

# **2013 Estcourt Offset Area Ecological Monitoring Report**

for

**Northparkes Mines**

December 2013



## Disclaimer

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## Executive summary

The 2013 Estcourt Offset Area (EOA) rehabilitation monitoring report is a result of work carried out by DnA Environmental on behalf of Northparkes Mines (NPM) to satisfy monitoring requirements of the Voluntary Conservation Agreement with Office of Environment and Heritage (OEH), formerly Department of Environment, Climate Change and Water (DECCW). This report describes the results of the annual rehabilitation monitoring program established in the EOA at NPM in 2010 and provides quantified data from representative reference sites as a benchmark for rehabilitation outcomes to assist with the compliance process.

The Estcourt Offset Area is approximately 65ha in area and is situated approximately 2km northeast of the NPM (GHD 2010). The vegetation within the area is comprised of approximately 42 ha of *Eucalyptus microcarpa* (Inland Grey Box) - *E. populnea* (Bimble Box) - *Callitris glaucophylla* (White Cypress Pine) woodland with the remaining 23ha being derived native grassland. The grassy woodland has been subjected to selective thinning and grazing and is now dominated by *Callitris glaucophylla*, with scattered occurrences of *Eucalyptus microcarpa*. Shrubs are scarce but there are several individuals of *Acacia decora* (Western Silver Wattle). The grassy understorey is dominated by a variety of native grasses, herbs and native daisies are common. The derived grasslands have also been described as formerly part of this *E. microcarpa* - *E. populnea* - *Callitris glaucophylla* tall woodland but apart from some isolated paddocks trees it has been extensively cleared and has endured a long cultivation and grazing history.

The offset site has been divided into two functional management zones by GHD based on the level of environmental management activities required. Zone 1 (Revegetation Zone) will include rehabilitation of the derived native grasslands through revegetation activities and Zone 2 (Regeneration Zone) will include rehabilitation of existing native vegetation through bush regeneration activities, natural regeneration and supplementary plantings where appropriate.

The monitoring methodology used included a combination of Landscape Function Analyses, accredited soil analyses and various measurements of ecosystem diversity and habitat values based on and adapted from the Biometric methodology and was consistent with that used in previous monitoring years and with the NPM annual rehabilitation monitoring program. Data obtained from within replicated reference woodland site were used to provide upper and lower ecological performance indicator ranges. As not all key performance indicators are considered to be fundamental to completion, or in some cases achievable (eg. average trunk diameter), key performance indicators have been further separated into “Completion performance indicators” and “Desirable performance indicators”.

Completion performance indicators are those chosen as completion criteria targets and revegetation sites should equal, exceed or show positive trends towards those attributes of the reference sites. When these completion performance indicators have been met, or trending in the right direction, the sites should therefore theoretically be eligible for closure sign off. The range values of each performance indicator are adapted annually to reflect seasonal conditions and disturbance events. The same five monitoring sites established in the EOA in 2010 have been revisited each year. This year an additional site was established in an area within the EOA where a grass fire initiated by harvesting machinery in adjacent cropland burnt approximately 1ha in November 2013. Vegetation monitoring has been undertaken during spring in all monitoring years and this year was undertaken between 14 – 18<sup>th</sup> October.

## Summary of results

Most sites have demonstrated a further decline in ecological function largely due to a decrease in perennial plant cover and in some sites there was also less litter depth and states of decomposition

however in most instances these changes were also reflected within the woodland reference sites, indicating it has been a direct response to the seasonal conditions and levels of macropod activity.

These data indicate that even the most historically disturbed derived grassland sites EOA-01 and EOA-02 were ecologically functional communities and were comparable or similar to the local woodland reference communities, despite the absence of a mature canopy layer. The new EOA-06 site which suffered a grass fire last year also appears to have recovered and was ecologically comparable with an unaffected woodland, despite having a cover of litter which had not yet accumulated to depth and the presence of very hard setting soils.

Mature trees (>5cm dbh) were recorded in EOA-04, EOA-05 and EOA-06 however the population density was low in EOA-05. Common species of trees and mature shrubs recorded in the reference sites were *Allocasuarina luehmannii*, *Callitris glaucophylla*, *Eucalyptus albens*, *E. microcarpa*, *E. populnea* and *Acacia hakeoides*. There continued to be natural tree (and shrub) recruitment in all EOA monitoring sites as well as in the woodland reference sites with the vast majority being *Callitris glaucophylla* seedlings probably initiated during the high rainfall activity of the 2011/12 summer. There tended to be a decline in shrub densities across most sites this year as a result of the dry conditions and no EOA site yet contained an adequate shrub density or diversity. In the reference sites the most common shrubs included *Allocasuarina luehmannii*, *Eucalyptus microcarpa*, *Dodonaea viscosa subsp. cuneata*, *Senna artemisioides subsp. filifolia* but there were some *Acacia hakeoides*, *Acacia deanei*, *Alectryon oleifolius* and *Eucalyptus albens* recorded in at least one reference site. Numerous ecological attributes that were not met were largely related to the mature tree population and the structural complexity of the sites due to the lack of a well developed overstorey.

Total ground cover typically remained high but some may have been affected by disturbance by macropods but all EOA sites continued to exceed the minimum KPI target. Total ground cover was derived from various combinations of dead leaf litter, annual and perennial plants and in some sites there were small contribution from cryptogams and logs. This year there tended to be a reduction in perennial plant cover but there were often increased covers of dead leaf litter and annual plants which were almost always exotics weeds. There was an increase in total and exotic species diversity this year, and native species diversity was usually lower. Site EOA-06 had particularly high species diversity with 72 species and 76% were native species. Sites EOA-04 and EOA-05 also contained an adequate diversity and abundance of native species and EOA-03 was only slightly lower. While the cover provided by native species also tended to decline this year, sites EOA-01 and EOA-02 continued to be dominated by exotic species and were weedier than desired. Site EOA-06 was the only site which contained an appropriate composition of species this year, with most sites having a low diversity of tree (and shrub) species and there were a low number of herbs and grasses in the derived grassland areas.

This year there were 117 species recorded across the six Estcourt Offset monitoring sites and of these 37 (32%) were exotic species. Twelve species were common to all EOA monitoring sites and these included three native grasses *Austrodanthonia eriantha*, *Austrostipa scabra subsp. falcata* and *Austrostipa nodosa* and this year, *Callitris glaucophylla* was also recorded in all six sites. There were also eight exotic species, including *Centaurea melitensis*, *Trifolium arvense*, *T. campestre*, *T. glomeratum*, *Carthamus lanatus*, *Echium plantagineum*, *Lolium rigidum* and *Sonchus oleraceus* and these were also present in numerous reference sites which are a reflection of the historical disturbances associated with the local NPM area.

The soils were often moderately acidic, low in organic matter, phosphorous, nitrates and CEC however in most cases these were similar to those recorded within the local woodland reference sites and a reflection of the low fertility state of the soils in the NPM area. The soils were also non saline and non sodic in most cases. The results of the soils analyses also indicates there are numerous elements that may occur at elevated levels within soils surrounding the Northparkes Mine, especially Magnesium,



Potassium, Manganese and Iron and are likely to be a reflection of the long agricultural and/or mining history of the local area. There was however excessively high concentrations of Manganese in EOA-04.

### Conclusion and management recommendations

The Estcourt Offset Area monitoring sites have shown a slight decline in ecological function since 2011 due to the dry seasonal conditions but most sites continued to have a range of ecological traits which were very similar to the surrounding woodland reference sites despite a long disturbance history. Ecological attributes which fell short of meeting the target ranges were largely associated with a low diversity of tree (and shrub) species and in the more disturbed grassland areas, there was low native species richness and exotic species were dominant. There was also a lack of shrubs and juvenile trees in most sites, however natural recruitment was recorded in all monitoring sites as a result of above average rainfall conditions in the 2011/12 summer.

The proposed revegetation activity within the EOA (GHD 2010) aims to increase biodiversity and habitat values within the EOA through tubestock planting within the more cleared grassland areas and encourage natural regeneration and supplementary planting of shrubs within the more open woodland areas as they are currently limited in abundance and distribution. Areas where natural regeneration is evident should be identified and the methods of revegetation, species and planting densities adapted to take into account the natural regeneration such that the final woodland communities are comparable with the surrounding remnant woodlands. There were little other management issues that have not already been addressed in the Rehabilitation Management Plan (GHD 2010). Regular slashing of the main access tracks is also advised to allow safe and easy access for maintenance and monitoring of the conservation area.



Large logs burnt very hot and left bare scorched earth across the 1 ha area after a grass fire in November last year, but there was a particularly high diversity of native wild flowers in this area (left). The old quarry which has filled with rain water provides habitat for eastern long-necked turtle (right).

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# 1 2013 Estcourt Offset Area Ecological Monitoring Report

The 2013 Estcourt Offset Area (EOA) rehabilitation monitoring report is a result of work carried out by DnA Environmental on behalf of Northparkes Mines (NPM) to satisfy monitoring requirements of the Voluntary Conservation Agreement with Office of Environment and Heritage (OEK formerly Department of Environment, Climate Change and Water (DECCW)).

This report describes the results of the annual rehabilitation monitoring program established in the EOA at NPM in 2010 and provides quantified data from representative reference sites as a benchmark for rehabilitation outcomes to assist with the compliance process. The primary objective of the monitoring program is to compare the progress of revegetation areas in fulfilling long-term landuse objectives by comparing a selection of ecological targets or completion criteria against less disturbed areas of remnant vegetation (reference sites) that are representative of the final landuse and vegetation assemblage. The rehabilitation monitoring program has defined a set of completion criteria that are consistent with Northparkes Mines Landscape Management Plan (NPM 2008), community expectations as well as relevant NSW legislation, policies and best practice guidelines (eg. NSW I&I 2010, NSW T&I 2012).

Results of the monitoring are first presented in a comparative summary against the woodland reference sites since monitoring began in 2010. The remainder of the report includes detailed descriptions of the monitoring sites, indicating the changes that have occurred since that time and how they compare to the KPI's.

## 2 Estcourt Offset Area

A Vegetation Management Plan (VMP) was developed by GHD (2010) which outlines a revegetation strategy for the Estcourt Offset Area. The following description was taken from this VMP.

The objectives of the VMP are to:

- Conserve and improve biodiversity values of the offset site;
- Enhance connectivity with adjacent areas of vegetation;
- Manage the restoration process to ensure the retention of suitable habitat for those threatened and/or significant flora and fauna species present within the offset site and surrounds; and
- Identify opportunities for research and development projects in ecological restoration that assist in mine site [rehabilitation].

The Estcourt Offset Area is approximately 65ha in area and is situated approximately 2km northeast of the NPM (GHD 2010). The vegetation within the area is comprised of approximately 42 ha of woodland with the remaining 23ha derived native grassland. The woodland has been described as *Eucalyptus microcarpa* (Inland Grey Box) - *E. populnea* (Bimble Box) - *Callitris glaucophylla* (White Cypress Pine) tall woodland (GHD 2010) and it contains an unusual occurrence of *E. melliodora* (Yellow Box) on the ridge near an old quarry site. The grassy woodland has been subjected to selective thinning and grazing and is now dominated by *Callitris glaucophylla*, with scattered occurrences of *Eucalyptus microcarpa*. Although the *E. populnea* is present within the woodland, it is not a dominant species and has generally been restricted to small pockets in various locations. The understorey is largely absent with scattered occurrences of Ruby Saltbush (*Enchylaena tomentosa*) and Western Silver Wattle (*Acacia decora*) with the ground cover dominated by native tussock grasses, native herbs and various native daisies.

The derived grasslands have also been described as formerly part of this *E. microcarpa* - *E. populnea* - *Callitris glaucophylla* tall woodland (GHD 2010) but apart from some isolated paddocks trees it has

been extensively cleared and has endured cultivation and grazing. It has been described as highly degraded/cropland (GHD 2010) as well as derived tussock grassland of the central western plains and lower slopes of NSW (DECCW 2010). Despite the agricultural history, GHD (2010) have indicated it retained a moderate diversity of native plants and that it would exhibit some capacity for natural regeneration.

The offset site was divided into two functional management zones based on the level of environmental management activities required. Zone 1 – Revegetation Zone will include rehabilitation of cleared agricultural land through revegetation activities and Zone 2 – Regeneration Zone will include rehabilitation of existing native vegetation through bush regeneration activities, natural regeneration and supplementary plantings where appropriate. Zone 2 shows a higher level of ‘natural resilience’ than Zone 1.

The VMP outlines the restoration program for these zones and includes details on plant species, planting techniques, revegetation methods and maintenance requirements for the offset site. The revegetation activities will consist of appropriate mixes of canopy, mid-storey and groundcover species representative of the Inland Grey Box Woodland vegetation community listed as an Endangered Ecological Community under the *Threatened Species Conservation (TSC) Act 1995 (NSW)*. The restoration program will be the subject of a five year maintenance program that will include watering, weed and feral control, bushfire management and supplementary planting where necessary.

### 3 Rehabilitation monitoring methodology

The monitoring methodology adopted is a standard and simple procedure that can be easily replicated over any vegetation community or rehabilitation area and importantly results in a system that essentially compares “apples with apples”. The monitoring project 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:

- 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 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.

Data obtained from within replicated reference woodland site were used to provide upper and lower ecological performance indicator limits. As not all key performance indicators are considered to be fundamental to completion, or in some cases achievable (eg trunk diameter), key performance indicators (KPIs) have been further separated into “*Completion performance indicators*” and “*Desirable performance indicators*”. Completion performance indicators are those chosen as completion criteria targets and rehabilitation sites should equal, exceed or show positive trends towards those attributes of the reference sites. When these completion performance indicators have been met, or trending in the right direction, the sites should therefore theoretically be eligible for closure sign off. The range values of each ecological performance indicator are adapted annually to reflect seasonal conditions and disturbance events. The same five monitoring sites established in the EOA in 2010 are monitored each year. This year an additional site was established in an area within the EOA where a grass fire initiated by harvesting machinery in adjacent cropland burnt approximately 1ha in November 2013.

The full process associated with establishing the completion criteria relevant to rehabilitated native ecosystems can be found in “Rehabilitation monitoring methodology & Determination of completion criteria” (DnA Environmental 2011). Vegetation monitoring has been undertaken during spring in all

monitoring years in this year was undertaken from 14 – 18<sup>th</sup> October. The monitoring methodology was consistent with that used in 2010 (DnA Environmental 2011a) and the NPM annual rehabilitation monitoring program (DnA Environmental 2010a, b, 2011b, 2012, 2013a, 2013b). The methodology used included a combination of Landscape Function Analyses (CSIRO Tongway & Hindley 1996), accredited soil analyses and various measurements of ecosystem diversity and habitat values based on and adapted from the Biometric methodology (Gibbons 2002, Gibbons *et al* 2008a, 2008b) and these have been described in more detail below.

### 3.1 ***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.

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**”.

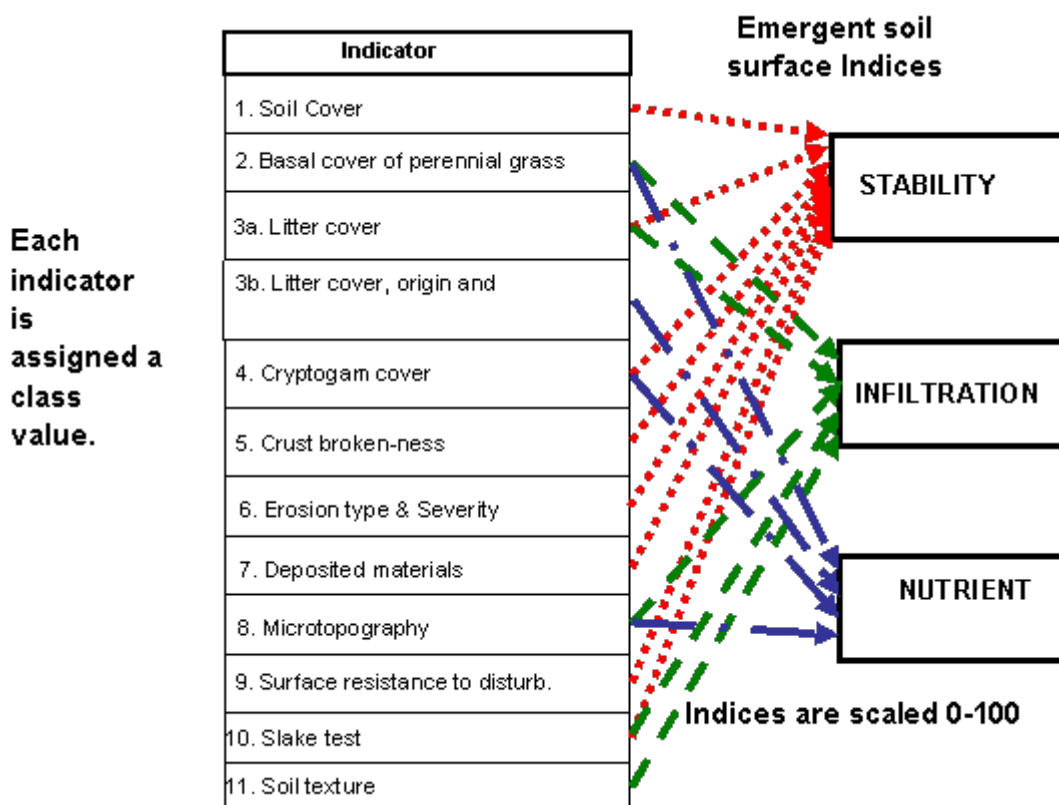
In the second stage, called “**soil surface condition**” (**SSC**) assessment, it is possible to assess and monitor soil quality using simple indicators including:

- 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).





### 3.2 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. The heavy metals including Cadmium (Cd), Lead (Pb), Arsenic (As), Chromium (Cr), Nickel (Ni), Mercury (Hg) and Silver (Ag) are also tested.

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.

### 3.3 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), and were developed for assessment habitat quality across a range of vegetation types in the southern NSW Murray-Darling Basin. 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.

Permanent transects and photo-points are established to record changes in these attributes over time.

## 4 Reference sites

Despite 42 ha of the Estcourt site being derived native grassland, the VMP and VCA specify that these grassland areas are to be revegetated back to the original *Eucalyptus microcarpa* (Inland Grey Box) - *E. populnea* (Bimble Box) - *Callitris glaucophylla* (White Cypress Pine) tall woodland community (GHD 2010). Subsequently all five of the Estcourt monitoring sites were compared to woodland reference sites to assess the changes occurring within the existing woodland and active revegetation areas.

Four woodland communities have been identified across the NPM and surrounding properties (NPM 2008) and include:

- Tall *Eucalyptus microcarpa* (Grey Box) Open Woodlands;
- Mid – High/Tall *Callitris glaucophylla* (White Cypress Pine) – *Eucalyptus populnea* (Poplar Box) open woodland to savannah grassland;
- Mid – High/Tall *Eucalyptus populnea* (Poplar Box) open woodland to woodland; and
- Mid – High/Tall *Eucalyptus albens* (White Box) – *Callitris glaucophylla* (White Cypress Pine) woodland.

These communities are typical of the Parkes-Goonumbla area and occur within the majority of agricultural properties, roadside corridors and in the local Travelling Stock Routes of the area. The communities are generally confined to scattered remnants within agricultural areas while the forested areas in the bioregion include conservation reserves containing, larger, less disturbed remnants, some of which are floristically similar to the vegetation communities' onsite (NPM 2008).

The remnant vegetation on NPM property is generally in a poor condition and is considered to have a low conservation value (NPM 2008). In areas onsite where a native overstorey remains, the understorey is primarily dominated by introduced species. A few small areas have more than 50% native understorey however these are isolated and patchy within the general landscape of a highly modified and weed infested assemblage (NPM 2008). Remnants located on the adjacent Travelling Stock Routes are generally in better condition due to the different management practices and reduced grazing pressure.

These major vegetation communities have a patchy distribution across the local area and vary according to soil type and topography and often form ecotones. Species commonly associated with

these communities include *Alectryon oleifolius* (Rosewood), *Allocasuarina luehmannii* (Bulloak), *Brachychiton populneus* (Kurrajong) and *Geijera parviflora* (Wilga). On the heavier soils, subjected to inundation, *Acacia pendula* (Weeping Myall) and *Casuarina cristata* (Belah) can also be common. There are also areas dominated by *Eucalyptus melliodora* (Yellow Box) woodland and native grasslands (or derived native grasslands).

The composition and structure of the shrubby understorey is also variable but native shrubs including *Acacia decora* (Western Golden Wattle), *A. hakeoides* (Hakea Wattle), *Dodonaea viscosa subsp. cuneata* (Wedge-leaf Hopbush) and *Senna artemisioides* (Silver Cassia) are commonly encountered. The ground cover was often dominated by *Austrostipa* (Spear grasses) and *Austrodanthonia* species (Wallaby Grasses) with a scattering of native herbs such as *Vittadinia* (Fuzzweeds) and *Calotis* (Burr Daisies) and chenopod sub-shrubs including *Sclerolaena diacantha* (Grey Copperburr), *Atriplex spinibractea* (Spiny-fruit saltbush) and *Enchylaena tomentosa* (Ruby Saltbush). There were numerous patches of bare ground but leaf litter was a dominant form of ground cover in most sites.

All reference sites have been subjected to some form of disturbance, in particular clearing, logging and grazing and some sites were likely to be older regrowth. Exotic annual grasses and agricultural weeds such as *Carthamus lanatus* (Saffron Thistle), *Echium plantagineum* (Paterson's Curse) and *Sisymbrium orientale* (Hedge Mustard) were also common. These sites however are typical of the local area and will help set realistic rehabilitation targets and set a benchmark of the transitional processes that can be expected or that are presently occurring in the rehabilitation areas.

To account for variations in ecosystems across the landscape, we selected four woodland reference sites as examples of these woodland communities to allow for these inherent variations, range of local conditions and ecological transition. The reference sites selected were in close proximity to the NPM mine and the Estcourt Offset Area but were spread out where possible to maximize their spatial distribution. Different compositions of the dominant species of each reference site types were also targeted where possible. These reference sites were established in 2009 and are used as a point reference for rehabilitation sites which are monitored as part of the NPM annual rehabilitation program.

