm (Table 9-3), an indication of relatively young population and indicative of their regrowth status. In DWoodLQ, the average dbh was 22 cm and ranged from 15 - 27 cm. In DReveg1, the saplings dbh ranged from 5 - 10 cm.

9.3.3 Condition

The trees and mature shrubs in the Red Gum woodland reference sites appear to have further declined as a result of the drought with 22 – 60% of individuals being in moderate health, but 6 – 22% were in a state of advanced dieback and there was an increase in the number (dead) stags where 20 – 68% were now dead. All three sites had at least some individuals bearing reproductive structures such as buds, flowers or fruit. A small percentage of individuals in DWood1 and DWood2 contained hollows suitable for nesting sites (>10 cm), and mistletoe was recorded in DWood3 this year. In DWoodLQ, all trees were typically in medium health but there was an increase in the number with advanced dieback, with some bearing mature fruit. The eucalypt saplings in DReveg1 were all considered to be healthy but may have had some insect damage.

9.3.4 Species composition

The 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*. DWoodLQ woodland was dominated by *E. dwyeri* and contained one *E. albens* (White Box). The individuals in DReveg1 were *E. dwyeri* saplings.

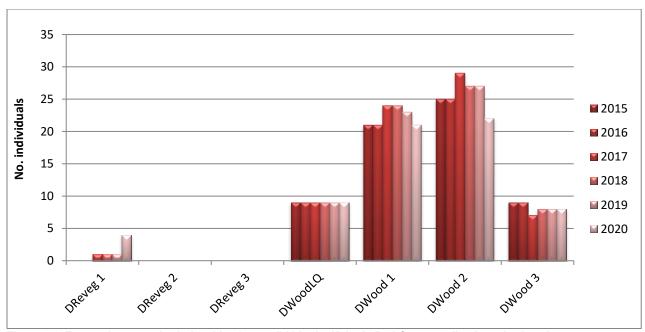


Figure 9-6. Tree and mature shrub densities (>5cm dbh) in the Kokoda Red Gum woodland monitoring sites.

Table 9-3. Trunk diameters and condition of the trees and mature shrubs in the Red Gum monitoring sites in 2020.

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	7	10	5	4	1	100	100	0	0	0	0	0	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	22	27	15	9	6	100	0	56	44	0	0	11	0
DWood 1	3	12	29	6	65	0	32	5	22	6	68	0	2	12
DWood 2	3	17	50	5	32	1	69	3	44	22	31	0	38	3
DWood 3	3	23	32	7	10	2	80	0	60	20	20	10	50	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 this year as a result of drought mortality. In DWood3 however, many shrubs had persisted and there continued to be significant numbers of Callitris seedlings which were difficult to count with accuracy. Nonetheless seedling densities in the reference sites were in the order of 35 – 952 individuals (Figure 9-7). In DWoodLQ, there continued to be 8 seedlings this year. In the derived grasslands, there were 1 - 8 seedlings.

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 (Table 9-4). In DReveg1 there were a range of heights and most height classes continue to be represented, while in DReveg2, DReveg3 and DWoodLQ, all individuals were less than 1.0 m in height.

9.4.3 Species diversity

In the woodland reference sites, there were 3 - 4 species of shrubs and juvenile trees with the most abundant species being young *Callitris endlicheri* seedlings. There were also low occurrences of a range of other species including *Acacia doratoxylon* (Spearwood), *Calytrix tetragona* (Fringe Myrtle), *Brachyloma daphnoides* (Daphne Heath), *E. dealbata*, *Allocasuarina verticillata* (Drooping She oak) and *Cassinia laevis* (Cough Bush). 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*.

In DReveg1 most individuals were *E. dwyeri* saplings, but one *A. decora* seedling continued to be recorded. In DReveg2 there was one each of *A. decora*, *Callitris endlicheri* and *Cassinia laevis*. In DReveg3, there continued to be one *Allocasuarina verticillata*.

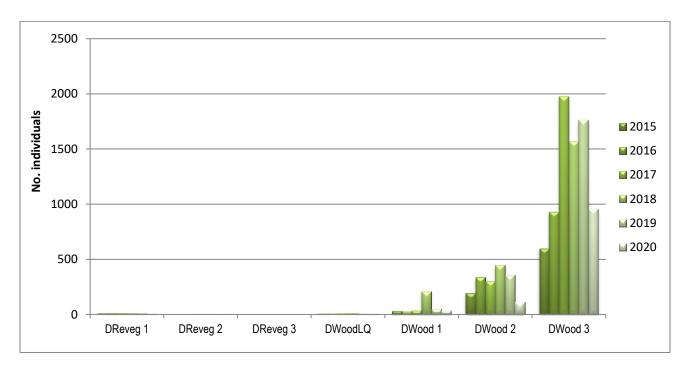


Figure 9-7. Total shrubs and juvenile trees recorded in the Red Gum monitoring sites.

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	1	1	0	2	4	8	2	100
DReveg 2	1	2	0	0	0	3	3	100
DReveg 3	1	0	0	0	0	1	1	100
DWoodLQ	6	2	0	0	0	8	1	100
DWood 1	35	0	0	0	0	35	3	100
DWood 2	78	30	2	0	0	110	4	100
DWood 3	678	226	40	8	0	952	4	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 were extensive areas of ant nests, though these did not look active this year.

This year there was increased ground cover recorded in all monitoring sites with 96 - 98% cover being recorded in the reference sites (Figure 9-8). In the grassland areas and DWoodLQ, ground cover ranged from 81 – 100%. All sites except DReveg2 had a total ground cover comparable to or higher than the reference sites this year, as a result of deep ripping.

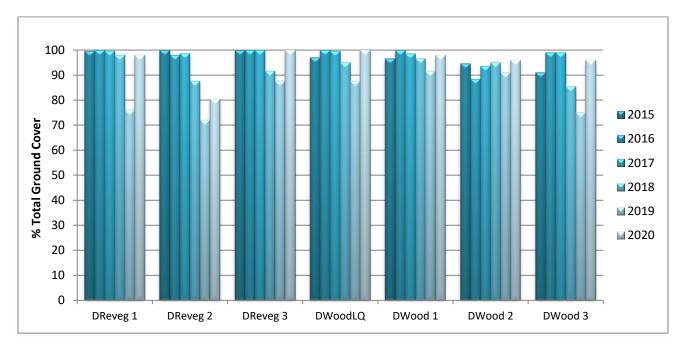


Figure 9-8. Total ground cover recorded in the Red Gum woodland monitoring sites.

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, the dominant ground covers were a combination of annual plants which provided 10 - 51% and dead leaf litter which provided 23 - 30% of the total ground cover. There was 1 - 37% cover provided by perennial vegetation and cryptogams provided 5 - 15% of the total cover. Fallen branches were typical in all three sites and these provided 2 - 11% cover, and in DWood1 there was 8% cover from scattered rocks.

The ground cover in DWoodLQ was similar and was also dominated by annual plants and dead litter, with scattered cryptogam and perennial ground covers. The reference sites and DWoodLQ were also characterised by having a mature canopy cover which exceeded 6.0 m in height with low hanging branches and scattered shrubs also providing occasional projected cover in the lower height classes in the reference sites.

In the grassland revegetation sites, annual plants were also dominant and provided 28 - 63% of the total ground cover, and there was an increase in perennial cover with 16 - 64% cover. There was a relatively high proportion of cryptogams in DReveg1 and DReveg2. There continued to be an absence of foliage cover >0.5 m in height.

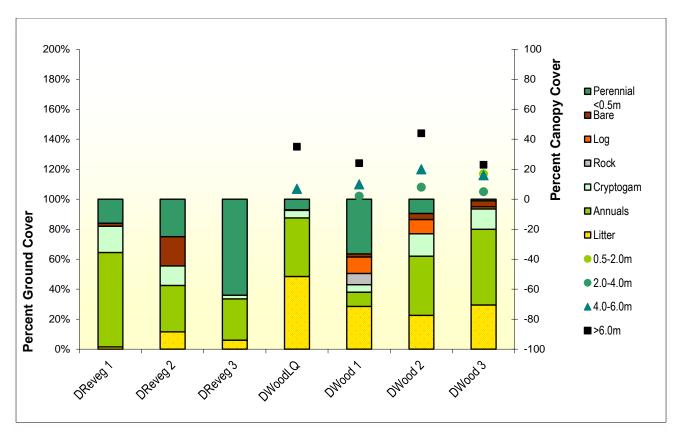


Figure 9-9. Average percent ground cover and projected foliage cover recorded in the Red Gum monitoring sites.

9.7 Floristic Diversity

Total floristic diversity recorded within the 20 x 20 m Red Gum monitoring sites has significantly increase this year and is almost as high as was first recorded in 2016, as a result of the favourable seasonal conditions. This year there were 38 - 51 species recorded (Figure 9-10), and of these 30 - 42 were native species (Figure 9-11) and 8 - 12 were exotic (Figure 9-12).

In DWoodLQ, there were a total of 58 species, and while there was a comparable number of native species as the reference sites, there was a higher diversity of exotics with 22 species. In the grassland revegetation sites, there was 39 - 44 species, and while native species were more diverse than exotics, there were a higher diversity of exotics compared to the reference sites with 14 - 19 exotic species.

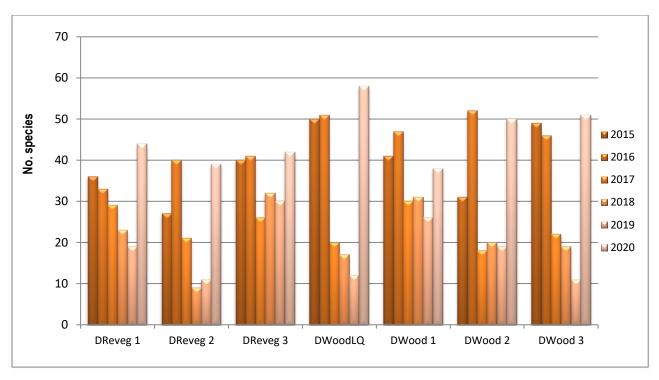


Figure 9-10. Total species diversity recorded in the Red Gum monitoring sites.

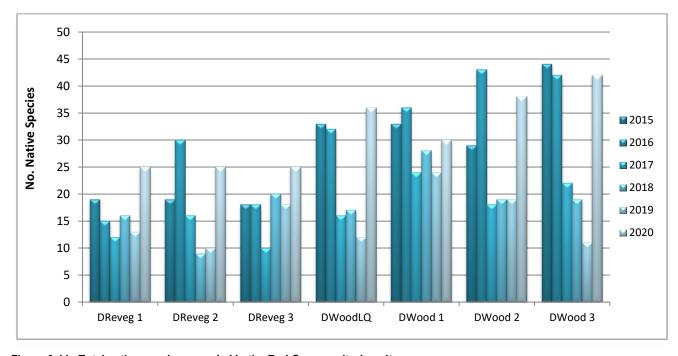


Figure 9-11. Total native species recorded in the Red Gum monitoring sites.

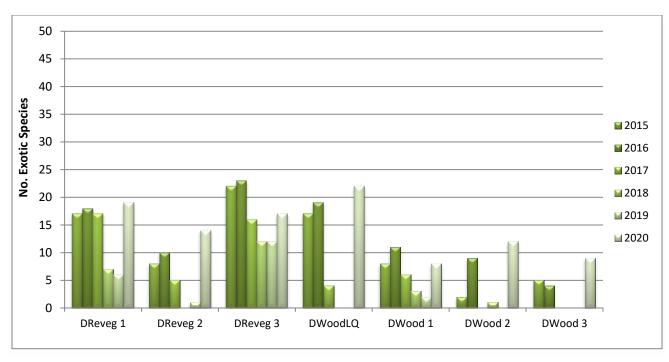


Figure 9-12. Total exotic species recorded in the Red Gum monitoring sites.

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

In the previous two years, most of the live plant cover in the reference sites has been provided by native species. This year however, the flush of exotic annual plant cover has resulted in a declining proportion of native cover with 83 - 93% native plant cover (Figure 9-13). Similar trends have been recorded in the grassland sites; however, exotics were more abundant than in the reference sites with native plants providing 64 - 80% of the live plant cover this year.

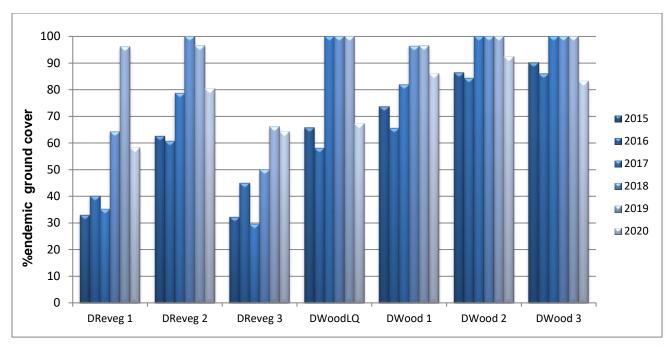


Figure 9-13. Percent endemic ground cover recorded in the Red Gum monitoring sites.

