2019 Kokoda Biodiversity Offset Area Ecological Monitoring Report

for

Northparkes Mines

December 2019

DnA Environmental

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Signed: 

Dr Donna Johnston
Restoration Ecologist
PhD, BAppSc (Hons) MEIANZ

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Reviewed by: Chris Higgins – Senior Environmental Advisor NPM
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DnA Environmental
417 Mandurama Rd
Mandurama
NSW 2792

Ph/Fax: (02) 63 675 251
Mobile: 0408 221 922
donna@dnaenviro.com.au

ABN 19 607 392 634

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Cover photo

Eucalyptus sideroxylon (Mugga Ironbark) was extensively flowering this year.

Executive summary

The 2019 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 (DnA Environmental 2010 – 2014a; 2018a) and the Estcourt Offset Area ecological monitoring program (DnA Environmental 2010b – 2014; 2018b). The monitoring programs are compliant and consistent with a range of approval conditions, specifically the Biodiversity Offset Strategy and associated Biodiversity Offset Management Plan (BOMP) and ESG3 MOP guidelines. The monitoring methodology includes a combination of Landscape Function Analyses, accredited soil analyses and various measurements of ecosystem diversity and habitat values adapted from the Biometric Manual 3.1.

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 landuse establishment; and
- Ecosystem and landuse sustainability.

The annual vegetation monitoring has been undertaken during spring and this year was undertaken from the 8 - 10th October 2019.

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 this postponed in 2018 due to the drought. Revegetation is being planned for spring 2020, providing the seasonal conditions are suitable for tubestock planting.

Subsequently, additional monitoring of the existing monitoring sites are required as part of the Conservation Agreement with OEH including additional photo-point monitoring, and the completion of the OEH 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 with a total annual rainfall of 833 mm being recorded. In 2017, very low rainfall activity occurred except in 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 only a total of 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.

The Grey Box and Dwyer's Red Gum (DRG) woodland reference sites were typically 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. 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. The Grey Box and DRG derived grassland revegetation sites presently existed as degraded grassland and were structurally different to the woodland reference sites, they typically had good ground cover comprised of a combination and perennial plants and cryptogams and in favourable seasons annual plants are abundant. Over the last two years there has been limited live ground cover and often the integrity of the litter and cryptogam layers had declined. Despite this all monitoring sites continued to have high functional patch areas, however there was a marginal loss of functional patch area in DReveg1, DReveg2 and DWood3 this year.

There continued to be an absence of trees and mature shrubs (>5cm dbh) in the derived grassland areas, however some regenerating eucalypt seedlings were recorded in low densities in some sites. There was also natural regeneration of a variety of species scattered throughout the native pasture areas, including small pockets of *Acacia spectabilis* (Mudgee Wattle). 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. For example, in the DRG reference sites (DWood3) up to 44,050 *Callitris endlicheri* seedlings per hectare were recorded.

The prolonged dry conditions typically resulted in the further decline in species richness in most monitoring sites, however there was an increased diversity in some Grey Box grassland revegetation sites as relatively recent rainfall had stimulated a flush of plant growth. There was however a higher diversity of exotic species in these sites. In the derived grasslands, most sites were dominated by native plant cover with the exception of GBReveg1 and GBReveg3, and all grassland sites were weedier than the reference sites.

The results of the soil analyses indicate that the soils associated with the Grey Box and Dwyer's Red Gum woodland and derived native grasslands are naturally moderately 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 ESP below the sodic threshold, the soils may have a tendency to be sodic. 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 indicates the performance of the Kokoda monitoring sites against a selection of Primary Completion Performance Indicators obtained from their relevant reference sites in 2019. 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. The grey shaded boxes highlight the lack of shrubs in the Grey Box woodland derived grassland areas, despite having met this criteria according to the woodland reference sites as no shrubs were present in one of the reference sites.

Performance of the Grey Box, White Box, Ironbark and Red Gum woodland monitoring sites against primary completion performance indicators in 2019.

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Unit of measurement (*desirable)	DReveg1	DReveg2	DReveg3	DWoodLQ	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
Performance indicators are quantified by the range of values obtained from replicated reference sites					2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019
Phase 2: Landform establishment and stability	Landform slope, gradient	Landform suitable for final landuse and generally compatible with surrounding topography	Slope	< Degrees (18°)	4	3	4	3	5	4	3	4	3	3	4
	Active erosion	Areas of active erosion are limited	No. Rills/Gullies	No.	0	0	0	0	0	0	0	0	0	0	0
Phase 3: Growth medium development	Soil chemical, physical properties and amelioration	Soil properties are suitable for the establishment and maintenance of selected vegetation species	pH	pH (*5.6 - 7.3)	5.4	5.2	5.4	5.0	6.7	5.3	6.0	5.7	6.1	6.2	4.8
			Organic Matter	% (*>4.5)	3.5	4.3	2.9	4.8	3.4	5.5	3.1	2.8	2.5	3.1	4.8
			Phosphorous	ppm (*50)	9.2	10.8	6.9	8.5	7.9	9.8	9.2	8.2	7.2	7.9	5.9
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	%	73.2	66.5	64.5	65.0	73.6	61.0	73.1	67.5	73.9	62.7	62.5
			LFA Landscape organisation	%	89	86	100	100	100	100	100	100	100	100	100
	Vegetation diversity	Vegetation contains a diversity of species comparable to that of the local remnant vegetation	Diversity of shrubs and juvenile trees	species/area	2	3	1	1	1	0	0	0	0	5	6
				% population	100	100	100	100	100	0	0	0	0	100	100

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Unit of measurement (*desirable)	DReveg1	DReveg2	DReveg3	DWoodLQ	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
			Exotic species richness	<No./area	6	1	12	0	14	4	15	10	13	1	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	11	3	1	8	1	0	0	0	0	8	129
	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	0	0	0	4	6
			Shrubs	No./area	1	2	0	0	0	0	0	0	0	3	2
			Herbs	No./area	10	2	20	3	15	16	17	15	21	11	4
Phase 5: Ecosystem & Landuse Sustainability	Landscape Function Analysis (LFA): Landform function and ecological performance	Landform is ecologically functional and performing as it was designed to do	LFA Infiltration	%	43	37.8	41.2	55.9	45.5	33.6	47	42.6	45.2	52.7	48.4
			LFA Nutrient recycling	%	39.7	37.8	35.8	54.9	44.1	31.1	42.1	37.6	43.9	53.2	44.3
	Protective ground cover	Ground layer contains protective ground cover and habitat structure comparable with the local remnant vegetation	Perennial plant cover (< 0.5m)	%	10	5	16.5	1.5	26.5	11	11	17	16	3	0
			Total Ground Cover	%	76	72	87.5	87.5	96	72.5	89.5	83	96.5	99	80.5
	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	%	96	97	66	100	47.8	73	37.3	59.6	58.7	96.7	100

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Unit of measurement (*desirable)	DReveg1	DReveg2	DReveg3	DWoodLQ	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
	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	2	1	8	1	0	0	0	0	6	94
			shrubs and juvenile trees 1.5 - 2m in height	No./area	1	0	0	0	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	% cover	2	0	0	0	0	0	0	0	0	0	0
			Foliage cover >6m	% cover	0	0	0	40	0	0	0	0	0	48	45
	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	1	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	0	2.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Unit of measurement (*desirable)	DReveg1	DReveg2	DReveg3	DWoodLQ	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
			Flowers/fruit: Trees	% population	**0**	**0**	**0**	**66.7**	**0**	**0**	**0**	**0**	**0**	**62.5**	**20**

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 as presently there is limited regeneration occurring within the 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 lack of mature tree and shrub populations and limited structural complexity of these sites.

The proposed revegetation activities within the derived grassland areas as described in the BOMP and VCA aim 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 are likely to result in the cleared grassland areas developing into woodland communities and therefore meeting most 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. Particularly in the Grey Box woodlands reference sites, there was limited abundance and diversity of the grassy understorey and there were limited shrubs. Subsequently the revegetation activities proposed should include a range of species known to occur within these communities and not just restricted to those occurring within the existing reference sites.

Where possible revegetation practices should follow "Best Practice Revegetation Guidelines" such as Sydes *et al* Greening Australia (2003) and described in the DRAFT Revegetation Plan for the Kokoda VCA. It is good practice to establish a mosaic of shrub thickets, open woodland and grassy clearings to increase heterogeneity and patchiness of revegetation areas. The patchiness will be critical in the long-term sustainability of the woodlands, whilst promoting and maintaining biodiversity and varying habitats for woodland wildlife. High planting densities are likely to result in the decline in diversity of the herbaceous understorey and restrict regeneration opportunities in the longer-term, thus grassy clearings are essential.

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. Strategic grazing is likely to be a critical management strategy 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 the longer-term. This process has however been affected by drought conditions and heavy grazing by pests and feral animals. Presently, extensive disturbance and herbivory by macropods and goats has become an important management issue. NPM have been erecting new exclusion fencing around the boundary fences of the Kokoda property and plan to implement a series of pest control events over the coming years. Exclusion fencing in strategic locations may also be required in order to achieve successful revegetation outcomes.

In 2015 and 2016 several species of 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 and strategic grazing. Most orchids are only identifiable during a limited time period during suitable conditions during spring and/or autumn. As a result of the dry conditions experienced throughout most of 2017 - 2019, none of these populations have been observed to be flowering, thus emphasising the need to continue to update mapping with any new individuals and or populations as they are located.

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.

Strategic grazing using sheep or cattle may assist in the management of the herbaceous understorey and help regulate the degree of Callitris and eucalypt regeneration in more favourable seasonal conditions and when pest and feral animal control has been achieved in the medium to longer-term. Other control techniques may include the "cut and paste method" and targeted herbicide spraying when seedling densities are deemed too high.

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 needs basis.

There were little other management issues that have not already been addressed in the BOMP.

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1 Introduction: 2019 Kokoda Offset Area Ecological Monitoring Report

The 2019 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 Landuse

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 Status	EPBC Act Status	Vegetation within Kokoda Offset Site (ha)
Grey Box Grassy Woodland	EEC	EEC	13
Grey Box Grassy DNG	EEC	EEC	96
White Box Grassy Woodland	EEC	CEEC	2.2
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest			150
Rocky Rise Shrubby Woodland			26
Grey Box – Ironbark Woodland			25

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

2.3 Threatened Species

2.3.1 Flora

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

2.3.2 Fauna

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

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

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

2.4 Management zones

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

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

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

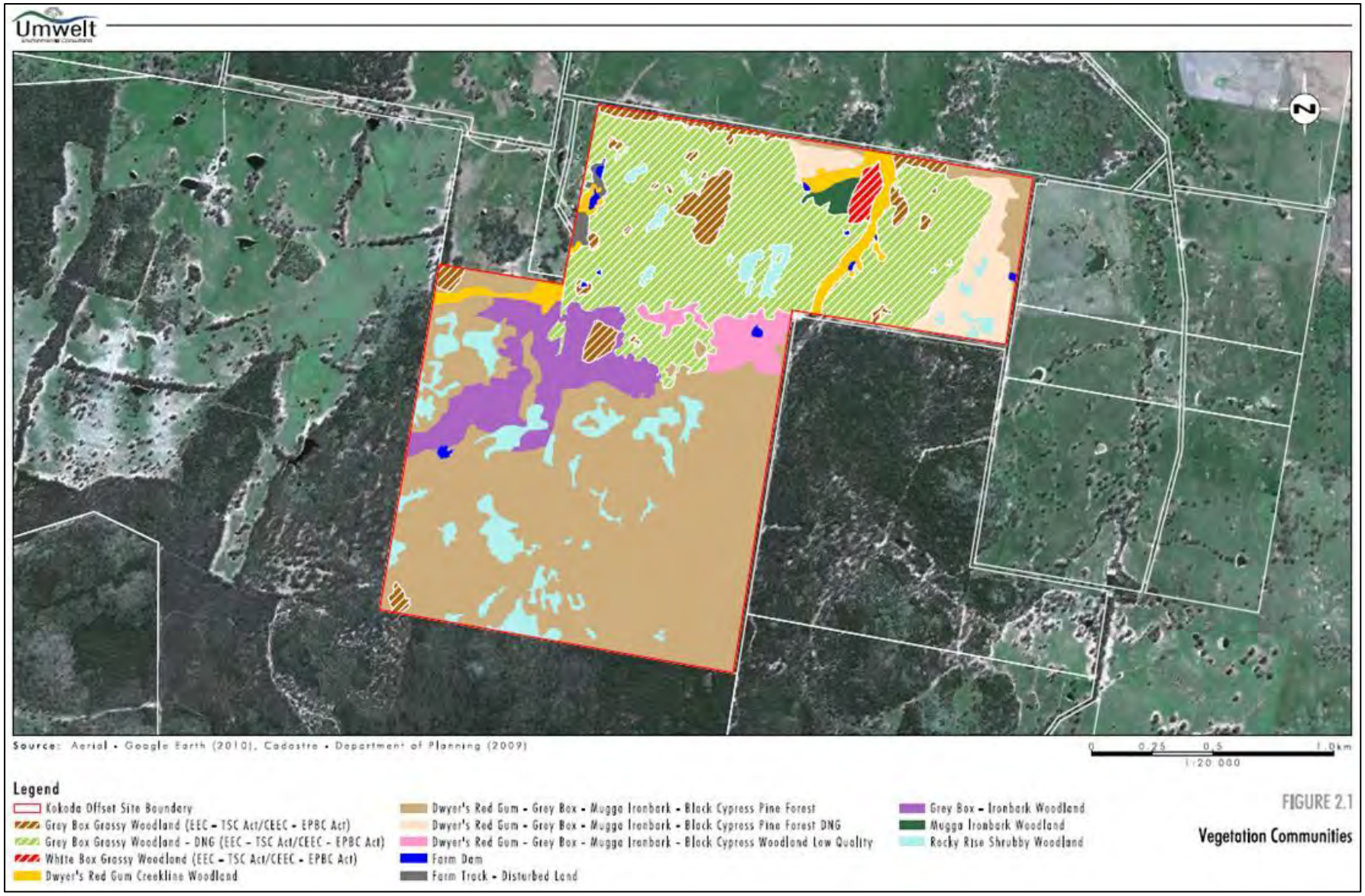


Figure 2-1. Distribution of the various vegetation communities within the Kokoda Offset Area (Umwelt 2014a)

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

2.5 Biodiversity Management targets

There are a range of biodiversity management targets which will be required to be met as part of the approval conditions. These have been determined by Umwelt (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) and the Estcourt Offset Area ecological monitoring program (DnA Environmental 2010 – 2014a; 2019b). The annual vegetation monitoring has been undertaken during spring and this year was undertaken from the 8 - 10th 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".

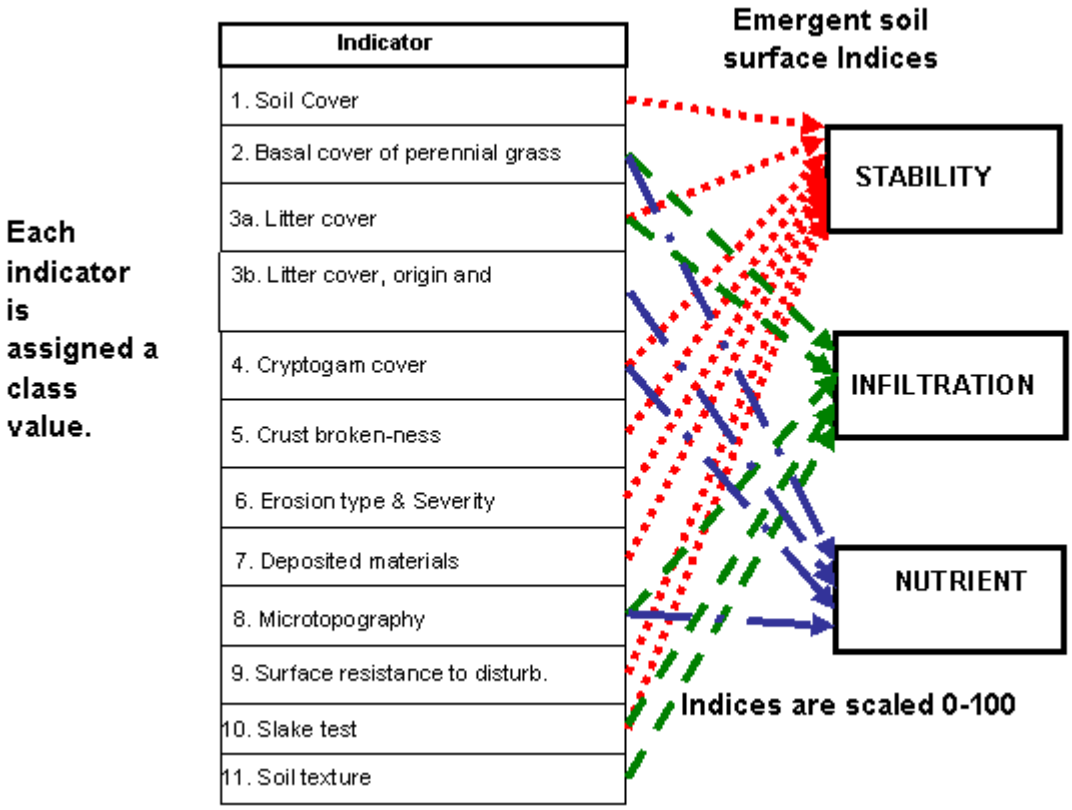
In the second stage, called "**soil surface condition" (SSC)** assessment, it is possible to assess and monitor soil quality using simple indicators including:

- 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 analysis consist of assessing the parameters, pH, Electrical Conductivity (EC), available calcium (Ca), magnesium (Mg), potassium (K), nitrate nitrogen (N), sulphur (S), organic matter (OM), exchangeable Sodium (Na), Ca, Mg, K, hydrogen (H), cation exchange capacity, available and extractable phosphorus (P), micronutrients zinc (Zn), manganese (Mn), Iron (Fe), copper (Cu), boron (B), silicon (Si), aluminium (Al), molybdenum (Mo), Cobalt (Co) and selenium (Se) and total carbon. A report with analysis and desirable levels recommended in the agricultural industry is provided by the laboratory. Exchangeable Sodium Percentages were calculated as a measure of sodicity or dispersion.

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

4.3 Monitoring structural diversity, floristic and other biodiversity attributes

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

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

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

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

4.3.1 The permanent monitoring quadrats

The permanent monitoring quadrats are 20 x 20m and original transects established by Umwelt were utilised where possible. The 20m LFA transect 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 2019 due to the ongoing drought. Revegetation is being planned for spring 2020, providing the seasonal conditions are suitable for tubestock planting.

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 OEH including additional photo-point monitoring, and the completion of the OEH 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 OEH 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	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.

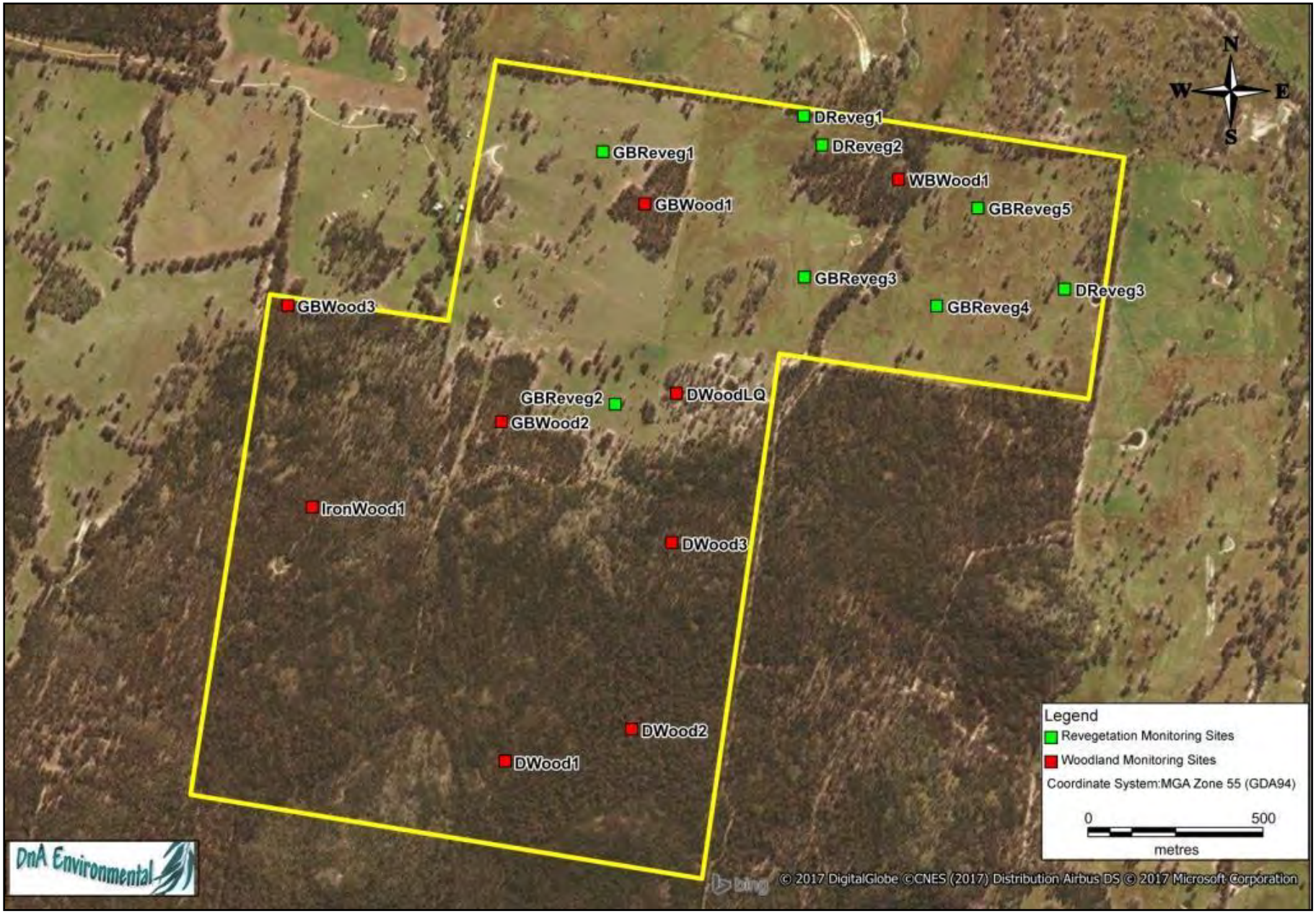


Figure 6-1. Map showing the location of the vegetation monitoring sites at Kokoda.

7 Rainfall

The average annual rainfall at Parkes Airport is 599 mm (BoM 2019), 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 only a total of 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.

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.

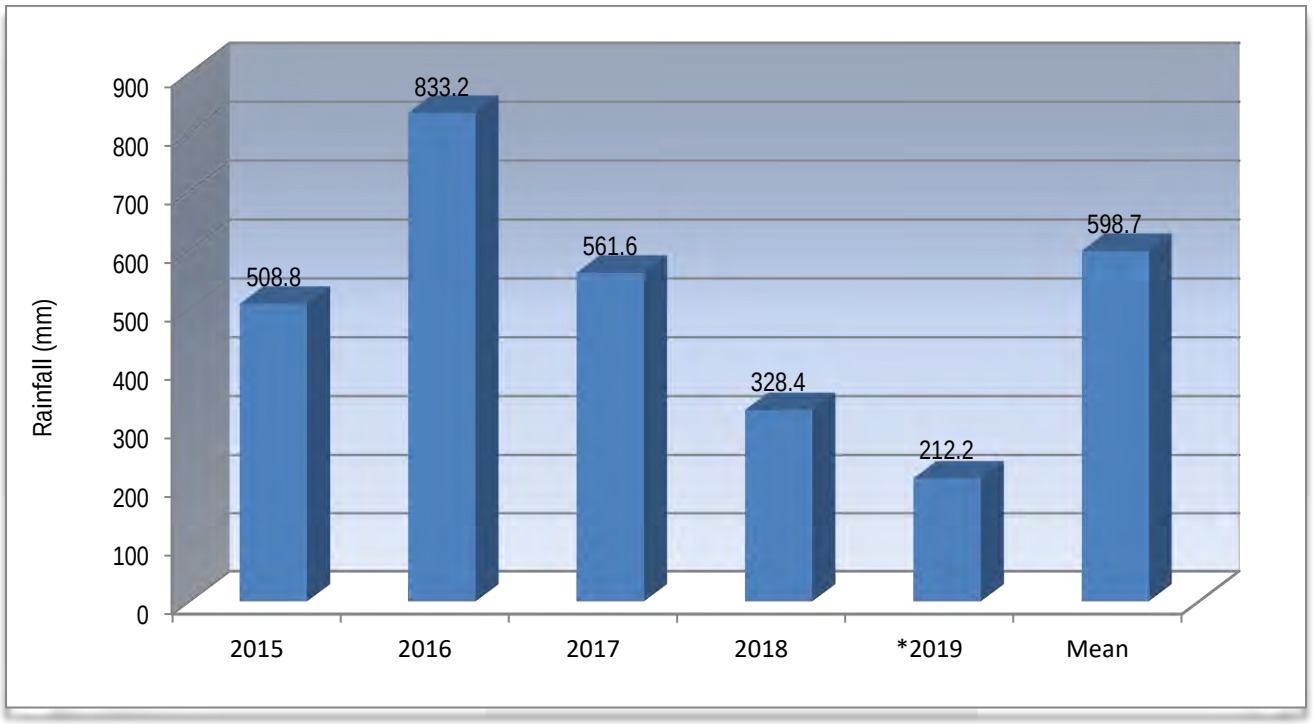


Figure 7-1. Total annual rainfall recorded at Parkes Airport 2015 to the end of October 2019 (*) compared to the long-term mean (BoM 2019).

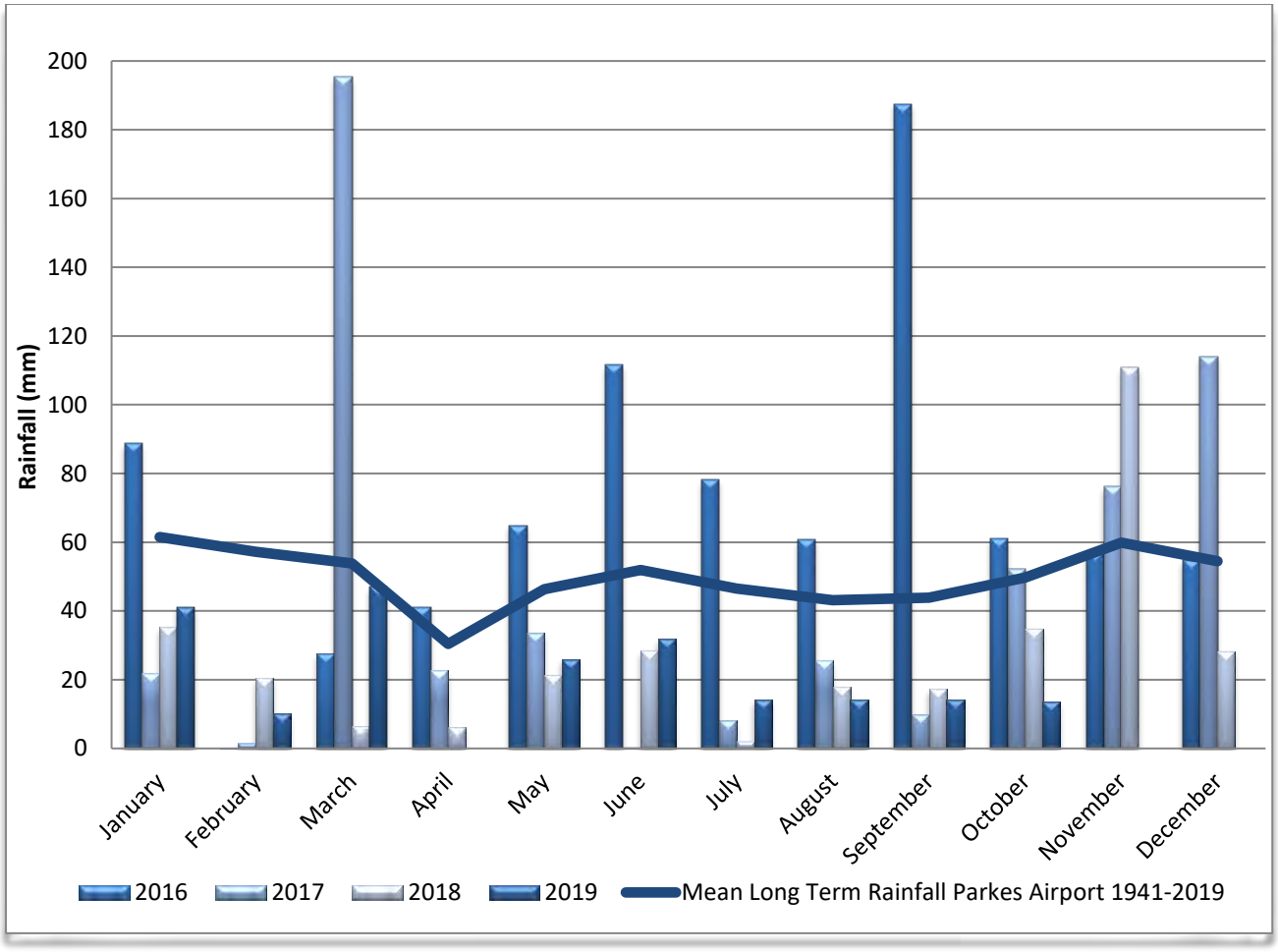


Figure 7-2. Monthly rainfall recorded at Parkes January 2016 to the end of October 2019 compared to the long-term monthly averages recorded at Parkes Airport (BoM 2019).

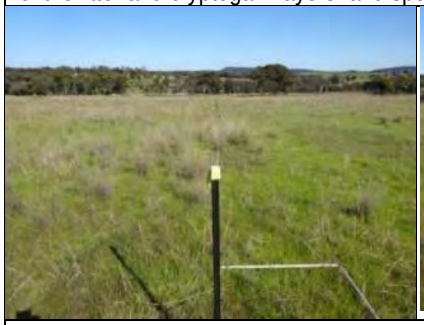
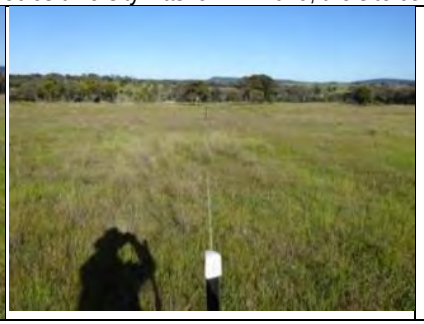
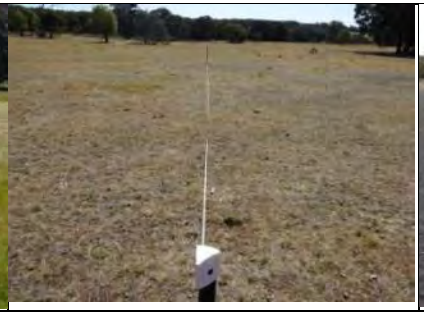
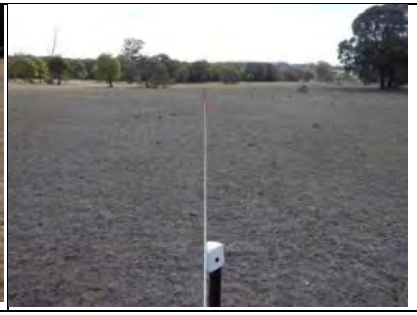
8 Results Grey Box Woodland monitoring sites

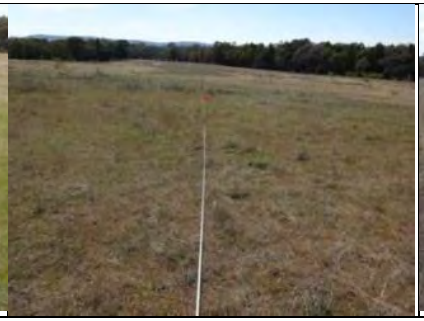
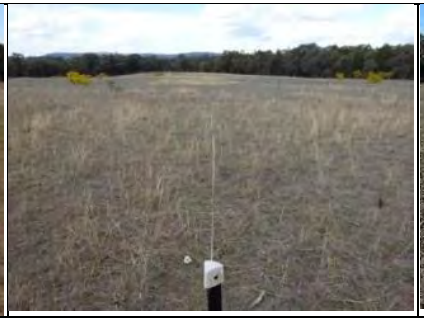
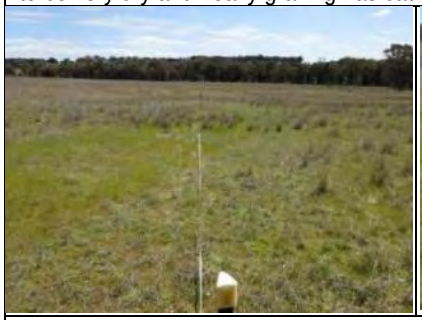
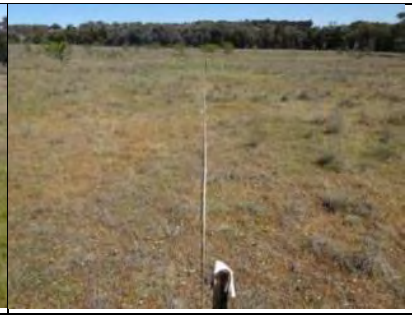
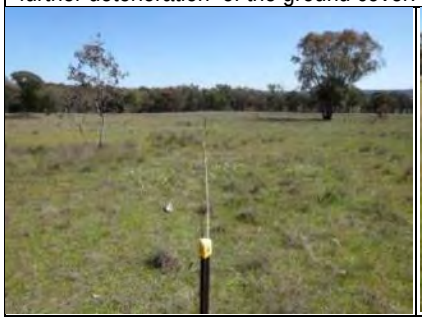
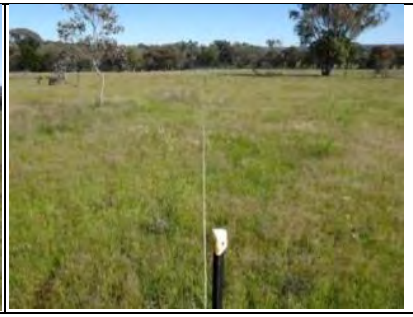
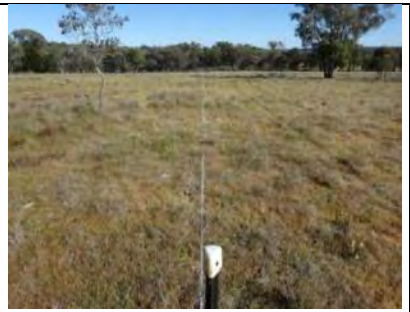
This section provides the results of the monitoring within the Grey Box monitoring sites and demonstrates ecological trends and performance of the revegetation sites against a selection of ecological performance indicators. This section has also included the White Box grassy woodland and Grey Box Ironbark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

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

2015	2016	2017	2018	2019
GBReveg1: Degraded native pasture dominated by the exotic annuals *Trifolium angustifolium* (Narrow-leaf Clover) and *Vulpia muralis* (Rats-tail Fescue). The site was however relatively diverse and maintained relatively good ground cover. The natives *Bothriochloa macra* Red-leg Grass and *Rytidosperma spp.* (Wallaby Grass) were also very common. In 2018, the pastures were heavily grazed causing the deterioration of the litter and cryptogam layers and species diversity was low. In 2019, the site continued to be were very dry and heavy grazing has caused the further deterioration of the ground cover.				
				