## 5 Rainfall

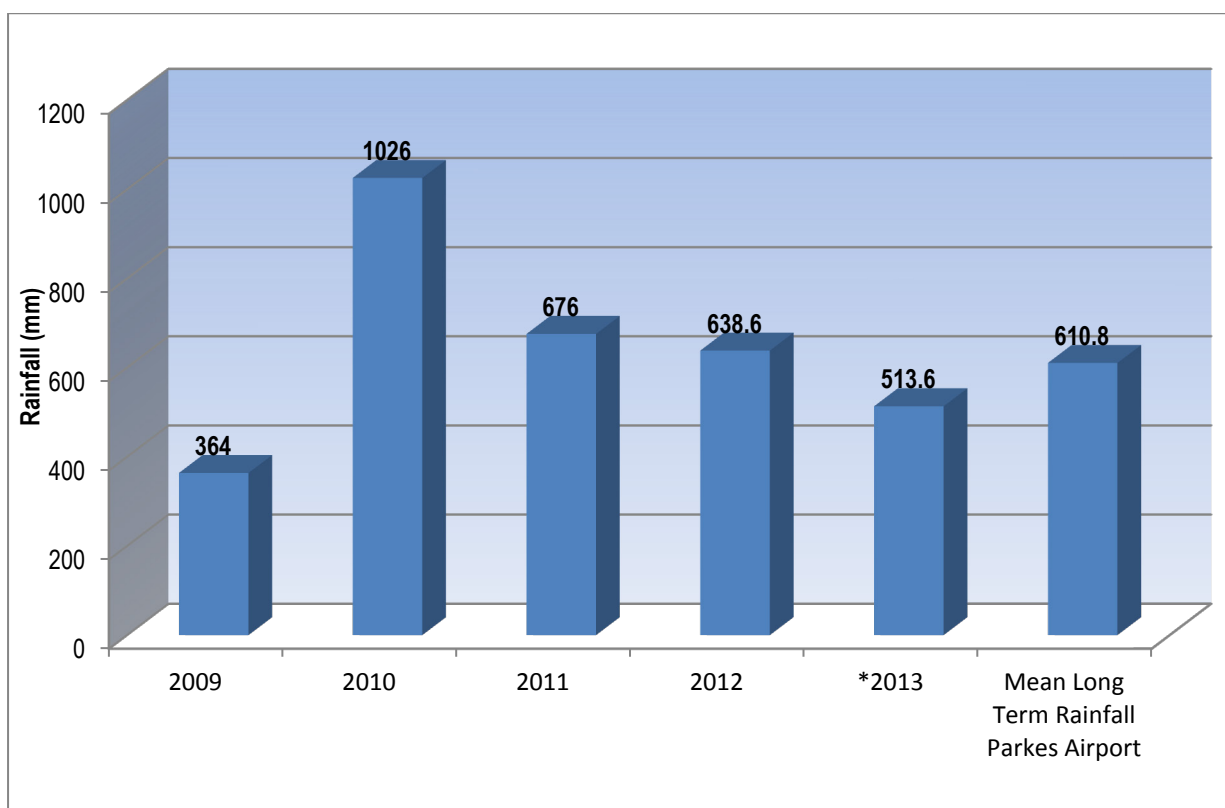
Total annual rainfalls recorded at the NPM compared to the long-term annual averages recorded at the Parkes Airport are shown in Figure 5-1. It should be noted that rainfall data for 2009 – 2011 was obtained from NPM weather station, however since then rainfall data has been taken from the Parkes Airport (BoM 2013).

In 2009 the total rainfall was 250mm below average and with only 364mm was a particularly dry year and during the monitoring period the weather was very hot ( $>40^{\circ}\text{C}$ ) and windy with dust storms being a frequent occurrence. Subsequently there was little active plant growth and species diversity was very low.

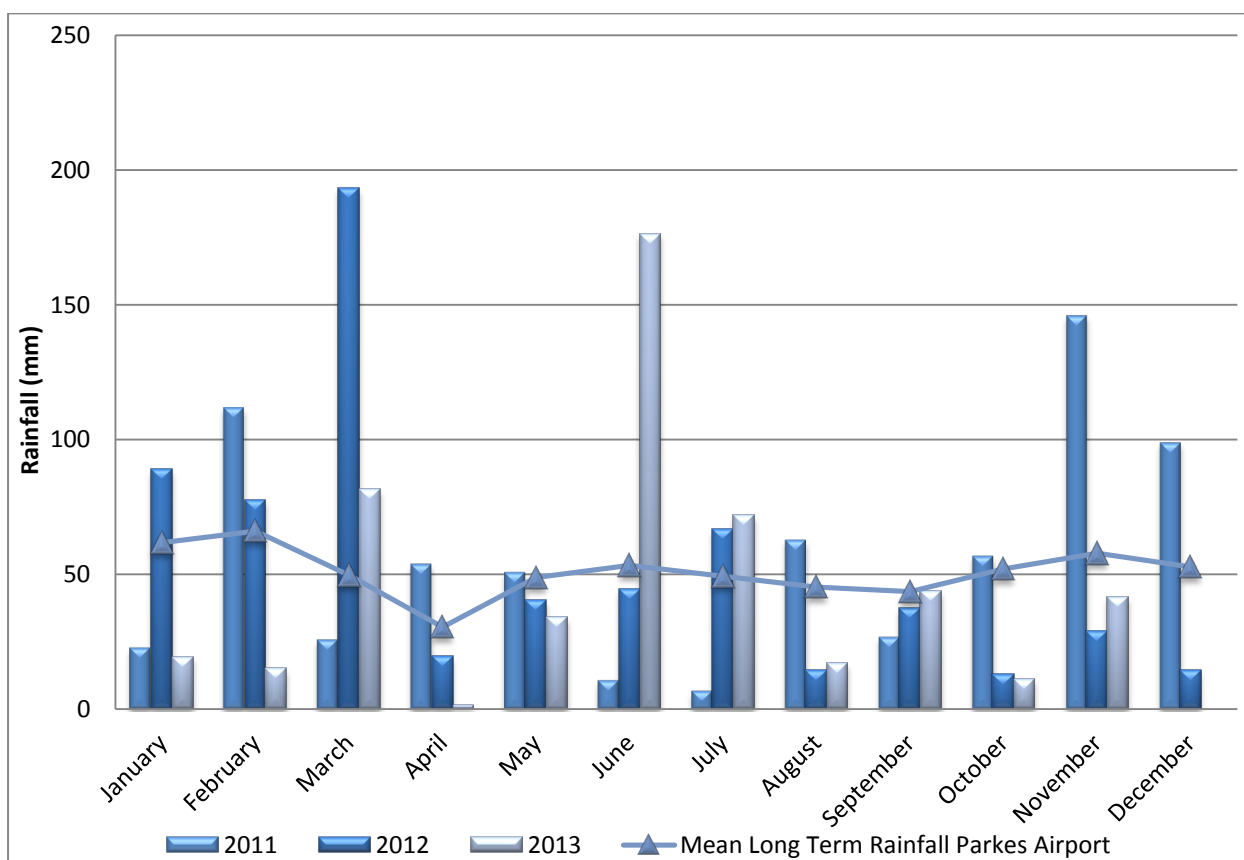
In contrast, 2010 had a total rainfall of 1026mm with most months providing above average growing conditions and the temperatures were milder. The substantial increase in rainfall in 2010 resulted in significant changes occurring within the vegetation, in particular increases in total ground cover and species diversity and abundance across the range of sites.

Rainfall in 2011 continued to be above the long-term average with 676mm recorded, however 36% of this was experienced after the monitoring period in November and December with the above average rainfall continuing into March 2012, producing widespread floods. Apart from July, conditions become very dry with significantly low rainfall falling throughout most of 2012 and this extended into 2013, with practically no rain falling during April and generally below average monthly rainfall (Figure 5-2). The exceptions included March (81.6mm) and June (176.4mm) when 68mm was received within a 24 hour period causing localised flooding. Above average rain also occurred in July with 71.8mm. While rainfall in September was on average, August and October were very dry. Rainfall up until November 2013 was 513.6mm and this was 44.5mm below the 11month average.

Subsequently the drier conditions over summer as well as the latter part of the year has continued to influence the diversity, abundance and composition of the monitoring sites, and these have been compounded by the prolonged dry conditions which tended to result in increased levels of browsing and disturbances created by resident macropod populations, especially under the shelter of the tree canopies.



**Figure 5-1. Annual rainfall recorded at NPM 2009-2013 compared to long-term mean annual rainfall for Parkes Airport AWS.** (NB: All rainfall data from 2012 onwards from Parkes Airport AWS) \*Jan-Nov 2013 only



**Figure 5-2. Monthly rainfall recorded at the Northparkes Mines from January 2011 to November 2013 compared to the long term monthly averages recorded at Parkes Airport AWS.** (Nb:all rainfall data from 2012 onwards from Parkes Airport AWS [BoM 2013])

## 6 General site descriptions and permanent photo-points

### 6.1 Reference sites

The location of the woodland reference sites in relation to the Estcourt Offset Area is shown in Figure 6-1. General descriptions of the reference sites, including photographs taken in the permanent monitoring quadrats along the vegetation transect in 2009 – 2013 have been provided in Table 6-1. GPS coordinates and other site specific information is provided in Table 6-2.



Figure 6-1. Map showing the location of the Woodland reference sites in relation to the Estcourt Offset Area (Image: Google Earth Pro 2010).



Table 6-1. General site descriptions and permanent photo-points of the reference monitoring sites.





















Photo 2009	Photo 2010	Photo 2011	Photo 2012	Photo 2013
<b>RWood01:</b> Open grassy woodland dominated by <i>E. microcarpa</i> with some <i>Allocasuarina luehmannii</i> and <i>Alectryon oleifolius</i> sub dominants. There were some large old regrowth trees, scattered regrowth and some limited regeneration of the overstorey species. The site had small scattered patches of <i>Dodonaea viscosa</i> subsp. <i>cuneata</i> , <i>Acacia hakeoides</i> and <i>Maireana microphylla</i> . The ground cover included scattered tussocks of <i>Austrostipa</i> and <i>Austrodanthonia</i> species as well as a variety of small chenopod sub-shrubs. There were some fallen branches. Leaf litter was abundant beneath tree canopies but there were numerous patches of bare ground particularly in the more open areas, which were commonly covered with cryptogams. In 2009 the wildflowers were flowering. In 2010, the area had been recently grazed by travelling stock with some shrubs damaged and some grass tussocks had been pulled out. In 2011, there was no evidence of recent livestock grazing however there was less plant diversity due to the drier conditions. In 2011 the <i>Austrostipas</i> were flowering and one large <i>E. microcarpa</i> had fallen down. In 2012 and 2013 the site continued to be very dry.				
				
<b>RWood02:</b> Open regrowth woodland dominated by <i>E. albens</i> , <i>E. populnea</i> and <i>Callitris glaucophylla</i> with some older <i>Callitris</i> and eucalypt regeneration. The site had small scattered patches of <i>Acacia deanei</i> with some limited regeneration of the overstorey species. The ground cover included sparsely scattered tussocks of <i>Bothriochloa macra</i> , <i>Austrostipa</i> and <i>Austrodanthonia</i> species as well as a diverse range of herbs and forbs. Leaf litter was abundant beneath tree canopies but there were numerous patches of bare ground particularly in the more open areas, which were commonly covered in cryptogams. There were some fallen branches and an active presence of ants and ant nests. In 2010, the area had been recently grazed by travelling stock with numerous deep hoofprint depressions scattered across the site, but there was little grazing damage. In 2011, there was no evidence of recent livestock grazing however there was less plant diversity due to increased grass cover and drier conditions. In 2012 and 2013 the site continued to be very dry.				
				
<b>RWood03:</b> Open grassy woodland dominated by <i>E. microcarpa</i> with an individual <i>Allocasuarina luehmannii</i> . There were some large old growth trees with hollows, scattered regrowth and some limited regeneration of the overstorey species. The site had small scattered patches of <i>Dodonaea viscosa</i> subsp. <i>cuneata</i> , <i>Acacia hakeoides</i> and <i>Senna artemisioides</i> . The ground cover included sparsely scattered tussocks of <i>Austrostipa</i> and <i>Austrodanthonia</i> species as well as a variety of small chenopod sub-shrubs. Leaf litter was abundant beneath tree canopies but there were numerous patches of bare ground particularly in the more open areas, which were commonly covered in cryptogams. There were some fallen branches. Grey Crowned Babblers were present at this site. In 2010, the area had been recently grazed by travelling stock with numerous deep hoofprint depressions scattered across the site, but there was little grazing damage. In 2011, there was no evidence of recent livestock grazing however there was less plant diversity due to increased grass cover and drier conditions. In 2012 and 2013 the site continued to be very dry.				



Photo 2009	Photo 2010	Photo 2011	Photo 2012	Photo 2013
				
<p><b>RWood04:</b> Open woodland dominated by <i>E. populnea</i>, <i>E. melliodora</i> and <i>Callitris glaucophylla</i> which has some large old growth trees and numerous stumps but in 2009 there was no shrub or tree regeneration. The ground cover was patchy and contained sparsely scattered tussocks of <i>Austrostipa</i> and <i>Austrodanthonia</i> species. In 2009 there was a limited diversity of herbs and forbs, but generally total ground cover was good with large patches of <i>Xerochrysum bracteatum</i> (Golden everlasting) scattered across the forest area. In 2010, there was a high diversity of native understorey species, including significant patches of <i>Dichopogon</i> (Chocolate lily). There were also old stock camps beneath the trees which were dominated by weeds. The area is not subjected to livestock grazing but maintains a healthy macropod population. In 2011, there had been a significant increase in grass cover resulting in lower plant diversity and fewer weeds, especially beneath the tree canopies in the old stockcamps. The patch of <i>Dichopogon</i> was reduced to about one dozen individuals due to increased competition and drier conditions. In 2012 the site continued to be exceptionally dry but there was some <i>Callitris</i> regeneration. In 2013, it continued to be very dry, but significant regeneration of <i>Callitris</i> was evident across the larger Limestone Forest area, with seedlings having grown over the year.</p>				
				

**Table 6-2. GPS co-ordinates, aspects and slopes of the woodland reference sites.**

Site Reference	LFA Start	LFA Finish	LFA slope°	LFA bearing°	Veg transect start	Veg transect finish	Veg transect bearing °
<b>RWood01</b>	55599368 E 6361978 N	55599386 E 6361982 N	0	52 NE	55599378 E 6361978 N	55599399 E 6361934 N	142 SE
<b>RWood02</b>	55604368 E 6350055N	55604386 E 6350060 N	5	56 NE	55604378 E 6350058 N	55604394 E 6350012 N	158 SE
<b>RWood03</b>	55600792 E 6359342 N	55600772 E 6359350 N	1	269 W	55600781 E 6359348 N	55600794 E 6359393 N	0 N
<b>RWood04</b>	55597396 E 6356649 N	55597398 E 6356626 N	4	159 S	55597398 E 6356637 N	55597350 E 6356628 N	240 SW

## **6.2     *Estcourt Offset Area monitoring sites***

The monitoring sites were chosen to capture changes occurring within the different community types or “zones” and their associated restoration activities. Subsequently five sites were established with two of these occurring within the derived grassland area destined for replanting to re-establish the original grassy woodland community. Three sites occurred in the existing woodland areas (zone two), whereby one site is situated in a grassy clearing (sub-zone 2b) and will require supplementary planting with the remaining two sites situated within open woodland areas where natural regeneration will be anticipated, and some supplementary hand planting will be undertaken (GHD 2010).

The location of the revegetation monitoring sites in the Estcourt Offset Area is shown in Figure 6-2. General site descriptions including photographs taken during 2010 – 2013 are provided in Table 6-3. The site coordinates and other details are given in Table 6-4.

## **6.3     *Additional photo points***

As part of the VMP, GHD established seven photo points within the Estcourt Offset Area in 2009. These sites were also revisited 2010 - 2013 by DnA Environmental and the results have been provided in Table 6-5.



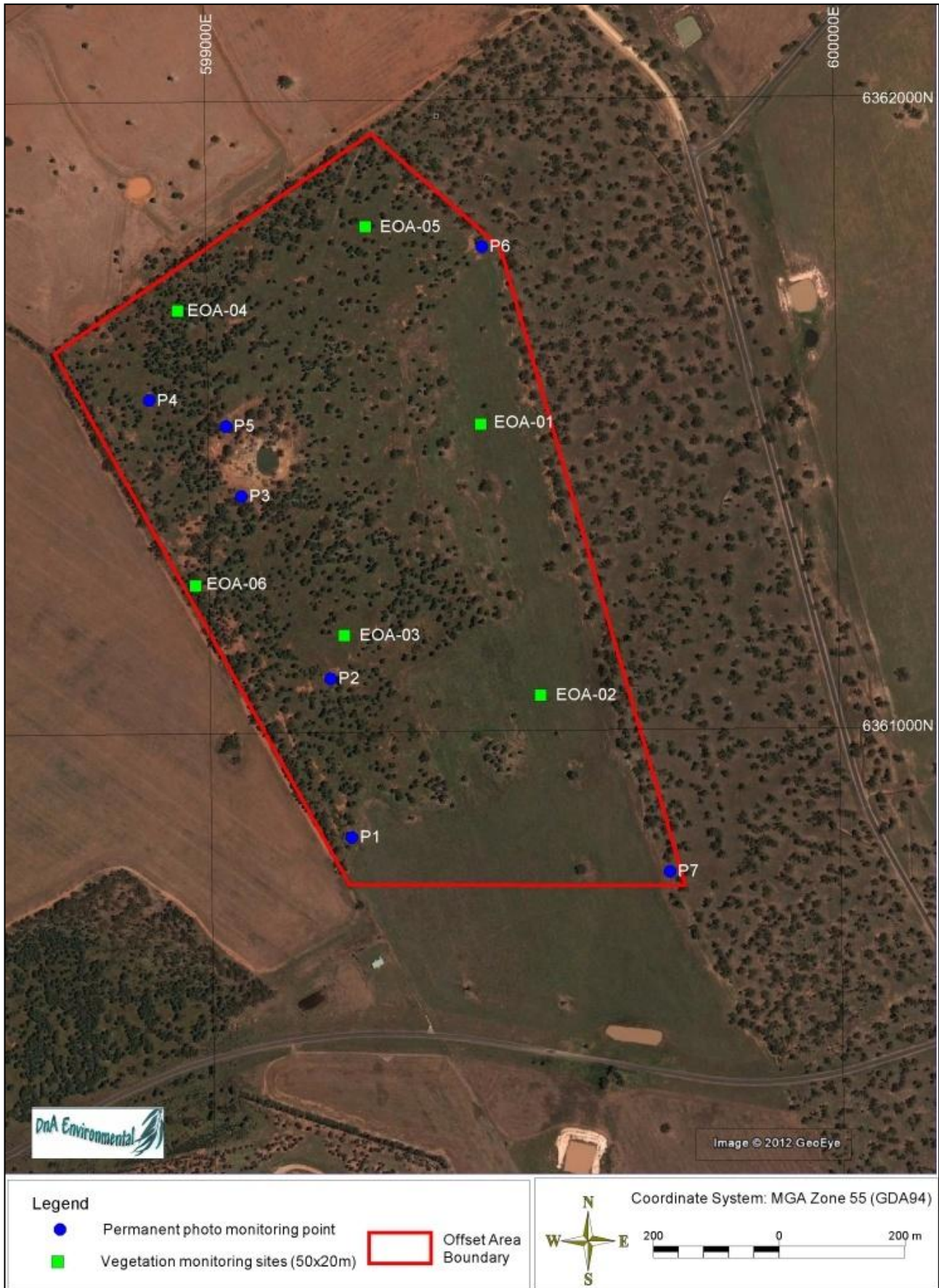







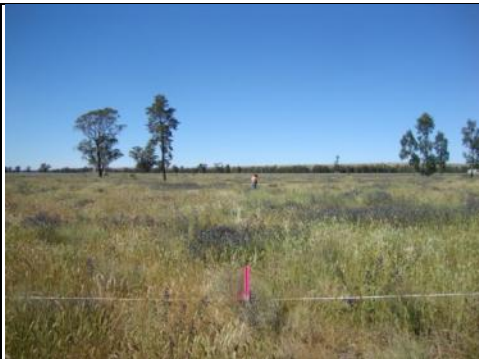


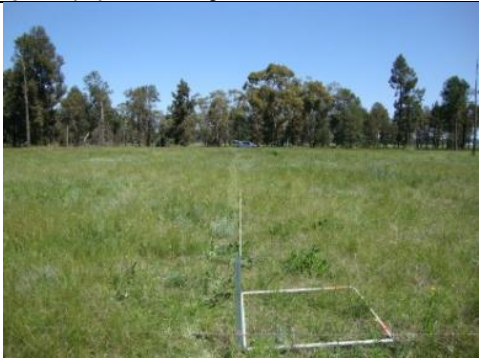







Figure 6-2. Map showing the locations of the vegetation monitoring sites and permanent photo points within the Estcourt Offset area (Image: Google Earth Pro 2010).



Table 6-3. General site description of the EOA monitoring sites.