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 23 - 33 herbs and 7 – 8 grasses. There were 3 tree species, 1 – 3 shrub species and 0 - 2 sub-shrubs as well as two species of reed and a fern was recorded at all three sites. DWoodLQ had a higher diversity of herbs and a similar number of grass, reeds and ferns but it had a low diversity of tree species and no shrubs or sub – shrubs were recorded this year. In the grassland revegetation areas, there was an adequate diversity of herbs and grasses, but there was a low diversity of trees and shrubs in most sites.

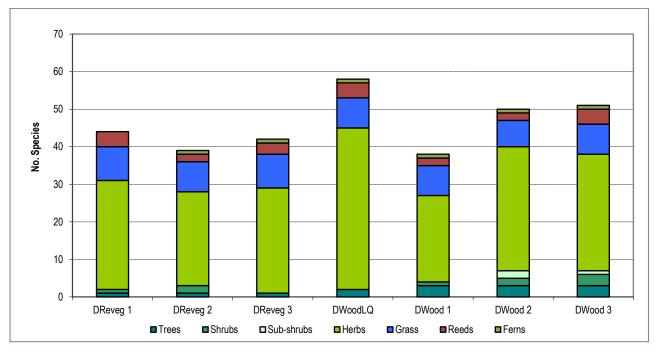


Figure 9-14. Composition of the vegetation recorded in the Red Gum monitoring sites in 2020.

9.9 Most common species

The most common species recorded in the revegetation sites is provided in Table 9-5, with 35 species being recorded in at least three of the four revegetation sites. Native species common to all revegetation sites include *Bothriochloa macra* (Red-leg Grass), *Stuartina muelleri* (Spoon Cudweed), *Triptilodiscus pygmaeus* (Austral Sunray) and *Xerochrysum bracteatum* (Golden Everlasting).

Exotic species common to all four sites included *Aira cupaniana* (Silvery Hairgrass), *Arctotheca calendula* (Capeweed), *Briza minor* (Shivery Grass), *Hypochaeris glabra* (Smooth Catsear), *Juncus capitatus* (Capitate Rush), *Lysimachia arvensis* (Scarlet Pimpernel), *Parentucellia latifolia* (Red Bartsia), *Tolpis umbellata* (Yellow Hawkweed) and *Trifolium glomeratum* (Clustered Clover). Many of these common species were also recorded in the reference sites. 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 2020.

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
*	Arctotheca calendula	Capeweed	h	1	1	1	1	4		1	1
	Bothriochloa macra	Red-leg Grass	g	1	1	1	1	4			1
*	Briza minor	Shivery Grass	g	1	1	1	1	4	1	1	1
*	Hypochaeris glabra	Smooth Catsear	h	1	1	1	1	4	1	1	1
*	Juncus capitatus	Capitate Rush	r	1	1	1	1	4			1
*	Lysimachia arvensis	Scarlet Pimpernel	h	1	1	1	1	4	1		1
*	Parentucellia latifolia	Red Bartsia	h	1	1	1	1	4	1		
	Stuartina muelleri	Spoon Cudweed	h	1	1	1	1	4	1	1	1
*	Tolpis umbellata	Yellow Hawkweed	h	1	1	1	1	4			
*	Trifolium glomeratum	Clustered Clover	h	1	1	1	1	4			
	Triptilodiscus pygmaeus	Austral Sunray	h	1	1	1	1	4	1	1	1
	Xerochrysum bracteatum	Golden Everlasting	h	1	1	1	1	4		1	1
	Aristida ramosa	Threeawn Grass	g	1	1	1		3		1	
*	Bromus molliformis	Soft Brome	g	1	1	1		3			
	Centrolepis strigosa	Hairy Centrolepis	h	1		1	1	3		1	1
	Cheilanthes sieberi subsp. sieberi	Rock Fern	f		1	1	1	3	1	1	1
*	Cicendia quadrangularis	Yellow Centaury	h	1		1	1	3		1	1
	Crassula colorata	Dense Stonecrop	h	1	1		1	3			
	Drosera peltata	Pale Sundew	h	1		1	1	3		1	1
*	Echium plantagineum	Paterson's Curse	h	1	1	1		3			
	Erodium crinitum	Blue Storksbill	h		1	1	1	3	1		
	Gonocarpus tetragynus	Raspwort	h		1	1	1	3	1	1	1
	Haloragis heterophylla	Rough Raspwort	h	1		1	1	3			1
	Juncus bufonius	Toad Rush	r	1	1		1	3			
	Lobelia gibbosa	Tall Lobelia	h		1	1	1	3		1	
	Oxalis perennans	Yellow Wood-sorrel	h		1	1	1	3	1		
*	Petrorhagia nanteuilii	Proliferous Pink	h	1	1	1		3			
	Schoenus apogon	Common Bog Rush	r	1		1	1	3	1	1	1
*	Trifolium arvense	Haresfoot Clover	h	1	1		1	3			

exotic	Scientific Name	Common Name	Habit	DReveg1	DReveg2	DReveg3	DWoodLQ	Total	DWood1	DWood2	DWood3
*	Trifolium campestre	Hop Clover	h	1	1	1		3			
*	Trifolium subterraneum	Subterraneum Clover	h	1		1	1	3			
*	Vulpia muralis	Rats-tail Fescue	g	1		1	1	3		1	1
	Wahlenbergia gracilenta	Australian Bluebell	h	1		1	1	3	1	1	1
	Wahlenbergia stricta	Tall Bluebell	h		1	1	1	3	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 set of species across the range of sites. This year it may be worth noting the high abundance of small annual herbs and sedges that are commonly associated with moist areas. These included the exotic *Juncus capitatus* (Capitate Rush), but common natives included *Haloragis heterophylla* (Rough Raspwort), *Centrolepis strigosa* (Hairy Centrolepis) and *Isolepis congrua* (Slender Club-sedge).

Table 9-6. The most abundant species recorded in the Red Gum monitoring sites in 2020.

Scientific Name	Common Name	DReveg1	DReveg2	DReveg3	OWoodLQ	DWood1	DWood2	DWood3
			_					
*Aira cupaniana	Silvery Hairgrass	10						
*Juncus capitatus	Capitate Rush	10						
Schoenus apogon	Common Bog Rush	22			12		12	15
Triptilodiscus pygmaeus	Austral Sunray	10	10					
Aristida ramosa	Threeawn Grass		13					
Bothriochloa macra	Red-leg Grass		10	11				
Cheilanthes sieberi subsp. sieberi	Rock Fern		11			19		
Crassula colorata	Dense Stonecrop		10					
Haloragis heterophylla	Rough Raspwort			26		15		
Gonocarpus tetragynus	Raspwort							
Centrolepis strigosa	Hairy Centrolepis						17	12
*Moenchia erecta	Erect Chickweed							10
Isolepis congrua	Slender Club-sedge							14

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 is 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 5.2 – 5.7 the soils were moderately to strongly acidic (Bruce & Rayment 1982). In the remaining sites the soil pH ranged from 5.2 - 5.8 and were typically comparable to the Red Gum reference sites and some were just within the minimum desirable range.

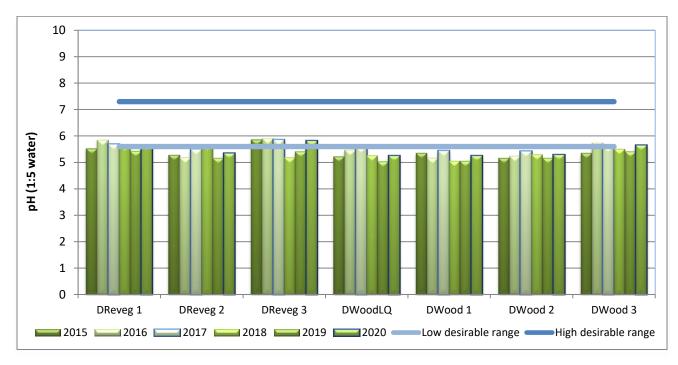


Figure 9-15. Soil pH recorded in the Red Gum monitoring sites compared to the desirable agricultural range.

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 0.009 – 0.015 dS/m. In the remaining sites EC ranged from a low of 0.012 dS/m in DReveg2 and DReveg3 to a high of 0.024 dS/m in DWoodLQ.

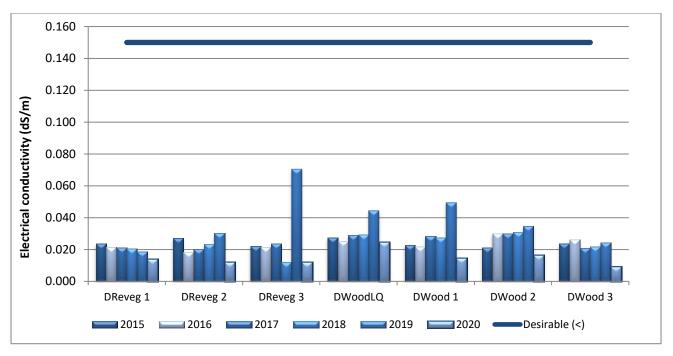


Figure 9-16. Electrical Conductivity recorded in the Red Gum monitoring sites compared to the desirable agricultural levels.

9.11.3 Organic Matter

In the Dwyer's Red Gum woodland reference sites OM levels ranged from 4.1 - 5.5% with high OM content recorded in DWood1 which slightly exceeded the desirable agricultural threshold of 4.5% (Figure 9-17). OM in the derived grassland sites were lower than the woodland reference sites with OM concentrations of 2.7 - 3.8%, and increasing OM was recorded in DWoodLQ which had an acceptable level of 5.5% OM.

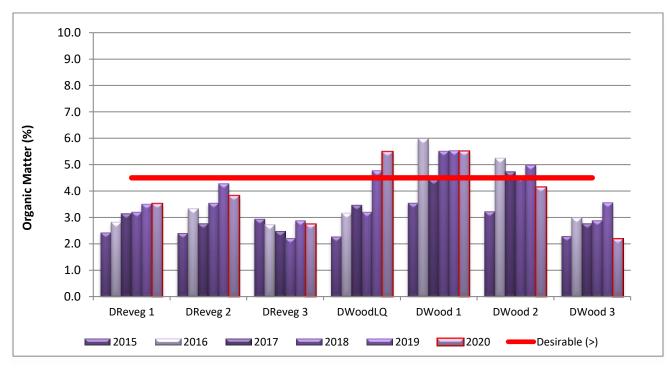


Figure 9-17. Organic Matter concentrations recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

9.11.4 Phosphorous

Phosphorous levels were lower than the agricultural standards across all Dwyer's Red Gum monitoring sites and these have further decreased over the past year. In the woodland reference sites P concentrations were 4 - 5 mg/kg. P in the remaining sites were slightly low or similar with concentrations of 3 - 7 mg/kg (Figure 9-18).

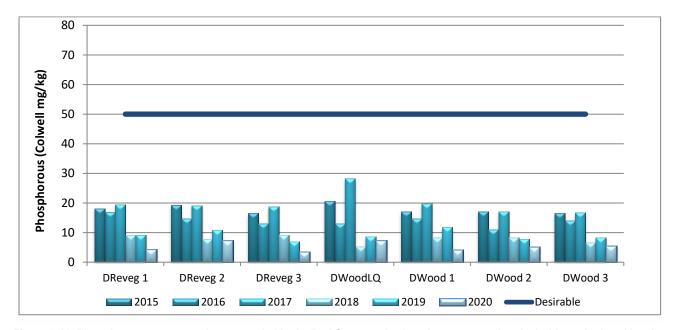


Figure 9-18. Phosphorous concentrations recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

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, except in DReveg3 and DWood1 last year which had a small spike. This year N was 1.5 - 1.6 mg/kg in the reference sites, and while N was low in DWoodLQ with 1.2 mg/kg, the remaining grassland sites had 1.5 - 1.9 mg/kg which were comparable to the reference sites this year (Figure 9-19).