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.				
				

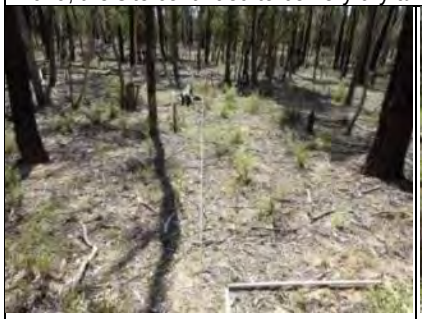
2015	2016	2017	2018	2019
GBReveg3: Native pasture dominated by *Bothriochloa macra* and the exotic annuals *Aira cupaniana, Hypochaeris glabra* (Smooth Catsear) with patches of *Vulpia muralis.* In 2018, the pastures were heavily grazed causing the deterioration of the litter and cryptogam layers and 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.				
				
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.				
				
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.				
				

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.





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.





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.





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.





GBWood3: Degraded regrowth woodland dominated *by E. microcarpa* with some scattered *E. sideroxylon*. There was a moderate density of regrowth trees and some limited but recent recruitment of volunteer shrubs. There were no dead stags, but some fallen branches occurred across the site. There was a high cover of dead leaf litter with a sparse cover of native ground cover species. In 2018, there continued to be deep litter layer however species diversity was low. In 2019, the site continued to be very dry and heavy grazing has caused the further deterioration of the ground cover.





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 the woodland reference sites maintained high functional patch area and a Landscape Organisation ranging from 98 - 100%.

While the Grey Box revegetation sites presently existed as degraded grassland 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, however all sites maintained high functional patch areas and continued to score LO's of 100% (Figure 8-1).

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

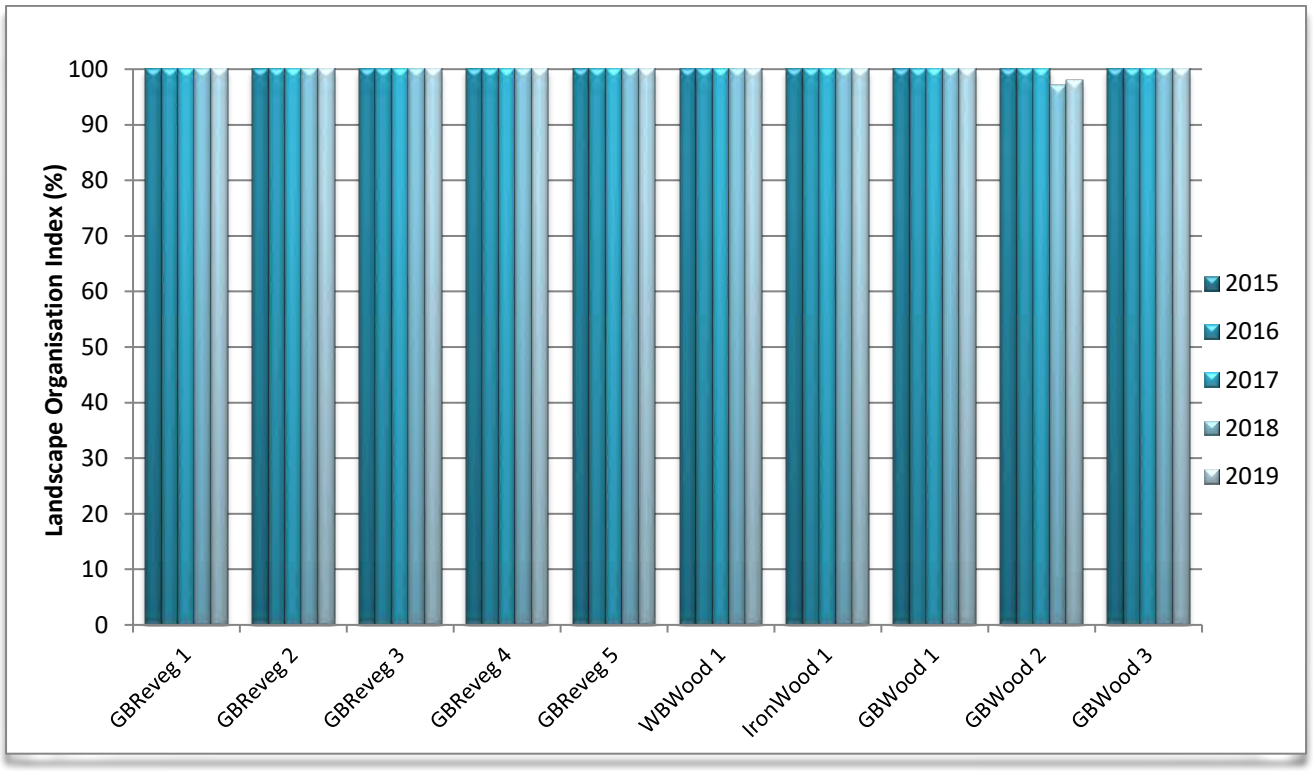


Figure 8-1. Landscape Organisation Indices recorded in the Grey Box woodland monitoring sites.

8.2.2 Soil surface assessments

8.2.2.1 Stability

LFA stability indices in the Grey Box woodland reference sites have slightly decreased this year and provided a stability range of 59.5 – 66.5. The stability of the reference sites were largely provided by the perennial tree cover, moderately deep litter layers and sandy clay loam soils which were very stable. This 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. The White Box and Ironbark woodlands were similar in structure to the reference sites. This year the stability indices had increased in WBWood1 and decreased in IronWood1, with indices of 62.7 and 62.5 respectively, with these having an ecological stability that was similar to the Grey Box woodland reference sites this year (Figure 8-2).

In the Grey Box revegetation sites, the stability increased in GBReveg1 and remained unchanged in GBReveg3. Stability had declined in GBReveg2, GBReveg4 and GBReveg5 due to heavy grazing pressure, however all sites continued to more stable than the Grey Box reference sites with stability indices ranging from 61.0 (GBReveg2) to 73.9 (GBReveg5).

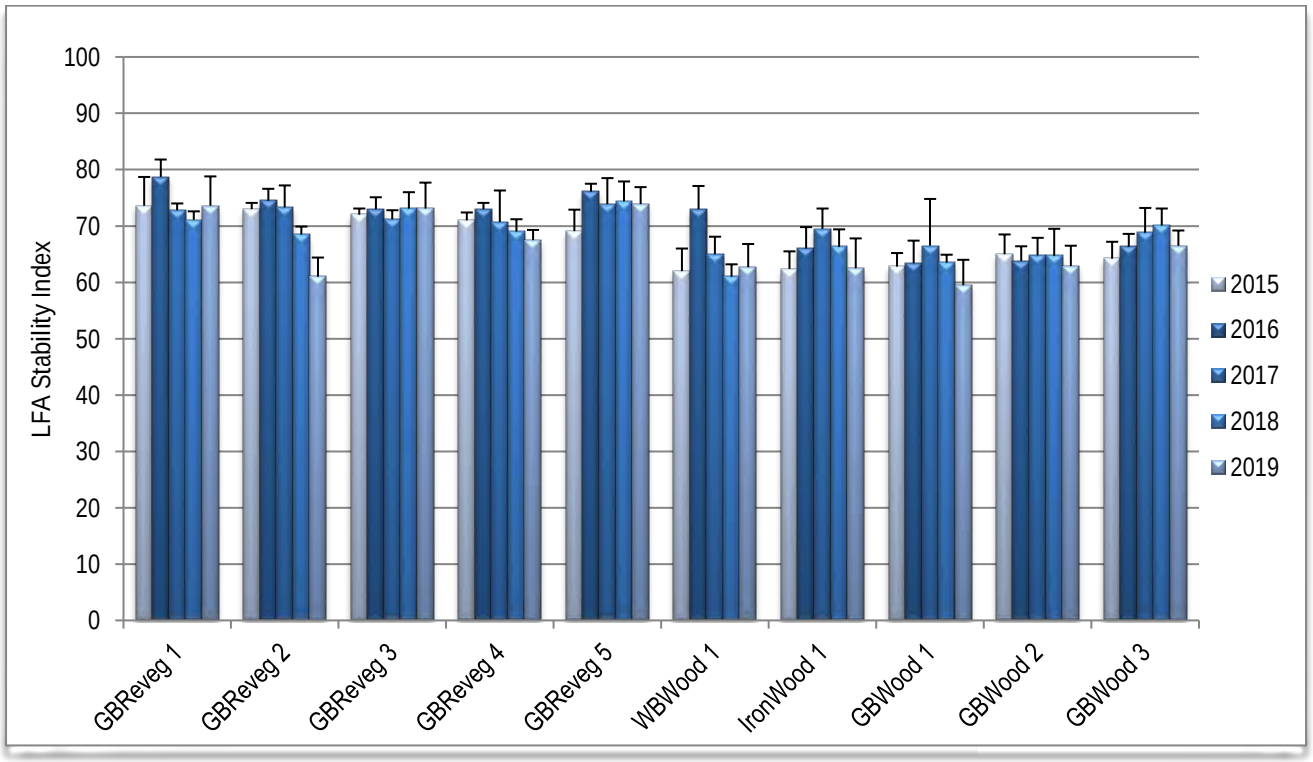


Figure 8-2. LFA stability indices recorded in the Grey Box woodland monitoring sites.

8.2.2.2 Infiltration

The infiltration capacity of the Grey Box reference sites and the White Box woodland continued to be similar to each other, with the Grey Box woodland reference sites having a stability range of 52.6 – 57.0 this year. (Figure 8-3). There continued to be a well-developed and decomposing litter layer that had often formed a rich spongy humus layer, however increased usage by wildlife may have increased surface crusting in some areas, however overall a marginal improvement was recorded. Similar changes were recorded in the White Box woodlands with an infiltration index of 52.7. The loss of litter and increased compaction resulted in a decline in infiltration capacity in the Ironbark woodland this year which had an index of 48.4.

In comparison to the reference sites the 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, however often they had increased cover of perennial ground covers. Infiltration capacity marginally increased in GBReveg1 and GBReveg3 but was slightly lower or had remained unchanged in the remaining sites. This year infiltration indices ranged from a low of 33.6 (GBReveg2) to a high of 47.0 (GBReveg3).

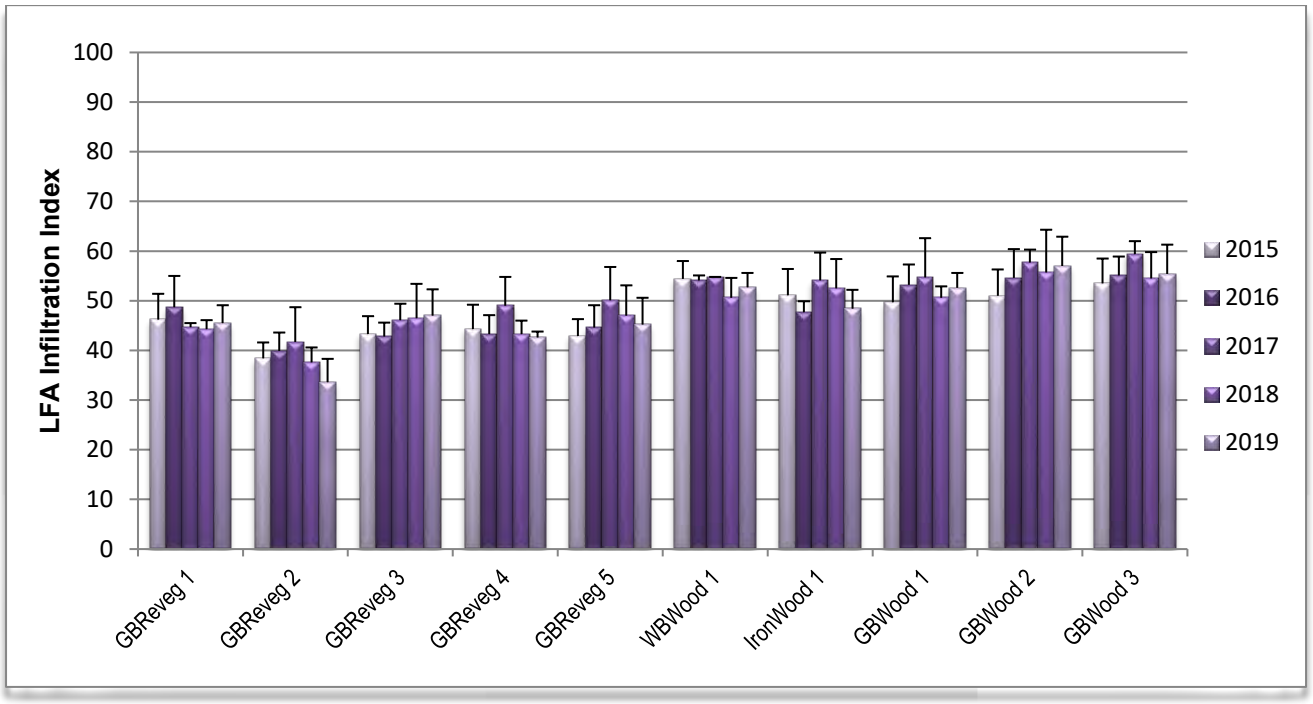


Figure 8-3. LFA infiltration indices recorded in the Grey Box woodland monitoring sites.

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. This year despite the drought a marginal increase in nutrient recycling capacity was recorded and provided a range of 49.0 – 53.2 (Figure 8-4). There was also an increase in the White Box woodland with an index of 53.2 which was similar to the reference sites, while a reduction was recorded in the Ironbark woodland with an index of 44.3 which was lower than desired.

In the Grey Box revegetation sites, there were limited to no perennial trees or shrubs and the litter and humus layers were presently less developed than the reference sites but cryptogams were usually abundant and there may have been an increase in perennial plant cover in some sites such as GBReveg1 with no change in nutrient recycling being this year. Heavy grazing has however typically caused a deterioration of grassy understorey and cryptogamic layer and subsequently nutrient recycling indices also declined in the remaining revegetation pasture areas. Nutrient recycling indices ranged from a low of 31.1 (GBReveg2) to a high of 44.1 (GBReveg1).

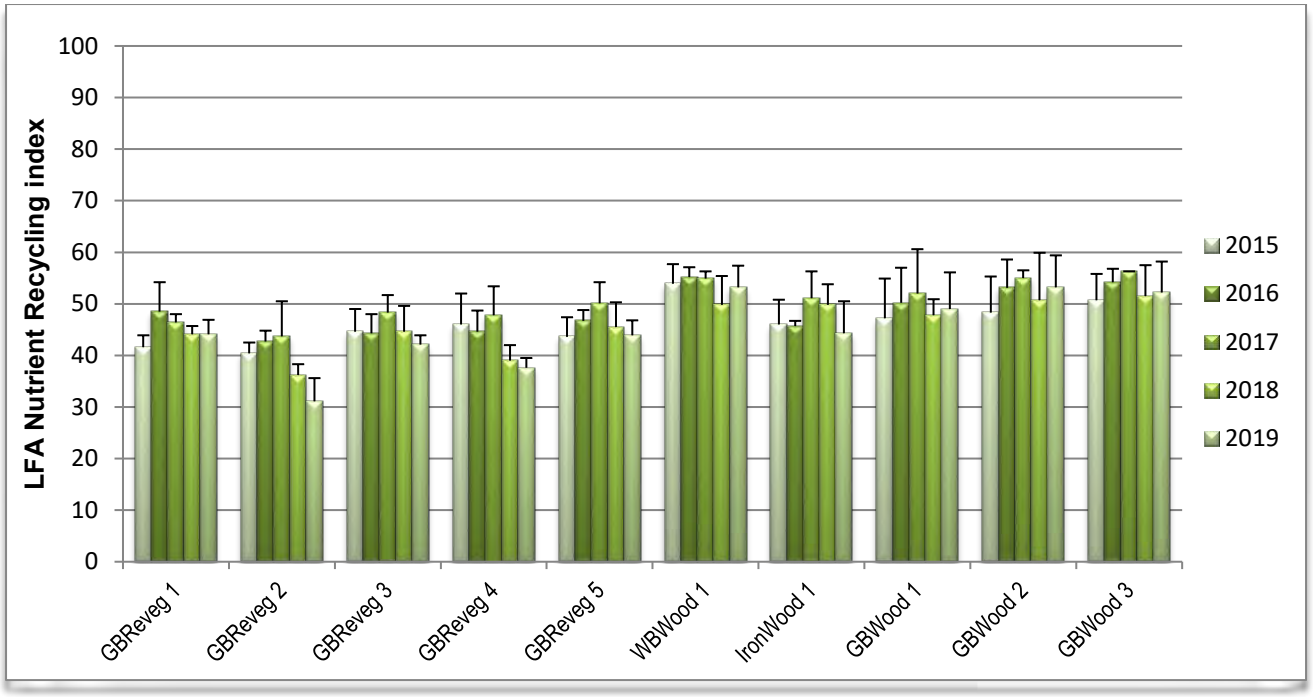


Figure 8-4. LFA nutrient recycling indices recorded in the Grey Box woodland monitoring sites

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 with the woodland reference sites GBWood3 continuing to be the most ecologically functional site with a total score of 174, followed closely by GBWood2 with 173. This was followed by WBWood1 with a sum of scores of 169. These sites contained high patch area, a mature tree canopy and well developed decomposing litter layer and spongy and stable soils.

Despite the lack of perennial overstorey in the pasture revegetation areas there was relatively high functionality in GBReveg1 and GBReveg5 with a sum of scores of 163 with these being more functional than the woodland sites GBWood1 (161) and IronWood1 (155). The grassland revegetation area GBReveg4 scored 148, while the least functional community continued to be GBReveg2 which scored 126.

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

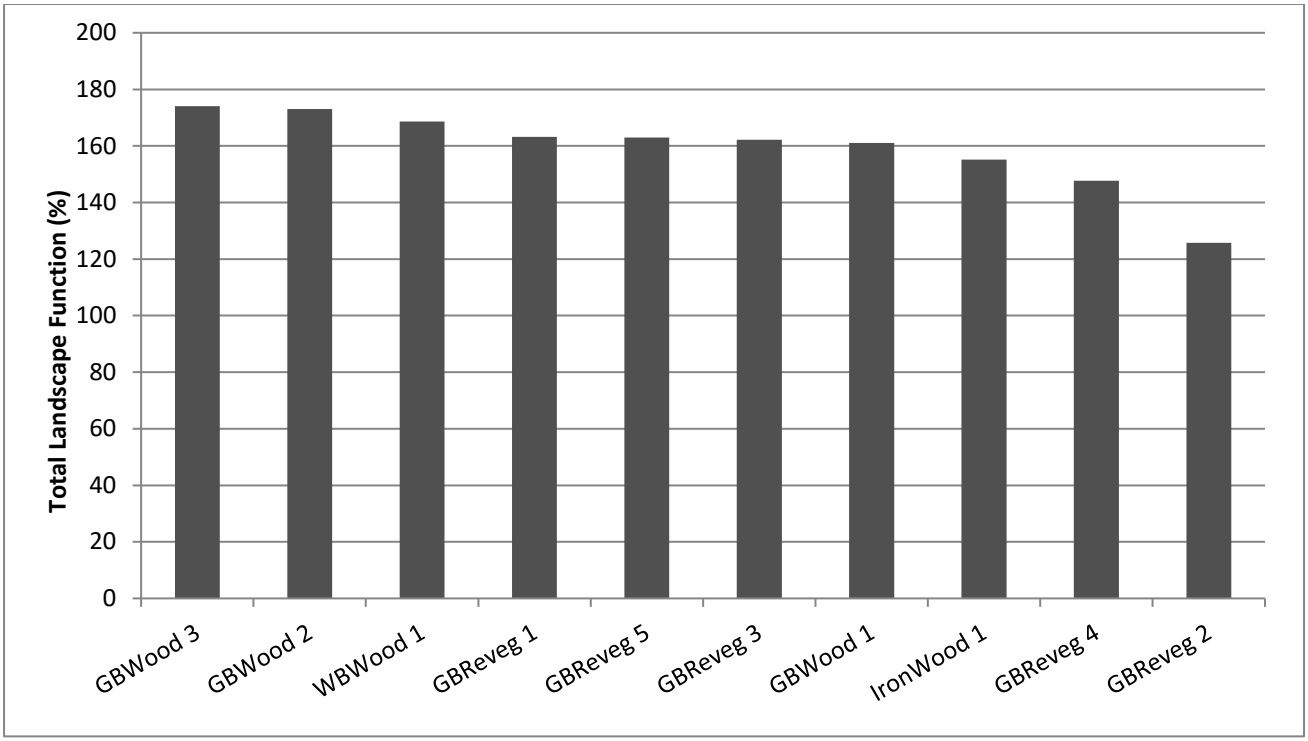


Figure 8-5. Sum of the LFA stability, infiltration and nutrient recycling components indicating the most functional to least functional monitoring site recorded in 2019

Table 8-2. Examples of the different ground covers in the Kokoda Grey Box monitoring sites in 2019.

GBReveg1	GBReveg2
	
GBReveg3	GBReveg4
	

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 during the past year, probably as a result of the ongoing drought. 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 17 – 34 cm with the minimum dbh being 6 cm and the maximum dbh 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 the 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 medium health but all sites contained individuals in a state of advanced dieback. In GBWood3 and Ironwood1 there continued to be some (dead) stags, and this year a stag was recorded in WBWood1. Reproductive structures such as buds, flowers or fruits were recorded in all sites except IronWood1, with 63% of individual flowering in WBWood1. There continued to be an absence of mistletoe however hollows suitable as nesting sites (>10cm) were noted in WBWood1, GBWood1 and GBWood2.

8.3.4 Species composition

The Grey Box reference sites were dominated by *Eucalyptus microcarpa* (Grey Box) however a single mature *Acacia implexa* (Hickory) was also recorded in GBWood2, while a single *E. sideroxylon* (Mugga Ironbark) was recorded in GBWood2 and GBWood3.

The White Box woodland was dominated by *E. albens* but a *Callitris endlicheri* and *E. blakelyi* were also present. The Ironbark woodland was dominated by *E. sideroxylon* and contained numerous individuals of *E. albens* and *E. dealbata,* and there was one *Callitris endlicheri.*

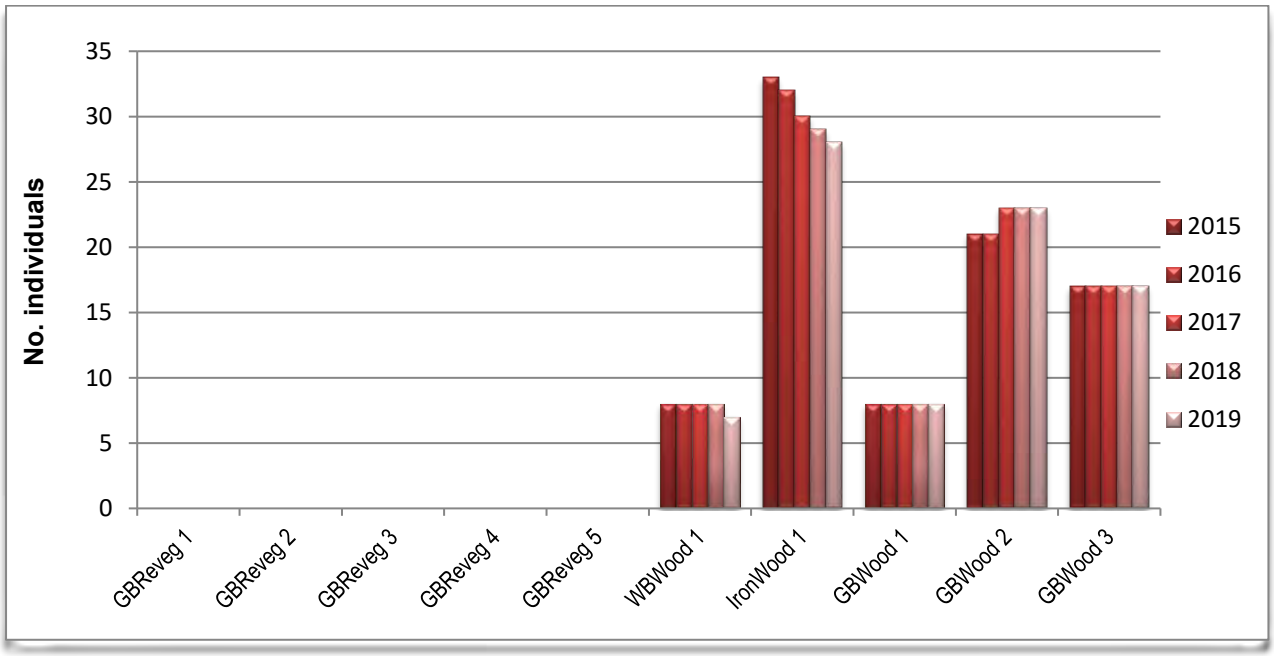


Figure 8-6. Tree and mature shrub densities (>5cm dbh) in the Kokoda Grey Box woodland monitoring sites.

Table 8-3. Trunk diameters and condition of the trees and mature shrubs in the woodland monitoring sites in 2019.

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
GBReveg1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GBReveg2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GBReveg3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GBReveg4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GBReveg5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
WBWood1	3	30	39	18	8	4	88	0	75	13	13	0	63	13
IronWood1	4	17	50	6	40	3	70	3	30	38	30	0	20	0
GBWood1	1	34	57	13	8	0	100	0	75	25	0	0	0	50
GBWood2	3	17	30	8	23	4	100	30	52	17	0	0	26	0
GBWood3	2	23	53	6	20	9	85	5	50	30	15	0	25	10

8.4 Shrubs and juvenile trees

8.4.1 Population density

In the woodland reference sites there were 1 - 18 shrubs and juvenile trees (Figure 8-7), equating to a maximum density of 25 - 450 stems per hectare.

In the White Box woodland some additional seedlings were located with eight individuals recorded this year. In the Ironbark woodland there were slightly fewer shrubs with 129 individuals being recorded. One *Callitris endlicheri* (Black Cypress Pine) seedling continued to be recorded in GBReveg1 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).

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* (C*ough Bush).* No *A. spectabilis* (Mudgee Wattle) or *Brachyloma daphnoides* (Daphne Heath) were recorded this year as they had recently died as a result of the drought.

In the White Box woodland there were three *A. decora* (Western Golden Wattle) and two *E. albens* seedlings and one each of *Acacia implexa, Brachychiton populneus* and *Callitris endlicheri* seedlings.

In the Ironbark woodland, the shrubby understorey was more diverse and continued to be dominated by *Brachyloma daphnoides* with numerous (19) *Callitris endlicheri* seedlings. There were also occasional juvenile of *Cassinia laevis, Brachychiton populneus, E. dealbata* and *E albens.* One *Callitris endlicheri* seedling continued to be recorded in GBReveg1 this year.

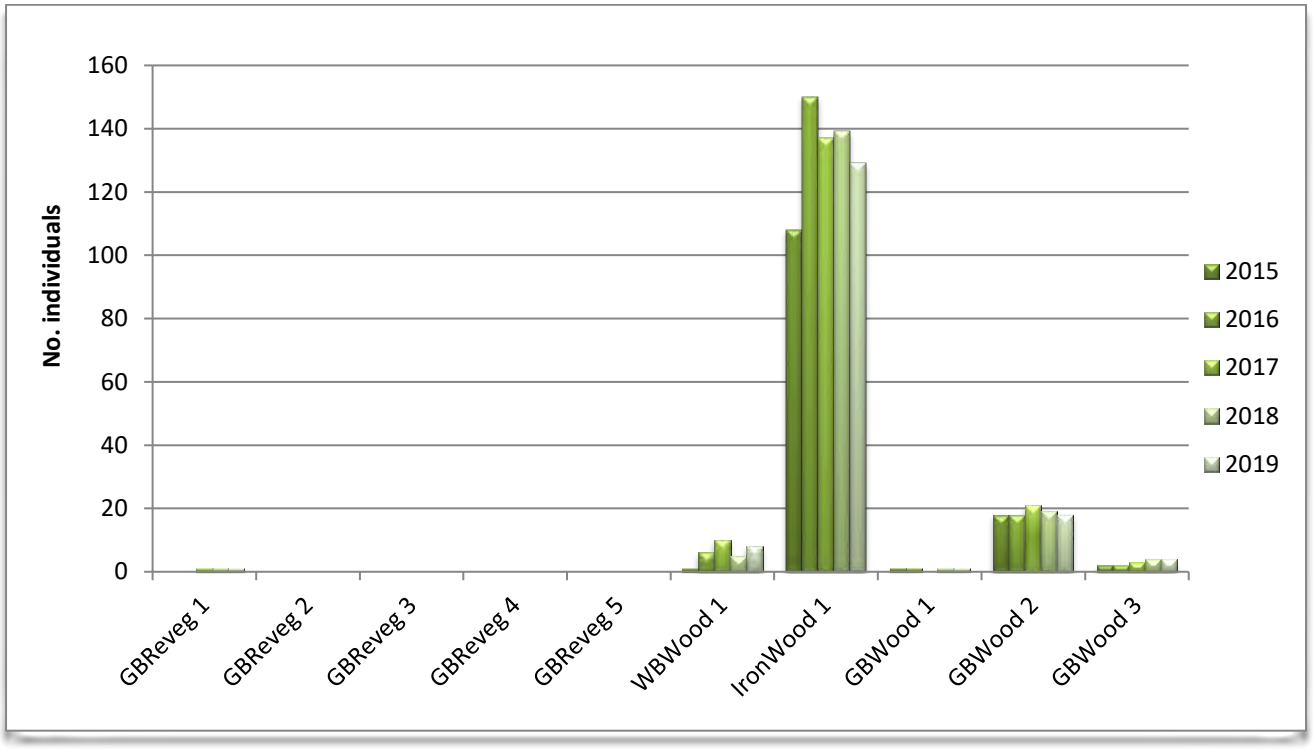


Figure 8-7. Total shrubs and juvenile trees recorded in the Grey Box monitoring sites.

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
GBReveg1	1	0	0	0	0	1	1	100
GBReveg2	0	0	0	0	0	0	0	0
GBReveg3	0	0	0	0	0	0	0	0
GBReveg4	0	0	0	0	0	0	0	0
GBReveg5	0	0	0	0	0	0	0	0
WBWood1	6	2	0	0	0	8	5	100
IronWood1	94	32	3	0	0	129	6	100
GBWood1	1	0	0	0	0	1	1	100
GBWood2	6	12	0	0	0	18	2	100
GBWood3	1	1	0	0	2	4	2	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 to provide a target range of 92.0 – 98.5% (Figure 8-8). Overgrazing has also resulted in a reduction in ground cover in all pasture sites as well as both WBWood1 and IronWood1 sites. The lowest cover was recorded in the pasture sites was recorded in GBReveg2 with 72.5% while the highest was recorded in GBReveg1 with 96%. Sites GBReveg2, GBReveg3, GBReveg4 and IronWood1 did not meet total ground cover targets this year.