Site	Photo 2010	Photo 2011	Photo 2012	Photo 2013
EOA-01	<p>A derived grassland situated to the northeast of the Estcourt Offset Area. The site was an old cropping paddock that has not been recently grazed. In 2010 it contained a diverse understorey of native and introduced species including <i>Dichondra repens</i>, <i>Hordeum leporinum</i>, <i>Chloris truncata</i> and <i>Medicago polymorpha</i>. There was high floristic diversity (57 species) and native species (34) were more abundant than exotic species (23). There was good ground cover and cryptogams were moderately abundant. There were scattered occurrences of <i>Echium plantagineum</i>, <i>Arctotheca calendula</i>, <i>Centaurea melitensis</i> and <i>Sonchus oleraceus</i>. In 2011, there were increased levels of ground over, decreased abundance of cryptogams and increased diversity of exotic species. One <i>Callitris glaucophylla</i> seedling was found. In 2012 the site was similar to but drier than last year and seven <i>C. glaucophylla</i> seedlings were found. In 2013, annual species continued to be dominant. Eleven <i>C. glaucophylla</i> seedlings were recorded.</p>			
				
EOA-02	<p>A derived grassland situated to the southeast of the Estcourt Offset Area. The site was an old cropping paddock that had not been recently grazed. In 2010 it contained a diverse understorey of native and introduced species including <i>Dichondra repens</i>, <i>Eragrostis parviflora</i> and <i>Medicago polymorpha</i>. There was a relatively high floristic diversity (48 species) and native species (26) were more abundant than exotic species (22). There was generally good ground cover and cryptogams were moderately abundant in the southern end of the transect. There were scattered occurrences of <i>Carthamus lanatus</i>, <i>Echium plantagineum</i> and <i>Arctotheca calendula</i>. In 2011, it was similar to EOA-01 with increased levels of ground over, decreased abundance of cryptogams but maintained a high diversity of native and exotic species and weeds were less abundant. In 2012 the site was similar to but drier than last year and 24 <i>C. glaucophylla</i> seedlings were found. In 2013, annual species continued to be dominant and only 15 <i>C. glaucophylla</i> seedlings were recorded.</p>			
				



Site	Photo 2010	Photo 2011	Photo 2012	Photo 2013
EOA-03	<p>An open grassy clearing situated in the centre of the southern woodland area on top of the hill. It was dominated by native grasses particularly <i>Austrostipa scabra</i> subsp. <i>falcata</i> and contained a very high diversity of native (43) and introduced species (18) including many Asteraceae and Poaceae species. There was good ground cover provided by perennial plants. There were sparse occurrences of <i>Carthamus lanatus</i>, <i>Echium plantagineum</i>, <i>Salvia verbenaca</i>, <i>Erodium cicutarium</i> and a variety of <i>Medicago</i> and <i>Trifolium</i> species. On the fringing woodland (photo point 2 GHD 2010), there was a diverse range of additional native species including <i>Arthropodium minus</i>, <i>Stackhousia monogyna</i>, <i>Pterostylis</i> sp. , <i>Bulbine bulbosa</i>, <i>Goodenia pinnatifida</i> and <i>Calotis cuneifolia</i> to name a few. In 2011 and 2012 the site was very dry with macropod grazing maintaining low grass cover. There was a significant decline in floral diversity but the site retained good ground cover. In 2012 seven <i>C. glaucophylla</i> seedlings were found. In 2013 there continued to be moderate abundance of native grasses and scattered <i>Xerochrysum bracteatum</i> and <i>Dichopogon stricta</i> but <i>Echium plantagineum</i> was also quite abundant. Twelve <i>C. glaucophylla</i> seedlings were recorded.</p>			
				
EOA-04	<p>Estcourt Offset Area 04 (EOA-04) was situated on the edge of a woodland stand to the west of the site which contained a moderate canopy of <i>Callitris glaucophylla</i> trees of varying health, including numerous dead stags. The vegetation transect extended into an area of open grassland, which contained a higher diversity of native ground cover species than beneath the tree canopies. The understorey was relatively weedy with <i>Lolium</i> and <i>Trifolium</i> species being very common, but it retained high native species diversity (51 species) and native perennial grasses were particularly dominant. There were no shrubs and no tree hollows were observed. The site had very high species diversity (71 species). In 2011 and 2012 the drier seasonal conditions has resulted in a reduction in floristic diversity. In 2011 four regenerating <i>Dodonaea viscosa</i> subsp. <i>cuneata</i> were recorded. In 2012, there were 7 <i>Dodonaea</i> and two <i>Callitris</i> seedlings. In 2013 there continued to be good cover of native grasses but there were patches of <i>Echium plantagineum</i>. Only one seedling each of <i>Dodonaea</i> and <i>Callitris</i> were found this year.</p>			
				








Site	Photo 2010	Photo 2011	Photo 2012	Photo 2013
EOA-05	<p>Estcourt Offset Area 05 (EOA-05) was situated to the north east of the site within a sparse woodland stand of <i>Callitris glaucophylla</i> trees, including two dead stags. There was no <i>C. glaucophylla</i> recruitment but the trees were flowering or contained fruit. The understorey was relatively weedy (23 exotic species) especially beneath the trees where there were remnant stockcamps, with <i>Lolium</i> and <i>Trifolium</i> species being very common, but it retained high native species diversity (49 species) and native perennial grasses were particularly dominant. There were no shrubs and one tree hollow was observed in one of the dead stags. The site had very high species diversity (72 species). In 2011, later monitoring and drier seasonal conditions has resulted in a reduction in floristic diversity. In 2012 the site was very dry with macropod grazing maintaining low grass cover. There was a significant decline in floral diversity but the site retained good ground cover. In 2012 11 <i>C. glaucophylla</i> seedlings were found. In 2013 there continued to be good cover of native grasses but there were patches of <i>Echium plantagineum</i>. Fourteen <i>C. glaucophylla</i> seedlings were recorded. An echidna had destroyed a large any nest.</p>			
				
EOA-06	<p>In 2013 this site was established after a grass fire in November 2013 which was initiated by harvesting machinery in adjacent cropland and burnt approximately 1ha within the EOA. The LFA transect = vegetation transect. there were log patches and fallen trees which had caught fire and continued to burn at high temperatures leaving scorched tree canopies and charred blackened coals and bare scorched earth in these immediate areas. Much of the remaining burnt area however appears to have recovered with a very high diversity of scattered native grasses and wild flowers, however total ground cover was patchy. Exotic species tended to dominate areas beneath tree canopies.</p>			
	NA	NA	NA	

Table 6-4. GPS co-ordinates, aspects and slopes of the offset monitoring sites (GDA94).

Site Reference	LFA Start	LFA Finish	LFA slope°	LFA bearing°	Veg transect start	Veg transect finish	Veg transect bearing°
EOA-01	55 599435E 6361486N	55 599455E 6361488N	1	78 E	55 599447E 6361487N	55 599450E 6361440N	170 S
EOA-02	55 599526E 6361056N	55 599551E 6361055N	1	83 E	55 599539E 6361055N	55 599541E 6361010N	175 S
EOA-03	55 599215E 6361154N	55 599229E 6361139N	0	119 SE	55 599226E 6361145N	55 599188E 6361111N	212 SW
EOA-04	55 598954E 6361670N	55 598968E 6361674N	1	41 NE	55 598961E 6361672N	55 598991E 6361635N	132 SE
EOA-05	55 599254E 6361808N	55 599276E 6361785N	1	92 E	55 599269E 6361791N	55 599256E 6361743N	183 S
EOA-06	55 598978E 6361234N	55 598911E 6361218N	2	125 SE	55 598978E 6361234N	55599011E 6361192N	125SE



Table 6-5. Permanent Photo Points within the offset area

Photo point/ Coordinates	2010 Photo	2011 Photo	2012 Photo	2013 Photo
P1 55 599223E 6360834N				
P2 55 599191E 6361085N				
P3 55 599052E 6361375N				















Photo point/ Coordinates	2010 Photo	2011 Photo	2012 Photo	2013 Photo
P4 55 598907E 6361528N				
P5 55 599028E 6361486N				
P6 55 599438E 6361766N				

Photo point/ Coordinates	2010 Photo	2011 Photo	2012 Photo	2013 Photo
P7  55 599728E 6360775N	 A photograph of a grassy field with a wooden fence post in the foreground. The grass is green and the sky is blue.	 A photograph of a grassy field with a wooden fence post in the foreground. The grass is green and the sky is blue.	 A photograph of a grassy field with a wooden fence post in the foreground. The grass is green and the sky is blue.	 A photograph of a grassy field with a wooden fence post in the foreground. The grass is green and the sky is blue.

## 7 Ecological trends and performance against a selection of primary ecological performance indicators

The following section provides a summary of results from the six EOA rehabilitation sites compared to the woodland reference sites obtained during 2010 - 2013. Full descriptions of the individual sites are provided in Section 10.

### 7.1 Landscape Function Analyses

#### 7.1.1 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).

All five sites previously monitored continued to have excellent ground over and scored a Landscape Organisation Index (LOI) of 100% (Figure 7-1) and were similar in character to the woodland reference sites which had little to no leakage of resources. The newly established EOA-06 site was also a complete functional patch area and scored an LOI of 100%.

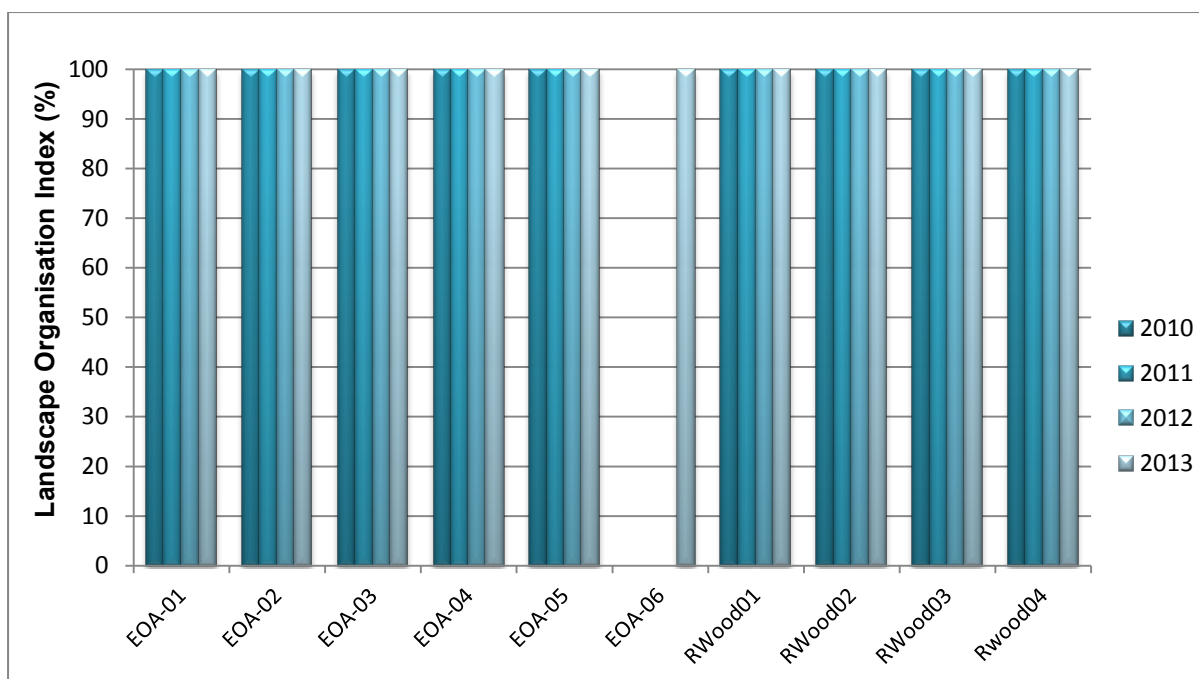


Figure 7-1. Landscape organisation indices recorded in the Estcourt Offset sites compared to the woodland reference sites 2010 - 2013.

#### 7.1.2 Soil surface assessments

##### 7.1.2.1 Stability

Since 2011 the LFA stability indices of the revegetation sites have typically declined across all of the Estcourt revegetation sites but this trend was also evident within the woodland reference sites and was



a reflection of the prolonged dry conditions and declining perennial vegetation cover was common. Subsequently the LFA stability range was slightly lower this year and ranged from 62.9 – 69.0.

There continued to be high ecological stability in all EOA sites and all exceeded the stability target range this year, including the burnt woodland EOA-06 (Figure 7-2). In the EOA monitoring sites the lowest stability index recorded was 65.5 in EOA-06, while the highest index of 73.0 was recorded in EOA-01. The high stability in the EOA-01 and EOA-02 were largely due to the development of very hard soil crusts and they contained a higher abundance of cryptogam cover.

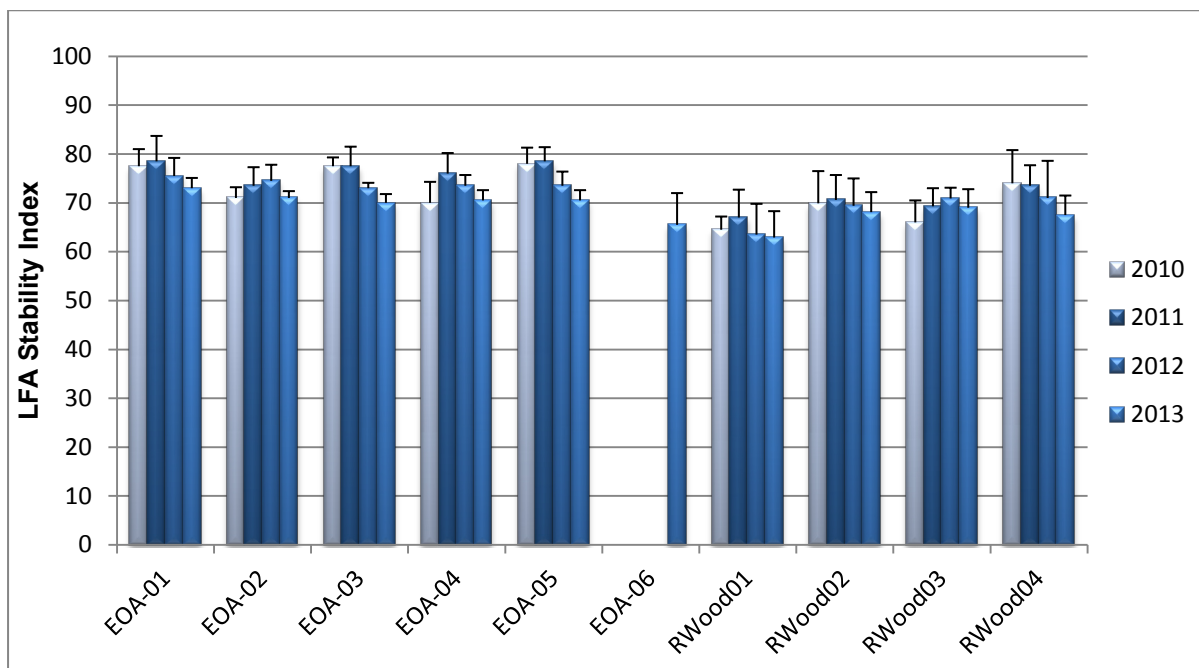


Figure 7-2. Comparison of LFA stability indices between the Estcourt Offset monitoring sites and the woodland reference sites 2010 - 2013.

### 7.1.2.2 Infiltration

While there was no consistent trend in changes in LFA infiltration indices within the monitoring sites typically they were marginally lower than last year and this was also observed within two of the woodland reference sites which provided a wider LFA infiltration range of 41.1 – 55.7 (Figure 7-3).

This year all EOA sites met LFA infiltration targets, with the exception of EOA-06 as this site did not yet have a well developed litter layer and it contained very hard soil crusts but it was only negligibly lower than the minimum target with an index of 40.5.

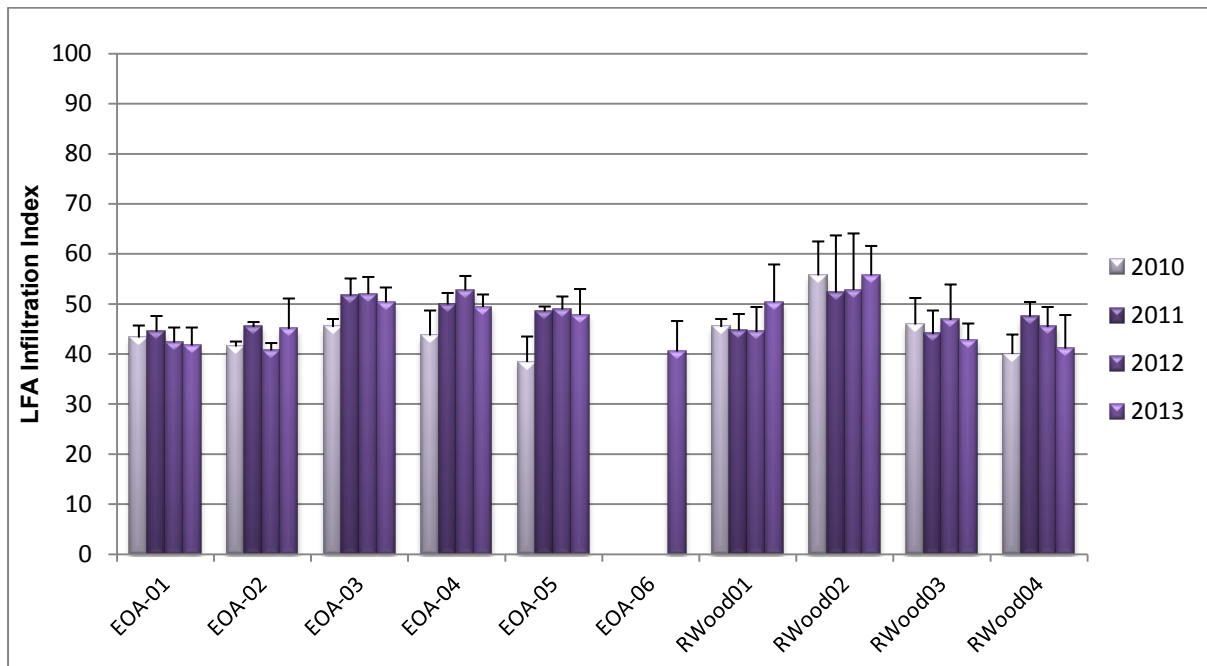


Figure 7-3. Comparison of LFA infiltration indices between the Estcourt Offset monitoring sites and the woodland reference sites 2010 - 2013.

### 7.1.2.3 Nutrient recycling

There was no consistent trend in changes in LFA nutrient recycling indices within the monitoring sites with some sites demonstrating a small but increasing trend and this was largely due to the accumulation of dead leaf litter and increasing states of litter decomposition, indicating increased levels of microbial and fungal activity. While this was commonly observed across numerous sites, the decline in perennial plant and cryptogam cover across most sites may have resulted in a reduction in nutrient recycling capacity. In the woodland reference sites nutrient recycling indices ranged from 36.2 – 53.0 and all EOA sites fell within this range, including the new EOA-06 site which had an index of 36.2 (Figure 7-4).

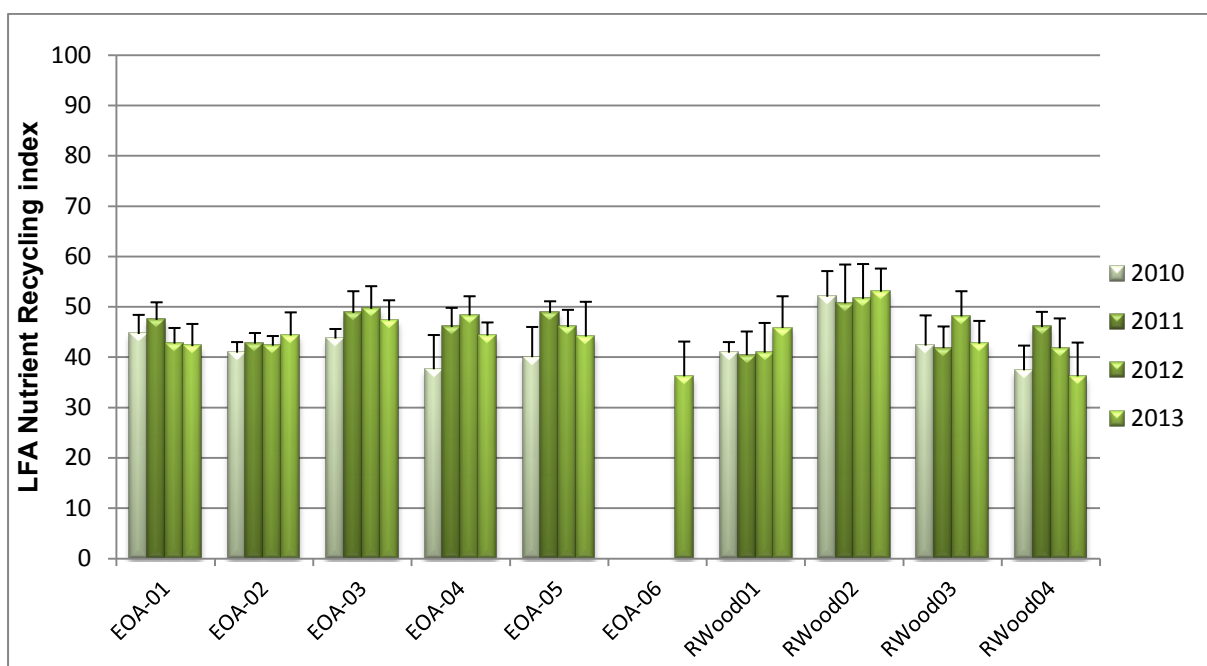




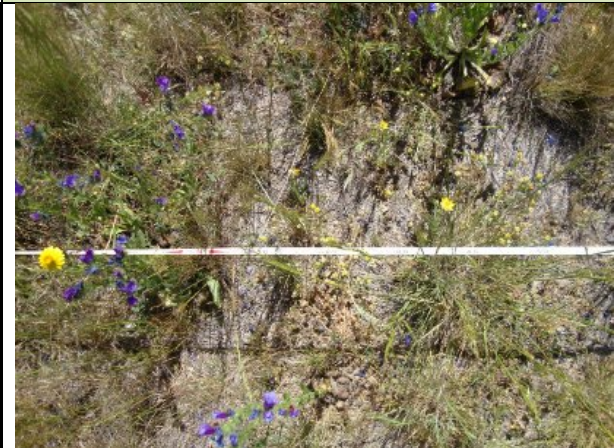

Figure 7-4. Comparison of LFA nutrient recycling indices between the Estcourt Offset monitoring sites and the woodland reference sites 2010 - 2013.

### 7.1.2.4 LFA Summary

Most sites have demonstrated a further decline in ecological function largely due to a decrease in perennial plant cover and in some sites there was also less litter depth and states of decomposition however in most instances these changes were also reflected within the woodland reference sites, indicating it has been a direct response to the seasonal conditions and probably macropod activity.

These data indicate that even the most historically disturbed derived grassland sites EOA-01 and EOA-02 were ecologically functional communities and were comparable or similar to the local woodland reference communities, despite the absence of a mature canopy layer. The new EOA-06 site which suffered a grassfire last year also appears to have recovered and was ecologically comparable with unaffected woodland, despite having a cover of litter cover which had not yet accumulated to depth and the presence of very hard setting soils. Examples of the various combinations of ground covers which are critical to overall ecosystem function have been provided in Table 7-1.

**Table 7-1. Examples of the different ground covers in the woodland monitoring sites.**

EOA-01	EOA-02
	
EOA-03	EOA-04
	





## 7.2 Tree density

Mature trees and shrubs with a stem diameter >5cm dbh continued to be recorded in all reference sites and this year there was a loss of one individual in RWood01 as it had died and fallen over. Nonetheless tree densities recorded in the local woodlands continued to range from 5 – 19 individuals or 50 – 190 individuals per hectare (Figure 7-5).

There continued to be 14 trees recorded in EOA-04 and three in EOA-05. In site EOA-06 there were 13 mature trees. No trees or mature shrubs were yet present in the recovering grassland EOA-01 and EOA-02 sites or in the grassy clearing of EOA-03 (Figure 7-5). Common species of trees and mature shrubs recorded in the reference sites were *Allocasuarina luehmannii*, *Callitris glaucophylla*, *Eucalyptus*

*albens*, *E. microcarpa*, *E. populnea* and *Acacia hakeoides*. The average dbh recorded was 28cm, however they ranged from an 11cm *E. populnea* (EOA-06) to a dead *Callitris* stag in EOA-05 which measured 67cm.