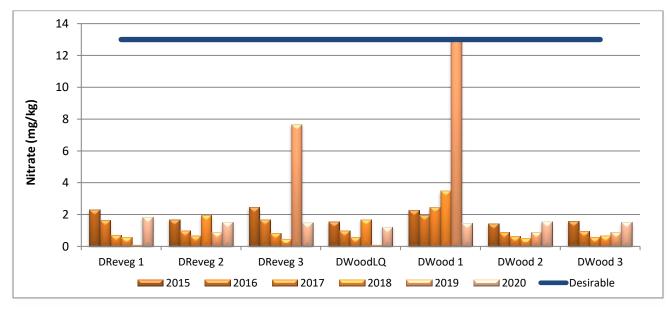


Figure 9-19. Nitrate concentrations recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

9.11.6 Cation Exchange Capacity

All of the Red Gum monitoring sites had a low CEC and in the reference sites CEC ranged from 2.2 – 3.9 cmol/kg. In the remaining sites, CEC ranged from a low of 2.8 cmol/kg in DReveg3 to a high of 3.3 cmol/kg in DWoodLQ and were therefore comparable to the reference sites this year (Figure 9-20).

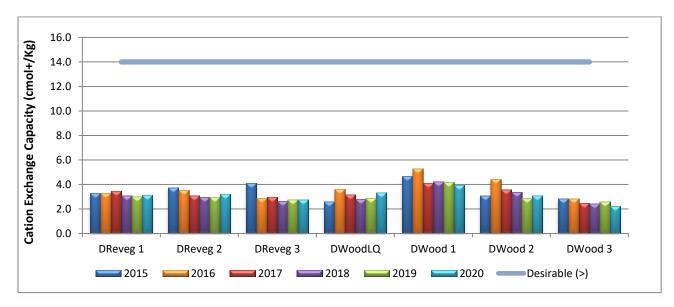


Figure 9-20. Cation Exchange Capacity recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

9.11.7 Exchangeable Sodium Percentage

ESP recorded in the woodland reference sites has been highly variable and this year ranged from 0.7 - 4.2% and these remained below the 5% threshold for sodicity (Figure 9-21). In DWoodLQ, the ESP continued to be slightly elevated with an ESP of 5.2% indicating the soils may be sodic, and this may also be the case in DReveg1 with an ESP of 4.9% this year (Isbell 1996). In the remaining sites the soils were non-sodic.

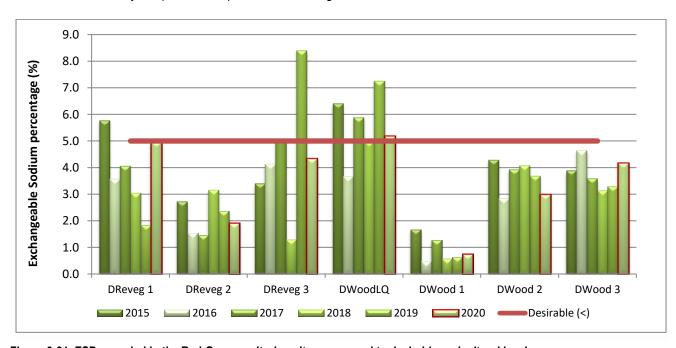


Figure 9-21. ESP recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

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 2020 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 <u>shaded</u> 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 2020. 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 <u>striped shaded</u> 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 2020.

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 Gum Wo ecosyste 20	oodland em range	DReveg 1	DReveg 2	DReveg 3	DWoodLQ
	Performance in	dicators are quantific	ed by the range of	values obtained from repl	icated reference sites		2020	2020	2020	Lower	Upper		20	20	•
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	рН	pH is typical of that of the surrounding landscape or falls within desirable ranges provided by the agricultural industry		pH (*5.6 - 7.3)	5.2	5.3	5.7	5.2	5.7	5.6	5.3	5.8	5.3
		1 7 3 3 3 3	EC		Electrical Conductivity is typical of that of the surrounding landscape or fall within desirable	< dS/m (*<0.150)	0.015	0.016	0.009	0.009	0.016	0.014	0.012	0.012	0.024

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	Gum We	's Red codland em range 20	DReveg 1	DReveg 2	DReveg 3	DWoodLQ
					ranges provided by the agricultural industry										
			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)	5.5	4.1	2.2	2.2	5.5	3.5	3.8	2.7	5.5
			Phosphorous	Available Phosphorus is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		ppm (*50)	4.0	5.0	5.3	4.0	5.3	4.2	7.2	3.4	7.2
			Nitrate		Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	ppm (*>12.5)	1.5	1.6	1.5	1.5	1.6	1.9	1.5	1.5	1.2
			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)	3.9	3.1	2.2	2.2	3.9	3.1	3.2	2.8	3.3
			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	3.0	4.2	0.7	4.2	4.9	1.9	4.3	5.2
Phase 4: Ecosystem & Landuse 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		%	72.8	71.5	69.5	69.5	72.8	71.5	69.9	77.8	71.0
			LFA Landscape organisation	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and is		%	100	100	100	100	100	100	86	100	100

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	Gum We	's Red oodland em range 20	DReveg 1	DReveg 2	DReveg 3	DWoodLQ
				comparable to that of the local remnant vegetation											
	Vegetation diversity	Vegetation contains a diversity of species comparable to that of the local	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	3	4	4	3	4	2	3	1	1
		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		% population	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	38	50	51	38	51	44	39	42	58
			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	30	38	42	30	42	25	25	25	36
			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<="" td=""><td>8</td><td>12</td><td>9</td><td>8</td><td>12</td><td>19</td><td>14</td><td>17</td><td>22</td></no.>	8	12	9	8	12	19	14	17	22
	Vegetation density	Vegetation contains a density of species comparable to that of the local	Density of shrubs and juvenile trees	The density of shrubs or juvenile trees with a stem diameter < 5cm is comparable to that of the local remnant vegetation		No./area	35	110	952	35	952	8	3	1	8

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	Gum We	's Red oodland em range 20	DReveg 1	DReveg 2	DReveg 3	DWoodLQ
		remnant vegetation													
	Ecosystem composition	The vegetation is comprised by a range of growth forms comparable to that of the local remnant	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	3	3	3	3	1	1	1	2
		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	1	2	3	1	3	1	2	0	0
			Sub-shrubs		The number of sub-shrub species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	2	1	0	2	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	23	33	31	23	33	29	25	28	43
			Grasses		The number of grass species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	8	7	8	7	8	9	8	9	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	2	4	2	4	4	2	3	4
			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

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	Gum W	's Red codland em range 20	DReveg 1	DReveg 2	DReveg 3	DWoodLQ
			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
			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 & Function Analysis Sustainability (LFA): Landform function and ecological	Function Analysis (LFA): Landform function and	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		%	52.0	48.5	49.5	48.5	52.0	41.5	31.1	48.1	58.1
			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		%	50.1	45.5	49.0	45.5	50.1	40.9	31.6	46.4	58.1
	Protective ground cover	Ground layer contains protective ground cover and habitat structure	Litter cover		Percent ground cover provided by dead plant material is comparable to that of the local remnant vegetation	%	29	23	30	23	30	1.5	11.5	6	48.5
		comparable with the local remnant vegetation	Annual plants		Percent ground cover provided by live annual plants is comparable to that of the local remnant vegetation	<%	10	40	51	10	51	63	31	27.5	39
			Cryptogam cover		Percent ground cover provided by cryptogams (e.g. mosses, lichens) is comparable to that of the local remnant vegetation	%	5	15	14	5	15	17.5	13	2.5	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	

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	Gum We	r's Red oodland em range 120	DReveg 1	DReveg 2	DReveg 3	DWoodLQ
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	11	10	2	2	11	0	0	0	0.5
			Bare ground		Percentage of bare ground is less than or comparable to that of the local remnant vegetation	< %	2	4	4	2	4	2	19.5	0	0
			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		%	37	10	1	1	37	16	25	64	7
			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		%	98	96	96	96	98	98	80.5	100	100
	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/m²	8.4	11.4	14.0	8.4	14.0	9.2	9.8	8.8	11.2
			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/m²	2.0	1.4	3.2	1.4	3.2	7.8	3	7.2	5.8

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	Gum We	r's Red oodland em range 20	DReveg 1	DReveg 2	DReveg 3	DWoodLQ
	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		%	86	93	83	83.3	92.5	58.2	80.4	64.2	67.2
	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	35	78	678	35	678	1	1	1	6
			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	0	30	226	0	226	1	2	0	2
			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	2	40	0	40	0	0	0	0
			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	8	0	8	2	0	0	0

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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	Gum Wo	's Red oodland em range 20	DReveg 1	DReveg 2	DReveg 3	DWoodLQ
			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	0	0	0	4	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	0	17	0	17	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	2	8	5	2	8	0	0	0	0
			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	10	20	16	10	20	0	0	0	7
			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	24	44	23	23	44	0	0	0	35
	Tree diversity	Vegetation contains a diversity of maturing tree and shrubs species comparable to	Tree diversity		The diversity of trees or shrubs with a stem diameter > 5cm is comparable to the local remnant vegetation. Species used in	species/area	2	3	3	2	3	1	0	0	2

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	Gum We	r's Red oodland em range 20	DReveg 1	DReveg 2	DReveg 3	DWoodLQ
		that of the local remnant vegetation			rehabilitation will be endemic to the local area										
				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 density	Vegetation contains a density of maturing tree and shrubs species comparable to	Tree density	The density of shrubs or trees with a stem diameter > 5cm is comparable to that of the local remnant vegetation		No./area	65	32	10	10	65	4	0	0	9
		that of the local remnant vegetation The vegetation is	Average dbh		Average tree diameter of the tree population provides a measure of age, (height) and growth rate and that it is trending towards that of the local remnant vegetation.	ст	12	17	23	12	23	7	0	0	22
	Ecosystem health		Live trees	The percentage of the tree population which are live individuals, and that the percentage is comparable to the local remnant vegetation		% population	32	69	80	32	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	5	3	0	0	5	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	44	60	22	60	0	0	0	55.6

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	Gum We	's Red codland em range 20	DReveg 1	DReveg 2	DReveg 3	DWoodLQ
			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	6	22	20	6	22	0	0	0	44.4
			Dead Trees		The percentage of the tree population which are dead (stags), and that the percentage is comparable to the local remnant vegetation	% population	68	31	20	20	68	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 comparable to the local remnant vegetation	% population	0	0	10	0	10	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	2	38	50	2	50	0	0	0	11.1
			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	12	3	0	0	12	0	0	0	0

10 Management considerations

10.1 Priority weeds

No priority weed species of the Central Tablelands LLS were recorded in the range of monitoring sites. Most weeds observed were limited to common annual agricultural weeds which were quite dominant this year as a result of overgrazing caused by the drought.

10.2 Orchid observations

A map showing the locations of orchids observed in 2015 and 2016 is provided in Figure 10-1. This year, *Caladenia aff. tentaculata* (Greencomb Spider Orchid), *Calochilus robertsonii* (Purplish Beard Orchid) and *Caladenia gracilis* (Musky Caladenia) were observed at some of these locations (Table 10-1, Figure 10-2).

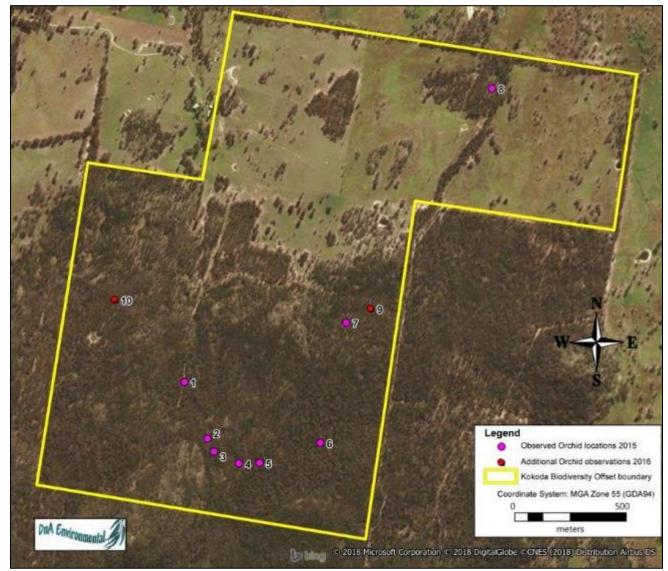


Figure 10-1. A map showing the approximate locations of orchid species sighted around the Kokoda property in 2015, 2016 and 2020.

Table 10-1. Approximate coordinates and orchid species observed at Kokoda in 2015, 2016 and 2020.

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)
3	55 635568	6316778	Caladenia aff. tentaculata (Greencomb Spider Orchid), Diuris goonooensis (Western Donkey Orchid)
4	55 635679	6316724	Glossodia major (Wax-lip Orchid)
5	55 635771	6316725	Glossodia major (Wax-lip Orchid)
6	55 636043	6316811	Thelymitra spp., Glossodia major (Wax-lip Orchid)
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)
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 10-2. Calochilus robertsonii (Purplish Beard Orchid) and Caladenia aff. tentaculata (Greencomb Spider Orchid).

