2018 Kokoda Biodiversity Offset Area Ecological Monitoring Report

for

Northparkes Mines

December 2018

DnA Environmental

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The field work, data analyses and resultant report were undertaken and prepared by Dr Donna Johnston and Andrew Johnston, DnA Environmental.

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Cover photo

Natural regeneration of *Acacia spectabilis* (Mudgee Wattle) had matured and was extensively flowering this year.

Executive summary

The 2018 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 in spring and this year was undertaken during 24th - 26th September.

Summary of results

The average annual rainfall at Parkes Airport is 608 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, with a total of 562 mm being recorded for the year. Extremely dry conditions extended into 2018 and these included the key growing seasons in autumn and spring where very limited rainfall fell. Up until November this year only 300 mm was received, compared to an expected average of 553 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 exist as degraded native grasslands but they typically had good ground cover comprised of a combination of annual and perennial plants and cryptogams.

This year, drought conditions and heavy grazing has resulted in a reduction in the stability, infiltration and nutrient recycling capacity of all sites. Heavy grazing and disturbance by animals has tended to reduce the integrity of the ground covers and litter layers where the soils have become more susceptible to erosion. Most sites continued to maintain high functional patch areas however a decline in patch area was recorded in DReveg2 and DWood3.

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; see front cover). In some areas however, significant regeneration of *E. dwyeri* had occurred with stems densities estimated to be ~18, 700 stems per hectare. In the DRG reference sites (DWood3) up to 29,450 *Callitris endlicheri* seedlings per hectare were recorded.

Since 2017 floristic diversity has continued to decline, however most revegetation sites had a higher floristic diversity than their respective reference sites. There was significant reduction in exotic annual species this year, however numerous grassland sites continued to have a higher diversity of exotic species compared to the reference sites. Despite the decline in diversity and abundance in exotic species, most grassland sites continued to be dominated by exotic species and were weedier than desired.

The results of the soil analyses indicate that the soils associated with the Grey Box and DRG woodlands 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 non 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 revegetation monitoring sites against "proposed" Primary Completion Performance Indicators

The table below indicates the performance of the woodland revegetation monitoring sites against a selection of proposed Primary Completion Performance Indicators in 2018. The selection of criteria has been presented in order of rehabilitation phases according to the ESG3 MOP guidelines. The range values of the ecological performance targets are amended annually. Revegetation sites meeting or exceeding the range values of their representative target community type have been identified with a coloured box and have therefore been deemed to meet these primary completion performance targets this year. Hashed coloured boxes associated with soil condition indicate they may be outside of the reference target ranges, but within acceptable agricultural limits.

Performance of the Grey Box, White Box, Ironbark and Dwyer's Red Gum woodland revegetation sites against primary completion performance indicators in 2018.

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Unit of measurement	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					2018	2018	2018	20185	2018	2018	2018	2018	2018	2018	2018
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)	5.6	5.7	5.2	5.3	6.6	5.3	6.1	6.0	6.1	6.2	5.1
			Organic Matter	% (>4.5)	3.2	3.5	2.2	3.2	2.7	5.2	3.4	2.3	1.8	3.1	3.6
			Phosphorous	ppm (50)	9.2	7.9	9.2	5.2	6.6	9.2	7.2	7.9	6.2	7.9	7.2
Phase 4: Ecosystem & Landuse Establishment	Landscape Function Analysis (LFA): Landform stability and organisation	Landform is stable and performing as it was designed to do	LFA Stability	%	74.1	68.4	66.5	65.2	71.1	68.5	73.1	69.0	74.4	61.0	66.3
			LFA Landscape organisation	%	100	86	100	99	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	2	1	3	1	0	0	0	0	3	6
				% population	100	100	100	100	100	0	0	0	0	100	100
			Exotic species richness	<No./area	7	0	12	0	13	6	11	12	13	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Unit of measurement	DReveg1	DReveg2	DReveg3	DWoodLQ	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
	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	2	1	11	1	0	0	0	0	5	139
	Ecosystem composition	The vegetation is comprised by a range of growth forms comparable to that of the local remnant vegetation	Trees	No./area	1	0	1	2	1	0	0	0	0	3	4
			Shrubs	No./area	1	2	0	2	0	0	0	0	0	2	3
			Herbs	No./area	15	3	23	8	15	14	15	13	19	14	7
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	%	45.7	38.4	41.5	54.5	44.3	37.6	46.5	43.3	47	50.6	52.5
			LFA Nutrient recycling	%	42.7	40.9	36.2	53.7	44.1	36.2	44.6	39	45.5	49.8	49.8
	Protective ground cover	Ground layer contains protective ground cover and habitat structure comparable with the local remnant vegetation	Perennial plant cover (< 0.5m)	%	3.5	3.5	3.5	2.5	9.5	6.5	20.5	5.5	6	4.5	2.5
			Total Ground Cover	%	98	87.5	91.5	95	100	94	97.5	99	99	99.5	94
	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	%	64.3	100	50	100	46.6	75	47.2	51.9	49.1	100	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	No./area	1	2	1	11	1	0	0	0	0	4	99

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Unit of measurement	DReveg1	DReveg2	DReveg3	DWoodLQ	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood1
			shrubs and juvenile trees 1.5 - 2m in height	No./area	4	0	0	0	0	0	0	0	0	0	1
	Ecosystem structure	The vegetation is developing in structure and complexity comparable to that of the local remnant vegetation	Foliage cover 0.5 - 2 m	% cover	0	0	0	0	0	0	0	0	0	0	1
			Foliage cover >6m	% cover	0	0	0	26	0	0	0	0	0	53	46
	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	100	72.5
			Healthy trees	% population	100	0	0	0.0	0	0	0	0	0	12.5	2.5
			Flowers/fruit: Trees	% population	0	0	0	66.7	0	0	0	0	0	50	22.5

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 the sites.

The proposed revegetation activities within the derived grassland areas as described in the BOMP 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 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). 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.

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. Presently, extensive disturbance and herbivory by macropods and goats has become an important management issue. A control program may need to be implemented with advice from the Local Land Services with the most beneficial outcomes being obtained by a cooperative approach with neighbouring landholders. 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, particularly as most orchids are only identifiable during a limited time period. As a result of the dry conditions experienced throughout most of 2017 and 2018, none of these populations were observed to be flowering, thus emphasising the need to map their known locations.

Other potential management issues may be related to high density *E. dwyeri* and/or *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 is likely to suppress the herbaceous understorey as they become more established, thereby adversely affecting floristic and biodiversity targets in the medium to longer term. Dense tree cover may also encourage herbivores which may increase predation and disturbance. Strategic grazing may reduce the density of existing seedlings and regulate the degree of regeneration through manipulation of the herbaceous understorey and germination niches, in more favourable seasonal conditions.

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. Several areas of boundary fence also require maintenance to ensure neighbouring livestock cannot freely access the property.

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

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1 2018 Kokoda Offset Area Ecological Monitoring Report

1.1 Introduction

The 2018 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 hectare 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 cucullata*	V		1/1
Grey-crowned babbler (eastern subspecies)	*Pomatostomus temporalis temporalis*	V		95/20
Varied sittella	*Daphoenositta chrysoptera*	V		2/2
Diamond firetail	*Stagonopleura guttata*	V		8/3
Eastern bentwing-bat	*Miniopterus schreibersii oceanensis*	V		-/2
Little pied bat	*Chalinolobus picatus*	V		-/2
Yellow-bellied 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

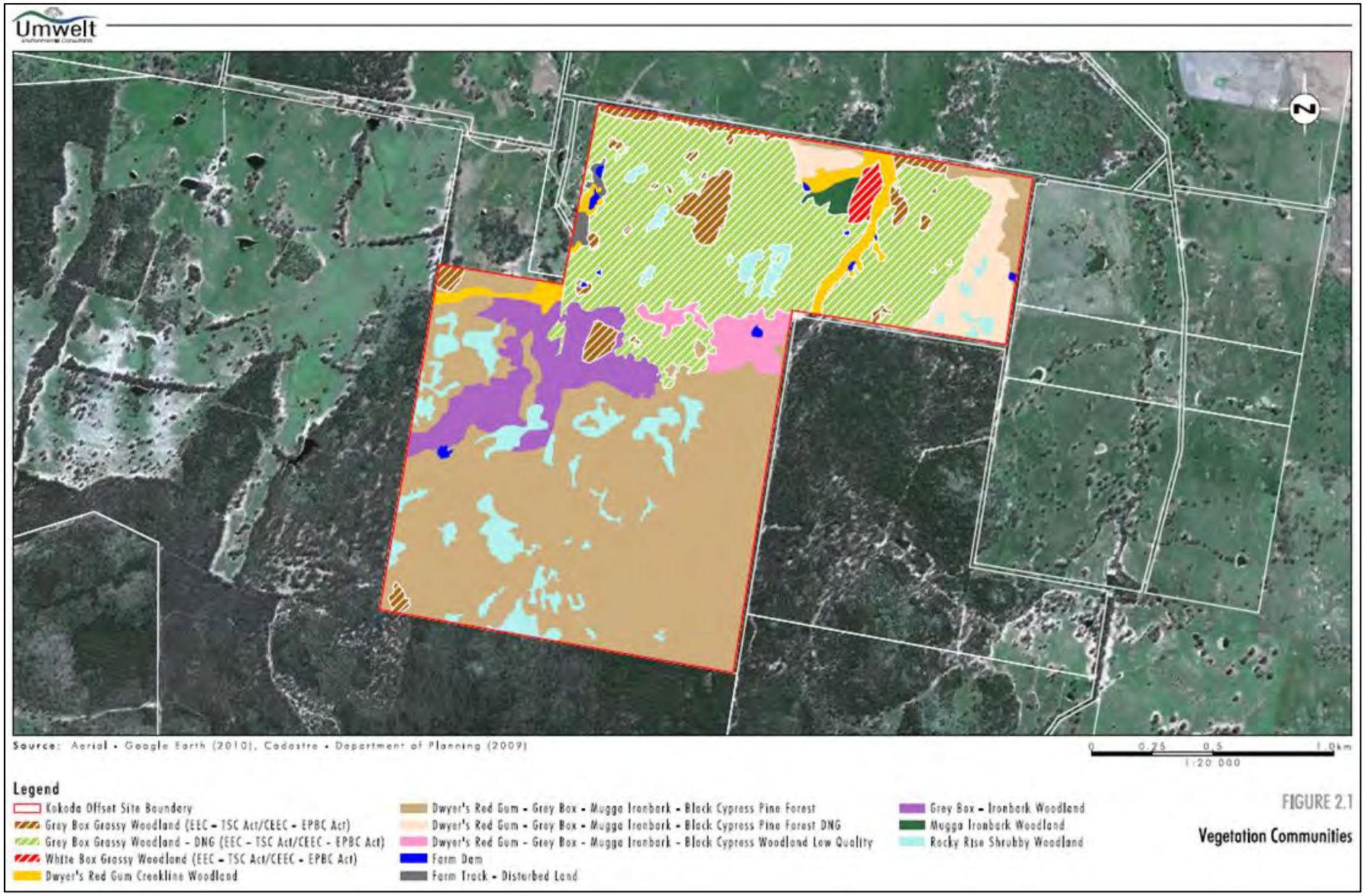


Figure 2-1. Distribution of the various vegetation communities within the Kokoda Offset Area (Umwelt 2014a)

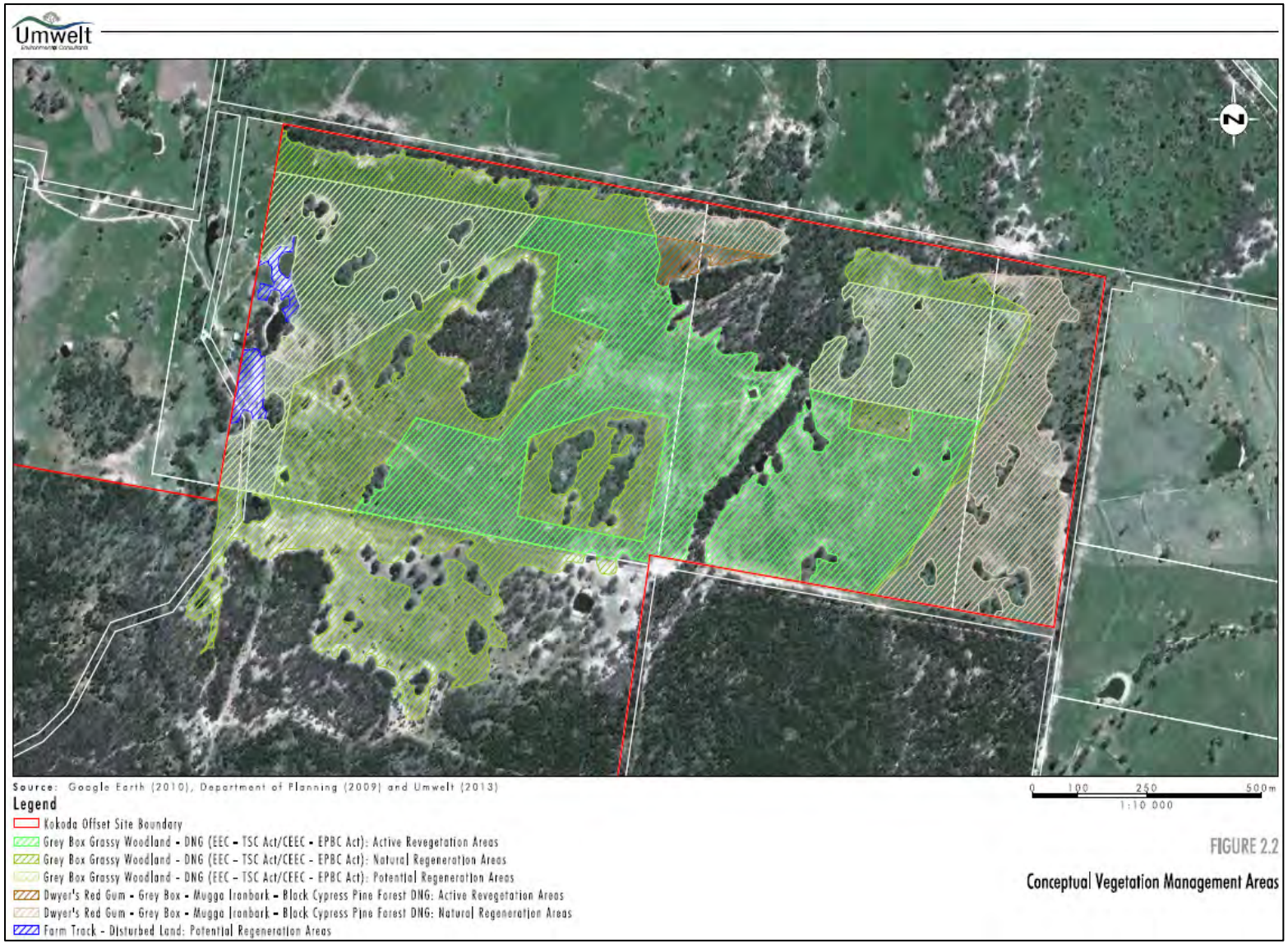


Figure 2-2. Conceptual plan of the different management areas according to potential regenerative capacity and active revegetation management requirements (Umwelt 2014a).

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 natives 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 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

It has been proposed that the ecological monitoring will be annual for the first five years, then every three years for the following 15 years (Umwelt 2014a).

The first ecological monitoring surveys were completed in Winter and Spring 2014 (Umwelt 2014b). Where possible subsequent monitoring events should occur in the same season and preferentially 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 Ecological monitoring methodology

It has been 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 surveys

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).

3.2 2015 vegetation assessments

3.2.1 Conceptual approach

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 includes:

- 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.

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 affect 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 will aim to be undertaken during spring where possible and this year was undertaken from the 24 - 26th September.

4 Vegetation monitoring methodology

The methodology includes 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".

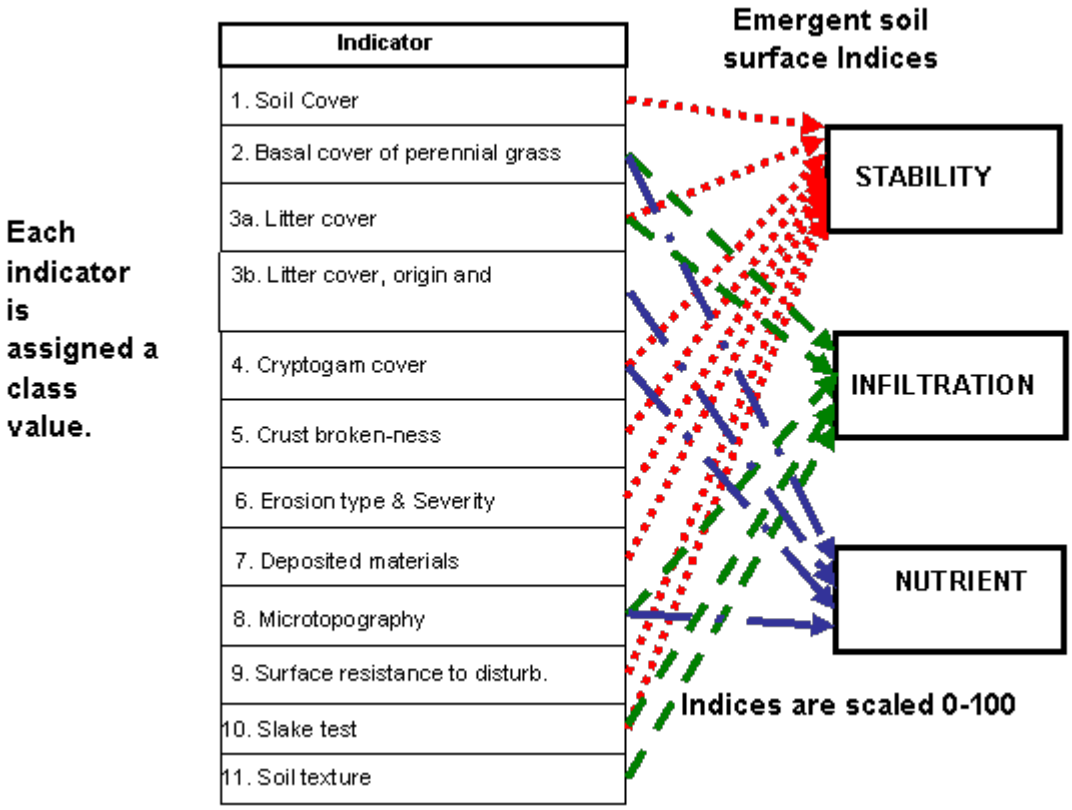
In the second stage, called "soil surface condition" (SSC) assessment, it is possible to assess and monitor soil quality using simple indicators including:

- 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.

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:

- Floristic diversity including species area curves and growth forms;
- Ground cover diversity and abundance;
- Vegetation structure and habitat characteristics (including ground cover, cryptogams, logs, rocks, litter, projected foliage cover at various height increments);
- Understorey density and growth (including established shrubs, direct seeding and tubestock plantings and tree regeneration);
- Overstorey characteristics including tree density, health and survival; and
- Other habitat attributes such as the presence of hollows, mistletoe and the production of buds, flowers and fruit.

4.3.1 The permanent monitoring quadrats

The permanent monitoring quadrats are a standard 20 x 20m. 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.

4.3.2 Amendments

Since 2017, comprehensive soil sampling and analyses for heavy metals were not undertaken as previous soil results indicated that all sites did not have a heavy metal contaminants, other than high iron levels which were typical of the local area as demonstrated in the various woodland reference sites.

Rather, a “Basic agricultural soil analyses” was undertaken and included analyses of the following parameters: Soil pH and EC (1:5 water); Available (Calcium, Magnesium, Potassium, Ammonium, Nitrate, Phosphate, Sulfur); Exchangeable (Sodium, Potassium, Calcium, Magnesium, Hydrogen, Aluminium, Cation Exchange Capacity); Bray I and II Phosphorus; Colwell Phosphorus; Available Micronutrients (Zinc, Manganese, Iron, Copper, Boron, Silicon); Total Carbon (TC), Total Nitrogen (TN), Organic Matter, TC/TN Ratio; Basic Colour, Basic Texture.

4.3.3 Changes to completion targets

On review of the proposed completion targets in 2017, a few changes were considered and these were:

- Inclusion of Landform slope as a primary completion criteria;

- Inclusion of Phosphorous (P) as a primary completion criteria;
- Omission of Nitrate (N) as a primary completion criteria; and
- Inclusion of Tree and mature shrubs (>5cm dbh) density as a primary completion criteria.

These changes have been reflected in the relevant KPI tables throughout the document since 2017.

5 Ecological 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.

In 2015, 17 permanent monitoring sites were established which included three Grey Box Grassy woodland reference sites and five DNG sites which will be regenerated back to Grey Box Grassy woodland (Table 5-1). There were three Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress woodland reference sites and three DNG which will be regenerated back to the Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress woodland community.

There were also one site established in each of represented examples of White Box Grassy Woodland CEEC, Grey Box – Ironbark woodland and Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest which was mapped as low quality woodland. The remaining two vegetation communities were rather patchy and/or narrow linear corridors and made an overall relatively minor contribution in terms of overall biodiversity significance or influence on biodiversity targets that would not already be reflected within the existing range of monitoring sites.

Table 5-1. The numbers of permanent monitoring sites established in each of the vegetation communities as compared to those mapped by Umwelt and their 2014 surveys.

Community type (as per Umwelt 2014)	Size (ha)	Site description	No sites established by Umwelt 2014	No. sites established by DnA 2015
Grey Box Grassy woodland DNG (EEC)	96	Probable active rehabilitation area	6	5
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine DNG	15	Probable active rehabilitation area	4	3
Grey Box Grassy woodland EEC	13	reference site	3	3
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest	150	reference site	3	3
Dwyer's Red Gum – Grey Box – Mugga Ironbark – Black Cypress Pine Forest	8.6	Low quality	0	1
White Box Grassy Woodland CEEC	2.2	CEEC	0	1
Grey Box – Ironbark woodland	25	Non EEC	0	1
Dwyer's Red Gum creek-line woodland	9.4	Non EEC – narrow linear	0	0
Rocky Rise Shrubby woodland	26	Non EEC – Numerous small pockets	0	0
Total No. monitoring Sites			16	17

6 Monitoring site descriptions and locations

GPS co-ordinates (GDA94), aspects and slopes of the ecological monitoring sites first established at Kokoda in 2015 are provided in Table 6-1. The map showing the locations of the monitoring sites is shown in Figure 6-1.

Table 6-1. 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

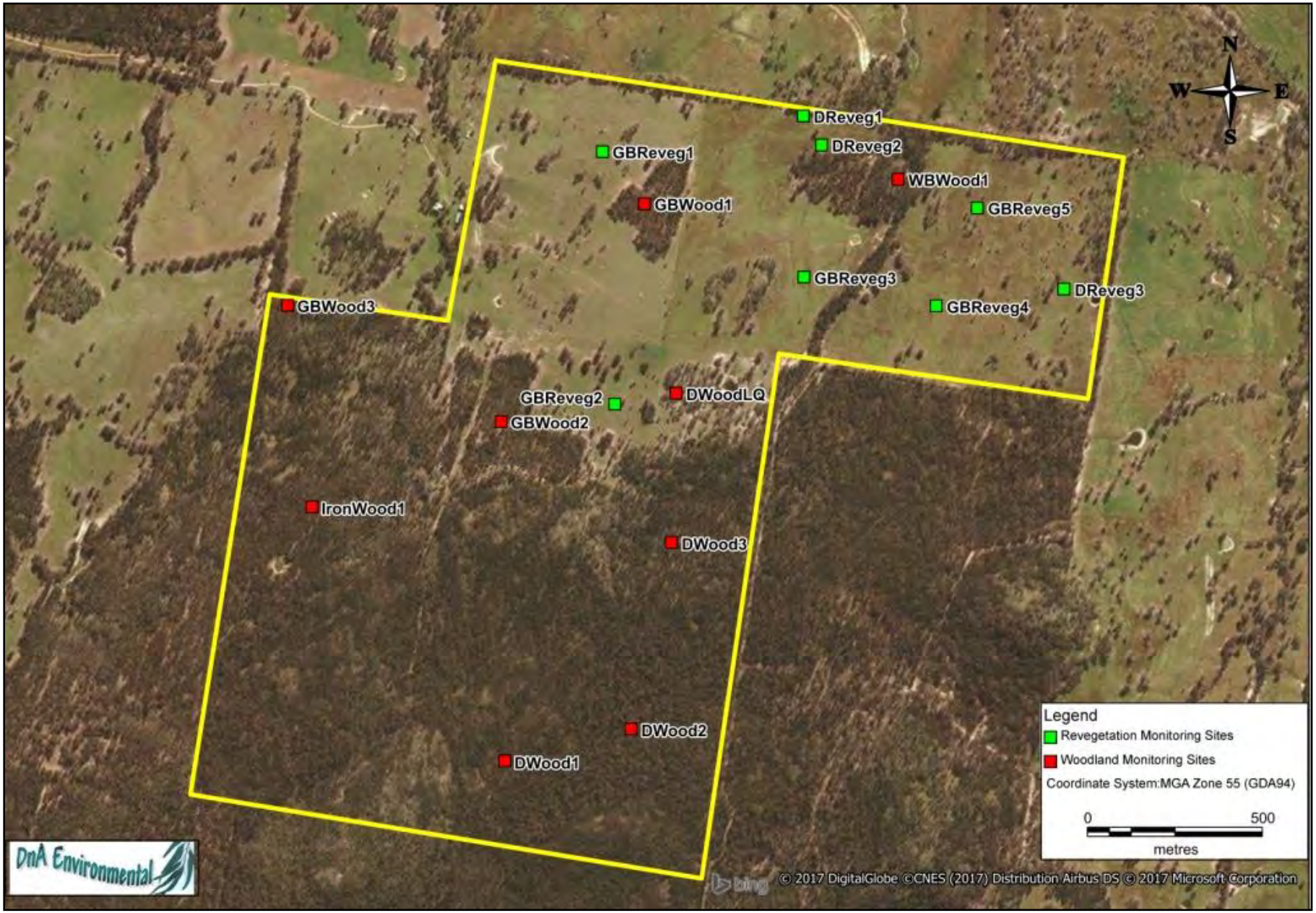


Figure 6-1. Map showing the location of the ecological monitoring sites at Kokoda.

7 Rainfall

The average annual rainfall at Parkes Airport is 608mm (BoM 2018), however there have been extreme seasonal conditions with below average rainfall being recorded in 2015 and 2017. This was followed by widespread flooding in 2016 with a total annual rainfall of 833mm 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 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 Kokoda monitoring period.

April 2016, marked the beginning of a long period of above average monthly rainfall, with record breaking rains falling from April through to October causing widespread flooding. In this nine month period, 605 mm was recorded, with expected averages also being recorded in November and December. In 2017, very low rainfall activity occurred and except in March where 195mm of rainfall was recorded. Rainfall remained well below the expected monthly averages for most of the year, with a total of 562 mm being recorded for the year.

Extremely dry conditions extended in 2018 and these included the key growing seasons in autumn and spring where very limited rainfall fell. Up until November this year, only 300 mm was received compared to the expected average of 553 mm for the first 11 months of the year.

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.

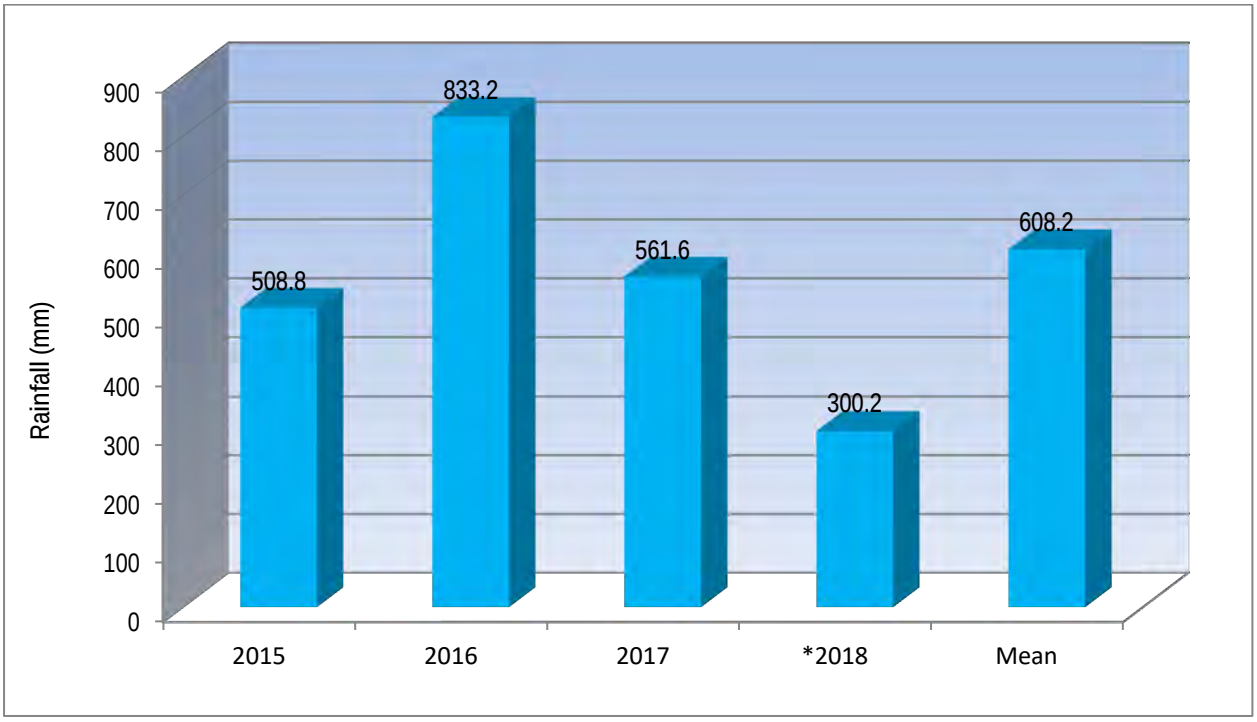


Figure 7-1. Total annual rainfall recorded at Parkes January 2015 to November 2018 compared to the long term averages recorded at Parkes Airport (BoM 2018).

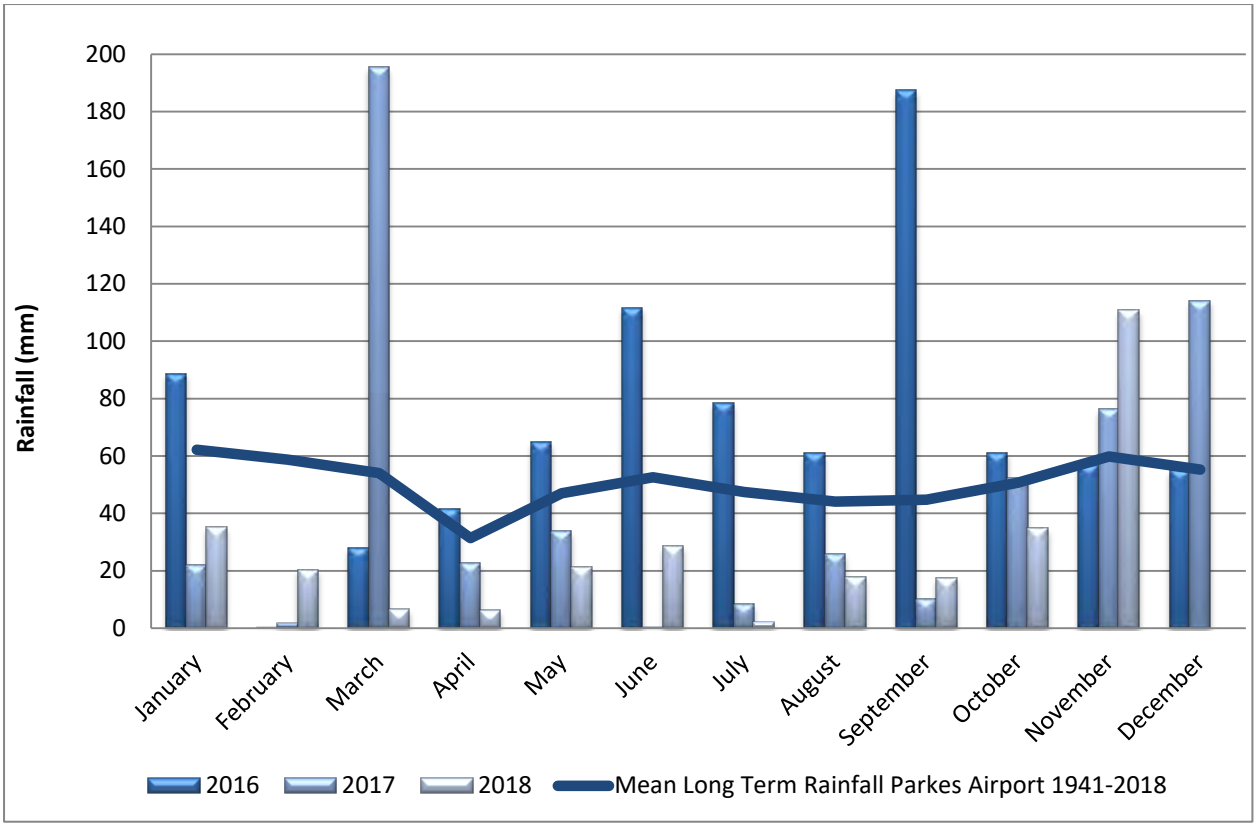


Figure 7-2. Monthly rainfall recorded at Parkes January 2015 to November 2018 compared to the long term monthly averages recorded at Parkes Airport (BoM 2018).