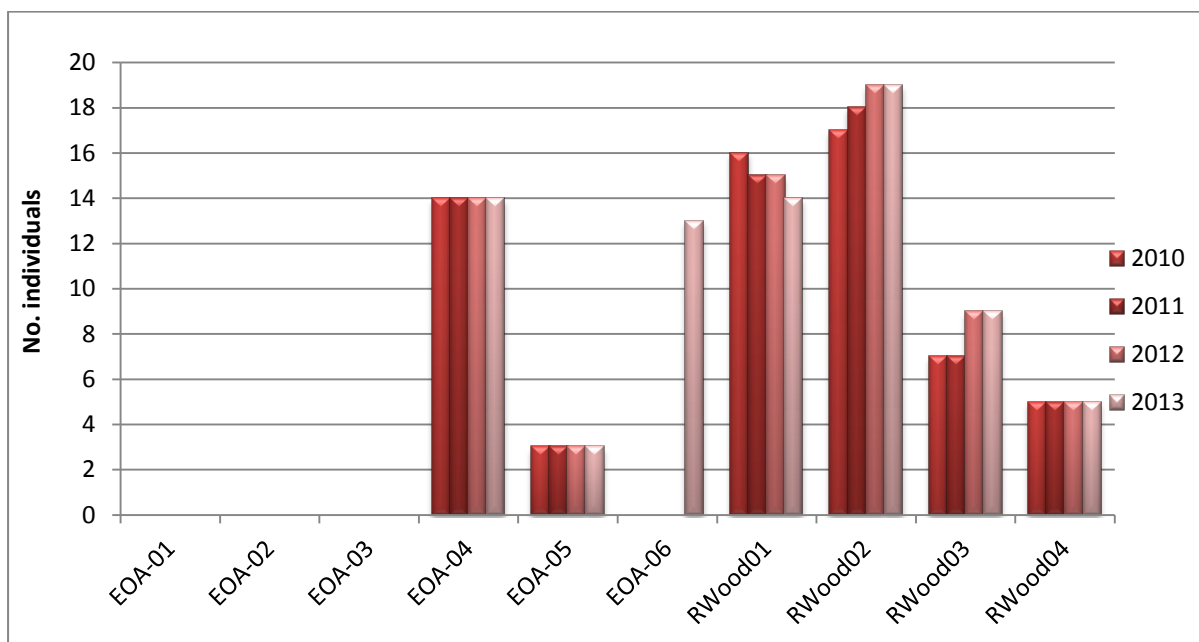


Figure 7-5. Tree densities (>5cm dbh) in the Estcourt Offset sites compared to the woodland reference sites 2010 - 2013.

### 7.3 Shrubs and juvenile trees

The number of shrubs and juvenile trees with a stem diameter <5cm dbh continued to be highly variable within the reference sites and while there has been an increasing trend in all four sites, the prolonged dry this year combined with increased grazing pressure has resulted in a loss of seedlings in three sites, while in RWood04 additional seedlings were recorded (Figure 7-6).

Subsequently the resultant target range was lower with 29 – 110 shrubs and juvenile trees per 0.1ha monitoring site and no EOA site yet contained this shrub density. Young seedlings however continued to be recorded in all EOA monitoring sites including the new EOA-06 site with the lowest density of two being recorded in EOA-04 as eight individuals had apparently died, while the highest density continued to be recorded in EOA-02 with 15 individuals despite the loss of nine individuals (Figure 7-6).

While in almost all EOA monitoring sites the seedlings were *Callitris glaucophylla*, one *Dodonaea viscosa* subsp. *cuneata* persisted in EOA-04 and there were nine *E. populnea* saplings in EOA-06. In the reference sites the most common shrubs included *Allocasuarina luehmannii*, *Eucalyptus microcarpa*, *Dodonaea viscosa* subsp. *cuneata*, *Senna artemisioides* subsp. *filifolia* but there were some *Acacia hakeoides*, *Acacia deanei*, *Alectryon oleifolius* and *Eucalyptus albens* recorded in at least one of the reference sites.



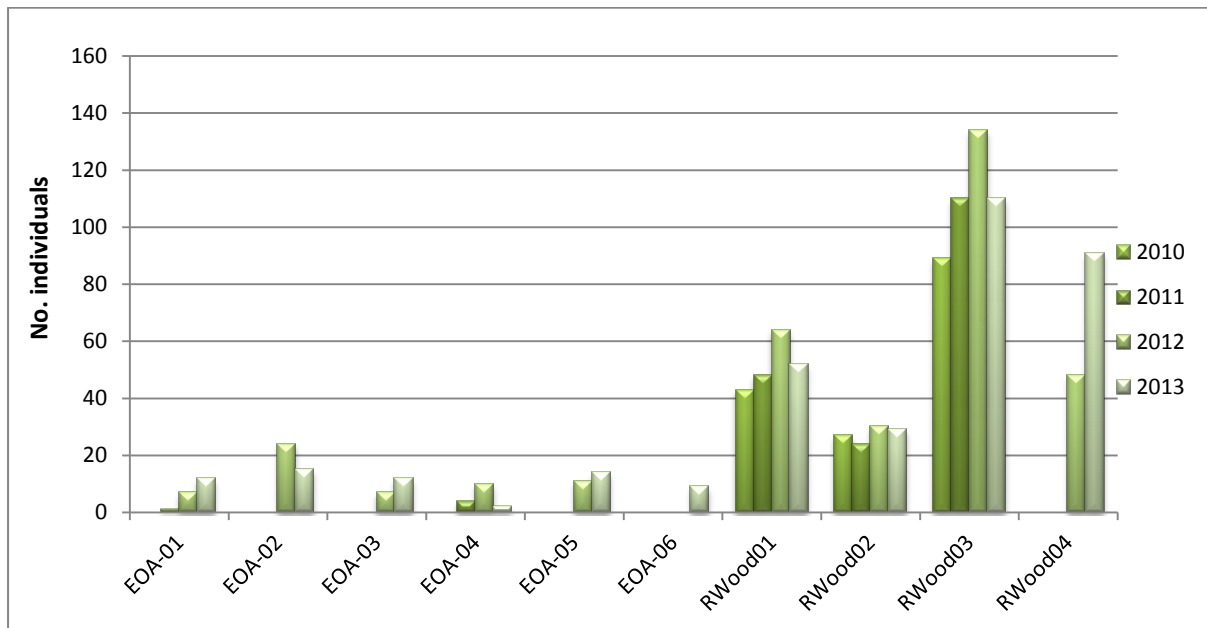


Figure 7-6. Total live shrubs recorded in the Estcourt Offset sites compared to the woodland reference sites 2010 – 2013.

#### 7.4 Total ground Cover

Total ground cover is derived from various combinations of dead leaf litter, annual and perennial plants and in some sites there were small contribution from cryptogams and logs. In 2010 grazing by the travelling stock within the reference sites left numerous hoof print depressions which had destroyed the protective cover across numerous sites. However due to the absence of grazing since 2011 these sites have been able to recover and there has generally been an increase in total ground cover however this year the prolonged dry conditions have led to increased disturbance by macropods, resulting in a marginal decline in total ground cover in three of the four reference sites and a resultant target range of 89.0 – 94.55% (Figure 7-7).

Total ground cover recorded in the EOA monitoring sites continued to be high and in the burnt EOA-05 site, there was a minimum cover of 98.5% total ground cover recorded and this also exceeded the target range.

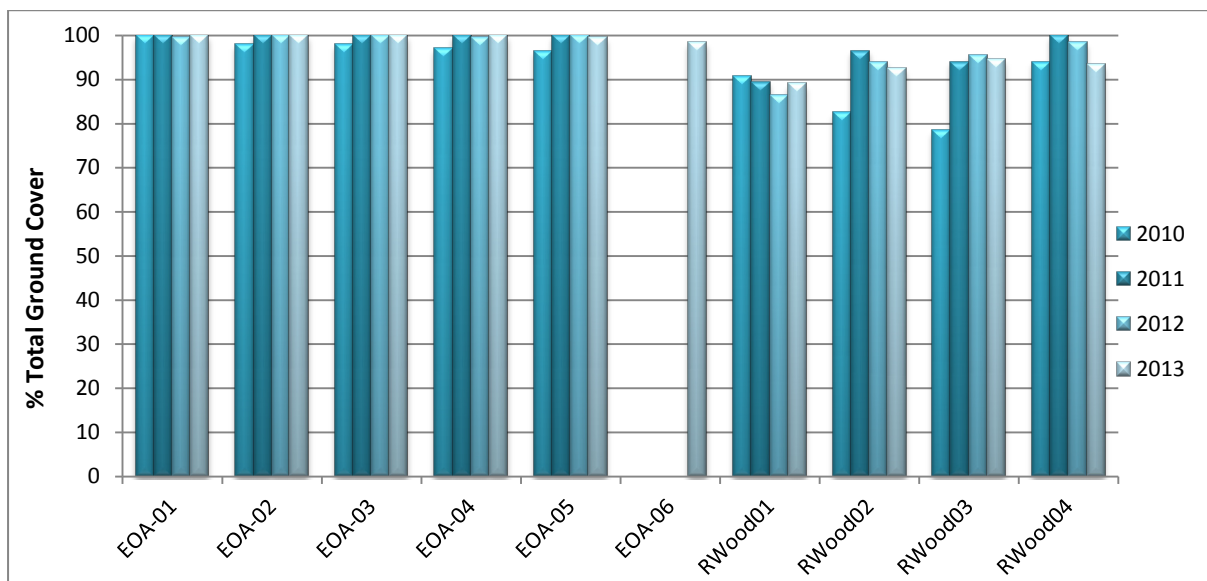


Figure 7-7. Total ground cover recorded in the Estcourt Offset sites compared to the woodland reference sites 2010 - 2013.

## 7.5 Structural composition

The various combinations of the ground covers and structural compositions of the woodland sites are provided in Figure 7-8 which indicates the most dominant form of ground cover continued to be dead leaf litter which has increased since 2010 due to the declining trend in perennial plant cover. Perennial grasses and forbs however continued to be an important component of the local woodlands and while these provided relatively low cover values which ranged from 6.8 – 25.0%, all EOA monitoring sites met this target. There was a minimum perennial ground cover of 8.5% recorded in EOA-01, while EOA-04 contained a high of 36.5% perennial plant cover.

This year annual plants were recorded in all EOA and reference monitoring sites with a large increase in cover recorded in RWood04 which had 21.5% annual plant cover, but exotic cover was limited to 1.5 – 5.5% in the remaining three sites. In the EOA sites annual plants which were almost always exotic species also continued to provide significant levels of ground cover within the two derived grassland areas as these were in the early recovery stages and had a higher disturbance history. This year there was also a large increase in annual plant cover recorded in the remaining EOA sites, but these tended to remain within local levels and were in response to the seasonal conditions.

While cryptogams provided important ground cover in all but one site in 2010 cryptogams continued to be present in low abundance in three of the reference sites this year. There was however less than 1% of cover which was recorded in EOA-01 and EOA-06 and none were recorded in the remaining sites due to an increasing trend in other vegetative cover. Fallen branches were common but provided only limited ground cover in the reference sites and rocks were not important habitat components in the grassy ecosystems. Presently EOA-05 and EOA-06 were the only sites to contain fallen logs and branches.

The reference sites were characterised by having at least some mature canopy cover which exceeded 6.0m in height but typically there was limited projected foliage 0.5 - 4.0m in height. All EOA areas had limited shrub/low canopy covers however the more open woodland areas EOA-04, EOA-05 and EOA-06 contained some limited canopy cover 4.0 – 6.0m in height. The structural composition of the woodland monitoring sites has been provided in Table 7-2.

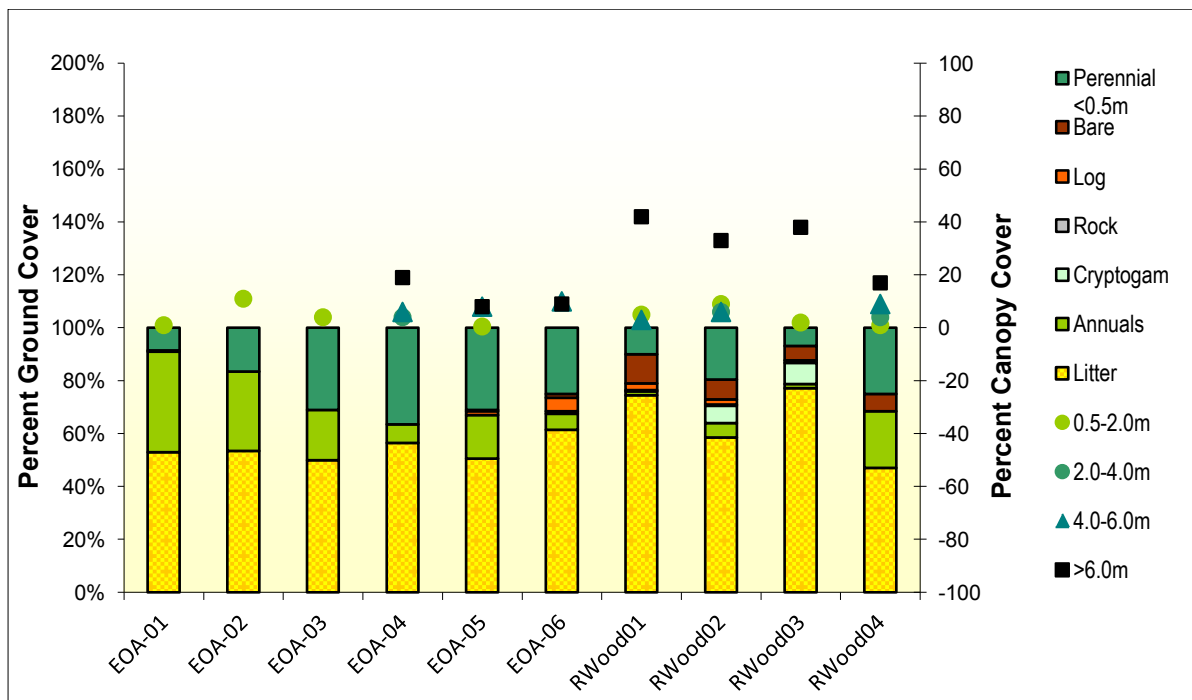


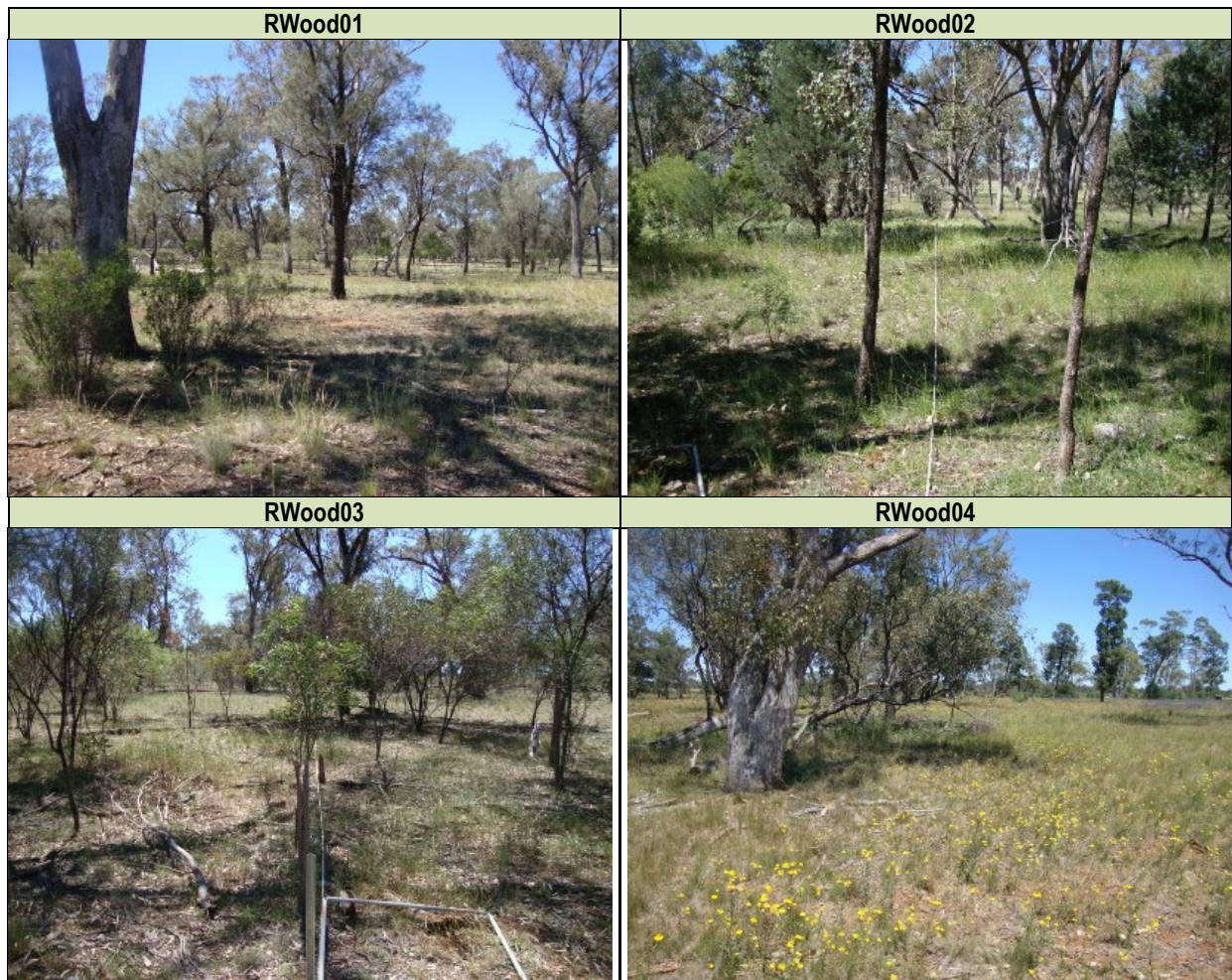
Figure 7-8. Average percent ground cover and projected foliage cover recorded in the woodland monitoring sites in 2013.



**Table 7-2. The structural composition of the woodland monitoring sites.**

EOA-01	EOA-02
	
EOA-03	EOA-04
	
EOA-05	EOA-06
	





## 7.6 *Species Diversity*

### 7.6.1 Species diversity

Floristic diversity was its highest in 2010 as a result of drought breaking rains and since then there has been no consistent change across the range of sites but this variability was also usually observed within the reference sites. This year there appears to be an increasing trend in all sites except EOA-01 and EOA-02 and in RWood02, species diversity even exceeded that recorded in 2010 with a total of 76 live plant species recorded in the 50 x 20m monitoring plot (Figure 7-9). The burnt EOA area also demonstrated very high floral diversity and had a total of 72 different plant species. The minimum diversity recorded in the reference sites was 53 in RWood01 and sites which did not meet the total diversity target included EOA-01, EOA-02 and EOA-03.

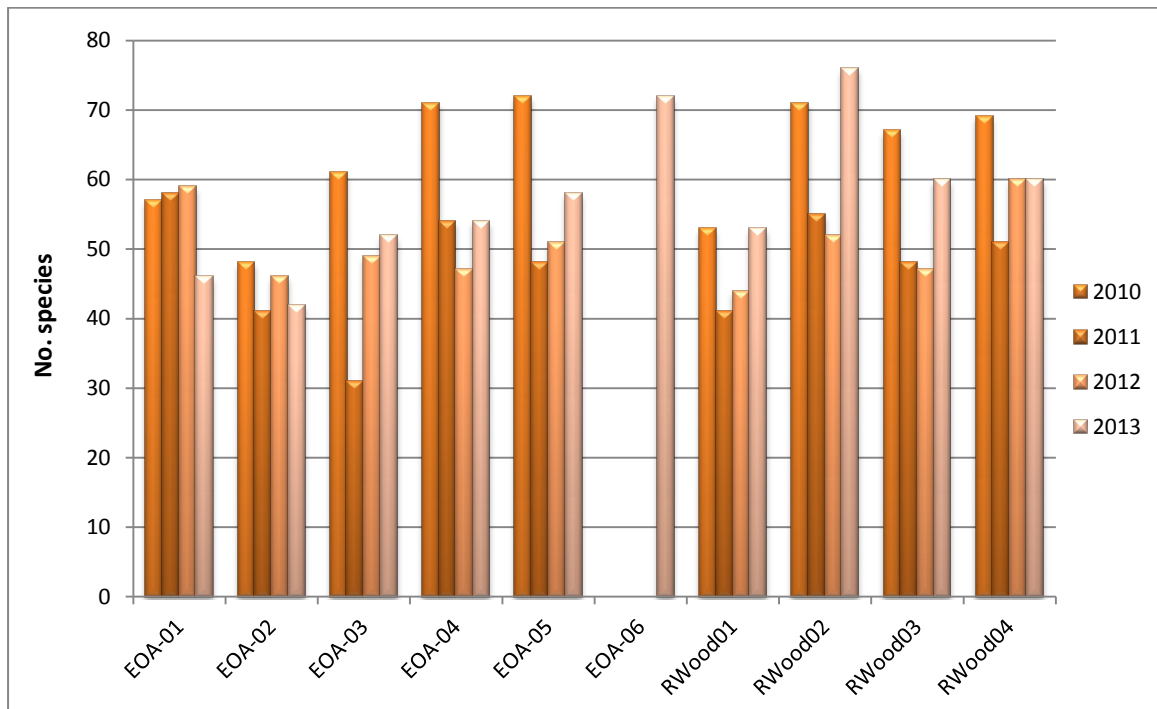


Figure 7-9. Total species diversity recorded in the Estcourt Offset sites compared to the woodland reference sites 2010 – 2013.

### 7.6.2 Native species diversity

There has also been a lot of variability in native species richness over the range of sites across the years and this year, there were increased numbers of native species in three of the four reference sites while there was a large reduction in RWood04, providing a target range of 33 – 53 species (Figure 7-10). In the EOA areas however there was a decline in native species across all sites but sites which met native diversity targets included EOA-04, EOA-05 and in the burnt woodland area EOA-06 there were 55 native species, with this exceeding the local woodland targets. The lowest number of native species was recorded in EOA-02 which had 20 species.