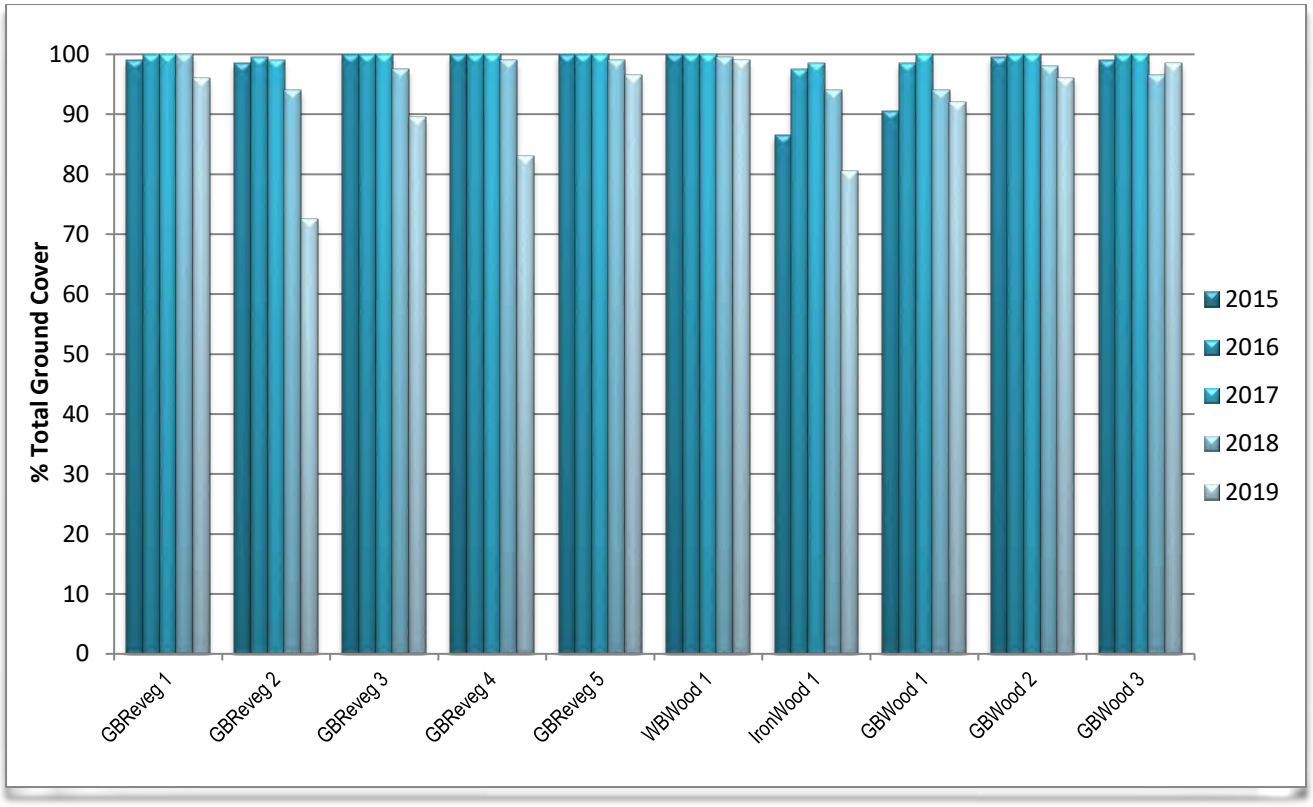


Figure 8-8. Total ground cover recorded in the Grey Box woodland monitoring sites.

8.6 Structural composition

The ground cover composition and structure of the Grey Box monitoring sites are provided in Figure 8-9. In the reference sites, the most dominant form of ground cover continued to be provided by dead leaf litter which were largely derived from fallen eucalypt leaves and twigs and provided 87.5 – 95.5% of the total ground cover this year. As a result of the dry conditions there was much less perennial ground cover in the woodland sites with only 0.5 – 2.5% cover and no annual plants were recorded. There continued to be a small contribution of cover provided by fallen branches (0.5 – 4.0%) however no cryptogams or rocks were recorded.

The White Box woodland site was very similar in structure but had a slightly higher cover of perennial ground cover plants which provided 3.0% of the total ground cover. In the Ironbark woodland, leaf litter was also most dominant, and cryptogams and logs provided 1.5% and 5.5% respectively, while no perennial plants were recorded this year. This year no annual plants were recorded at either WBWood1 or IronWood1.

In the derived grassland revegetation sites, annual plant cover had declined in all sites and this year all sites were dominated by dead litter which was derived from dead ground cover plants. Due to a relatively recent rainfall events, annual plants continued to be recorded in all sites with a low cover of 3.5% in GBReveg2 to a high of 12.5% in GBReveg3. Cryptogam cover had also declined, and none were recorded in GBReveg4 this year, while they provided 3.5 – 14.5% of the total ground cover in the remaining sites. Perennial ground cover had slightly increased as a result of the recent rain and provided 11 – 26.5% of the total ground cover, with these continuing to exceed perennial ground cover requirements compared to the reference sites.

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

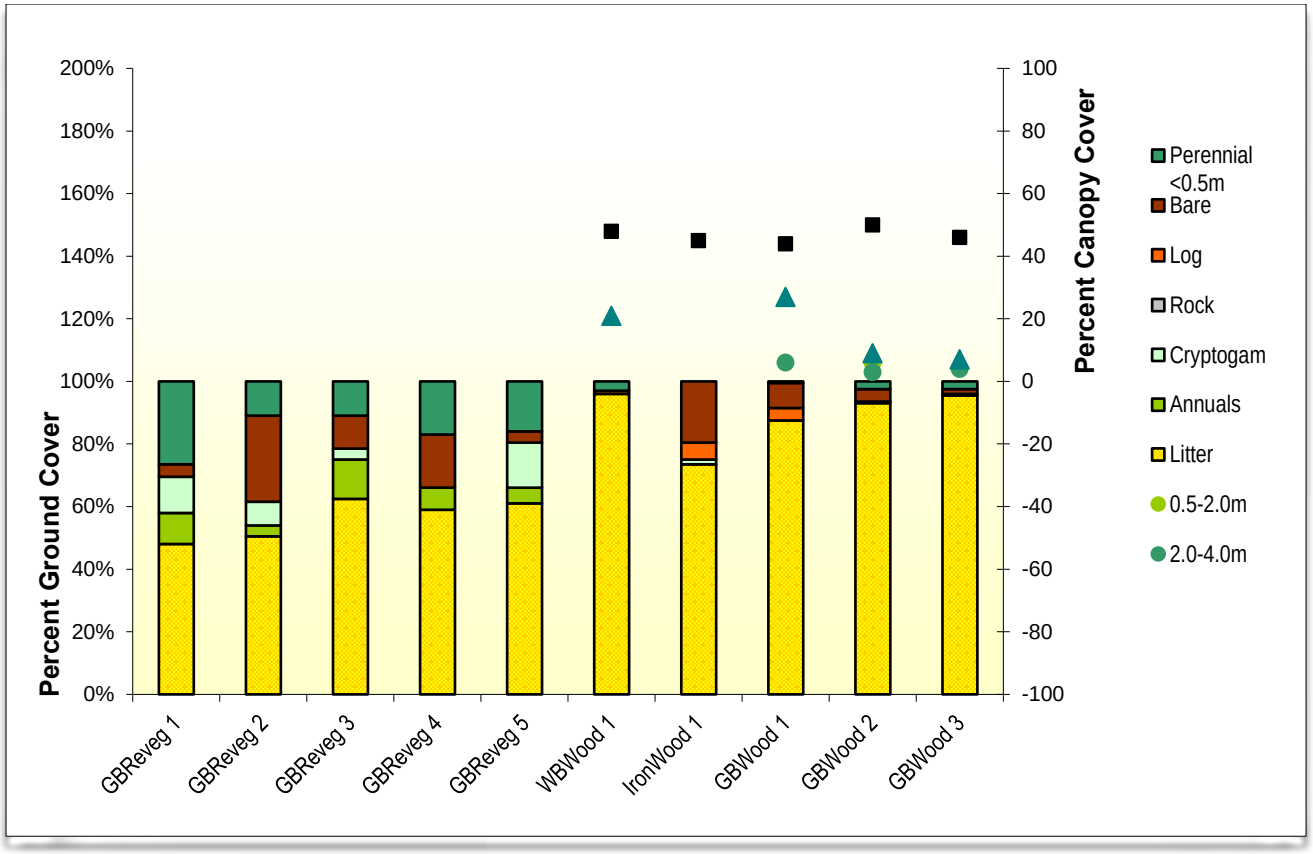


Figure 8-9. Average percent ground cover and projected foliage cover recorded in the Grey Box monitoring sites in 2019.

8.7 Floristic Diversity

Total floristic diversity recorded within the 20 x 20 m Grey Box woodland reference sites was highly variable between the sites and in 2016 there was a high diversity of species as a result of the wet seasonal conditions with 36 – 58 species being recorded (Figure 8-10). The dry conditions experienced in 2017 resulted in a significantly lower diversity of species with 10 – 22 species and in 2018 there were 7 – 15. This year only 4 – 12 species were recorded.

There were 29 species in the White Box woodland, while in the Ironbark woodland there were a total of 20 species. In the grassland revegetation sites an increased species diversity was recorded as relatively recent rainfall had stimulated a flush of plant growth, and the grassland sites continued to be more diverse than the reference sites. This year there were 24 (GBReveg2, GBReveg4) to 30 (GBReveg5) different species recorded.

In the woodland reference sites, all species were native (Figure 8-11). In both WBWood1 and IronWood1 only one exotic species was recorded (Figure 8-12). The derived grassland sites contained a higher diversity of species than the reference sites, however there was also a much higher diversity of exotic species with 4 (GBReveg2) – 15 (GBReveg3) exotic species. All grassland sites however had an acceptable diversity of native species.

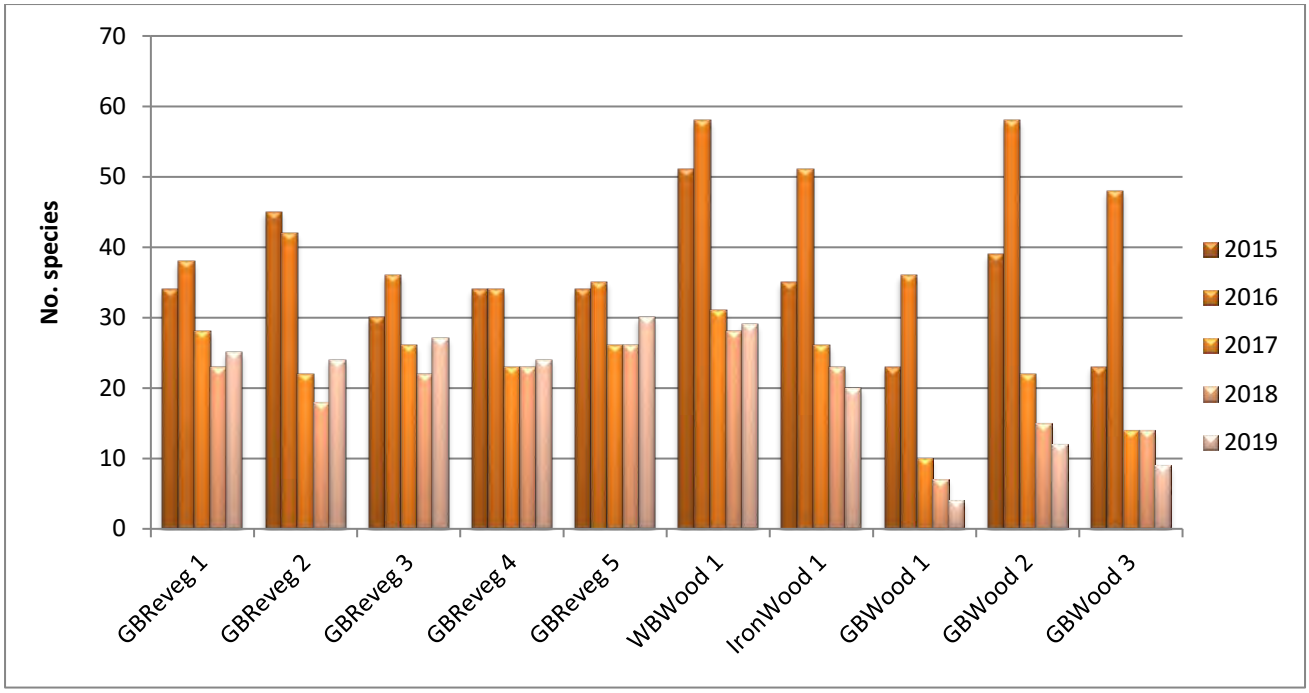


Figure 8-10. Total species diversity recorded in the Grey Box monitoring sites.

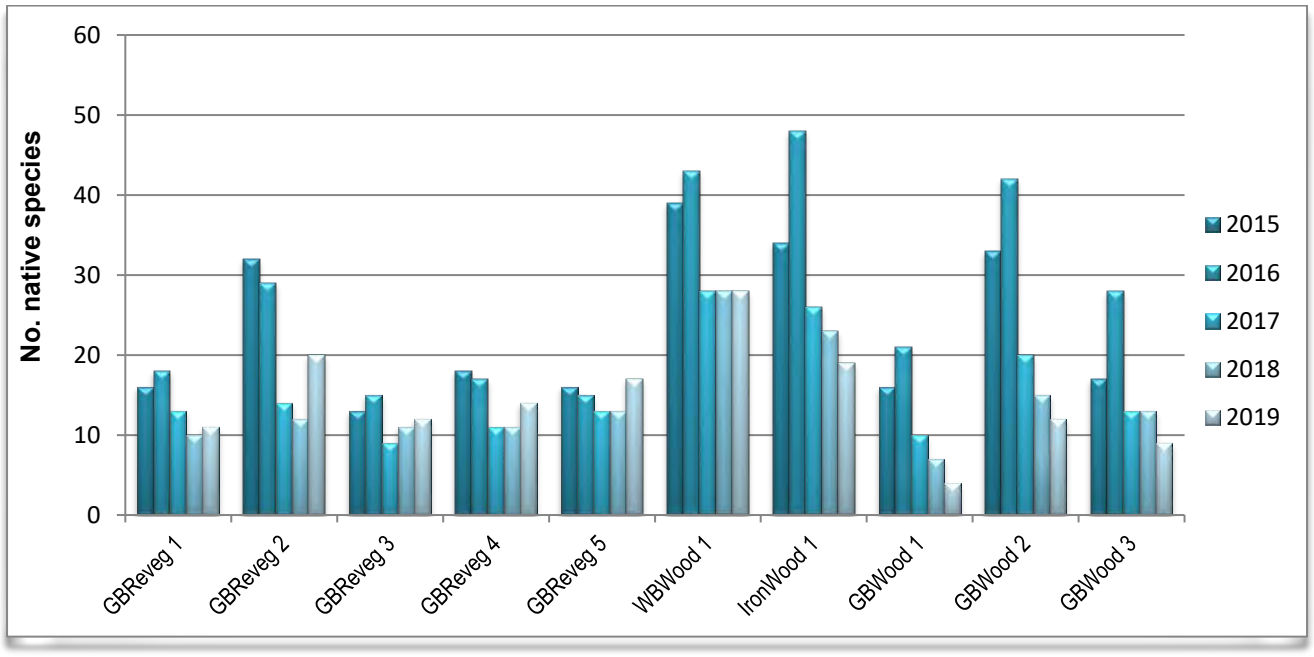


Figure 8-11. Total native species diversity recorded in the Grey Box monitoring sites.

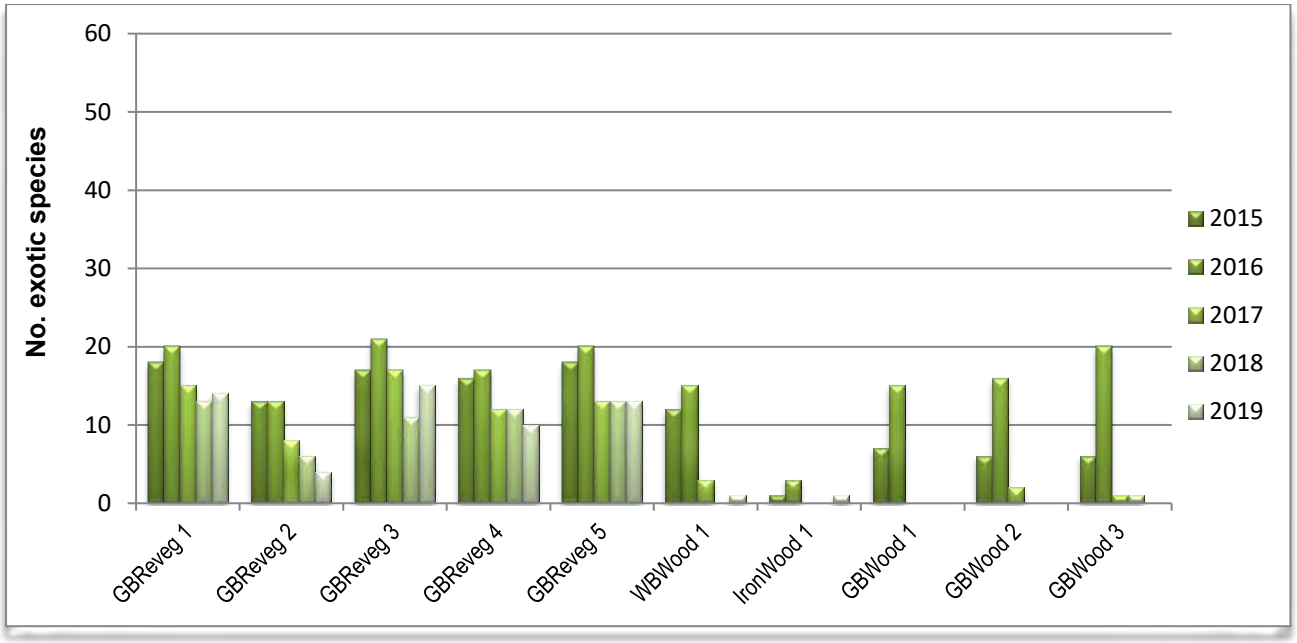


Figure 8-12. Total exotic species recorded in the Grey Box monitoring sites.

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

In 2016 most of the live plant cover in the Grey Box woodland reference sites was provided by native species however due to the increase in exotic annual plant cover, endemic plant cover scores had declined from that recorded in 2015, and ranged from 82.7 – 85.2% (Figure 8-13). From 2017 - 2019, there has been limited live annual plant cover in the woodland reference sites with all plant cover being provided by native ground cover plants. This was also evident in WBWood1 and IronWood1, however a marginal decline was recorded in WBWood1 this year (Figure 8-13).

In the derived grasslands, three sites GBReveg2, GBReveg4 and GBReveg5 were dominated by native plant cover (59 – 73%) this year, however GBReveg1 (48%) and GBReveg3 37%) were weedier than desired, and all grassland sites were weedier than the reference sites.

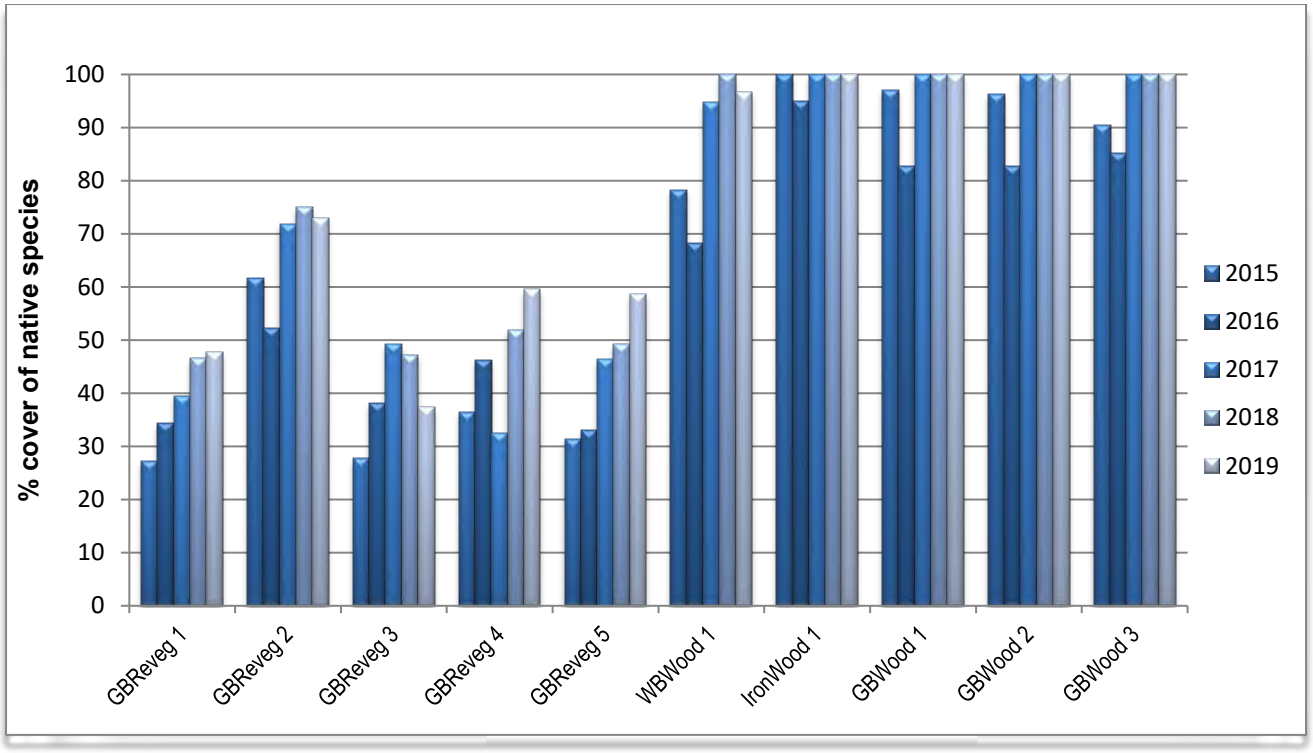


Figure 8-13. Percent endemic ground cover recorded in the Grey Box monitoring sites.

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 reduction in plant diversity with only 1 – 4 herbs and 2 – 4 grasses being recorded. There continued to be were 1 - 2 tree species but there were slightly fewer 2 shrubs with 0 – 2 species, 0 – 1 reeds and no sub-shrubs or ferns were recorded.

Compared to the reference sites, the White Box and Ironbark woodlands were more diverse and were comprised of an adequate representation of the major plant groups. In the grassland revegetation sites there was also an adequate representation of most growth forms apart from a low diversity of tree species in all sites except GBReveg1. There also continued to be an absence of shrubs in all grassland sites.

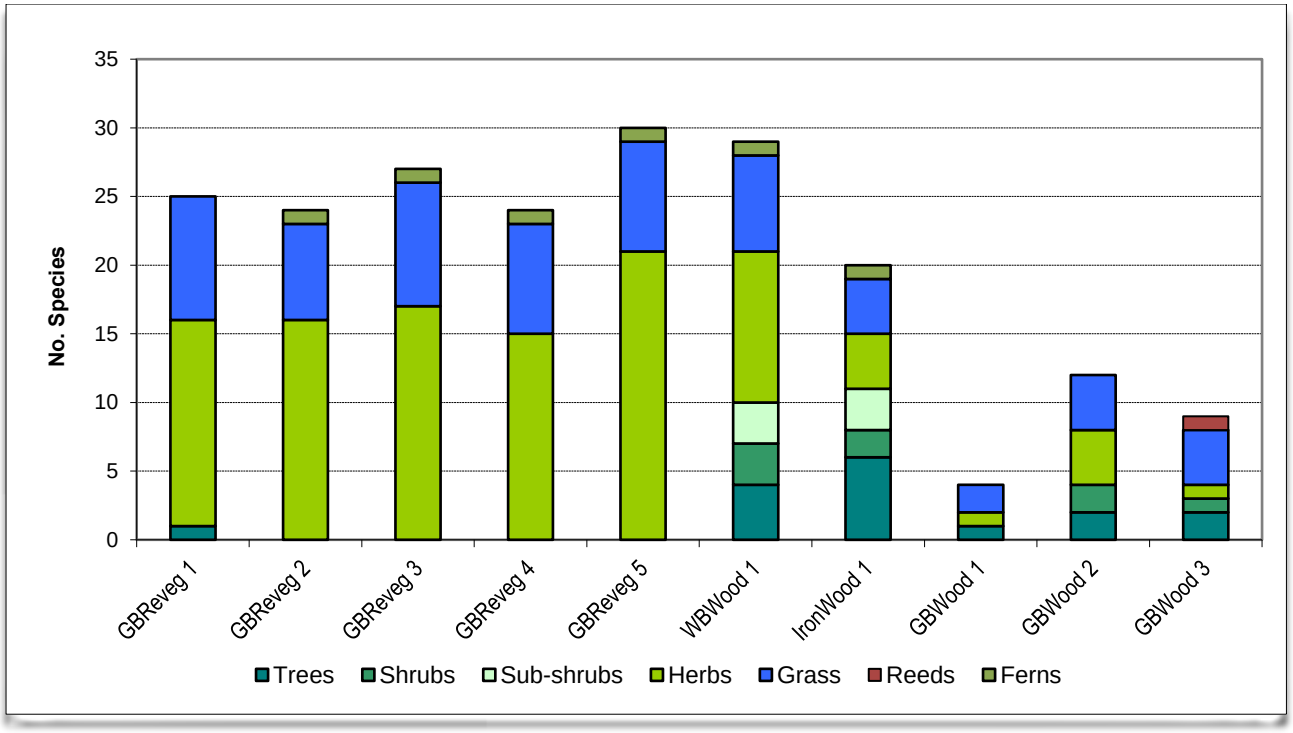


Figure 8-14. Composition of the vegetation recorded in the Grey Box monitoring sites in 2019.

8.9 Most common species

The most common species, those that were recorded in at least four of the seven revegetation sites are provided in Table 8-5. Native perennials *Bothriochloa macra* (Red-leg Grass), *Panicum* sp. (A Panic), *Austrostipa scabra* subsp. *scabra* (Rough Speargrass) and *Oxalis perennans* (Yellow Wood-sorrel) were recorded in all sites except IronWood1, while *Cheilanthes sieberi* subsp. *sieberi* (Rock Fern) a native fern was also recorded in all sites except GBReveg1. Of these only *Austrostipa scabra* subsp. *scabra* was recorded in the woodland reference sites.

The native species *Calotis lappulacea* (Yellow Burr Daisy), *Chloris truncata* (Windmill Grass), *Aristida ramosa* (Threeawn Grass), *Triptilodiscus pygmaeus* (Austral Sunray) and *Haloragis heterophylla* (Rough Raspwort) were recorded in at least four or five sites as was the exotic annual *Hypochaeris glabra* (Smooth Catsear). There was a variety of other common exotic species including *Aira spp.* (Silvery Hairgrass), *Bromus molliformis* (Soft Brome), *Chondrilla juncea* (Skeleton Weed) and *Echium plantagineum* (Paterson's Curse). 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 2019.

exotic	Scientific Name	Common Name	Habit	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	Total	GBWood1	GBWood2	GBWood3
	Bothriochloa macra	Red-leg Grass	g	1	1	1	1	1	1		6			
	Cheilanthes sieberi subsp. sieberi	Rock Fern	f		1	1	1	1	1	1	6			
	Oxalis perennans	Yellow Wood-sorrel	h	1	1	1	1	1	1		6			
	Panicum spp.		g	1	1	1	1	1	1		6			
	Austrostipa scabra subsp. scabra	Rough Speargrass	g	1	1	1	1		1	1	6	1	1	1
	Calotis lappulacea	Yellow Burr Daisy	h	1	1	1	1	1			5			
	Chloris truncata	Windmill Grass	g	1	1	1	1	1			5			

exotic	Scientific Name	Common Name	Habit	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	Total	GBWood1	GBWood2	GBWood3
*	*Hypochaeris glabra*	Smooth Catsear	h	1	1	1	1	1			5			
	Aristida ramosa	Threeawn Grass	g	1	1		1	1	1		5		1	
*	*Aira spp.*	Silvery Hairgrass	g	1		1	1	1			4			
*	*Bromus molliformis*	Soft Brome	g	1		1	1	1			4			
*	*Chondrilla juncea*	Skeleton Weed	h	1		1	1	1			4			
*	*Echium plantagineum*	Paterson's Curse	h	1		1	1	1			4			
	Triptilodiscus pygmaeus	Austral Sunray	h		1	1	1	1			4			
	Haloragis heterophylla	Rough Raspwort	h		1	1	1	1			4		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.

No species was particularly abundant in the understorey in the Grey Box woodland reference sites or in the woodland sites WBWood1 or IronWood1, with no species meeting the required abundance criteria this year. The native perennial grass *Bothriochloa macra* (Red-leg Grass) was recorded as the most abundant species in all pasture sites except GBReveg2, where *Rytidosperma racemosum* (Wallaby Grass) was the most abundant species. *Hypochaeris glabra* (Smooth Catsear) an exotic annual was also continued to be relatively abundant species in GBReveg1.

Table 8-6. The most abundant species recorded in the Grey Box monitoring sites in 2019.

Scientific Name	Common Name	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	GBWood1	GBWood2	GBWood3
**Hypochaeris glabra*	Smooth Catsear	12									
Bothriochloa macra	Red-leg Grass	17		14	14	15					
Rytidosperma racemosum	Wallaby Grass		10								

8.11 Soil analyses

Results of the soil analyses for the Grey Box monitoring sites is provided in Appendix 3, however changes in a few important parameters have been briefly described in the following section.

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 5.0 – 5.3 the soils were strongly (Bruce & Rayment 1982).

In GBReveg2, the soil pH was similar to the reference sites with pH of 5.3, however in IronWood1 the pH declined to 4.8 and was very strongly acidic this year. The White Box woodland and remaining derived grassland areas had a slightly higher pH which ranged from 5.7 (GBReveg4) to 6.7 (GBReveg1) with these soils being moderately acidic to neutral and within local and/or desirable agricultural ranges.

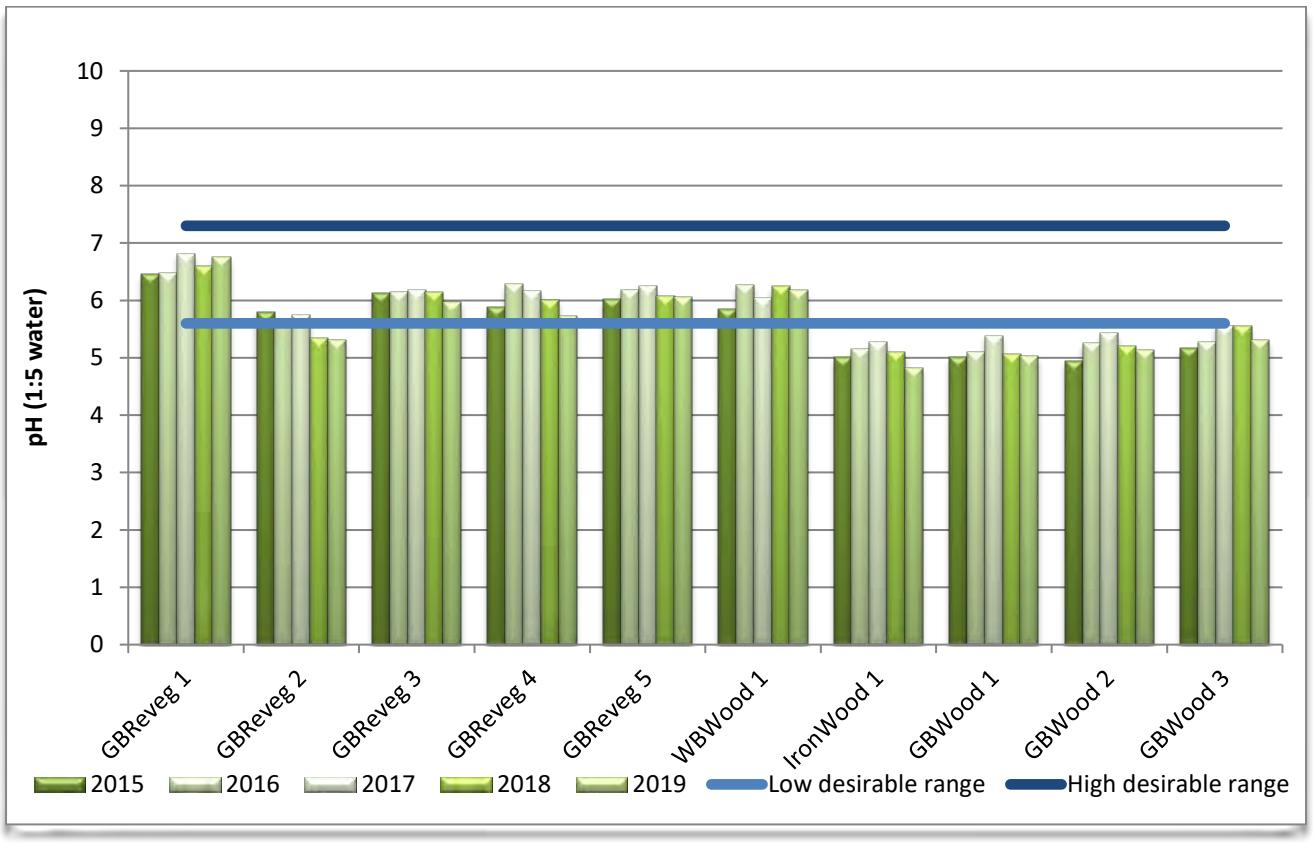


Figure 8-15. Soil pH recorded in the Grey Box monitoring sites compared to the desirable agricultural range.

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 0.066 – 0.079 dS/m. In the remaining sites EC ranged from a low of 0.017 dS/m in GBReveg5 to a high of 0.064 dS/m in GBReveg2.

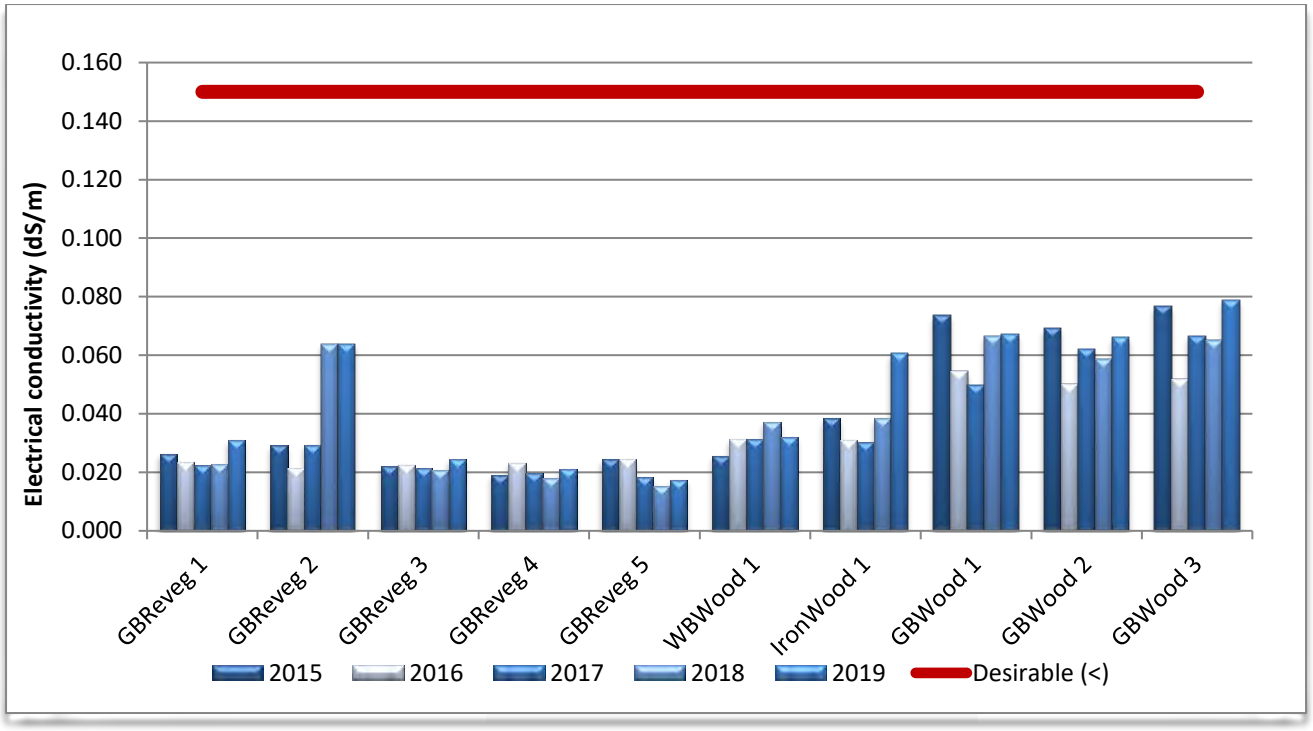


Figure 8-16. Electrical Conductivity recorded in the Grey Box monitoring sites compared to the desirable agricultural levels.