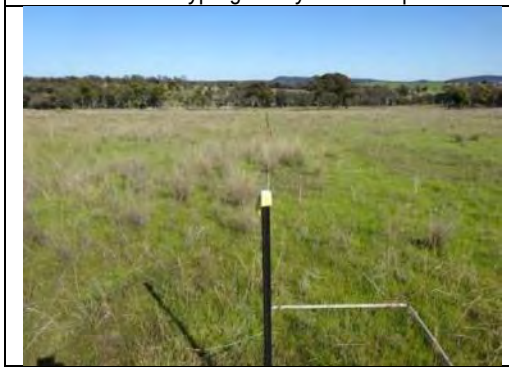
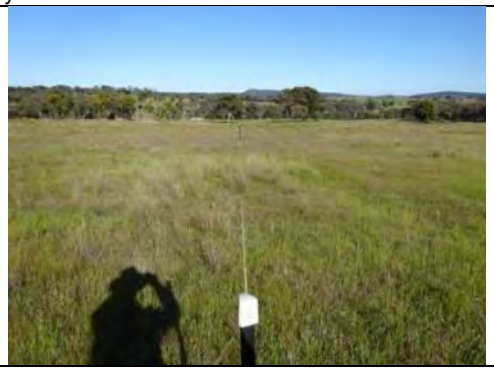
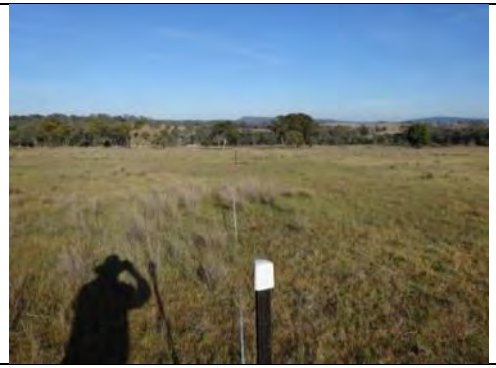
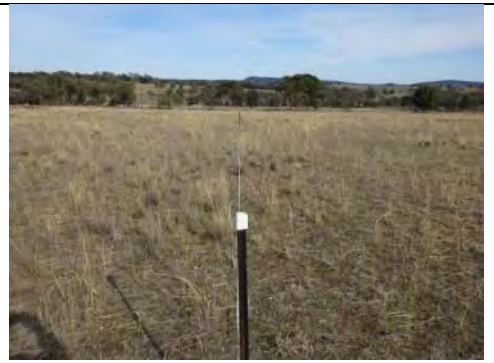
8 Results Grey Box Woodland monitoring sites

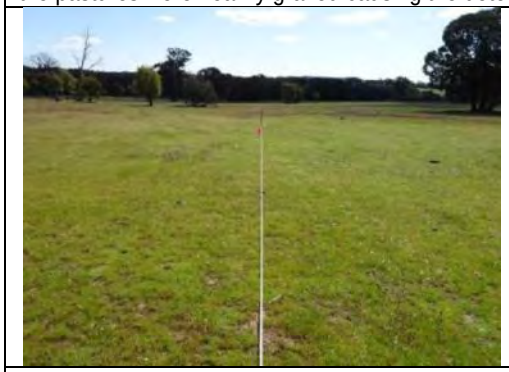
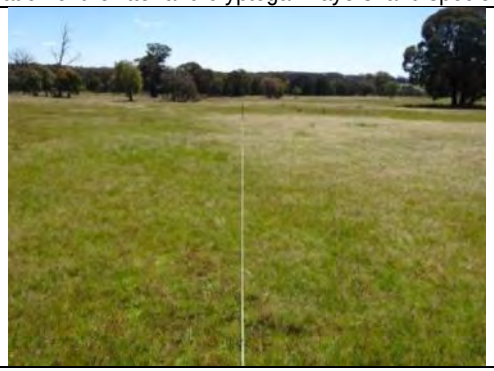
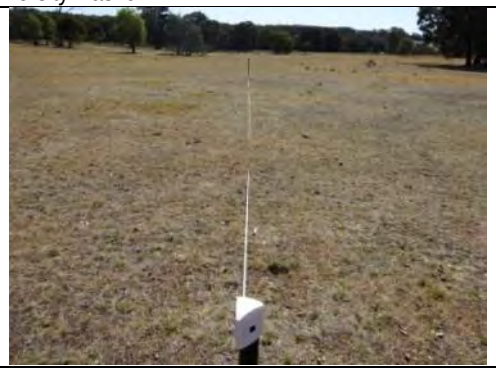
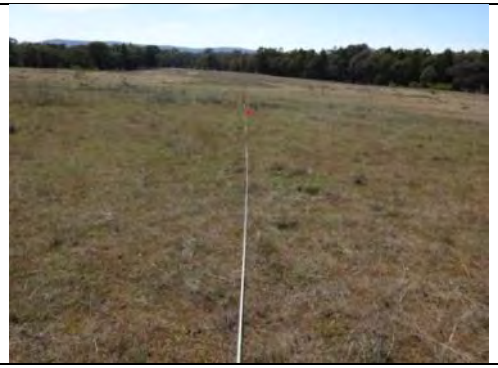
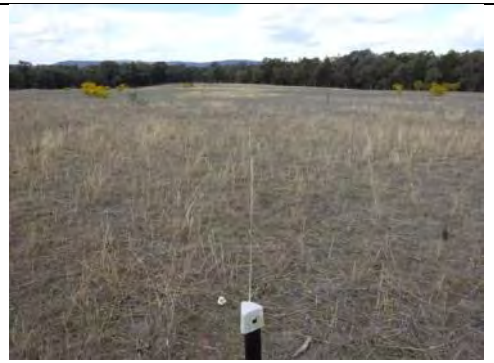
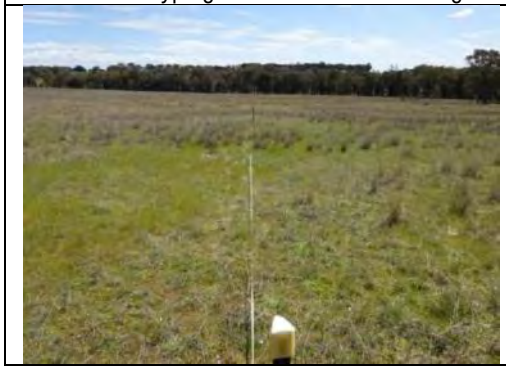
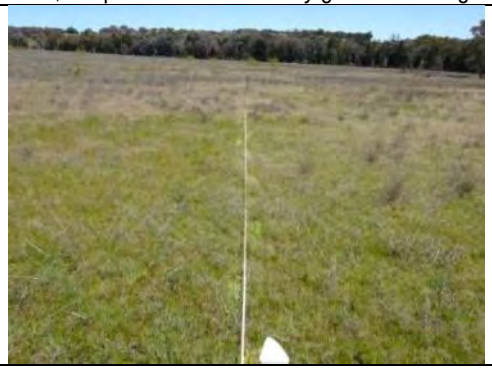
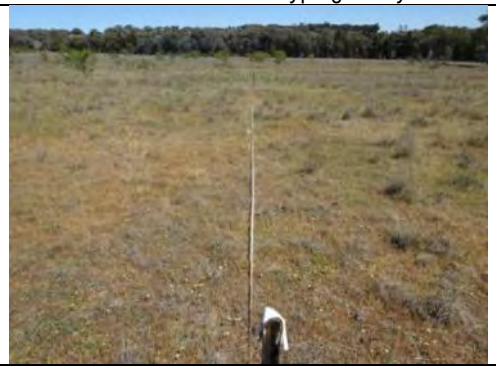
This section provides the results of the monitoring within the Grey Box monitoring sites and demonstrates ecological trends and performance of the revegetation sites against a selection of ecological performance indicators. This section has also included the White Box grassy woodland and Grey Box Ironbark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

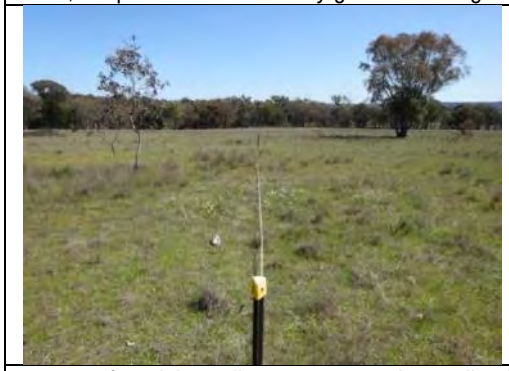
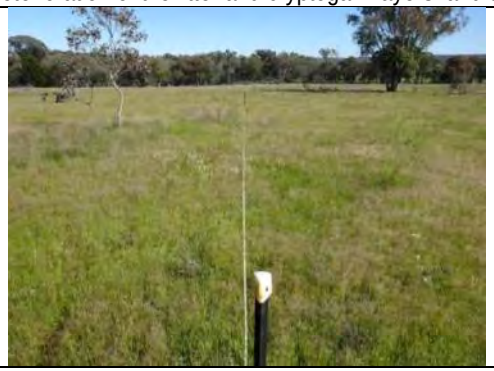
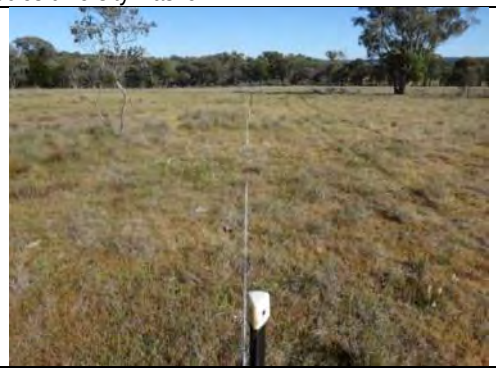
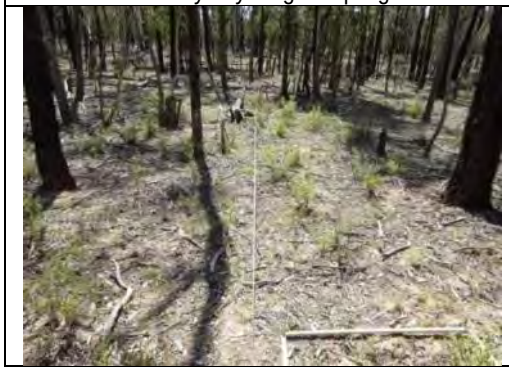
8.1 Photo-points

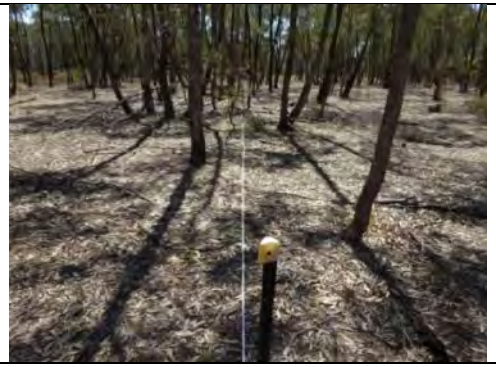
General descriptions of the Grey Box Grassy Woodland monitoring sites established at Kokoda in 2015 including photographs taken along the vegetation transect are provided in Table 8-1.

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

2015	2016	2017	2018
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.			
			

2015	2016	2017	2018
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.			
			
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.			
			
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.			
			

2015	2016	2017	2018
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.			
			
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.			
			
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.			
			

2015	2016	2017	2018
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.			
			
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 braches 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.			
			

2015	2016	2017	2018
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 braches 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.			
			

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 heavy grazing pressure the woodland reference sites maintained high functional patch area and a Landscape Organisation ranging from 97 - 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. This year, there was limited live ground cover and often the integrity of the litter layer 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%.

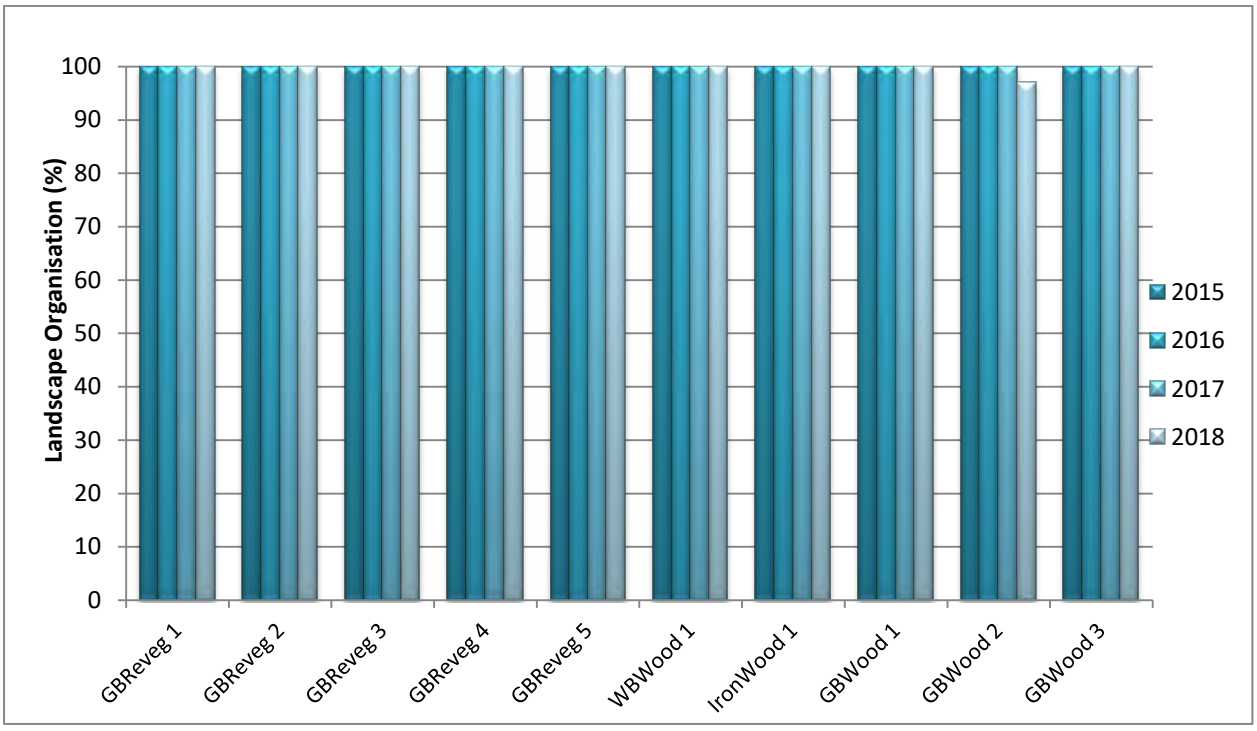


Figure 8-1. Landscape Organisation Indices recorded in the Grey Box woodland monitoring sites.

8.2.2 Soil surface assessments

8.2.2.1 Stability

LFA stability indices in the Grey Box woodland reference sites slightly improved in GBWood3 and no change was recorded in GBWood2, however a marginal decline was recorded in GBWood1 and this year they provided a stability range of 63.5 – 70.1. The stability of the reference sites were being 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 declined in WBWood1 and IronWood1, with indices of 61.0 and 66.3 respectively. While IronWood1 had an ecological stability that was similar to the Grey Box woodland reference sites, stability was slightly too low in WBWood1 this year (Figure 8-2).

In the Grey Box revegetation sites the stability continued to decline in three sites including GBReveg1, GBReveg2 and GBReveg4 but they continued to more stable than the Grey Box reference sites. While there was a reduction in live ground cover and loss of integrity of the litter and cryptogam layers in some sites, there was limited erosion or deposition occurring in the sites. There was a marginal increase in stability in GBReveg3 and GBReveg5 and with indices of 73.1 and 74.4 respectively, continued to be more ecological stable than the reference sites.

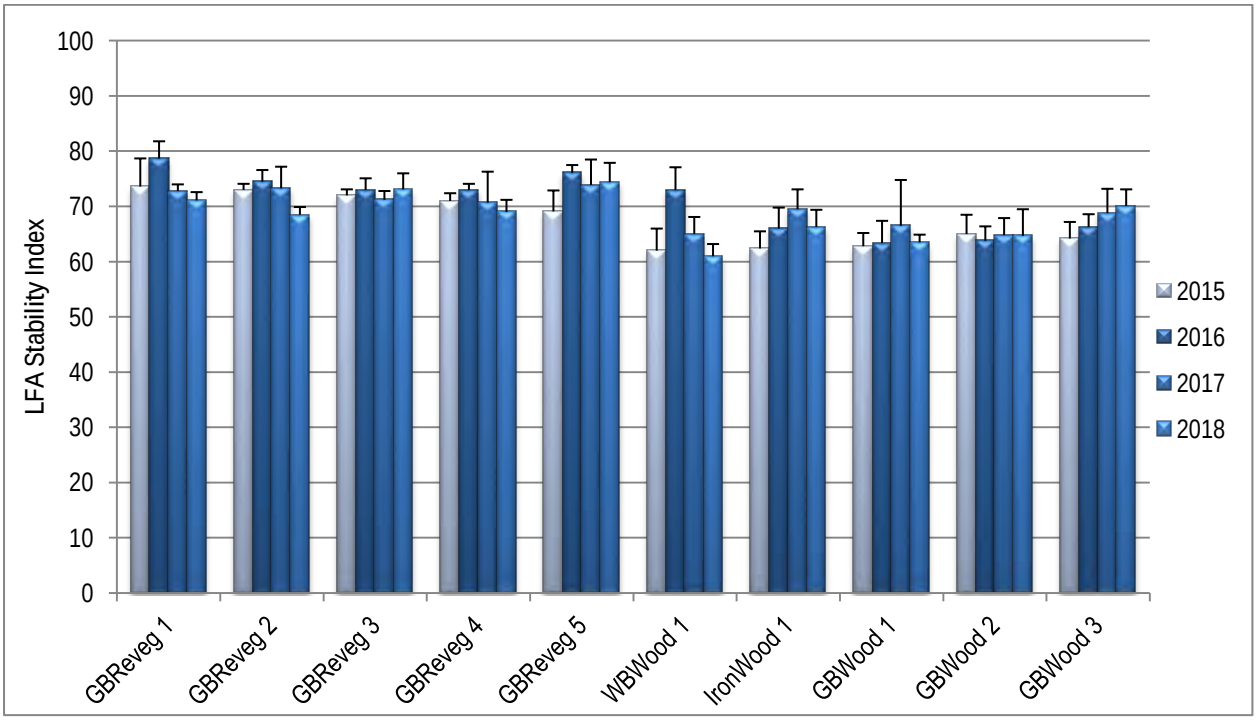


Figure 8-2. LFA stability indices recorded in the Grey Box woodland monitoring sites.

8.2.2.2 Infiltration

The infiltration capacity of the Grey Box, White Box and Ironbark woodland sites continued to be similar to each other with the Grey Box woodland reference sites providing a slightly lower target range of 50.6 – 55.7 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 this year there was a loss of integrity of the litter layers and increased usage by wildlife has tended to result in increase surface crusting, thus reducing infiltration capacity. Similar changes

were recorded in the White Box and Iron Bark woodlands and this year had an infiltration capacity which was comparable to the Grey Box woodlands.

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. Infiltration capacity was slightly lower or had remained unchanged and this year had infiltration indices that ranged from a low of 37.6 (GBReveg2) to a high of 47.0 (GBReveg5).

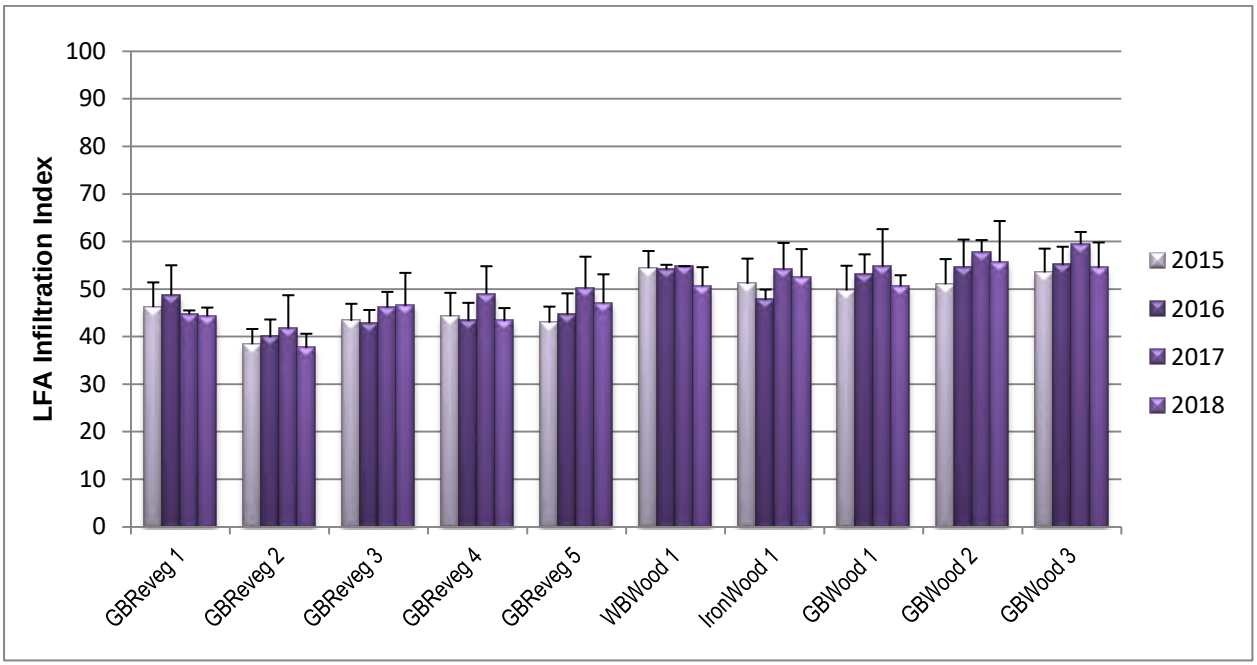


Figure 8-3. LFA infiltration indices recorded in the Grey Box woodland monitoring sites.

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 there was a further reduction in perennial plant cover and there was a loss of integrity of the litter layer, therefore the nutrient recycling capacity had decreased to provide a range of 47.8 – 51.5 (Figure 8-4). There was also a decline in the White Box and Iron Bark woodlands which both had indices of 49.8 this year with this nutrient recycling capacity being similar to the reference sites.

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 but cryptogams were usually abundant. Heavy grazing has however caused a deterioration of grassy understorey and subsequently nutrient recycling indices also declined in all of the revegetation pasture areas. Nutrient recycling indices ranged from a low of 36.2 (GBReveg2) to a high of 45.5 (GBReveg5).

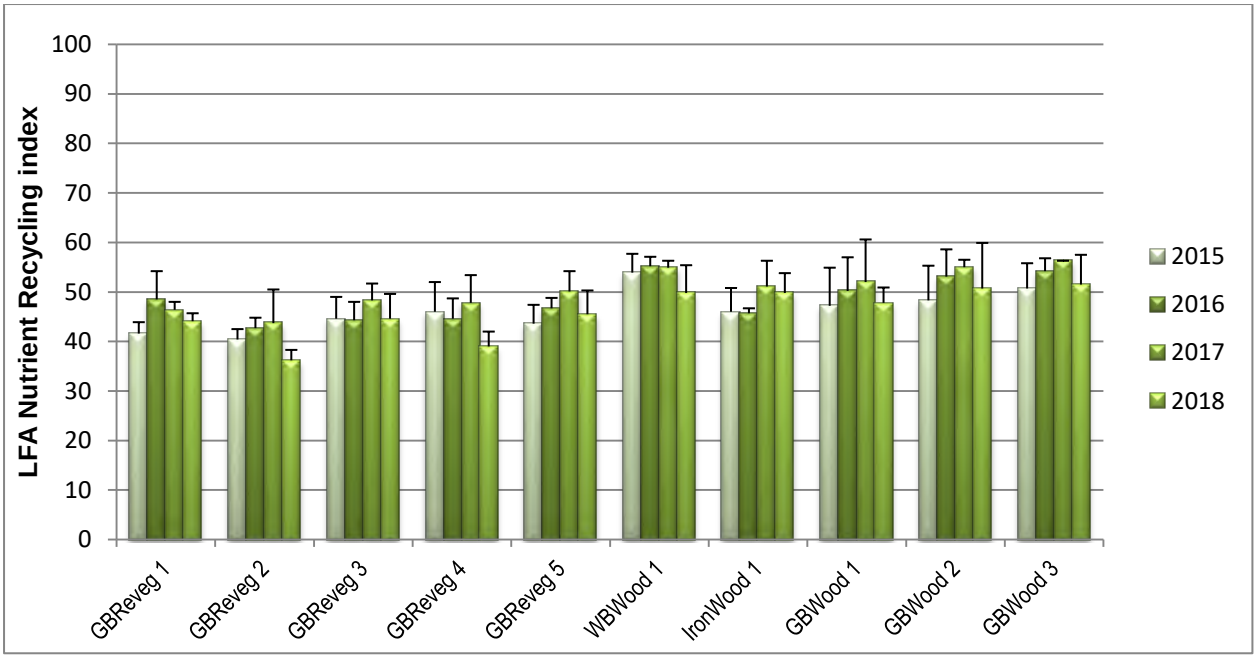


Figure 8-4. LFA nutrient recycling indices recorded in the Grey Box woodland monitoring sites

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 176, followed by GBWood2 with 171, followed closely by Ironwood1 with a sum of scores of 169. These sites contained high patch area, a mature tree canopy and well developed grassy ground cover layer, with high levels of decomposing litter and had very spongy and stable soils.

Despite the lack of perennial overstorey there was relatively high functionality in GBReveg5 and GBReveg3 and with a sum of scores of 167 and 164 respectively were more functional than the woodland sites GBWood1 (162) and WBWood1 (161). The derived native grassland revegetation areas, GBReveg1 scored 160, GBReveg4 scored 151 while the least functional community continued to be GBReveg2 which scored 142.

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

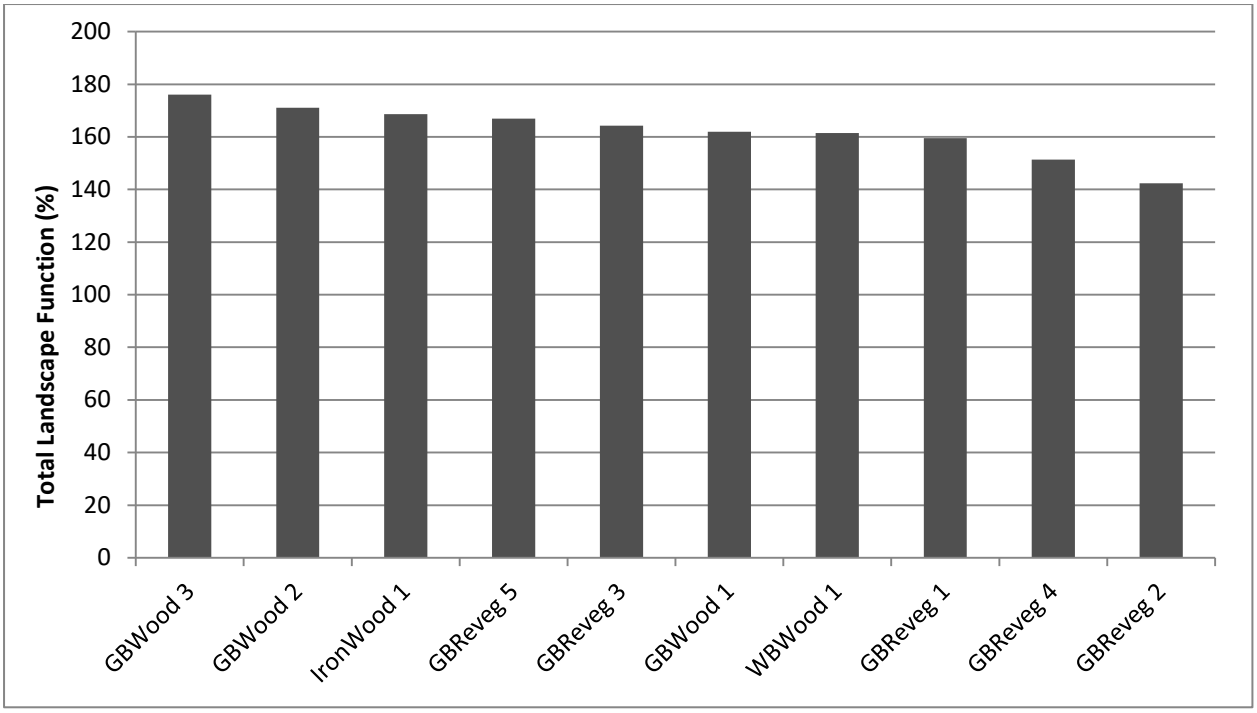


Figure 8-5. Sum of the LFA stability, infiltration and nutrient recycling components indicating the most functional to least functional monitoring site recorded in 2018.

Table 8-2. Examples of the different ground covers in the Kokoda Grey Box monitoring sites in 2018.

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 Ironwood1 another individual had died during the past year. The resultant population densities recorded in the Grey Box reference sites were 8 - 23, equating to a density of 200 – 575 stems per hectare (Figure 8-6). There continued to be eight individuals in the

White Box site and there were 29 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 – 34cm with the minimum dbh being 6cm and the maximum dbh 57cm (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 were also some (dead) stags. There continued to be an absence of mistletoe and this year only GBWood1 and GBWood3 had some trees bearing reproductive structures such as buds, flowers or fruits. Hollows suitable as nesting sites (>10cm) were noted in GBWood1 and GBWood2.

8.3.4 Species composition

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

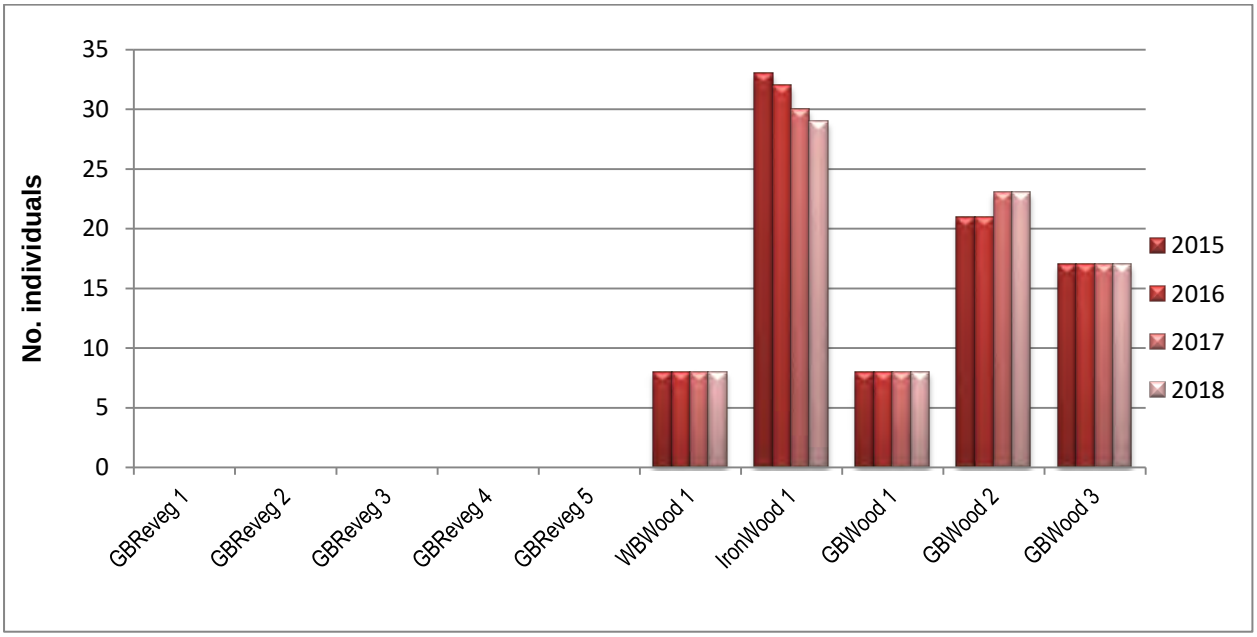


Figure 8-6. Tree and mature shrub densities (>5cm dbh) in the Kokoda Grey Box woodland monitoring sites.