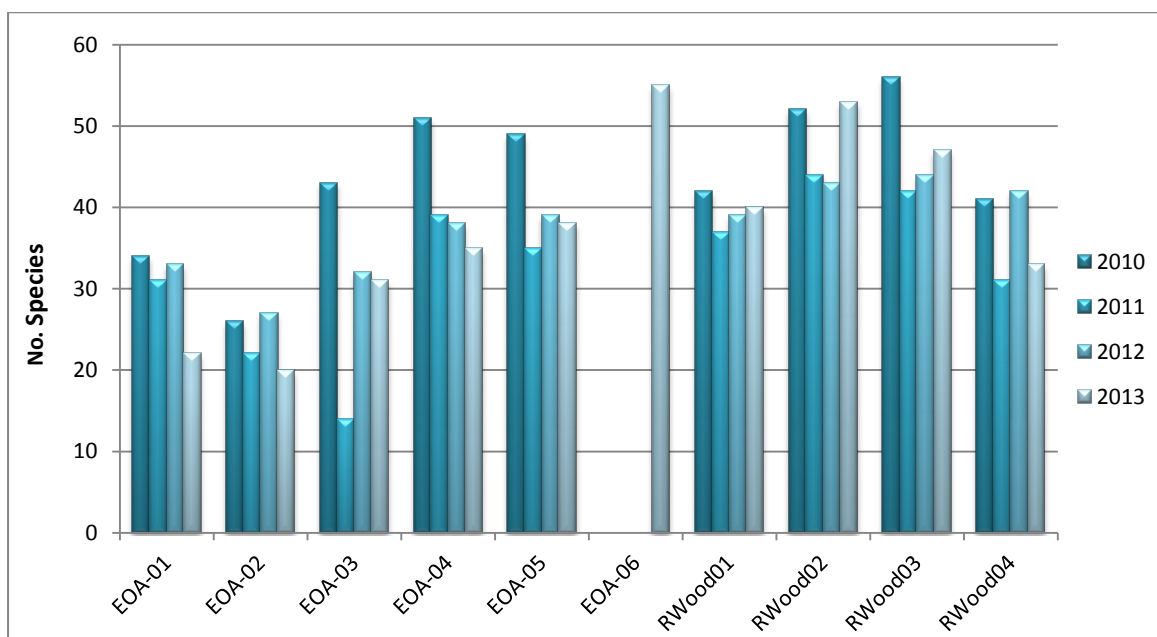


Figure 7-10. Total native species recorded in the Estcourt Offset sites compared to the woodland reference sites 2010 – 2013.

### 7.6.3 Exotic species diversity

In most cases the number of exotic species had been demonstrated a declining trend across almost all monitoring sites due to the drier conditions. This year however the floods in June have resulted in a significant increase in exotic diversity in all sites, except EOA-01 where there were fewer species recorded. There were 13 – 27 exotic species recorded in the reference sites and all EOA sites contained fewer than the maximum target. Interestingly, site EOA-06 had the least number of exotic species, but this may be because of its more secluded location at the back of the reserve where it may have been subjected to a lower disturbance history. RWood04 had the highest number of exotic weeds due to its historical association as an old stock camp (Figure 7-11).

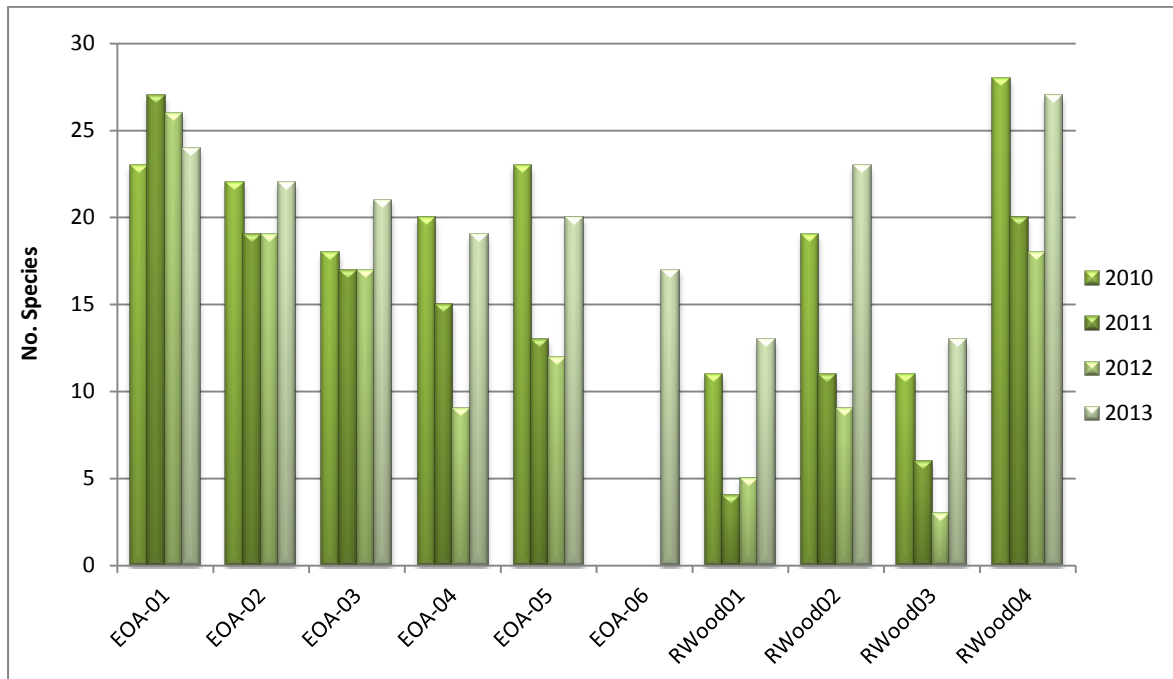


Figure 7-11. Total exotic species recorded in the Estcourt Offset sites compared to the woodland reference sites 2010 - 2013.

### 7.6.4 Percent endemic ground cover

The percent endemic ground cover provides some measure of the cover abundance of the native vegetation and an indication of the weediness.

Since 2010 there was an increasing trend in cover provided by native species within the local woodlands and this was also observed in EOA-05. This year however a significant decline was apparent in all sites, including the local woodlands reflecting it is likely to be the result of the local seasonal conditions rather than other management activities. In the local woodlands there was 63.4 – 87.1% endemic plant cover this year and Offset sites which fell within this target included EOA-04, EOA-05 and EOA-06 while the remaining sites did not and are presently weedier than desired. The new burnt woodland site had 87.1% endemic plant cover which was equivalent to the maximum woodland target.

Sites EOA-01 and EOA-02 had comparatively low native plant ground covers of 30.7% and 29.5% respectively but these are expected to improve over time as the exotic weeds begin to decline and the native perennials begin to establish. Site EOA-03 had a relatively high 62.9% endemic plant cover but some weeds have persisted in an old stock camp area.

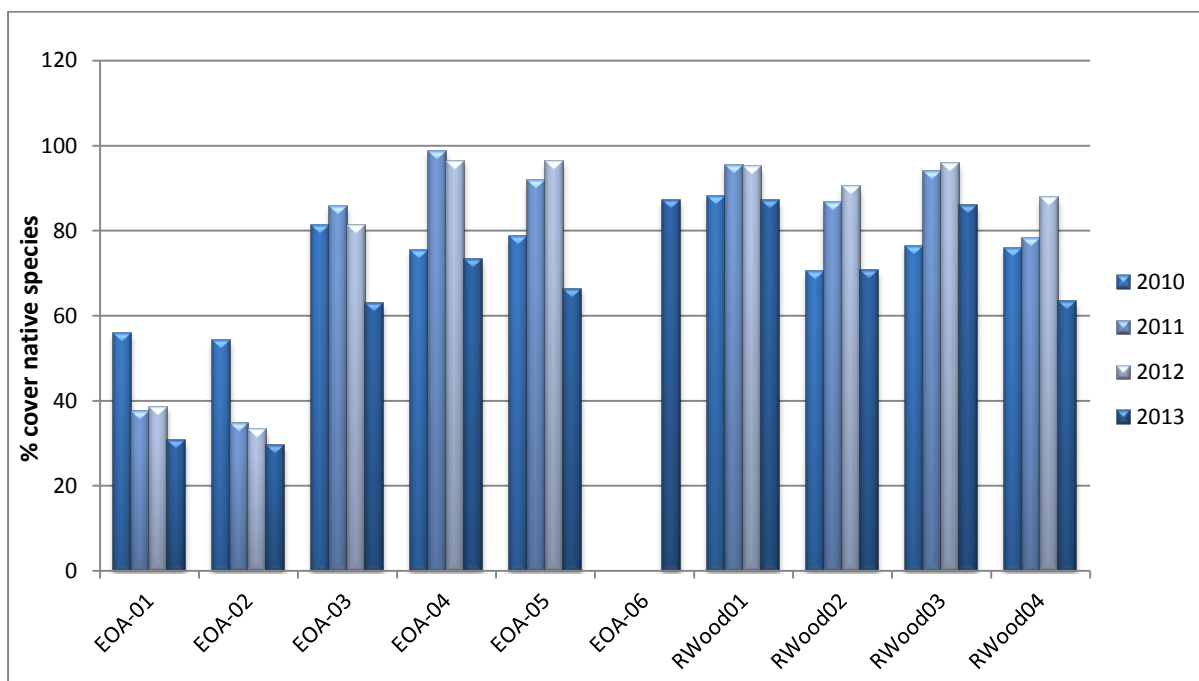


Figure 7-12. Percent endemic ground cover recorded in the woodland monitoring sites 2010 - 2013.

## 7.7 Most common species

The number of species recorded across the range of Estcourt Offset sites has ranged between 105 – 143 species since 2010 with 27 – 32% of these being exotic species (Table 7-3).

Table 7-3. Summary of the number of species recorded in the Estcourt Offset monitoring sites since 2010.

Year	No. sites	Total species	% Exotic species
2010	5	131	31
2011	5	143	27
2012	5	105	31
2013	6	117	32

The most common species (those that were recorded in at least five of the six monitoring plots) in 2013 is given in Table 7-4 and there were 12 of these.

In 2013, twelve species were common to all EOA monitoring sites and these included the native perennial grasses *Austrodanthonia eriantha*, *Austrostipa scabra* subsp. *falcata* and *Austrostipa nodosa* and this year *Callitris glaucophylla* was also recorded in all six sites. There were also eight exotic species found in all sites, including *Centaurea melitensis*, *Trifolium arvense*, *T. campestre*, *T. glomeratum*, *Carthamus lanatus*, *Echium plantagineum*, *Lolium rigidum* and *Sonchus oleraceus* and these were also present in numerous reference sites which is a reflection of the historical disturbances associated with the local NPM area. *Elymus scaber* and *Convolvulus erubescens* were also very common native species. A comprehensive list of species recorded in all monitoring sites in 2013 has been included in Appendix 1.



Table 7-4. Species that were recorded in at least five of the six EOA monitoring sites in 2013.

Group	Family	exotic	Scientific Name	Common Name	Habit	EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06	Total	RWood01	RWood02	RWood03	RWood04
Dicotyledon	Asteraceae	*	<i>Centaurea melitensis</i>	Maltese Cockspur	h	1	1	1	1	1	1	6				1
Dicotyledon	Fabaceae (Faboideae)	*	<i>Trifolium arvense</i>	Haresfoot Clover	h	1	1	1	1	1	1	6		1		1
Dicotyledon	Fabaceae (Faboideae)	*	<i>Trifolium campestre</i>	Hop Clover	h	1	1	1	1	1	1	6		1		1
Monocotyledon	Poaceae		<i>Austrodanthonia eriantha</i>	Hill Wallaby Grass	g	1	1	1	1	1	1	6		1	1	1
Monocotyledon	Poaceae		<i>Austrostipa scabra subsp. falcata</i>	Speargrass	g	1	1	1	1	1	1	6		1	1	1
Coniferopsida	Cupressaceae		<i>Callitris glaucophylla</i>	White Cypress Pine	t	1	1	1	1	1	1	6	1	1		1
Dicotyledon	Asteraceae	*	<i>Carthamus lanatus</i>	Saffron Thistle	h	1	1	1	1	1	1	6	1	1		1
Dicotyledon	Plantaginaceae	*	<i>Echium plantagineum</i>	Paterson's Curse	h	1	1	1	1	1	1	6	1	1		1
Monocotyledon	Poaceae		<i>Austrostipa nodosa</i>	A Speargrass	g	1	1	1	1	1	1	6	1	1	1	1
Monocotyledon	Poaceae	*	<i>Lolium rigidum</i>	Wimmera Ryegrass	g	1	1	1	1	1	1	6	1	1	1	1
Dicotyledon	Asteraceae	*	<i>Sonchus oleraceus</i>	Milk Thistle	h	1	1	1	1	1	1	6	1	1	1	1
Dicotyledon	Fabaceae (Faboideae)	*	<i>Trifolium glomeratum</i>	Clustered Clover	h	1	1	1	1	1	1	6	1	1	1	1
Dicotyledon	Asteraceae	*	<i>Arctotheca calendula</i>	Capeweed	h	1	1	1	1	1		5				1
Monocotyledon	Poaceae	*	<i>Hordeum leporinum</i>	Barley Grass	g	1	1	1	1	1		5	1			1
Monocotyledon	Poaceae	*	<i>Vulpia spp.</i>		g	1	1	1	1	1		5		1		1
Monocotyledon	Poaceae		<i>Elymus scaber</i>	Common Wheatgrass	g	1		1	1	1	1	5		1	1	1
Dicotyledon	Brassicaceae	*	<i>Lepidium africanum</i>	Peppercress	h	1	1		1	1	1	5	1		1	1
Dicotyledon	Convolvulaceae		<i>Convolvulus erubescens</i>	Australian Bindweed	h	1		1	1	1	1	5	1	1	1	1

## 7.8 Vegetation composition

The composition of the vegetation as categorised by seven different growth forms is given in Figure 7-13. In the reference sites herbs continued to be the most dominant growth form with 33 - 46 different species followed by grasses which had 10 – 22 species. There were 2 - 4 tree species, 0 - 3 shrub species and 1 - 5 different sub-shrubs. This year one species of reed was present in RWood02 and there continued to be an absence of fern species.

Compared to the reference sites it appears that the composition of the EOA sites are imitating that of the woodland reference sites but notable differences include the lack of tree species and in EOA-01 and EOA-02 and there was a low number of herbs. Site EOA-06 was the only site which contained an appropriate composition of species this year. While no shrubs species were yet recorded in RWood04 as it too is a recovering woodland area, at least one shrub species would typically be expected to be present and would be a more desirable diversity target to improve habitat diversity within the recovering site woodland sites.

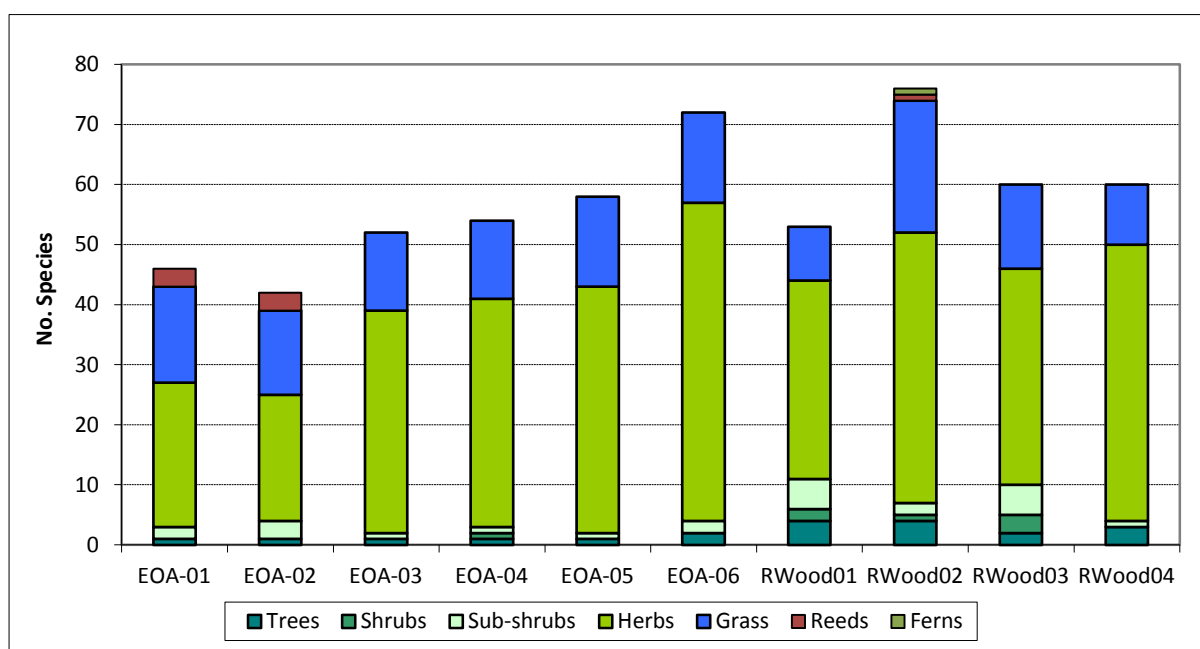


Figure 7-13. Composition of the vegetation recorded in the Estcourt Offset sites compared to the woodland reference sites in 2013.

## 7.9 Soil analyses

### 7.9.1 pH

Figure 7-14 shows the pH recorded in the EOA woodland sites compared to the upper and lower pH values recorded in the woodland reference sites and prescribed “desirable” levels in medium soils. The soil pH within the reference sites had widened to provide a range of 5.99 – 7.10 with the soils considered to be moderately acidic to neutral (Bruce & Rayment 1982). There was a slight decline in pH within the EOA sites with EOA-01, EOA-02 and EOA-03 having almost identical soil pH and within the local ranges and these were borderline slightly - moderately acidic. The remaining sites also demonstrated a decline in pH and these were lower than local levels this year and were moderately acidic. All EOA sites however continued to fall within the acceptable pH range of 5.6 – 7.3.



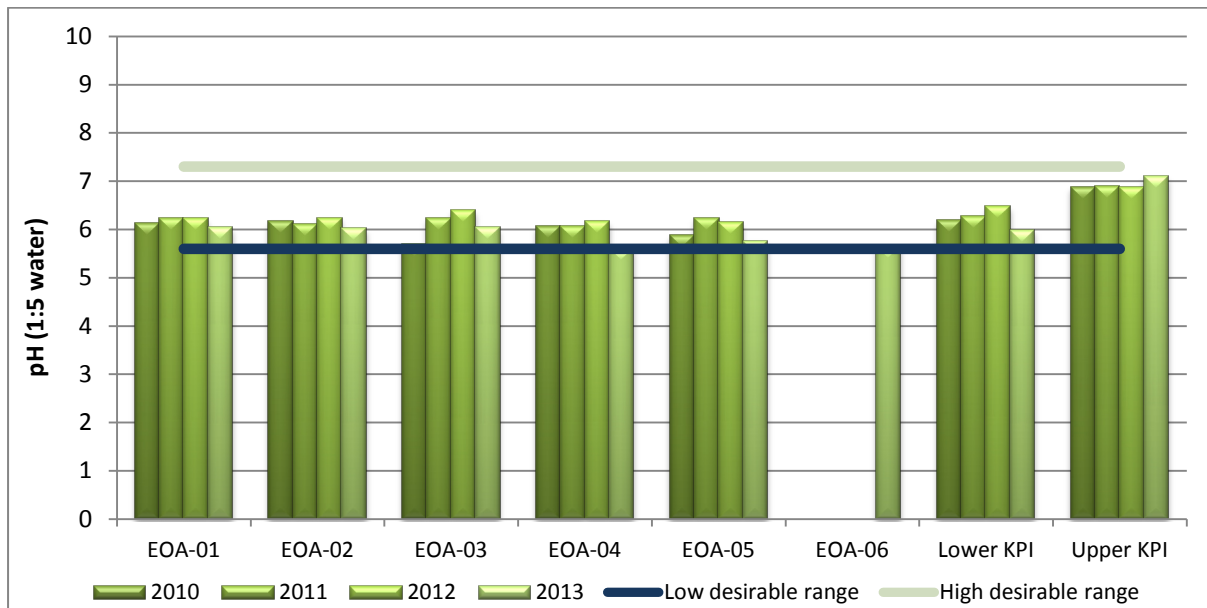


Figure 7-14. Comparison of pH values recorded in the Estcourt Offset sites compared to the upper and lower values from the woodland reference sites and the desirable level 2010 - 2013.

## 7.9.2 Conductivity

Figure 7-15 shows the Electrical Conductivity (EC) recorded in the EOA sites, the lower and upper values of the woodland reference sites as well as the “desirable” level provided by the laboratory in medium soils. This year there was a larger variability in soil EC within the reference sites and this ranged from 0.038 - 0.191 dS/m and site RWood03 had EC levels which exceeded the desirable threshold and were almost considered to be slightly saline (Slavich and Petterson 1993). In the EOA sites there was a declining trend across all sites and these ranged from a low of 0.030 dS/m in EOA-04 to a high of 0.054 dS/m in EOA-05. All sites therefore had EC levels which were within or lower than the target range and these were non saline.

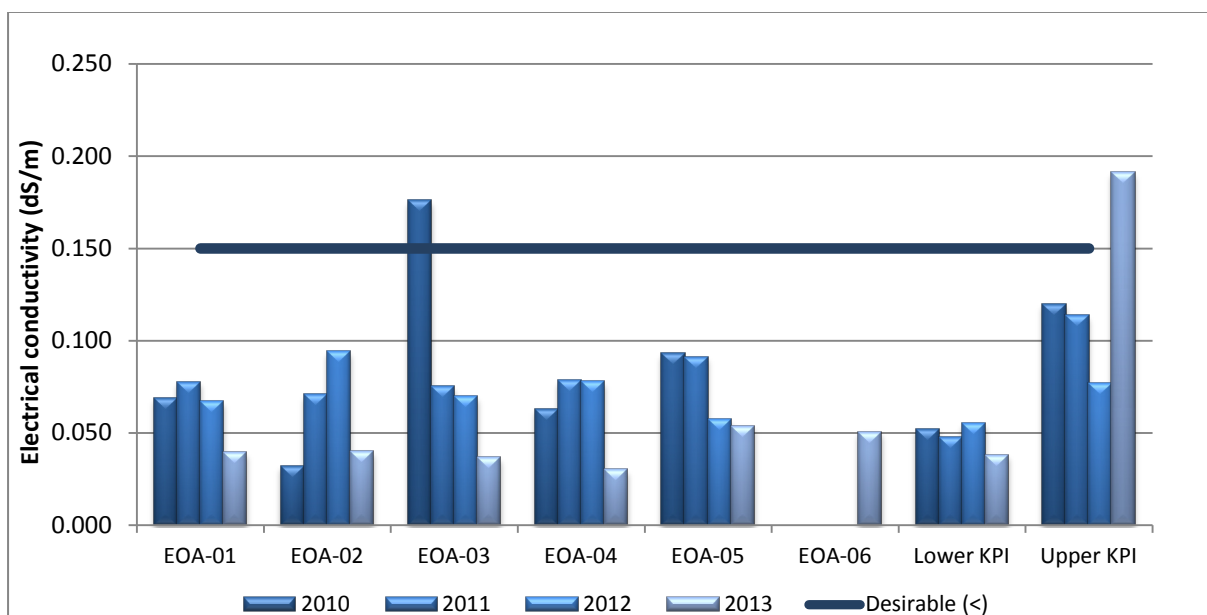


Figure 7-15. Comparison of conductivity values recorded in the Estcourt Offset sites compared to the upper and lower values from the woodland reference sites and the desirable level 2010 - 2013.