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 4.8 - 7.9% (Figure 8-17). At GBReveg2, there was 5.5% OM while at IronWood1 OM was 4.8% with these being similar to the local woodlands and higher than desirable ranges. OM in the remaining sites remained lower than the Grey Box woodlands despite a marginal increase and ranged from a low of 2.5% in GBReveg5 to a high of 3.4% in GBReveg1.

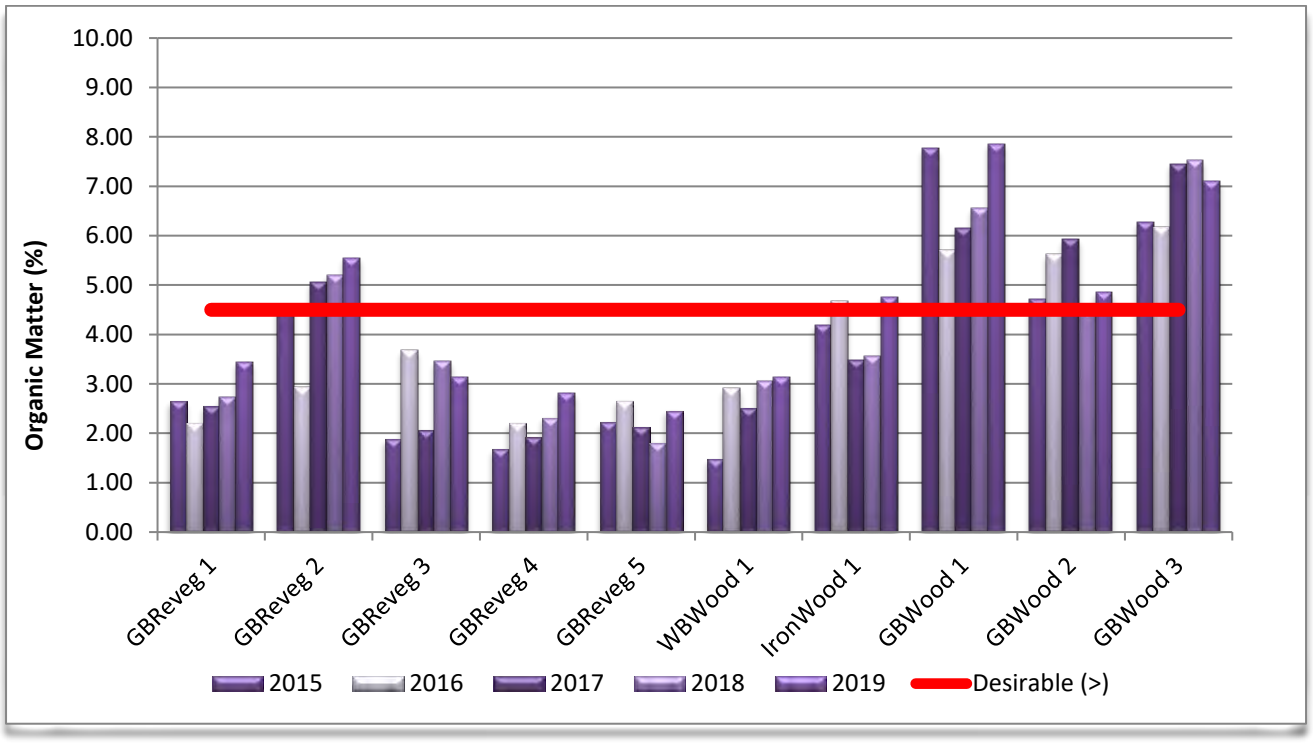


Figure 8-17. Organic Matter concentrations recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

8.11.4 Phosphorous

Phosphorous levels were lower than the agricultural standards across all Grey Box monitoring sites and this year there was marginal change in P recorded across all sites. They remained the highest within the woodland reference sites which had a P range of 10 – 20 mg/kg this year. P concentrations in the remaining revegetation were lowest at GBReveg5 with 7 mg/kg to a high of 10 in GBReveg2 (Figure 8-18).

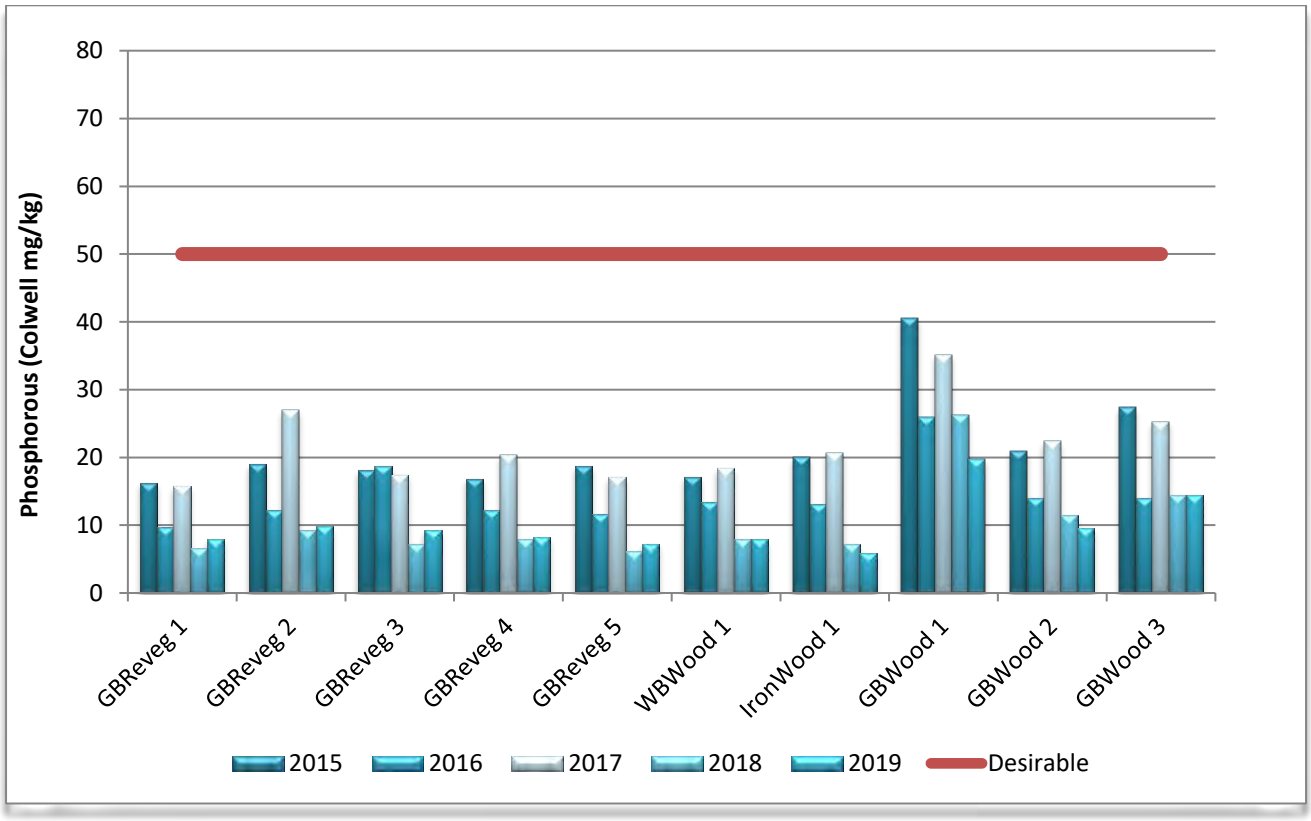


Figure 8-18. Phosphorous concentrations recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

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 occurring, with the exception of the small spike in GBReveg2 and an increased level in GBWood3 this year. In the reference sites N ranged from <0.1 – 4.1 mg/kg and the remaining sites had N concentrations which were very low with most except GBReveg2 with 8.2 mg/kg falling within this local range (Figure 8-19).

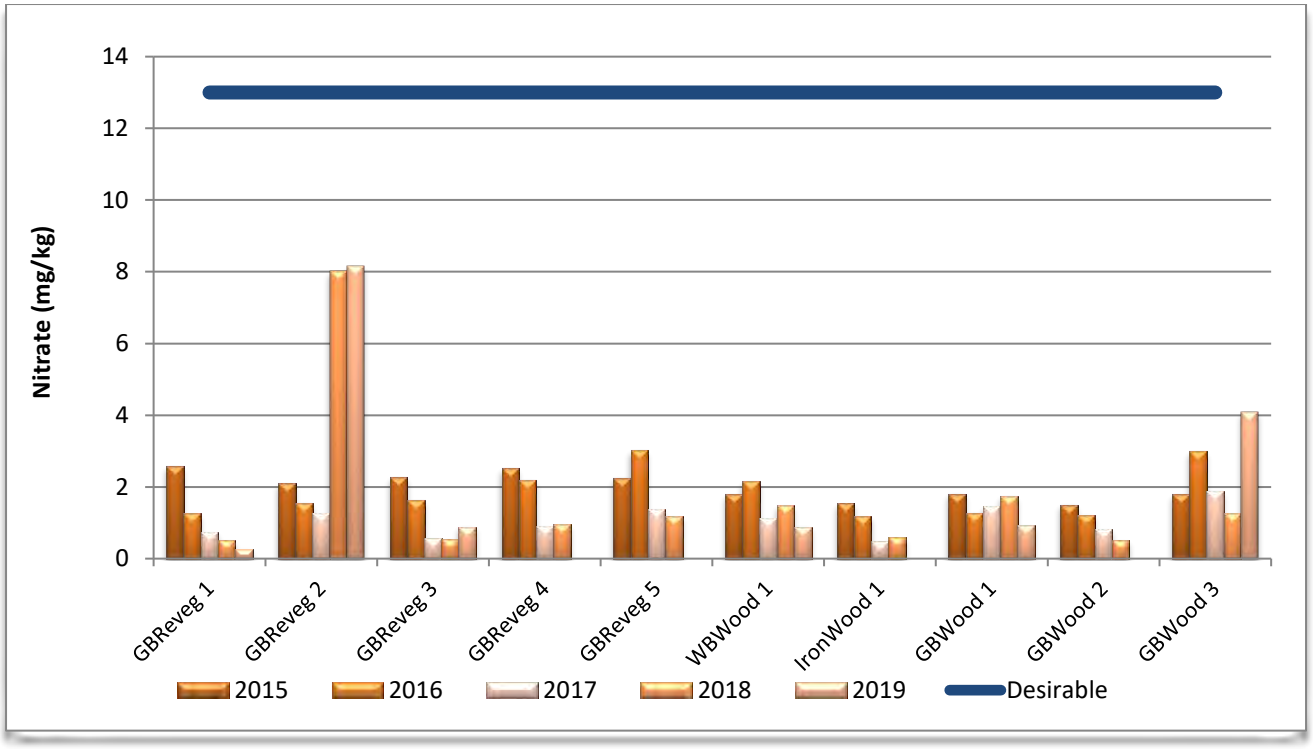


Figure 8-19. Nitrate concentrations recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

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 of the Grey Box monitoring sites had a low CEC and in the reference sites CEC ranged from 4.9 – 9.0 cmol/kg (Figure 8-20). Sites GBReveg1 and WBWood1 had a CEC which were similar to the reference sites. The remaining sites had a low CEC ranging from a low of 2.9 cmol/kg (IronWood1) to a high of 4.3 cmol/kg (GBReveg2).

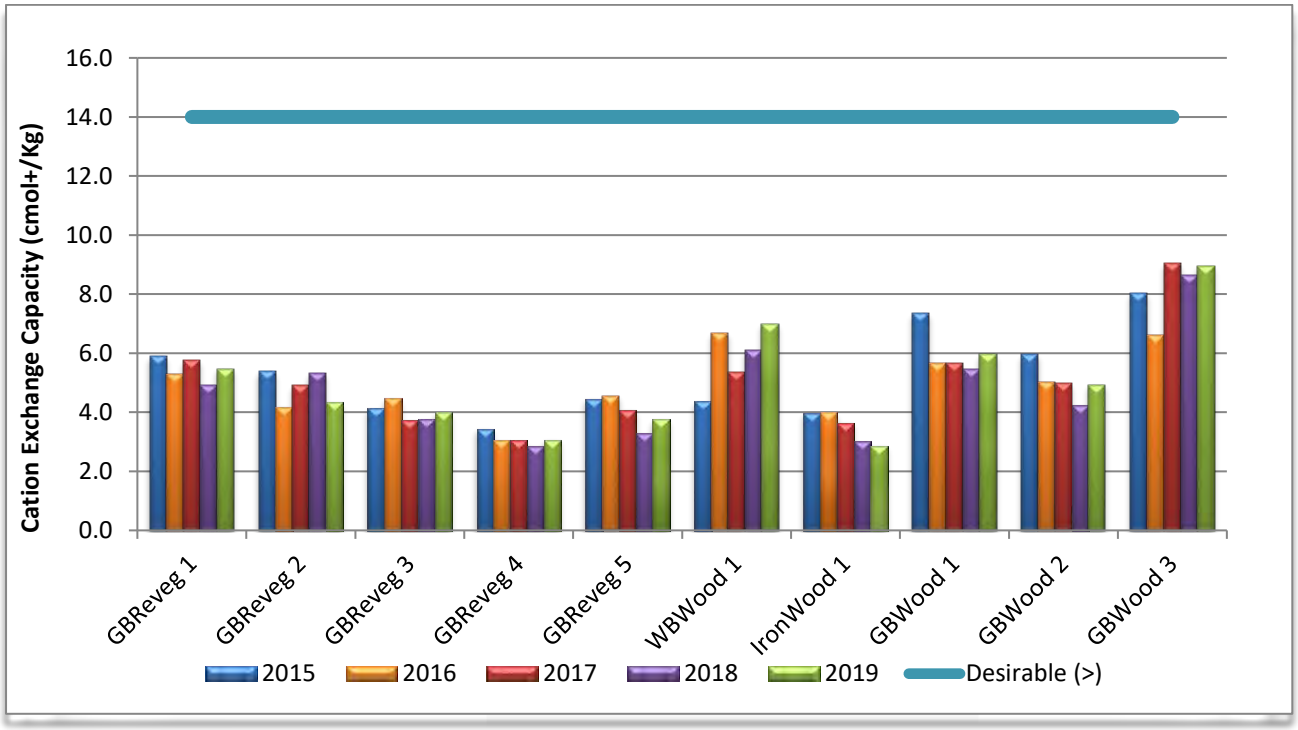


Figure 8-20. Cation Exchange Capacity recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

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 1.2 – 6.8% (Figure 8-21), with site GBWood2 continuing to exceed the minimum 5% threshold for sodicity with an ESP of 6.8%. This year IronWood1 also had a high ESP of 6.0% and while the soil may be sodic they remained within the local ESP levels. The remaining sites had an ESP that was well below the 5% threshold for sodicity and ranged from a low of 0.2% in GBReveg1 to a high of 4.1% in GBReveg2 (Isbell 1996).

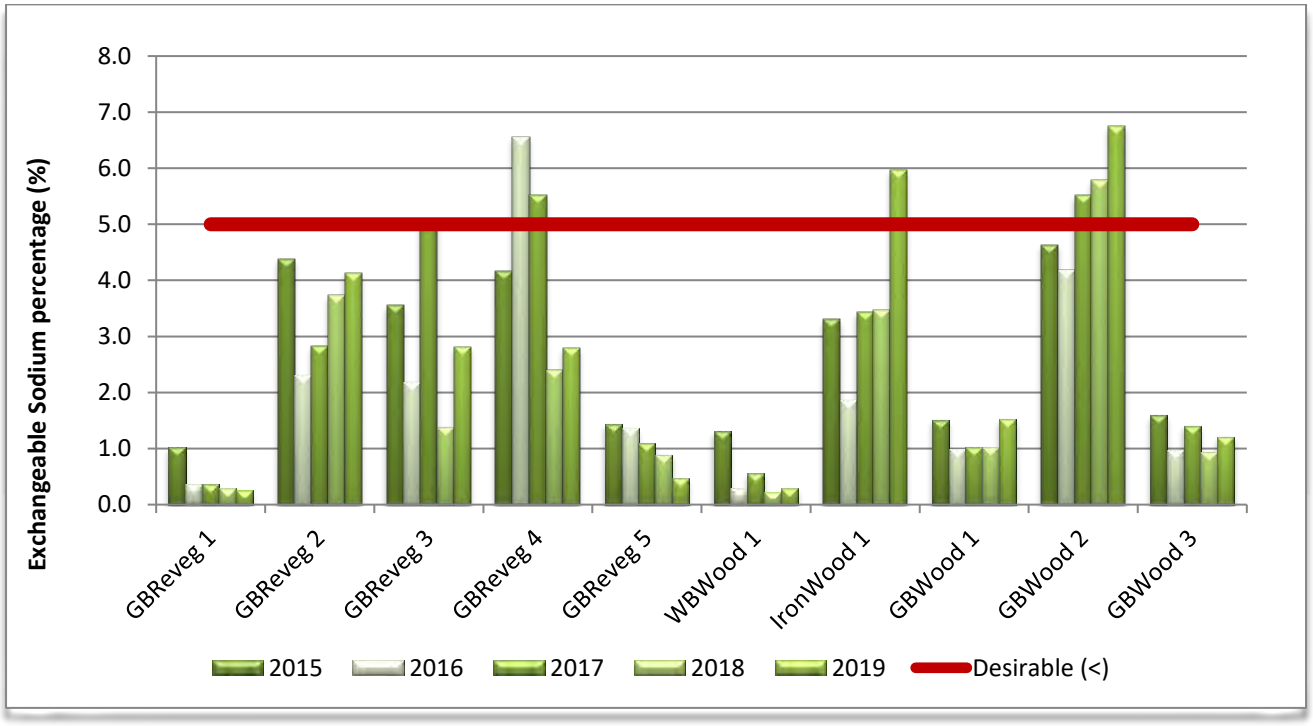


Figure 8-21. ESP recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

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

Table 8-7 indicates the performance of the Kokoda Grey Box monitoring sites against a selection of proposed Completion Performance Indicators during the 2019 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 landuse sustainability (blue). The range values are amended annually.

Monitoring sites meeting or exceeding the range values of the Grey Box woodland reference sites have been identified with a shaded colour box and have therefore been deemed to meet completion criteria targets. In the case of "growth medium development", upper and lower soil property indicators are also based on results obtained from the respective reference sites sampled in 2019. In some cases, the site may not fall within ranges based on these data but may be within "desirable" levels as prescribed by the agricultural industry. If this scenario occurs, the rehabilitation site has been identified using a striped shaded box to indicate that it falls within "desirable" ranges but does not fall within specified completion criteria targets using the adopted methodology. The grey shaded boxes highlight the lack of shrubs in the grassland areas, despite having met this criteria according to the woodland reference sites.

Table 8-7. Performance of the Grey Box monitoring sites against the Primary and Secondary Performance Indicators in 2019.

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2019		GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
Performance indicators are quantified by the range of values obtained from replicated reference sites							2019	2019	2019	Lower	Upper	2019	2019	2019	2019	2019	2019	2019
Phase 2: Landform establishment and stability	Landform slope, gradient	Landform suitable for final landuse and generally compatible with surrounding topography	Slope	Landform is generally compatible within the context of the local topography.		< Degrees (18°)	2	3	1	**1**	**3**	**5**	**4**	**3**	**4**	**3**	**3**	**4**
	Active erosion	Areas of active erosion are limited	No. Rills/Gullies	Number of gullies or rills >0.3m in width or depth in a 50m transect are limited and stabilising		No.	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
			Cross-sectional area of rills		Provides an assessment of the extent of soil loss due to gully and rill erosion and that it is limited and/or is stabilising	m2	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2019		GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
Phase 3: Growth medium development	Soil chemical, physical properties and amelioration	Soil properties are suitable for the establishment and maintenance of selected vegetation species	pH	pH is typical of that of the surrounding landscape or falls within desirable ranges provided by the agricultural industry		pH (*5.6 - 7.3)	**5.0**	**5.1**	**5.3**	**5.0**	**5.3**	**6.7**	**5.3**	**6.0**	**5.7**	**6.1**	**6.2**	**4.8**
			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)	**0.067**	**0.066**	**0.079**	**0.066**	**0.079**	**0.031**	**0.064**	**0.024**	**0.021**	**0.017**	**0.032**	**0.061**
			Organic Matter	Organic Carbon levels are typical of that of the surrounding landscape, increasing or fall within desirable ranges provided by the agricultural industry		% (*>4.5)	**7.9**	**4.8**	**7.1**	**4.8**	**7.9**	**3.4**	**5.5**	**3.1**	**2.8**	**2.5**	**3.1**	**4.8**
			Phosphorous	Available Phosphorus is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		ppm (*50)	**19.7**	**9.5**	**14.4**	**9.5**	**19.7**	**7.9**	**9.8**	**9.2**	**8.2**	**7.2**	**7.9**	**5.9**
			Nitrate		Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	ppm (*>12.5)	**0.9**	**<0.1**	**4.1**	**0.9**	**4.1**	**0.3**	**8.2**	**0.9**	**<0.1**	**<0.1**	**0.9**	**<0.1**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2019		GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
			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)	6.0	4.9	9.0	4.9	9.0	5.5	4.3	4.0	3.1	3.8	7.0	2.9
			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	6.8	1.2	1.2	6.8	0.2	4.1	2.8	2.8	0.5	0.3	6.0
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		%	59.5	62.9	66.5	59.5	66.5	73.6	61.0	73.1	67.5	73.9	62.7	62.5
			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	98	100	98.0	100.0	100	100	100	100	100	100	100	100
	Vegetation diversity	Vegetation contains a diversity of species comparable to that of the local remnant vegetation	Diversity of shrubs and juvenile trees	The diversity of shrubs and juvenile trees with a stem diameter < 5cm is comparable to that of the local remnant vegetation.		species/ area	1	2	2	1	2	1	0	0	0	0	5	6

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2019		GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
				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	0	0	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	4	12	9	4	12	25	24	27	24	30	29	20
			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	4	12	9	4	12	11	20	12	14	17	28	19
			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	0	0	0	0	0	14	4	15	10	13	1	1
	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	1	18	4	1	18	1	0	0	0	0	8	129

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2019		GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
	Ecosystem composition	The vegetation is comprised by a range of growth forms comparable to that of the local remnant vegetation	Trees	The number of tree species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	1	2	2	1	2	1	0	0	0	0	4	6
			Shrubs	The number of shrub species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	0	2	1	0	2	0	0	0	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	0	0	0	0	0	0	0	0	0	3	3
			Herbs	The number of herbs or forb species comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	1	4	1	1	4	15	16	17	15	21	11	4
			Grasses		The number of grass species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	2	4	4	2	4	9	7	9	8	8	7	4
			Reeds		The number of reeds, sedge or rush species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	0	1	0	1	0	0	0	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2019		GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
			Ferns		The number of ferns comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	0	0	0	0	0	1	1	1	1	1	1
			Vines		The number of vines or climbing species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	0	0	0	0	0	0	0	0	0	0	0
			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 & Landuse Sustainability	Landscape Function Analysis (LFA): Landform function and ecological performance	Landform is ecologically functional and performing as it was designed to do	LFA Infiltration	LFA infiltration index provides an indication of the sites infiltration capacity and is comparable to or trending towards that of the local remnant vegetation		%	52.6	57.0	55.4	52.6	57.0	45.5	33.6	47	42.6	45.2	52.7	48.4
			LFA Nutrient recycling	LFA nutrient recycling index provides an indication of the sites ability to recycle nutrient and is comparable to or trending towards that of the local remnant vegetation		%	49.0	53.2	52.2	49.0	53.2	44.1	31.1	42.1	37.6	43.9	53.2	44.3
	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	%	88	93	96	87.5	95.5	48	50.5	62.5	59	61	96	73.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2019		GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
		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	0	0	0.0	0.0	10	3.5	12.5	7	5	0	0
			Cryptogam cover		Percent ground cover provided by cryptogams (e.g. mosses, lichens) is comparable to that of the local remnant vegetation	%	0	0	0	0.0	0.0	11.5	7.5	3.5	0	14.5	0	1.5
			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
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	4	1	1	0.5	4.0	0	0	0	0	0	0	5.5
			Bare ground		Percentage of bare ground is less than or comparable to that of the local remnant vegetation	< %	8	4	2	1.5	8.0	4	27.5	10.5	17	3.5	1	19.5
			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		%	1	3	3	0.5	2.5	26.5	11	11	17	16	3	0
			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		%	92	96	99	92.0	98.5	96	72.5	89.5	83	96.5	99	80.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2019		GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
	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	**2.0**	**1.6**	**2.2**	**1.6**	**2.2**	**3.4**	**4**	**1.8**	**3.2**	**4.8**	**4.4**	**3.2**
			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/m^2	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5.2**	**1.4**	**4.6**	**3**	**3.8**	**0.2**	**0**
	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		%	**100**	**100**	**100**	**100**	**100**	**47.8**	**73**	**37.3**	**59.6**	**58.7**	**96.7**	**100**
	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	**1**	**6**	**1**	**1**	**6**	**1**	**0**	**0**	**0**	**0**	**6**	**94**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2019		GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
			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	12	1	0	12	0	0	0	0	0	2	32
			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	0	0	0	0	0	0	0	0	0	0	3
			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	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2019		GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
			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**	**2**	**0**	**2**	**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	**0**	**6**	**0**	**0**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
			Foliage cover 2 - 4m		Projected foliage cover provided by perennial plants in the 2 - 4m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation	% cover	**6**	**3**	**4**	**3**	**6**	**0**	**0**	**0**	**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	**27**	**9**	**7**	**7**	**27**	**0**	**0**	**0**	**0**	**0**	**21**	**0**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2019		GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
			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	**44**	**50**	**46**	**44**	**50**	**0**	**0**	**0**	**0**	**0**	**48**	**45**
	Tree diversity	Vegetation contains a diversity of maturing tree and shrubs species comparable to that of the local remnant vegetation	Tree diversity		The diversity of trees or shrubs with a stem diameter > 5cm is comparable to the local remnant vegetation. Species used in rehabilitation will be endemic to the local area	species/ area	**1**	**3**	**2**	**1**	**3**	**0**	**0**	**0**	**0**	**0**	**3**	**4**
				The percentage of maturing trees and shrubs with a stem diameter > 5cm dbh which are local endemic species and these percentages are comparable to the local remnant vegetation		%	**100**	**100**	**100**	**100**	**100**	**0**	**0**	**0**	**0**	**0**	**100**	**100**
	Tree density	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**	**17**	**23**	**17**	**34**	**0**	**0**	**0**	**0**	**0**	**30**	**17**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2019		GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
	Ecosystem health	The vegetation is in a condition comparable to that of the local remnant vegetation.	Live trees	The percentage of the tree population which are live individuals and that the percentage is comparable to the local remnant vegetation		% population	100	100	85	85	100	0	0	0	0	0	88	70
			Healthy trees	The percentage of the tree population which are in healthy condition and that the percentage is comparable to the local remnant vegetation		% population	0	30	5	0	30	0	0	0	0	0	0	2.5
			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	75	52	50	50	75	0	0	0	0	0	75	30
			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	25	17	30	17	30	0	0	0	0	0	12.5	37.5
			Dead Trees		The percentage of the tree population which are dead (stags) and that the percentage is comparable to the local remnant vegetation	% population	0	0	15	0	15	0	0	0	0	0	12.5	30.0
			Mistletoe		The percentage of the tree population which have mistletoe provides an indication of community health and habitat value and	% population	0	0	0	0	0	0	0	0	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure (*desirable)	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2019		GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
					that the percentage is comparable to the local remnant vegetation													
			Flowers/fruit: Trees	The percentage of the tree population with reproductive structures such as buds, flowers or fruit provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources comparable to that of the local remnant vegetation		% population	**0**	**26**	**25**	**0**	**26**	**0**	**0**	**0**	**0**	**0**	**62.5**	**20**
			Hollows: Trees		The percentage of the tree population which have hollows provides an indication of the habitat value and that the percentage is comparable to the local remnant vegetation	% population	**50**	**0**	**10**	**0**	**50**	**0**	**0**	**0**	**0**	**0**	**12.5**	**0**

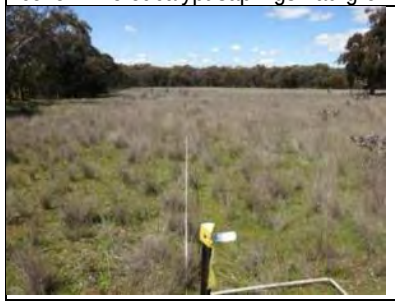
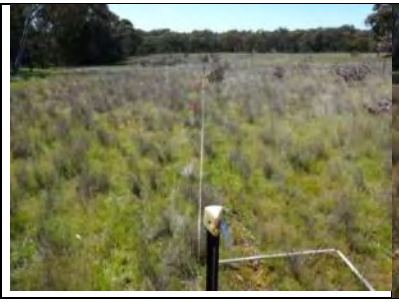
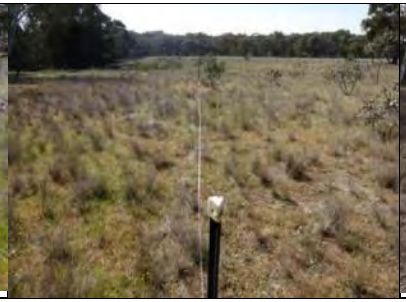
9 Results Dwyer's Red Gum monitoring sites

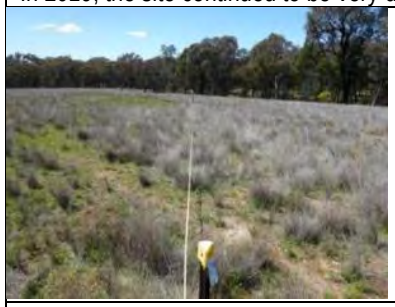
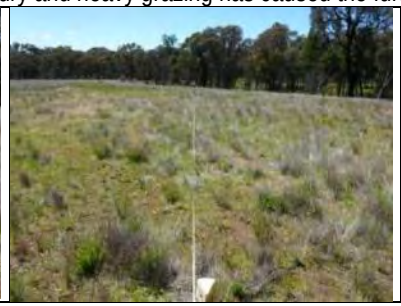
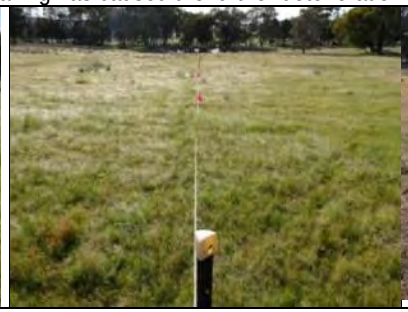
This section provides the results of the monitoring within the Dwyer's Red Gum monitoring sites and demonstrates ecological trends and performance of the revegetation sites against a selection of ecological performance indicators. This section has also included the Low Quality Dwyer's Red Gum woodland.

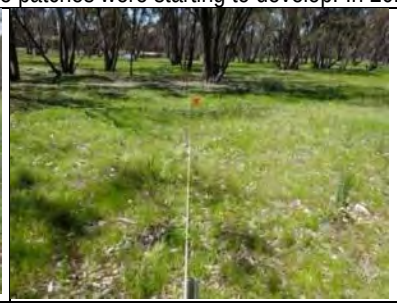
9.1 Photo-points

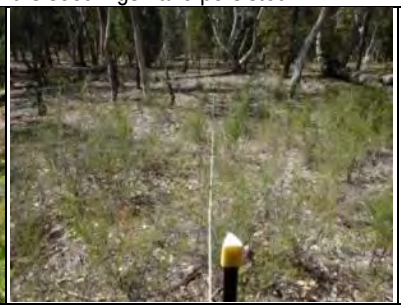
General descriptions of the Dwyer's Red Gum Woodland monitoring sites established at Kokoda including photographs taken along the vegetation transect are provided Table 9-1.

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

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

2015	2016	2017	2018	2019
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.				
				
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.				
				

2015	2016	2017	2018	
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.				
				
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.				
				

2015	2016	2017	2018	2019
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.				
				
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.				
				

9.2 Landscape Function Analyses

9.2.1 Landscape Organisation

The three Dwyer's 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. This year heavy grazing and disturbance by animals resulted in a reduction in patch area in DWood3, to provide a slightly lower target LO range of 90 - 100%.

While the Dwyer's Red Gum 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. This year heavy grazing and disturbance by animals also resulted in a reduction in patch area in DReveg1 while no change was recorded in DReveg2, with these having an LO of 89% and 86% respectively (Figure 9-1). Despite the drought and increased levels of grazing, functional patch area remained at 100% in DReveg3.

The low quality Dwyer's Red Gum woodland site 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. While there was limited live plant cover this year, this site continued to have high functional patch area and an LO of 100%.