Table 8-3. Trunk diameters and condition of the trees and mature shrubs in the woodland monitoring sites in 2018.

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	100	13	63	25	0	0	50	0
IronWood1	4	17	50	6	40	3	73	3	33	38	28	0	23	0
GBWood1	1	34	57	12	8	0	100	0	75	25	0	0	13	50
GBWood2	2	17	30	8	23	4	100	30	43	26	0	0	0	52
GBWood3	2	24	53	6	20	9	85	15	50	20	15	0	50	0

8.4 Shrubs and juvenile trees

8.4.1 Population density

In the woodland reference sites there were 1 - 21 shrubs and juvenile trees (Figure 8-7), equating to a maximum density of 25 - 525 stems per hectare.

In the White Box woodland some seedlings had died with only five individuals recorded this year as a result of the prolonged dry conditions. In the Ironbark woodland there were 139 individuals. One seedling continued to be recorded in GBReveg1 this year.

8.4.2 Height class

In the reference sites most individuals continued to be less than 0.5m in height but there were increasing numbers that were 0.5 – 1.0m tall. In WBWood1 and IronWood1 most were less than 1.5m in height. In IronWood1 a few individuals were > 2.0 m tall (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), *A. spectabilis* (Mudgee Wattle), *Cassinia laevis (Cough Bush) and/*or *Brachyloma daphnoides* (Daphne Heath).

In the White Box woodland there were three *A. decora* (Western Golden Wattle) and one each of *Acacia implexa* and *Callitris endlicheri* (Black Cypress Pine). In the Ironbark woodland, the shrubby understorey was much more diverse and continued to be dominated by *Brachyloma daphnoides* with numerous *Callitris endlicheri* seedlings. There were also occasional juvenile of *Cassinia laevis, Acacia implexa*, *E. dealbata* and *E albens.* This year no *Callitris glaucophylla* seedlings were found in GBReveg1, but there was one *Cassinia laevis* seedling.

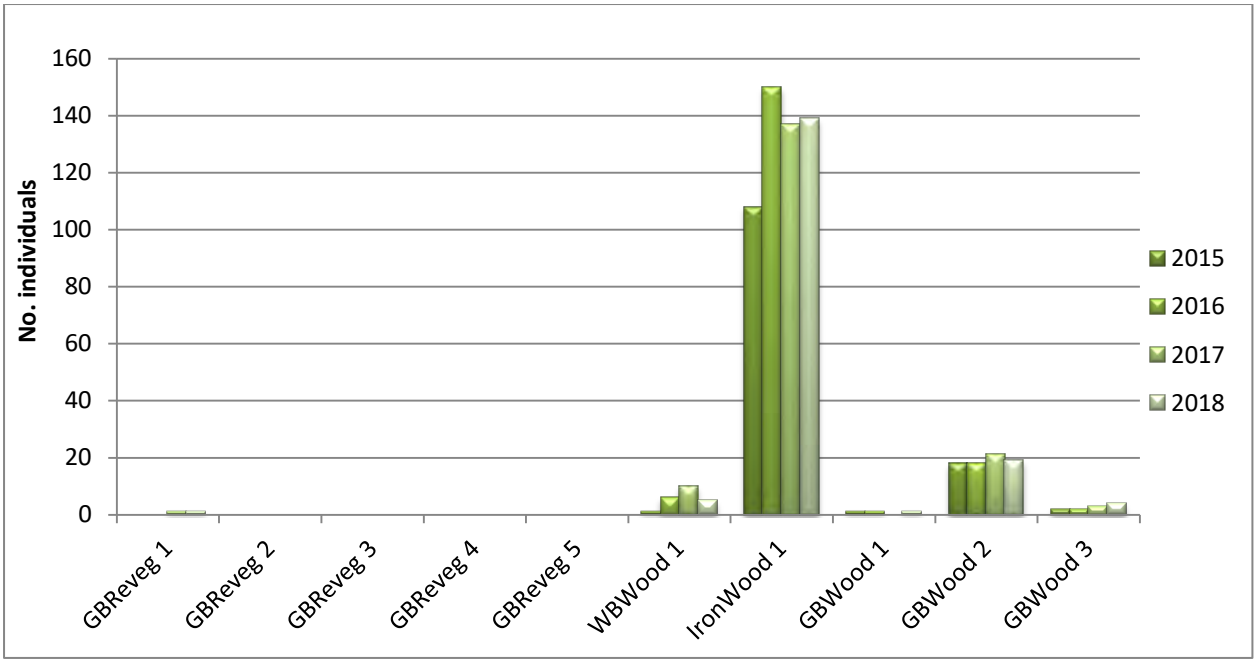


Figure 8-7. Total shrubs and juvenile trees recorded in the Grey Box monitoring sites.

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	4	1	0	0	0	5	3	100
IronWood1	99	36	2	1	1	139	6	100
GBWood1	1	0	0	0	0	1	1	100
GBWood2	9	8	2	0	0	19	3	100
GBWood3	2	1	0	0	1	4	3	100

8.5 Total ground Cover

Total ground cover, which is a combination of leaf litter, annual plants, cryptogams, rocks, logs and live perennial plants (<0.5m in height) continued to be relatively high in the woodland reference sites though this year it had slightly decreased to provide a target range of 94.0 – 98.0% (Figure 8-8). Despite some minor reductions in ground cover in the some of the remaining sites, all sites had an adequate total ground cover this year and ranged from 94.0 %(GBReveg2, IronWood1) to 100% cover in GBReveg1.

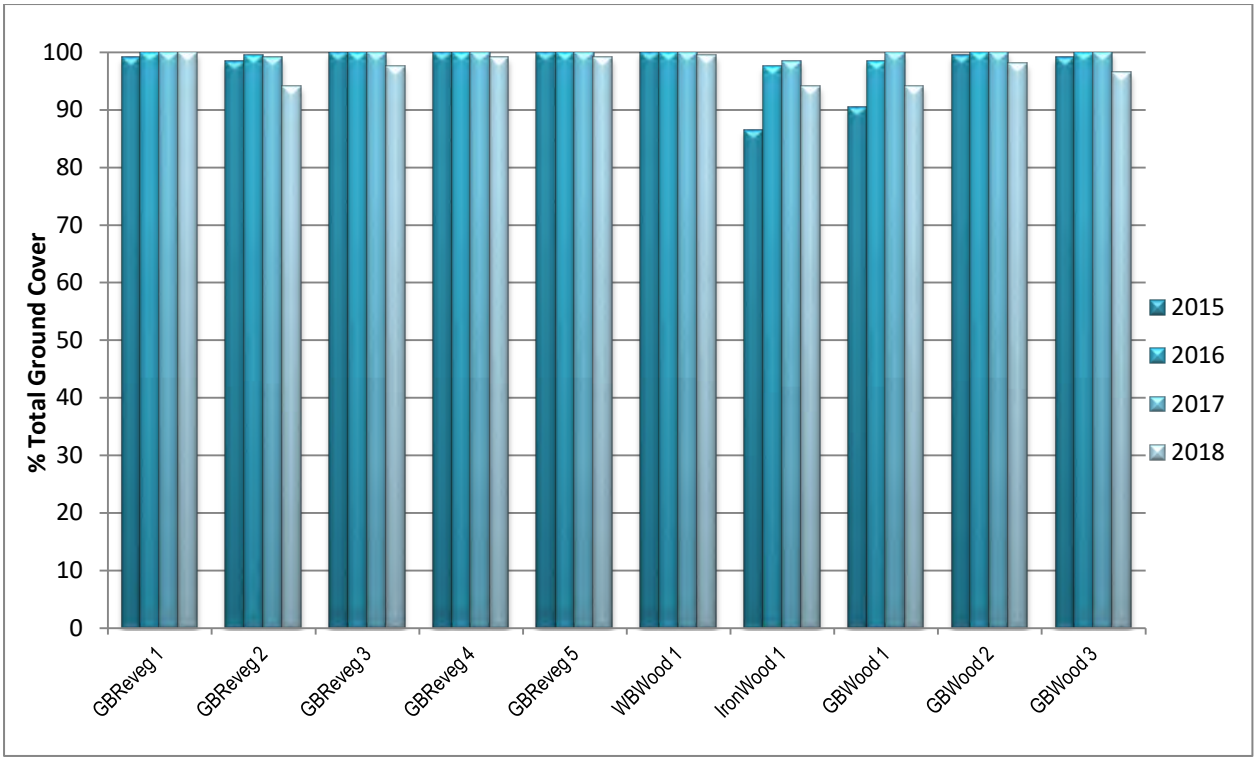


Figure 8-8. Total ground cover recorded in the Grey Box woodland monitoring sites.

8.6 Structural composition

The various combinations of the ground covers and structural compositions of the woodland sites are provided in Figure 8-9. In the Grey Box woodland 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 which provided 87.0 – 97.5% of the total ground cover this year. As a result of the dry conditions there was much less perennial ground cover with only 0 – 4% cover provided by perennial ground cover plants. There were no annual plants and there continued to be a small contribution of cover provided by fallen branches (0.5 – 6.5%). Cryptogams and rocks were not important ground cover components.

The White Box woodland was very similar in structure this year and had a slightly higher cover of 4.5% perennial ground cover plants. In the Ironbark woodland, perennial plants provided only 2.5% of the total cover and cryptogams and logs provided 3.5% and 4.0% respectively. This year no annual plants were recorded at either WBWood1 or IronWood1 site this year.

In the derived grassland revegetation sites, annual plant cover had declined in all sites and this year all sites were dominated by dead litter, derived from dead ground cover plants. Annual plants however continued to be recorded in low abundances in all sites with a low cover of 4.5% in GBReveg2 to a high of 24.0% in GBReveg1. Cryptogams were also recorded in high abundance in GBReveg2 which provided 29.5% of the total ground cover, while in GBReveg1 they provided 7.0% cover. Cryptogams were present but in lower abundance in the remaining Reveg sites. Perennial plants provided 5.5 – 20.5 % in GBReveg4 and GBReveg3 respectively, with these exceeding minimum perennial ground cover requirements.

The reference sites were also characterised by having a mature canopy cover which exceeded 6.0m in height with low hanging braches 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 > 0.5m in

height in the derived grassland revegetation areas. Examples of the various structural compositions of the individual sites have been provided in Table 8-5.

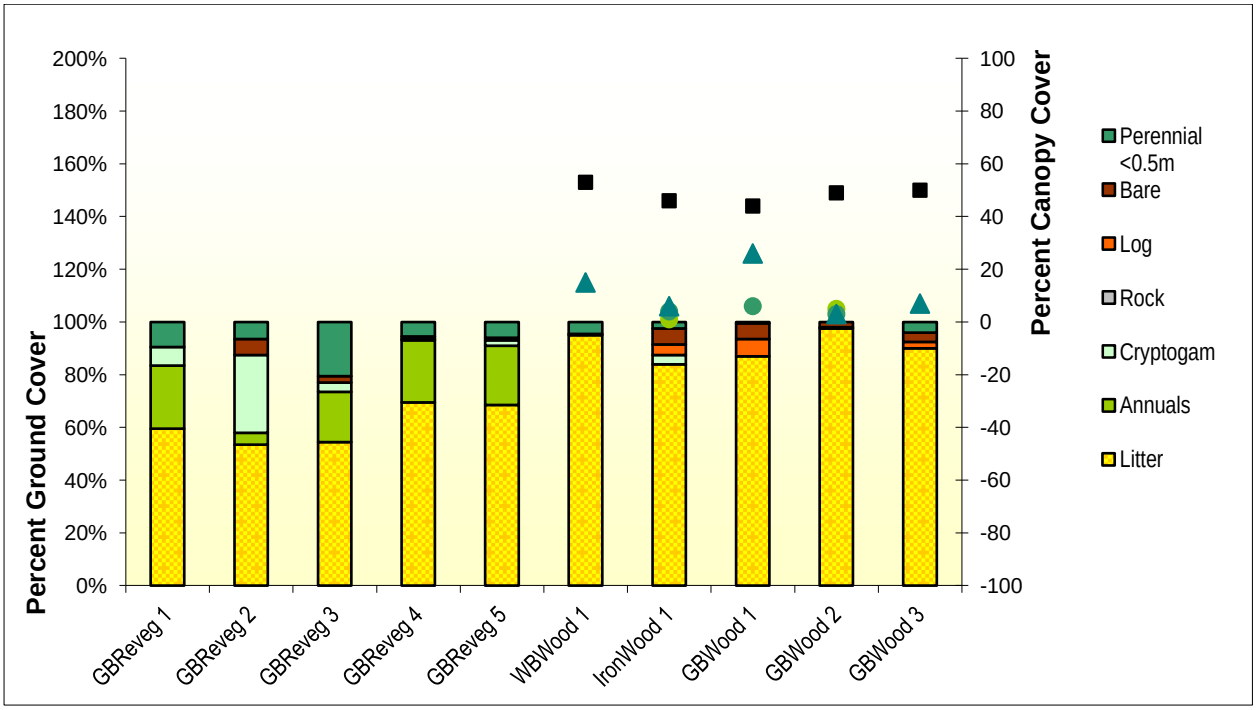


Figure 8-9. Average percent ground cover and projected foliage cover recorded in the Grey Box monitoring sites in 2018.

Table 8-5. Structural compositions of the Grey Box monitoring sites in 2018.

GBReveg1	GBReveg2
	
GBReveg3	**GBReveg4**
	

GBReveg5	WBWood1
	
IronWood1	GBWood1
	
GBWood2	GBWood3
	

8.7 Floristic Diversity

Total floristic diversity recorded within the 20 x 20m 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 being recorded in the three reference sites. This year prolonged dry conditions resulted in the further decline in species richness across all monitoring sites, where 7 – 15 species were recorded in the Grey Box woodland reference sites.

There were 28 species in the White Box woodland, while in the Ironbark woodland there were a total of 23 species. The grassland revegetation sites were more diverse than the reference sites and this year there were 18 (GBReveg2) – 26 (GBReveg5) different species recorded.

In the woodland reference sites, native species continued to be far more diverse than exotic species with 7 – 15 native species being recorded this year (Figure 8-11) and only one exotic species was recorded in GBWood3. In WBWood1 and IronWood1 native species were also more diverse with 28 and 23 native species respectively and this year no exotic species were found in either site (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 6 (GBReveg2) – 13 (GBReveg1, GBReveg5) exotic species. All grassland sites had an acceptable diversity of native species.

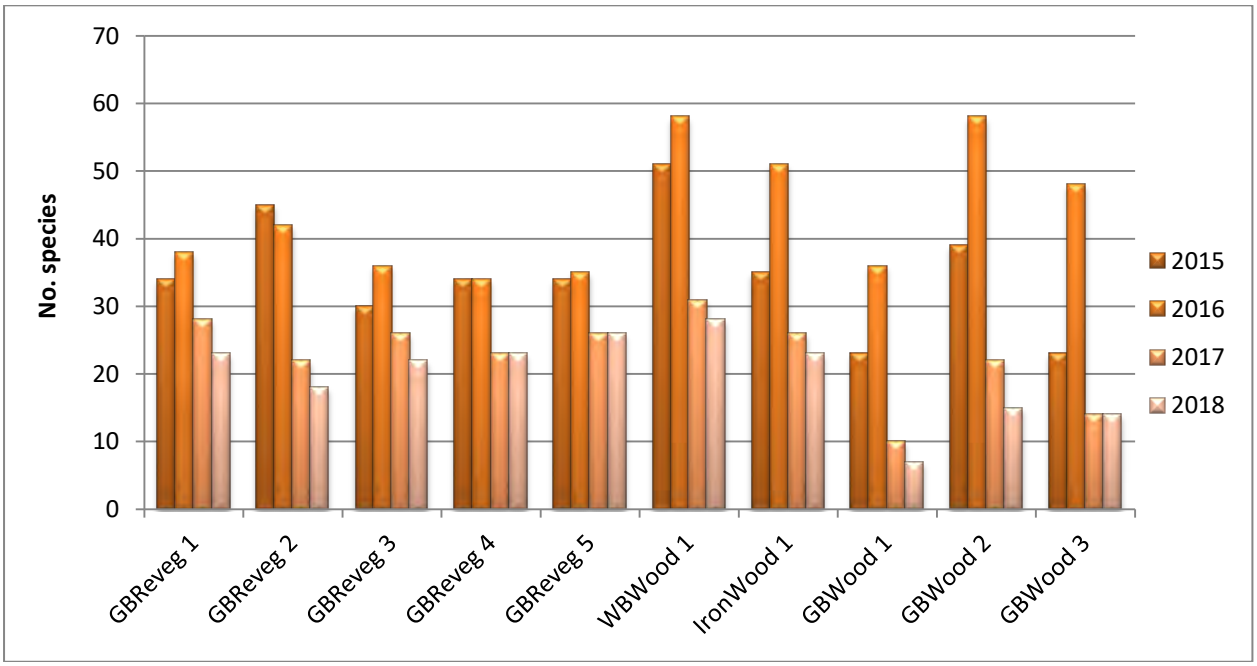


Figure 8-10. Total species diversity recorded in the Grey Box monitoring sites.

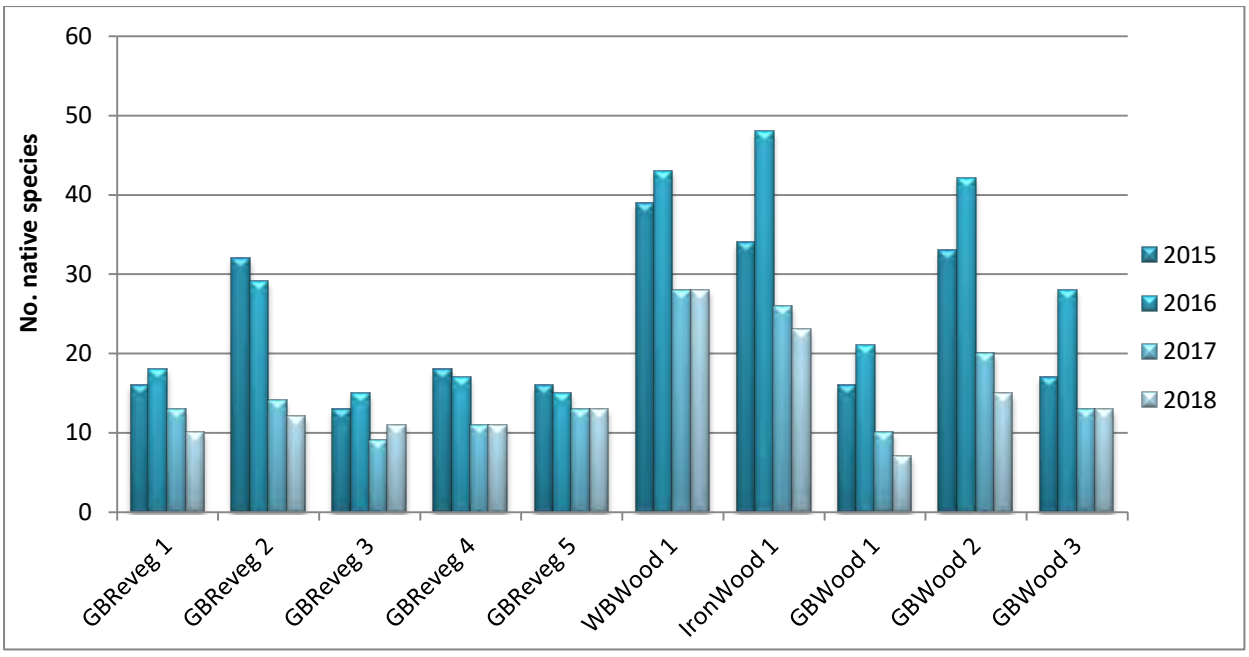


Figure 8-11. Total native species diversity recorded in the Grey Box monitoring sites.

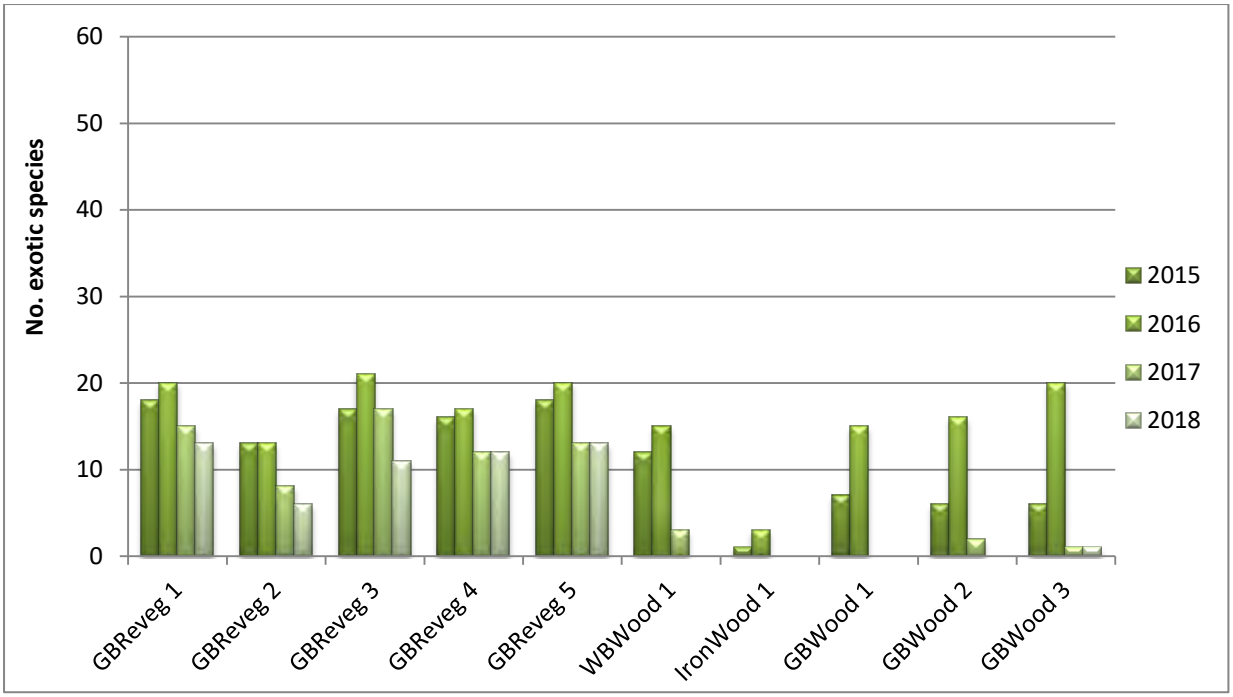


Figure 8-12. Total exotic species recorded in the Grey Box monitoring sites.

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 2015, and ranged from 82.7 – 85.2% (Figure 8-13). In 2017 and 2018, there was 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 this year (Figure 8-13).

In the derived grasslands, there has been an increasing trend in native plant abundance in numerous sites however GBReveg2 was the only site dominated by native species, where native plants provided 75% of the live plant cover. In the remaining grassland sites, native plants provided 47 – 52% of the live plant cover and were weedier than desired.

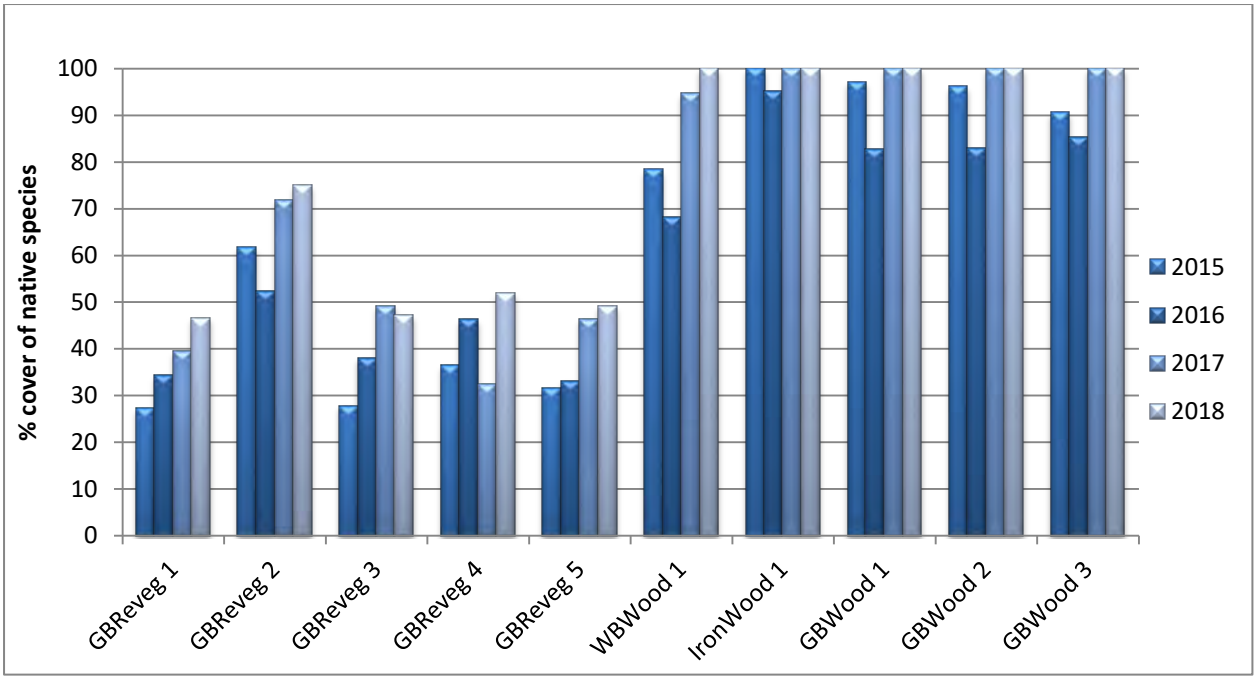


Figure 8-13. Percent endemic ground cover recorded in the Grey Box monitoring sites.

8.8 Vegetation composition

The composition of the vegetation as categorised by seven different growth forms is given in Figure 8-14. In the Grey Box woodland reference sites herbs were the most diverse plant group with 3 - 7 different species followed by grasses with 3 – 4 species. There were 1 - 2 tree species, 1 - 3 shrubs and there may have been a sub-shrub. There may also have been one reeds and no fern species were recorded this year.

The White Box and Ironbark woodland were comprised of an adequate representation of the major plant groups. In the grassland revegetation areas there was also an adequate representation of most growth forms except that there were was a low diversity of tree species in all sites except GBReveg1. There also continued to be an absence of shrubs in all grassland sites this year.

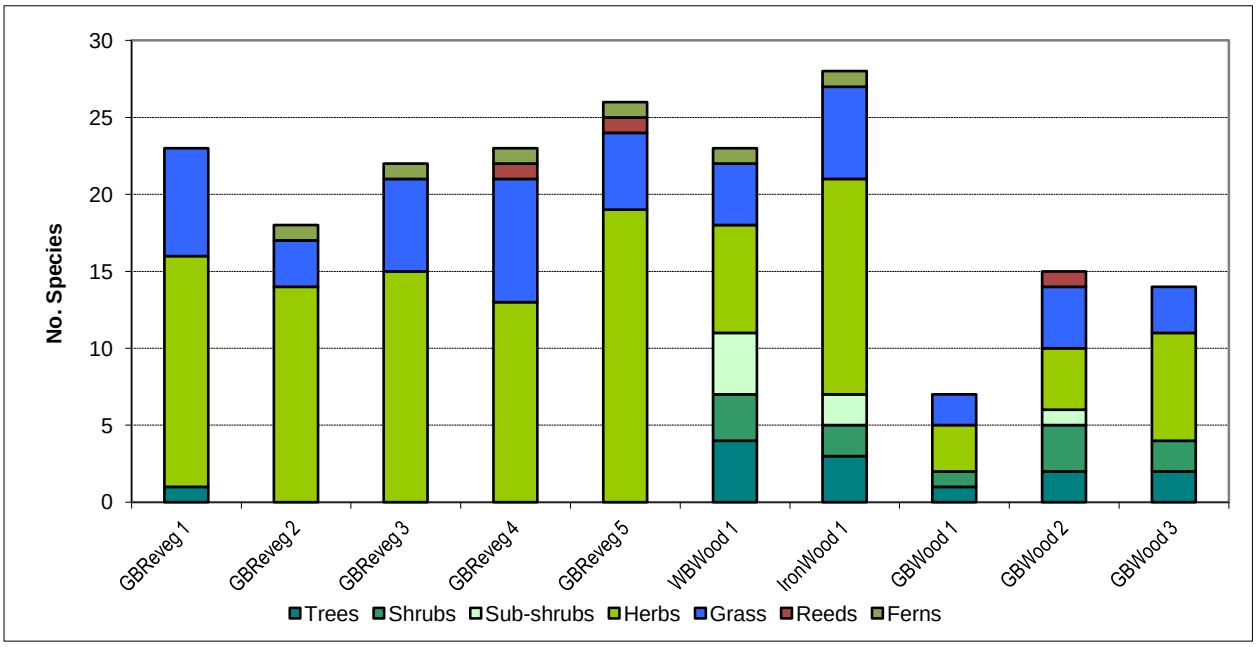


Figure 8-14. Composition of the vegetation recorded in the Grey Box monitoring sites in 2018.

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 8-6. This year *Bothriochloa macra* (Red-leg Grass) continued to be recorded in all sites except IronWood1, while *Cheilanthes sieberi* subsp*. sieberi* (Rock Fern) a native fern was also recorded in all sites except GBReveg1. Neither species were recorded in any of the woodland reference sites.

The exotic annuals *Arctotheca calendula* (Capeweed) and *Hypochaeris glabra* (Smooth Catsear) were recorded in five of the revegetation monitoring sites and so were the native perennials *Aristida ramosa* (Threeawn Grass) and *Oxalis perennans* (Yellow Wood-sorrel). Other common species were the natives species *Panicum* sp. and *Triptilodiscus pygmaeus* (Austral Sunray) and there were a variety of other annual exotics.. A comprehensive list of species recorded in all monitoring sites has been included in Appendix 1.

Table 8-6. The most common species recorded in the Grey Box monitoring sites in 2018.

exotic	Scientific Name	Common Name	Habit	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	IronWood1	WBWood1	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			
*	*Arctotheca calendula*	Capeweed	h	1	1	1	1	1			5			
	Aristida ramosa	Threeawn Grass	g	1		1	1	1		1	5		1	
*	*Hypochaeris glabra*	Smooth Catsear	h	1	1	1	1	1			5			
	Oxalis perennans	Yellow Wood-sorrel	h	1	1	1	1	1			5			1
*	*Trifolium subterraneum*	Subterraneum Clover	h	1	1	1	1	1			5			
*	*Briza minor*	Shivery Grass	g	1		1	1	1			4			
*	*Echium plantagineum*	Paterson's Curse	h	1		1	1	1			4			
	Panicum sp.		g	1	1		1	1			4			
*	*Petrorhagia nanteuilii*	Proliferous Pink	h	1		1	1	1			4			
	Triptilodiscus pygmaeus	Austral Sunray	h		1	1	1	1			4			

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 8-7. 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 with only *Rytidosperma racemosum* (Wallaby Grass) meeting the required abundance criteria in GBWood3 this year. *Rytidosperma racemosum* was also the most abundant species in GBReveg2 this year. *Hypochaeris glabra* (Smooth Catsear) an exotic annual was the most abundant species in four of the five grassland sites, while the native perennial grass *Bothriochloa macra* (Red-leg Grass) was recorded as the most abundant species three sites.

Table 8-7. The most abundant species recorded in the Grey Box monitoring sites in 2018.

Scientific Name	Common Name	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	WBWood1	IronWood 1	GBWood1	GBWood2	GBWood3
**Hypochaeris glabra*	Smooth Catsear	16		11	12	11					
Bothriochloa macra	Red-leg Grass			18	10	12					
Rytidosperma racemosum	Wallaby Grass		15								10

8.11 Soil analyses

8.11.1 pH

Figure 8-15 shows the pH recorded in the Grey Box monitoring sites compared to the "desirable" range in medium or clay loam soils as prescribed by the agricultural industry for growing introduced pastures and crops. There was minimal change in the soil pH range recorded in the woodland reference sites and they continued to remain lower than desirable agricultural ranges. With soil pH ranging from 5.1 – 5.6 the soils were strongly to moderately acidic (Bruce & Rayment 1982).

In GBReveg2 and the Ironbark woodland, the soil pH was similar to the reference sites with pHs of 5.3 and 5.1 respectively and were also strongly acidic. The White Box woodland and remaining derived grassland areas had a slightly higher pH which ranged from 6.0 (GBReveg4) to 6.6 (GBReveg1) with these soils being moderately acidic to neutral and within desirable agricultural ranges.