### 7.9.3 Organic Matter

There was a consistent and declining trend in OM recorded across the monitoring sites this year with the target range further narrowing to 3.01 – 4.61% (Figure 7-16). The derived grassland sites EOA-01 and EOA-02 continued to have low OM levels and this year so did the other sites, except EOA-04 which had the highest OM of 5.1%. While the OM was often lower than the prescribed desirable levels, they continued to be representative of the local NOM soils. The decline in OM was likely due to inherent site and sampling variability.

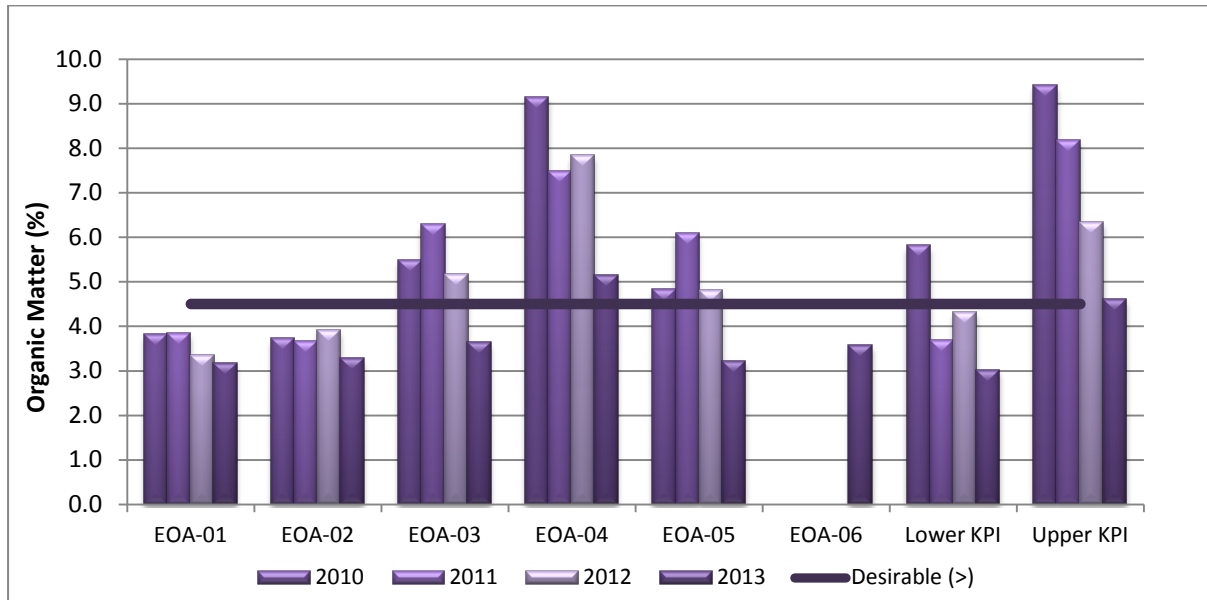


Figure 7-16. Comparison of organic matter recorded in the Estcourt Offset sites compared to the upper and lower values from the woodland reference sites and the desirable level 2010 - 2013.

### 7.9.4 Phosphorous

Phosphorous levels have continued to decline across the range of EOA monitoring sites and this year phosphorous levels in the woodland reference sites ranged from 6.4 – 17.3 mg/kg and these continued to be well below the “desirable” level reflecting the naturally low soil fertility in the area (Figure 7-17). Phosphorous levels in the derived grassland sites EOA-01 and EOA-02 had fallen below the desirable threshold but continued to exceed those of the local area probably due to their long cropping history. The remaining sites had comparatively low levels of phosphorous but these continued to fall within the local NPM ranges.

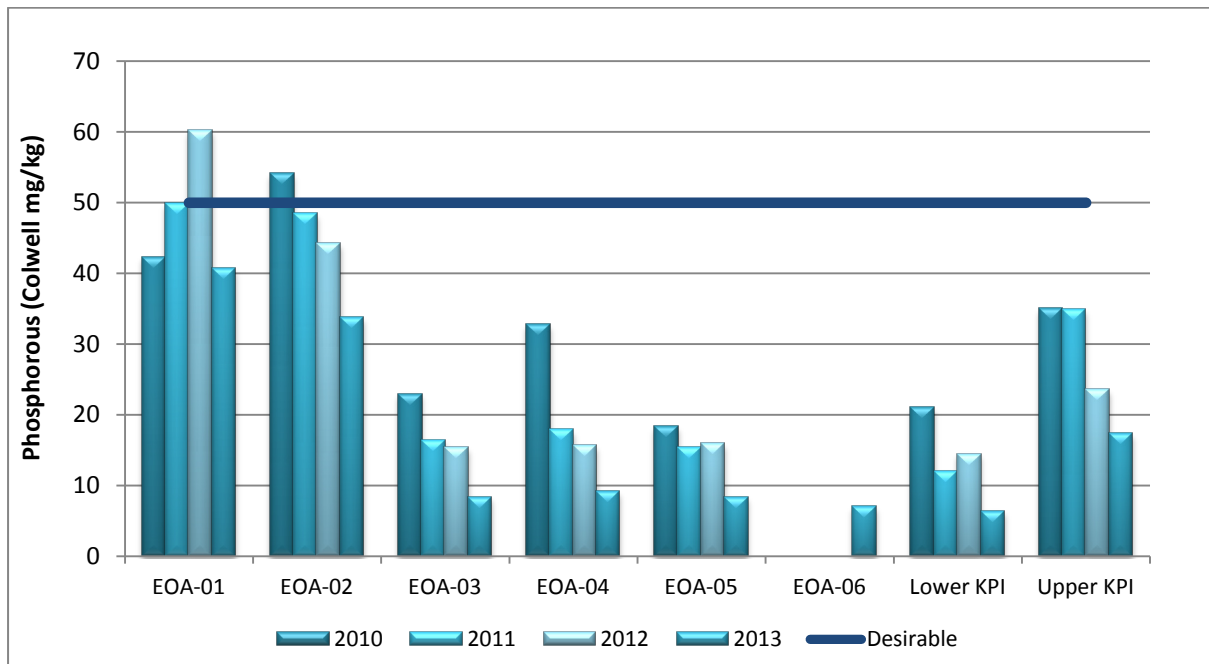


Figure 7-17. Comparison of phosphorous levels recorded in the Estcourt Offset sites compared to the upper and lower values from the woodland reference sites and the desirable level 2010 - 2013.

### 7.9.5 Nitrate

There has been no consistent trend in changes across the monitoring sites since 2010 but the most significant changes occurred in site EOA-03 and EOA-05 between 2010 and 2011 probably due to higher rainfall activity (Figure 7-18). Since then nitrate ranges in the reference sites have declined and this year provided a very low target of 1.2 – 1.9 mg/kg. While these concentrations are considerably lower than desirable levels they are a reflection of the low fertility soils and the unpredictable nature of N cycles within the soil profiles, which are also be affected by the changing seasonal conditions. Nitrate levels in the EOA sites have also demonstrated a decline this year however all sites except EOA-01 which was marginally lower with N concentrations of 0.6mg/kg, were within the local levels.

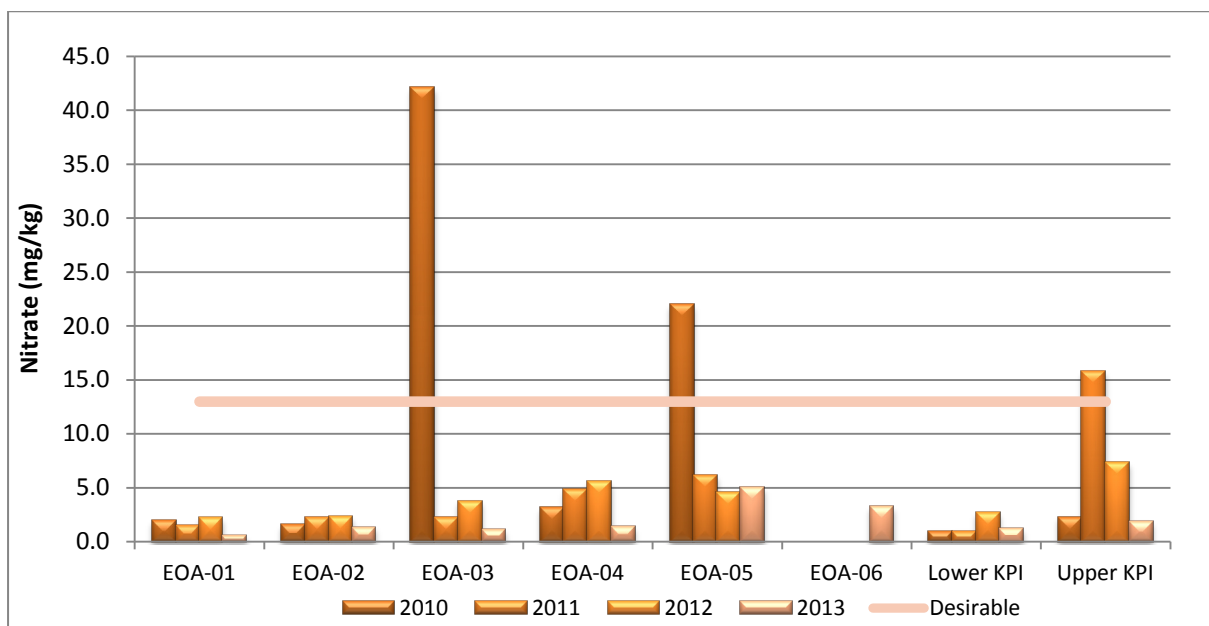


Figure 7-18. Comparison of Nitrate levels recorded in the Estcourt Offset sites compared to the upper and lower values from the woodland reference sites and the desirable level 2010 - 2013.



### 7.9.6 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. Since 2010 there has been no consistent trend in the changes in CEC across all monitoring sites and most changes have been relatively minor. This year the reference sites provided a range of 12.1 – 22.9 cmol/kg and these were slightly lower than or significantly higher than the desirable level indicating large variations in CEC exist in the local soils (Figure 7-19). All EOA sites demonstrated a decline in CEC this year and with a range from 7.9 cmol/kg (EOA-03) to 13.9 cmol/kg (EOA-05).

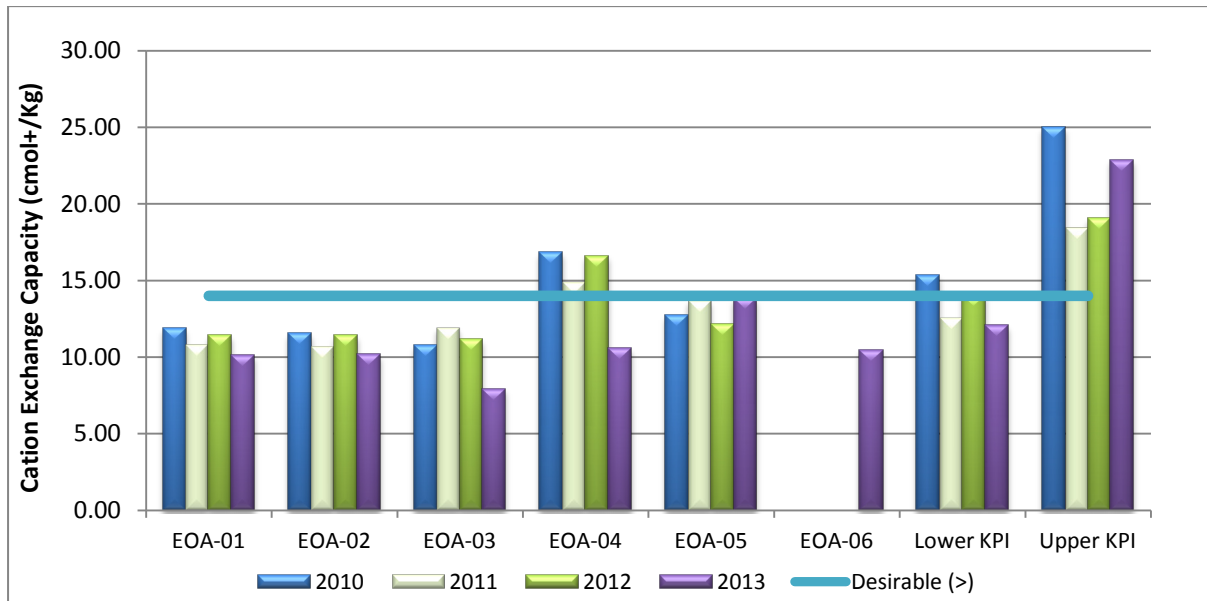


Figure 7-19. Comparison of Cation Exchange Capacity recorded in the Estcourt Offset sites compared to the upper and lower values from the woodland reference sites and the desirable level in 2010, 2011 and 2013.

### 7.9.7 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.

All of the EOA monitoring sites and reference sites continued to have non sodic soils and were below the desirable levels of 5% ESP (Figure 7-20) and in most cases there have been marginal changes over the past year. The reference sites provided a higher lower range of 0.29 – 2.42% and sites EOA-01 (4.01%) and EOA-02 (2.77%) continued to exceed this local range.

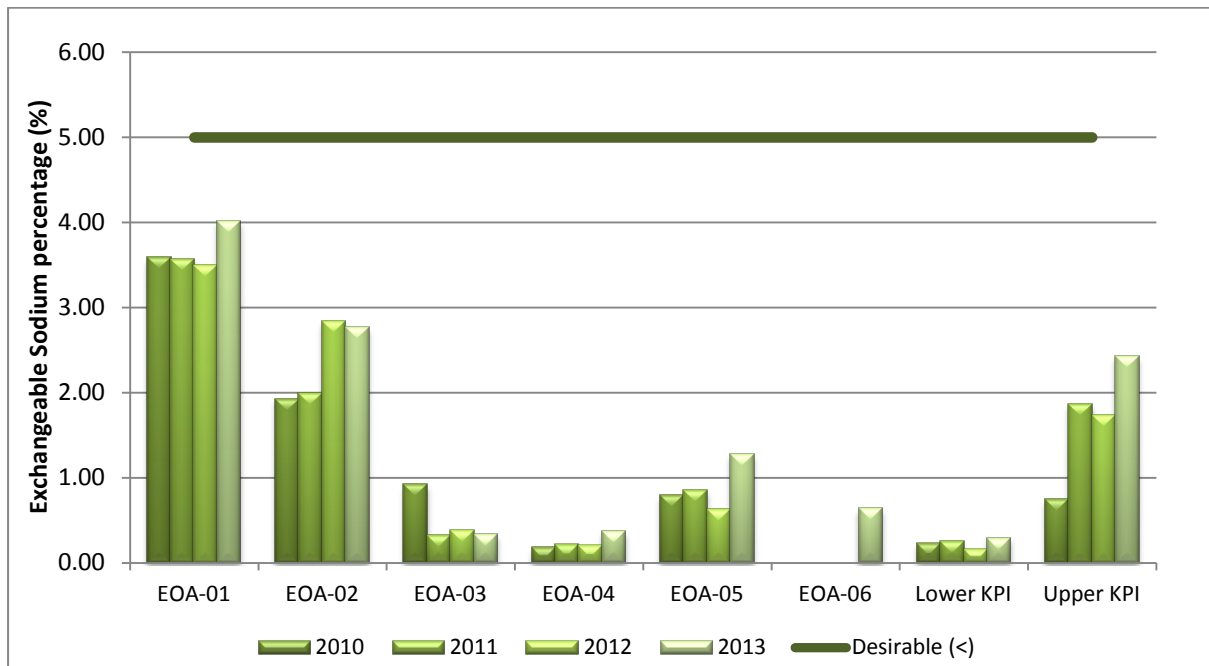


Figure 7-20. Comparison of ESP recorded in the Estcourt Offset sites compared to the upper and lower values from the woodland reference sites and the desirable level 2010 - 2013.

### 7.9.8 Other soil tests

The full results of the soil analysis are provided in Appendix 2 but a summarised version highlighting abnormal results is provided in Table 7-5. The results indicate there are numerous elements which occur at elevated levels in the Estcourt Offset Area, however in most cases these are also found to be elevated within the woodland reference sites. The results tend to indicate that various elements occur at naturally higher levels within soils surrounding the Northparkes Mine, especially Magnesium, Potassium, Manganese and Iron and are likely to be a reflection of the long agricultural and/or mining history of the local area. There was however excessively high concentrations of Manganese in EOA-04.

**Table 7-5. Summarised soil analyses highlighting abnormal test results.**

Method		Nutrient	Site		EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06	RWood01	RWood02	RWood03	RWood04	Medium Soil e.g Clay Loam
	Morgan 1	Calcium	Ca	mg/kg	514	540	543	786	1508	1183	2118	796	569	697	750
		Magnesium	Mg		277	247	128	171	458	520	682	228	220	218	105
		Potassium	K		222	260	225	150	256	181	134	242	227	175	75
	KCl	Sulfur	S	mg/kg	1.9	5.3	2.7	7.6	7.1	4.3	8.0	10.1	8.4	9.8	8.0
	DTPA	Zinc	Zn	mg/kg	0.9	1.2	0.7	1.7	1.4	0.7	0.5	6.9	0.7	1.5	5.0
		Manganese	Mn		76	63	25	136	108	37	46	92	86	98	22
		Iron	Fe		122	117	90	91	40	30	36	61	87	59	22
		Copper	Cu		4.2	5.5	4.0	7.1	3.5	5.5	3.0	15.8	3.8	7.1	2.0
	CaCl <sub>2</sub>	Silicon	Si	mg/kg	69	71	34	56	32	108	34	66	50	72	45
	Total Acid Extractable	Chromium	Cr	mg/kg	20	24	14	29	21	73	21	20	26	22	<25 Cr

Purple = Excessively high; Brown = significantly high; Red = very high; Yellow = moderately high; Green = slightly high



## 8 Estcourt Offset Area: Site performance towards meeting woodland completion criteria targets

Table 8-1 indicates the performance of the Estcourt Offset Area monitoring sites against a selection of proposed Completion Performance Indicators developed for woodland communities during the 2013 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 development (blue). The range values are amended annually.

Revegetation sites meeting or exceeding the range values of their representative community type 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 2013. 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 8-1. Performance of the Estcourt Offset Area monitoring sites against a selection of proposed Woodland Completion Performance Indicators or completion criteria.**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06
Performance indicators are quantified by the range of values obtained from replicated reference sites						Lower	Upper	2013	2013	2013	2013	2013	2013
Phase2: Landform establishment and stability	Landform function	Landform is functional and performing as it was designed to do	LFA Stability	Based on key physical, biological and chemical characteristics the LFA stability index provides an indication of the sites stability and that it is comparable to or trending towards that of the local remnant vegetation	%	62.9	69.0	73.0	71.0	70.0	70.5	70.5	65.5
			LFA Infiltration	Based on key physical, biological and chemical characteristics the LFA infiltration index provides an indication of the sites infiltration capacity and that it is comparable to or trending towards that of the local remnant vegetation	%	41.1	55.7	41.7	45.0	50.3	49.4	47.8	40.5
			LFA Nutrient recycling	Based on key physical, biological and chemical characteristics the LFA nutrient recycling index provides an indication of the sites ability to recycle nutrient and that it is comparable to or trending towards that of the local remnant vegetation	%	36.2	53.0	42.2	44.3	47.3	44.3	44.1	36.2

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06
			LFA Landscape organisation	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and that it is comparable to that of the local remnant vegetation	%	100	100	100	100	100	100	100	100
	Active erosion	Areas of active erosion are limited	No. Rills/Gullies	Provides an assessment of the number of gullies or rills occurring in a 50m transect and that these are limited and stabilising	No.	0	0	0	0	0	0	0	0
Phase 3: Growth medium development	Soil chemical, physical properties and amelioration	Soil properties are suitable for the establishment and maintenance of selected vegetation species	pH	pH is typical of that of the surrounding landscape or falls within desirable ranges provided by the agricultural industry	pH (5.6 - 7.3)	6.0	7.1	6.0	6.0	6.0	5.62	5.76	5.68
			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)	3.0	4.6	3.2	3.3	3.6	5.1	3.2	3.6
			Nitrate	Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	ppm (>12.5)	1.2	1.9	0.6	1.4	1.2	1.4	5.0	3.2
Phase 4: Ecosystem & Landuse Establishment	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	6	1	1	1	2	1	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	100	100
			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	13	27	24	22	21	19	20	17
	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	29	110	12	15	12	2	14	9

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06
	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	2	4	1	1	1	1	1	2
			Shrubs	The number of shrub species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	3	0	0	0	1	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	33	46	24	21	37	38	41	53
Phase 5: Ecosystem & Landuse Development	Protective ground cover	Ground layer contains protective ground cover and habitat structure comparable with 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	%	7	25	8.5	16.5	31	36.5	31	25
			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	%	89	95	100	100	100	100	99.5	98.5
	Native ground cover abundance	Native ground cover abundance is comparable to that of the local remnant vegetation	Percent ground cover provided by native vegetation <0.5m tall	The percent ground cover abundance of native species (<0.5m height) compared to exotic species is comparable to that of the local remnant vegetation	%	63.4	87.1	30.7	29.5	62.9	73.4	66.3	87.1
	Ecosystem growth and natural recruitment	The vegetation is maturing and/or natural recruitment is occurring at rates similar to those of the local remnant vegetation	shrubs and juvenile trees 0 - 0.5m in height	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	7	89	12	15	12	2	14	6
			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	18	0	0	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06
	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	1	9	1	11	4	0	0.5	0
			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	17	42	0	0	0	19	8	9
	Tree diversity	Vegetation contains a diversity of maturing tree and shrubs species comparable to that of the local remnant vegetation	Tree diversity	The percentage of maturing trees and shrubs with a stem diameter > 5cm dbh which are local endemic species and these percentages are comparable to the local remnant vegetation	%	100	100	0	0	0	100	100	100
	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	83	100	0	0	0	66.7	60	76.5
			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	7	47	0	0	0	14.3	60.0	23.5
			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	50	83	0	0	0	38.1	60	47.1



## 9 Recommendations and management actions

Most sites have demonstrated a further decline in ecological function largely due to a decrease in perennial plant cover and in some sites there was also less litter depth and states of decomposition however in most instances these changes were also reflected within the woodland reference sites, indicating it has been a direct response to the seasonal conditions and levels of macropod activity.