10.3 Other wildflower observations

Myriocephalus rhizocephalus (Woolly Heads; Figure 10-3), a small annual daisy was found on the edge of the main access track at the entrance into Kokoda 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).

Mimulus gracilis (Slender Monkey-flower) and Lobelia gibbosa (Tall Lobelia) were common in damp depressions / moist springs across the Kokoda property (Figure 10-4). Wurmbea dioica (Early Nancy) and Microtis unifolia (Onion Orchid) were also relatively common in the grassland areas this year (Figure 10-5).



Figure 10-3. Myriocephalus rhizocephalus (Woolly Heads).



Figure 10-4. Mimulus gracilis (Slender Monkey-flower) and Lobelia gibbosa (Tall Lobelia).



Figure 10-5. Wurmbea dioica (Early Nancy) and Microtis unifolia (Onion Orchid).

10.4 Site access

The recently upgraded access tracks around and throughout the steeper areas of bushland had suffered from erosion, with severe rilling noted in numerous areas including one of the main drainage lines. In addition, high mortality of Callitris saplings has resulted to many individuals falling over, with many having fallen over the main access tracks.





11 Annexure D Voluntary Conservation Agreement

Comparison of Kokoda monitoring sites results against Benchmark data for each Biometric Vegetation Type/ Plant Community Type, October 2020 (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.

		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		24	0	0.01	30	0	2.25	67.75	0	0
GBReveg2		27	0	0	45	0	20	15	0	0
GBReveg3		25	0	0.1	45	0	35	20	0	0
GBReveg4		30	0	0	10	0	48	40	0	0
GBReveg5		27	0	0	20	0	15	55	0	1
GBWood1		21	37.25	0	0.9	0.05	4.8	0.71	101	13
GBWood2		46	57	0	7.75	2.65	22.5	0.8	48.5	0
GBWood3		28	52	0	2.5	0.06	59	1.4	168.5	2
Average		28.5	18.3	0.0	20.1	0.3	25.8	25.1	39.75	2

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

LA165 - Mugga South Western			oress Pin	e woodlar	nd on hillslo	pes and ri	dges of the	Central L	achlan region	of the NSW
		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		25	0	9.25	37.5	0.25	27.25	30	0	0
DReveg2		25	0	0	7	0.2	26.25	2	4	0
DReveg3		25	0	0.01	25	0	60	15	0	0
DWood1		30	23	1	4.5	0.1	57.5	0.4	316	4
DWood2		38	25	0	23.75	2.7	40	0.75	230	3
DWood3		42	30	0.2	23.75	15.5	26.8	2.9	65	0
DWoodLQ		36	32	0	30	0	35	25	17.5	0
IronWood1		43	37	2.45	40	3.4	32.5	0.51	100	0
Average		33.0	18.4	1.6	23.9	2.8	38.2	9.6	91.6	0.9

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

LA218 - White I Western Slopes		• •	s Pine - \	Western (Grey Box s	hrub/gras	s/forb woo	odland in	the NSW Sou	ith					
	NPSR NOS NMS NGCG NGCS NGCO EPC Logs (m) Hollows														
Benchmark	NPSR NOS NMS NGCG NGCS NGCO EPC Logs (m) Hollow min 23 8 1 15 3 3 66 0.8														
	max		35	20	70	5	20								
WBWood1		48	33	0	8	1.4	9.75	62.5	68	2					
Average		48.0	33.0	0.0	8.0	1.4	9.8	62.5	68.0	2.0					

12 Conclusion

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.

The derived grassland revegetation sites presently did not meet many completion targets related to diversity and density of tree and shrub species. While there are areas where natural regeneration is occurring, there has been limited regeneration occurring within the larger clearings and selected grassland monitoring sites. Most of the derived grassland sites also contained a high dominance of exotic annual species and were weedier than the 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.

In the remnant woodland sites, there has typically been a decline in tree health and increasing numbers of stags in most sites as a result of prolonged drought, especially in the Red Gum sites. While the shrub populations have also suffered, numerous young tree and shrub seedlings were observed in some of the woodland areas after the improved seasonal conditions. It is anticipated that naturally regenerating seedlings will benefit from the reduction in 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 this year. The aim is to increase biodiversity and habitat values through the removal of livestock grazing to allow natural regeneration, supplemented with direct seeding and tubestock planting. These activities aim to assist in the development of woodland communities that are similar to the local remnant woodlands, with the performance of the revegetation activities being compared to their comparative ecological performance indicators in the medium to longer term. It must be noted that the reference sites at Kokoda are typically degraded and of low quality which subsequently have provided low benchmarks for some performance targets. In the Grey Box woodlands reference sites in particular, there was limited abundance and diversity of the grassy understorey and there were limited shrubs. Subsequently the revegetation activities undertaken have included a range of other local species associated with the respective community types.

While floristic diversity targets were often met, the revegetation sites tended to be dominated by exotic annual species, which are likely to decline in the medium to longer-term as perennial plants including trees and shrubs become more abundant. Most weeds observed were limited to common annual agricultural weeds which have become quite dominant this year as a result of the drought, combined with years of overgrazing. Extensive disturbance and herbivory by macropods and goats has therefore become an important management issue.

NPM have 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. Strategic grazing is likely to be a critical management strategy in the longer-term which will be required 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.

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. Most orchids are only identifiable during a limited time period during suitable conditions during spring and/or autumn, depending on the species. As a result of the dry conditions experienced throughout most of 2017 - 2019, none of these orchid

populations have been observed to be flowering, thus emphasising the need to map and refer to their known locations. This year a few of these orchid species were sighted again but they occurred in lower diversity and densities.

Other potential management issues may be related to high density *E. dwyeri* and *Callitris endlicheri* regeneration which was observed to be occurring within and adjacent to woodland areas where mature trees were present. The increase in competition from high density stands such as these are likely to suppress the herbaceous understorey as they become more established, thereby adversely affecting 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, property maintenance and bushfire management. Regular inspections should be undertaken with slashing and/or strategic grazing management implemented on an as needed basis. This year the recently upgraded access tracks around and throughout the steeper areas of woodland have suffered from erosion, with severe rilling noted in numerous areas, including one of the main drainage lines. In addition, high mortality of Callitris saplings has resulted in many individuals falling over, with many having fallen over the main access tracks. Fallen trees require removal and some parts of the tracks require amelioration where erosion has become severe.

The improved seasonal conditions and reduction in feral animal disturbance is likely to see an improved rate of recovery of the woodland occurring at the Kokoda Offset area. Regular and ongoing monitoring of the performance of the revegetation activities undertaken in 2020 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 2020

Group	Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Coniferopsida	Cupressaceae		Callitris endlicheri	Black Cypress Pine	t				1					1	1	1	1	1		1		
Dicotyledon	Acanthaceae		Rostellularia adscendens subsp. adscendens	7,	h																	1
Dicotyledon	Apiaceae		Daucus glochidiatus	Australian Carrot	h		1	1	1					1	1	1	1	1		1		1
Dicotyledon	Araliaceae		Hydrocotyle laxiflora	Stinking Pennywort	h		1	1						1	1	1		1				1
Dicotyledon	Asteraceae	*	Arctotheca calendula	Capeweed	h	1	1	1	1	1	1	1	1		1		1	1	1	1	1	1
Dicotyledon	Asteraceae		Calotis cuneifolia	Purple Burr Daisy	h			1														
Dicotyledon	Asteraceae		Calotis lappulacea	Yellow Burr Daisy	h	1	1	1	1	1	1	1	1						1		1	
Dicotyledon	Asteraceae	*	Carthamus lanatus	Saffron Thistle	h						1	1	1									
Dicotyledon	Asteraceae		Cassinia laevis	Cough Bush	s	1	1	1							1					1		
Dicotyledon	Asteraceae	*	Centaurea melitensis	Maltese Cockspur	h						1											
Dicotyledon	Asteraceae		Centipeda cunninghamii	Common Sneezeweed	h																	1
Dicotyledon	Asteraceae	*	Chondrilla juncea	Skeleton Weed	h												1					
Dicotyledon	Asteraceae		Chrysocephalum apiculatum	Common Everlasting	h					1												
Dicotyledon	Asteraceae	*	Cirsium vulgare	Spear Thistle	h										1		1					
Dicotyledon	Asteraceae	*	Conyza bonariensis	Fleabane	h	1	1	1				1					1					1
Dicotyledon	Asteraceae		Cotula australis	Common Cotula	h	1	1	1														
Dicotyledon	Asteraceae	*	Cotula bipinnata	Ferny Cotula	h																	1
Dicotyledon	Asteraceae		Cymbonotus lawsonianus	Bear's Ear	h									1								
Dicotyledon	Asteraceae		Euchiton sphaericus	Japanese Cudweed	h	1	1	1	1		1	1	1	1	1		1	1	1	1		
Dicotyledon	Asteraceae	*	Gamochaeta americana	Cudweed	h	1		1	1				1									1
Dicotyledon	Asteraceae	*	Hypochaeris glabra	Smooth Catsear	h	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Dicotyledon	Asteraceae	*	Hypochaeris radicata	Flatweed	h	1		1	1		1	1										
Dicotyledon	Asteraceae	*	Lactuca serriola	Prickly Lettuce	h		1	1								1	1					

Group	Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
						g	9	9	9	9	9	9	9	8	=							٥
Dicotyledon	Asteraceae		Senecio hispidulus	Hill Fireweed	h			1														
Dicotyledon	Asteraceae		Senecio spp.		h		1															
Dicotyledon	Asteraceae		Solenogyne bellioides		h									1								1
Dicotyledon	Asteraceae	*	Sonchus asper	Prickly Sowthistle	h			1														
Dicotyledon	Asteraceae	*	Sonchus oleraceus	Milk Thistle	h	1	1	1						1	1	1	1					1
Dicotyledon	Asteraceae		Stuartina muelleri	Spoon Cudweed	h	1	1	1	1	1		1		1	1	1	1	1	1	1	1	1
Dicotyledon	Asteraceae	*	Tolpis umbellata	Yellow Hawkweed	h			1	1	1	1	1	1	1					1	1	1	1
Dicotyledon	Asteraceae		Triptilodiscus pygmaeus	Austral Sunray	h		1	1	1	1	1	1	1		1	1	1	1	1	1	1	1
Dicotyledon	Asteraceae		Vittadinia cuneata	Fuzzweed	h	1			1	1										1	1	
Dicotyledon	Asteraceae		Vittadinia gracilis	A Fuzzweed	h	1		1	1	1												
Dicotyledon	Asteraceae		Vittadinia spp.	Fuzzweed	h								1									
Dicotyledon	Asteraceae		Xerochrysum bracteatum	Golden Everlasting	h		1	1							1		1	1	1	1	1	1
Dicotyledon	Brassicaceae	*	Capsella bursa-pastoris	Shepherd's Purse	h	1		1														
Dicotyledon	Brassicaceae	*	Lepidium bonariense		h			1														
Dicotyledon	Campanulaceae		Wahlenbergia communis	Tufted Bluebell	h							1					1	1				
Dicotyledon	Campanulaceae		Wahlenbergia gracilenta	Australian Bluebell	h				1			1	1		1	1	1	1	1		1	1
Dicotyledon	Campanulaceae		Wahlenbergia gracilis	Sprawling Bluebell	h		1			1				1								
Dicotyledon	Campanulaceae		Wahlenbergia stricta	Tall Bluebell	h		1	1	1	1				1	1	1	1	1		1	1	1
Dicotyledon	Caryophyllaceae	*	Cerastium glomeratum	Mouse-ear Chickweed	h																	1
Dicotyledon	Caryophyllaceae	*	Moenchia erecta	Erect Chickweed	h												1	1				
Dicotyledon	Caryophyllaceae	*	Paronychia brasiliana	Chilean Whitlow Wort	h		1															1
Dicotyledon	Caryophyllaceae	*	Petrorhagia nanteuilii	Proliferous Pink	h			1	1		1	1	1	1					1	1	1	
Dicotyledon	Caryophyllaceae	*	Polycarpon tetraphyllum	Four-leaved Allseed	h	1																
Dicotyledon	Caryophyllaceae	*	Silene gallica	French Catchfly	h			1	1		1	1	1	1								<u> </u>
Dicotyledon	Caryophyllaceae	*	Spergularia rubra	Sandspurry	h																	1
Dicotyledon	Caryophyllaceae	*	Stellaria media	Chickweed	h	1																