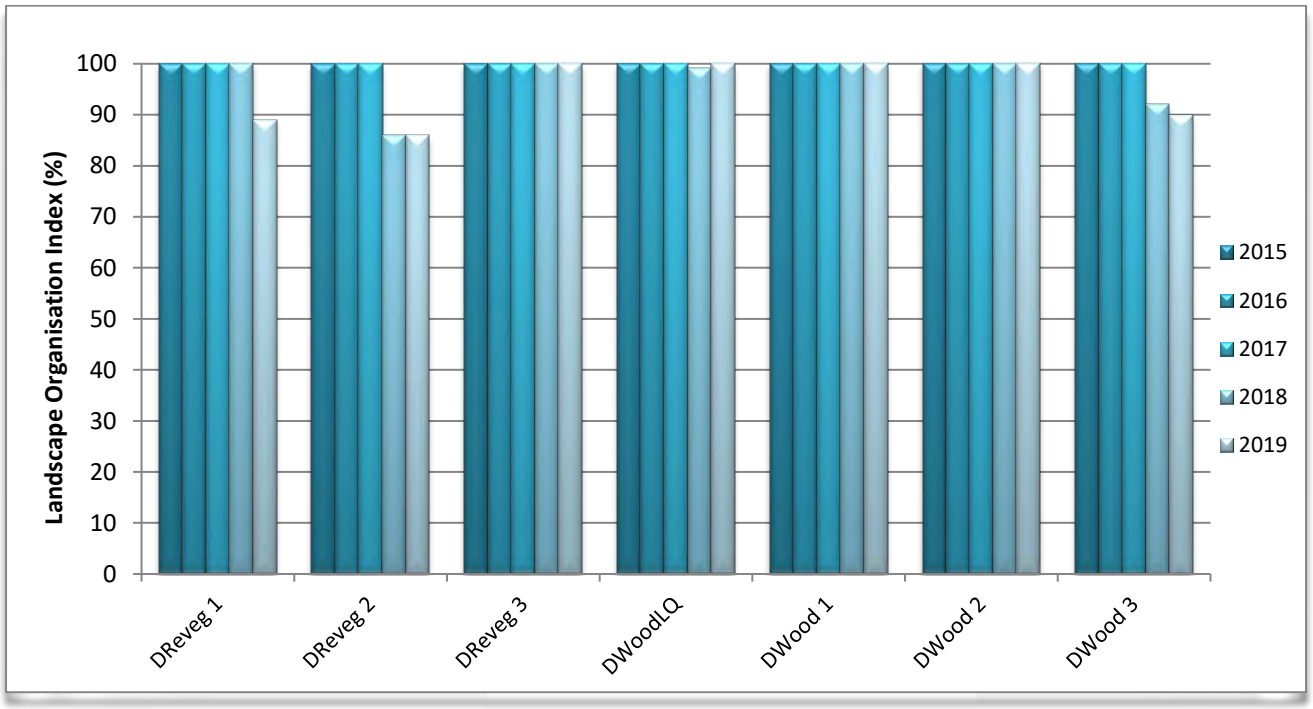


Figure 9-1. Landscape Organisation Indices recorded in the **Dwyer's Red Gum** woodland monitoring sites.

9.2.2 Soil surface assessments

9.2.2.1 Stability

LFA stability indices in the Dwyer's Red Gum reference sites were previously demonstrating an increasing trend, however since 2018 decreasing stability has been recorded in DWood1 and DWood2. This year an increase was recorded in DWood3 with the resultant range being 64.5 – 71.7. The stability in these sites was being provided by the perennial tree and ground cover, moderately deep and decomposing litter layers and cryptogams were often moderately abundant. This year however, heavy grazing and disturbance by animals has tended to reduce

the integrity of the ground covers in most sites and litter layers where the soils become more susceptible to erosion and deposition especially in DWood1 and DWood2. In the low quality woodland the stability index had also slightly decreased to 65.0 however it remained comparable to the woodland reference sites (Figure 9-2).

In the Dwyer's Red Gum derived native grasslands stability declined in all sites and stability indices ranged from a low of 64.5 (DReveg3) to a high of 73.2 (DReveg1) and all sites continued to have a stability which was similar to or more stable than the 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.

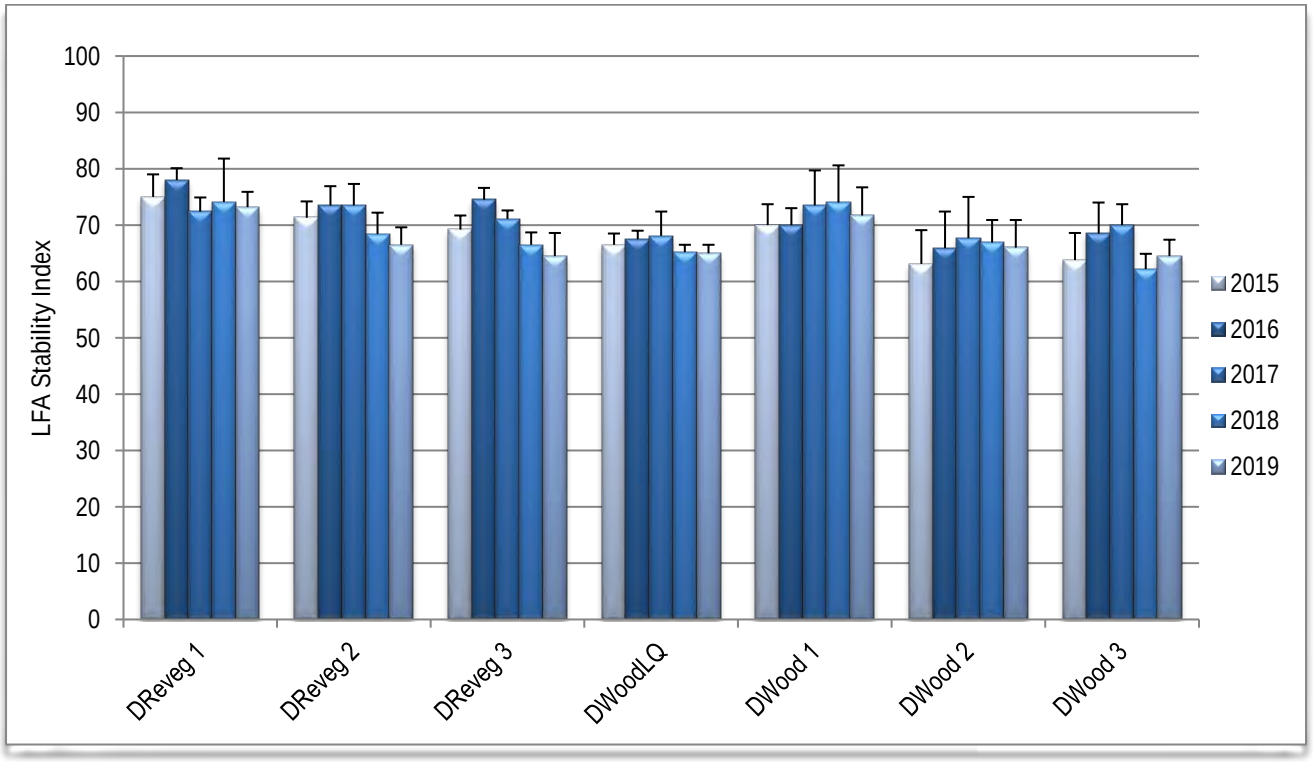


Figure 9-2. LFA stability indices recorded in the **Dwyer's Red Gum** woodland monitoring sites.

9.2.2.2 Infiltration

The infiltration capacity of the Dwyer's Red Gum woodland reference sites have slightly decreased over the past two years, as drought conditions resulted in the deterioration of the litter and an increased resistance of the soil crusts. This year the infiltration capacity of the reference sites was 48.9 – 54.6. Despite the drought, a marginal increase in infiltration capacity was recorded in the low quality woodland with this site having a higher infiltration index of 55.9 (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 two 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. Thus, the infiltration capacity in these sites has marginally declined to provide indices ranging from 37.8 – 43.0. All Dwyer's Red Gum revegetation sites therefore had a low infiltration capacity compared to the reference sites again this year.

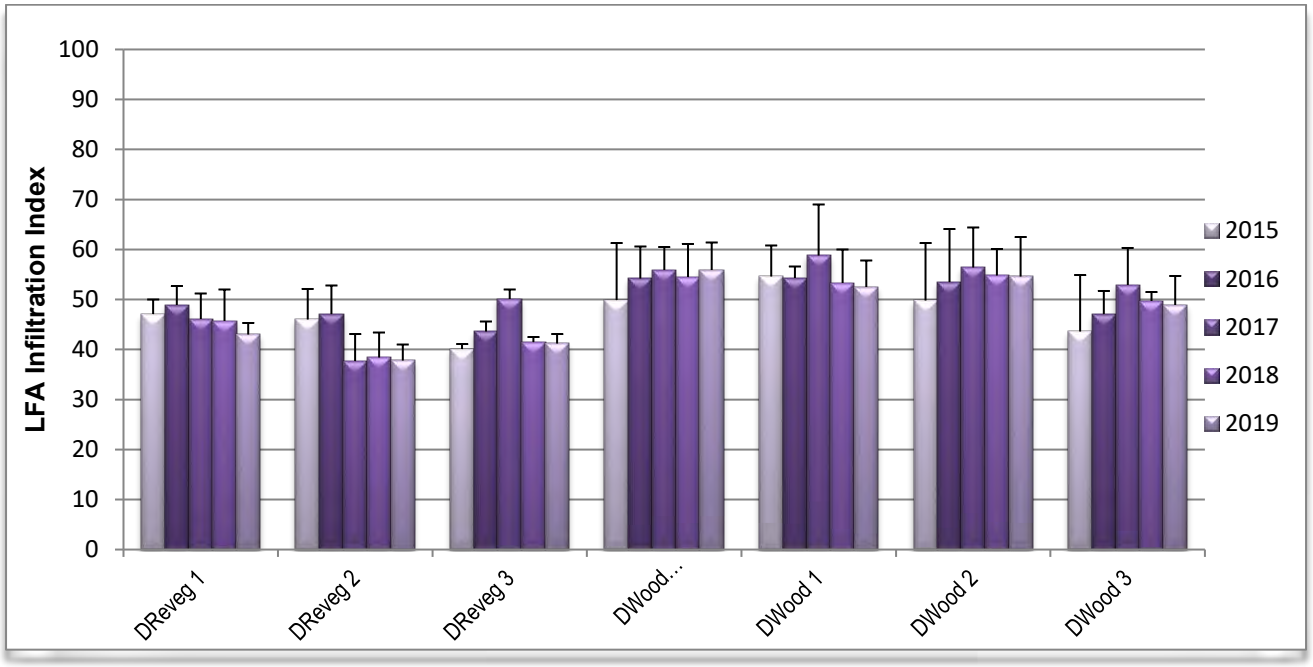


Figure 9-3. LFA infiltration indices recorded in the **Dwyer's Red Gum** woodland monitoring sites.

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 the low quality woodland, 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 has typically resulted in a marginal decrease in nutrient recycling capacity in the Dwyer's Red Gum woodland reference sites to provide a range of 47.7 – 51.0 with the low quality woodland scoring 54.9 this year (Figure 9-4).

In the Dwyer's Red Gum revegetation sites there was also a reduction in nutrient recycling capacity this year with a low of 35.8 in DReveg3 and a high of 39.7 in DReveg1.

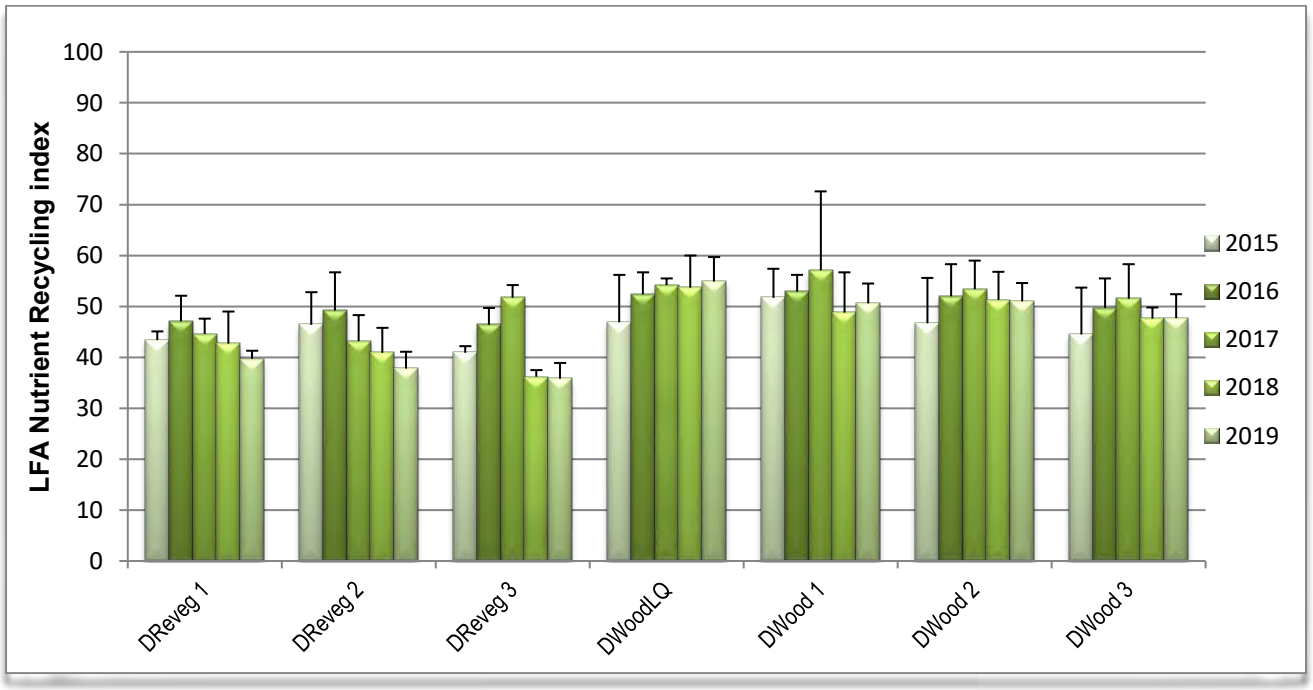


Figure 9-4. LFA nutrient recycling indices recorded in the **Dwyer's Red Gum** woodland monitoring sites.

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) and the Dwyer's Red Gum reference site DWood1 being the most ecologically functional sites with total scores of 176 and 175 respectively. The next most functional site was DWood2 with a sum of scores of 172, followed by DWood3 with a total score of 161. This was followed by the pasture revegetation site DReveg1 with156, while DReveg2 and DReveg3 continued to be the least functional sites with the same score of 142.

Examples of the various combinations of ground covers which are critical to overall ecosystem function have been provided in Table 9-2.

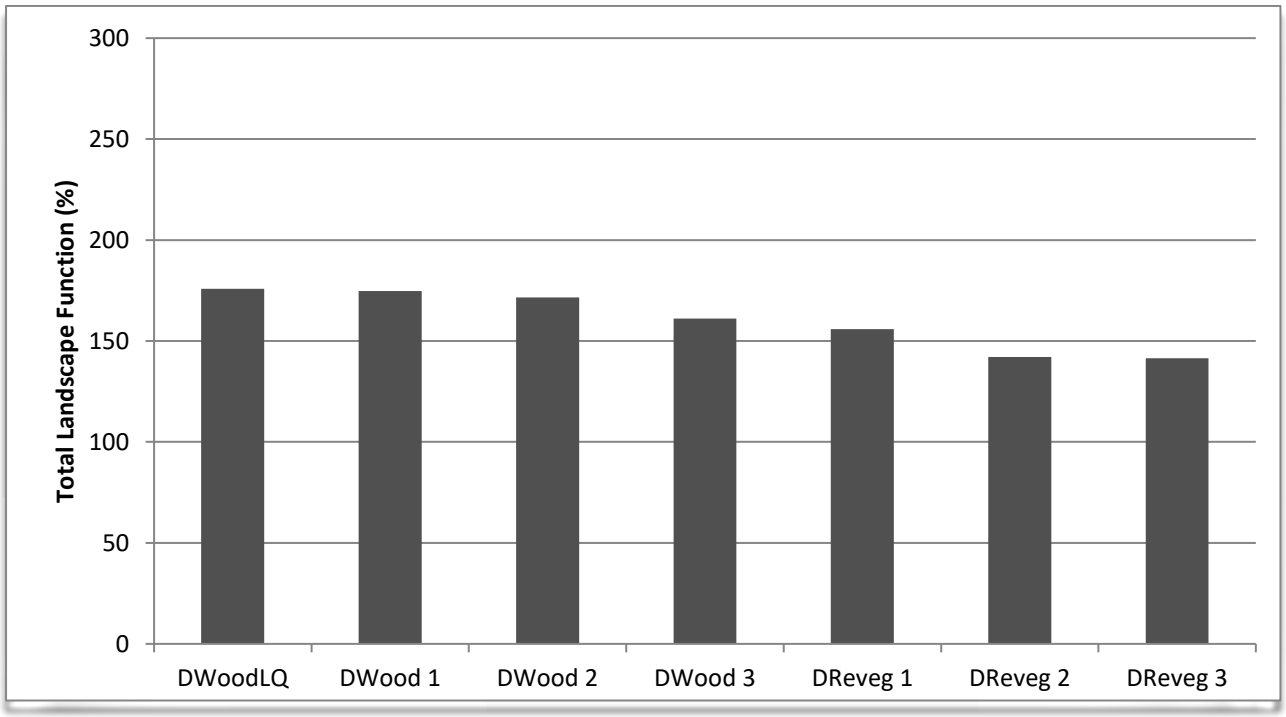


Figure 9-5. Sum of the LFA stability, infiltration and nutrient recycling components indicating the most functional to least functional monitoring site recorded in 2019.

Table 9-2. Examples of the different ground covers in the Kokoda **Dwyer's Red Gum** monitoring sites in 2019.

DReveg1	DReveg2
	

9.3 Trees and mature shrubs

9.3.1 Population density

There were no changes in densities of trees and mature shrubs with a stem diameter >5 cm dbh within the three Dwyer's Red Gum woodland reference sites this year with 8 – 27 live individuals in the reference sites, equating to a density of 200 – 725 stems per hectare (Figure 9-6). There continued to be nine trees in the low quality Dwyer's Red Gum woodland (DWoodLQ) and one eucalypt sapling continued to be recorded in DReveg1. 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 Dwyer's Red Gum reference sites continued to be 11 – 23 cm but ranged from 5 – 50 cm (Table 9-3). The small trunk diameters indicate the trees are relatively young and indicative of their regrowth status. In the low quality woodland, the average dbh was 22 cm and ranged from 15 – 26 cm. In DReveg1, the sapling had grown and had a slightly larger dbh of 8 cm.

9.3.3 Condition

The trees and mature shrubs in the Dwyer's Red Gum woodland reference sites were typically in moderate health but 68% of the population were (dead) stags in DWood1, while in DWood2 and DWood3 20 – 27% were stags. All three sites had individuals bearing reproductive structures such as buds, flowers or fruit this year with 70% of individuals in DWood3 with mature fruit. A small percentage of individuals in DWood1 and DWood3 contained hollows suitable for nesting sites (>10 cm) but no mistletoe was recorded this year. In the low quality woodland, all trees were typically in medium health with some in a state of advanced dieback, with most bearing mature fruit. The eucalypt sapling in DReveg1 was considered to be healthy.

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*. The low quality woodland was dominated by *E. dwyeri* and contained one *E. albens* (White Box). The single individual in DReveg1 was an *E. dwyeri* sapling.

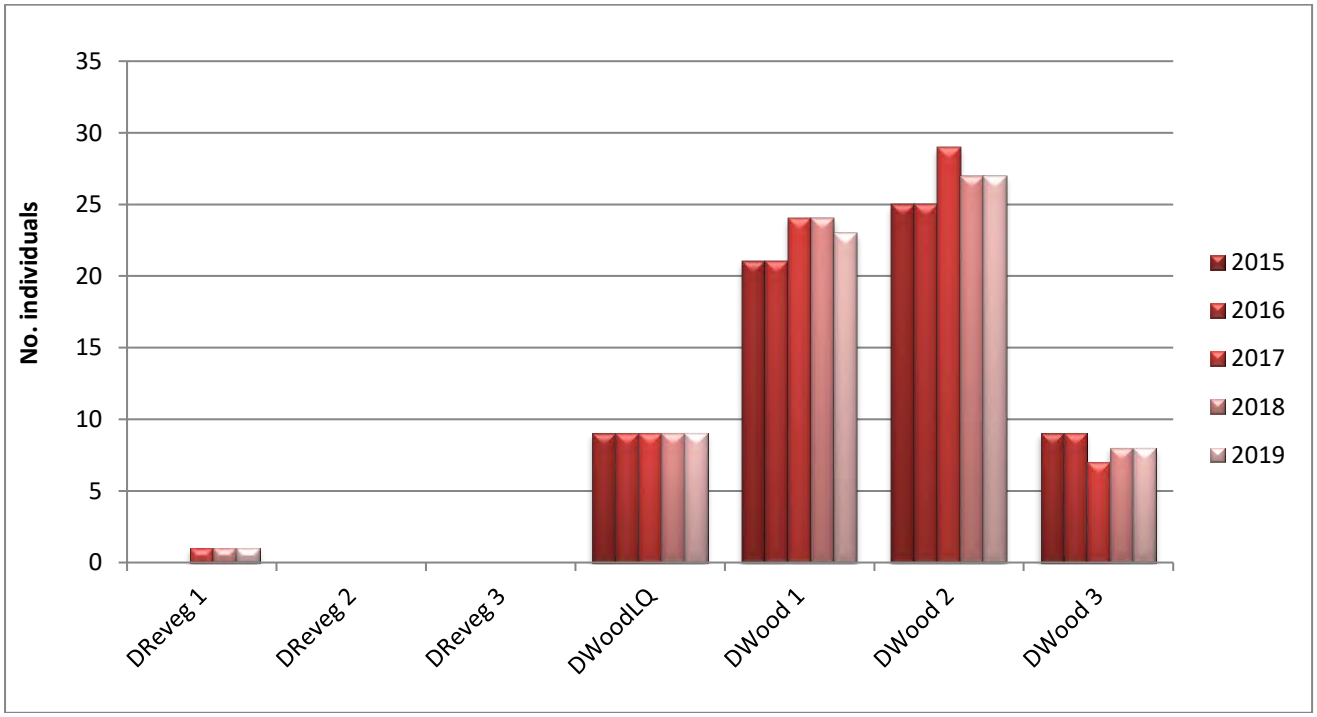


Figure 9-6. Tree and mature shrub densities (>5cm dbh) in the Kokoda **Dwyer's Red Gum** woodland monitoring sites.

Table 9-3. Trunk diameters and condition of the trees and mature shrubs in the **Dwyer's Red Gum** monitoring sites in 2019.

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
DReveg1	1	8	8	8	1	1	100	100	0	0	0	0	0	0
DReveg2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DReveg3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DWoodLQ	2	22	26	15	9	7	100	0	0	0	0	0	67	0
DWood1	3	11	29	5	71	1	32	0	0	0	0	0	11	4
DWood2	3	17	50	5	37	1	73	5	49	19	27	0	38	3
DWood3	3	23	32	7	10	2	80	0	80	0	20	0	70	0

9.4 Shrubs and juvenile trees

9.4.1 Population density

There was a large variation on the number of shrubs and juvenile trees (<5 cm dbh) recorded in the Red Gum reference sites with densities declining in DWood1 and DWood2 this year as a result of drought mortality. In DWood3 however, many shrubs had persisted and there were continued to be significant numbers of Callitris seedlings which were difficult to count with accuracy. Nonetheless seedling densities were in the range of 46 – 1762 individuals (Figure 9-7). In the low quality woodland, there were 8 seedlings this year. In the derived grasslands, there were 11 seedlings recorded in DReveg1, three in DReveg2 and in DReveg3 there was one *Allocasuarina verticillata* seedling with these being the result of natural regeneration.

9.4.2 Height class

In the reference sites the vast majority of individuals were less than 0.5 m in height, with some individuals being >2.0 m in height in DWood2 (Table 9-4). In DReveg1 most height classes continue to be represented, while in DReveg2 some seedlings were 0.5 – 1.0 m in height. In DReveg3 and the low quality woodland (DWoodLQ), all individuals continued to be less than 0.5 m in height.

9.4.3 Species diversity

In the woodland reference sites, there were 3 - 5 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 nine scattered *E. dwyeri*, but the acacia seedlings were not found this year.

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

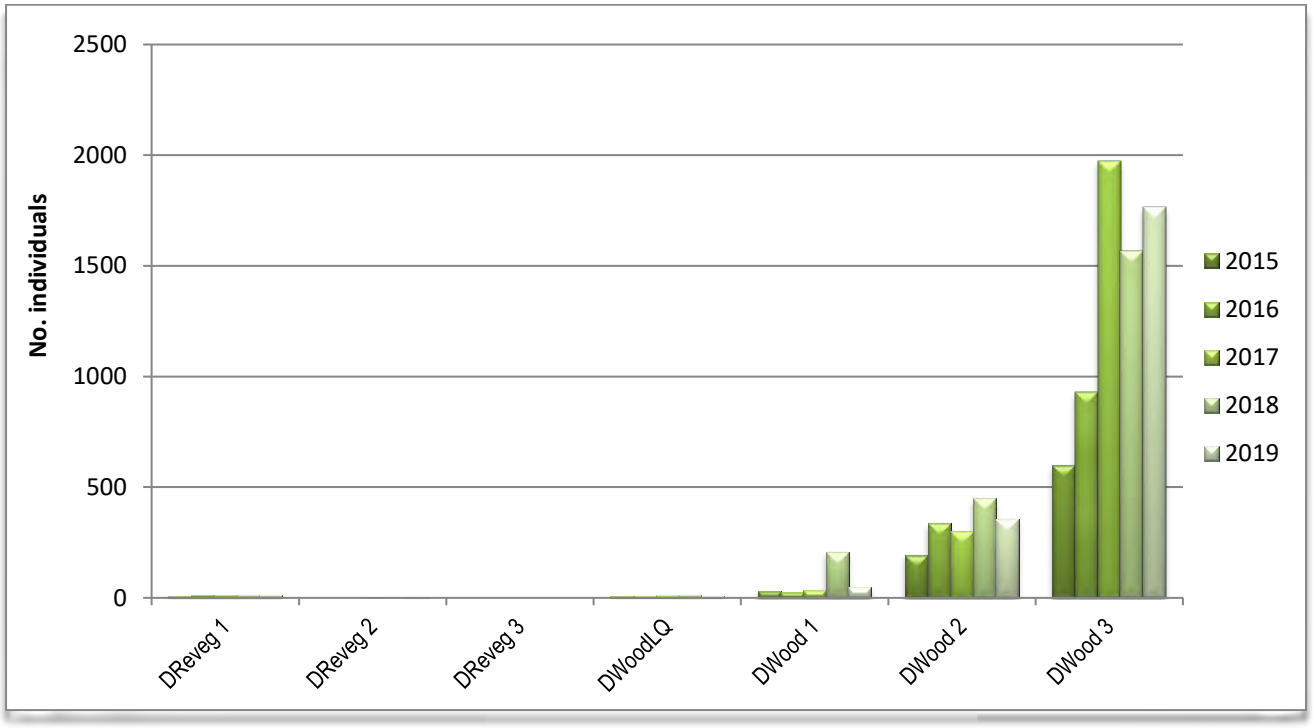


Figure 9-7. Total shrubs and juvenile trees recorded in the Red Gum monitoring sites.

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
DReveg1	1	0	3	1	6	11	2	100
DReveg2	2	1	0	0	0	3	3	100
DReveg3	1	0	0	0	0	1	1	100
DWoodLQ	8	0	0	0	0	8	1	100
DWood1	46	0	0	0	0	46	3	100
DWood2	332	22	0	0	2	356	4	100
DWood3	1458	250	54	0	0	1762	5	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 but these did not look active this year.

This year there was 75 – 92% total ground cover in the reference sites (Figure 9-8). Heavy grazing also caused a reduction on total ground cover in the grassland areas and they ranged from a low of 72% in DReveg1 to a high of 87.5% in DReveg3 and DWoodLQ. All sites except DReveg2 had a total ground cover comparable to or higher than the reference sites this year.

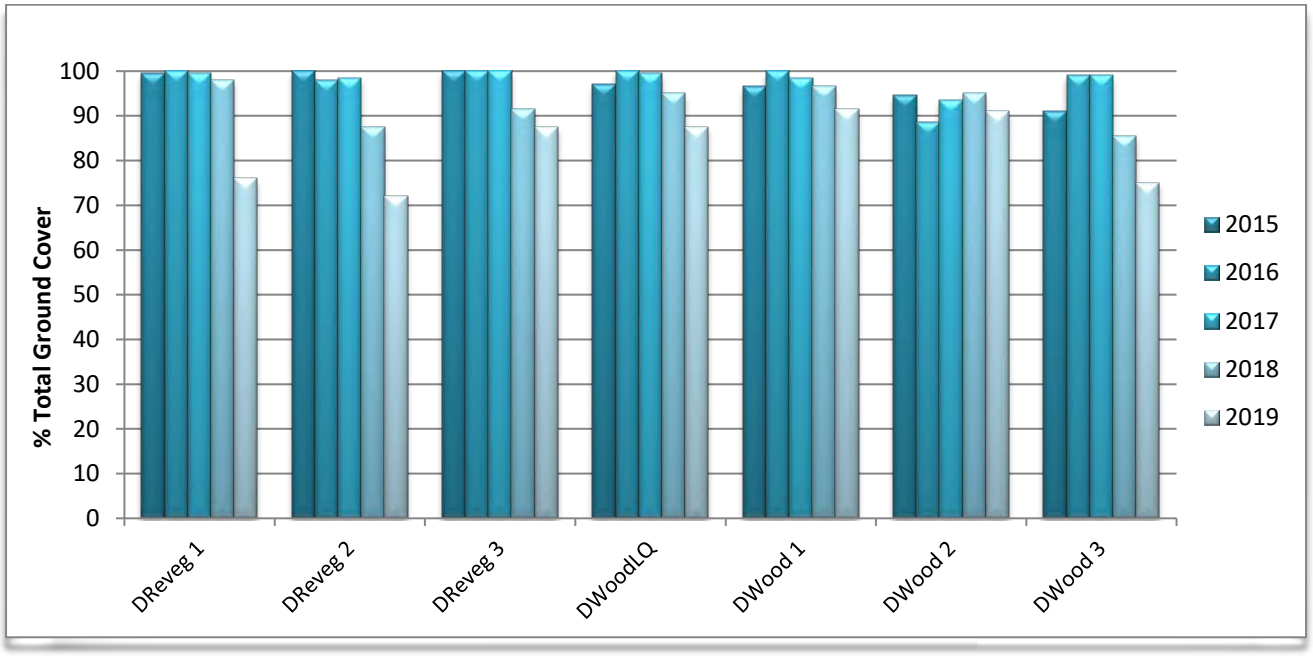


Figure 9-8. Total ground cover recorded in the Red Gum woodland monitoring sites.

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 most dominant form of ground cover continued to be dead leaf litter which provided 57.5 – 77.5% of the total ground cover this year. There was 3.5 – 8.0% cover provided by perennial vegetation and cryptogams provided 1.5 – 10.0% of the total cover. There was 6.5 – 8.5% cover provided by fallen branches in two sites, and in DWood1 there were 7% cover from scattered rocks. No annual ground cover was recorded in the reference sites this year as a result of the prolonged dry conditions.

The ground cover in the low quality woodland was also dominated by litter and had a small amount of cover of cryptogam and perennial ground covers, but perennial ground cover was comparatively low this year with 1.5% cover on average. DWoodLQ also did not tend to have fallen branches or rocks. The reference sites and the low quality woodland 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 comparison the pasture revegetation sites were dominated by dead litter and in DReveg1 and DReveg2, cryptogams were relatively abundant and provided 17 – 17.5% of the total ground cover, while there was 5 – 10% perennial plant cover. In DReveg3, ground cover was provided by dead litter (56.5%), and perennial (16.5%) and annual plants (14.5%), however no cryptogam cover was recorded this year. No cover >0.5 m in height was recorded this year due to heavy grazing and lack of shrub or tree canopies, except in DReveg1 where the eucalypt sapling provided some additional cover at 14 m along the transect.