These data indicate that even the most historically disturbed derived grassland sites EOA-01 and EOA-02 were ecologically functional communities and were comparable or similar to the local woodland reference communities, despite the absence of a mature canopy layer. The new EOA-06 site which suffered a grass fire last year also appears to have recovered and was ecologically comparable with an unaffected woodland, despite having a cover of litter cover which had not yet accumulated to depth and the presence of very hard setting soils.

Ecological attributes which fell short of meeting the target ranges were largely associated with low native species diversity and in the derived grasslands, annual exotic species remained dominant and were weedier than desired. Despite natural recruitment being recorded in all sites this year, there continued to a low density of shrubs and juvenile trees and a low diversity of tree (and shrub) species in all EOA sites. Many ecological attributes that were not met were largely related to the mature tree population and the structural complexity of the sites due to the lack of a well developed overstorey.

The proposed revegetation activity within the EOA (GHD 2010) aims to increase biodiversity and habitat values through tubestock planting within the more cleared grassland areas (eg EOA-01 and EOA-02) and encourage natural regeneration within more open woodland areas (eg EOA-03, EOA-04 and EOA-05) combined with supplementary planting of shrubs which were currently limited in distribution across the conservation area. Care should be taken to limit disturbance or additional planting in areas that are already successfully regenerating at least in the short term, until active regeneration requirements can clearly be identified.

While the composition of the ground cover in the cleared grassland sites contained a high proportion of exotic species these sites have demonstrated a significant improvement in many other ecological attributes indicating a positive successional response. However the extreme seasonal conditions between monitoring years has had a significant effect on the ground cover composition in all sites therefore profound changes in ecological recovery should also be considered with a degree of flexibility. While some sites contained many weedy species, these species are part of the successional process and will make a positive contribution in providing protective ground cover and assisting with the development of the microbial and nutrient recycling process and most species are likely to decline in abundance over time. However some species are also common components of the native grasslands and agricultural land in the local NPM environment and therefore some species are likely to persist and these will be reflected in the reference sites.

There are few other management issues that have not already been addressed in the Rehabilitation Management Plan (GHD 2010).

Regular slashing of the main access tracks is recommended to allow safe and easy access for maintenance and monitoring of the sites.

## 10 Individual site descriptions

### 10.1 EOA-01 site description

EOA-01 is a derived grassland situated in the northeast of the Estcourt Offset Area. The site was an old cropping paddock that has not been recently grazed.

In 2010 it contained a diverse understorey of native and introduced species including *Dichondra repens*, *Hordeum leporinum*, *Chloris truncata* and *Medicago polymorpha*. There was high floristic diversity (57 species) and native species (34) were more abundant than exotic species (23). There was good ground cover with perennial plants providing 30.5% of the ground cover. Annuals provided 30.5% and cryptogams were moderately abundant. There were scattered occurrences of *Echium plantagineum*, *Arctotheca calendula*, *Centaurea melitensis* and *Sonchus oleraceus*. In 2011, there were increased levels of ground over, decreased abundance of cryptogams but maintained a high diversity of native and exotic species. In 2012 the site was similar to but drier than the previous year and seven *C. glaucophylla* seedlings were found. In 2013, annual species continued to be dominant. Eleven *C. glaucophylla* seedlings were recorded.

#### 10.1.1 Landscape Function Analysis

##### 10.1.1.1 Landscape organisation

EOA-01 continued to be characterised as a grassland patch and with excellent ground cover scored a Landscape Organisation Index of 1.0 and was 100% capable of harnessing mobile resources (Figure 10-1, Table 10-1). Between 2010 and 2011 there was a marginal improvement in ecological function largely due to increased levels of litter cover which have begun to accumulate some depth across most of the site and this had also slightly increased the soil surface relief. In 2012 and 2013 there has been a slight decline in ecological function due to the declining levels of perennial plant and cryptogam cover.

The resultant LFA indices for stability, infiltration and nutrient recycling were 73.0, 41.7 and 42.2 respectively and this year these were within the local levels and were 10.1, 0.6 and 6.0 LFA units higher than the minimum target range.



Figure 10-1. Permanent photo point taken from the top of the LFA transect in 2012 (left) and 2013 (right).

Table 10-1. Summary of landscape organisation and LFA indices in 2010, 2011, 2012 and 2013.

EOA-01		24/09/2010		20/10/2011		18/10/2012		16/10/2013	
Number of Patches/10m		0.5		0.5		0.5		0.5	
Total Patch Area (m2)		200		200		200		200.00	
Patch Area Index		1		1		1		1.00	
Landscape Organisation Index		1		1		1		1.00	
Average Interpatch Length (m)		NA		NA		NA		NA	
Range Interpatch length (m)		NA		NA		NA		NA	
Patch or Interpatch Type		Grassland Patch		Grassland Patch		Grassland Patch		Grassland patch	
Patch or Interpatch Proportion (%)		100	100	100	100	100	100	100.0	100
Soil Surface Assessment									
Within Individual Zones	Stability	77.5		78.5		75.5		73.0	
	Infiltration	43.3		44.5		42.3		41.7	
	Nutrients	44.6		47.4		42.7		42.2	
			Total		Total		Total		Total
Individual zones contribution to the whole of Landscape	Stability	77.5	77.5	78.5	78.5	75.5	75.5	73.0	73.0
	Infiltration	43.3	43.3	44.5	44.5	42.3	42.3	41.7	41.7
	Nutrients	44.6	44.6	47.4	47.4	42.7	42.7	42.2	42.2

### 10.1.1.2 Soil Surface Assessment

There continues to be a decline in perennial plant cover within the recovering grassland area as a result of the dry conditions and this has resulted in less protection against the impacts of raindrops and less perennial basal cover within the site (Table 10-2). There were however marginal improvements in the cover provided by dead leaf litter and this has been accumulating some depth and while slight decomposition was evident in most cases, one sample indicated moderate levels of decomposition were occurring, and this is an indication of improved microbial and fungal activity.

The soil surface remained crusted and cryptogams were less abundant with only minor populations observed on two occasions this year, due to increasing levels of litter cover. There continued to be moderate soil surface relief which was provided by the scattered plants and there was little evidence of erosion or deposition despite the high rainfall activity during June. The clay loam soils were very hard this year and the slake test continued to indicate the soils were very stable.

**Table 10-2 . Results of the Soils Surface Assessment for the Grassland patch.**

Features	Max score	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Soil Cover	5	3	2	2	2	2
Per. basal / canopy cover	4	2	2	2	2	2
Litter cover, orig & incorp.	10	6ls	6ls	5ls	5ls	6lm
Cryptogam cover	4	1	2	2	1	1
Crust broken-ness	4	4	4	4	4	4
Erosion type & severity	4	4	4	4	4	4
Deposited materials	4	4	4	4	4	4
Soil surface roughness	5	3	3	3	3	3
Surface resist. to disturb.	5	4	4	4	4	4
Slake test	4	4	4	4	4	4
Texture	4	2	2	2	2	2

### 10.1.2 Soil analyses

The result of the soil analyses indicates there have only been minor changes in the soil characteristics since 2010 and this year minor reductions in numerous attributes were recorded and were likely to have been due to the prolonged dry conditions and inherent site and sampling variability. The soil pH was borderline slightly - moderately acidic but within local ranges (Table 10-3). The Electrical Conductivity continued to be low indicating low levels of soluble salts and the presence of non saline soils. Organic Matter content was typical of the local area but phosphorous levels were high and nitrates and CEC were low. There was a minor increase in ESP and while it remained higher than the reference sites it was below the desirable level indicating that the soils are non sodic.

**Table 10-3. Results of the soil analysis for EOA-01 compared to the upper and lower values for the woodland reference sites and desirable levels in 2010, 2011, 2012 and 2013.**

Nutrient	Units	EOA-01				Lower KPI	Upper KPI	Desirable Level
		2010	2011	2012	2013			
pH (1:5 water)	units	6.13	6.22	6.22	6.04	5.99	7.10	5.6 – 7.6
Conductivity (1:5 water)	dS/m	0.069	0.078	0.067	0.039	0.04	0.19	0.150
Organic Matter	%	3.8	3.8	3.3	3.2	3.01	4.61	>4.5
Phosphorus (Colwell)	mg/kg	42	50	60	41	6.41	17.29	50
Nitrate	mg/kg	2.0	1.5	2.2	0.6	1.20	1.88	13.0
Cation Exchange Capacity	cmol <sup>+</sup> /Kg	11.90	10.83	11.42	10.10	12.05	22.87	14.00
Exchangeable Sodium Percentage	%	3.59	3.57	3.49	4.01	0.29	2.42	<5

### 10.1.3 Rill assessment

No rills were observed within the monitoring quadrat in any monitoring year.

### 10.1.4 Tree density and health condition

No trees or shrubs with a stem dbh >5cm were recorded within this site.



### 10.1.5 Shrubs and regeneration

This year twelve *Callitris glaucophylla* seedlings were found and have been the result of natural recruitment event probably initiated during high rainfall activity over the summer of 2011-2012. All seedlings remained less than 0.5m in height and at the time of monitoring were approximately 10 - 20cm tall. Many other juvenile *C. glaucophylla*, *E. microcarpa* and *E. populnea* were now visible within the larger paddock areas a result of natural recruitment stimulated by the good summer rainfall over the past two years.

Table 10-4. Shrubs and young trees occurring within the monitoring site.

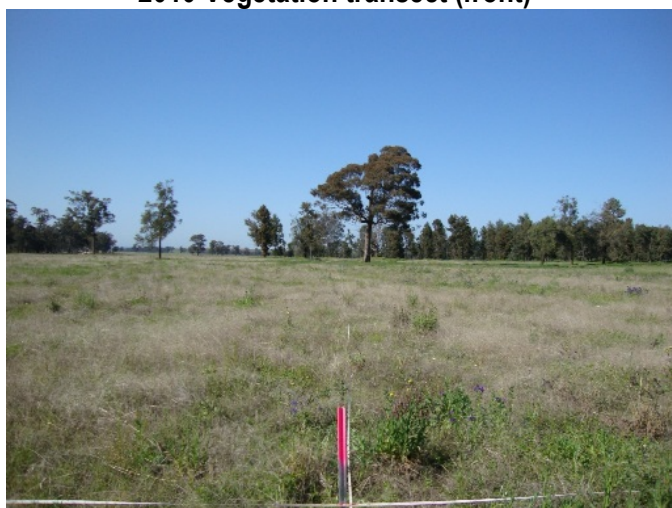
Species	0 - 0.5m	0.5 - 1.0m	1.0 - 1.5m	1.5 - 2.0m	>2.0m	Total	endemic	not endemic
<i>Callitris glaucophylla</i>	12					12	12	
<b>Total</b>	<b>12</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>12</b>	<b>12</b>	<b>0</b>
<b>% endemic species</b>							<b>100</b>	<b>0</b>

### 10.1.6 Structural diversity and habitat complexity

There has been very little change in the overall structure of this recovering native grassland which remains devoid of a shrub and canopy layer (Figure 10-2). The site continues to be structurally simple and has maintained very high levels of total ground cover which provided 100% cover this year (Figure 10-3). The understorey continued to be dominated by dead leaf litter and annual plants which provided 53% and 38% of ground cover respectively. There continued to be low levels of cryptogams (0.5%) and perennial plants (8.5%) but these were in similar proportions as found in the reference sites.

No other habitat features such as rocks or logs were recorded. With the relatively dry spring weather combined with some macropod grazing the vegetative cover had been kept quite low, apart from some a few scattered weed which provide limited cover >0.5m in height on two occasions. Table 10-5 provides the average and minimum and maximum values obtained along the vegetation transect in 2013.

2010 Vegetation transect (front)



2010 Vegetation transect (rear)





Figure 10-2. Permanent photo points taken from the front (left) and rear (right) of the vegetation transect.



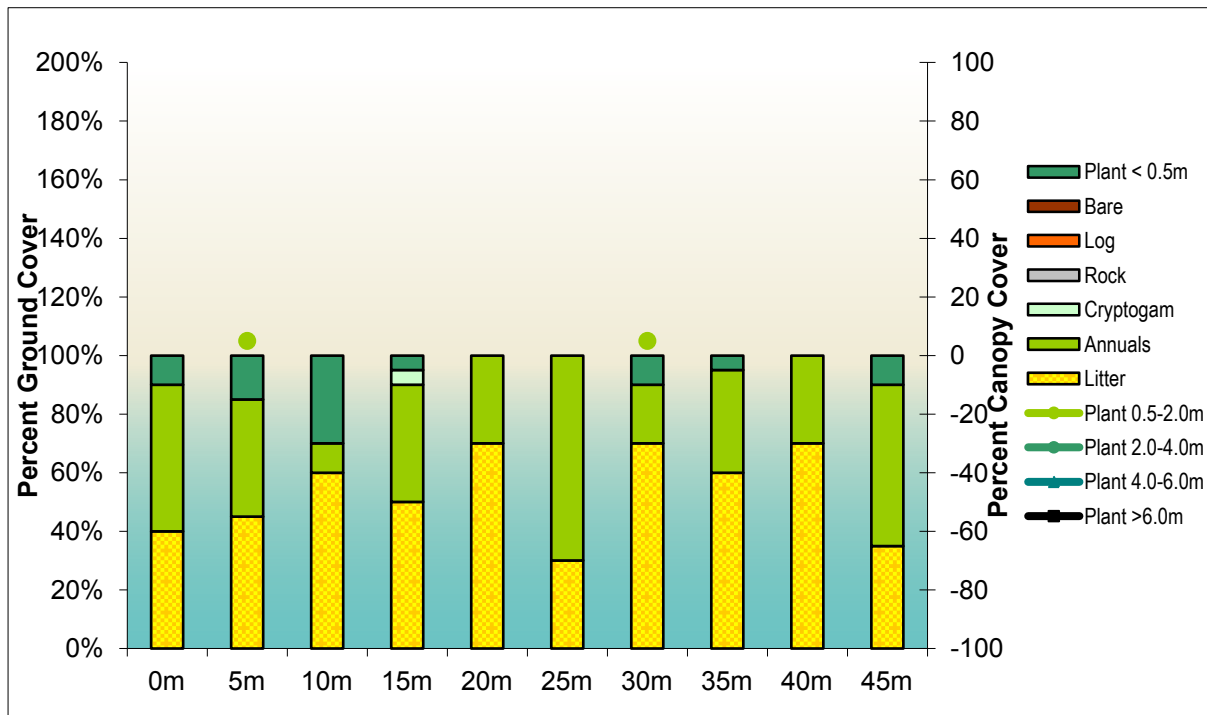


Figure 10-3. Graph illustrating the structural diversity and habitat complexity of the monitoring site.

Table 10-5. Average and minimum and maximum values of the structural diversity of the monitoring site.

Vegetation structure	0m	5m	10m	15m	20m	25m	30m	35m	40m	45m	Average	Min	Max
Litter	40	45	60	50	70	30	70	60	70	35	53	30	70
Annuals	50	40	10	40	30	70	20	35	30	55	38	10	70
Cryptogam	0	0	0	5	0	0	0	0	0	0	0.5	0	5
Rock	0	0	0	0	0	0	0	0	0	0	0	0	0
Log	0	0	0	0	0	0	0	0	0	0	0	0	0
Bare	0	0	0	0	0	0	0	0	0	0	0	0	0
Perennial <0.5m	10	15	30	5	0	0	10	5	0	10	8.5	0	30
Total Ground Cover	100	100	100	100	100	100	100	100	100	100	100	100	100
0.5-2.0m	0	5	0	0	0	0	5	0	0	0	1	0	5
2.0-4.0m	0	0	0	0	0	0	0	0	0	0	0	0	0
4.0-6.0m	0	0	0	0	0	0	0	0	0	0	0	0	0
>6.0m	0	0	0	0	0	0	0	0	0	0	0	0	0

### 10.1.7 Species cover abundance

There was 25 species recorded in the five 1m<sup>2</sup> quadrats on the permanent vegetation transect line including 14 exotic species. Using the Braun-blauquet scale, the highest possible cover score that can be obtained is 30 and cover abundance is illustrated as a sum of scores (class values) obtained along the five 1m<sup>2</sup> quadrats.

In previous years *Medicago truncatula* has been the most common and abundant species followed by *Bromus molliformis* and the native grass species *Chloris truncata* while *Trifolium* species and *Wahlenbergia gracilis* were very also very common.

This year the exotic annual grass *Bromus molliformis* was the most dominant species, with other common species being *Trifolium campestre*, *Echium plantagineum*, *Carthamus lanatus* and *Medicago truncatula* (Figure 10-4, Table 10-6). The native species *Enteropogon acicularis* was also relatively common as was *Chloris truncata* and *Wahlenbergia gracilis*. The remaining species were less common

and/or provided lower cover values. Of the live plant cover scores recorded 30.7% was provided by native species and this was a reduction from 38.6% recorded last year.

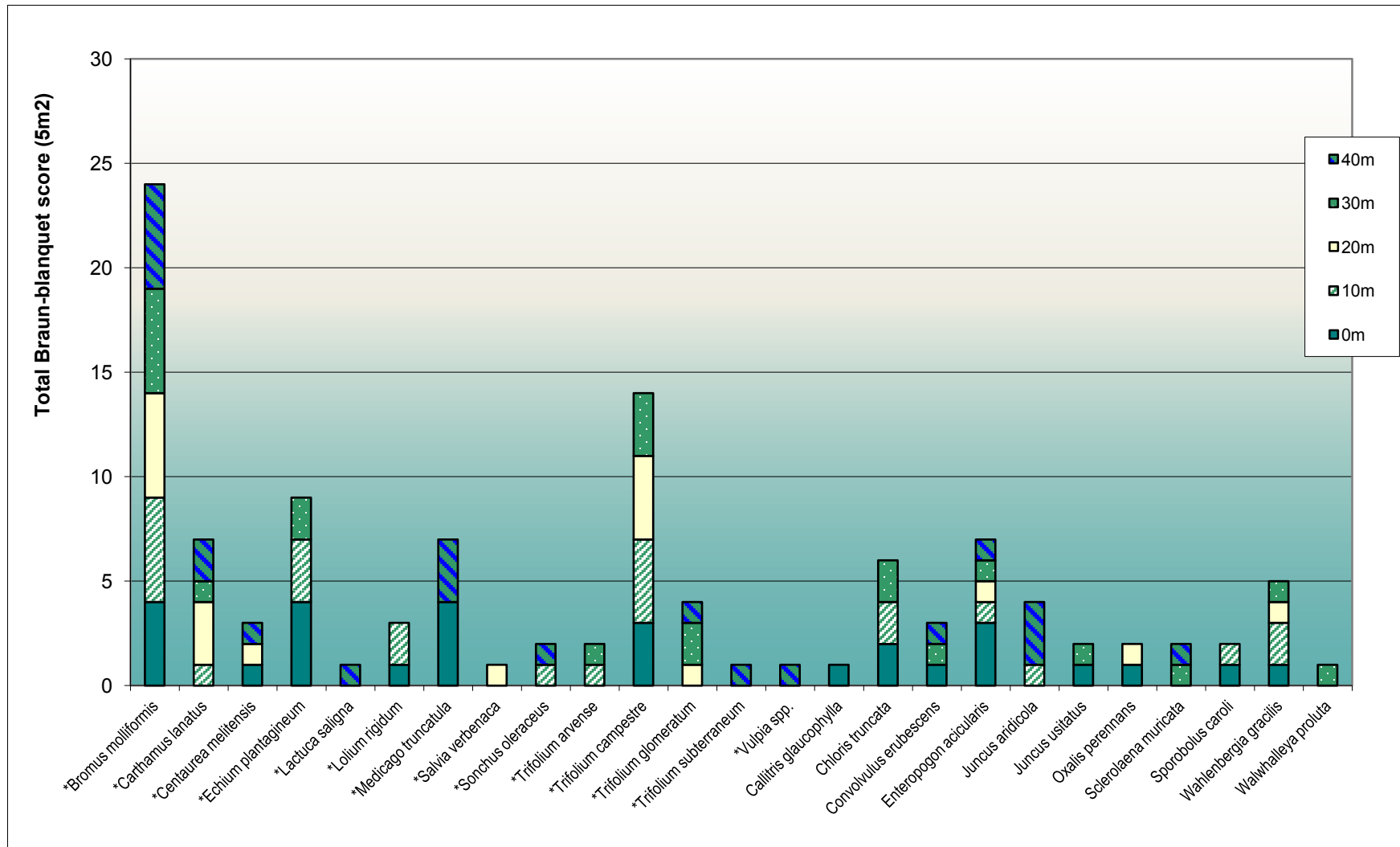


Figure 10-4. Total species recorded across the five, 1m<sup>2</sup> quadrats using the Braun-blauquet scale (max possible score is 30) as a measure of cover abundance in 2013.