Group	Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Dicotyledon	Casuarinaceae		Allocasuarina verticillata	Drooping Sheoak	t											1					1	
Dicotyledon	Centrolepidaceae		Centrolepis strigosa	Hairy Centrolepis	h		1			1	1				1		1	1	1		1	1
Dicotyledon	Chenopodiaceae		Einadia nutans	Climbing Saltbush	h			1														
Dicotyledon	Chenopodiaceae		Einadia nutans subsp. nutans	Climbing Saltbush	h	1																
Dicotyledon	Convolvulaceae		Dichondra repens	Kidney Weed	h	1	1															
Dicotyledon	Crassulaceae		Crassula colorata	Dense Stonecrop	h	1	1	1	1			1	1						1	1		1
Dicotyledon	Crassulaceae		Crassula peduncularis	Purple Stonecrop	h												1	1				
Dicotyledon	Crassulaceae		Crassula sieberiana	Austral Stonecrop	h		1												1			1
Dicotyledon	Dilleniaceae		Hibbertia obtusifolia	Hoary Guinea Flower	SS									1								
Dicotyledon	Dilleniaceae		Hibbertia riparia	Silky Guinea Flower	SS		1							1	1							
Dicotyledon	Droseraceae		Drosera glanduligera	Scarlet Sundew	h													1				
Dicotyledon	Droseraceae		Drosera peltata	Pale Sundew	h						1	1		1	1		1	1	1		1	1
Dicotyledon	Epacridaceae		Astroloma humifusum	Native Cranberry	SS										1		1					
Dicotyledon	Epacridaceae		Brachyloma daphnoides	Daphne Heath	s		1								1	1	1	1				
Dicotyledon	Epacridaceae		Lissanthe strigosa	Peach Heath	SS									1	1		1	1				
Dicotyledon	Euphorbiaceae		Euphorbia drummondii	Caustic Weed	h				1											1		
Dicotyledon	Euphorbiaceae		Poranthera microphylla	Small Poranthera	h										1	1	1					
Dicotyledon	Fabaceae (Faboideae)		Bossiaea buxifolia	Box-leaved Bitter-pea	S													1				
Dicotyledon	Fabaceae (Faboideae)		Glycine clandestina	Climbing Glycine	h									1								
Dicotyledon	Fabaceae (Faboideae)		Glycine tabacina	Variable Glycine	h								1									
Dicotyledon	Fabaceae (Faboideae)	*	Trifolium angustifolium	Narrow-leaf Clover	h								1									
Dicotyledon	Fabaceae (Faboideae)	*	Trifolium arvense	Haresfoot Clover	h	1	1	1	1		1	1	1	1					1	1		1
Dicotyledon	Fabaceae (Faboideae)	*	Trifolium campestre	Hop Clover	h			1	1		1	1	1	1					1	1	1	
Dicotyledon	Fabaceae (Faboideae)	*	Trifolium dubium	Yellow Suckling Clover	h								1			1			1			1
Dicotyledon	Fabaceae (Faboideae)	*	Trifolium glomeratum	Clustered Clover	h	1	1	1	1		1	1	1	1					1	1	1	1

Group	Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Dicotyledon	Fabaceae (Faboideae)	*	Trifolium subterraneum	Subterraneum Clover	h					1	1	1	1						1		1	1
Dicotyledon	Fabaceae (Mimosoideae)		Acacia decora	Western Golden Wattle	S						1			1					1	1		
Dicotyledon	Fabaceae (Mimosoideae)		Acacia implexa	Hickory	s		1	1			1			1								
Dicotyledon	Fabaceae (Mimosoideae)		Acacia paradoxa	Kangaroo Thorn	s		1															
Dicotyledon	Gentianaceae	*	Cicendia quadrangularis		h				1	1	1			1			1	1	1		1	1
Dicotyledon	Gentianaceae		Sebaea ovata	Yellow Centaury	h				1	1	1	1	1	1			1					1
Dicotyledon	Geraniaceae	*	Erodium botrys	Long Storksbill	h				1													
Dicotyledon	Geraniaceae		Erodium crinitum	Blue Storksbill	h			1	1	1			1			1				1	1	1
Dicotyledon	Geraniaceae		Geranium solanderi	Native Geranium	h									1								
Dicotyledon	Goodeniaceae		Goodenia hederacea	Forest Goodenia	h										1	1	1			1		
Dicotyledon	Haloragaceae		Gonocarpus elatus	Hill Raspwort	h											1	1					
Dicotyledon	Haloragaceae		Gonocarpus tetragynus	Raspwort	h		1	1		1			1	1	1	1	1	1		1	1	1
Dicotyledon	Haloragaceae		Haloragis heterophylla	Rough Raspwort	h		1			1	1	1	1	1				1	1		1	1
Dicotyledon	Hypericaceae		Hypericum gramineum	Small St. John's Wort	h		1					1		1	1		1	1	1			
Dicotyledon	Lamiaceae		Ajuga australis	Australian Bugle	h									1								
Dicotyledon	Lamiaceae	*	Salvia verbenaca	Wild Sage	h				1												ļ	
Dicotyledon	Lobeliaceae		Lobelia gibbosa	Tall Lobelia	h						1	1	1	1			1			1	1	1
Dicotyledon	Myrtaceae		Calytrix tetragona	Common Fringe Myrtle	s												1	1				
Dicotyledon	Myrtaceae		Eucalyptus albens	White Box	t									1	1			1			ļ	1
Dicotyledon	Myrtaceae		Eucalyptus blakelyi	Blakely's Red Gum	t									1							ļ	
Dicotyledon	Myrtaceae		Eucalyptus dealbata	Tumbledown Gum	t										1	1	1	1				
Dicotyledon	Myrtaceae		Eucalyptus dwyeri	Dwyer's Red Gum	t														1		ļ	1
Dicotyledon	Myrtaceae		Eucalyptus microcarpa	Grey Box	t	1	1	1			1										ļ	
Dicotyledon	Myrtaceae		Eucalyptus sideroxylon	Mugga Ironbark	t		1	1			1				1		1					
Dicotyledon	Orobanchaceae	*	Orobanche minor	Broomrape	h			1					1	1								

Group	Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Dicotyledon	Orobanchaceae	*	Parentucellia latifolia	Red Bartsia	h				1	1	1	1	1	1	1	1			1	1	1	1
Dicotyledon	Oxalidaceae		Oxalis perennans	Yellow Wood-sorrel	h	1	1	1	1	1	1	1	1	1	1	1				1	1	1
Dicotyledon	Plantaginaceae	*	Echium plantagineum	Paterson's Curse	h	1			1		1	1	1						1	1	1	
Dicotyledon	Plantaginaceae		Plantago varia	Variable Plantain	h											1						
Dicotyledon	Polygonaceae		Rumex brownii	Swamp Dock	h	1	1	1	1				1									1
Dicotyledon	Primulaceae	*	Lysimachia arvensis	Scarlet Pimpernel	h	1	1	1	1	1	1	1	1	1		1		1	1	1	1	1
Dicotyledon	Ranunculaceae		Ranunculus sessiliflorus var. sessiliflorus	Small-flowered Buttercup	h	1	1	1						1	1	1	1	1	1			1
Dicotyledon	Rubiaceae		Galium gaudichaudii	Rough Bedstraw	h		1		1		1	1		1	1	1	1	1	'			
Dicotyledon	Rubiaceae		Opercularia diphylla	Stinkweed	h				<u>'</u>					<u>'</u>		1						
,			Dodonaea viscosa subsp.													·						
Dicotyledon	Sapindaceae		cuneata	Wedge-leaf Hopbush	S									1								
Dicotyledon	Schrophulariaceae		Limosella australis		h													1				1
Dicotyledon	Scrophulariaceae		Mimulus gracilis	Slender Monkey Flower	h						1											1
Dicotyledon	Scrophulariaceae	*	Verbascum virgatum	Twiggy Mullein	h								1									
Dicotyledon	Solanaceae		Solanum cinereum	Narrawa Burr	h			1						1								
Dicotyledon	Solanaceae	*	Solanum nigrum	Blackberry Nightshade	h									1								
Dicotyledon	Stackhousiaceae		Stackhousia monogyna	Creamy Candles	h								1	1								
Dicotyledon	Sterculiaceae		Brachychiton populneus	Kurrajong	t		1							1								
Dicotyledon	Stylidiaceae		Levenhookia dubia	Hairy Stylewort	h		1								1		1	1				
Dicotyledon	Violaceae		Hybanthus monopetalus	Slender Violet Bush	h										1	1						
Monocotyledon	Anthericaceae		Arthropodium minus	Small Vanilla Lily	h	1		1		1				1		1						
Monocotyledon	Anthericaceae		Dichopogon strictus	Chocolate Lily	h		1							1	1		1					
Monocotyledon	Anthericaceae		Laxmannia gracilis	Slender Wire Lily	h										1							
Monocotyledon	Anthericaceae		Thysanotus patersonii	Twining Fringe Lily	h										1			1				
Monocotyledon	Anthericaceae		Tricoryne elatior	Yellow Autumn-lily	h		1						1	1	1			1	1	1		
Monocotyledon	Asphodelaceae		Bulbine bulbosa	Bulbine Lily	h									1								

Group	Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Monocotyledon	Asphodelaceae		Bulbine semibarbata	Leek Lily	h		1															
Monocotyledon	Colchicaceae		Wurmbea dioica	Early Nancy	h					1		1					1	1			1	1
Monocotyledon	Cyperaceae		Eleocharis spp.	A Rush	r													1	1			
Monocotyledon	Cyperaceae		Isolepis congrua	Slender Club-sedge	r		1			1	1	1			1		1	1			1	
Monocotyledon	Cyperaceae		Lepidosperma laterale	Broad Sword-sedge	r											1						
Monocotyledon	Cyperaceae		Schoenus apogon	Common Bog Rush	r		1			1	1	1	1	1	1	1	1	1	1		1	1
Monocotyledon	Cyperaceae		Scleria spp.		r						1											
Monocotyledon	Hypoxidaceae		Hypoxis spp.		h					1								1				
Monocotyledon	Iridaceae	*	Sisyrinchium rosulatum	Scourweed	h						1		1								1	1
Monocotyledon	Juncaceae		Juncus bufonius	Toad Rush	r		1				1	1		1					1	1		1
Monocotyledon	Juncaceae	*	Juncus capitatus	Capitate Rush	r				1	1	1	1	1	1				1	1	1	1	1
Monocotyledon	Juncaceae		Juncus usitatus		r	1	1	1														1
Monocotyledon	Lomandraceae		Lomandra multiflora	Many-flowered Mat- rush	h	1																
Monocotyledon	Ophioglossaceae		Ophioglossum lusitanicum	Adders Tongue	h					1	1		1						1			
Monocotyledon	Orchidaceae		Caladenia aff. tentaculata	Greencomb Spider Orchid	h									1								
Monocotyledon	Orchidaceae		Caladenia gracilis	Musky Caladenia	h										1							
Monocotyledon	Orchidaceae		Caladenia spp.	Spider Orchid	h													1				
Monocotyledon	Orchidaceae		Calochilus robertsonii	Brown-bearded Orchid, Pale Beard Orchid	h										1							
Monocotyledon	Orchidaceae		Diuris goonooensis	Western Donkey Orchid	h									1								
Monocotyledon	Orchidaceae		Microtis unifolia	Common Onion Orchid	h				1	1	1	1	1	1		1	1	1	1		1	
Monocotyledon	Orchidaceae		Pterostylis bicolor	Bicolor Greenhood	h					1		1	1									
Monocotyledon	Phormiaceae		Dianella longifolia	Blueberry Lily	h									1								
Monocotyledon	Poaceae	*	Aira cupaniana	Silvery Hairgrass	g		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Monocotyledon	Poaceae		Aristida jerichoensis var. jerichoensis	Jericho Wiregrass	g										1							
Monocotyledon	Poaceae		Aristida ramosa	Threeawn Grass	g		1		1			1	1	1			1		1	1	1	