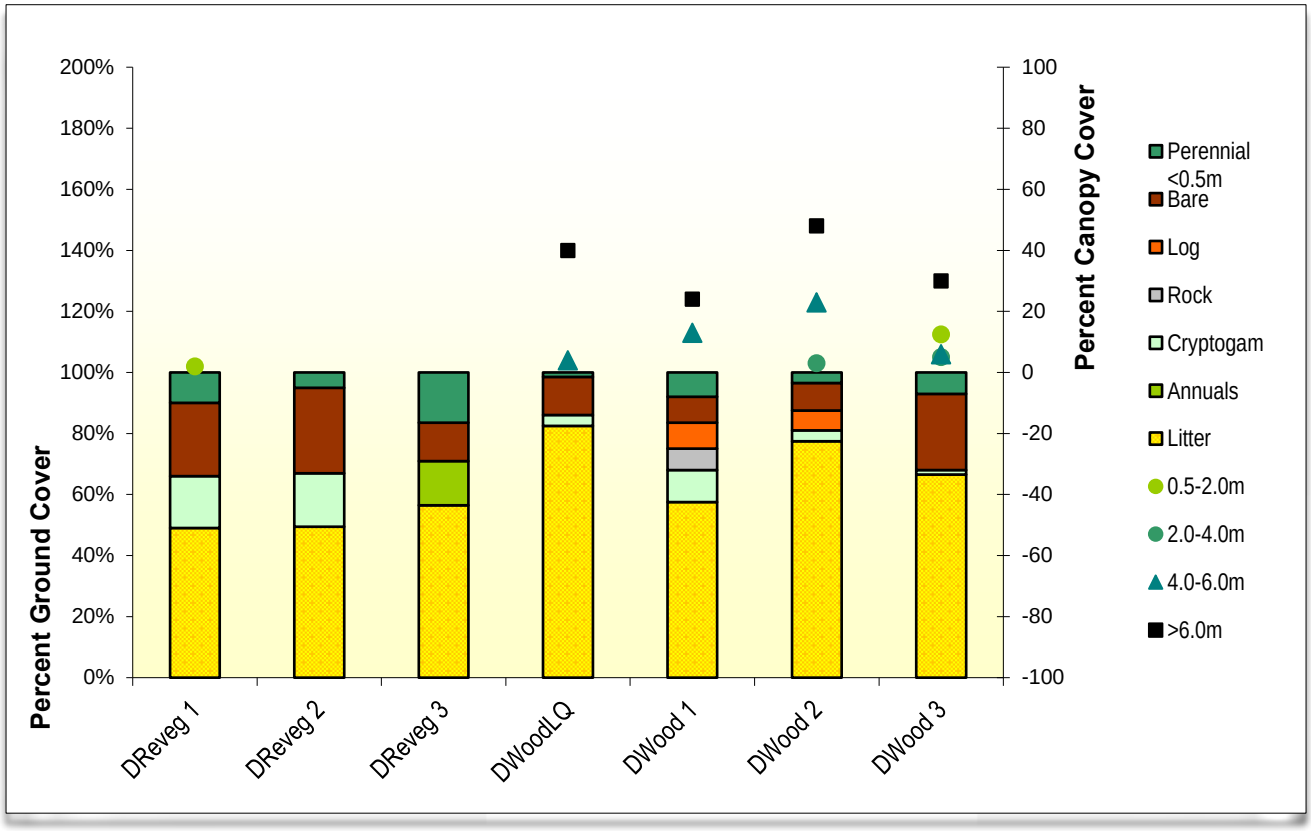


Figure 9-9. Average percent ground cover and projected foliage cover recorded in the Red Gum monitoring sites.

9.7 Floristic Diversity

Total floristic diversity recorded within the 20 x 20 m Red Gum monitoring sites was the highest since monitoring began as result of the favourable seasonal conditions with 46 – 52 species being recorded (Figure 9-10). Since 2017 there have been prolonged dry conditions and floristic diversity continued to decline with only 11 - 26 species recorded in the reference sites this year.

In the low quality woodland, there were a total of 12 species which was comparable to the reference sites. All other revegetation monitoring sites demonstrated a similar reduction in diversity and ranged from 11 – 30 species, with these having a similar or higher total species diversity than the reference sites.

In the Red Gum woodland reference sites, native species continued to be more diverse than exotic species with 11 – 24 native species and only 0 – 2 exotic species being recorded this year. In the low quality woodland floristic diversity was comparable to the reference sites with 12 native species (Figure 9-11, Figure 9-12). In the revegetation grassland sites there were more native species than exotics this year, with the native species diversity being comparable to the reference sites except in DReveg2 with 10 species. While only one exotic species was recorded in DReveg2, there were too many in DReveg1 and DReveg3 with six and 12 exotic species respectively.

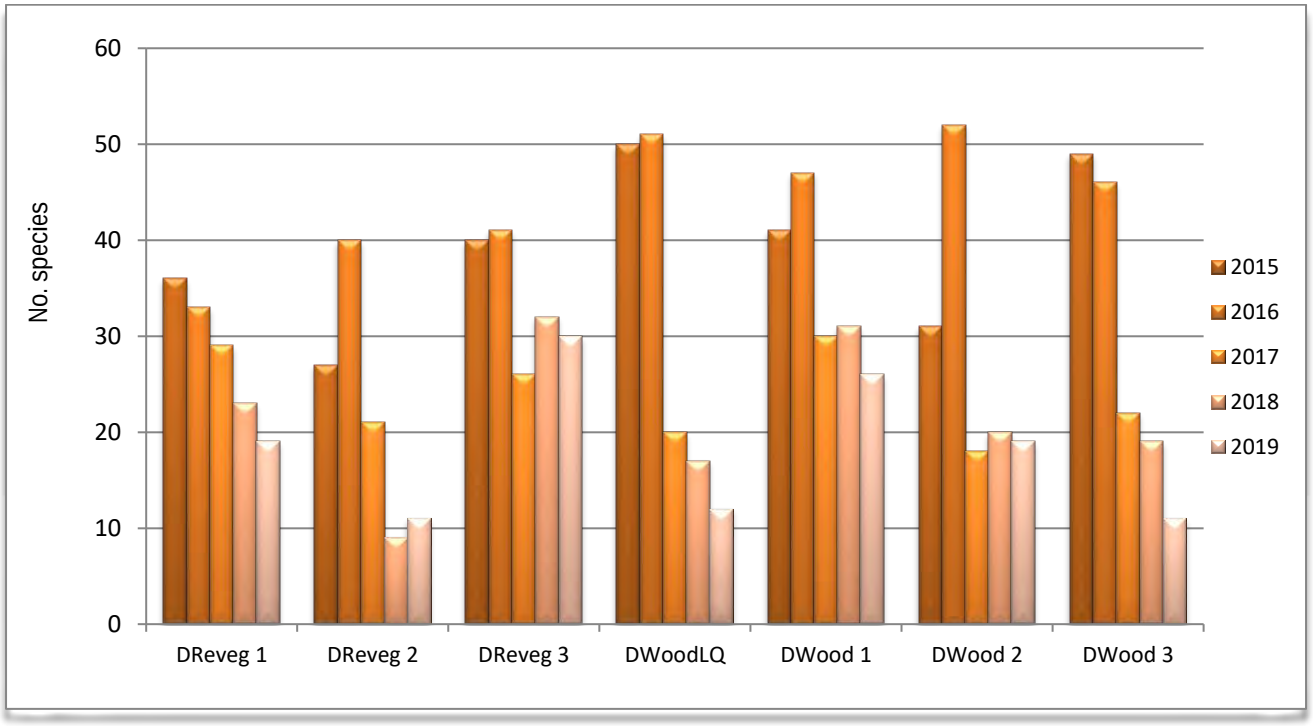


Figure 9-10. Total species diversity recorded in the Red Gum monitoring sites.

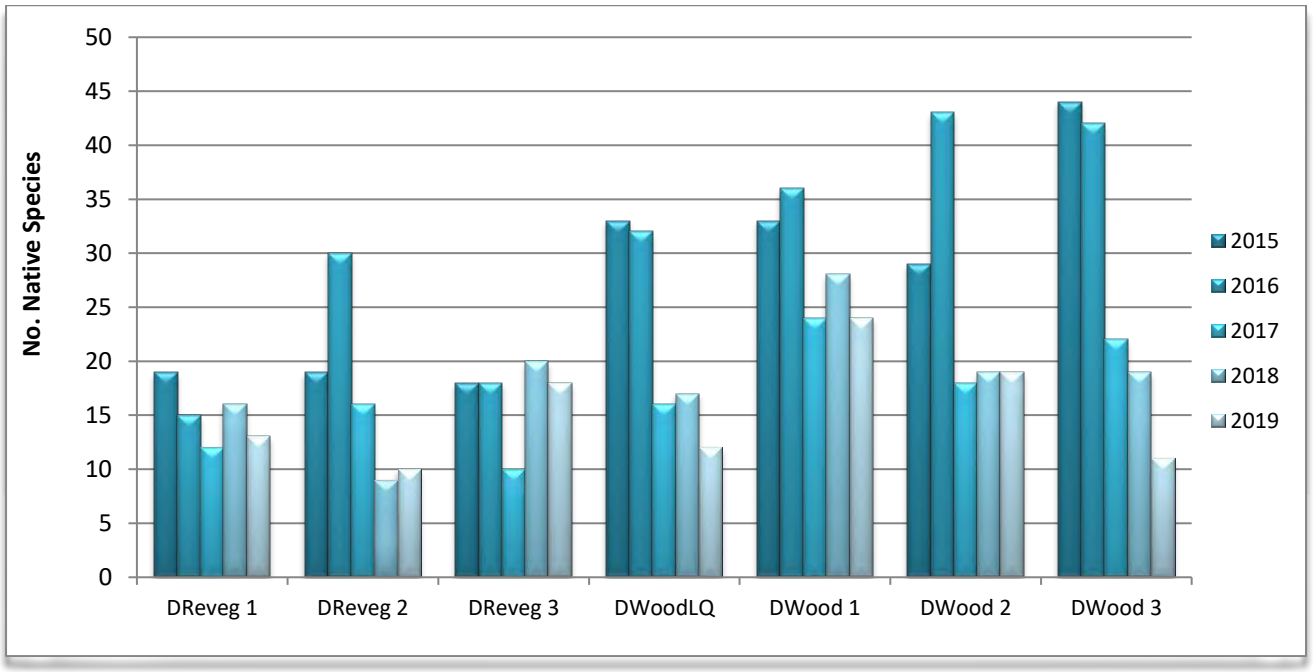


Figure 9-11. Total native species recorded in the Red Gum monitoring sites.

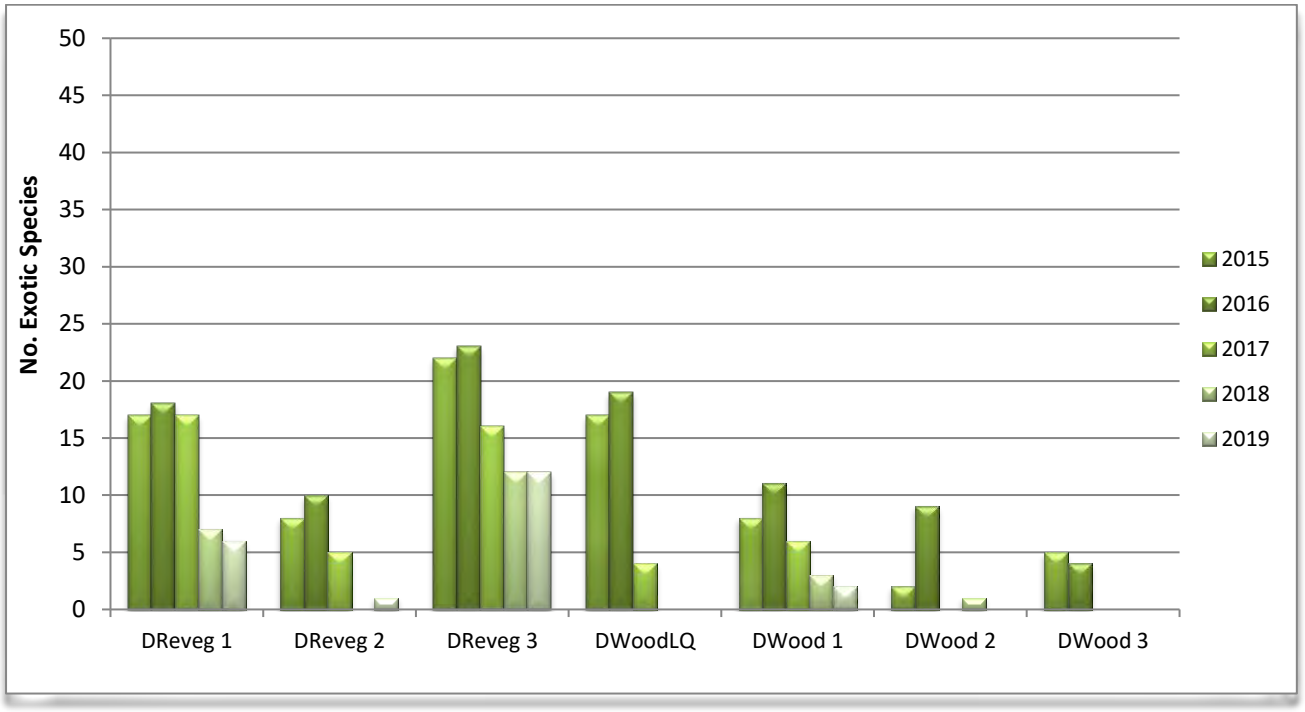


Figure 9-12. Total exotic species recorded in the Red Gum monitoring sites.

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 Red Gum woodland reference sites, most of the live plant cover has been provided by native species, however in 2016 there was an increase in exotic annual plant cover due to the wet seasonal conditions. Since 2017 it has been very dry resulting in a decline in exotic plant cover, with 97 – 100% of the live plant cover being native species this year (Figure 9-13).

This increase in native plant cover has also occurred in the revegetation sites this year, as the dry conditions and heavy grazing have not been favourable for exotic annual species, leaving mostly hardy perennial native species. Native plants continued to provide 100% cover in DWoodLQ, and native plant cover ranged from 66 – 97% in the grassland revegetation areas, with the lowest cover being recorded in DReveg3 which continued to be weedier than desired.

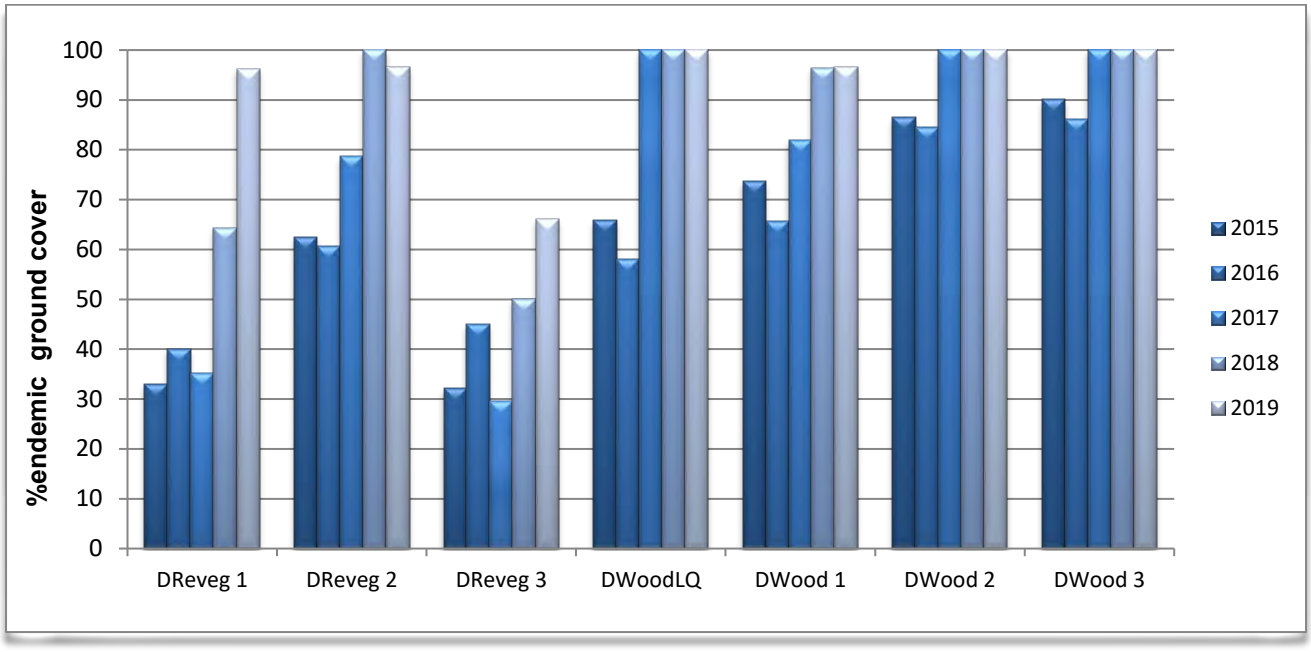


Figure 9-13. Percent endemic ground cover recorded in the Red Gum monitoring sites.

9.8 Vegetation composition

The composition of the vegetation as categorised by eight different growth forms is given in Figure 9-14. In the Red Gum woodland reference sites herbs and grasses were the most diverse plant groups with 0 - 12 and 2 – 6 species respectively. There were 3 - 4 tree species, 2 – 3 shrub species and 1 - 3 sub-shrubs were recorded in the reference sites. There was a fern at all three sites and 0 – 1 reed species.

The low quality woodland site had similar composition of the herbaceous ground covers, 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 a high diversity of herbs and greases but presently there was a low diversity of trees, shrubs and sub-shrubs except in DReveg2 where there was presently an adequate diversity of shrubs.

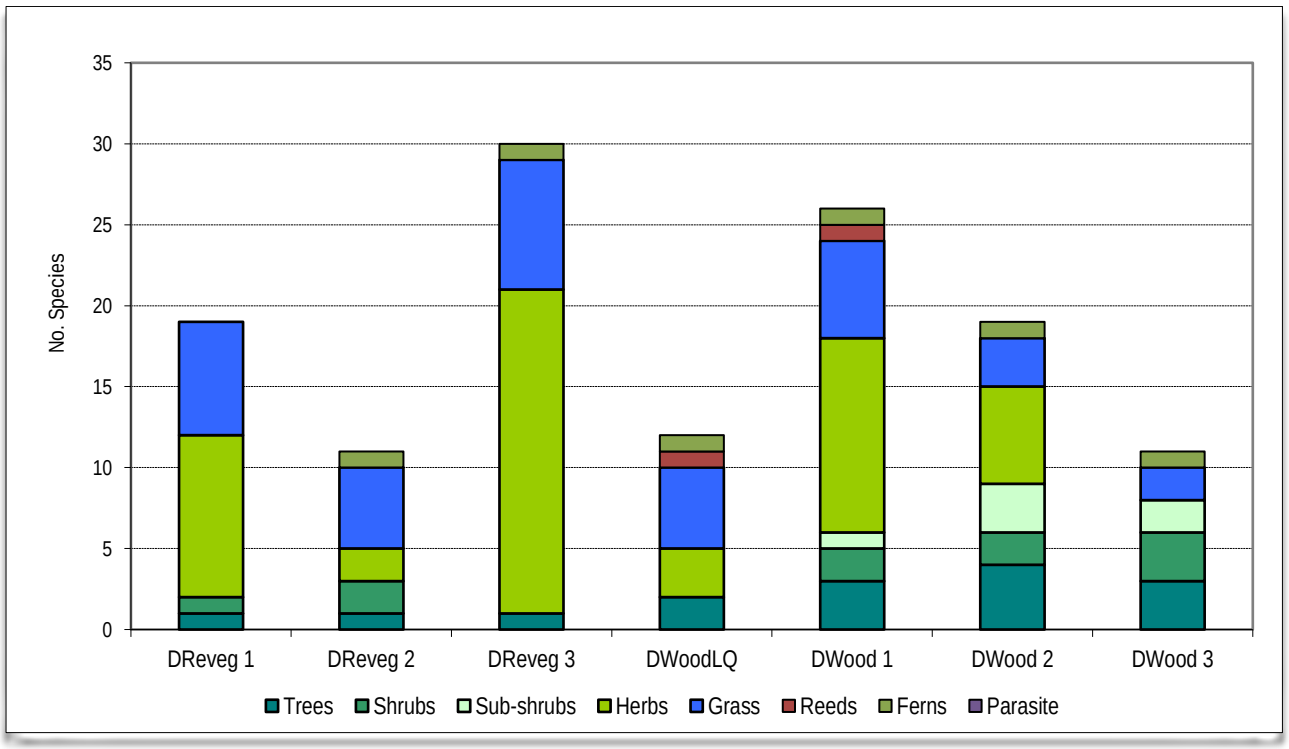


Figure 9-14. Composition of the vegetation recorded in the Red Gum monitoring sites in 2019.

9.9 Most common species

The most common species recorded in the revegetation sites is provided in Table 9-5, with six native perennial ground covers being recorded in three of the four sites. *Chloris truncata* (Windmill Grass), *Panicum* sp. and *Xerochrysum bracteatum* (Golden Everlasting) were found in three sites but were not recorded in the reference sites. *Aristida ramosa* (Threeawn Grass), *Cheilanthes sieberi* subsp*. sieberi* (Rock Fern) and *Rytidosperma sp.* (Wallaby Grass) were also recorded in at least three sites as well as all three reference sites this year. 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 2019.

exotic	Scientific Name	Common Name	Habit	DReveg1	DReveg2	DReveg3	DWoodLQ	Total	DWood1	DWood2	DWood3
	Chloris truncata	Windmill Grass	g	1	1	1		3			
	Panicum spp.	A Panic	g	1	1	1		3			
	Xerochrysum bracteatum	Golden Everlasting	h	1		1	1	3			
	Aristida ramosa	Threeawn Grass	g	1	1	1		3	1	1	1
	Cheilanthes sieberi subsp. sieberi	Rock Fern	f		1	1	1	3	1	1	1
	Rytidosperma spp.	Wallaby Grass	g		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.

This year only *Aristida ramosa* (Threeawn Grass) a native grass was sufficiently abundant to meet the criteria in DReveg1 and DReveg2.

Table 9-6. The most abundant species recorded in the Red Gum monitoring sites in 2019.

Scientific Name	Common Name	DReveg1	DReveg2	DReveg3	DWoodLQ	DWood1	DWood2	DWood3
Aristida ramosa	Three-awn Grass	11	10					

9.11 Soil analyses

Results of the soil analyses for the Red Gum monitoring sites is provided in Appendix 4, however changes in a few important parameters have been briefly described in the following section.

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 5.0 – 5.4 the soils were strongly to very strongly acidic (Bruce & Rayment 1982).

In the remaining sites the soil pH also ranged from 5.0 - 5.4 and were therefore comparable to the local woodlands and just within the desirable agricultural range.

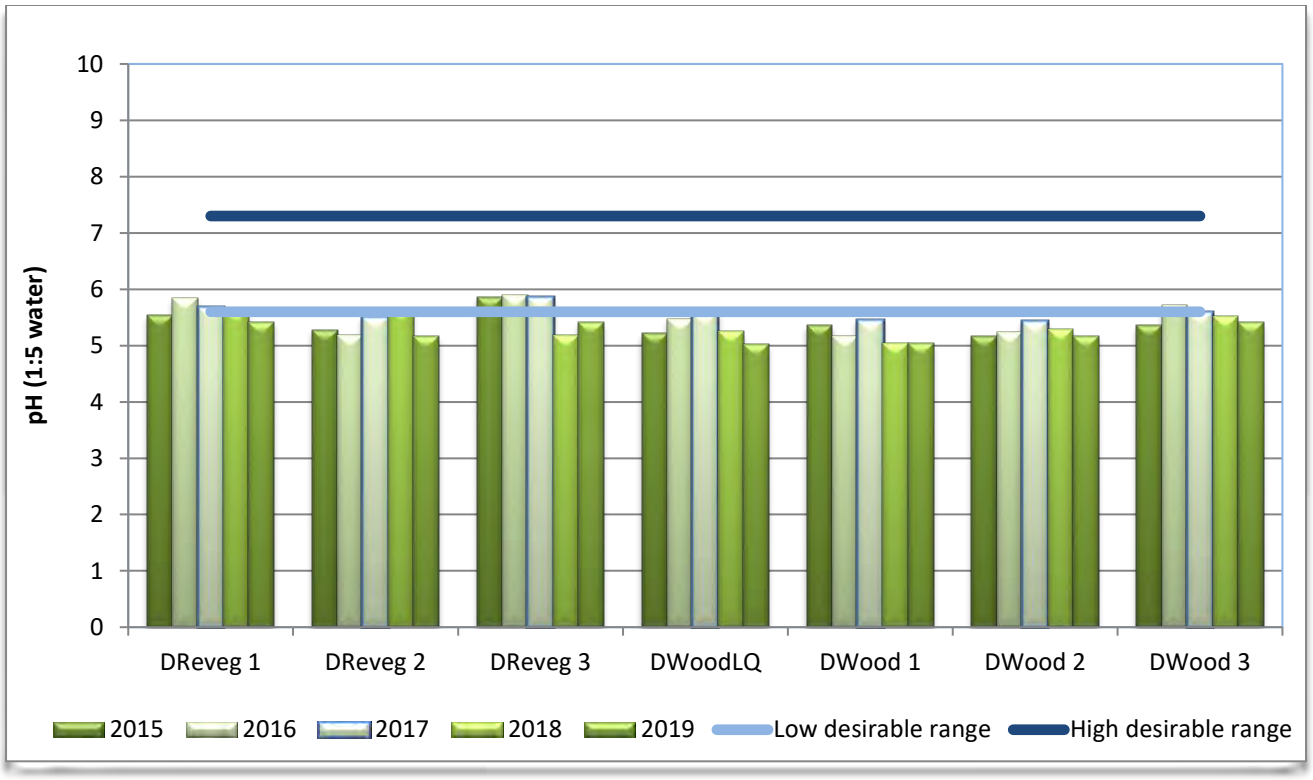


Figure 9-15. Soil pH recorded in the Red Gum monitoring sites compared to the desirable agricultural range.

9.11.2 Conductivity

Figure 9-16 shows the Electrical Conductivity (EC) recorded in the Red Gum monitoring sites compared to the "desirable" range in medium or clay loam soils as prescribed by the agricultural industry for growing introduced pastures and crops. The EC recorded across the range of sites remained well below the agricultural threshold indicating there are very low levels of soluble salts in the soil profile and that they are non-saline. The EC readings in the reference sites ranged from 0.024 – 0.050 dS/m. In the remaining sites EC ranged from a low of 0.019 dS/m in DReveg1 to a high of 0.070 dS/m in DReveg3.

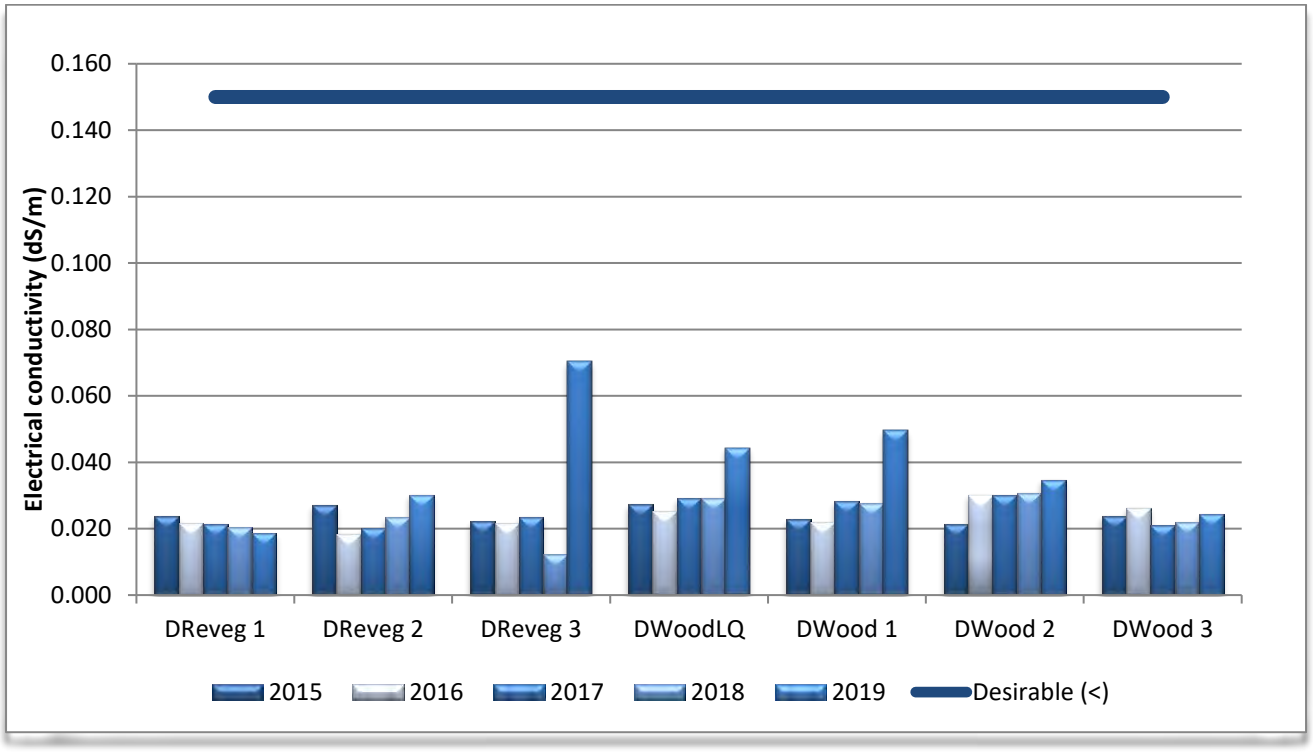


Figure 9-16. Electrical Conductivity recorded in the Red Gum monitoring sites compared to the desirable agricultural levels.

9.11.3 Organic Matter

In the Dwyer's Red Gum woodland reference sites OM levels ranged from 3.6 – 5.5% with high OM content recorded in DWood1 and DWood2 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 2.9 – 4.3%, however this year a significant increase was recorded in the low quality woodland which had an acceptable level of 4.8% OM.

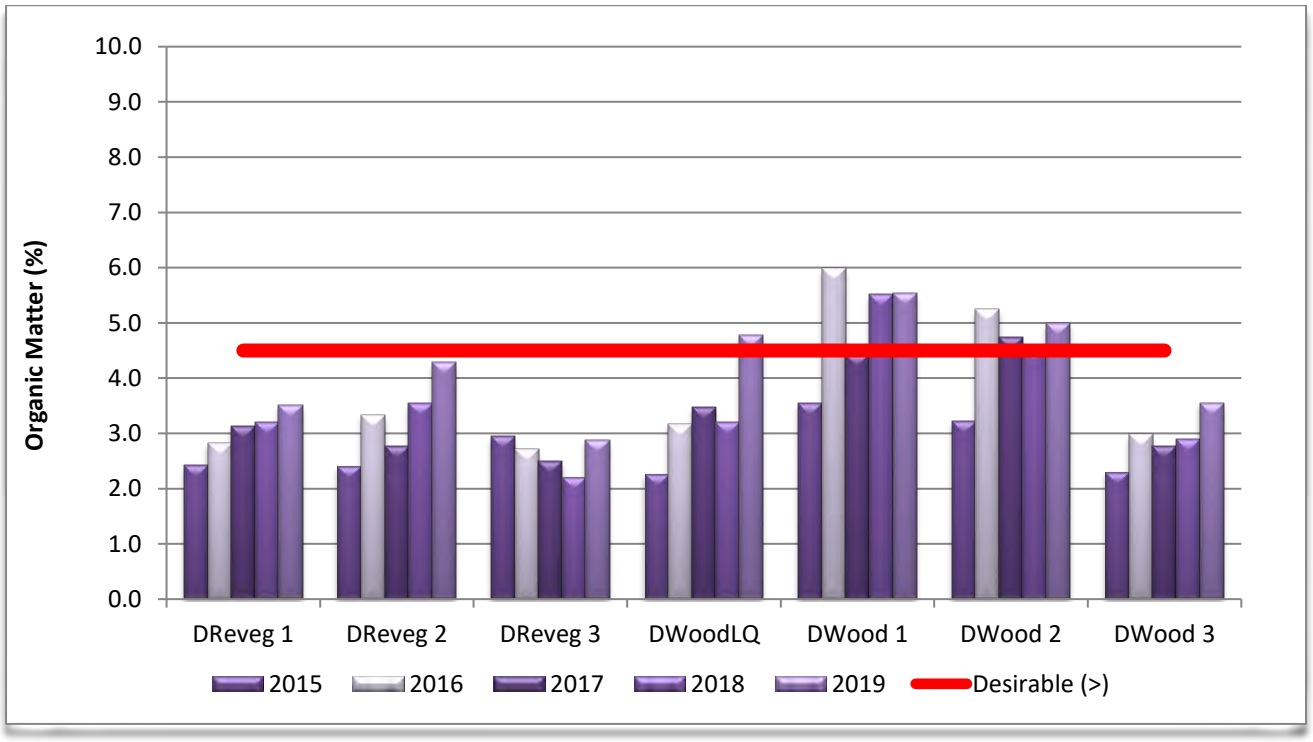


Figure 9-17. Organic Matter concentrations recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

9.11.4 Phosphorous

Phosphorous levels were lower than the agricultural standards across all Dwyer's Red Gum monitoring sites and these remained low over the past year. In the woodland reference sites P concentrations were 8 – 12 mg/kg. P in the remaining sites were similar with concentrations of 7 – 12 mg/kg (Figure 9-18).

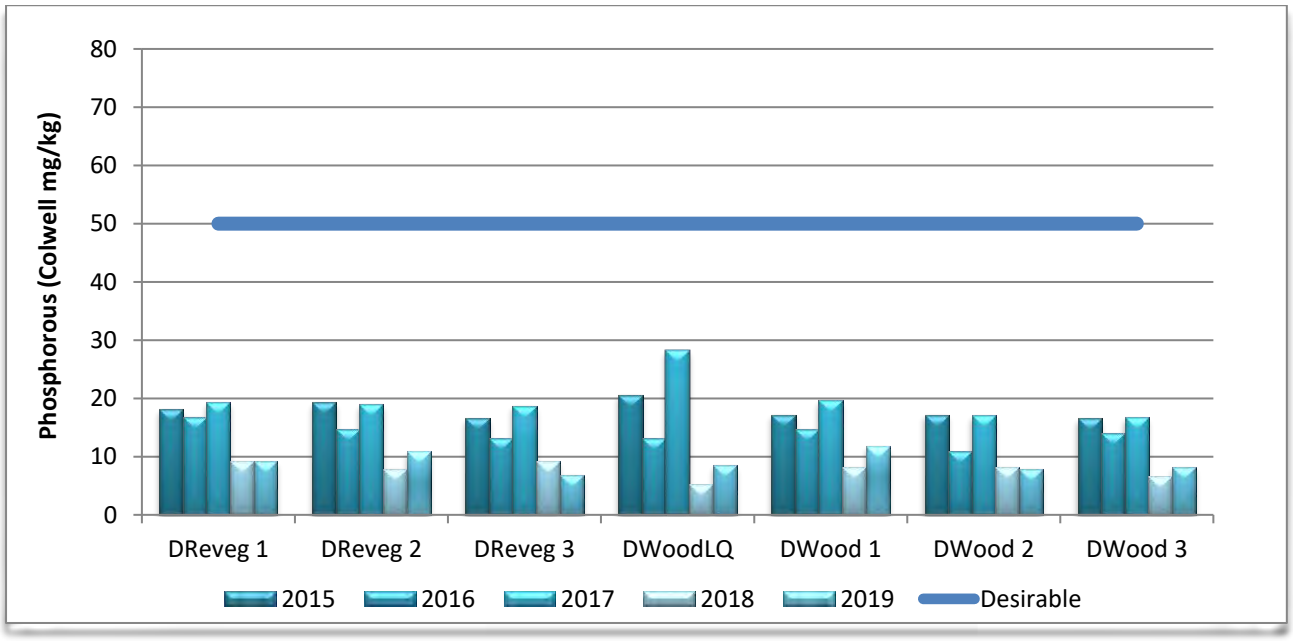


Figure 9-18. Phosphorous concentrations recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

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. This year however, significant increases were recorded in DWood1 significantly altering the local target range to 0.9 – 13.0 mg/kg, with P reaching the desirable agricultural concentrations. While N increased to 7.7 mg/kg in DReveg3, it remained very low in the remaining sites. N ranged from a low of 0.1 mg/kg in DReveg1 and DWoodLQ to a high of 0.9 mg/kg in DReveg2 (Figure 9-19).