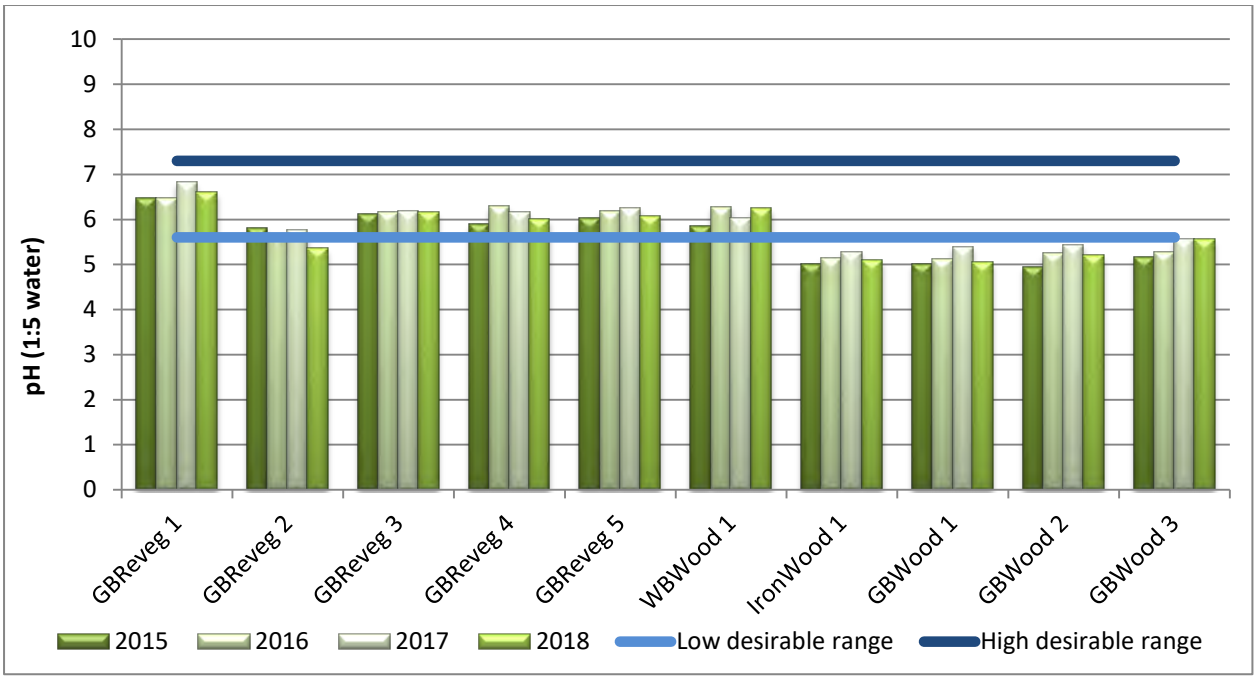


Figure 8-15. Soil pH recorded in the Grey Box monitoring sites compared to the desirable agricultural range.

8.11.2 Conductivity

Figure 8-16 shows the Electrical Conductivity (EC) recorded in the Grey Box monitoring sites compared to the "desirable" range in medium or clay loam soils as prescribed by the agricultural industry for growing introduced pastures and crops. The EC recorded across the range of sites was well below the agricultural threshold

indicating there are very low levels of soluble salts in the soil profile and that they are non saline. The highest EC readings were recorded in the reference sites which ranged from 0.059 – 0.067 dS/m. In the remaining sites EC ranged from a low of 0.015 dS/m in GBReveg5 to a high of 0.064 dS/m in GBReveg2.

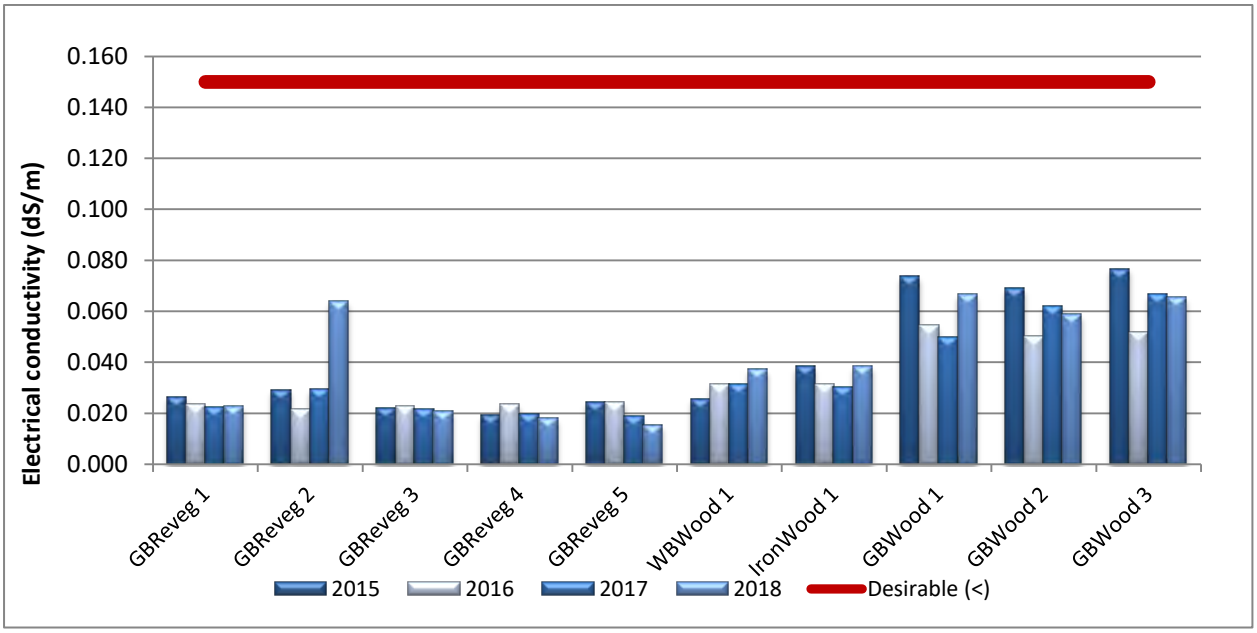


Figure 8-16. Electrical Conductivity recorded in the Grey Box monitoring sites compared to the desirable agricultural levels.

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 4.5 - 7.5% (Figure 8-17). At GBReveg2, there was 5.2% OM recorded this year with these being similar to the local woodlands and desirable ranges. OM in the remaining sites were lower than the Grey Box woodlands and ranged from a low of 1.8% in GBReveg5 to a high of 3.6% in the Ironbark woodland.

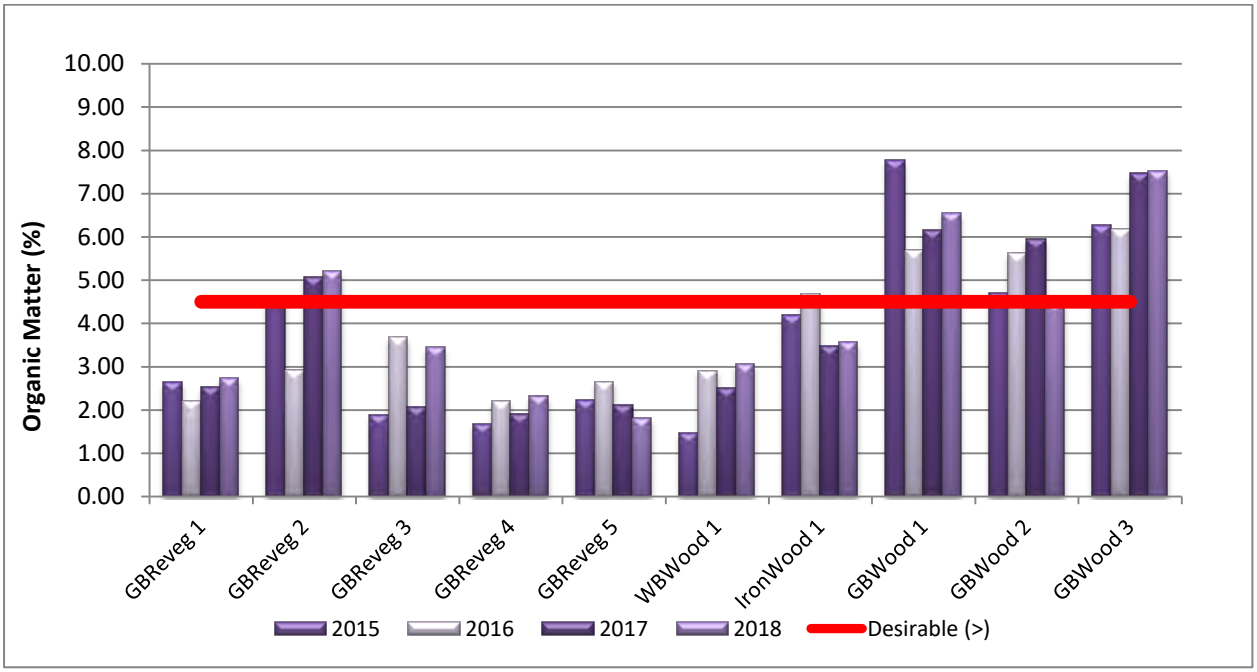


Figure 8-17. Organic Matter concentrations recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

8.11.4 Phosphorous

Phosphorous levels were lower than the agricultural standards across all Grey Box monitoring sites and this year there was a decrease in P recorded across all sites. They remained the highest within the woodland reference sites which had a P range of 11 – 26 mg/kg this year. P concentrations in the remaining revegetation sites, WBWood1 and IronWood1 were lower than this range and were lowest at GBReveg5 with 5 mg/kg to a high of 9 in GBReveg2 (Figure 8-18).

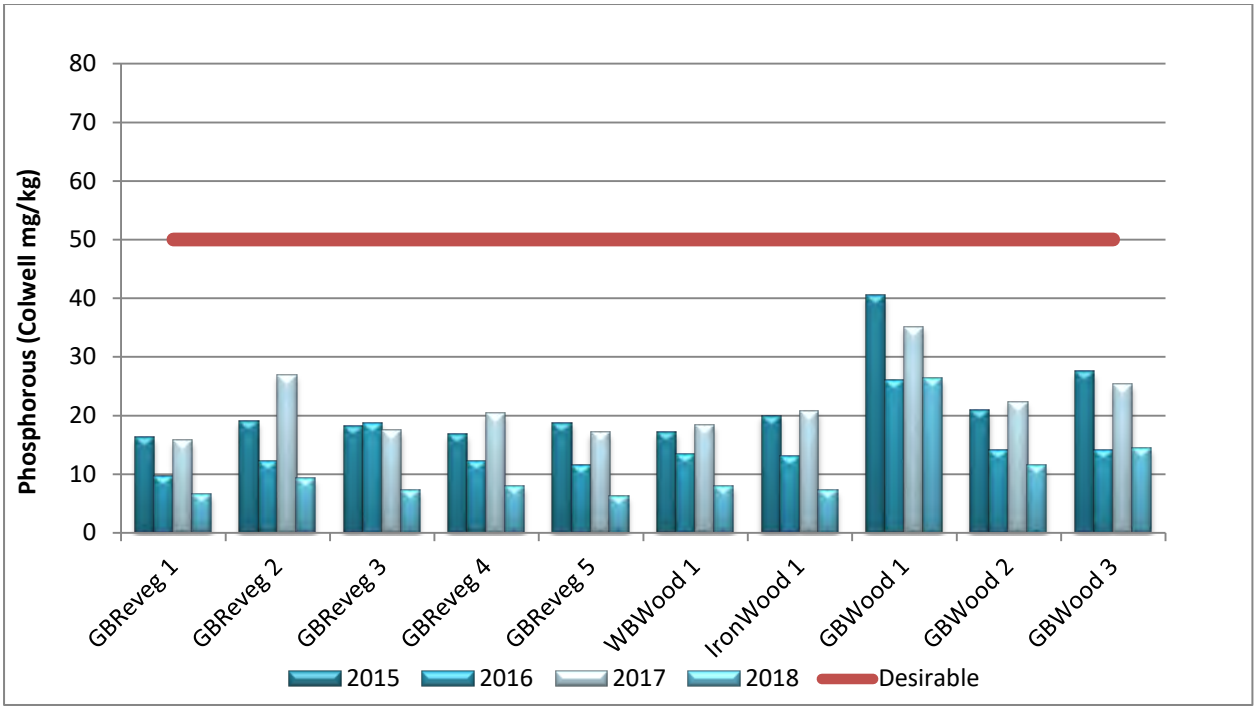


Figure 8-18. Phosphorous concentrations recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

8.11.5 Nitrate

Nitrate levels were lower than the agricultural standards across all Grey Box monitoring sites and there continued to be little differences between the sites, with the exception of a small spike in GBReveg2 this year with 8.0 mg/kg. In the reference sites N ranged from 0.5 – 1.7 mg/kg and the remaining sites had N concentrations which fell within this range (Figure 8-19).

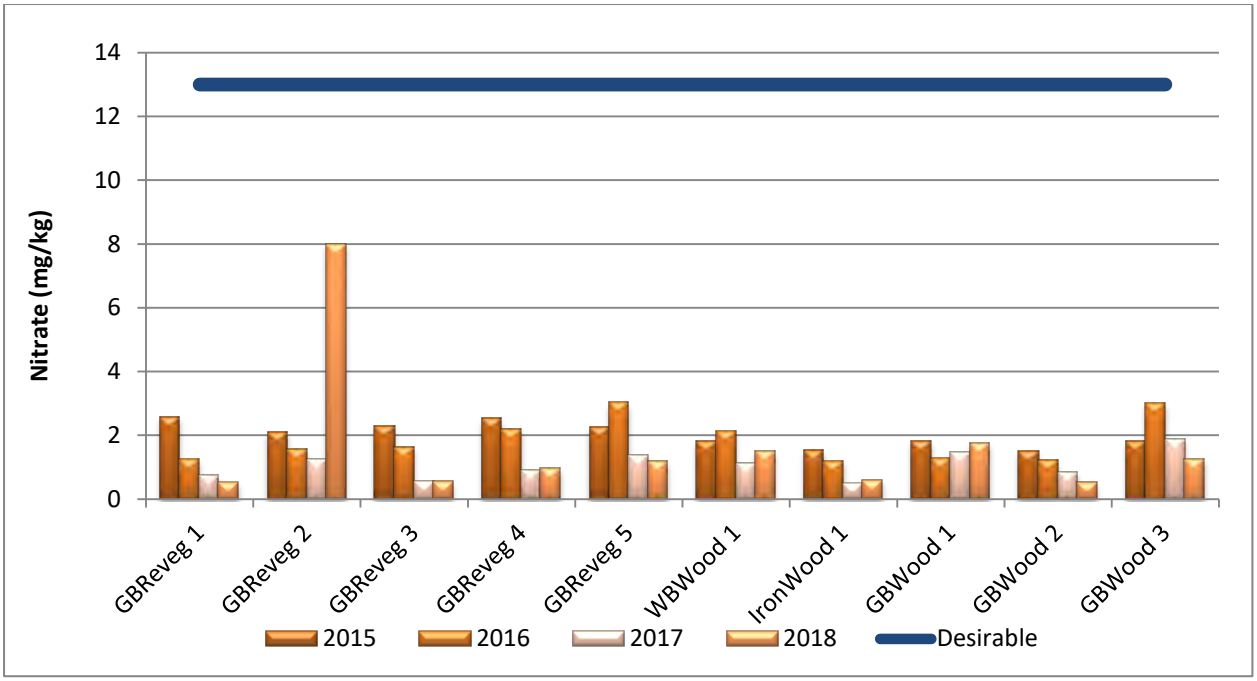


Figure 8-19. Nitrate concentrations recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

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 4.2 – 8.6 cmol/kg (Figure 8-20). Sites GBReveg1, GBReveg2 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 (GBReveg4) to a high of 3.8 cmol/kg (GBReveg2).

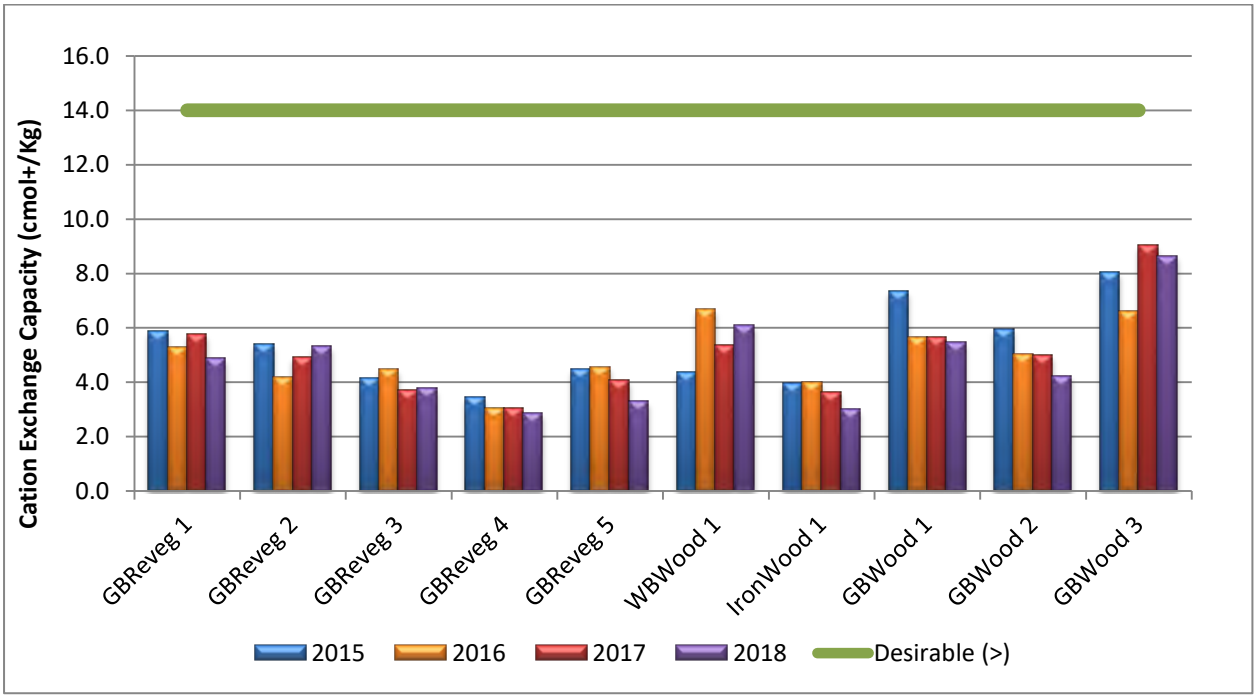


Figure 8-20. Cation Exchange Capacity recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

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 0.9 – 5.8% (Figure 8-21), with site GBWood2 slightly exceeding the minimum 5% threshold for sodicity. This year all remaining sites had an ESP that was well below the 5% threshold for sodicity and ranged from a low of 0.3% in GBReveg1 to a high of 3.7% in GBReveg2 indicating the soils are non sodic (Isbell 1996).

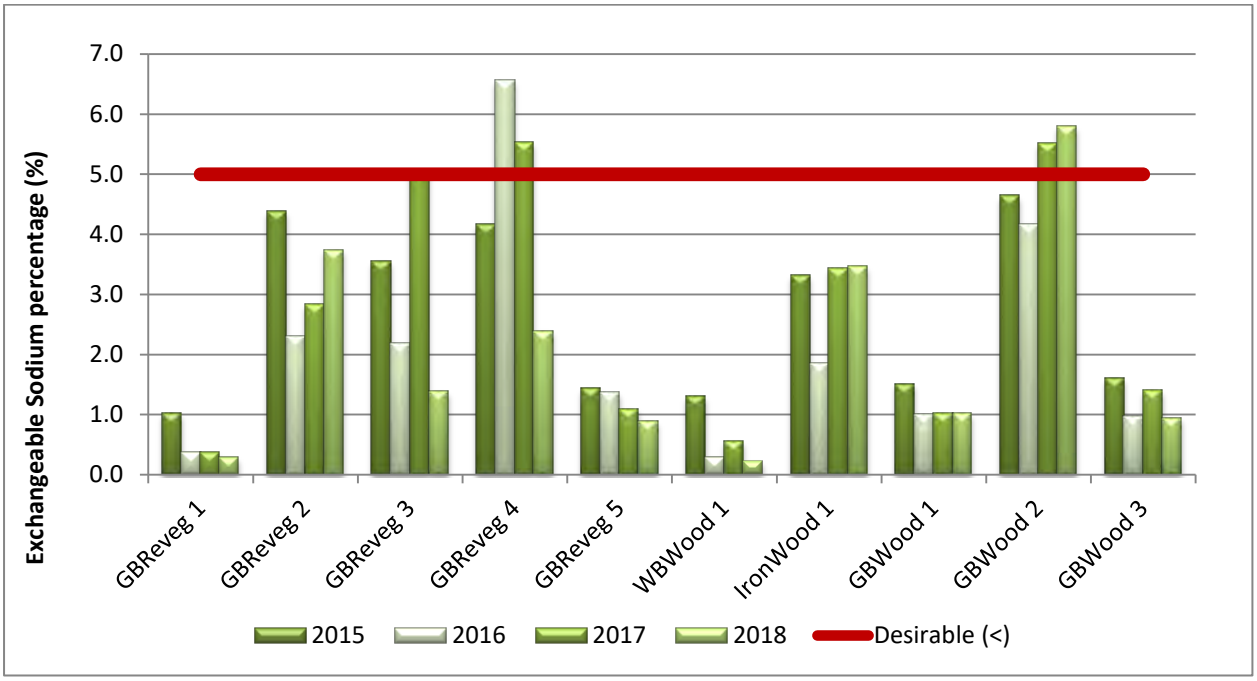


Figure 8-21. ESP recorded in the Grey Box monitoring sites compared to desirable agricultural levels.

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

Table 8-8 indicates the performance of the Kokoda Grey Box monitoring sites against a selection of proposed Completion Performance Indicators during the 2018 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 2018. In some cases, the site may not fall within ranges based on these data, but may be within "desirable" levels as prescribed by the agricultural industry. If this scenario occurs, the rehabilitation site has been identified using a striped shaded box to indicate that it falls within "desirable" ranges but does not fall within specified completion criteria targets using the adopted methodology.

Table 8-8. Performance of the Grey Box revegetation monitoring sites against the Primary and Secondary Performance Indicators in 2018.

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2018		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
Performance indicators are quantified by the range of values obtained from replicated reference sites							2018			Lower	Upper	2018						
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 measurement	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2018		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
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)	5.1	5.2	5.6	5.1	5.6	6.6	5.3	6.1	6.0	6.1	6.2	5.1
			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	0.059	0.065	0.059	0.067	0.023	0.064	0.021	0.018	0.015	0.037	0.038
			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)	6.5	4.5	7.5	4.5	7.5	2.7	5.2	3.4	2.3	1.8	3.1	3.6
			Phosphorous	Available Phosphorus is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		ppm (50)	26.2	11.5	14.4	11.5	26.2	6.6	9.2	7.2	7.9	6.2	7.9	7.2
			Nitrate		Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	ppm (>12.5)	1.7	0.5	1.3	0.5	1.7	0.5	8.0	0.5	1.0	1.2	1.5	0.6

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2018		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 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)	**5.5**	**4.2**	**8.6**	**4.2**	**8.6**	**4.9**	**5.3**	**3.8**	**2.9**	**3.3**	**6.1**	**3.0**
			ESP		Exchangeable Sodium Percentage (a measure of sodicity) is typical of the surrounding landscape or is less than the 5% threshold for sodicity	% (<5)	**1.0**	**5.8**	**0.9**	**0.9**	**5.8**	**0.3**	**3.7**	**1.4**	**2.4**	**0.9**	**0.2**	**3.5**
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		%	**63.5**	**64.7**	**70.1**	**63.5**	**70.1**	**71.1**	**68.5**	**73.1**	**69.0**	**74.4**	**61.0**	**66.3**
			LFA Landscape organisation	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and is comparable to that of the local remnant vegetation		%	**100**	**97**	**100**	**97**	**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	The diversity of shrubs and juvenile trees with a stem diameter < 5cm is comparable to that of the local remnant vegetation.		species/area	**1**	**3**	**3**	**1**	**3**	**1**	**0**	**0**	**0**	**0**	**3**	**6**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2018		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
				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	7	15	14	7	15	23	18	22	23	26	28	23
			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	7	15	13	7	15	10	12	11	11	13	28	23
			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	1	0	1	13	6	11	12	13	0	0
	Vegetation density	Vegetation contains a density of species comparable to that of the local remnant	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		No./area	1	19	4	1	19	1	0	0	0	0	5	139

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2018		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
		vegetation		vegetation														
	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	3	4
			Shrubs	The number of shrub species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	1	3	2	1	3	0	0	0	0	0	2	3
			Sub-shrubs		The number of sub-shrub species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	1	0	0	1	0	0	0	0	0	2	4
			Herbs	The number of herbs or forb species comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	3	4	7	3	7	15	14	15	13	19	14	7
			Grasses		The number of grass species comprising the vegetation community is	No./area	2	4	3	2	4	7	3	6	8	5	6	4

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2018		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
					comparable to that of the local remnant vegetation													
			Reeds		The number of reed, sedge or rush species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	1	0	0	1	0	0	0	1	1	0	0
			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		%	50.6	55.7	54.5	50.6	55.7	44.3	37.6	46.5	43.3	47	50.6	52.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2018		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
			LFA Nutrient recycling	LFA nutrient recycling index provides an indication of the sites ability to recycle nutrient and is comparable to or trending towards that of the local remnant vegetation		%	47.8	50.7	51.5	47.8	51.5	44.1	36.2	44.6	39	45.5	49.8	49.8
	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	%	87	98	90	87	98	59.5	53.5	54.5	69.5	68.5	95	84
			Annual plants		Percent ground cover provided by live annual plants is comparable to that of the local remnant vegetation	<%	0	0	0	0	0	24	4.5	19	23.5	22.5	0	0
			Cryptogam cover		Percent ground cover provided by cryptogams (eg mosses, lichens) is comparable to that of the local remnant vegetation	%	0	0	0	0	0	7	29.5	3.5	0.5	2	0	3.5
			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
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	6.5	0.5	2.5	1	7	0	0	0	0	0	0	4
			Bare ground		Percentage of bare ground is less than or comparable to	< %	6	2	4	2	6	0	6	2.5	1	1	0.5	6

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2018		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
					that of the local remnant vegetation													
			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**	**0**	**4**	**0**	**4**	**9.5**	**6.5**	**20.5**	**5.5**	**6**	**4.5**	**2.5**
			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		%	**94**	**98**	**97**	**94**	**98**	**100**	**94**	**97.5**	**99**	**99**	**99.5**	**94**
	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	**1.4**	**1.6**	**2.0**	**1**	**2**	**3.6**	**4**	**2.2**	**3.6**	**3.4**	**4.8**	**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	< species/m^2	**0**	**0**	**0**	**0**	**0**	**5.2**	**1.4**	**4.2**	**3.6**	**4**	**0**	**0**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2018		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
					vegetation													
	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**	**46.6**	**75**	**47.2**	**51.9**	**49.1**	**100**	**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**	**9**	**2**	**1**	**9**	**1**	**0**	**0**	**0**	**0**	**4**	**99**
			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**	**8**	**1**	**0**	**8**	**0**	**0**	**0**	**0**	**0**	**1**	**36**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2018		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
			shrubs and juvenile trees 1 - 1.5m in height		The number of shrubs or juvenile trees 1-1.5m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	**0**	**2**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**2**
			shrubs and juvenile trees 1.5 - 2m in height	The number of shrubs or juvenile trees 1.5-2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation		No./area	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
			shrubs and juvenile trees >2m in height		The number of shrubs or juvenile trees > 2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
	Ecosystem structure	The vegetation is developing in structure and complexity comparable to that of the	Foliage cover 0.5 - 2 m	Projected foliage cover provided by perennial plants in the 0.5 - 2m vertical height stratum indicates the community		% cover	**0**	**5**	**0**	**0**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**1**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2018		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
		local remnant vegetation		structure is comparable to that of the local remnant vegetation														
			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	0	0	6	0	0	0	0	0	0	4
			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	26	3	7	3	26	0	0	0	0	0	15	6
			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	49	50	44	50	0	0	0	0	0	53	46
	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	2	2	1	2	0	0	0	0	0	3	4

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2018		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
				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	24	17	34	0	0	0	0	0	30	17
	Ecosystem health	The vegetation is in a condition comparable to that of the local remnant vegetation.	Live trees	The percentage of the tree population which are live individuals and that the percentage is comparable to the local remnant vegetation		% population	100	100	85	85	100	0	0	0	0	0	100	72.5
			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	15	0	30	0	0	0	0	0	12.5	2.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2018		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
			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	43	50	43	75	0	0	0	0	0	62.5	32.5
			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	26	20	20	26	0	0	0	0	0	25	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	0	27.5
			Mistletoe		The percentage of the tree population which have mistletoe provides an indication of community health and habitat value and that the percentage is comparable to the local remnant vegetation	% population	0	0	0	0	0	0	0	0	0	0	0	0
			Flowers/fruit: Trees	The percentage of the tree population with reproductive structures such as buds, flowers or fruit provides evidence that the ecosystem is maturing, capable		% population	13	0	50	0	50	0	0	0	0	0	50	22.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measurement	GBWood1	GBWood2	GBWood3	Grey Box Woodland ecosystem range 2018		GBReveg 1	GBReveg 2	GBReveg 3	GBReveg 4	GBReveg 5	WBWood 1	IronWood 1
				of recruitment and can provide habitat resources 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	**50**	**52**	**0**	**0**	**52**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

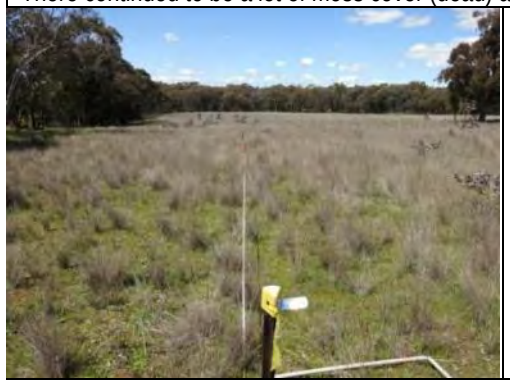
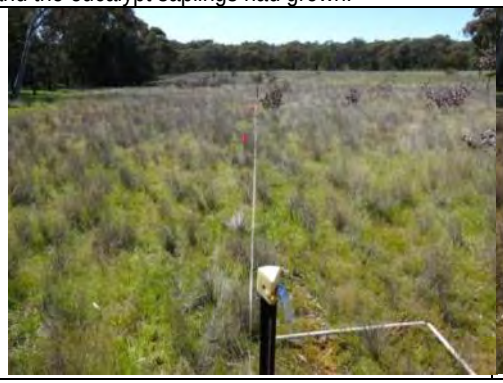
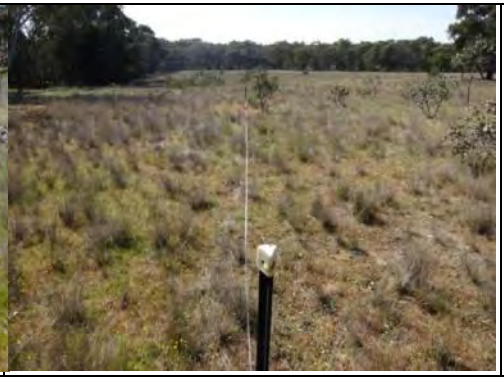
9 Results Dwyer's Red Gum monitoring sites

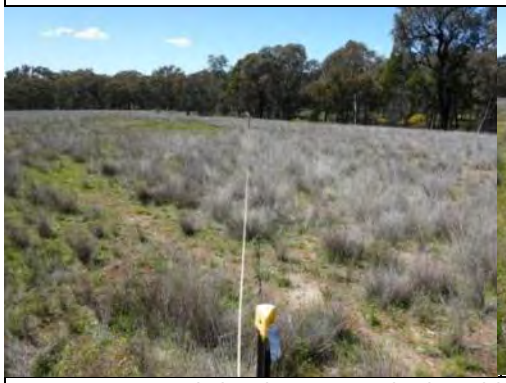
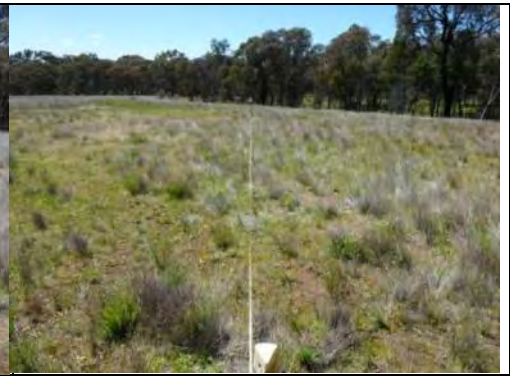
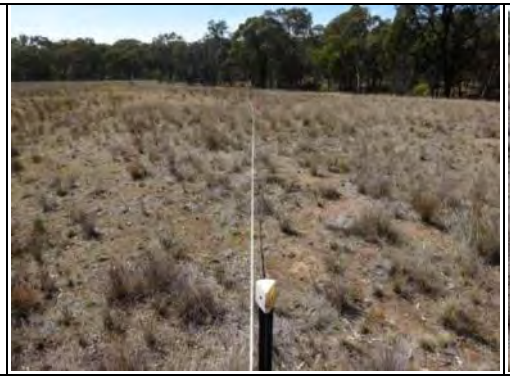
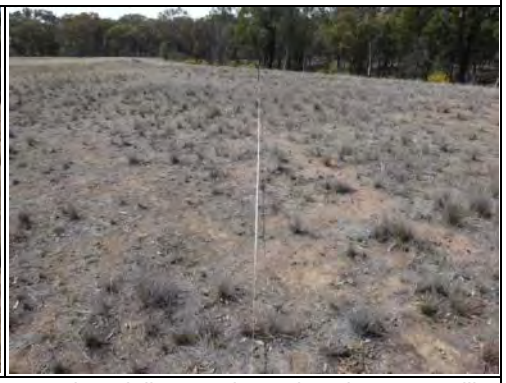
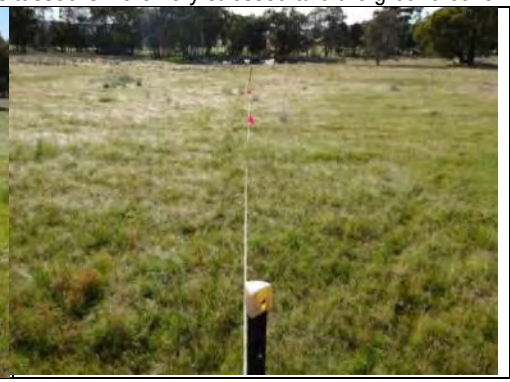
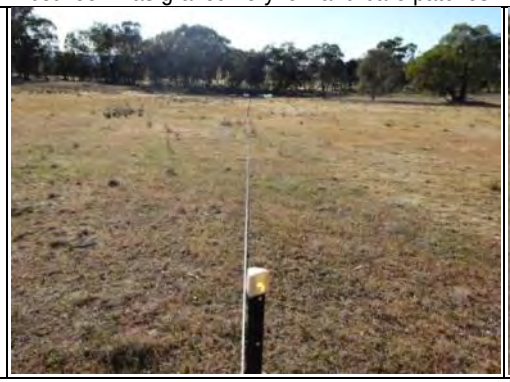
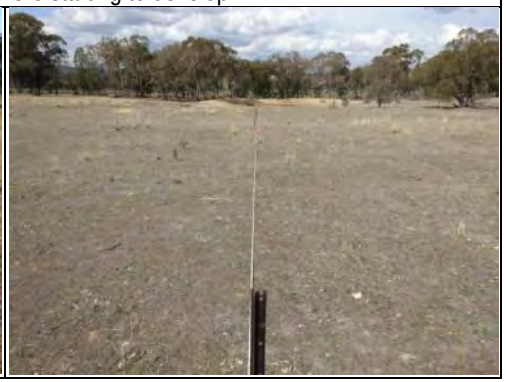
This section provides the results of the monitoring within the Dwyer's Red Gum monitoring sites and demonstrates ecological trends and performance of the revegetation sites against a selection of ecological performance indicators. This section has also included the Low Quality Dwyer's Red Gum woodland.