Group	Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
Monocotyledon	Poaceae		Austrostipa densiflora	Foxtail Speargrass	0										_	1						
					g	4	1	1	4	1		1	4	4		1	4	1		1		
Monocotyledon	Poaceae	*	Austrostipa scabra	Speargrass	g	1	1	1	1	I		ı	ı	1		ı	ı	ı		ı		\vdash
Monocotyledon	Poaceae	<u>"</u>	Avena fatua	Wild Oats	g					4		_		1								
Monocotyledon	Poaceae	*	Bothriochloa macra	Red-leg Grass	g				1	1	1	1	1	1				1	1	1	1	1
Monocotyledon	Poaceae		Briza minor	Shivery Grass	g	1	1				1	1	1	1		1	1	1	1	1	1	1
Monocotyledon	Poaceae	*	Bromus molliformis	Soft Brome	g				1		1		1	1					1	1	1	\vdash
Monocotyledon	Poaceae	*	Bromus rubens	Red Brome	g							1										
Monocotyledon	Poaceae		Chloris truncata	Windmill Grass	g					1	1	1									1	
Monocotyledon	Poaceae		Digitaria spp.		g							1										
Monocotyledon	Poaceae		Echinopogon ovatus	Forest Hedgehog Grass	g		1								1							
Monocotyledon	Poaceae		Elymus scaber	Common Wheatgrass	g		1		1		1	1	1	1	1			1				
Monocotyledon	Poaceae		Eragrostis spp.	Lovegrass	g							1	1								1	
Monocotyledon	Poaceae	*	Hordeum leporinum	Barley Grass	g									1								
Monocotyledon	Poaceae		Lachnagrostis filiformis	Blown Grass	g										1		1	1			1	
Monocotyledon	Poaceae	*	Lolium rigidum	Wimmera Ryegrass	g		1	1						1					1			
Monocotyledon	Poaceae		Microlaena stipoides	Weeping Rice-grass	g		1								1							1
Monocotyledon	Poaceae		Panicum spp.		g							1								1		
Monocotyledon	Poaceae		Paspalidium sp.		g	1	1															
Monocotyledon	Poaceae	*	Rostraria cristata	Annual Cats Tail	g			1														
Monocotyledon	Poaceae		Rytidosperma bipartitum	Wallaby Grass	g										1							
Monocotyledon	Poaceae		Rytidosperma caespitosum	Wallaby Grass	g																	1
Monocotyledon	Poaceae		Rytidosperma fulvum	Wallaby Grass	g	1								1		1						1
Monocotyledon	Poaceae		Rytidosperma racemosum	Wallaby Grass	g	1	1	1	1	1			1			1	1	1		1		1
Monocotyledon	Poaceae		Rytidosperma spp.	Wallaby Grass	g							1							1			
Monocotyledon	Poaceae	*	Vulpia muralis	Rats-tail Fescue	g		1	1	1		1	1	1	1			1	1	1		1	1
Monocotyledon	Poaceae		Walwhalleya subxerophila	Cane Panic	q		·												1			

Group	Family	exotic	Scientific Name	Common Name	Habit	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ
			Cheilanthes sieberi subsp.																			
Pteridophyta	Adiantaceae		sieberi	Rock Fern	f		1		1	1	1	1	1	1	1	1	1	1		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

Appendix 3. ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT: Grey Box Woodland Sites Kokoda Offset Area 2020

Soil samples supplied by DnA Environmental on 22nd October 2020 - Lab Job No. J9710

	Site	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood1	GBWood 1	GBWood 2	GBWood 3	Heavy Soil Clay	Medium Soil Clay Loam	Light Soil Loam	Sandy Soil Loamy Sand
Parameter	Method reference	J9710/ 4	J9710/ 5	J9710/ 6	J9710/ 7	J9710/ 8	J9710/1 5	J9710/1 6	J9710/1 2	J9710/1 3	J9710/1 4			delines 6 and 8	
Soluble Calcium (mg/kg)		476	300	306	185	283	434	103	232	182	314	115 0	750	375	175
Soluble Magnesium (mg/kg)	**Inhouse S10 - Morgan 1	66	92	78	72	56	102	47	144	103	204	160	105	60	25
Soluble Potassium (mg/kg)	illilouse o to - Morgan 1	111	67	66	85	103	83	59	125	90	147	113	75	60	50
Soluble Phosphorus (mg/kg)		<1	<1	<1	<1	<1	2.0	<1	1.2	<1	<1	15	12	10	5.0
	**Rayment & Lyons 2011 - 9E2 (Bray 1)	2.5	3.8	2.4	2.0	2.1	3.8	3.2	15	7.8	7.9	45 not e 8	30 ^{not} e 8	24 not e 8	20 ^{not} e 8
Phosphorus (mg/kg P)	**Rayment & Lyons 2011 - 9B2 (Colwell)	8.7	6.1	5.5	6.7	5.1	4.8	4.8	24	7.8	14	80	50	45	35
	**Inhouse S3A (Bray 2)	5.6	5.3	3.4	3.3	2.9	3.6	3.2	19	7.3	9.5	90 ^{not} e 8	60 ^{not} e 8	48 ^{not} e 8	40 ^{not} e 8
Nitrate Nitrogen (mg/kg N)		1.5	1.5	2.2	1.5	1.6	1.2	1.3	2.6	2.1	1.5	15	13	10	10
Ammonium Nitrogen (mg/kg N)	**Inhouse S37 (KCI)	11	10	9.8	9.0	2.9	4.5	7.1	15	10.0	10	20	18	15	12
Sulfur (mg/kg S)		1.6	5.1	2.3	2.5	2.1	2.1	2.6	8.1	7.1	5.6	10.0	8.0	8.0	7.0
рН	Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.54	5.62	6.27	5.81	5.90	5.70	5.04	5.24	5.25	5.48	6.5	6.5	6.3	6.3
Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.020	0.034	0.018	0.012	0.013	0.019	0.023	0.050	0.079	0.044	0.20 0	0.15 0	0.12 0	0.10 0
Estimated Organic Matter (% OM)	**Calculation: Total Carbon x 1.75	3.3	5.0	3.3	2.0	2.3	3.3	4.7	7.0	6.0	7.6	> 5.5	>4 .5	> 3.5	> 2.5
Exchangeable (cmol+/k Calcium g)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	4.3	2.6	2.6	1.3	2.3	3.2	0.83	2.3	1.9	3.2	15.6	10.8	5.0	1.9

		Site	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood1	GBWood 1	GBWood 2	GBWood 3	Heavy Soil Clay	Medium Soil Clay Loam	Light Soil Loam	Sandy Soil Loamy Sand
	(kg/ha)		1,940	1,159	1,148	575	1,039	1,425	373	1,034	852	1,419	700 0	481 6	224 0	840
	(mg/kg)		866	517	513	257	464	636	167	462	380	633	312 5	215 0	100 0	375
	(cmol+/k g)		0.72	0.97	0.81	0.67	0.58	0.98	0.44	1.6	1.2	2.3	2.4	1.7	1.2	0.60
Exchangeable Magnesium	(kg/ha)		196	264	220	182	157	268	121	429	329	616	650	448	325	168
	(mg/kg)		87	118	98	81	70	119	54	191	147	275	290	200	145	75
	(cmol ₊ /k g)		0.40	0.25	0.21	0.26	0.34	0.30	0.26	0.44	0.33	0.54	0.60	0.50	0.40	0.30
Exchangeable Potassium	(kg/ha)		348	215	185	230	301	261	224	386	285	475	526	426	336	224
	(mg/kg)		155	96	83	103	134	117	100	172	127	212	235	190	150	100
	(cmol+/k g)		<0.065	0.19	0.15	<0.065	<0.065	<0.065	0.09	0.08	0.39	0.08	0.3	0.26	0.22	0.11
Exchangeable Sodium	(kg/ha)		<33	99	75	<33	<33	<33	48	41	200	43	155	134	113	57
	(mg/kg)		<15	44	33	<15	<15	<15	21	18	89	19	69	60	51	25
	(cmol ₊ /k g)		0.01	0.27	0.02	0.15	0.04	0.06	0.84	0.47	0.60	0.29	0.6	0.5	0.4	0.2
Exchangeable Aluminium	(kg/ha)	**Inhouse S37 (KCI)	2.3	55	4.7	29	8.5	12	170	95	121	59	121	101	73	30
	(mg/kg)		1.0	25	2.1	13	3.8	5.4	76	43	54	26	54	45	32	14
	(cmol ₊ /k g)		<0.01	0.30	0.07	0.15	0.11	0.11	0.63	0.40	0.55	0.26	0.6	0.5	0.4	0.2
Exchangeable Hydrogen	(kg/ha)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<1	6.8	1.6	3.4	2.4	2.5	14	8.9	12	5.8	13	11	8	3
	(mg/kg)		<1	3.0	<1	1.5	1.1	1.1	6.3	4.0	5.5	2.6	6	5	4	2
Effective Cation Exchan Capacity (ECEC) (cmol+/kg)	ge	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol₊/kg)	5.5	4.6	3.8	2.6	3.4	4.7	3.1	5.3	5.0	6.6	20.1	14.3	7.8	3.3
Calcium (%)			79	57	67	50	68	68	27	44	38	48	77.6	75.7	65.6	57.4

	Site	GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood1	GBWood 1	GBWood 2	GBWood 3	Heavy Soil Clay	Medium Soil Clay Loam	Light Soil Loam	Sandy Soil Loamy Sand
Magnesium (%)		13	21	21	26	17	21	14	30	24	34	11.9	11.9	15.7	18.1
Potassium (%)		7.3	5.4	5.5	10	10	6.4	8.3	8.4	6.5	8.2	3.0	3.5	5.2	9.1
Sodium - ESP (%)	**Base Saturation Calculations - Cation cmol ₊ /kg / ECEC x 100	0.17	4.2	3.8	1.9	0.42	0.62	3.0	1.5	7.8	1.3	1.5	1.8	2.9	3.3
Aluminium (%)		0.21	6.0	0.61	5.7	1.2	1.3	27	9.0	12	4.4	6.0	7.1	10.5	10.1
Hydrogen (%)		0.00	6.6	1.8	6.0	3.2	2.4	20	7.5	11	3.9	0.0	7.1	10.5	12.1
Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol./kg)	6.0	2.7	3.2	1.9	4.0	3.2	1.9	1.5	1.6	1.4	6.5	6.4	4.2	3.2
Zinc (mg/kg)	, , ,	<0.5	0.60	<0.5	<0.5	<0.5	<0.5	<0.5	0.73	0.52	0.76	6.0	5.0	4.0	3.0
Manganese (mg/kg)	Rayment & Lyons 2011 - 12A1	10	11	9.1	5.4	22	11	15	10	22	15	25	22	18	15
Iron (mg/kg)	(DTPA)	47	250	172	134	105	138	240	264	469	358	25	22	18	15
Copper (mg/kg)		0.24	0.39	0.33	0.24	0.35	0.23	0.15	0.35	0.34	0.42	2.4	2.0	1.6	1.2
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot CaCl ₂)	0.17	0.21	0.21	0.19	0.23	0.29	0.25	0.41	0.25	0.59	2.0	1.7	1.4	1.0
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	27	22	20	20	24	20	17	33	33	33	50	45	40	35
Total Carbon (%)	Inhouse S4a (LECO Trumac	1.9	2.9	1.9	1.1	1.3	1.9	2.7	4.0	3.4	4.4	> 3.1	> 2.6	> 2.0	> 1.4
Total Nitrogen (%)	Analyser)	0.12	0.13	0.11	0.07	0.09	0.08	0.09	0.19	0.13	0.20	> 0.30	> 0.25	> 0.20	> 0.15
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	16	23	17	16	15	24	32	21	26	22	10– 12	10– 12	10– 12	10– 12
Basic Texture		Loam		:											
Basic Colour	-**Inhouse S65	Brownis h													
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	13	22	11	7.9	8.6	12	15	32	50	28				

Appendix 4. ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT: Dwyer's Red Gum Sites Kokoda Offset Area 2020

Soil samples supplied by DnA Environmental on 22nd October 2020 - Lab Job No. J9710

		Site	DReveg 1	DReveg 2	DReveg 3	DWoodLQ	DWood 1	DWood 2	DWood 3	Heavy Soil Clay	Medium Soil Clay Loam	Light Soil Loam	Sandy Soil Loamy Sand
Parameter		Method reference	J9710/1	J9710/2	J9710/3	J9710/17	J9710/9	J9710/10	J9710/11	Indicati	ive guideling an	es - refer to d 8	Notes 6
Soluble Calcium (mg/kg)			156	168	200	56	194	63	85	1150	750	375	175
Soluble Magnesium (mg/kg)		**Inhausa C40 Massas 4	55	38	59	71	46	52	42	160	105	60	25
Soluble Potassium (mg/kg)		**Inhouse S10 - Morgan 1	57	57	42	63	56	68	63	113	75	60	50
Soluble Phosphorus (mg/kg)			<1	<1	<1	<1	<1	<1	<1	15	12	10	5.0
		**Rayment & Lyons 2011 - 9E2 (Bray 1)	2.3	5.9	2.1	2.7	2.1	5.1	3.0	45 ^{note 8}	30 ^{note 8}	24 ^{note 8}	20 ^{note 8}
Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9B2 (Colwell)	4.2	7.2	3.4	7.2	4.0	5.0	5.3	80	50	45	35
		**Inhouse S3A (Bray 2)	3.6	7.3	3.3	7.0	3.3	3.5	2.4	90note 8	60 ^{note 8}	48 note 8	40 note 8
Nitrate Nitrogen (mg/kg N)			1.9	1.5	1.5	1.2	1.5	1.6	1.5	15	13	10	10
Ammonium Nitrogen (mg/kg N)		**Inhouse S37 (KCI)	9.3	8.5	8.1	5.1	11	11	9.2	20	18	15	12
Sulfur (mg/kg S)			2.7	4.1	2.3	2.3	3.9	2.7	1.4	10.0	8.0	8.0	7.0
рН		Rayment & Lyons 2011 - 4A1 (1:5 Water)	5.64	5.34	5.82	5.25	5.24	5.29	5.65	6.5	6.5	6.3	6.3
Electrical Conductivity (dS/m)	ty (dS/m) Rayment & Lyons 2011 - 3A1 (1:5		0.014	0.012	0.012	0.024	0.015	0.016	0.009	0.200	0.150	0.120	0.100
Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	3.5	3.8	2.7	5.5	5.5	4.1	2.2	> 5.5	>4.5	> 3.5	> 2.5
Fushanusahla Calainus	(cmol ₊ /kg)	Rayment & Lyons 2011 - 15D3		1.3	1.6	0.50	1.7	0.39	0.74	15.6	10.8	5.0	1.9
Exchangeable Calcium	(kg/ha)	(Ammonium Acetate)	529	581	700	226	774	175	330	7000	4816	2240	840