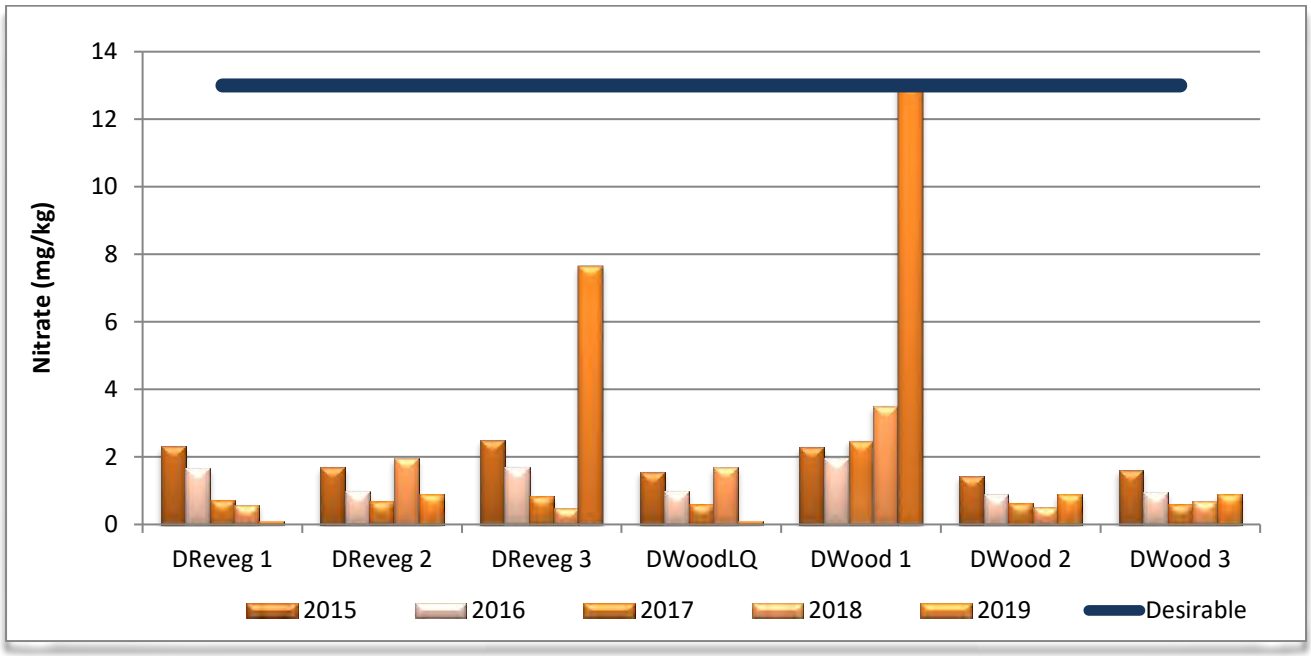


Figure 9-19. Nitrate concentrations recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

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 2.6 – 4.2 cmol/kg. In the remaining sites, CEC ranged from a low of 2.8 cmol/kg in DReveg3 to a high of 3.0 cmol/kg in DReveg1 and DReveg2 (Figure 9-20).

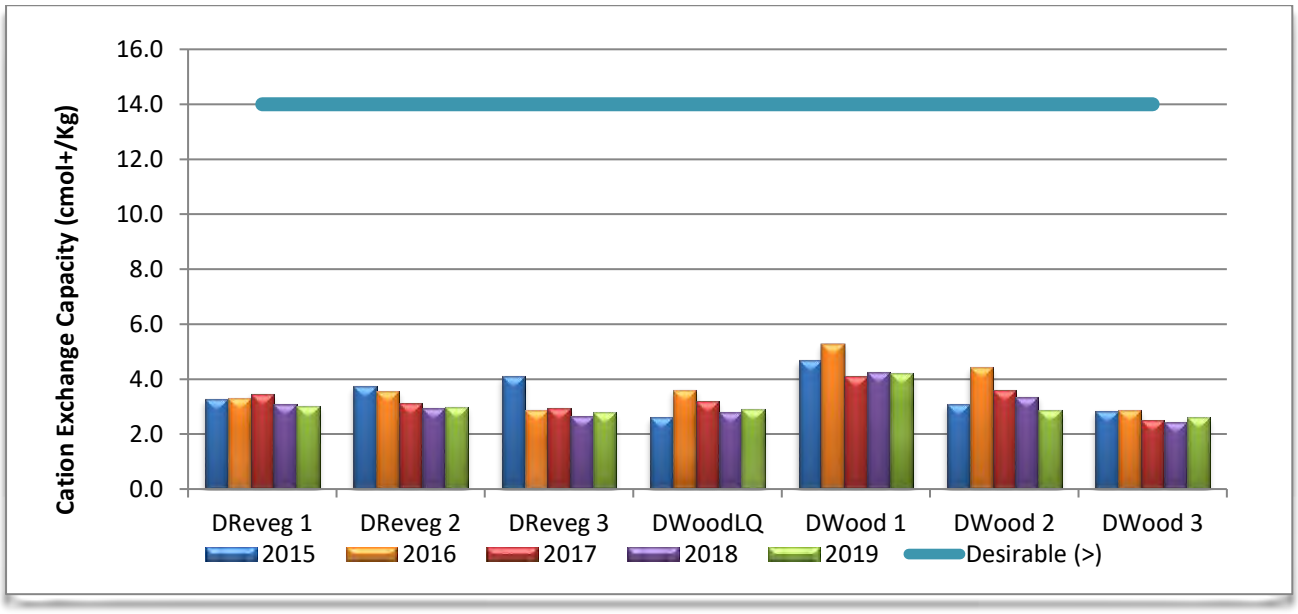


Figure 9-20. Cation Exchange Capacity recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

9.11.7 Exchangeable Sodium Percentage

ESP recorded in the woodland reference sites was highly variable and this year ranged from 0.6 – 3.7% and these remained below the 5% threshold for sodicity (Figure 9-21). In the low quality woodland, the ESP continued to be elevated with an ESP of 7.3% indicating the soils may be sodic, and this was also the case in DReveg3 with an ESP of 8.4% this year (Isbell 1996). ESP in DReveg1 was 1.8% and in DReveg2 ESP was 2.4%, with these being classified as non-sodic.

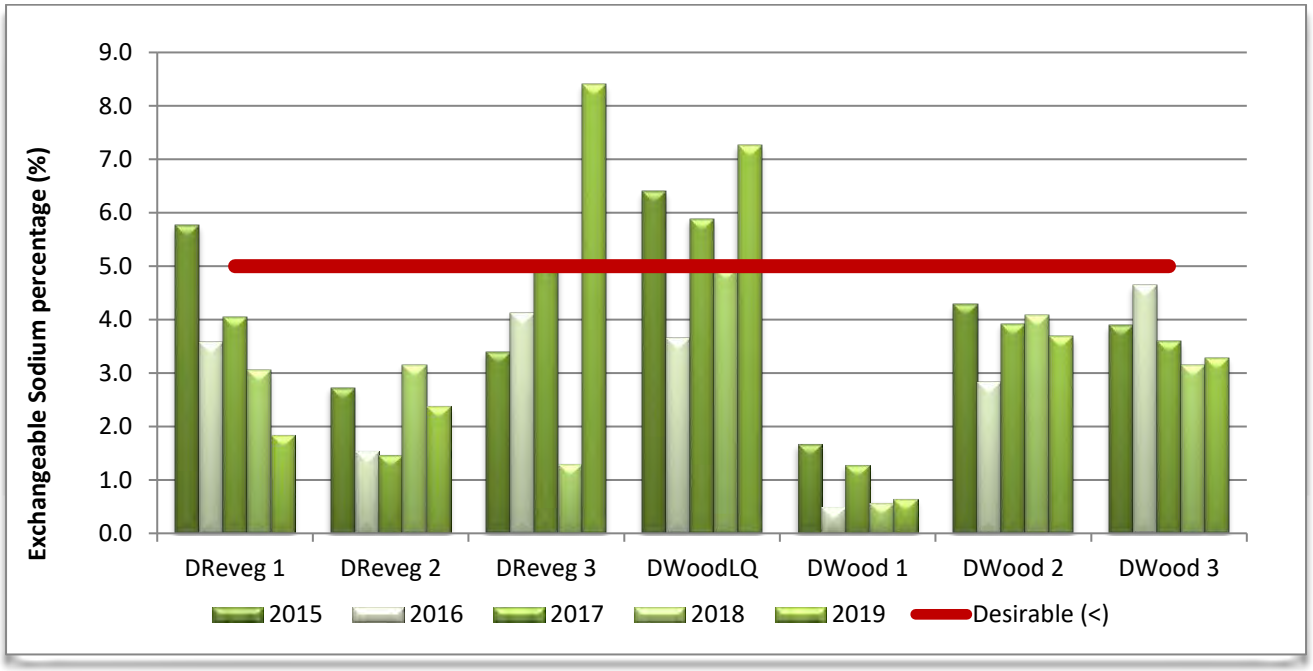


Figure 9-21. ESP recorded in the Red Gum monitoring sites compared to desirable agricultural levels.

9.12 Dwyer's 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 2019 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 landuse sustainability (blue). The range values are amended annually.

Monitoring sites meeting or exceeding the range values of the Red Gum woodland reference sites have been identified with a shaded colour box and have therefore been deemed to meet completion criteria targets. In the case of "growth medium development", upper and lower soil property indicators are also based on results obtained from the respective reference sites sampled in 2019. In some cases, the site may not fall within ranges based on these data but may be within "desirable" levels as prescribed by the agricultural industry. If this scenario occurs, the rehabilitation site has been identified using a striped shaded box to indicate that it falls within "desirable" ranges but does not fall within specified completion criteria targets using the adopted methodology.

Table 9-7. Performance of the Red Gum revegetation monitoring sites against the Primary and Secondary Performance Indicators in 2019.

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2019		DReveg1	DReveg2	DReveg3	DWoodLQ
Performance indicators are quantified by the range of values obtained from replicated reference sites							2019	2019	2019	Lower	Upper	2019	2019	2019	2019
Phase 2: Landform establishment and stability	Landform slope, gradient	Landform suitable for final landuse 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	Soil properties are suitable for the establishment and	pH	pH is typical of that of the surrounding landscape or falls within desirable ranges provided by the agricultural industry		pH (*5.6 - 7.3)	**5.0**	**5.2**	**5.4**	**5.0**	**5.4**	**5.4**	**5.2**	**5.4**	**5.0**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2019		DReveg1	DReveg2	DReveg3	DWoodLQ
	and amelioration	maintenance of selected vegetation species	EC		Electrical Conductivity is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	< dS/m (*<0.150)	0.050	0.035	0.024	0.024	0.050	0.019	0.030	0.070	0.044
			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	5.0	3.6	3.6	5.5	3.5	4.3	2.9	4.8
			Phosphorous	Available Phosphorus is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		ppm (*50)	11.8	7.9	8.2	7.9	11.8	9.2	10.8	6.9	8.5
			Nitrate		Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	ppm (*>12.5)	13.0	0.9	0.9	0.9	13.0	<0.1	0.9	7.7	<0.1
			CEC		Cation Exchange Capacity is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	Cmol+/kg *(>14)	4.2	2.9	2.6	2.6	4.2	3.0	3.0	2.8	2.9
			ESP		Exchangeable Sodium Percentage (a measure of sodicity) is typical of the surrounding landscape or is less than the 5% threshold for sodicity	% (*<5)	0.6	3.7	3.3	0.6	3.7	1.8	2.4	8.4	7.3
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		%	71.7	66.0	64.5	64.5	71.7	73.2	66.5	64.5	65.0
			LFA Landscape organisation	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and is comparable to that of the local remnant vegetation		%	100	100	90	90	100	89	86	100	100

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2019		DReveg1	DReveg2	DReveg3	DWoodLQ
	Vegetation diversity	Vegetation contains a diversity of species comparable to that of the local remnant vegetation		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	5	3	5	2	3	1	1
			Diversity of 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		% 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	26	19	11	11	26	19	11	30	12
			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	24	19	11	11	24	13	10	18	12
			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	2	0	0	0	2	6	1	12	0
	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	46	356	1762	46	1762	11	3	1	8
	Ecosystem composition	The vegetation is comprised by a range of growth forms	Trees	The number of tree species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	3	4	3	3	4	1	1	1	2

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2019		DReveg1	DReveg2	DReveg3	DWoodLQ
		comparable to that of the 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	2	2	3	2	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	1	3	2	1	3	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	12	6	0	0	12	10	2	20	3
			Grasses		The number of grass species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	6	3	2	2	6	7	5	8	5
			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	0	0	0	1	0	0	0	1
			Ferns		The number of ferns comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	1	1	1	1	1	0	1	1	1
			Vines		The number of vines or climbing species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	0	0	0	0	0	0	0	0
			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

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2019		DReveg1	DReveg2	DReveg3	DWoodLQ
Phase 5: Ecosystem & Landuse Sustainability	Landscape Function Analysis (LFA): Landform function and ecological performance	Landform is ecologically functional and performing as it was designed to do	LFA Infiltration	LFA infiltration index provides an indication of the sites infiltration capacity and is comparable to or trending towards that of the local remnant vegetation		%	52.5	54.6	48.9	48.9	54.6	43	37.8	41.2	55.9
			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		%	50.6	51.0	47.7	47.7	51.0	39.7	37.8	35.8	54.9
	Protective ground cover	Ground layer contains protective ground cover and habitat structure comparable with the local remnant vegetation	Litter cover		Percent ground cover provided by dead plant material is comparable to that of the local remnant vegetation	%	58	78	67	58	78	49	49.5	56.5	82.5
			Annual plants		Percent ground cover provided by live annual plants is comparable to that of the local remnant vegetation	<%	0	0	0	0	0	0	0	15	0
			Cryptogam cover		Percent ground cover provided by cryptogams (e.g. mosses, lichens) is comparable to that of the local remnant vegetation	%	11	4	2	2	11	17	17.5	0	3.5
			Rock		Percent ground cover provided by stones or rocks (> 5cm diameter) is comparable to that of the local remnant vegetation	%	7	0	0	0	7	0	0	0	0
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	9	7	0	0	9	0	0	0	0
			Bare ground		Percentage of bare ground is less than or comparable to that of the local remnant vegetation	< %	9	9	25	9	25	24	28	12.5	12.5
			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		%	8	4	7	4	8	10	5	16.5	1.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2019		DReveg1	DReveg2	DReveg3	DWoodLQ
			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		%	**92**	**91**	**75**	**75**	**92**	**76**	**72**	**87.5**	**87.5**
	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	**4**	**3**	**2**	**2.0**	**4.4**	**3**	**3.6**	**5.6**	**1.2**
			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/m^2	**0**	**0**	**0**	**0.0**	**0.2**	**0.2**	**0.2**	**2.4**	**0**
	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**	**100**	**100**	**97**	**100**	**96**	**97**	**66**	**100**
	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	**46**	**332**	**1458**	**46**	**1458**	**1**	**2**	**1**	**8**
			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	No./area	**0**	**22**	**250**	**0**	**250**	**0**	**1**	**0**	**0**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2019		DReveg1	DReveg2	DReveg3	DWoodLQ
					comparable to that of the local remnant vegetation										
			shrubs and juvenile trees 1 - 1.5m in height		The number of shrubs or juvenile trees 1-1.5m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	**0**	**0**	**54**	**0**	**54**	**3**	**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**	**0**	**0**	**0**	**1**	**0**	**0**	**0**
			shrubs and juvenile trees >2m in height		The number of shrubs or juvenile trees > 2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	**0**	**2**	**0**	**0**	**2**	**6**	**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**	**13**	**0**	**13**	**2**	**0**	**0**	**0**
			Foliage cover 2 - 4m		Projected foliage cover provided by perennial plants in the 2 - 4m vertical height stratum indicates the community structure is comparable to	% cover	**0**	**3**	**5**	**0**	**5**	**0**	**0**	**0**	**0**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2019		DReveg1	DReveg2	DReveg3	DWoodLQ
					that of the local remnant vegetation										
			Foliage cover 4 - 6m		Projected foliage cover provided by perennial plants in the 4 -6m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation	% cover	13	23	6	6	23	0	0	0	4
			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	48	30	24	48	0	0	0	40
	Tree diversity	Vegetation contains a diversity of maturing tree and shrubs species comparable to that of the local remnant vegetation	Tree diversity		The diversity of trees or shrubs with a stem diameter > 5cm is comparable to the local remnant vegetation. Species used in rehabilitation will be endemic to the local area	species/area	3	3	3	3	3	1	0	0	2
				The percentage of maturing trees and shrubs with a stem diameter > 5cm dbh which are local endemic species and these percentages are comparable to the local remnant vegetation		%	100	100	100	100	100	100	0	0	100
	Tree density	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	71	37	10	10	71	1	0	0	9
			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	11	17	23	11	23	8	0	0	22

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2019		DReveg1	DReveg2	DReveg3	DWoodLQ
	Ecosystem health	The vegetation is in a condition comparable to that of the local remnant vegetation.	Live trees	The percentage of the tree population which are live individuals and that the percentage is comparable to the local remnant vegetation		% population	32	73	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	3	5	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	25	49	80	25	80	0	0	0	77.8
			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	4	19	0	0	19	0	0	0	22.2
			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	27	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	0	0	0	0	0	0	0
			Flowers/fruit: Trees	The percentage of the tree population with reproductive structures such as buds, flowers or fruit provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources		% population	11	38	70	11	70	0	0	0	66.7

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement (*desirable)	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2019		DReveg1	DReveg2	DReveg3	DWoodLQ
				comparable to that of the local remnant vegetation											
			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	**4**	**3**	**0**	**0**	**4**	**0**	**0**	**0**	**0**

10 Priority weeds

No priority weed species of the Central Tablelands LLS were recorded in the range of monitoring sites.

11 Orchid and other wildflower observations

A map showing the locations of orchids observed in 2015 and 2016 is provided in Figure 11-1. Due to the dry conditions no orchids were observed this year.

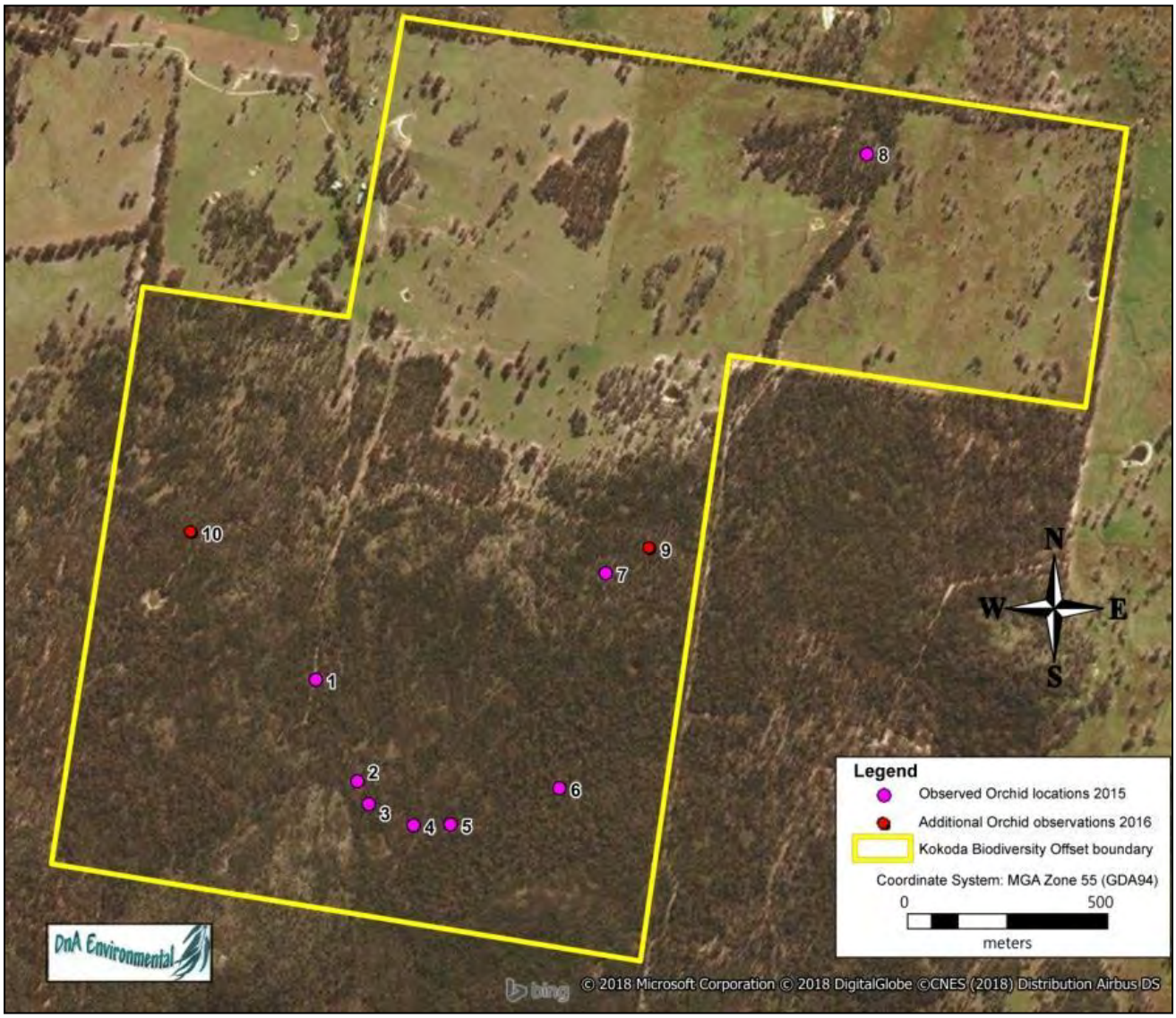


Figure 11-1. A map showing the approximate locations of orchid species sighted around the Kokoda property in 2015 and 2016.

Table 11-1. Approximate coordinates and Orchid species observed at Kokoda in 2015 and 2016.

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.*

12 Annexure D Voluntary Conservation Agreement

Comparison of Kokoda monitoring sites results against Benchmark data for each Biometric Vegetation Type/ Plant Community Type, October 2019 (Table 12-1, Table 12-2, Table 12-3) 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 12-1. Comparison of Kokoda monitoring sites results against Benchmark data for LA151.

LA151 - Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion										
		NPSR	NOS	NMS	NGCG	NGCS	NGCO	EPC	Logs (m	Hollows
Benchmark	min	30	8	3	3	3	3		46	2
	max		35	35	25	25	20			
GBReveg1		11	0	0.01	30	0	1	38.75	0	0
GBReveg2		20	0	0	25	0	0.8	7.5	0	0
GBReveg3		12	0	0	22.5	0	5.5	19	0	0
GBReveg4		14	0	0	38.75	0	20	11	0	0
GBReveg5		17	0	0	28	0	3.2	37.5	0	1
GBWood1		4	37.25	0	2.75	0	0.1	0	97.5	13
GBWood2		12	56.75	0	0.04	1.17	0	0	34	0
GBWood3		9	49.75	0	0.4	0.05	0.05	0	168.5	2
Average		12.4	18.0	0.0	18.4	0.2	3.8	14.2	37.5	2

Table 12-2. Comparison of Kokoda monitoring sites results against Benchmark data for LA165.

LA165 - Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion										
		NPSR	NOS	NMS	NGCG	NGCS	NGCO	EPC	Logs (m	Hollows
Benchmark	min	30	8	3	3	3	3		46	2
	max		35	35	25	25	20			
DReveg1		13	0	5.5	32.5	0.1	0.55	10.1	0	0
DReveg2		10	0	0	6.75	0.02	0.37	0	4	0
DReveg3		18	0	0	22.5	0	3.5	31	0	0
DWood1		24	24	0	4.25	0	1.3	0	316	4
DWood2		19	29.25	0	0	5.2	0.2	0	209.5	3
DWood3		11	26.75	0	0	10.75	0	0	61	0
DWoodLQ		12	29.5	0	3.9	0.1	2.1	0	9	0
IronWood1		19	45.25	0	0	5.7	0	0	78	0
Average		15.8	19.3	0.7	8.7	2.7	1.0	5.1	84.7	0.9

Table 12-3. Comparison of Kokoda monitoring sites results against Benchmark data for LA218.

LA218 - White Box - White Cypress Pine - Western Grey Box shrub/grass/forb woodland in the NSW South Western Slopes Bioregion										
		NPSR	NOS	NMS	NGCG	NGCS	NGCO	EPC	Logs (m	Hollows
Benchmark	min	23	8	1	15	3	3		66	0.8
	max		35	20	70	5	20			
WBWood1		28	28	0	7.25	2	0.5	0	55.5	2
Average		28.0	28.0	0.0	7.3	2.0	0.5	0.0	55.5	2.0

13 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 as presently there is limited regeneration occurring within the 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 lack of mature tree and shrub populations and limited structural complexity of these sites.

The proposed revegetation activities within the derived grassland areas as described in the BOMP and VCA aim 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 are likely to result in the cleared grassland areas developing into woodland communities and therefore meeting most 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 proposed should include a range of species known to occur within these communities and not just restricted to those occurring within the existing reference sites.

Where possible revegetation practices should follow “Best Practice Revegetation Guidelines” such as Sydes *et al* Greening Australia (2003) and described in the DRAFT Revegetation Plan for the Kokoda VCA. It is good practice to establish a mosaic of shrub thickets, open woodland and grassy clearings to increase heterogeneity and patchiness of revegetation areas. The patchiness will be critical in the long-term sustainability of the woodlands, whilst promoting and maintaining biodiversity and varying habitats for woodland wildlife. High planting densities are likely to result in the decline in diversity of the herbaceous understorey and restrict regeneration opportunities in the longer-term, thus grassy clearings are essential.

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. Strategic grazing is likely to be a critical management strategy 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 the longer-term. This process has however been affected by drought conditions and heavy grazing by pests and feral animals. Presently, extensive disturbance and herbivory by macropods and goats has become an important management issue. NPM have been erecting new exclusion fencing around the boundary fences of the Kokoda property and plan to implement a series of pest control events over the coming years. Exclusion fencing in strategic locations may also be required in order to achieve successful revegetation outcomes.

In 2015 and 2016 several species of 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 and strategic grazing. Most orchids are only identifiable during a limited time period during suitable conditions during spring and/or autumn. As a result of the dry conditions experienced throughout most of 2017 - 2019, none of these populations have been observed to be flowering, thus emphasising the need to map and refer to their known locations.

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.

Strategic grazing using sheep or cattle may assist in the management of the herbaceous understorey and help regulate the degree of Callitris and eucalypt regeneration in more favourable seasonal conditions and when pest and feral animal control has been achieved in the medium to longer-term. Other control techniques may include the “cut and paste method” and targeted herbicide spraying when seedling densities are deemed too high.

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 needs basis.

There were little other management issues that have not already been addressed in the BOMP.

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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 2019

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	Apiaceae		*Daucus glochidiatus*	Australian Carrot	h												1					
Dicotyledon	Araliaceae		*Hydrocotyle laxiflora*	Stinking Pennywort	h		1							1		1	1					
Dicotyledon	Asteraceae	*	*Arctotheca calendula*	Capeweed	h					1	1		1								1	
Dicotyledon	Asteraceae		*Calotis lappulacea*	Yellow Burr Daisy	h				1	1	1	1	1						1		1	
Dicotyledon	Asteraceae	*	*Carthamus lanatus*	Saffron Thistle	h						1		1									
Dicotyledon	Asteraceae		*Cassinia laevis*	Cough Bush	s			1							1					1		
Dicotyledon	Asteraceae	*	*Chondrilla juncea*	Skeleton Weed	h				1		1	1	1									
Dicotyledon	Asteraceae	*	*Hypochaeris glabra*	Smooth Catsear	h				1	1	1	1	1			1			1			
Dicotyledon	Asteraceae	*	*Hypochaeris radicata*	Flatweed	h				1		1	1									1	
Dicotyledon	Asteraceae		*Rhodanthe laevis*	Smooth Sunray	h											1						
Dicotyledon	Asteraceae		*Solenogyne bellioides*		h									1								1
Dicotyledon	Asteraceae		*Stuartina muelleri*	Spoon Cudweed	h											1						
Dicotyledon	Asteraceae	*	*Tolpis umbellata*	Yellow Hawkweed	h					1	1	1									1	
Dicotyledon	Asteraceae		*Triptilodiscus pygmaeus*	Austral Sunray	h					1	1	1	1						1		1	
Dicotyledon	Asteraceae		*Vittadinia cuneata*	Fuzzweed	h					1		1									1	
Dicotyledon	Asteraceae		*Vittadinia gracilis*	A Fuzzweed	h				1	1											1	
Dicotyledon	Asteraceae		*Vittadinia spp.*	Fuzzweed	h								1								1	
Dicotyledon	Asteraceae		*Vittadinia tenuissima*	Western New Holland Daisy	h					1												
Dicotyledon	Asteraceae		*Xerochrysum bracteatum*	Golden Everlasting	h					1				1	1				1		1	1
Dicotyledon	Campanulaceae		*Wahlenbergia communis*	Tufted Bluebell	h					1											1	
Dicotyledon	Campanulaceae		*Wahlenbergia spp.*	Bluebell	h											1						
Dicotyledon	Caryophyllaceae	*	*Moenchia erecta*	Erect 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	Caryophyllaceae	*	*Petrorhagia nanteuilii*	Proliferous Pink	h						1	1	1						1		1	
Dicotyledon	Caryophyllaceae	*	*Spergularia spp.*	Sandspurry	h											1						
Dicotyledon	Casuarinaceae		*Allocasuarina verticillata*	Drooping Sheoak	t											1	1				1	
Dicotyledon	Chenopodiaceae		*Einadia nutans subsp. nutans*	Climbing Saltbush	h	1		1														
Dicotyledon	Convolvulaceae		*Dichondra repens*	Kidney Weed	h		1															
Dicotyledon	Crassulaceae		*Crassula colorata*	Dense Stonecrop	h					1			1									
Dicotyledon	Dilleniaceae		*Hibbertia obtusifolia*	Hoary Guinea Flower	ss									1								
Dicotyledon	Dilleniaceae		*Hibbertia riparia*	Silky Guinea Flower	ss									1	1							
Dicotyledon	Epacridaceae		*Astroloma humifusum*	Native Cranberry	ss										1	1	1	1				
Dicotyledon	Epacridaceae		*Brachyloma daphnoides*	Daphne Heath	s									1	1		1	1				
Dicotyledon	Epacridaceae		*Lissanthe strigosa*	Peach Heath	ss									1	1		1	1				
Dicotyledon	Euphorbiaceae		*Euphorbia drummondii*	Caustic Weed	h														1			
Dicotyledon	Euphorbiaceae		*Phyllanthus virgatus*	A Spurge	ss												1					
Dicotyledon	Euphorbiaceae		*Poranthera microphylla*	Small Poranthera	h											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 spp.*	Glycine	h								1									
Dicotyledon	Fabaceae (Faboideae)	*	*Trifolium arvense*	Haresfoot Clover	h				1			1	1							1	1	
Dicotyledon	Fabaceae (Faboideae)	*	*Trifolium campestre*	Hop Clover	h						1	1										
Dicotyledon	Fabaceae (Faboideae)	*	*Trifolium dubium*	Yellow Suckling Clover	h				1										1			
Dicotyledon	Fabaceae (Faboideae)	*	*Trifolium glomeratum*	Clustered Clover	h						1											
Dicotyledon	Fabaceae (Faboideae)	*	*Trifolium subterraneum*	Subterraneum Clover	h				1												1	
Dicotyledon	Fabaceae (Mimosoideae)		*Acacia decora*	Western Golden Wattle	s									1					1	1		
Dicotyledon	Fabaceae (Mimosoideae)		*Acacia doratoxylon*	Spearwood	s											1						
Dicotyledon	Fabaceae (Mimosoideae)		*Acacia implexa*	Hickory	s		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 (Mimosoideae)		*Acacia paradoxa*	Kangaroo Thorn	s		1															
Dicotyledon	Geraniaceae	*	*Erodium botrys*	Long Storksbill	h				1												1	
Dicotyledon	Geraniaceae	*	*Erodium cicutarium*	Common Crowsfoot	h						1		1									
Dicotyledon	Geraniaceae		*Erodium crinitum*	Blue Storksbill	h					1			1								1	
Dicotyledon	Haloragaceae		*Gonocarpus tetragynus*	Raspwort	h					1			1	1		1	1			1		1
Dicotyledon	Haloragaceae		*Haloragis heterophylla*	Rough Raspwort	h		1			1	1	1	1						1		1	
Dicotyledon	Hypericaceae		*Hypericum gramineum*	Small St. John's Wort	h					1				1								
Dicotyledon	Lamiaceae		*Ajuga australis*	Australian Bugle	h									1								
Dicotyledon	Lamiaceae	*	*Salvia verbenaca*	Wild Sage	h				1													
Dicotyledon	Myrtaceae		*Calytrix tetragona*	Common Fringe Myrtle	s											1	1	1				
Dicotyledon	Myrtaceae		*Eucalyptus albens*	White Box	t									1	1			1				1
Dicotyledon	Myrtaceae		*Eucalyptus blakelyi*	Blakely's Red Gum	t									1								
Dicotyledon	Myrtaceae		*Eucalyptus dealbata*	Tumbledown Gum	t										1	1	1	1				
Dicotyledon	Myrtaceae		*Eucalyptus dwyeri*	Dwyer's Red Gum	t														1			1
Dicotyledon	Myrtaceae		*Eucalyptus microcarpa*	Grey Box	t	1	1	1							1							
Dicotyledon	Myrtaceae		*Eucalyptus sideroxylon*	Mugga Ironbark	t		1	1							1		1					
Dicotyledon	Orobanchaceae	*	*Parentucellia latifolia*	Red Bartsia	h				1		1		1								1	
Dicotyledon	Oxalidaceae		*Oxalis perennans*	Yellow Wood-sorrel	h				1	1	1	1	1	1		1					1	
Dicotyledon	Plantaginaceae	*	*Echium plantagineum*	Paterson's Curse	h				1		1	1	1						1		1	
Dicotyledon	Plantaginaceae		*Plantago varia*	Variable Plantain	h											1						
Dicotyledon	Polygonaceae		*Rumex brownii*	Swamp Dock	h								1									
Dicotyledon	Primulaceae	*	*Lysimachia arvensis*	Scarlet Pimpernel	h																1	
Dicotyledon	Rubiaceae		*Galium gaudichaudii*	Rough Bedstraw	h							1										
Dicotyledon	Scrophulariaceae	*	*Verbascum virgatum*	Twiggy Mullein	h								1									
Dicotyledon	Stackhousiaceae		*Stackhousia monogyna*	Creamy Candles	h								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	Sterculiaceae		*Brachychiton populneus*	Kurrajong	t									1	1							
Monocotyledon	Anthericaceae		*Arthropodium milleflorum*	Vanilla-lily	h		1									1	1					
Monocotyledon	Anthericaceae		*Dichopogon strictus*	Chocolate Lily	h									1								
Monocotyledon	Anthericaceae		*Laxmannia gracilis*	Slender Wire Lily	h										1		1					
Monocotyledon	Anthericaceae		*Thysanotus patersonii*	Twining Fringe Lily	h											1						
Monocotyledon	Anthericaceae		*Tricoryne elatior*	Yellow Autumn-lily	h										1				1			
Monocotyledon	Cyperaceae		*Lepidosperma laterale*	Broad Sword-sedge	r											1						
Monocotyledon	Iridaceae	*	*Sisyrinchium rosulatum*	Scourweed	h						1											
Monocotyledon	Juncaceae		*Juncus usitatus*		r			1														1
Monocotyledon	Orchidaceae		*Caladenia spp.*	Spider Orchid	h												1					
Monocotyledon	Orchidaceae		*Calochilus robertsonii*	Brown-bearded Orchid	h										1							
Monocotyledon	Orchidaceae		*Pterostylis spp.*	Greenhood Orchid	h				1			1										
Monocotyledon	Phormiaceae		*Dianella longifolia*	Blueberry Lily	h									1								
Monocotyledon	Poaceae	*	*Aira spp.*	Silvery Hairgrass	g				1		1	1	1						1		1	
Monocotyledon	Poaceae		*Aristida jerichoensis var. jerichoensis*	Jericho Wiregrass	g						1				1							
Monocotyledon	Poaceae		*Aristida ramosa*	Threeawn Grass	g		1		1	1		1	1	1		1	1	1	1	1	1	
Monocotyledon	Poaceae		*Austrostipa densiflora*	Foxtail Speargrass	g											1						
Monocotyledon	Poaceae		*Austrostipa scabra subsp. scabra*	Rough Speargrass	g	1	1	1	1	1	1	1		1	1	1	1			1		1
Monocotyledon	Poaceae		*Bothriochloa macra*	Red-leg Grass	g				1	1	1	1	1	1					1		1	
Monocotyledon	Poaceae	*	*Briza maxima*	Quaking Grass	g					1												
Monocotyledon	Poaceae	*	*Briza minor*	Shivery Grass	g								1								1	
Monocotyledon	Poaceae	*	*Bromus molliformis*	Soft Brome	g				1		1	1	1						1			
Monocotyledon	Poaceae		*Chloris truncata*	Windmill Grass	g				1	1	1	1	1						1	1	1	
Monocotyledon	Poaceae		*Dichelachne spp.*	A Plumegrass	g										1							
Monocotyledon	Poaceae		*Digitaria spp.*		g																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		*Eragrostis spp.*	Lovegrass	g			1														
Monocotyledon	Poaceae		*Microlaena stipoides*	Weeping Rice-grass	g																	1
Monocotyledon	Poaceae		*Panicum spp.*		g				1	1	1	1	1	1					1	1	1	
Monocotyledon	Poaceae		*Paspalidium sp.*		g		1				1			1		1			1			1
Monocotyledon	Poaceae		*Rytidosperma racemosum*	Wallaby Grass	g			1	1	1	1					1						1
Monocotyledon	Poaceae		*Rytidosperma spp.*	Wallaby Grass	g	1	1	1				1	1	1		1	1	1		1	1	1
Monocotyledon	Poaceae	*	*Vulpia spp.*	Rat's-tail Fescue	g				1					1	1							
Pteridophyta	Adiantaceae		*Cheilanthes sieberi subsp. sieberi*	Rock Fern	f					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 2019