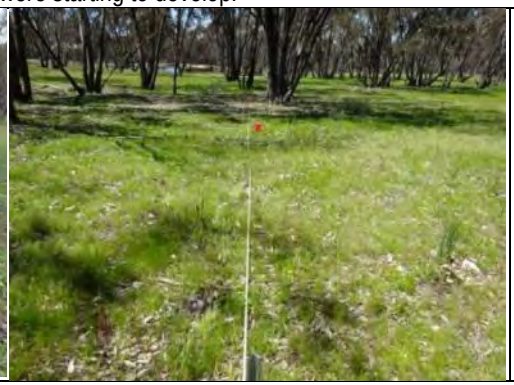
9.1 Photo-points

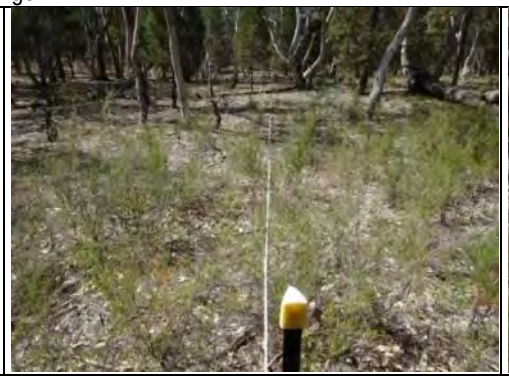
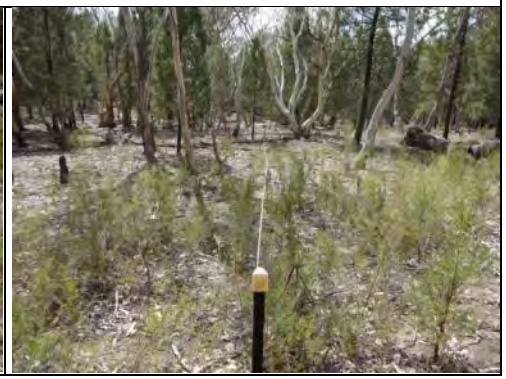
General descriptions of the Dwyer's Red Gum Woodland monitoring sites established at Kokoda in 2015 including photographs taken along the vegetation transect are provided Table 9-1.

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

2015	2016	2017	2018
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.			
			

2015	2016	2017	2018
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.			
			
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.			
			

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 trees 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.			
			
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.			
			

2015	2016	2017	2018
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 daphnoide*s (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.			
			
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.			
			

9.2 Landscape Function Analyses

9.2.1 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 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 92 - 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. These sites also had a high functional patch areas had 100% LO except for DReveg2 which had slightly declined to 86% LO this year due to heavy grazing (Figure 9-1).

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. This site also had a high functional patch area and continued to score an LO of 100%.

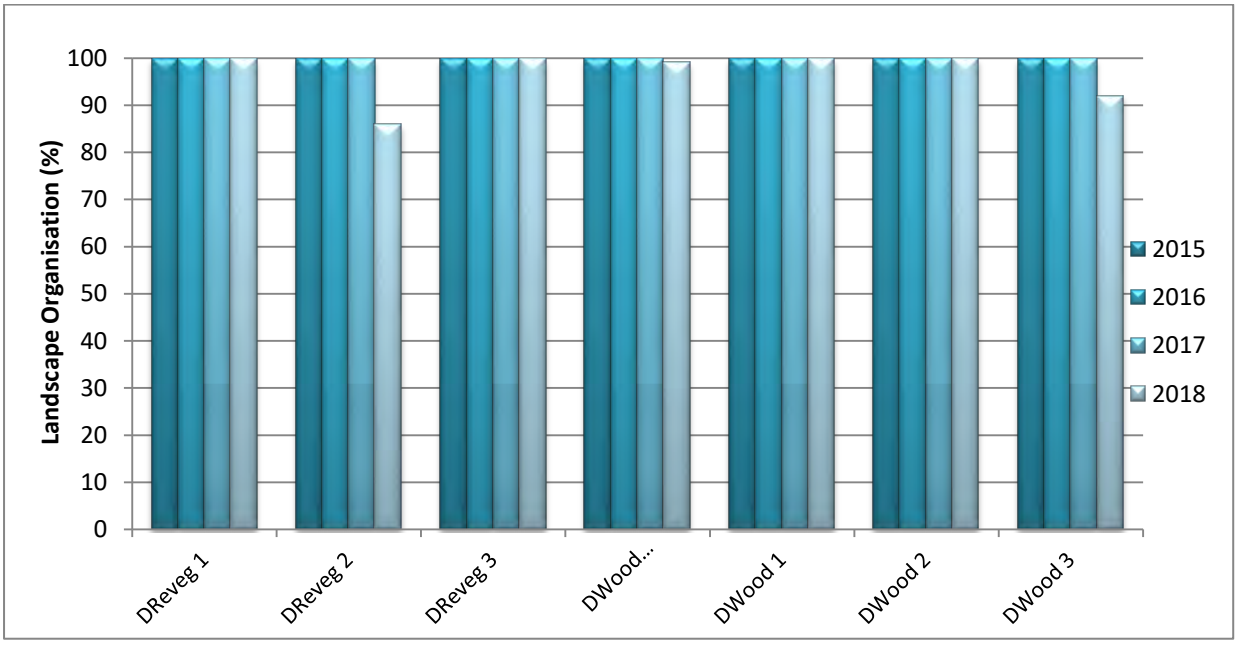


Figure 9-1. Landscape Organisation Indices recorded in the Dwyer's Red Gum woodland monitoring sites.

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 this year slight decreases were recorded in DWood2 and DWood3 to provide a range of 62.2 – 74.0. 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 and litter layers where the soils become more susceptible to erosion and deposition. In the low quality woodland the stability index had also slightly decreased to 65.2 however it remained comparable to the woodland reference sites (Figure 9-2).

In the Dwyer's Red Gum derived native grasslands stability also tended to decline in all sites except DReveg1 and stability indices ranged from a low of 65.5 (DReveg3) to a high of 74.1 (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 high 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.

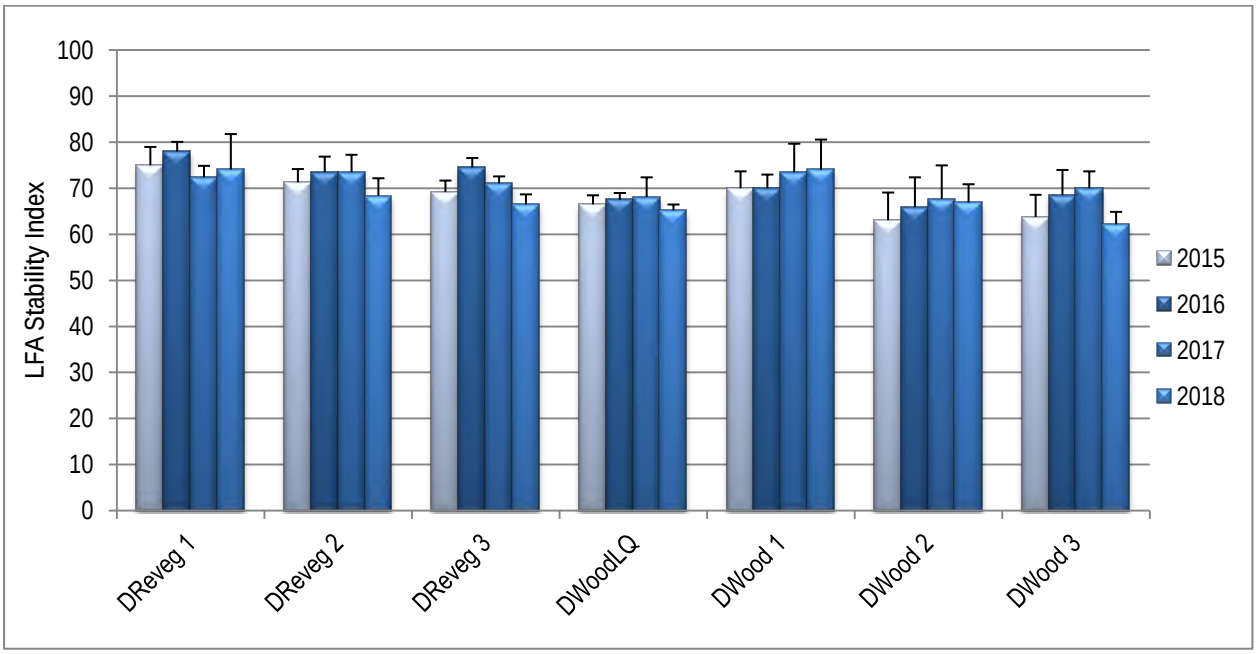


Figure 9-2. LFA stability indices recorded in the Dwyer's Red Gum woodland monitoring sites.

9.2.2.2 Infiltration

The infiltration capacity of the Dwyer's Red Gum and the low quality woodland (DWoodLQ) were quite similar to each other and these have demonstrated an increasing trend up until this year. The drought conditions have resulted in the deterioration of the litter and an increased resistance of the soils crusts. This year the infiltration capacity of the reference sites was 49.7 – 54.8, with the low quality woodland site having a comparable index of 54.5 (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 however, there has tended to be an increase in leaf litter and cryptogams and the soils had become more coherent and stable. In the grassland revegetation sites 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 declined to provide indices ranging from 38.4 – 45.7. All Dwyer's Red Gum revegetation sites therefore had a low infiltration capacity compared to the reference sites again this year.

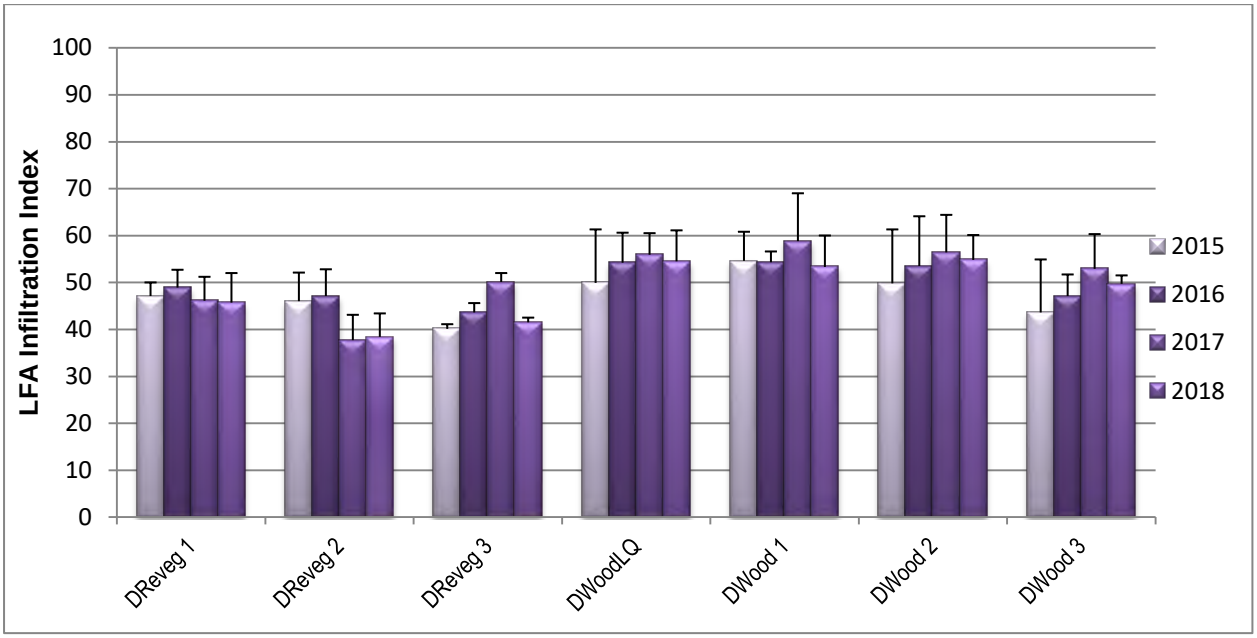


Figure 9-3. LFA infiltration indices recorded in the Dwyer's Red Gum woodland monitoring sites.

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. Similarly the drought conditions has resulted in a decrease in nutrient recycling capacity in the Dwyer's Red Gum woodland reference sites to provide a range of 47.6 – 51.3 with the low quality woodland scoring 53.7 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 36.2 in DReveg3 and a high of 42.7 in DReveg1.

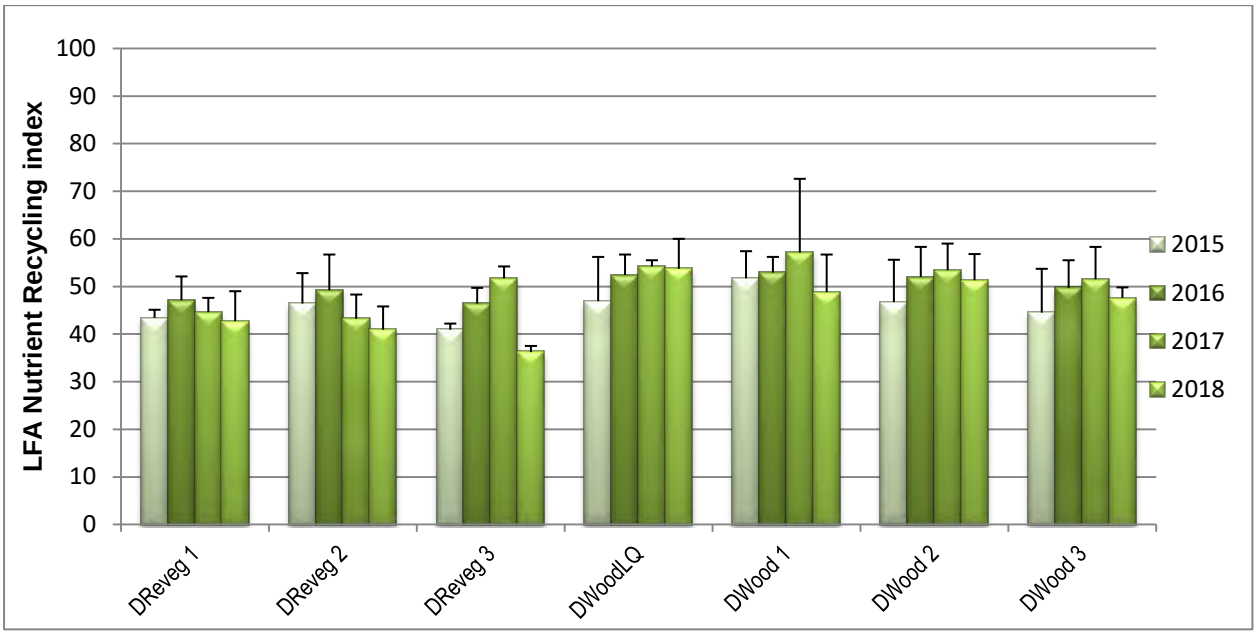


Figure 9-4. LFA nutrient recycling indices recorded in the Dwyer's Red Gum woodland monitoring sites.

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 Dwyer's Red Gum reference site DWood1 continuing to be the most ecologically functional site with a total score of 176. The low quality woodland DWoodLQ and DWood2 were very similar to each other with a sum of scores of 173. This was followed by DReveg1 and DWood3 with163 and 160 respectively. DReveg2 and DReveg3 were the least functional sites this year with scores of 148 and 144.

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

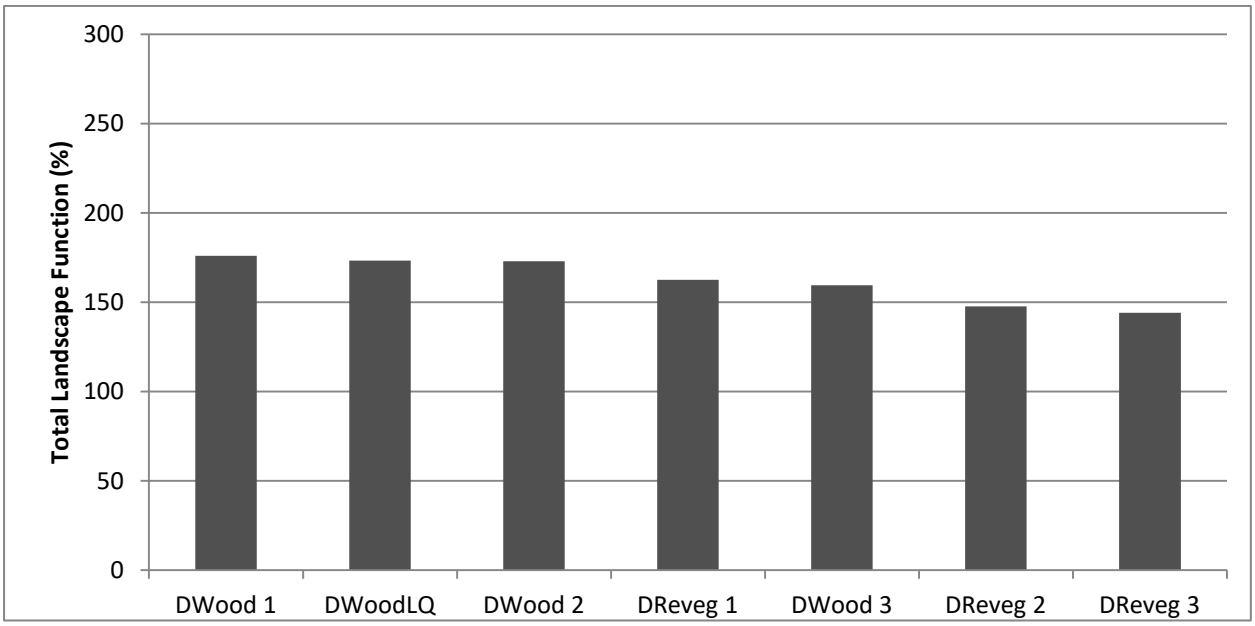


Figure 9-5. Sum of the LFA stability, infiltration and nutrient recycling components indicating the most functional to least functional monitoring site recorded in 2018.

Table 9-2. Examples of the different ground covers in the Kokoda Dwyer's Red Gum monitoring sites in 2018.

DReveg1	DReveg2
	

DReveg3

DWoodLQ

DWood1

DWood2

DWood3

DWood3(2)

9.3 Trees and mature shrubs

9.3.1 Population density

Trees and mature shrubs with a stem diameter >5cm dbh were recorded in the three Dwyer's Red Gum woodland reference sites as well as the low quality Dwyer's Red Gum woodland. This year there were 8 – 27 live individuals in the reference sites, equating to a density of 200 – 725 stems per hectare (Figure 9-6). An additional tree was recorded in DWood3, but in DWood2, two individuals had died. There continued to be nine individuals in the low quality woodland. One juvenile eucalypt continued to be recorded in DReveg1, but 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 – 23cm but ranged from 5 – 50cm (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 with the maximum dbh of 26cm. In DReveg1, the sapling had a slightly larger dbh of 6 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 67% of the population were (dead) stags in DWood1, while in DWood2 and DWood3 20 – 22% were stags. A small percentage of the population in all three sites were bearing reproductive structures such as buds, flowers or fruit this year. Mistletoe was recorded in DWood3 while in DWood1 a small percentage of individuals contained hollows suitable for nesting sites (>10cm). In the low quality woodland all trees were typically in medium health with some in a state of advanced dieback. Most eucalypts were bearing mature fruit. The eucalypt sapling in DReveg1 was considered to be healthy.

9.3.4 Species composition

The Dwyer's Red Gum reference sites were dominated by *Callitris endlicheri* (Black Cypress Pine) although there may also have been scattered individuals of *Allocasuarina verticillata* (Drooping Sheoak), *E. dealbata* (Tumbledown Red Gum), *E. sideroxylon* and/or *E. albens*. The 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.

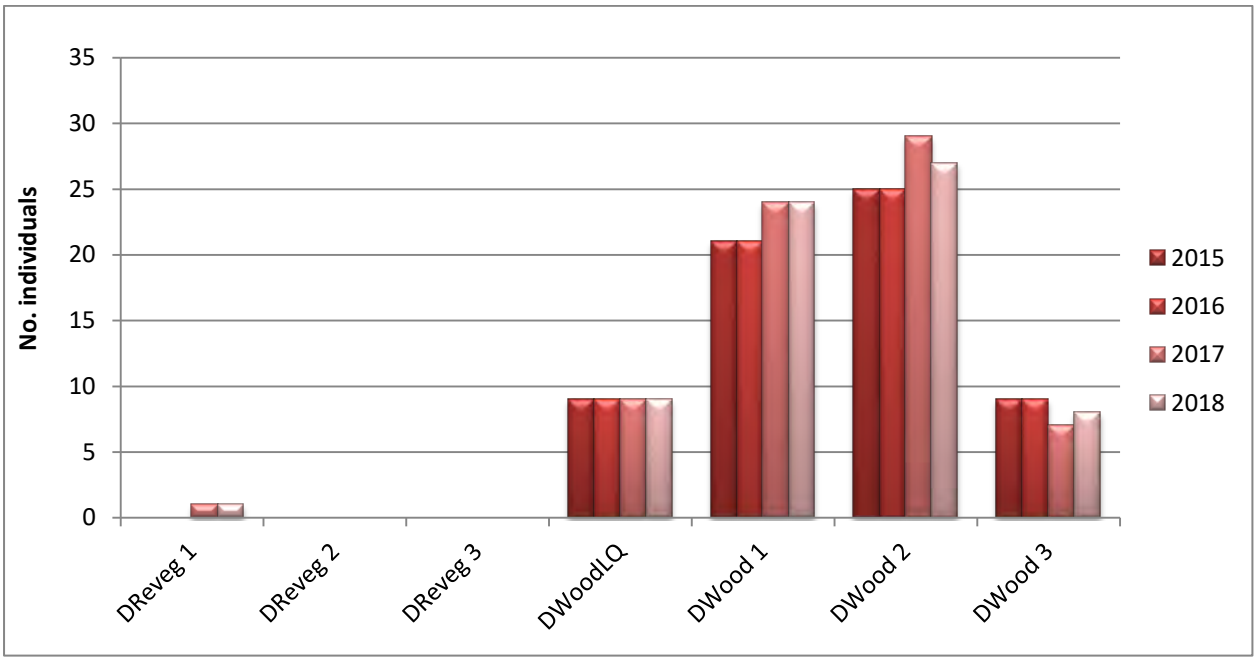


Figure 9-6. Tree and mature shrub densities (>5cm dbh) in the Kokoda Dwyer's Red Gum woodland monitoring sites.

Table 9-3. Trunk diameters and condition of the trees and mature shrubs in the Dwyer's Red Gum monitoring sites in 2018.

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	6	6	6	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	16	9	7	100	0	33	67	0	0	67	0
DWood1	3	11	29	5	73	1	33	8	21	4	67	0	18	4
DWood2	3	17	50	5	37	1	73	3	54	16	27	0	35	0
DWood3	3	23	32	7	10	2	80	20	30	30	20	10	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 (<5cm dbh) recorded in the Dwyer's Red Gum reference sites with densities ranging from 208 – 1566 individuals (Figure 9-7). In the low quality woodland there were 11 shrubs and juvenile trees this year. In the derived grasslands, there were 11 seedlings recorded in DReveg1, two 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 0.5m in height, with some individuals being >2.0m in height in DWood3 (Table 9-4). In DReveg2, DReveg3 and the low quality woodland (DWoodLQ) all individuals were less than 0.5m in height. In DReveg1 all height classes continue to be represented.

9.4.3 Species diversity

In the woodland reference sites there were 3 - 7 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 spp* (Spearwood?), *Brachyloma daphnoides* (Daphne Heath), *E. dealbata*, *Allocasuarina verticillata* (Drooping She oak), *Cassinia laevis* (Cough Bush). In DWood3 there was a high density of *Callitris endlicheri* seedlings and *Calytrix tetragona* (Fringe Myrtle). In DWoodLQ, there were nine scattered *E. dwyeri*, one *A. lanigera* (Varnish Wattle) and one *A. implexa* Hickory) seedlings.

In DReveg1 most individuals were *E. dwyeri* saplings but one *A. decora* seedlings continued to be recorded. One *A. decora* and one *Cassinia laevis* seedling was also recorded in DReveg2. In DReveg3, one *Allocasuarina verticillata* was present which had been heavily browsed.

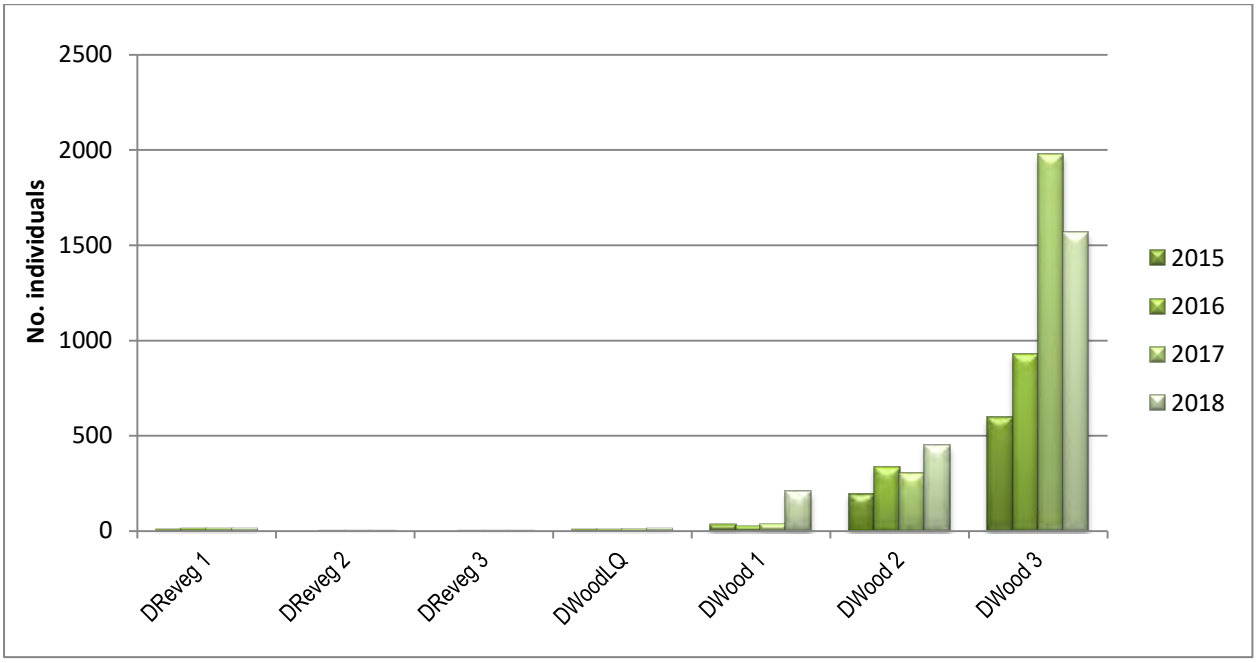


Figure 9-7. Total shrubs and juvenile trees recorded in the Dwyer's Red Gum monitoring sites.

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	1	3	4	2	11	2	100
DReveg2	2	0	0	0	0	2	2	100
DReveg3	1	0	0	0	0	1	1	100
DWoodLQ	11	0	0	0	0	11	3	100
DWood1	208	0	0	0	0	208	3	100
DWood2	404	44	0	0	0	448	3	100
DWood3	1244	262	58	0	2	1566	7	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 (<0.5m in height) was relatively high in the Dwyer's Red Gum woodland reference sites. This year ground cover decreased in two of the three reference sites due to overgrazing and ant nests, while a marginal increase was recorded in DWood02. This year the target range was 85.5 – 96.5% total ground cover (Figure 9-8). Heavy grazing also caused a reduction on total ground cover in the grassland areas however they ranged from a low of 87.5% in DReveg2 to a high of 98% in DReveg1, with all revegetation sites and the low quality woodland having total ground cover that was similar to or better than the reference sites this year.