		Site	DReveg 1	DReveg 2	DReveg 3	DWoodLQ	DWood 1	DWood 2	DWood 3	Heavy Soil Clay	Medium Soil Clay Loam	Light Soil Loam	Sandy Soil Loamy Sand
	(mg/kg)		236	259	312	101	345	78	147	3125	2150	1000	375
	(cmol ₊ /kg)		0.56	0.37	0.58	0.72	0.49	0.53	0.45	2.4	1.7	1.2	0.60
Exchangeable Magnesium	(kg/ha)		152	100	158	195	133	145	123	650	448	325	168
	(mg/kg)		68	45	70	87	59	65	55	290	200	145	75
	(cmol ₊ /kg)		0.18	0.20	0.13	0.31	0.21	0.24	0.19	0.60	0.50	0.40	0.30
Exchangeable Potassium	(kg/ha)		161	172	<112	269	180	209	166	526	426	336	224
	(mg/kg)		72	77	<50	120	80	93	74	235	190	150	100
	(cmol ₊ /kg)		0.16	<0.065	0.12	0.17	<0.065	0.09	0.09	0.3	0.26	0.22	0.11
Exchangeable Sodium	(kg/ha)		80	<33	62	88	<33	47	48	155	134	113	57
	(mg/kg)		36	<15	28	39	<15	21	21	69	60	51	25
	(cmol ₊ /kg)		0.60	0.81	0.20	0.86	1.00	0.94	0.40	0.6	0.5	0.4	0.2
Exchangeable Aluminium	(kg/ha)	**Inhouse S37 (KCI)	120	163	41	173	201	189	80	121	101	73	30
	(mg/kg)		54	73	18	77	90	84	36	54	45	32	14
	(cmol ₊ /kg)		0.47	0.49	0.18	0.76	0.50	0.91	0.36	0.6	0.5	0.4	0.2
Exchangeable Hydrogen	(kg/ha)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	10	11	4.0	17	11	20	8.1	13	11	8	3
	(mg/kg)	, , ,	4.7	4.9	1.8	7.6	5.0	9.1	3.6	6	5	4	2
Effective Cation Exchange Capa (ECEC) (cmol-/kg)	city	**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol-/kg)	3.1	3.2	2.8	3.3	3.9	3.1	2.2	20.1	14.3	7.8	3.3
Calcium (%)			38	40	56	15	44	13	33	77.6	75.7	65.6	57.4
Magnesium (%)		**Base Saturation Calculations - Cation cmol√kg / ECEC x 100	18	11	21	22	12	17	20	11.9	11.9	15.7	18.1
Potassium (%)			5.9	6.1	4.6	9.3	5.2	7.7	8.5	3.0	3.5	5.2	9.1

	Site	DReveg 1	DReveg 2	DReveg 3	DWoodLQ	DWood 1	DWood 2	DWood 3	Heavy Soil Clay	Medium Soil Clay Loam	Light Soil Loam	Sandy Soil Loamy Sand
Sodium - ESP (%)		4.9	1.9	4.3	5.2	0.73	3.0	4.2	1.5	1.8	2.9	3.3
Aluminium (%)		19	25	7.4	26	25	30	18	6.0	7.1	10.5	12.1
Hydrogen (%)		15	15	6.5	23	13	29	16	0.0	7.1	10.5	12.1
Calcium/Magnesium Ratio	**Calculation: Calcium / Magnesium (cmol-/kg)	2.1	3.5	2.7	0.71	3.5	0.74	1.6	6.5	6.4	4.2	3.2
Zinc (mg/kg)		<0.5	0.61	0.54	0.59	0.55	<0.5	<0.5	6.0	5.0	4.0	3.0
Manganese (mg/kg)	Daymont 9 Lyran 2004 (1204 (DTDA)	4.8	2.9	5.3	6.0	18	5.0	5.4	25	22	18	15
Iron (mg/kg)	Rayment & Lyons 2011 - 12A1 (DTPA)	362	224	196	430	218	305	242	25	22	18	15
Copper (mg/kg)		0.31	0.20	0.31	0.18	0.26	0.26	0.29	2.4	2.0	1.6	1.2
Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot CaCl ₂)	0.20	0.10	0.16	0.24	0.30	0.19	0.12	2.0	1.7	1.4	1.0
Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	25	21	19	24	22	21	19	50	45	40	35
Total Carbon (%)	Inhama CAs // ECO Trumos Anglusa)	2.0	2.2	1.6	3.1	3.2	2.4	1.3	> 3.1	> 2.6	> 2.0	> 1.4
Total Nitrogen (%)	Inhouse S4a (LECO Trumac Analyser)	0.09	0.09	0.09	0.15	0.13	0.07	0.05	> 0.30	> 0.25	> 0.20	> 0.15
Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	22	24	18	21	24	34	27	10–12	10–12	10–12	10–12
Basic Texture	**Inhouse S65	Loam	Loam	Loam	Loam	Loam	Loam	Loam				
Basic Colour	innouse 505	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish				
Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	8.9	7.6	7.7	16	9.3	10	5.9				

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.
- 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,
- 11. Conversions to $kg/ha = mg/kg \times 2.24$
- 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).
- 17. This report was issued on 30/10/2020.

Quality Checked: Kris Saville Agricultural Co-Ordinator

Appendix 5. 2020 Annexure D: Completed field monitoring forms and photo-points

Monitoring Data Sheet									
Monitoring Point Number	GBReveg1		Date	13/10/20					
Vegetation Community		=		e shrubby woodland on stony footslopes in the and Riverina Bioregion					
1. Site Photo(s)Taken	Four photo po 55 635978E, 6		om the cent	re of monitoring site facing N,S, E & W:					
2. Floristic BioMetric attributes	;								
Native cover									
Overstorey:				0					
Midstorey:				0.01					
Groundcover(grass):				30					
Groundcover (shrub):				0					
Groundcover (other):				2.25					
Native species richness:				24					
Proportion of canopy species re	generating		0						
Exotic cover				67.75					
Number of trees with hollows				0					
Total length of fallen logs				0					
3. Opportunistic observations	GPS coordinates	Photo number	Observation	ons					
Natural regeneration of disturbed areas			One <i>Calli</i>	tris endlicheri					
Threatened species sightings			Superb Parrot						
Fire event/fuel			Low - mo						
Weeds			Annual ex	xotics are dominant					
Pest animals			Limited						
Visitor impact/vehicles			Nil						
Rubbish dumping	bbish dumping Nil								



Monitoring Data Sheet											
Monitoring Point Number	GBReveg2		Date	13/10/20							
Vegetation Community		•	• •	e shrubby woodland on stony footslopes in the and Riverina Bioregion							
1. Site Photo(s)Taken	Four photo po 55 636002E, 63		om the cent	re of monitoring site facing N,S, E & W:							
2. Floristic BioMetric attributes	•										
Native cover											
Overstorey:			0								
Midstorey:			0								
Groundcover(grass):			45								
Groundcover (shrub):				0							
Groundcover (other):				20							
Native species richness:				27							
Proportion of canopy species re	generating		0								
Exotic cover				15							
Number of trees with hollows				0							
Total length of fallen logs				0							
3. Opportunistic observations	GPS coordinates	Photo number	Observati	ons							
Natural regeneration of disturbed areas	latural regeneration of			Nil							
Threatened species sightings			Babblers heard								
Fire event/fuel			Low								
Weeds			Annual e	xotics							
Pest animals			Pigs								
Visitor impact/vehicles			Nil								
Rubbish dumping			Nil								

Photo Points GBReveg2 55 636002E, 6317748N

North







Monitoring Data Sheet										
Monitoring Point Number	GBReveg3		Date	15/10/20						
Vegetation Community		-		e shrubby woodland on stony footslopes in the and Riverina Bioregion						
1. Site Photo(s)Taken	Four photo po 55 636570E, 6		om the cent	re of monitoring site facing N,S, E & W:						
2. Floristic BioMetric attributes	;									
Native cover										
Overstorey:				0						
Midstorey:			0.1							
Groundcover(grass):				45						
roundcover (shrub):				0						
Groundcover (other):				35						
Native species richness:				25						
Proportion of canopy species re	generating		1							
Exotic cover				20						
Number of trees with hollows				0						
Total length of fallen logs				0						
3. Opportunistic observations	GPS coordinates	Photo number	Observati							
Natural regeneration of disturbed areas			Tubestoc	k planted in October 2020						
hreatened species sightings			Superb Parrots heard							
Fire event/fuel			Moderate	e						
Weeds			Exotic An	nuals						
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	14/10/20							
Vegetation Community		-		I e shrubby woodland on stony footslopes in the and Riverina Bioregion							
1. Site Photo(s)Taken	Four photo po 55 636926E, 6		om the cent	re of monitoring site facing N,S, E & W:							
2. Floristic BioMetric attributes	;										
Native cover											
Overstorey:				0							
Midstorey:			0								
Groundcover(grass):				10							
Groundcover (shrub):				0							
Groundcover (other):				48							
Native species richness:				30							
Proportion of canopy species re	generating		0								
Exotic cover				40							
Number of trees with hollows				0							
Total length of fallen logs				0							
3. Opportunistic observations	GPS coordinates	Photo number	Observati								
Natural regeneration of disturbed areas	latural regeneration of			A. <i>spectabilis</i> nearby							
hreatened species sightings			Nil								
Fire event/fuel			Moderate								
Weeds			Exotic An	nuals							
Pest animals			Limited								
Visitor impact/vehicles			Nil								
Rubbish dumping			Nil								



Monitoring Data Sheet										
	CDD over 5		Date	14/10/20						
Monitoring Point Number	GBReveg5									
Vegetation Community		-		e shrubby woodland on stony footslopes in the and Riverina Bioregion						
1. Site Photo(s)Taken	Four photo po 55 637055E, 6		om the cent	re of monitoring site facing N,S, E & W:						
2. Floristic BioMetric attributes	3									
Native cover										
Overstorey:			0							
Midstorey:			0							
Groundcover(grass):				20						
roundcover (shrub):				0						
Groundcover (other):				15						
Native species richness:				27						
Proportion of canopy species re	generating		0							
Exotic cover				55						
Number of trees with hollows				1						
Total length of fallen logs				0						
3. Opportunistic observations	GPS coordinates	Photo number	Observati	ons						
Natural regeneration of disturbed areas			Scattered	d Eucalyptus dwyeri around mature trees						
Threatened species sightings			Nil							
Fire event/fuel			Moderate	е						
Weeds			Exotic An	nuals						
Pest animals			Limited							
Visitor impact/vehicles			Nil							
Rubbish dumping			Nil							

Photo Points GBReveg5 55 637055E, 6318301N

North

West

South

East

Monitoring Data Sheet							
Monitoring Point Number	GBWood1		Date	13/10/20			
Vegetation Community				e shrubby woodland on stony footslopes in the 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:				37.25			
Midstorey:				0			
Groundcover(grass):				0.9			
Groundcover (shrub):			0.05				
Groundcover (other):			4.8				
Native species richness:			21				
Proportion of canopy species re	generating		0.5				
Exotic cover			0.71				
Number of trees with hollows			13				
Total length of fallen logs			101				
3. Opportunistic observations	GPS coordinates	Photo number	Observati	ons			
Natural regeneration of disturbed areas			Limited <i>E. microcarpa</i> regeneration				
Threatened species sightings			Babblers, Superb Parrots				
Fire event/fuel			Low				
Weeds			Limited				
Pest animals			Kangaroo camps				
Visitor impact/vehicles			Nil				
Rubbish dumping			Nil				