Soil samples supplied by DnA Environmental on 18th October 2019 - Lab Job No. i6976

			Site	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	GBWood1	GBWood2	GBWood3	***Heavy Soil*** *Clay*	***Medium Soil*** *Clay Loam*	***Light Soil*** *Loam*	***Sandy Soil*** *Loamy Sand*
	Parameter		**Method reference**	**i6976/4**	**i6976/5**	**i6976/6**	**i6976/7**	**i6976/8**	**i6976/15**	**i6976/16**	**i6976/12**	**i6976/13**	**i6976/14**	**Indicative guidelines - refer to Notes 6 and 8**			
	Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	562	252	297	218	302	469	80	214	166	417	*1150*	*750*	*375*	*175*
	Soluble Magnesium (mg/kg)			64	81	82	77	75	104	47	138	107	215	*160*	*105*	*60*	*25*
	Soluble Potassium (mg/kg)			68	77	57	66	79	96	61	116	80	122	*113*	*75*	*60*	*50*
	Soluble Phosphorus (mg/kg)			1.6	<1	<1	<1	1.3	1.6	<1	2.0	<1	2.1	*15*	*12*	*10*	*5.0*
	Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	2.7	3.0	1.2	1.7	1.2	2.5	1.5	12	2.8	6.2	*45 not e 8*	*30 not e 8*	*24 not e 8*	*20 not e 8*
			**Rayment & Lyons 2011 - 9B2 (Colwell)	7.9	9.8	9.2	8.2	7.2	7.9	5.9	20	9.5	14	*80*	*50*	*45*	*35*
			**Inhouse S3A (Bray 2)	3.1	3.9	1.6	2.2	1.5	3.0	1.7	16	3.5	7.2	*90 not e 8*	*60 not e 8*	*48 not e 8*	*40 not e 8*
	Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	0.27	8.2	0.88	<0.1	<0.1	0.89	<0.1	0.92	<0.1	4.1	*15*	*13*	*10*	*10*
	Ammonium Nitrogen (mg/kg N)			3.5	11	4.5	3.2	2.6	2.4	2.5	4.0	4.1	4.1	*20*	*18*	*15*	*12*
	Sulfur (mg/kg S)			<1	5.4	<1	2.4	<1	1.6	4.4	6.1	5.1	6.5	*10.0*	*8.0*	*8.0*	*7.0*
	pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.74	5.31	5.97	5.72	6.05	6.17	4.81	5.02	5.13	5.30	*6.5*	*6.5*	*6.3*	*6.3*
	Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.031	0.064	0.024	0.021	0.017	0.032	0.061	0.067	0.066	0.079	*0.200*	*0.150*	*0.120*	*0.100*
	Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	3.4	5.5	3.1	2.8	2.5	3.1	4.8	7.9	4.8	7.1	*> 5.5*	*>4 .5*	*> 3.5*	*> 2.5*
	Exchangeable Calcium	($cmol_+/kg$)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	4.5	2.4	2.7	1.8	2.6	5.2	0.63	2.5	1.9	5.2	*15.6*	*10.8*	*5.0*	*1.9*
		(kg/ha)		2,031	1,062	1,202	792	1,147	2,314	284	1,129	838	2,325	*7000*	*4816*	*2240*	*840*
		(mg/kg)		907	474	537	354	512	1,033	127	504	374	1,038	*3125*	*2150*	*1000*	*375*
	Exchangeable Magnesium	($cmol_+/kg$)		0.66	0.94	0.92	0.80	0.83	1.3	0.53	1.9	1.4	2.9	*2.4*	*1.7*	*1.2*	*0.60*
		(kg/ha)		180	255	251	219	226	366	144	513	379	781	*650*	*448*	*325*	*168*

			Site	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	GBWood1	GBWood2	GBWood3	***Heavy Soil*** *Clay*	***Medium Soil*** *Clay Loam*	***Light Soil*** *Loam*	***Sandy Soil*** *Loamy Sand*
		(mg/kg)		80	114	112	98	101	163	64	229	169	349	*290*	*200*	*145*	*75*
	Exchangeable Potassium	($cmol_+$/kg)		0.26	0.32	0.22	0.25	0.31	0.43	0.26	0.58	0.40	0.57	*0.60*	*0.50*	*0.40*	*0.30*
		(kg/ha)		229	282	193	221	269	379	231	506	354	500	*526*	*426*	*336*	*224*
		(mg/kg)		102	126	86	99	120	169	103	226	158	223	*235*	*190*	*150*	*100*
	Exchangeable Sodium	($cmol_+$/kg)		<0.065	0.18	0.11	0.09	<0.065	<0.065	0.17	0.09	0.33	0.11	*0.3*	*0.26*	*0.22*	*0.11*
		(kg/ha)		<33	92	58	44	<33	<33	88	47	171	56	*155*	*134*	*113*	*57*
		(mg/kg)		<15	41	26	20	<15	<15	39	21	76	25	*69*	*60*	*51*	*25*
	Exchangeable Aluminium	($cmol_+$/kg)	**Inhouse S37 (KCl)	<0.01	0.42	0.05	0.12	0.02	0.01	0.98	0.73	0.75	0.17	*0.6*	*0.5*	*0.4*	*0.2*
		(kg/ha)		1.0	84	9.3	25	3.3	2.3	197	146	151	34	*121*	*101*	*73*	*30*
		(mg/kg)		<1	38	4.2	11	1.5	1.0	88	65	68	15	*54*	*45*	*32*	*14*
	Exchangeable Hydrogen	($cmol_+$/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	0.12	0.02	0.04	0.03	0.02	0.28	0.17	0.18	0.06	*0.6*	*0.5*	*0.4*	*0.2*
		(kg/ha)		<1	2.8	<1	<1	<1	<1	6.4	3.8	3.9	1.3	*13*	*11*	*8*	*3*
		(mg/kg)		<1	1.2	<1	<1	<1	<1	2.8	1.7	1.8	<1	*6*	*5*	*4*	*2*
	Effective Cation Exchange Capacity (ECEC) ($cmol_+$/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H ($cmol_+$/kg)	5.5	4.3	4.0	3.1	3.8	7.0	2.9	6.0	4.9	9.0	*20.1*	*14.3*	*7.8*	*3.3*
	Calcium (%)		**Base Saturation Calculations - Cation $cmol_+$/kg / ECEC x 100	83	54	67	57	68	74	22	42	38	58	*77.6*	*75.7*	*65.6*	*57.4*
	Magnesium (%)			12	22	23	26	22	19	19	32	28	32	*11.9*	*11.9*	*15.7*	*18.1*
	Potassium (%)			4.8	7.4	5.5	8.2	8.2	6.2	9.2	9.7	8.2	6.4	*3.0*	*3.5*	*5.2*	*9.1*
	Sodium - ESP (%)			0.25	4.1	2.8	2.8	0.47	0.29	6.0	1.5	6.8	1.2	*1.5*	*1.8*	*2.9*	*3.3*
	Aluminium (%)			0.09	9.6	1.2	4.1	0.43	0.16	34	12	15	1.9	*6.0*	*7.1*	*10.5*	*12.1*
	Hydrogen (%)			0.00	2.9	0.45	1.3	0.71	0.35	9.9	2.9	3.6	0.66				
	Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium ($cmol_+$/kg)	6.8	2.5	2.9	2.2	3.1	3.8	1.2	1.3	1.3	1.8	*6.5*	*6.4*	*4.2*	*3.2*
	Zinc (mg/kg)		Rayment & Lyons 2011 - 12A1 (DTPA)	<0.5	0.77	<0.5	0.62	<0.5	<0.5	<0.5	0.81	0.56	0.78	*6.0*	*5.0*	*4.0*	*3.0*

		Site	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1	GBWood1	GBWood2	GBWood3	***Heavy Soil*** *Clay*	***Medium Soil*** *Clay Loam*	***Light Soil*** *Loam*	***Sandy Soil*** *Loamy Sand*
	Manganese (mg/kg)		9.2	19	6.6	8.9	19	9.2	11	12	16	23	*25*	*22*	*18*	*15*
	Iron (mg/kg)		30	209	149	174	91	112	241	312	405	257	*25*	*22*	*18*	*15*
	Copper (mg/kg)		0.18	0.15	0.12	0.12	0.24	0.19	<0.1	0.33	0.25	0.20	*2.4*	*2.0*	*1.6*	*1.2*
	Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.18	0.28	0.17	0.16	0.18	0.30	0.22	0.42	0.22	0.64	*2.0*	*1.7*	*1.4*	*1.0*
	Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	23	24	17	24	23	24	20	28	29	27	*50*	*45*	*40*	*35*
	Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	2.0	3.2	1.8	1.6	1.4	1.8	2.7	4.5	2.8	4.1	*> 3.1*	*> 2.6*	*> 2.0*	*> 1.4*
	Total Nitrogen (%)		0.14	0.17	0.11	0.12	0.09	0.11	0.10	0.23	0.12	0.21	*> 0.30*	*> 0.25*	*> 0.20*	*> 0.15*
	Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	14	19	16	14	15	17	27	20	23	19	*10–12*	*10–12*	*10–12*	*10–12*
	Basic Texture	**Inhouse S65	Loam	Loam	Loam	Loam	Loam	Loam	Loam	Loam	Loam	Loam	..	..	..	..
	Basic Colour		Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	..	..	..	..
	Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640	20	41	16	14	11	20	39	43	42	50	..	..	..	..

Appendix 4. ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT– Dwyer's Red Gum Sites Kokoda Offset Area 2019

Soil samples supplied by DNA Environmental on 18th October 2019 - Lab Job No. i6976

	Site		DReveg1	DReveg2	DReveg3	DWoodLQ	DWood1	DWood2	DWood3	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
	Parameter	Method reference	**i6976/1**	**i6976/2**	**i6976/3**	**i6976/17**	**i6976/9**	**i6976/10**	**i6976/11**	Indicative guidelines - refer to Notes 6 and 8			
	Soluble Calcium (mg/kg)	**Inhouse S10 - Morgan 1	188	124	178	59	257	79	136	*1150*	*750*	*375*	*175*
	Soluble Magnesium (mg/kg)		59	38	77	64	48	65	63	*160*	*105*	*60*	*25*
	Soluble Potassium (mg/kg)		51	56	<50	63	<50	65	58	*113*	*75*	*60*	*50*
	Soluble Phosphorus (mg/kg)		1.3	<1	<1	<1	<1	<1	<1	*15*	*12*	*10*	*5.0*
	Phosphorus (mg/kg P)	**Rayment & Lyons 2011 - 9E2 (Bray 1)	2.4	8.0	1.2	2.6	1.0	1.2	1.5	*45note 8*	*30note 8*	*24note 8*	*20note 8*
		**Rayment & Lyons 2011 - 9B2 (Colwell)	9.2	11	6.9	8.5	12	7.9	8.2	*80*	*50*	*45*	*35*
		**Inhouse S3A (Bray 2)	2.7	8.4	1.8	3.4	<1	1.4	2.0	*90note 8*	*60note 8*	*48note 8*	*40note 8*
	Nitrate Nitrogen (mg/kg N)	**Inhouse S37 (KCl)	<0.1	0.89	7.7	<0.1	13	0.89	0.88	*15*	*13*	*10*	*10*
	Ammonium Nitrogen (mg/kg N)		3.2	3.8	3.9	3.2	9.2	4.4	2.7	*20*	*18*	*15*	*12*
	Sulfur (mg/kg S)		2.3	4.0	2.9	2.8	4.7	1.9	2.6	*10.0*	*8.0*	*8.0*	*7.0*
	pH	Rayment & Lyons 2011 - 4A1 (1:5 Water)	5.42	5.16	5.41	5.03	5.04	5.17	5.41	*6.5*	*6.5*	*6.3*	*6.3*
	Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.019	0.030	0.070	0.044	0.050	0.035	0.024	*0.200*	*0.150*	*0.120*	*0.100*
	Estimated Organic Matter (% OM)	**Calculation: Total Carbon x 1.75	3.5	4.3	2.9	4.8	5.5	5.0	3.6	*> 5.5*	*>4 .5*	*> 3.5*	*> 2.5*
	Exchangeable Calcium (cmol+/kg)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	1.6	1.1	1.4	0.43	2.5	0.66	1.2	*15.6*	*10.8*	*5.0*	*1.9*
	Exchangeable Calcium (kg/ha)		708	484	615	194	1,100	298	532	*7000*	*4816*	*2240*	*840*
	Exchangeable Calcium (mg/kg)		316	216	275	87	491	133	238	*3125*	*2150*	*1000*	*375*
	Exchangeable Magnesium (cmol+/kg)		0.64	0.44	0.77	0.80	0.57	0.74	0.68	*2.4*	*1.7*	*1.2*	*0.60*
	Exchangeable Magnesium (kg/ha)		175	118	210	218	156	202	184	*650*	*448*	*325*	*168*

			Site	DReveg1	DReveg2	DReveg3	DWoodLQ	DWood1	DWood2	DWood3	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
		(mg/kg)		78	53	94	98	70	90	82	*290*	*200*	*145*	*75*
	Exchangeable Potassium	(cmol+/kg)		0.19	0.22	<0.12	0.32	0.21	0.27	0.21	*0.60*	*0.50*	*0.40*	*0.30*
		(kg/ha)		166	190	<112	279	186	240	182	*526*	*426*	*336*	*224*
		(mg/kg)		74	85	<50	124	83	107	81	*235*	*190*	*150*	*100*
	Exchangeable Sodium	(cmol+/kg)		<0.065	0.07	0.23	0.21	<0.065	0.11	0.09	*0.3*	*0.26*	*0.22*	*0.11*
		(kg/ha)		<33	36	120	108	<33	54	44	*155*	*134*	*113*	*57*
		(mg/kg)		<15	16	54	48	<15	24	20	*69*	*60*	*51*	*25*
	Exchangeable Aluminium	(cmol+/kg)	**Inhouse S37 (KCl)	0.42	0.96	0.22	0.74	0.82	0.85	0.32	*0.6*	*0.5*	*0.4*	*0.2*
		(kg/ha)		84	194	44	150	166	171	65	*121*	*101*	*73*	*30*
		(mg/kg)		38	87	20	67	74	77	29	*54*	*45*	*32*	*14*
	Exchangeable Hydrogen	(cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.13	0.21	0.08	0.40	0.13	0.23	0.13	*0.6*	*0.5*	*0.4*	*0.2*
		(kg/ha)		2.9	4.7	1.8	8.9	2.8	5.2	2.9	*13*	*11*	*8*	*3*
		(mg/kg)		1.3	2.1	<1	4.0	1.3	2.3	1.3	*6*	*5*	*4*	*2*
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	3.0	3.0	2.8	2.9	4.2	2.9	2.6	*20.1*	*14.3*	*7.8*	*3.3*
	Calcium (%)		**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	52	36	49	15	58	23	46	*77.6*	*75.7*	*65.6*	*57.4*
	Magnesium (%)			21	15	28	28	14	26	26	*11.9*	*11.9*	*15.7*	*18.1*
	Potassium (%)			6.3	7.3	3.6	11	5.0	9.5	8.0	*3.0*	*3.5*	*5.2*	*9.1*
	Sodium - ESP (%)			1.8	2.4	8.4	7.3	0.64	3.7	3.3	*1.5*	*1.8*	*2.9*	*3.3*
	Aluminium (%)			14	32	7.9	26	20	30	12	*6.0*	*7.1*	*10.5*	*12.1*
	Hydrogen (%)			4.3	7.1	2.9	14	3.0	8.1	4.9				
	Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol+/kg)	2.4	2.5	1.8	0.54	4.3	0.89	1.8	*6.5*	*6.4*	*4.2*	*3.2*
	Zinc (mg/kg)		Rayment & Lyons 2011 - 12A1 (DTPA)	0.75	<0.5	<0.5	0.52	0.69	<0.5	<0.5	*6.0*	*5.0*	*4.0*	*3.0*
	Manganese (mg/kg)			5.1	2.4	6.1	4.5	20	9.9	9.0	*25*	*22*	*18*	*15*

			Site	DReveg1	DReveg2	DReveg3	DWoodLQ	DWood1	DWood2	DWood3	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
	Iron (mg/kg)			240	209	190	390	210	377	272	*25*	*22*	*18*	*15*
	Copper (mg/kg)			0.25	0.16	0.14	<0.1	0.13	0.11	0.18	*2.4*	*2.0*	*1.6*	*1.2*
	Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)		0.19	0.12	0.12	0.10	0.25	0.25	0.11	*2.0*	*1.7*	*1.4*	*1.0*
	Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)		27	21	20	19	19	19	22	*50*	*45*	*40*	*35*
	Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)		2.0	2.5	1.6	2.7	3.2	2.9	2.0	*> 3.1*	*> 2.6*	*> 2.0*	*> 1.4*
	Total Nitrogen (%)			0.13	0.10	0.11	0.14	0.14	0.11	0.09	*> 0.30*	*> 0.25*	*> 0.20*	*> 0.15*
	Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen		16	26	16	19	22	27	23	*10–12*	*10–12*	*10–12*	*10–12*
	Basic Texture	**Inhouse S65		Loam	Loam	Loam	Loam	Loam	Loam	Loam	..	..	..	..
	Basic Colour			Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	Brownish	..	..	..	..
	Chloride Estimate (equiv. mg/kg)	**Calculation: Electrical Conductivity x 640		12	19	45	28	32	22	16	..	..	..	..

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.*CSIRO Publishing: Collingwood.
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.
5. Guidelines for phosphorus have been reduced for Australian soils.
6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.
7. Total Acid Extractable Nutrients indicate a store of nutrients.
8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
   Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.
9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.
10. Conversions for 1 $cmol_+/kg$ = 230 mg/kg Sodium, 390 mg/kg Potassium,

11. Conversions to kg/ha = mg/kg x 2.24
12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate
13. ** NATA accreditation does not cover the performance of this service.
14. Analysis conducted between sample arrival date and reporting date.
15. This report is not to be reproduced except in full. Results only relate to the item tested.
16. All services undertaken by EAL are covered by the EAL Laboratory Services Terms and Conditions (refer scu.edu.au/eal).
17. This report was issued on 23/10/2019.

Quality Checked: Kris Saville
Agricultural Co-Ordinator

Appendix 5. 2019 Annexure D: Completed field monitoring forms and photo-points

Monitoring Data Sheet			
Monitoring Point Number	GBReveg1	Date	8/10/2019
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 635978E, 6318477N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:			0
Midstorey:			0.01
Groundcover(grass):			30
Groundcover (shrub):			0
Groundcover (other):			1
Native species richness:			11
Proportion of canopy species regenerating			0
Exotic cover			38.75
Number of trees with hollows			0
Total length of fallen logs			0
3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			
Threatened species sightings			Superb Parrot
Fire event/fuel			Low
Weeds			Annual
Pest animals			Goats & Kangaroos
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points GBReveg1 55 635978E, 6318477N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	GBReveg2	Date	10/10/2019
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636002E, 6317748N		

2. Floristic BioMetric attributes	
Native cover	
Overstorey:	0
Midstorey:	0
Groundcover(grass):	25
Groundcover (shrub):	0
Groundcover (other):	0.8
Native species richness:	20
Proportion of canopy species regenerating	0
Exotic cover	7.5
Number of trees with hollows	0
Total length of fallen logs	0

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Nil
Threatened species sightings			Nil
Fire event/fuel			Low
Weeds			Annual
Pest animals			Goats & Kangaroos
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points GBReveg2 55 636002E, 6317748N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	GBReveg3	Date	10/10/2019
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636570E, 6318095N		

2. Floristic BioMetric attributes	
Native cover	
Overstorey:	0
Midstorey:	0
Groundcover(grass):	22.5
Groundcover (shrub):	0
Groundcover (other):	5.5
Native species richness:	12
Proportion of canopy species regenerating	0
Exotic cover	19
Number of trees with hollows	0
Total length of fallen logs	0

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Nil
Threatened species sightings			Babblers in adjacent woodland
Fire event/fuel			Low
Weeds			Annual
Pest animals			Goats & Kangaroos
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	8/10/2019
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636926E, 6318020N		

2. Floristic BioMetric attributes	
Native cover	
Overstorey:	0
Midstorey:	0
Groundcover(grass):	38.75
Groundcover (shrub):	0
Groundcover (other):	20
Native species richness:	14
Proportion of canopy species regenerating	20
Exotic cover	11
Number of trees with hollows	0
Total length of fallen logs	0

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Nil
Threatened species sightings			Nil
Fire event/fuel			Low
Weeds			Annual
Pest animals			Kangaroos & Goats
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points GBReveg4 55 636926E, 6318020N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	GBReveg5	Date	8/10/2019
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 637055E, 6318301N		

2. Floristic BioMetric attributes	
Native cover	
Overstorey:	0
Midstorey:	0
Groundcover(grass):	28
Groundcover (shrub):	0
Groundcover (other):	3.2
Native species richness:	17
Proportion of canopy species regenerating	0
Exotic cover	37.5
Number of trees with hollows	1
Total length of fallen logs	0

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			*Eucalyptus dwyeri*
Threatened species sightings			Nil
Fire event/fuel			Low
Weeds			Annual
Pest animals			Goats & Kangaroos
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	8/10/2019
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636101E, 6318236N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:			37.25
Midstorey:			0
Groundcover(grass):			2.75
Groundcover (shrub):			0
Groundcover (other):			0.1
Native species richness:			4
Proportion of canopy species regenerating			0
Exotic cover			0
Number of trees with hollows			13
Total length of fallen logs			97.5
3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Nil
Threatened species sightings			Babblers
Fire event/fuel			Low
Weeds			Nil
Pest animals			Kangaroos/ Goats
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points: GBWood1 55 636101E, 6318236N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	GBWood2	Date	9/10/2019
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 635682E, 6317708N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:			56.75
Midstorey:			0
Groundcover(grass):			0.04
Groundcover (shrub):			1.17
Groundcover (other):			0
Native species richness:			12
Proportion of canopy species regenerating			0
Exotic cover			0
Number of trees with hollows			0
Total length of fallen logs			34
3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			*Acacia paradoxa*
Threatened species sightings			Nil
Fire event/fuel			Low
Weeds			Nil
Pest animals			Goats/ Kangaroos
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points: GBWood2 55 635682E, 6317708N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	GBWood3	Date	10/10/2019
Vegetation Community	LA151 Western Grey Box - Cypress Pine shrubby woodland on stony footslopes in the NSW South Western Slopes Bioregion and Riverina Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 635080E, 6318033 N		
2. Floristic BioMetric attributes			
Native cover			
Overstorey:			49.75
Midstorey:			0
Groundcover(grass):			0.4
Groundcover (shrub):			0.05
Groundcover (other):			0.05
Native species richness:			9
Proportion of canopy species regenerating			0.5
Exotic cover			0
Number of trees with hollows			2
Total length of fallen logs			168.5
3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			*Eucalyptus microcarpa*
Threatened species sightings			Superb Parrot, Grey Crowned Babbler
Fire event/fuel			Low
Weeds			Nil
Pest animals			Goats & Kangaroos
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points GBWood3 55 635080E, 6318033 N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	DReveg1	Date	8/10/2019
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636561E, 6318547N		

2. Floristic BioMetric attributes	
Native cover	
Overstorey:	0
Midstorey:	5.5
Groundcover(grass):	32.5
Groundcover (shrub):	0.1
Groundcover (other):	0.55
Native species richness:	13
Proportion of canopy species regenerating	0.5
Exotic cover	10.1
Number of trees with hollows	0
Total length of fallen logs	0

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			*Eucalyptus dwyeri*
Threatened species sightings			Babblers
Fire event/fuel			Low
Weeds			Annual
Pest animals			Kangaroos, Goats & Rabbits
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points DReveg1 55 636561E, 6318547N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	DReveg2	Date	8/10/2019
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636623E, 6318461N		

2. Floristic BioMetric attributes	
Native cover	
Overstorey:	0
Midstorey:	0
Groundcover(grass):	6.75
Groundcover (shrub):	0.02
Groundcover (other):	0.37
Native species richness:	10
Proportion of canopy species regenerating	0
Exotic cover	0
Number of trees with hollows	0
Total length of fallen logs	4

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			*Acacia decora, Eucalyptus dwyeri*
Threatened species sightings			Nil
Fire event/fuel			Very Low
Weeds			Very low
Pest animals			Goats, Rabbits, Kangaroos
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points DReveg2 55 636623E, 6318461N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	DReveg3	Date	8/10/2019
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 637305E, 6318039N		

2. Floristic BioMetric attributes	
Native cover	
Overstorey:	0
Midstorey:	0
Groundcover(grass):	22.5
Groundcover (shrub):	0
Groundcover (other):	3.5
Native species richness:	18
Proportion of canopy species regenerating	0
Exotic cover	31
Number of trees with hollows	0
Total length of fallen logs	0

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Nil
Threatened species sightings			Nil
Fire event/fuel			Low
Weeds			Annual weeds abundant
Pest animals			Goats & Kangaroos
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points DReveg3 55 637305E, 6318039N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	DWood1	Date	9/10/2019
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:	24
Midstorey:	0
Groundcover(grass):	4.25
Groundcover (shrub):	0
Groundcover (other):	1.3
Native species richness:	24
Proportion of canopy species regenerating	0.3
Exotic cover	0
Number of trees with hollows	4
Total length of fallen logs	316

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			*Callitris endlicheri*
Threatened species sightings			Nil
Fire event/fuel			Low
Weeds			Very low
Pest animals			Goats & Kangaroos
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points DWood1 55 635665E, 6316756N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	DWood2	Date	9/10/2019
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:	29.25
Midstorey:	0
Groundcover(grass):	0
Groundcover (shrub):	5.2
Groundcover (other):	0.2
Native species richness:	19
Proportion of canopy species regenerating	0.3
Exotic cover	0
Number of trees with hollows	3
Total length of fallen logs	209.5

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			*Callitris endlicheri*
Threatened species sightings			Nil
Fire event/fuel			Low – moderate
Weeds			Nil
Pest animals			Kangaroos & Goats
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points DWood2 55 636044E, 6316797N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	DWood3	Date	9/10/2019
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 6361176E, 6317341N		

2. Floristic BioMetric attributes	
Native cover	
Overstorey:	26.75
Midstorey:	0
Groundcover(grass):	0
Groundcover (shrub):	10.75
Groundcover (other):	0
Native species richness:	11
Proportion of canopy species regenerating	0.6
Exotic cover	0
Number of trees with hollows	0
Total length of fallen logs	61

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

Photo Points DWood3 55 6361176E, 6317341N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	DWoodLQ	Date	9/10/2019
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636191E, 6317757N		

2. Floristic BioMetric attributes	
Native cover	
Overstorey:	29.5
Midstorey:	0
Groundcover(grass):	3.9
Groundcover (shrub):	0.1
Groundcover (other):	2.1
Native species richness:	12
Proportion of canopy species regenerating	0.5
Exotic cover	0
Number of trees with hollows	0
Total length of fallen logs	9

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			*Eucalyptus dwyeri* (extensive in wider area)
Threatened species sightings			Nil
Fire event/fuel			Low
Weeds			Nil
Pest animals			Goats & Kangaroos
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points DWoodLQ 55 636191E, 6317757N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	IronWood1	Date	10/10/2019
Vegetation Community	LA165 Mugga Ironbark - Black Cypress Pine woodland on hillslopes and ridges of the Central Lachlan region of the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 635146E, 6317472N		

2. Floristic BioMetric attributes	
Native cover	
Overstorey:	45.25
Midstorey:	0
Groundcover(grass):	0
Groundcover (shrub):	5.7
Groundcover (other):	0
Native species richness:	19
Proportion of canopy species regenerating	0.3
Exotic cover	0
Number of trees with hollows	0
Total length of fallen logs	78

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			*Callitris endlicheri*
Threatened species sightings			Nil
Fire event/fuel			Low
Weeds			Few
Pest animals			Goats & Kangaroos
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points IronWood1 55 635146E, 6317472N

North	West
	
South	East
	

Monitoring Data Sheet			
Monitoring Point Number	WBWood1	Date	8/10/2019
Vegetation Community	LA218 White Box - White Cypress Pine - Western Grey Box shrub/grass/forb woodland in the NSW South Western Slopes Bioregion		
1. Site Photo(s)Taken	Four photo points taken from the centre of monitoring site facing N,S, E & W: 55 636833E, 6318381N		

2. Floristic BioMetric attributes	
Native cover	
Overstorey:	28
Midstorey:	0
Groundcover(grass):	7.25
Groundcover (shrub):	2
Groundcover (other):	0.5
Native species richness:	28
Proportion of canopy species regenerating	0.5
Exotic cover	0
Number of trees with hollows	2
Total length of fallen logs	55.5

3. Opportunistic observations	GPS coordinates	Photo number	Observations
Natural regeneration of disturbed areas			Nil
Threatened species sightings			Nil
Fire event/fuel			Low
Weeds			Nil
Pest animals			Goats & Kangaroos
Visitor impact/vehicles			Nil
Rubbish dumping			Nil

Photo Points WBWood1 55 636833E, 6318381N

North	West
	
South	East