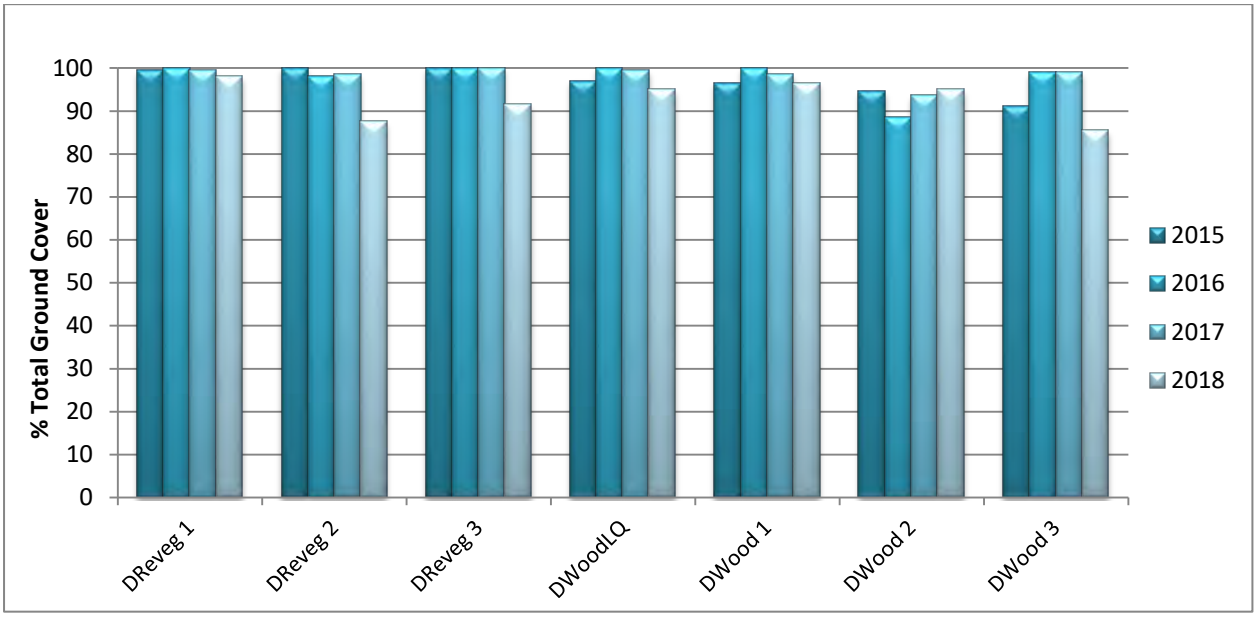


Figure 9-8. Total ground cover recorded in the Dwyer's Red Gum woodland monitoring sites.

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 Dwyer's Red Gum woodland reference sites the most dominant form of ground cover continued to be dead leaf litter with these providing 71 – 86.5% of the total ground cover. This year there was 2.5 – 6.5% perennial vegetation cover and there was no annual ground cover as a result of the prolonged dry conditions. There continued to be a small contribution provided by cryptogams which provided 1.0 – 7.0% ground cover. There was up to 7.0% cover provided by fallen branches, and in DWood1 there were scattered rocks.

The low quality woodland had similar features and in similar proportions to the reference sites but 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 6.0m in height with low hanging branches (and scattered shrubs) also providing occasional projected cover in the lower height classes.

In comparison the revegetation sites continued to be dominated by various proportions of annual and perennial plants and dead leaf litter and this year all three sites had adequate covers of perennial plants and cryptogams. No cover >0.5m in height was recorded this year due to heavy grazing and lack of shrub or tree canopies. Examples of the various structural compositions of the individual sites have been provided in Table 9-5.

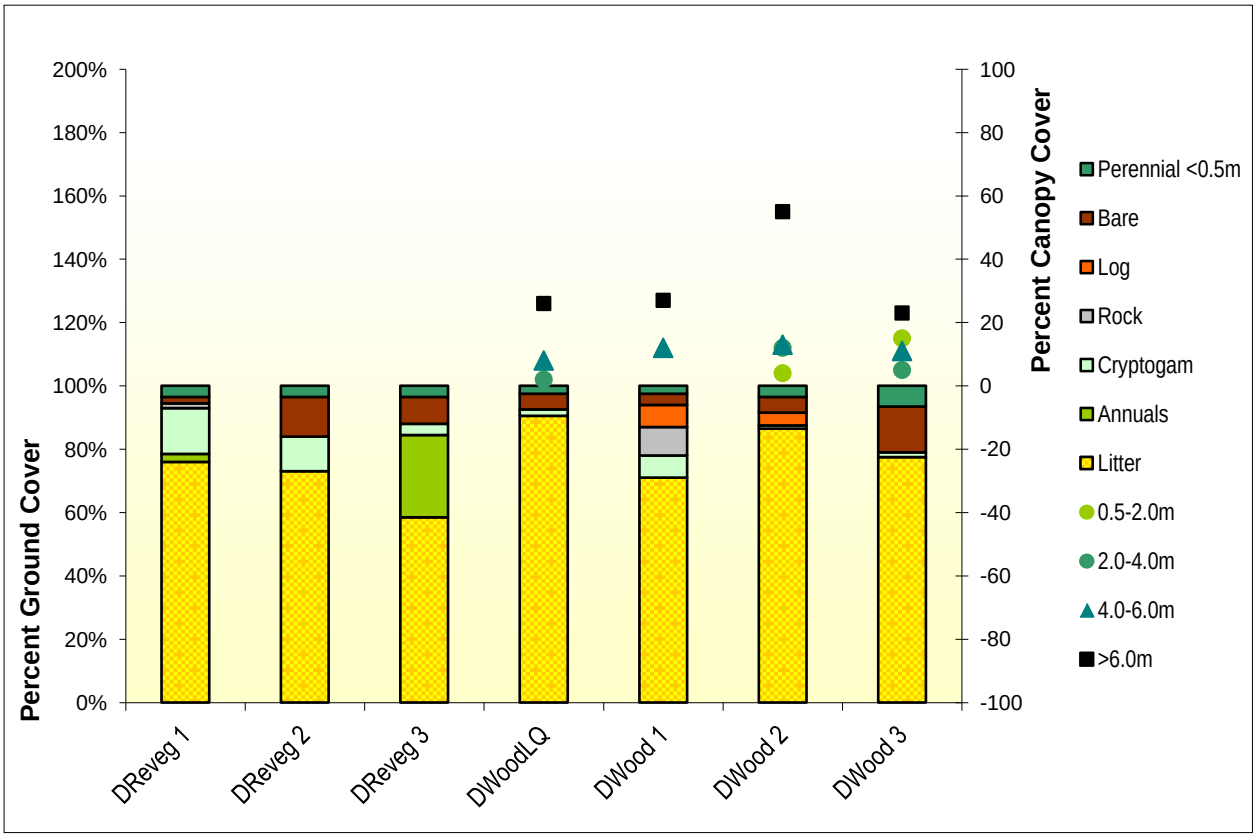


Figure 9-9. Average percent ground cover and projected foliage cover recorded in the Dwyer's Red Gum monitoring sites.

Table 9-5. Structural compositions of the Dwyer's Red Gum monitoring sites in 2018.

DReveg1	DReveg2
	
DReveg3	**DWoodLQ**
	

DWood1	DWood2
	
DWood3	**General: acacia regeneration**
	

9.7 Floristic Diversity

Total floristic diversity recorded within the 20 x 20m Dwyer's Red Gum monitoring sites significantly increased in 2016 as result of the favourable seasonal conditions with 46 – 52 species being recorded, with increased diversity typically being recorded across all monitoring sites (Figure 9-10). Since 2017 there have been prolonged dry conditions and floristic diversity continued to decline with only 19 - 31 species recorded in the reference sites this year.

In the low quality woodland there were a total of 17 species which was slightly low compared to the reference sites. All other revegetation monitoring sites demonstrated a similar reduction in diversity, however only nine species were recorded in DReveg2 this year which was significantly lower than was recorded in previous years and much lower than the reference sites. There were 23 and 32 species in DReveg1 and DReveg3 respectively, with these having a similar or higher total diversity than the reference sites.

In the Dwyer's Red Gum woodland reference sites, native species continued to be more diverse than exotic species with 19 – 28 native species and only 0 – 3 exotic species being recorded this year. There were 17 native species in the low quality woodland which was slightly lower than was recorded in the reference sites, however no exotic species were recorded (Figure 9-11, Figure 9-12). In the revegetation grassland sites there were more native species than exotics this year. While no exotic species were recorded in DReveg2, there were seven and 12 in DReveg1 and DReveg3 respectively.

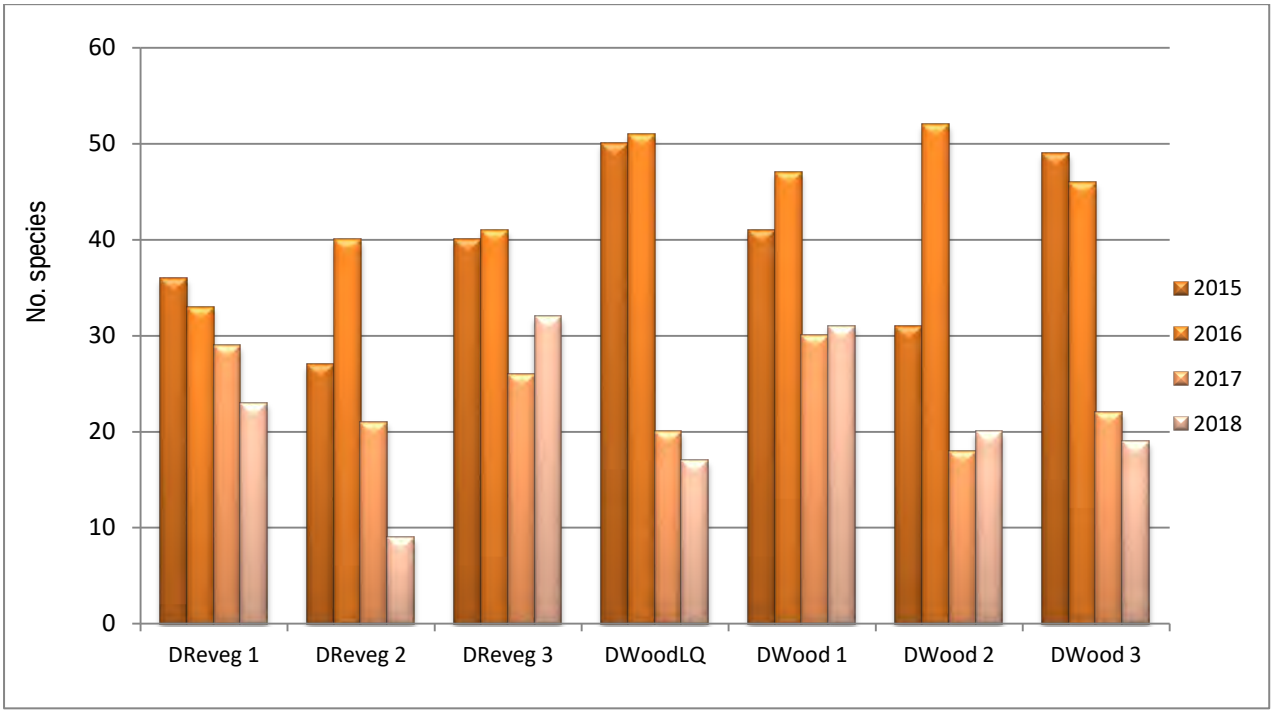


Figure 9-10. Total species diversity recorded in the Dwyer's Red Gum monitoring sites.

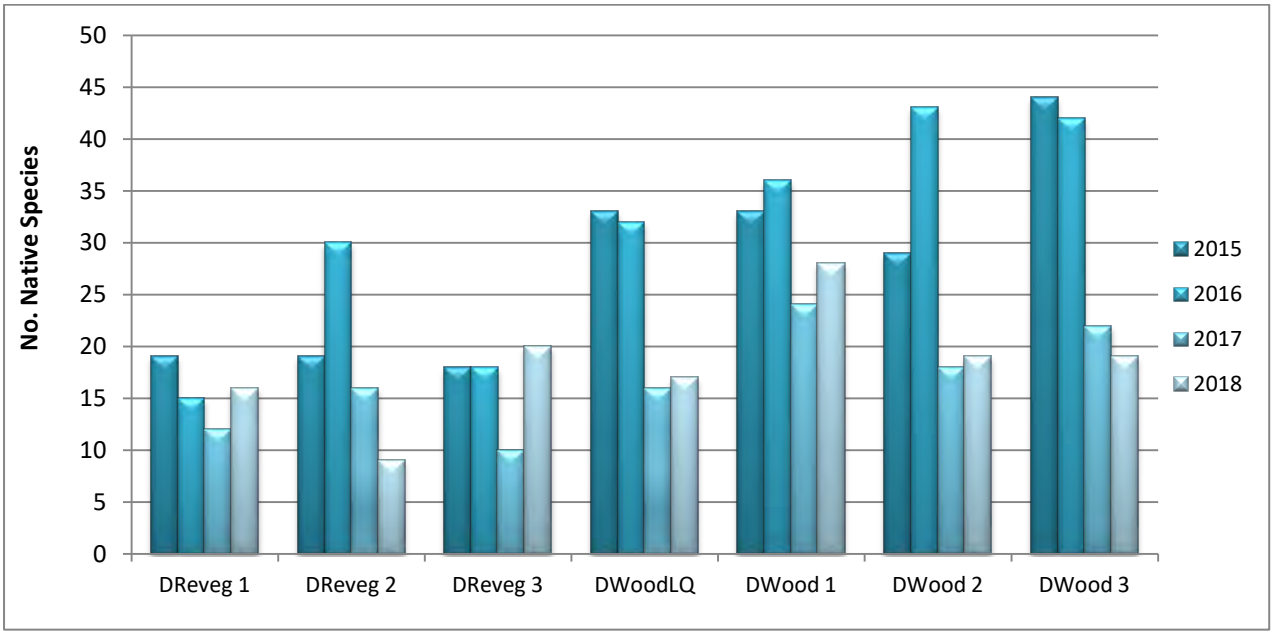


Figure 9-11. Total native species recorded in the Dwyer's Red Gum monitoring sites.

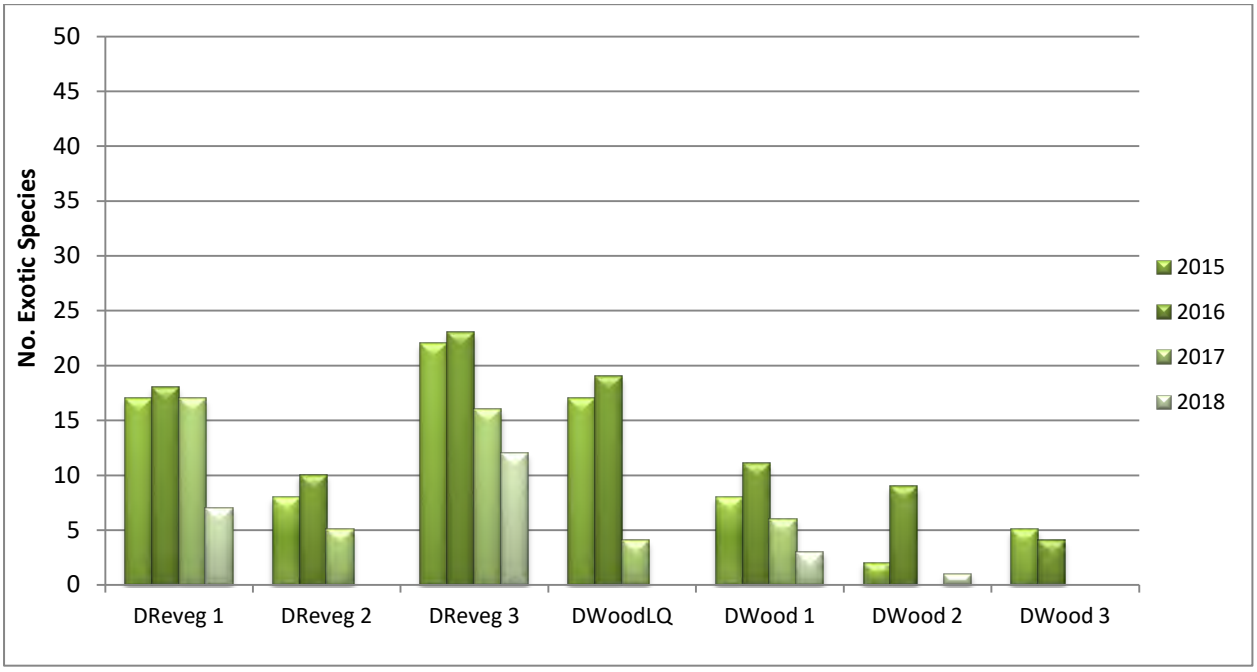


Figure 9-12. Total exotic species recorded in the Dwyer's Red Gum monitoring sites.

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 Dwyer's Red Gum woodland reference sites most of the live plant cover has been provided by native species, however cover provide by native plants in 2016 was slightly lower due to the increase in exotic annual plant cover. Since 2017, there has been a decline in exotic plant cover, with 96 – 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 had resulted in the loss of or absence of exotic species, leaving mostly hardy perennial native species. There was no change in DWoodLQ. Native plants provided 100% cover in DReveg2 and DWoodLQ this year. In DReveg1 and DReveg3 native plants provided 64% and 50% of the live ground cover and therefore were weedier than desired.

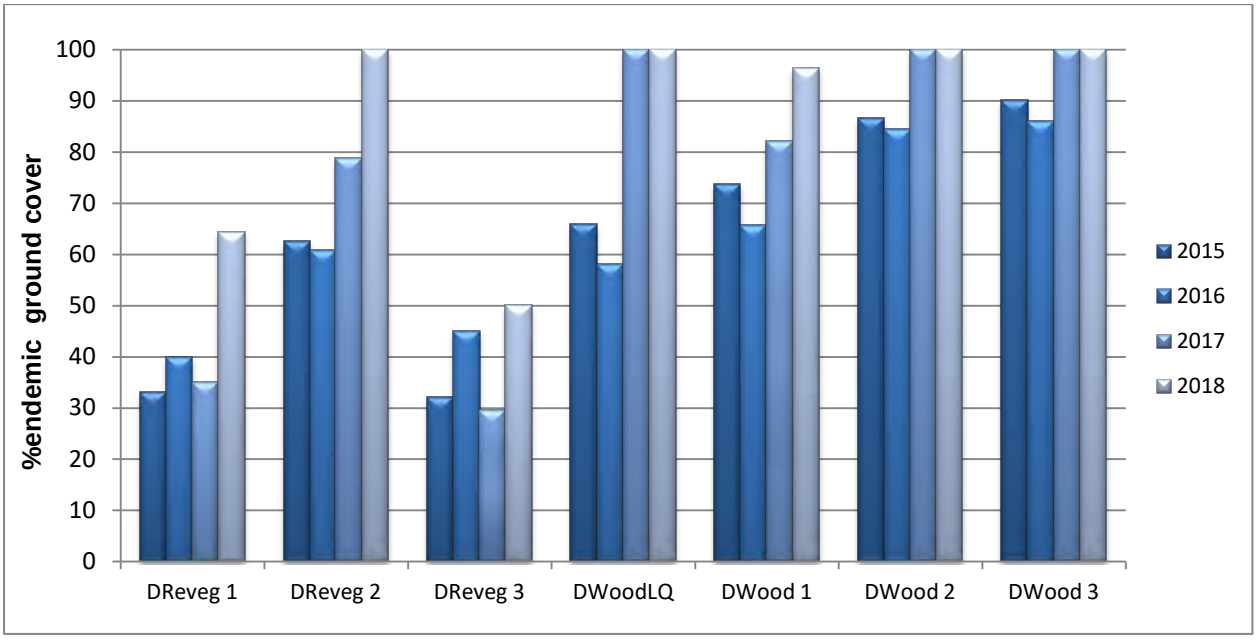


Figure 9-13. Percent endemic ground cover recorded in the Dwyer's Red Gum monitoring sites.

9.8 Vegetation composition

The composition of the vegetation as categorised by eight different growth forms is given in Figure 9-14. In the Dwyer's Red Gum woodland reference sites herbs were the most diverse plant group with 3 - 15 different species followed by grasses with 3 – 7 species. There were 3 - 4 tree species, 2 – 4 shrub species and 2 sub-shrubs were recorded in the reference sites. There were 0 – 2 reed species, 0 – 1 species of fern, while DWood3 also had one parasite species i.e. (Mistletoe).

The low quality woodland site had similar composition of the herbaceous ground covers, but it had a low diversity of tree species and no sub – shrubs were recorded. In the grassland revegetation areas there was presently a low diversity of trees and no sub-shrubs were recorded. In DReveg1 and DReveg3 there was also a low diversity of shrubs.

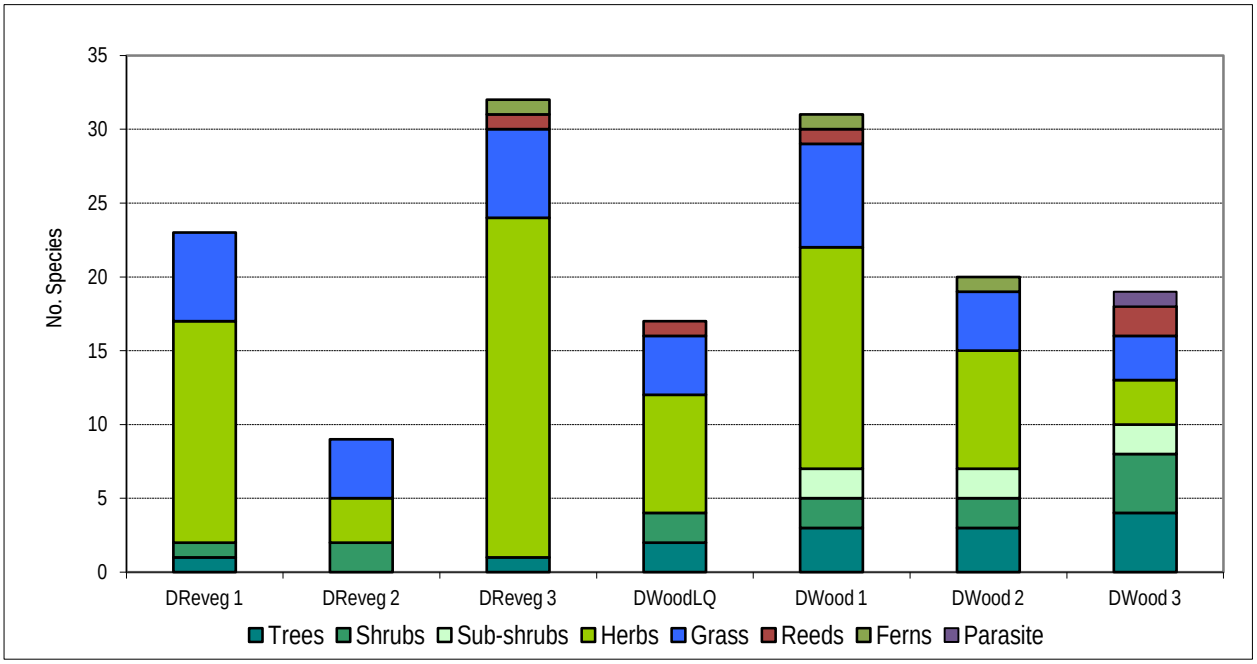


Figure 9-14. Composition of the vegetation recorded in the Dwyer's Red Gum monitoring sites in 2018.

9.9 Most common species

The most common species recorded in the revegetation sites is provided in (Table 9-6). This year the native perennial ground covers *Bothriochloa macra* (Red-leg Grass) and *Haloragis heterophylla* (Rough Raspwort) were recorded in all sites, however they were not present in the reference sites.

Other common native perennials included *Aristida ramosa* (Threeawn Grass) and *Tricoryne elatior* (Yellow Autumn-lily), while common annual natives included *Triptilodiscus pygmaeus* (Austral Sunray) and Xerochrysum bracteatum (Golden Everlasting). A comprehensive list of species recorded in all monitoring sites has been included in Appendix 1.

Table 9-6. The most common species recorded in the Dwyer's Red Gum monitoring sites in 2018.

exotic	Scientific Name	Common Name	Habit	DReveg1	DReveg2	DReveg3	DWoodLQ	Total	DWood1	DWood2	DWood3
	Bothriochloa macra	Red-leg Grass	g	1	1	1	1	4			
	Haloragis heterophylla	Rough Raspwort	h	1	1	1	1	4			
	Aristida ramosa	Threeawn Grass	g	1	1	1		3			1
	Tricoryne elatior	Yellow Autumn-lily	h	1	1		1	3	1		
	Triptilodiscus pygmaeus	Austral Sunray	h	1		1	1	3	1		
	Xerochrysum bracteatum	Golden Everlasting	h	1		1	1	3			

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 Dwyer's Red Gum monitoring sites this year are provided in Table 9-7. 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 were sufficiently abundant to meet the criteria in the Dwyer's Red Gum reference sites or in DReveg1 or DWoodLQ this year. *Aristida ramosa* (Threeawn Grass) a native grasses provided the most plant cover in DReveg2, while *Hypochaeris glabra (*Smooth Catsear) an exotic annual weed was the most abundant species in DReveg3 this year.

Table 9-7. The most abundant species recorded in the Dwyer's Red Gum monitoring sites in 2018.

Scientific Name	Common Name	DReveg1	DReveg2	DReveg3	DWoodLQ	DWood1	DWood2	DWood3
Aristida ramosa	Threeawn Grass		10					
**Hypochaeris glabra*	Smooth Catsear			12				

9.11 Soil analyses

9.11.1 pH

Figure 9-15 shows the pH recorded in the Dwyer's 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 – 5.5 the soils were strongly to very strongly acidic (Bruce & Rayment 1982).

In the remaining sites the soil pH ranged from a low of 5.2 in DReveg3 to a high of 5.7 in DReveg2 indicating the soils were moderately to strongly acidic. Soil pH in the revegetation sites and low quality woodland (DWoodLQ) were therefore comparable to the local woodlands and just within the desirable agricultural range.

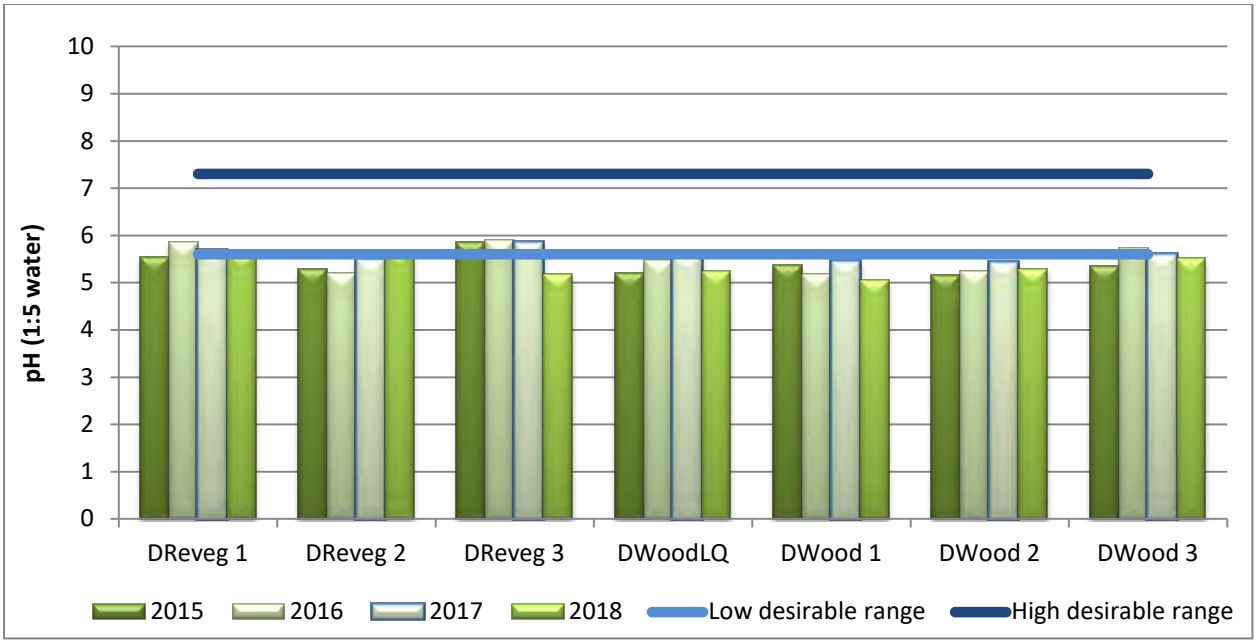


Figure 9-15. Soil pH recorded in the Dwyer's Red Gum monitoring sites compared to the desirable agricultural range.

9.11.2 Conductivity

Figure 9-16 shows the Electrical Conductivity (EC) recorded in the Dwyer's 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 0.022 – 0.031 dS/m. In the remaining sites EC ranged from a low of 0.012 dS/m in DReveg3 to a high of 0.029 dS/m in DWoodLQ.

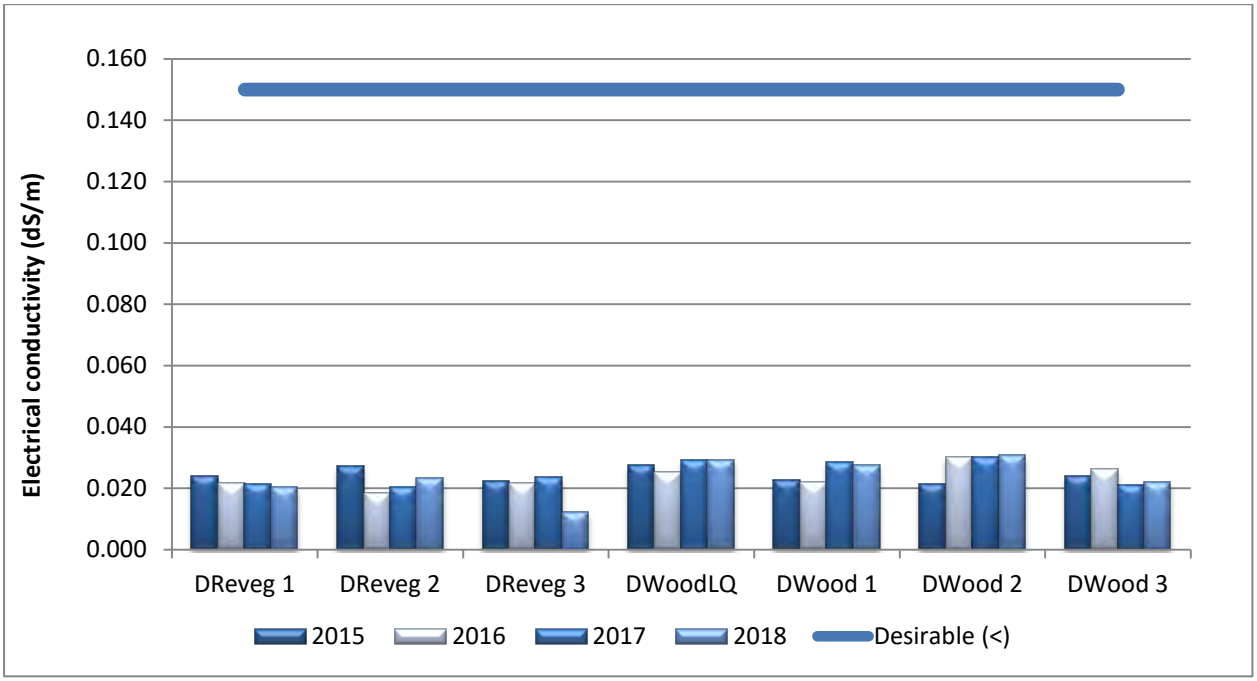


Figure 9-16. Electrical Conductivity recorded in the Dwyer's Red Gum monitoring sites compared to the desirable agricultural levels.

9.11.3 Organic Matter

In the Dwyer's Red Gum woodland reference sites OM levels ranged from 2.9 – 5.5% with high OM content recorded in DWood1 and DWood2 which were close to or slightly exceeding the desirable agricultural threshold of 4.5% (Figure 9-17). OM in the derived grassland sites were lower than the Dwyer's Red Gum woodland reference sites with OM concentrations of 2.2 – 3.5%, and so was OM in the low quality woodland which had 3.2% OM.

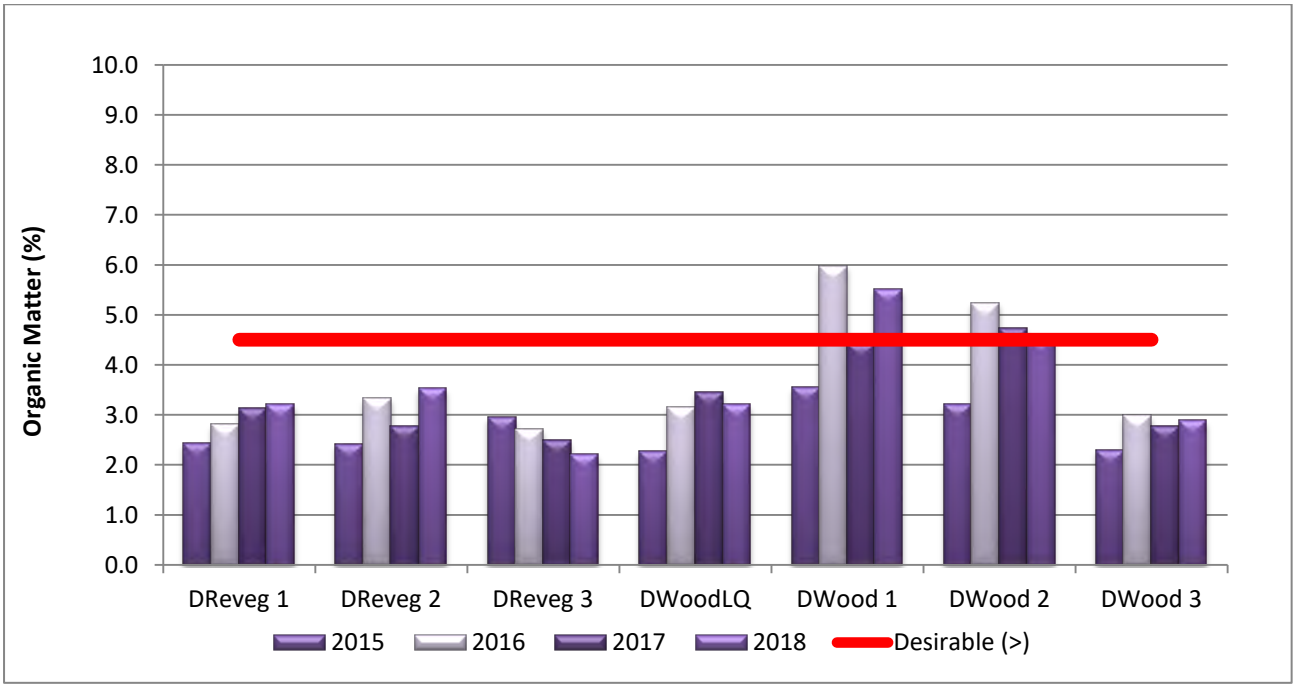


Figure 9-17. Organic Matter concentrations recorded in the Dwyer's Red Gum monitoring sites compared to desirable agricultural levels.