Photo Points: GBWood1 55 636101E, 6318236N



Monitoring Data Sheet							
Monitoring Point Number	GBWood2		Date	13/10/20			
Vegetation Community		-		e shrubby woodland on stony footslopes in the and Riverina Bioregion			
1. Site Photo(s)Taken	Four photo po 55 635682E, 6		om the cent	re of monitoring site facing N,S, E & W:			
2. Floristic BioMetric attributes							
Native cover							
Overstorey:				57			
Midstorey:				0			
Groundcover(grass):			7.75				
Groundcover (shrub):	Groundcover (shrub):			2.65			
Groundcover (other):			22.5				
Native species richness:	Native species richness:			46			
Proportion of canopy species re	generating			0			
Exotic cover				0.8			
Number of trees with hollows			0				
Total length of fallen logs			48.5				
3. Opportunistic observations	GPS coordinates	Photo number	Observations				
Natural regeneration of disturbed areas			Scattered	d Acacia regeneration, limited Eucalypt regen			
Threatened species sightings			Babblers	heard			
Fire event/fuel			Low				
Weeds			Nil				
Pest animals			Pigs				
Visitor impact/vehicles			Nil				
Rubbish dumping			Nil				

Photo Points: GBWood2 55 635682E, 6317708N



Monitoring Data Sheet						
Monitoring Point Number	GBWood3		Date	13/10/20		
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		ints taken fr		re of monitoring site facing N,S, E & W:		
2. Floristic BioMetric attributes	•					
Native cover						
Overstorey:				52		
Midstorey:				0		
Groundcover(grass):			2.5			
Groundcover (shrub):			0.06			
Groundcover (other):			59			
Native species richness:			28			
Proportion of canopy species re	generating		0.5			
Exotic cover			1.4			
Number of trees with hollows			2			
Total length of fallen logs			168.5			
3. Opportunistic observations	GPS coordinates	Photo number	Observati	ons		
Natural regeneration of disturbed areas			Limited Eucalyptus microcarpa			
Threatened species sightings			Grey Crowned Babbler heard			
Fire event/fuel			Low			
Weeds			Nil			
Pest animals			Limited – new boundary fence installed in 2020			
Visitor impact/vehicles			Nil			
Rubbish dumping			Nil			



Monitoring Data Sheet					
Monitoring Point Number	DReveg1		Date	14/10/2020	
Vegetation Community				Pine woodland on hillslopes and ridges of the uth Western Slopes Bioregion	
1. Site Photo(s)Taken	Four photo po 55 636561E, 6		om the cent	re of monitoring site facing N,S, E & W:	
2. Floristic BioMetric attributes	5				
Native cover					
Overstorey:				0	
Midstorey:				9.25	
Groundcover(grass):			37.5		
Groundcover (shrub):			0.25		
Groundcover (other):			27.25		
Native species richness:			25		
Proportion of canopy species re	egenerating		0.5		
Exotic cover			30		
Number of trees with hollows			0		
Total length of fallen logs			0		
3. Opportunistic observations	GPS coordinates	Photo number	Observati	ions	
Natural regeneration of disturbed areas			Scattered Eucalyptus dwyeri, Limited A. decora		
Threatened species sightings			Babblers	, Superb Parrots	
Fire event/fuel			Moderate		
Weeds			Exotic Annuals – Hypochaeris glabra		
Pest animals			Limited		
Visitor impact/vehicles			Deep rip	ping for planting	
Rubbish dumping			Nil		



Monitoring Data Sheet						
Monitoring Point Number	DReveg2		Date	14/10/2020		
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of th Central Lachlan region of the NSW South Western Slopes Bioregion					
1. Site Photo(s)Taken	Four photo po 55 636623E, 63		om the cent	re of monitoring site facing N,S, E & W:		
2. Floristic BioMetric attributes						
Native cover						
Overstorey:				0		
Midstorey:				0		
Groundcover(grass):			7			
Groundcover (shrub):			0.2			
Groundcover (other):			26.25			
Native species richness:			25			
Proportion of canopy species re	generating		0			
Exotic cover			2			
Number of trees with hollows			0			
Total length of fallen logs			4			
3. Opportunistic observations	GPS coordinates	Photo number	Observati	ons		
Natural regeneration of disturbed areas			Acacia decora, Eucalyptus dwyeri, Callitris			
Threatened species sightings			Superb Parrots			
Fire event/fuel			Low			
Weeds			Annual exotics			
Pest animals			Limited			
Visitor impact/vehicles			Rip lines	for planting		
Rubbish dumping			Nil			

Photo Points DReveg2 55 636623E, 6318461N

North

West

South

East

Manitoring Data Shoot					
Monitoring Data Sheet					
Monitoring Point Number	DReveg3		Date	14/10/2020	
Vegetation Community				Pine woodland on hillslopes and ridges of the ath Western Slopes Bioregion	
1. Site Photo(s)Taken		ints taken fr		tre of monitoring site facing N,S, E & W:	
2. Floristic BioMetric attributes					
Native cover					
Overstorey:				0	
Midstorey:				0.01	
Groundcover(grass):			25		
Groundcover (shrub):			0		
Groundcover (other):			60		
Native species richness:			25		
Proportion of canopy species re	generating		0		
Exotic cover			15		
Number of trees with hollows			0		
Total length of fallen logs			0		
3. Opportunistic observations	GPS coordinates	Photo number	Observati	ions	
Natural regeneration of disturbed areas			E. dwyeri saplings on rocky knoll		
Threatened species sightings			Nil		
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

Manitoring Data Chart						
Monitoring Data Sheet						
Monitoring Point Number	DWood1		Date	15/10/2020		
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:				23		
Midstorey:				1		
Groundcover(grass):			4.5			
Groundcover (shrub):			0.1			
Groundcover (other):			57.5			
Native species richness:			30			
Proportion of canopy species re	generating		0.66			
Exotic cover			0.4			
Number of trees with hollows			4			
Total length of fallen logs			316			
3. Opportunistic observations	GPS coordinates	Photo number	Observati	ons		
Natural regeneration of disturbed areas			Scattere	d Callitris endlicheri, E. dealbata seedling		
Threatened species sightings			Nil			
Fire event/fuel			Moderate			
Weeds			Limited – Hypochaeris glabra			
Pest animals			Limited			
Visitor impact/vehicles			Nil			
Rubbish dumping			Nil			



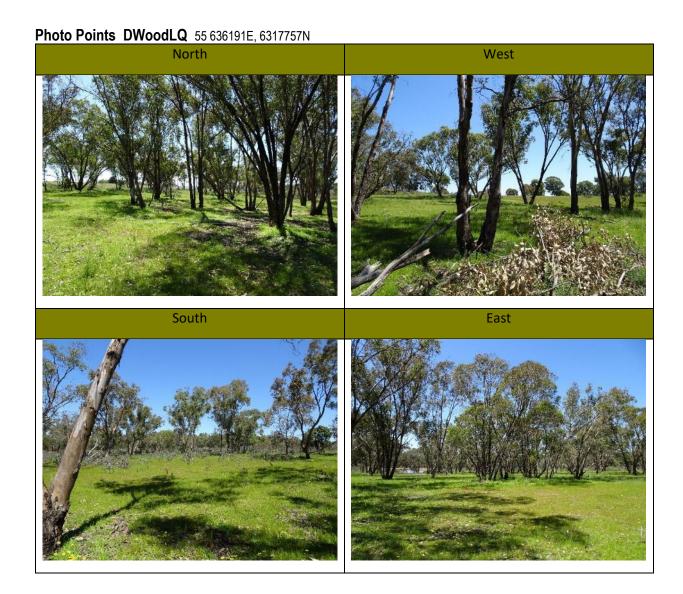
Manitoring Date Chart						
Monitoring Data Sheet						
Monitoring Point Number	DWood2		Date	15/10/2020		
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion					
1. Site Photo(s)Taken	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:				25		
Midstorey:				0		
Groundcover(grass):			23.75			
Groundcover (shrub):			2.7			
Groundcover (other):			40			
Native species richness:			38			
Proportion of canopy species re	generating		0.5			
Exotic cover			0.75			
Number of trees with hollows			3			
Total length of fallen logs			230			
3. Opportunistic observations	GPS coordinates	Photo number	Observati	ons		
Natural regeneration of disturbed areas			Callitris endlicheri and limited E. dealbata			
Threatened species sightings			Nil			
Fire event/fuel			Low – moderate – lots of fallen timber			
Weeds			Limited – Hypochaeris glabra, annual grasses			
Pest animals			Limited			
Visitor impact/vehicles			Nil			
Rubbish dumping			Nil			



Monitoring Data Sheet						
Monitoring Point Number	DWood3		Date	15/10/20		
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 po 55 6361176E,		om the cent	re of monitoring site facing N,S, E & W:		
2. Floristic BioMetric attributes	5					
Native cover						
Overstorey:				30		
Midstorey:				0.2		
Groundcover(grass):			23.75			
Groundcover (shrub):			15.5			
Groundcover (other):			26.8			
Native species richness:			42			
Proportion of canopy species re	generating		0.6			
Exotic cover			2.9			
Number of trees with hollows			0			
Total length of fallen logs			65			
3. Opportunistic observations	GPS coordinates	Photo number	Observati	ons		
Natural regeneration of disturbed areas			Abundant Callitris endlicheri, scattered E. dealb			
Threatened species sightings			Spider Orchid (<i>Caladenia spp.</i>)			
Fire event/fuel			Low-moderate			
Weeds			Hypochaeris glabra, annual grasses			
Pest animals			Limited			
Visitor impact/vehicles			Nil			
Rubbish dumping			Nil			



Monitoring Data Sheet						
Monitoring Point Number	DWoodLQ		Date	13/10/20		
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 po 55 636191E, 6		om the cent	re of monitoring site facing N,S, E & W:		
2. Floristic BioMetric attributes	;					
Native cover						
Overstorey:				32		
Midstorey:				0		
Groundcover(grass):			30			
Groundcover (shrub):			0			
Groundcover (other):			35			
Native species richness:			36			
Proportion of canopy species re	generating		0.5			
Exotic cover			25			
Number of trees with hollows			0			
Total length of fallen logs			17.5			
3. Opportunistic observations	GPS coordinates	Photo number	Observati	ons		
Natural regeneration of disturbed areas			Eucalyptus dwyeri (extensive in wider area)			
Threatened species sightings			Nil			
Fire event/fuel			Low			
Weeds			Nil			
Pest animals			Limited			
Visitor impact/vehicles			Nil			
Rubbish dumping			Nil			



Monitoring Data Sheet						
Monitoring Point Number	IronWood1		Date	15/10/20		
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of Central Lachlan region of the NSW South Western Slopes Bioregion					
1. Site Photo(s)Taken	Four photo po 55 635146E, 6		om the cent	re of monitoring site facing N,S, E & W:		
2. Floristic BioMetric attribute	s					
Native cover						
Overstorey:				37		
Midstorey:				2.45		
Groundcover(grass):			40			
Groundcover (shrub):			3.4			
Groundcover (other):			32.5			
Native species richness:			43			
Proportion of canopy species re	egenerating		0.3			
Exotic cover			00.51			
Number of trees with hollows			0			
Total length of fallen logs			100			
3. Opportunistic observations	GPS coordinates	Photo number	Observati	ons		
Natural regeneration of disturbed areas			Scattered Callitris endlicheri, limited E. dealbata			
Threatened species sightings			Nil			
Fire event/fuel			Moderate			
Weeds				Annual exotics		
Pest animals			Limited			
Visitor impact/vehicles			Nil			
Rubbish dumping			Nil			



Monitoring Data Sheet						
Monitoring Point Number	WBWood1		Date	14/10/20		
Vegetation Community	LA218 White Box - White Cypress Pine - Western Grey Box shrub/grass/forb woodlan in the NSW South Western Slopes Bioregion					
1. Site Photo(s)Taken	Four photo po 55 636833E, 6		om the cent	re of monitoring site facing N,S, E & W:		
2. Floristic BioMetric attributes	•					
Native cover						
Overstorey:				33		
Midstorey:				0		
Groundcover(grass):			8			
Groundcover (shrub):			1.4			
Groundcover (other):			9.75			
Native species richness:			48			
Proportion of canopy species re	generating		0.5			
Exotic cover			62.5			
Number of trees with hollows			2			
Total length of fallen logs			68			
3. Opportunistic observations	GPS coordinates	Photo number	Observation	ons		
Natural regeneration of disturbed areas			Limited Eucalypt and shrub regeneration			
Threatened species sightings			Superb Parrots, Babblers			
Fire event/fuel			Moderate			
Weeds			Abundant exotic annuals			
Pest animals			Limited			
Visitor impact/vehicles			Nil			
Rubbish dumping			Nil			