9.11.4 Phosphorous

Phosphorous levels were lower than the agricultural standards across all Dwyer's Red Gum monitoring sites and these had decreased over the past year. In the woodland reference sites P concentrations were 7 – 8 mg/kg. P in the derived grassland sites was similar to Dwyer's Red Gum woodland reference sites with concentrations of 8 – 9 mg/kg. P in the low quality woodland was slightly lower than the references sites with 5 mg/kg (Figure 9-18).

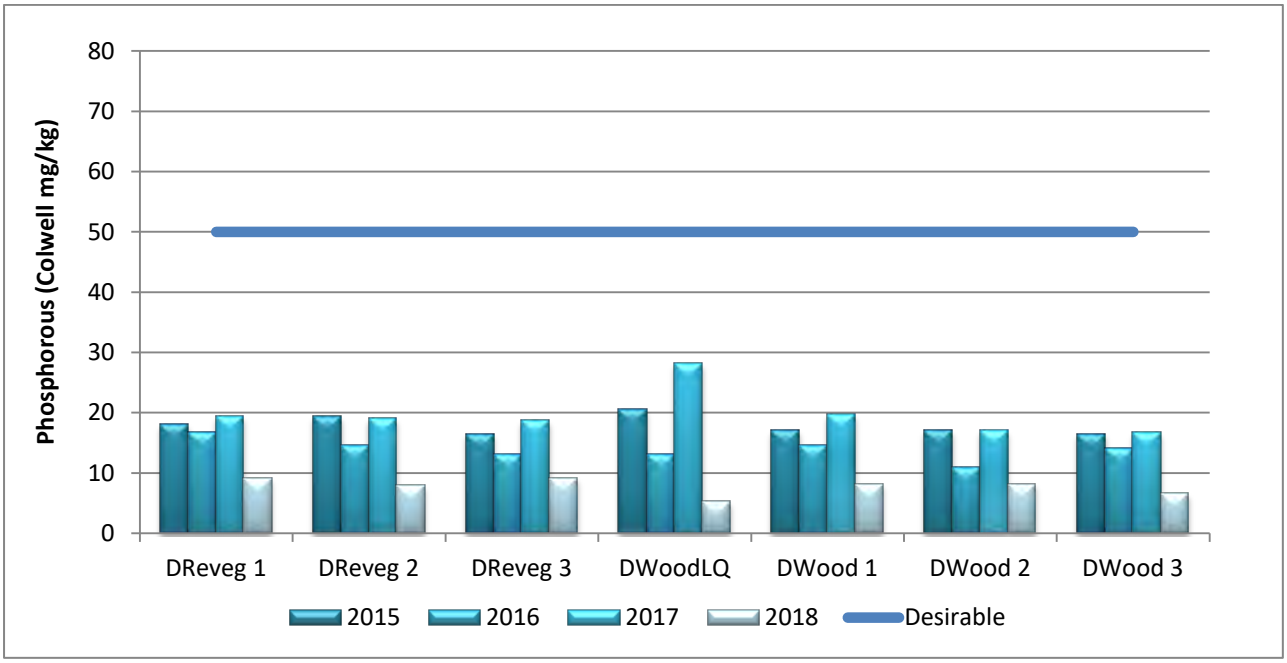


Figure 9-18. Phosphorous concentrations recorded in the Dwyer's Red Gum monitoring sites compared to desirable agricultural levels.

9.11.5 Nitrate

Nitrate levels were lower than the agricultural standards across all Dwyer's Red Gum monitoring sites and there were little differences between the sites. In the reference sites N ranged from 0.5 – 3.5 mg/kg and most of the other sites were similar, ranging from a low of 0.5 mg/kg in DReveg3 to a high of 1.9 mg/kg in DReveg2 (Figure 9-19).

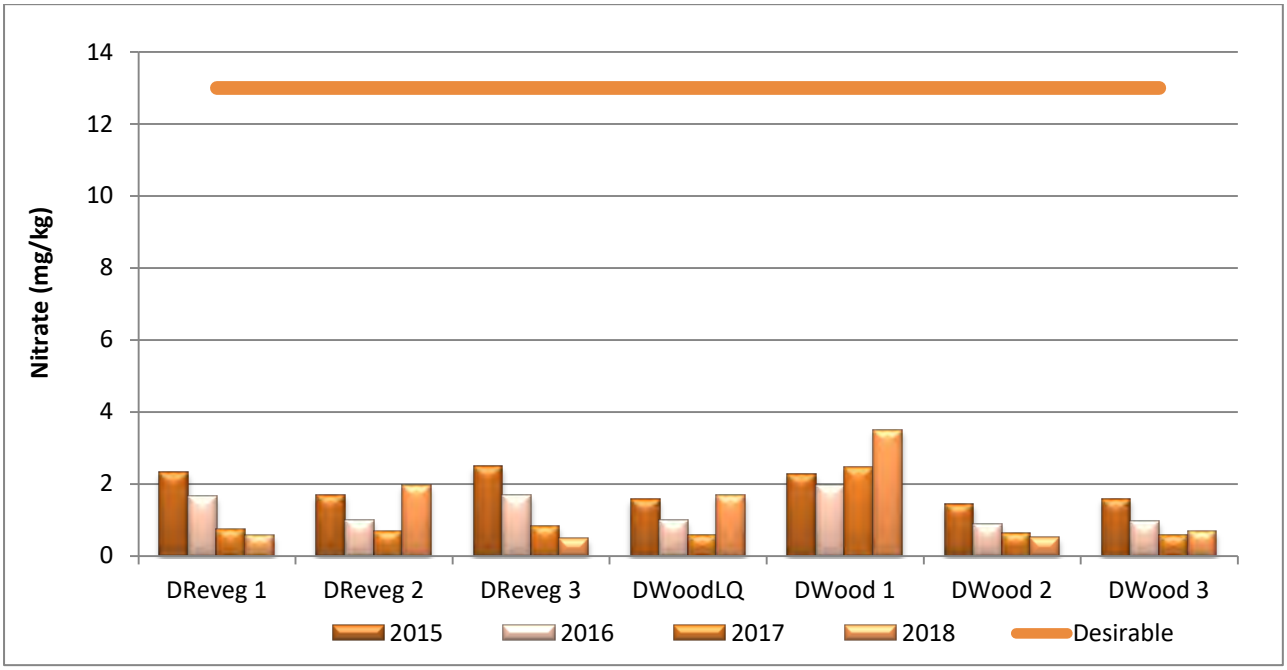


Figure 9-19. Nitrate concentrations recorded in the Dwyer's Red Gum monitoring sites compared to desirable agricultural levels.

9.11.6 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 Dwyer's Red Gum monitoring sites had a low CEC and in the reference CEC ranged from 2.4 – 4.2 cmol/kg. In the remaining sites CEC ranged from a low of 2.6 cmol/kg in DReveg3 to a high of 3.1 cmol/kg in DReveg1 (Figure 9-20).

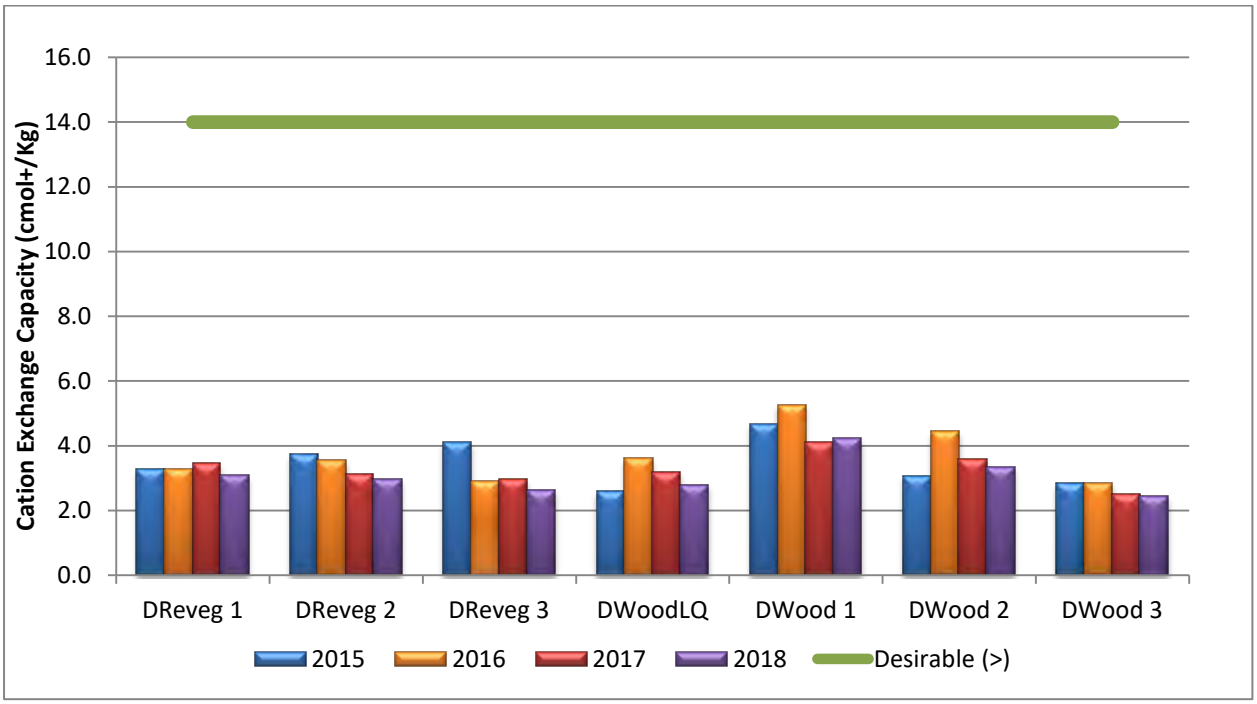


Figure 9-20. Cation Exchange Capacity recorded in the Dwyer's Red Gum monitoring sites compared to desirable agricultural levels.

9.11.7 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 this year ranged from 0.6 – 4.1% and these remained below the 5% threshold for sodicity (Figure 9-21). In the low quality woodland the ESP continued to be elevated and with ESP of 5.0% the soils may be sodic (Isbell 1996). ESP in the remaining sites ranged from 1.3 in DReveg3 to a high of 3.1 in DReveg2, with these being classified as non sodic.

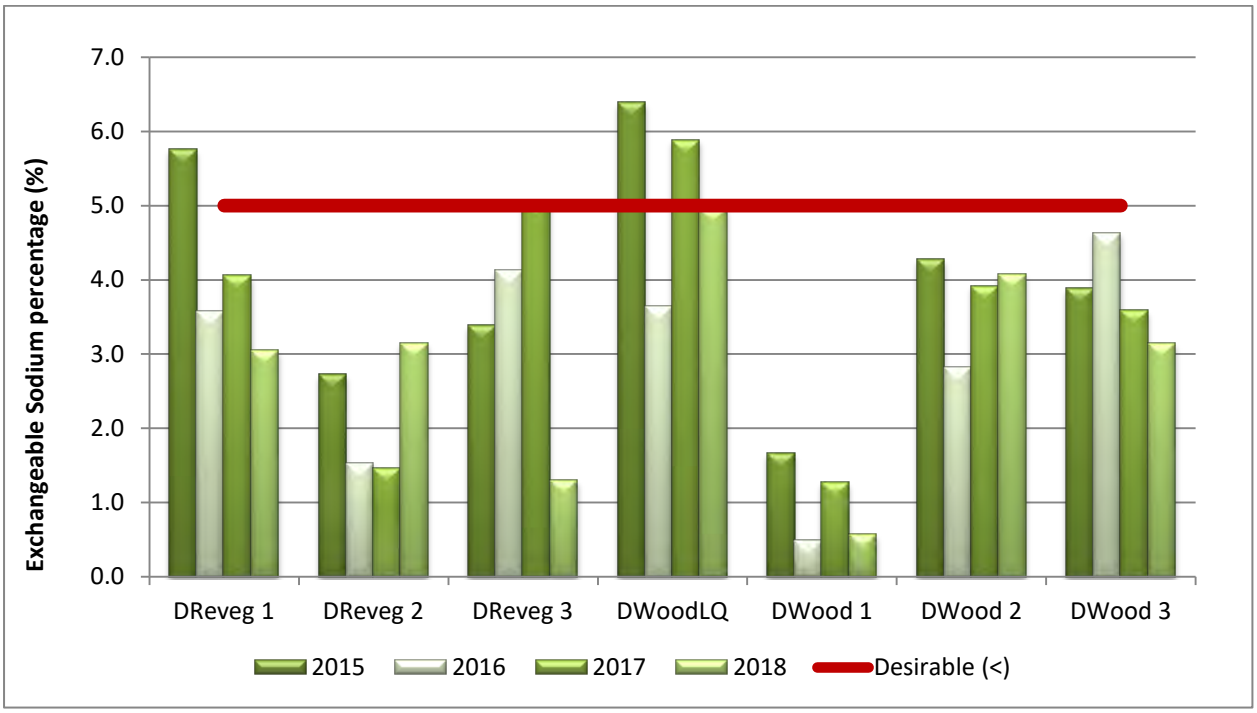


Figure 9-21. ESP recorded in the Dwyer's Red Gum monitoring sites compared to desirable agricultural levels.

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

Table 9-8 indicates the performance of the Kokoda Dwyer's Red Gum monitoring sites against a selection of proposed Completion Performance Indicators during the 2018 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 Dwyer's 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 2018. 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 9-8. Performance of the Dwyer's Red Gum revegetation monitoring sites against the Primary and Secondary Performance Indicators in 2018.

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2018		DReveg1	DReveg2	DReveg3	DWoodLQ
Performance indicators are quantified by the range of values obtained from replicated reference sites							2018	2018	2018	Lower	Upper	2018	2018	2018	20185
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 and	Soil properties are suitable for the establishmen	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	5.3	5.5	5.0	5.5	5.6	5.7	5.2	5.3

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2018		DReveg1	DReveg2	DReveg3	DWoodLQ
	amelioration	t and 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)	0.028	0.031	0.022	0.022	0.031	0.020	0.023	0.012	0.029
			Organic Matter	Organic Carbon levels are typical of that of the surrounding landscape, increasing or fall within desirable ranges provided by the agricultural industry		% (>4.5)	5.5	4.5	2.9	2.9	5.5	3.2	3.5	2.2	3.2
			Phosphorous	Available Phosphorus is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		ppm (50)	8.2	8.2	6.6	6.6	8.2	9.2	7.9	9.2	5.2
			Nitrate		Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	ppm (>12.5)	3.5	0.5	0.7	0.5	3.5	0.6	1.9	0.5	1.7
			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	3.4	2.4	2.4	4.2	3.1	3.0	2.6	2.8
			ESP		Exchangeable Sodium Percentage (a measure of sodicity) is typical of the surrounding landscape or is less than the 5% threshold for sodicity	% (<5)	0.6	4.1	3.1	0.6	4.1	3.0	3.1	1.3	5.0
Phase 4: Ecosystem & Landuse Establishment	Landscape Function Analysis (LFA): Landform stability and	Landform is stable and performing as it was designed to do	LFA Stability	The LFA stability index provides an indication of the sites stability and is comparable to or trending towards that of the local remnant vegetation		%	74.0	66.9	62.2	62.2	74.0	74.1	68.4	66.5	65.2

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2018		DReveg1	DReveg2	DReveg3	DWoodLQ
	organisation		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	92	92	100	100	86	100	99
	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	3	3	7	3	7	2	2	1	3
				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	31	20	19	19	31	23	9	32	17
			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	28	19	19	19	28	16	9	20	17
			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	3	1	0	0	3	7	0	12	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2018		DReveg1	DReveg2	DReveg3	DWoodLQ
	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	208	448	1566	208	1566	11	2	1	11
	Ecosystem composition	The vegetation is comprised by a range of growth forms comparable to that of the local remnant vegetation	Trees	The number of tree species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	3	3	4	3	4	1	0	1	2
			Shrubs	The number of shrub species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	2	2	4	2	4	1	2	0	2
			Sub-shrubs		The number of sub-shrub species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	2	2	2	2	2	0	0	0	0
			Herbs	The number of herbs or forb species comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	15	8	3	3	15	15	3	23	8
			Grasses		The number of grass species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	7	4	3	3	7	6	4	6	4
			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	2	0	2	0	0	1	1
			Ferns		The number of ferns comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	1	1	0	0	1	0	0	1	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2018		DReveg1	DReveg2	DReveg3	DWoodLQ
			Vines		The number of vines or climbing species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	0	0	0	0	0	0	0	0
			Parasite		The number of parasite species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	0	1	0	1	0	0	0	0
Phase 5: Ecosystem & Landuse Sustainability	Landscape Function Analysis (LFA): Landform function and ecological performanc e	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		%	53.3	54.8	49.7	49.7	54.8	45.7	38.4	41.5	54.5
			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		%	48.8	51.3	47.6	47.6	51.3	42.7	40.9	36.2	53.7
	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	%	71	87	78	71	87	76	73	58.5	90.5
			Annual plants		Percent ground cover provided by live annual plants is comparable to that of the local remnant vegetation	<%	0	0	0	0	0	3	0	26	0
			Cryptogam cover		Percent ground cover provided by cryptogams (eg mosses, lichens) is comparable to that of the local remnant vegetation	%	7	1	2	1	7	14.5	11	3.5	2
			Rock		Percent ground cover provided by stones or rocks (> 5cm diameter) is comparable to that of the local remnant vegetation	%	9	0	0	0	9	1.5	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2018		DReveg1	DReveg2	DReveg3	DWoodLQ
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	7	4	0	0	7	0	0	0	0
			Bare ground		Percentage of bare ground is less than or comparable to that of the local remnant vegetation	< %	4	5	15	4	15	2	12.5	8.5	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		%	3	4	7	3	7	3.5	3.5	3.5	2.5
			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		%	97	95	86	86	97	98	87.5	91.5	95
	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	4.0	1.6	2.4	2	4	3	3	4.6	1.6
			Exotic understorey abundance		The abundance of exotic species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it is has less than or an equal number of exotic species as the local remnant vegetation	< species/m^2	0.2	0.0	0.0	0	0	1.6	0	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		%	96	100	100	96	100	64.3	100	50	100

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2018		DReveg1	DReveg2	DReveg3	DWoodLQ
	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	**208**	**404**	**1244**	**208**	**1244**	**1**	**2**	**1**	**11**
			shrubs and juvenile trees 0.5 - 1m in height		The number of shrubs or juvenile trees 0.5-1m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	**0**	**44**	**262**	**0**	**262**	**1**	**0**	**0**	**0**
			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**	**58**	**0**	**58**	**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**	**4**	**0**	**0**	**0**
			shrubs and juvenile trees >2m in height		The number of shrubs or juvenile trees > 2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	**0**	**0**	**2**	**0**	**2**	**2**	**0**	**0**	**0**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2018		DReveg1	DReveg2	DReveg3	DWoodLQ
	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	4	15	0	15	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	0	12	5	0	12	0	0	0	2
			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	12	13	11	11	13	0	0	0	8
			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	27	55	23	23	55	0	0	0	26
	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

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Primary Performance Indicators Description	Secondary Performance Indicators Description	Unit of measure	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2018		DReveg1	DReveg2	DReveg3	DWoodLQ
	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	73	37	10	10	73	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	6	0	0	22
	Ecosystem health	The vegetation is in a condition comparable to that of the local remnant vegetation.	Live trees	The percentage of the tree population which are live individuals and that the percentage is comparable to the local remnant vegetation		% population	33	73	80	33	80	100	0	0	100
			Healthy trees	The percentage of the tree population which are in healthy condition and that the percentage is comparable to the local remnant vegetation		% population	8.2	2.7	20.0	3	20	100	0	0	0
			Medium health		The percentage of the tree population which are in a medium health condition and that the percentage is comparable to the local remnant vegetation	% population	20.5	54.1	30.0	21	54	0	0	0	33.3
			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	4.1	16.2	30.0	4	30	0	0	0	66.7
			Dead Trees		The percentage of the tree population which are dead (stags) and that the percentage is comparable to the local remnant vegetation	% population	67.1	27.0	20.0	20	67	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	DWood1	DWood2	DWood3	Dwyer's Red Gum Woodland ecosystem range 2018		DReveg1	DReveg2	DReveg3	DWoodLQ
			Mistletoe		The percentage of the tree population which have mistletoe provides an indication of community health and habitat value and that the percentage is comparable to the local remnant vegetation	% population	0	0	10	0	10	0	0	0	0
			Flowers/fruit: Trees	The percentage of the tree population with reproductive structures such as buds, flowers or fruit provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources comparable to that of the local remnant vegetation		% population	18	35	70	18	70	0	0	0	66.7
			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	0	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.

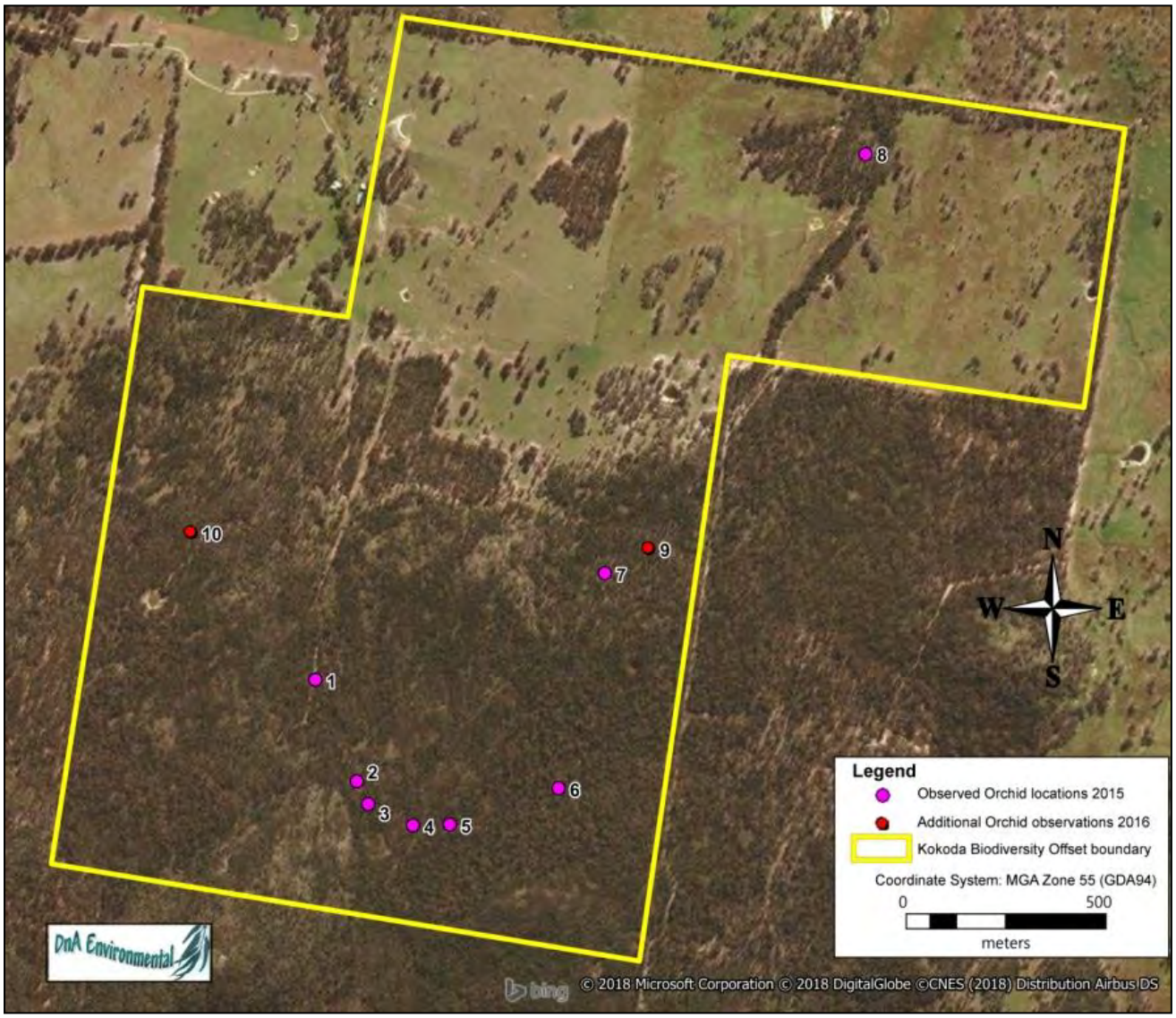


Figure 11-1. A map showing the approximate locations of orchid species sighted around the Kokoda property in 2015 and 2016.

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 Discussion

Grey Box woodlands

The Grey Box woodland reference sites were characterised by having a mature tree canopy and a well developed decomposing leaf litter layer with a sparse cover of native perennial forbs and grasses which collectively provided a highly functional patch area. The White Box and Ironbark woodlands also had a mature tree canopy and while both sites had a well developed leaf litter layer, native grasses and forbs were more abundant in the White Box woodland whereas in the Ironbark woodland there was an understorey of low and scattered shrubs with both sites having high functional patch areas. While the Grey Box 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 and also had a high functional patch areas.

This year, drought conditions and heavy grazing has resulted in a reduction in the stability, infiltration and nutrient recycling capacity of all sites. There was limited live ground cover vegetation and often the integrity of the litter and cryptogam layers had declined. All sites however all sites continued to maintain high functional patch areas.

The woodland reference site GBWood3 continued to be the most ecologically functional site with a total score of 176, followed by GBWood2 with 171, followed closely by Ironwood1 with a sum of scores of 169. These sites contained high patch area, a mature tree canopy and well developed grassy ground cover layer, with high levels of decomposing litter and had very spongy and stable soils. Despite the lack of perennial overstorey there was relatively high functionality in GBReveg5 and GBReveg3 and with a sum of scores of 167 and 164 respectively, were more functional than the woodland sites GBWood1 (162) and WBWood1 (161). The derived native grassland revegetation areas, GBReveg1 scored 160, GBReveg4 scored 151 while the least functional community continued to be GBReveg2 which scored 142.

The resultant population densities of trees and mature shrubs recorded in the Grey Box reference sites were 8 - 23, equating to a density of 200 – 575 stems per hectare. There continued to be eight individuals in the White Box woodland site and there were 29 in the Ironbark woodland. No trees or mature shrubs were yet present in the derived native grassland sites.

In the woodland reference sites there were 1 - 21 shrubs and juvenile trees, equating to a density of 25 - 525 stems per hectare represented by 1 - 3 species. In the White Box woodland some seedlings had died with only five individuals recorded this year as a result of the prolonged dry conditions. In the Ironbark woodland there were 139 individuals. One seedling continued to be recorded in GBReveg1 this year, while no shrubs or juvenile trees were recorded in the remaining sites.

In the Grey Box woodland 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. As a result of the dry conditions there was much less perennial ground cover and there were no annual plants. The reference sites were also characterised by having a mature canopy cover which exceeded 6.0m in height with low hanging braches also providing occasional projected cover in the lower height classes. The White Box and Ironbark woodlands had a similar community structure.

In the derived grassland revegetation sites, annual plant cover had declined in all sites and all sites were dominated by dead litter, derived from dead ground cover plants. Annual plants however continued to be recorded in low abundances in all sites. Cryptogams were also recorded in high abundance in GBReveg2 and were also present in the remaining revegetation sites. Perennial plant cover ranged from 5.5 – 20.5 % with

these exceeding minimum perennial ground cover requirements. Presently there is no vertical structure > 0.5m in height in the derived grassland revegetation areas.

This year prolonged dry conditions resulted in the further decline in species richness across all monitoring sites, where 7 – 15 species were recorded in the Grey Box woodland reference sites. The White Box and Iron Bark woodlands as well as the grassland revegetation sites were more diverse than the reference sites this year. All grassland revegetation sites had an acceptable diversity of native species however there was higher diversity of exotic species compared to the reference sites. In the derived grasslands, there has been an increasing trend in native plant abundance in numerous sites however GBReveg2 was the only site dominated by native species. The remaining grassland sites were weedier than desired.

Dwyer's Red Gum woodland

The Dwyer's Red Gum (DRG) woodland reference sites were also 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 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. The Dwyer's Red Gum derived grassland revegetation sites presently existed as degraded native grasslands but they typically had good ground cover comprised of a combination of annual and perennial plants and cryptogams and also had a high functional patch areas.

This year, drought conditions and heavy grazing has resulted in a reduction in the stability, infiltration and nutrient recycling capacity of all sites. Heavy grazing and disturbance by animals has tended to reduce the integrity of the ground covers and litter layers where the soils become more susceptible to erosion and deposition. All sites with the exception of DReveg2 and DWood3 continued to maintain high functional patch areas.

The Dwyer's Red Gum reference site DWood1 continued to be the most ecologically functional site with a total score of 176. The low quality woodland DWoodLQ and DWood2 were very similar to each other with a sum of scores of 173. This was followed by DReveg1 and DWood3 with 163 and 160 respectively. DReveg2 and DReveg3 were the least functional sites this year with scores of 148 and 144 respectively.

This year there were 8 – 29 live trees and mature shrubs (>5cm dbh), equating to a density of 200 – 725 stems per hectare. There continued to be nine individuals in the low quality woodland. One juvenile eucalypt continued to be recorded in DReveg1, but no trees or mature shrubs were present in the other two derived native grassland sites.

There was a large variation on the number of shrubs and juvenile trees (<5cm dbh) recorded in the Dwyer's Red Gum reference sites with densities ranging from 208 – 1566 individuals. In the woodland reference sites there were 3 - 7 species of shrubs and juvenile trees with the most abundant species being young *Callitris endlicheri* seedlings. In the low quality woodland there were 11 shrubs and juvenile trees this year. In the derived grasslands, there were 11 seedlings recorded in DReveg1, two in DReveg2 and in DReveg3 there was one seedling with these being the result of natural regeneration.

In the Dwyer's Red Gum woodland reference sites the most dominant form of ground cover continued to be dead leaf litter largely derived from fallen leaves and twigs. There were scattered perennial ground covers, cryptogams and logs however no annual ground covers were recorded this year. In DWood1 there were also scattered rocks. The low quality woodland had similar features and in similar proportions to the reference sites but did not tend to have fallen branches or rocks. In comparison the revegetation sites continued to be dominated by various proportions of annual and perennial plants and dead leaf litter and this year all three sites had adequate covers of perennial plants and cryptogams. No cover >0.5m in height was recorded this year due to heavy grazing and lack of shrub or tree canopies.

Since 2017 there have been prolonged dry conditions and floristic diversity continued to decline with only 19 - 31 species recorded in the reference sites this year. In the low quality woodland there were a total of 17 species which was slightly low compared to the reference sites. All other revegetation monitoring sites demonstrated a similar reduction in diversity, however only nine species were recorded in DReveg2 this year which was significantly lower than was recorded in previous years and much lower than the reference sites. There were 23 and 32 species in DReveg1 and DReveg3 respectively, with these having a similar or higher total diversity than the reference sites. In the revegetation grassland sites there were more native species than exotics this year. While no exotic species were recorded in DReveg2, there continued to be too many in DReveg1 and DReveg3.

Of the total live plant cover there was an increase in native plant percent cover in DWoodLQ and the revegetation sites this year, as the dry conditions and heavy grazing had resulted in the loss of or absence of exotic species, leaving mostly hardy perennial native species. Native plants provided 100% of the cover in DReveg2 and DWoodLQ, while DReveg1 and DReveg3 were weedier than desired.

All derived grassland revegetation sites presently did not meet many completion targets related to the mature tree population and the structural complexity of the sites due to the lack of a well developed overstorey and in the DRG revegetation sites, the lack of a shrub understorey. Other primary ecological attributes which fell short of meeting completion performance target tended to be largely associated with low density and diversity of trees and shrubs. Most of the derived grassland sites were dominated by exotic annual species and were presently weedier than desired.

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 non sodic.

13 Conclusion

The proposed revegetation activities within the derived grassland areas as described in the BOMP aim to increase biodiversity and habitat values through the removal of livestock grazing to allow natural regeneration, supplemented with tubestock planting. These activities are likely to result in the derived grassland areas developing into woodland communities and therefore meeting most ecological performance indicators in the medium to longer term. The reference sites at Kokoda are typically degraded and of low quality which subsequently have provided low performance targets. In the Grey Box woodlands in particular, there was limited abundance and diversity of the grassy understorey and there were limited shrubs and juvenile trees. 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 reasonable and feasible and to promote good establishment success, revegetation practices should follow Best Practice Revegetation Guidelines (Sydes *et al* Greening Australia 2003). Revegetation works should aim to create a mosaic of shrub thickets, open woodland and grassy clearings. Heterogeneity of different habitat types will increase biodiversity and promote the long-term sustainability of the various woodland communities.

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 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. Presently, extensive disturbance and herbivory by feral and pests species especially macropods and goats has become an important management issue. A control program may need to be implemented with the most beneficial outcomes being obtained by seeking advice from the Local Land Services and a cooperative approach with neighbouring landholders. Exclusion fencing in strategic locations may 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, particularly as most orchids are only identifiable during a limited time period. As a result of the dry conditions experienced throughout most of 2017 and 2018, none of these populations were observed to be flowering, thus emphasising the need to continue to map 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 is likely to suppress the herbaceous understorey as they become more established, thereby adversely affecting floristic and biodiversity targets in the medium to longer term. Strategic grazing may reduce the density of existing seedlings and regulate the degree of Callitris regeneration through manipulation of the herbaceous understorey and germination niches, in more favourable seasonal conditions.

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. Several areas of boundary fence also require maintenance to ensure neighbouring livestock cannot freely access the property.

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

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Appendix 1. List of flora species recorded in the Kokoda monitoring sites in 2018

Group	Family	exotic	Scientific Name	Common Name	Habit	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	IronWood1	WBWood1
Coniferopsida	Cupressaceae		*Callitris endlicheri*	Black Cypress Pine	t	1	1	1								1					1	1
Dicotyledon	Apiaceae		*Daucus glochidiatus*	Australian Carrot	h		1							1								
Dicotyledon	Araliaceae		*Hydrocotyle laxiflora*	Stinking Pennywort	h	1	1	1				1		1	1							1
Dicotyledon	Asteraceae	*	*Arctotheca calendula*	Capeweed	h						1					1	1	1	1	1		
Dicotyledon	Asteraceae		*Calotis lappulacea*	Yellow Burr Daisy	h				1		1		1		1	1	1					
Dicotyledon	Asteraceae	*	*Carthamus lanatus*	Saffron Thistle	h													1				
Dicotyledon	Asteraceae		*Cassinia laevis*	Cough Bush	s			1		1			1		1						1	
Dicotyledon	Asteraceae	*	*Chondrilla juncea*	Skeleton Weed	h				1		1					1			1	1		
Dicotyledon	Asteraceae		*Cymbonotus lawsonianus*	Bear's Ear	h																	1
Dicotyledon	Asteraceae	*	*Hypochaeris glabra*	Smooth Catsear	h	1	1		1		1					1	1	1	1	1		
Dicotyledon	Asteraceae	*	*Hypochaeris radicata*	Flatweed	h															1		
Dicotyledon	Asteraceae		*Isoetopsis graminifolia*	Grass Cushion	h						1							1				
Dicotyledon	Asteraceae		*Solenogyne bellioides*		h							1										1
Dicotyledon	Asteraceae	*	*Sonchus oleraceus*	Milk Thistle	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	1	1		
Dicotyledon	Asteraceae		*Vittadinia gracilis*	A Fuzzweed	h						1				1	1	1					
Dicotyledon	Asteraceae		*Vittadinia spp.*	Fuzzweed	h						1		1							1		
Dicotyledon	Asteraceae		*Xerochrysum bracteatum*	Golden Everlasting	h				1		1	1		1							1	
Dicotyledon	Campanulaceae		*Wahlenbergia communis*	Tufted Bluebell	h						1											
Dicotyledon	Campanulaceae		*Wahlenbergia gracilis*	Sprawling Bluebell	h						1											
Dicotyledon	Campanulaceae		*Wahlenbergia spp.*	Bluebell	h												1					
Dicotyledon	Caryophyllaceae	*	*Petrorhagia nanteuilii*	Proliferous Pink	h				1		1					1		1	1	1		
Dicotyledon	Casuarinaceae		*Allocasuarina verticillata*	Drooping Sheoak	t	1		1			1											
Dicotyledon	Chenopodiaceae		*Einadia nutans subsp. nutans*	Climbing Saltbush	h								1		1							
Dicotyledon	Dilleniaceae		*Hibbertia obtusifolia*	Hoary Guinea Flower	ss																1	1
Dicotyledon	Dilleniaceae		*Hibbertia riparia*	Silky Guinea Flower	ss									1							1	
Dicotyledon	Droseraceae		*Drosera peltata*	Pale Sundew	h						1							1				
Dicotyledon	Epacridaceae		*Astroloma humifusum*	Native Cranberry	ss	1	1	1													1	
Dicotyledon	Epacridaceae		*Brachyloma daphnoides*	Daphne Heath	s	1	1	1						1							1	
Dicotyledon	Epacridaceae		*Lissanthe strigosa*	Peach Heath	ss		1	1													1	1

Group	Family	exotic	Scientific Name	Common Name	Habit	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	IronWood1	WBWood1
Dicotyledon	Euphorbiaceae		*Euphorbia drummondii*	Caustic Weed	h				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)	*	*Trifolium arvense*	Haresfoot Clover	h											1				1		
Dicotyledon	Fabaceae (Faboideae)	*	*Trifolium campestre*	Hop Clover	h													1	1	1		
Dicotyledon	Fabaceae (Faboideae)	*	*Trifolium dubium*	Yellow Suckling Clover	h				1													
Dicotyledon	Fabaceae (Faboideae)	*	*Trifolium repens*	White Clover	h												1					
Dicotyledon	Fabaceae (Faboideae)	*	*Trifolium spp.*	A Clover	h	1										1						
Dicotyledon	Fabaceae (Faboideae)	*	*Trifolium subterraneum*	Subterraneum Clover	h				1		1					1	1	1	1	1		
Dicotyledon	Fabaceae (Mimosoideae)		*Acacia decora*	Western Golden Wattle	s				1	1												1
Dicotyledon	Fabaceae (Mimosoideae)		*Acacia implexa*	Hickory	s							1		1	1						1	1
Dicotyledon	Fabaceae (Mimosoideae)		*Acacia lanigera*	Woolly Wattle	s							1										
Dicotyledon	Fabaceae (Mimosoideae)		*Acacia paradoxa*	Kangaroo Thorn	s									1								
Dicotyledon	Fabaceae (Mimosoideae)		*Acacia spp.*	A Wattle	s	1																
Dicotyledon	Gentianaceae	*	*Cicendia quadrangularis*		h						1											
Dicotyledon	Geraniaceae	*	*Erodium botrys*	Long Storksbill	h						1					1						
Dicotyledon	Geraniaceae	*	*Erodium cicutarium*	Common Crowsfoot	h				1		1					1	1			1		
Dicotyledon	Geraniaceae		*Erodium crinitum*	Blue Storksbill	h															1		
Dicotyledon	Geraniaceae		*Geranium solanderi*	Native Geranium	h																	1
Dicotyledon	Goodeniaceae		*Goodenia hederacea*	Forest Goodenia	h																1	
Dicotyledon	Haloragaceae		*Gonocarpus tetragynus*	Raspwort	h	1	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
Dicotyledon	Lamiaceae		*Ajuga australis*	Australian Bugle	h																	1
Dicotyledon	Lamiaceae	*	*Salvia verbenaca*	Wild Sage	h											1						

Group	Family	exotic	Scientific Name	Common Name	Habit	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	IronWood1	WBWood1
Dicotyledon	Loranthaceae		*Amyema miquelii*	Box Mistletoe	p			1														
Dicotyledon	Myrtaceae		*Calytrix tetragona*	Common Fringe Myrtle	s		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							
Dicotyledon	Myrtaceae		*Eucalyptus sideroxylon*	Mugga Ironbark	t		1							1	1						1	
Dicotyledon	Myrtaceae		*Platysace ericoides*	Heathy Platysace	ss	1																
Dicotyledon	Orobanchaceae	*	*Parentucellia latifolia*	Red Bartsia	h											1						
Dicotyledon	Oxalidaceae		*Oxalis perennans*	Yellow Wood-sorrel	h	1			1		1				1	1	1	1	1	1		
Dicotyledon	Plantaginaceae	*	*Echium plantagineum*	Paterson's Curse	h						1					1		1	1	1		
Dicotyledon	Plantaginaceae		*Plantago varia*	Variable Plantain	h	1																
Dicotyledon	Polygonaceae		*Rumex brownii*	Swamp Dock	h				1			1								1		
Dicotyledon	Polygonaceae		*Rumex tenax*	Shiny Dock	h	1																
Dicotyledon	Primulaceae	*	*Anagallis arvensis*	Scarlet Pimpernel	h													1	1	1		
Dicotyledon	Rubiaceae		*Asperula conferta*	Common Woodruff	h													1				
Dicotyledon	Stackhousiaceae		*Stackhousia monogyna*	Creamy Candles	h															1		1
Monocotyledon	Anthericaceae		*Arthropodium minus*	Small Vanilla Lily	h										1							
Monocotyledon	Anthericaceae		*Arthropodium spp.?*	Vanilla Lily	h	1																
Monocotyledon	Anthericaceae		*Dichopogon spp.?*	Chocolate Lily	h	1																
Monocotyledon	Anthericaceae		*Dichopogon strictus*	Chocolate Lily	h		1							1								1
Monocotyledon	Anthericaceae		*Laxmannia gracilis*	Slender Wire Lily	h	1	1														1	
Monocotyledon	Anthericaceae		*Thysanotus patersonii*	Twining Fringe Lily	h	1	1		1												1	1
Monocotyledon	Anthericaceae		*Tricoryne elatior*	Yellow Autumn-lily	h	1			1	1		1							1			1
Monocotyledon	Cyperaceae		*Carex inversa*	Knob Sedge	r						1											
Monocotyledon	Cyperaceae		*Fimbristylis dichotoma*	Common Fringe Rush	r			1														
Monocotyledon	Cyperaceae		*Lepidosperma laterale*	Broad Sword-sedge	r	1																
Monocotyledon	Iridaceae	*	*Romulea rosea*	Onion Grass	h						1											
Monocotyledon	Juncaceae		*Juncus spp.*	A Rush	r														1	1		
Monocotyledon	Juncaceae		*Juncus usitatus*		r			1				1		1								
Monocotyledon	Juncaceae		*Luzula spp.*		h																	1
Monocotyledon	Ophioglossaceae		*Ophioglossum lusitanicum*	Adders Tongue	h						1						1			1		

Group	Family	exotic	Scientific Name	Common Name	Habit	DWood1	DWood2	DWood3	DReveg1	DReveg2	DReveg3	DWoodLQ	GBWood1	GBWood2	GBWood3	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	IronWood1	WBWood1
Monocotyledon	Orchidaceae		*Caladenia carnea*	Pink Fingers	h		1														1	
Monocotyledon	Orchidaceae		*Caladenia spp.*	Spider Orchid	h	1																
Monocotyledon	Orchidaceae		*Calochilus robertsonii*	Brown-bearded Orchid, Pale Beard Orchid	h			1													1	
Monocotyledon	Orchidaceae		*Pterostylis bicolor*	Bicolor Greenhood	h												1					
Monocotyledon	Phormiaceae		*Dianella longifolia*	Blueberry Lily	h																	1
Monocotyledon	Poaceae		*Aristida jerichoensis var. jerichoensis*	Jericho Wiregrass	g	1																
Monocotyledon	Poaceae		*Aristida ramosa*	Threeawn Grass	g			1	1	1	1			1		1		1	1	1		1
Monocotyledon	Poaceae		*Aristida spp.*	Wire Grass	g																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
Monocotyledon	Poaceae		*Bothriochloa macra*	Red-leg Grass	g				1	1	1	1				1	1	1	1	1		1
Monocotyledon	Poaceae	*	*Briza minor*	Shivery Grass	g						1					1		1	1	1		
Monocotyledon	Poaceae	*	*Bromus molliformis*	Soft Brome	g				1										1	1		
Monocotyledon	Poaceae	*	*Bromus spp.*	A Brome	g														1			
Monocotyledon	Poaceae		*Chloris truncata*	Windmill Grass	g				1							1						
Monocotyledon	Poaceae		*Dichelachne spp.*	A Plumegrass	g																1	
Monocotyledon	Poaceae		*Echinopogon ovatus*	Forest Hedgehog Grass	g		1														1	
Monocotyledon	Poaceae		*Elymus scaber*	Common Wheatgrass	g									1								
Monocotyledon	Poaceae		*Eragrostis spp.*	Lovegrass	g	1		1			1							1				
Monocotyledon	Poaceae		*Microlaena stipoides*	Weeping Rice-grass	g	1						1										1
Monocotyledon	Poaceae		*Panicum spp.*		g					1	1					1	1		1	1		
Monocotyledon	Poaceae		*Rytidosperma caespitosum*	Wallaby Grass	g		1															
Monocotyledon	Poaceae		*Rytidosperma fulvum*	Wallaby Grass	g									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
Monocotyledon	Poaceae		*Sporobolus creber*	Western Rat's-tail Grass	g				1									1	1			1
Monocotyledon	Poaceae	*	*Vulpia spp.*	Rat's-tail Fescue	g	1												1				
Pteridophyta	Adiantaceae		*Cheilanthes sieberi subsp. sieberi*	Rock Fern	f	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 2. ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT– Grey Box Woodland Sites Kokoda Offset Area 2018

Soil samples supplied by DnA Environmental on 3rd October, 2018 - Lab Job No. H4553

			Site	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	GBWood1	GBWood2	GBWood3	WBWood1	IronWood1	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
	Parameter		Method reference	H4553/4	H4553/5	H4553/6	H4553/7	H4553/8	H4553/12	H4553/13	H4553/14	H4553/15	H4553/16	Indicative guidelines - refer to Notes 6 and 8			
	Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	495	357	348	215	312	218	144	468	457	88	*1150*	*750*	*375*	*175*
	Soluble Magnesium (mg/kg)			58	87	82	71	54	139	86	210	91	38	*160*	*105*	*60*	*25*
	Soluble Potassium (mg/kg)			86	72	72	85	68	120	71	134	105	77	*113*	*75*	*60*	*50*
	Soluble Phosphorus (mg/kg)			1.4	1.2	<1	<1	<1	2.0	1.4	2.1	1.7	<1	*15*	*12*	*10*	*5.0*
	Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	1.7	2.6	1.2	1.3	1.0	13.5	2.9	4.9	1.6	1.4	*45 note 8*	*30 note 8*	*24 note 8*	*20 note 8*
			**Rayment & Lyons 2011 - 9B2 (Colwell)	7	9	7	8	6	26	11	14	8	7	*80*	*50*	*45*	*35*
			**Inhouse S3A (Bray 2)	2	4	2	2	1	20	3	8	2	2	*90 note 8*	*60 note 8*	*48 note 8*	*40 note 8*
	Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	0.5	8.0	0.5	1.0	1.2	1.7	0.5	1.3	1.5	0.6	*15*	*13*	*10*	*10*
	Ammonium Nitrogen (mg/kg N)			2.2	5.6	5.5	3.2	3.0	7.6	3.1	5.3	8.7	3.8	*20*	*18*	*15*	*12*
	Sulfur (mg/kg S)			<1	5.9	1.5	1.4	1.3	6.2	5.5	2.9	2.6	1.7	*10.0*	*8.0*	*8.0*	*7.0*
	pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	6.60	5.34	6.14	6.00	6.07	5.05	5.20	5.55	6.24	5.09	*6.5*	*6.5*	*6.3*	*6.3*
	Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.023	0.064	0.021	0.018	0.015	0.067	0.059	0.065	0.037	0.038	*0.200*	*0.150*	*0.120*	*0.100*
	Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	2.7	5.2	3.4	2.3	1.8	6.5	4.5	7.5	3.1	3.6	*> 5.5*	*>4.5*	*> 3.5*	*> 2.5*
	Exchangeable Calcium	($cmol_+/kg$)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	3.83	3.22	2.52	1.53	2.28	2.03	1.37	4.92	4.38	0.74	*15.6*	*10.8*	*5.0*	*1.9*
		(kg/ha)		1720	1446	1132	688	1022	910	616	2207	1967	331	*7000*	*4816*	*2240*	*840*
		(mg/kg)		768	646	505	307	456	406	275	985	878	148	*3125*	*2150*	*1000*	*375*
	Exchangeable Magnesium	($cmol_+/kg$)		0.64	1.02	0.84	0.73	0.59	1.70	1.07	2.80	1.19	0.43	*2.4*	*1.7*	*1.2*	*0.60*
		(kg/ha)		175	278	228	199	161	462	290	763	323	116	*650*	*448*	*325*	*168*

			Site	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	GBWood1	GBWood2	GBWood3	WBWood1	IronWood1	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
		(mg/kg)		78	124	102	89	72	206	129	340	144	52	*290*	*200*	*145*	*75*
	Exchangeable Potassium	($cmol_+$/kg)		0.38	0.35	0.29	0.36	0.35	0.55	0.37	0.64	0.48	0.34	*0.60*	*0.50*	*0.40*	*0.30*
		(kg/ha)		335	303	255	313	304	478	323	564	418	301	*526*	*426*	*336*	*224*
		(mg/kg)		150	135	114	140	136	214	144	252	187	135	*235*	*190*	*150*	*100*
	Exchangeable Sodium	($cmol_+$/kg)		<0.065	0.20	<0.065	0.07	<0.065	<0.065	0.24	0.08	<0.065	0.10	*0.3*	*0.26*	*0.22*	*0.11*
		(kg/ha)		<33	102	<33	35	<33	<33	126	42	<33	54	*155*	*134*	*113*	*57*
		(mg/kg)		<15	46	<15	16	<15	<15	56	19	<15	24	*69*	*60*	*51*	*25*
	Exchangeable Aluminium	($cmol_+$/kg)	**Inhouse S37 (KCl)	0.02	0.34	0.04	0.10	0.03	0.84	0.88	0.13	0.02	0.97	*0.6*	*0.5*	*0.4*	*0.2*
		(kg/ha)		4	69	9	20	5	168	178	26	4	196	*121*	*101*	*73*	*30*
		(mg/kg)		2	31	4	9	2	75	79	12	2	87	*54*	*45*	*32*	*14*
	Exchangeable Hydrogen	($cmol_+$/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.00	0.18	<0.01	0.07	0.02	0.29	0.29	0.07	<0.01	0.41	*0.6*	*0.5*	*0.4*	*0.2*
		(kg/ha)		<1	4	<1	2	<1	7	7	2	<1	9	*13*	*11*	*8*	*3*
		(mg/kg)		<1	2	<1	<1	<1	3	3	<1	<1	4	*6*	*5*	*4*	*2*
	Effective Cation Exchange Capacity (ECEC) ($cmol_+$/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H ($cmol_+$/kg)	4.89	5.31	3.75	2.86	3.29	5.45	4.23	8.64	6.09	3.00	*20.1*	*14.3*	*7.8*	*3.3*
	Calcium (%)		**Base Saturation Calculations - Cation $cmol_+$/kg / ECEC x 100	78.3	60.6	67.2	53.6	69.3	37.2	32.4	56.9	72.0	24.6	*77.6*	*75.7*	*65.6*	*57.4*
	Magnesium (%)			13.1	19.2	22.3	25.6	18.0	31.1	25.2	32.4	19.5	14.3	*11.9*	*11.9*	*15.7*	*18.1*
	Potassium (%)			7.8	6.5	7.8	12.5	10.5	10.0	8.7	7.5	7.8	11.5	*3.0*	*3.5*	*5.2*	*9.1*
	Sodium - ESP (%)			0.3	3.7	1.4	2.4	0.9	1.0	5.8	0.9	0.2	3.5	*1.5*	*1.8*	*2.9*	*3.3*
	Aluminium (%)			0.4	6.5	1.1	3.5	0.8	15.3	20.9	1.5	0.3	32.4	*6.0*	*7.1*	*10.5*	*12.1*
	Hydrogen			0.0	3.5	0.2	2.5	0.5	5.3	7.0	0.8	0.1	13.8				
	Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium ($cmol_+$/kg)	6.0	3.2	3.0	2.1	3.8	1.2	1.3	1.8	3.7	1.7	*6.5*	*6.4*	*4.2*	*3.2*
	Zinc (mg/kg)		Rayment & Lyons 2011 - 12A1 (DTPA)	<0.5	1.2	<0.5	<0.5	<0.5	0.9	0.7	0.8	<0.5	<0.5	*6.0*	*5.0*	*4.0*	*3.0*
	Manganese (mg/kg)			7	27	5	5	14	15	16	25	7	13	*25*	*22*	*18*	*15*

			Site	GBReveg1	GBReveg2	GBReveg3	GBReveg4	GBReveg5	GBWood1	GBWood2	GBWood3	WBWood1	IronWood1	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
	Iron (mg/kg)			49	264	118	134	94	301	423	243	117	248	*25*	*22*	*18*	*15*
	Copper (mg/kg)			0.1	0.2	0.4	0.2	0.2	0.3	0.3	0.3	0.2	0.1	*2.4*	*2.0*	*1.6*	*1.2*
	Boron (mg/kg)		**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.31	0.33	0.31	0.23	0.28	0.59	0.39	0.84	0.44	0.32	*2.0*	*1.7*	*1.4*	*1.0*
	Silicon (mg/kg Si)		**Inhouse S11 (Hot CaCl2)	23	32	21	21	25	33	33	32	24	22	*50*	*45*	*40*	*35*
	Total Carbon (%)		Inhouse S4a (LECO Trumac Analyser)	1.56	2.97	1.97	1.32	1.03	3.74	2.57	4.30	1.75	2.04	*> 3.1*	*> 2.6*	*> 2.0*	*> 1.4*
	Total Nitrogen (%)			0.10	0.16	0.11	0.08	0.06	0.22	0.10	0.22	0.09	0.08	*> 0.30*	*> 0.25*	*> 0.20*	*> 0.15*
	Carbon/Nitrogen Ratio		**Calculation: Total Carbon/Total Nitrogen	16.4	18.3	18.2	16.3	17.5	17.3	24.7	19.7	18.8	26.5	*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	14	41	13	12	10	43	38	42	24	25	..	..	..	..

Appendix 3. ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT– Dwyer's Red Gum Sites Kokoda Offset Area 2018

Soil samples supplied by DNA Environmental on 3rd October, 2018 - Lab Job No. H4533

			Site	DReveg1	DReveg2	DReveg3	DWood1	DWood2	DWood3	DWoodLQ	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
	Parameter		Method reference	H4553/1	H4553/2	H4553/3	H4553/9	H4553/10	H4553/11	H4553/17	Indicative guidelines - refer to Notes 6 and 8			
	Soluble Calcium (mg/kg)		**Inhouse S10 - Morgan 1	195	206	87	227	104	139	84	*1150*	*750*	*375*	*175*
	Soluble Magnesium (mg/kg)			46	63	24	37	70	45	58	*160*	*105*	*60*	*25*
	Soluble Potassium (mg/kg)			58	56	41	41	71	62	58	*113*	*75*	*60*	*50*
	Soluble Phosphorus (mg/kg)			1.0	<1	<1	<1	<1	1.1	<1	*15*	*12*	*10*	*5.0*
	Phosphorus (mg/kg P)		**Rayment & Lyons 2011 - 9E2 (Bray 1)	1.2	1.3	3.4	1.2	<1	<1	1.6	*45 note 8*	*30 note 8*	*24 note 8*	*20 note 8*
			**Rayment & Lyons 2011 - 9B2 (Colwell)	9	8	9	8	8	7	5	*80*	*50*	*45*	*35*
			**Inhouse S3A (Bray 2)	2	2	4	1	1	1	3	*90 note 8*	*60 note 8*	*48 note 8*	*40 note 8*
	Nitrate Nitrogen (mg/kg N)		**Inhouse S37 (KCl)	0.6	1.9	0.5	3.5	0.5	0.7	1.7	*15*	*13*	*10*	*10*
	Ammonium Nitrogen (mg/kg N)			2.6	3.2	1.9	4.0	2.8	3.9	3.1	*20*	*18*	*15*	*12*
	Sulfur (mg/kg S)			4.0	3.4	<1	4.2	2.5	2.4	2.7	*10.0*	*8.0*	*8.0*	*7.0*
	pH		Rayment & Lyons 2011 - 4A1 (1:5 Water)	5.63	5.65	5.18	5.04	5.29	5.51	5.25	*6.5*	*6.5*	*6.3*	*6.3*
	Electrical Conductivity (dS/m)		Rayment & Lyons 2011 - 3A1 (1:5 Water)	0.020	0.023	0.012	0.028	0.031	0.022	0.029	*0.200*	*0.150*	*0.120*	*0.100*
	Estimated Organic Matter (% OM)		**Calculation: Total Carbon x 1.75	3.2	3.5	2.2	5.5	4.5	2.9	3.2	*> 5.5*	*>4 .5*	*> 3.5*	*> 2.5*
	Exchangeable Calcium	($cmol_+/kg$)	Rayment & Lyons 2011 - 15D3 (Ammonium Acetate)	1.50	1.52	0.62	1.97	0.88	1.11	0.59	*15.6*	*10.8*	*5.0*	*1.9*
		(kg/ha)		675	680	278	885	393	498	267	*7000*	*4816*	*2240*	*840*
		(mg/kg)		301	304	124	395	175	222	119	*3125*	*2150*	*1000*	*375*
	Exchangeable Magnesium	($cmol_+/kg$)		0.54	0.67	0.25	0.43	0.78	0.48	0.65	*2.4*	*1.7*	*1.2*	*0.60*
		(kg/ha)		148	183	69	116	212	131	176	*650*	*448*	*325*	*168*
		(mg/kg)		66	82	31	52	94	58	79	*290*	*200*	*145*	*75*

			Site	DReveg1	DReveg2	DReveg3	DWood1	DWood2	DWood3	DWoodLQ	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
	Exchangeable Potassium	(cmol+/kg)		0.28	0.25	0.19	0.22	0.32	0.25	0.27	*0.60*	*0.50*	*0.40*	*0.30*
		(kg/ha)		249	221	170	194	281	215	238	*526*	*426*	*336*	*224*
		(mg/kg)		111	99	76	87	126	96	106	*235*	*190*	*150*	*100*
	Exchangeable Sodium	(cmol+/kg)		0.09	0.09	<0.065	<0.065	0.14	0.08	0.14	*0.3*	*0.26*	*0.22*	*0.11*
		(kg/ha)		48	48	<33	<33	70	39	72	*155*	*134*	*113*	*57*
		(mg/kg)		22	21	<15	<15	31	18	32	*69*	*60*	*51*	*25*
	Exchangeable Aluminium	(cmol+/kg)	**Inhouse S37 (KCl)	0.20	0.21	1.12	1.27	0.88	0.36	0.78	*0.6*	*0.5*	*0.4*	*0.2*
		(kg/ha)		41	42	225	257	178	73	158	*121*	*101*	*73*	*30*
		(mg/kg)		18	19	101	115	79	32	71	*54*	*45*	*32*	*14*
	Exchangeable Hydrogen	(cmol+/kg)	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	0.46	0.21	0.42	0.31	0.36	0.16	0.36	*0.6*	*0.5*	*0.4*	*0.2*
		(kg/ha)		10	5	9	7	8	4	8	*13*	*11*	*8*	*3*
		(mg/kg)		5	2	4	3	4	2	4	*6*	*5*	*4*	*2*
	Effective Cation Exchange Capacity (ECEC) (cmol+/kg)		**Calculation: Sum of Ca,Mg,K,Na,Al,H (cmol+/kg)	3.09	2.95	2.64	4.23	3.35	2.43	2.80	*20.1*	*14.3*	*7.8*	*3.3*
	Calcium (%)		**Base Saturation Calculations - Cation cmol+/kg / ECEC x 100	48.7	51.3	23.5	46.6	26.1	45.6	21.2	*77.6*	*75.7*	*65.6*	*57.4*
	Magnesium (%)			17.6	22.7	9.5	10.1	23.2	19.7	23.1	*11.9*	*11.9*	*15.7*	*18.1*
	Potassium (%)			9.2	8.5	7.3	5.2	9.6	10.1	9.7	*3.0*	*3.5*	*5.2*	*9.1*
	Sodium - ESP (%)			3.0	3.1	1.3	0.6	4.1	3.1	5.0	*1.5*	*1.8*	*2.9*	*3.3*
	Aluminium (%)			6.5	7.1	42.3	30.1	26.3	14.8	28.0	*6.0*	*7.1*	*10.5*	*12.1*
	Hydrogen			14.9	7.2	16.0	7.3	10.7	6.6	13.0				
	Calcium/Magnesium Ratio		**Calculation: Calcium / Magnesium (cmol+/kg)	2.8	2.3	2.5	4.6	1.1	2.3	0.9	*6.5*	*6.4*	*4.2*	*3.2*
	Zinc (mg/kg)		Rayment & Lyons 2011 - 12A1 (DTPA)	<0.5	0.6	<0.5	0.6	<0.5	<0.5	0.6	*6.0*	*5.0*	*4.0*	*3.0*
	Manganese (mg/kg)			4	6	2	20	9	11	7	*25*	*22*	*18*	*15*
	Iron (mg/kg)			308	233	253	199	299	222	352	*25*	*22*	*18*	*15*
	Copper (mg/kg)			0.2	0.2	0.1	0.2	0.2	0.2	0.1	*2.4*	*2.0*	*1.6*	*1.2*

		Site	DReveg1	DReveg2	DReveg3	DWood1	DWood2	DWood3	DWoodLQ	*Heavy Soil Clay*	*Medium Soil Clay Loam*	*Light Soil Loam*	*Sandy Soil Loamy Sand*
	Boron (mg/kg)	**Rayment & Lyons 2011 - 12C2 (Hot $CaCl_2$)	0.35	0.29	0.25	0.41	0.34	0.26	0.32	*2.0*	*1.7*	*1.4*	*1.0*
	Silicon (mg/kg Si)	**Inhouse S11 (Hot CaCl2)	25	21	15	21	21	22	23	*50*	*45*	*40*	*35*
	Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	1.83	2.02	1.26	3.15	2.59	1.65	1.83	*> 3.1*	*> 2.6*	*> 2.0*	*> 1.4*
	Total Nitrogen (%)		0.14	0.12	0.06	0.15	0.09	0.06	0.12	*> 0.30*	*> 0.25*	*> 0.20*	*> 0.15*
	Carbon/Nitrogen Ratio	**Calculation: Total Carbon/Total Nitrogen	13.1	17.4	21.4	20.5	29.1	26.6	15.4	*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	13	15	8	18	20	14	19	..	..	..	..

Notes:

1. All results presented as a 40°C oven dried weight. Soil sieved and lightly crushed to < 2 mm.

2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods - Australasia.*CSIRO Publishing: Collingwood.

3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH (unless requested).

4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and LaMotte Soil Handbook.

5. Guidelines for phosphorus have been reduced for Australian soils.

6. Indicative guidelines are based on 'Albrecht' and 'Reams' concepts.

7. Total Acid Extractable Nutrients indicate a store of nutrients.

8. National Environmental Protection (Assessment of Site Contamination) Measure 2013,
Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater. Table 5-A Background Ranges.

9. Information relating to testing colour codes is available on sheet 2 - 'Understanding your agricultural soil results'.

10. Conversions for 1 $cmol_+/kg$ = 230 mg/kg Sodium, 390 mg/kg Potassium,
122 mg/kg Magnesium, 200 mg/kg
Calcium

11. Conversions to kg/ha = mg/kg x 2.24

12. The chloride calculation of Cl mg/L = EC x 640 is considered an estimate, and most likely an over-estimate

13. ** NATA accreditation does not cover the performance of this service.

14. Analysis conducted between sample arrival date and reporting date.

15. This report is not to be reproduced except in full.

Quality Checked: Kris Saville
Agricultural Co-Ordinator