**Table 10-6. List of species and their average cover abundance score across the five, 1m<sup>2</sup> monitoring quadrats.**

<b>Species</b>	<b>0m</b>	<b>10m</b>	<b>20m</b>	<b>30m</b>	<b>40m</b>	<b>Total</b>
* <i>Bromus molliformis</i>	4	5	5	5	5	24
* <i>Carthamus lanatus</i>		1	3	1	2	7
* <i>Centaurea melitensis</i>	1		1		1	3
* <i>Echium plantagineum</i>	4	3		2		9
* <i>Lactuca saligna</i>					1	1
* <i>Lolium rigidum</i>	1	2				3
* <i>Medicago truncatula</i>	4				3	7
* <i>Salvia verbenaca</i>			1			1
* <i>Sonchus oleraceus</i>		1			1	2
* <i>Trifolium arvense</i>		1		1		2
* <i>Trifolium campestre</i>	3	4	4	3		14
* <i>Trifolium glomeratum</i>			1	2	1	4
* <i>Trifolium subterraneum</i>					1	1
* <i>Vulpia spp.</i>					1	1
<i>Callitris glaucophylla</i>	1					1
<i>Chloris truncata</i>	2	2		2		6
<i>Convolvulus erubescens</i>	1			1	1	3
<i>Enteropogon acicularis</i>	3	1	1	1	1	7
<i>Juncus aridicola</i>		1			3	4
<i>Juncus usitatus</i>	1			1		2
<i>Oxalis perennans</i>	1		1			2
<i>Sclerolaena muricata</i>				1	1	2
<i>Sporobolus caroli</i>	1	1				2
<i>Wahlenbergia gracilis</i>	1	2	1	1		5
<i>Walwhalleya proluta</i>				1		1
<b>Total cover</b>						114
<b>Sum of cover of native species</b>						35
<b>Percent endemic species cover</b>						30.7

### 10.1.8 Floristic diversity

The floristic diversity of the sites was measured using two different methods. One provides an assessment of the average number of species within five, one square metre (m<sup>2</sup>) sub-quadrats along the vegetation transect, while the other provides the total number of species within the entire 50x20m monitoring plot.

#### 10.1.8.1 Species diversity per m<sup>2</sup>

There has continued to be a slight decline in native species diversity from 5.6 - 5.4 native species per m<sup>2</sup> on average, and this year there was a reduction from 9.0 – 6.8 exotic species per m<sup>2</sup> (Table 10-7). The number of native species ranged between 3 – 8 species per m<sup>2</sup>, while the number of exotic species ranged between 6 – 9 species per m<sup>2</sup>.

**Table 10-7. Species diversity per 1m<sup>2</sup>.**

<b>Species /m2</b>	<b>0m</b>	<b>10m</b>	<b>20m</b>	<b>30m</b>	<b>40m</b>	<b>Avg/m2</b>	<b>SD</b>
Native	8	5	3	7	4	5.4	2.1
Exotic	6	7	6	6	9	6.8	1.3
<b>Total</b>	<b>14</b>	<b>12</b>	<b>9</b>	<b>13</b>	<b>13</b>	<b>12.2</b>	<b>1.9</b>

### 10.1.8.2 Total species diversity

The total floristic diversity has increased from 33 - 46 species in the 50 x 20m monitoring quadrat this year but this included 24 exotic species (Figure 10-5, Table 10-8). The gradual and relatively low shape of the species area curve indicates the site was relatively homogenous, with new species recorded at a relatively low rate. A list of species recorded within the monitoring site is provided in Appendix 1.

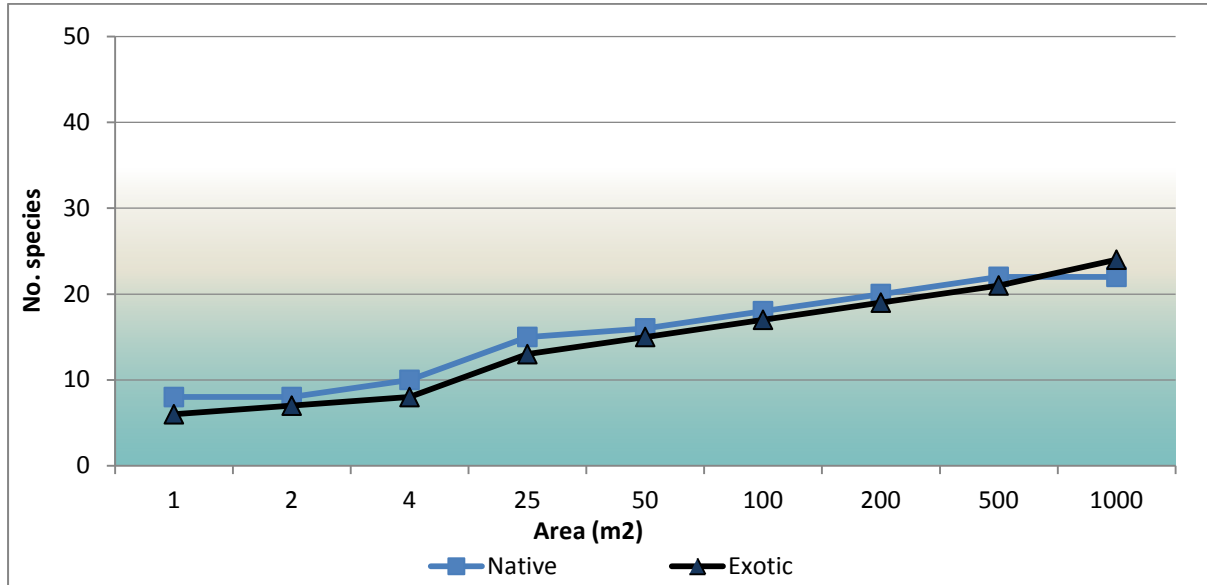


Figure 10-5. Cumulative species in the 50m x 20m (1000m²) monitoring quadrat.

Table 10-8. Cumulative species diversity.

Area (m2)	1	2	4	25	50	100	200	500	1000
Native	8	8	10	15	16	18	20	22	22
Exotic	6	7	8	13	15	17	19	21	24

### 10.1.9 Growth forms

Figure 10-6 is a summary of species in each growth form that were recorded in EOA-01. Herbs continued to be the most dominant plant type with 24 species including 18 exotic species followed by 16 different grass species which included 6 exotic species. There was one tree, two native sub-shrubs and three reed species. No shrubs or fern representatives were found. Compared to the woodland reference sites, there was a lack of tree (and shrub) species and a low number of herbs.

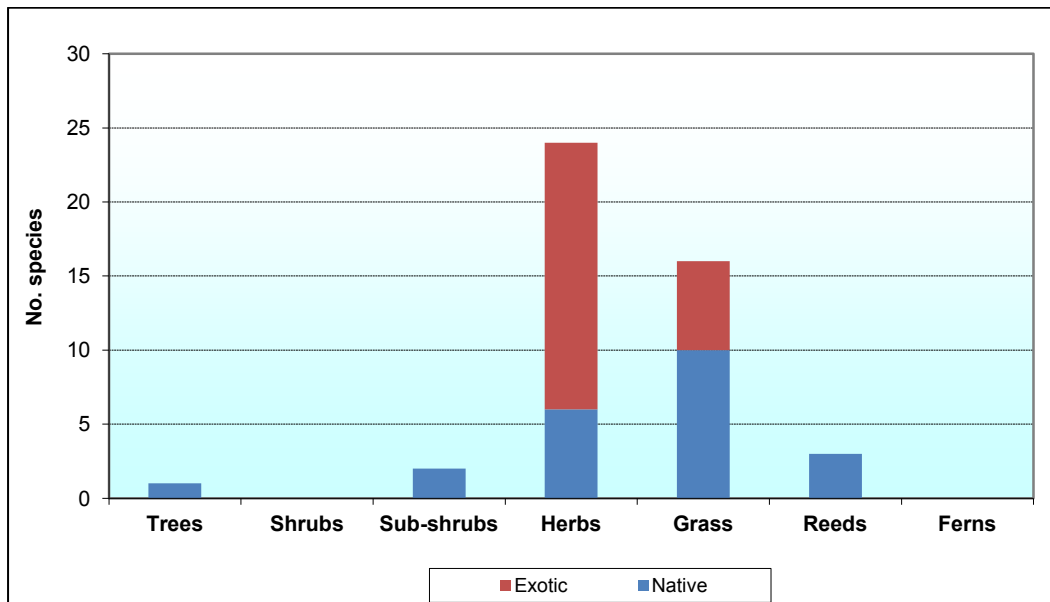


Figure 10-6. Graph illustrating the growth forms of species recorded in the 50m x 20m monitoring quadrat.

## 10.1.10 Comparison of rehabilitation data with key performance indicators

Table 10-9 indicates the performance of the monitoring site against the Completion and Desirable Performance Indicators developed for woodland sites during the 2013 monitoring period. The selection of criteria have been presented in order of ecosystem successional processes, beginning with landform establishment and stability (orange) for example and ending with indicators of ecosystem and landuse development (blue). The range values will be amended annually.

Rehabilitation sites meeting or exceeding the range values of their representative community type have 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 2013. 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 10-9. Comparison of key performance Indicators recorded in the offset site EOA-01 compared to lower and upper limits recorded in the woodland reference sites.**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-01			
Performance indicators are quantified by the range of values obtained from replicated reference sites							Lower	Upper	2010	2011	2012	2013
Phase2: 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°)	0	5	1	1	1	1
	Landform function	Landform is functional and performing as it was designed to do	LFA Stability	Based on key physical, biological and chemical characteristics the LFA stability index provides an indication of the sites stability and that it is comparable to or trending towards that of the local remnant vegetation		%	62.9	69.0	77.5	78.5	75.5	73.0
			LFA Infiltration	Based on key physical, biological and chemical characteristics the LFA infiltration index provides an indication of the sites infiltration capacity and that it is comparable to or trending towards that of the local remnant vegetation		%	41.1	55.7	43.3	44.5	42.3	41.7
			LFA Nutrient recycling	Based on key physical, biological and chemical characteristics the LFA nutrient recycling index provides an indication of the sites ability to recycle nutrient and that it is comparable to or trending towards that of the local remnant vegetation		%	36.2	53.0	44.6	47.4	42.7	42.2
			LFA Landscape organisation	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and that it is comparable to that of the local remnant vegetation		%	100	100	100	100	100	100



Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-01			
	Active erosion	Areas of active erosion are limited	No. Rills/Gullies	Provides an assessment of the number of gullies or rills occurring in a 50m transect and that these are limited and stabilising		No.	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
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)	6.0	7.1	6.18	6.22	6.22	6.0
			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)	0.038	0.191	0.069	0.078	0.067	0.039
			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)	3.0	4.6	3.8	3.8	3.3	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)	6.4	17.3	42.3	49.9	60.2	40.7
			Nitrate	Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		ppm (>12.5)	1.2	1.9	2.0	1.5	2.2	0.6
			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)	12.0	22.9	11.90	10.83	11.42	10.10
			ESP		Exchangeable Sodium Percentage (a measure of sodicity) is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	% (<5)	0.3	2.4	3.59	3.57	3.49	4.0
Phase 4: Ecosystem & Landuse Establishment	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	6	0	1	1	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	na	100	100	100
			Total species richness		The total number of live plant species provides an indication of the floristic diversity of the site and is comparable to the local remnant vegetation	No./area	53	76	57	58	59	46

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-01			
			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	33	53	34	31	33	22
			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	13	27	23	27	26	24
	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	29	110	0	1	7	12
	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	2	4	0	1	1	1
			Shrubs	The number of shrub species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	0	3	0	0	0	0
			Sub-shrubs		The number of sub-shrub species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	1	5	2	2	2	2
			Herbs	The number of herbs or forb species comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	33	46	39	38	33	24
			Grasses		The number of grass species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	9	22	15	14	20	16
			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	1	3	3	3
			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
			Ferns		The number of ferns comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	1	0	0	0	0
Phase 5: Ecosystem & Landuse Development	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	%	47	77	28.5	43.5	56	53
			Annual plants		Percent ground cover provided by live annual plants is comparable to that of the local remnant vegetation	<%	2	22	32	45.5	36	38

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-01			
			Cryptogam cover		Percent ground cover provided by cryptogams (eg mosses, lichens) is comparable to that of the local remnant vegetation	%	0	8	9	0	0	0.5
			Rock		Percent ground cover provided by stones or rocks (> 5cm diameter) is comparable to that of the local remnant vegetation	%	0	1	0	0	0	0
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	0	3	0.0	0	0.5	0
			Bare ground		Percentage of bare ground is less than or comparable to that of the local remnant vegetation	< %	6	11	0	0	0.5	0
			Perennial plant cover (< 0.5m)	Percent ground cover provided by live perennial vegetation (< 0.5m in height) is comparable to that of the local remnant vegetation		%	7	25	30.5	11	7	8.5
			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		%	89	95	100	100	99.5	100
	Ground cover diversity	Vegetation contains a diversity of species per square meter comparable to that of the local remnant vegetation	Native understorey abundance		The abundance of native species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it is has more than or an equal number of native species as the local remnant vegetation	> species/m <sup>2</sup>	7	8	9	7.6	5.6	5.4
			Exotic understorey abundance		The abundance of exotic species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it is has less than or an equal number of exotic species as the local remnant vegetation	< species/m <sup>2</sup>	1	4	7.2	9	9	6.8
	Native ground cover abundance	Native ground cover abundance is comparable to that of the local remnant vegetation	Percent ground cover provided by native vegetation <0.5m tall	The percent ground cover abundance of native species (<0.5m height) compared to exotic species is comparable to that of the local remnant vegetation		%	63	87	55.9	37.5	38.6	30.7
	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	7	89	0	1	7	12

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-01			
			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	2	15	0	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	13	0	0	0	0
			shrubs and juvenile trees 1.5 - 2m in height	The number of shrubs or juvenile trees 1.5-2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation		No./area	0	18	0	0	0	0
			shrubs and juvenile trees >2m in height		The number of shrubs or juvenile trees > 2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	0	48	0	0	0	0
	Ecosystem structure	The vegetation is developing in structure and complexity comparable to that of the local remnant vegetation	Foliage cover 0.5 - 2 m	Projected foliage cover provided by perennial plants in the 0.5 - 2m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation		% cover	1	9	0	11.5	0	1
			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	6	0	0	0	0
			Foliage cover 4 - 6m		Projected foliage cover provided by perennial plants in the 4 -6m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation	% cover	0	9	0	0	0	0
			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	17	42	0	0	0	0
	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	0	0	0	0



Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-01			
				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	0	0	0	0
	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	6	19	0	0	0	0
			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	18	54	0	0	0	0
	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	83	100	0	0	0	0
			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	7	47	0	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	44	57	0	0	0	0
			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	0	36	0	0	0	0
			Dead Trees		The percentage of the tree population which are dead (stags) and that the percentage is comparable to the local remnant vegetation	% population	0	17	0	0	0	0
			Mistletoe		The percentage of the tree population which have mistletoe provides an indication of community health and habitat value and that the percentage is comparable to the local remnant vegetation	% population	0	7	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	50	83	0	0	0	0

## 10.2 EOA-02 site description

EOA-02 was a derived grassland situated to the southeast of the Estcourt Offset Area. The site was an old cropping paddock that had not been recently grazed however stray stock had left hoof prints in the mud in 2010.

In 2010 it also contained a diverse understorey of native and introduced species including *Dichondra repens*, *Eragrostis parviflora* and *Medicago polymorpha*. There was a relatively high floristic diversity (48 species) and native species (26) were more abundant than exotic species (22). There was generally good ground cover with annual species dominating 50% of the site. There was 29% cover provided by perennial plants and cryptogams were moderately abundant in the southern end of the transect. There were scattered occurrences of *Carthamus lanatus*, *Echium plantagineum* and *Arctotheca calendula*. In 2011, it was similar to EOA-01 with increased levels of ground over, decreased abundance of cryptogams but maintained a high diversity of native and exotic species. Weeds were less abundant. In 2012 the site was similar to but drier than 2011 with 24 *C. glaucophylla* seedlings found. In 2013, annual species continued to be dominant and only 15 *C. glaucophylla* seedlings were recorded.

### 10.2.1 Landscape Function Analysis

#### 10.2.1.1 Landscape organisation

EOA-02 continued to be characterised as a grassland patch and with excellent ground cover scored a Landscape Organisation Index of 1.0 or was 100% indicating there is little to no leakage of resources (Figure 10-7, Table 10-10). Between 2010 and 2011 there was a marginal improvement in ecological function largely due to increased levels of litter cover which have begun to accumulate some depth across most of the site and slightly increased soil surface relief. In 2012 however there was slight decline in ecological function due to less cover of perennial plants and increased soil surface hardness. In 2013 there continued to be a decline in ecological stability and this was largely due to a decline in perennial plants and cryptogam cover, but there were improvements in infiltration and nutrient recycling due to a reduction in soil surface hardness.

The resultant LFA indices for stability, infiltration and nutrient recycling were 71.0, 45.0 and 44.3 respectively and these were 8.1, 3.9 and 8.1 LFA units higher than the minimum target range.

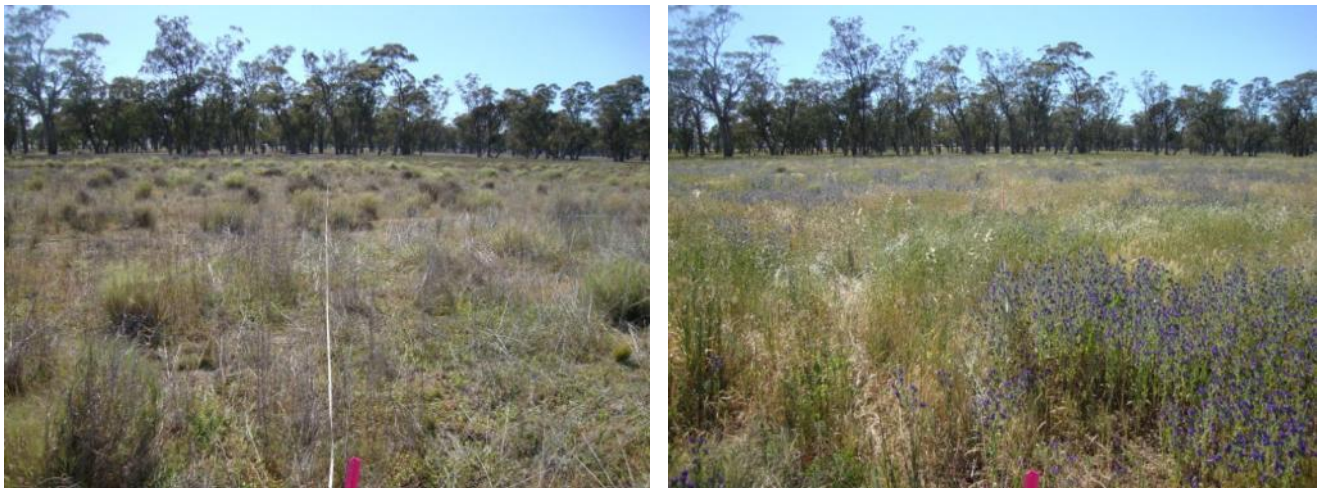


Figure 10-7. Permanent photo point taken from the top of the LFA transect in 2012 (left) and 2013 (right).

Table 10-10. Summary of landscape organisation and LFA indices in 2010, 2011, 2012 and 2013.

EOA-02		24/09/2010		20/10/2011		18/10/2012		16/10/2013	
Number of Patches/10m		0.5		0.5		0.5		0.5	
Total Patch Area (m2)		200		200		200		200.00	
Patch Area Index		1		1		1		1.00	
Landscape Organisation Index		1		1		1		1.00	
Average Interpatch Length (m)		NA		NA		NA		NA	
Range Interpatch length (m)		NA		NA		NA		NA	
Patch or Interpatch Type		Grassland Patch		Grassland Patch		Grassland Patch		Grassland Patch	
Patch or Interpatch Proportion (%)		100	100	100	100	100	100	100.0	100
Soil Surface Assessment									
Within Individual Zones	Stability	71		73.5		74.5		71.0	
	Infiltration	41.5		45.4		40.7		45.0	
	Nutrients	40.9		42.7		42.3		44.3	
			Total		Total		Total		Total
Individual zones contribution to the whole of Landscape	Stability	71	71	73.5	73.5	74.5	74.5	71.0	71.0
	Infiltration	41.5	41.5	45.4	45.4	40.7	40.7	45.0	45.0
	Nutrients	40.9	40.9	42.7	42.7	42.3	42.3	44.3	44.3

### 10.2.1.2 Soil Surface Assessment

There was a further decline in cover provided by perennial plants which provided only low basal cover and protection against rain splash in most cases (Table 10-11). There continued to be high levels of annual plant and dead litter cover which had accumulated to some depth and there were increased rates of microbial and fungal decomposition with moderate decomposition observed in the majority of samples across the site.

The soil surface continued to be crusted and in most cases cryptogams persisted in low abundance. The scattered grass tussocks continued to provide moderate soil surface relief and due to the good ground cover, there was little to no evidence of erosion or deposition despite the heavy rainfall which occurred during June. The clay loam soils appeared less hard as the humus material continued to build up the soil prolife and they remained very stable.

**Table 10-11 . Results of the Soils Surface Assessment for the Grassland patch.**

Features	Max score	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Soil Cover	5	2	1	2	2	2
Per. basal / canopy cover	4	2	1	2	2	2
Litter cover, orig & incorp.	10	6lm	6lm	5lm	5ls	5ls
Cryptogam cover	4	1	2	2	2	2
Crust broken-ness	4	4	4	4	4	4
Erosion type & severity	4	4	4	4	4	4
Deposited materials	4	4	4	4	4	4
Soil surface roughness	5	3	3	3	3	3
Surface resist. to disturb.	5	3	3	3	4	4
Slake test	4	4	4	4	4	4
Texture	4	2	2	2	2	2

### 10.2.2 Soil analyses

The result of the soil analyses indicates there have only been minor changes in the soil characteristics since 2010 and this year minor reductions in numerous attributes were recorded and were likely to have been due to the prolonged dry conditions and inherent site and sampling variability. The soil pH was borderline slightly to moderately acidic but remained just within local ranges (Table 10-12). The Electrical Conductivity continued to be low indicating low levels of soluble salts and the presence of non saline soils. Organic Matter content was typical of the local area but phosphorous levels were high and nitrates and CEC were low. There was little change in ESP and while it remained higher than the reference sites it was below the desirable level indicating that the soils are non sodic.

**Table 10-12. Results of the soil analysis for EOA-02 compared to the upper and lower values for the woodland reference sites and desirable levels 2010 - 2013.**

Nutrient	Units	EOA-02				Lower KPI	Upper KPI	Desirable Level
		2010	2011	2012	2013			
pH (1:5 water)	units	6.17	6.11	6.24	6.03	5.99	7.10	5.6 – 7.3
Conductivity (1:5 water)	dS/m	0.032	0.070	0.094	0.040	0.04	0.19	0.150
Organic Matter	%	3.7	3.7	3.9	3.3	3.01	4.61	>4.5
Phosphorus (Colwell)	mg/kg	54	49	44	34	6.41	17.29	50
Nitrate	mg/kg	1.6	2.2	2.3	1.4	1.20	1.88	13.0
Cation Exchange Capacity	cmol <sup>+</sup> /Kg	11.56	10.70	11.43	10.17	12.05	22.87	14.00
Exchangeable Sodium Percentage	%	1.93	1.99	2.83	2.77	0.29	2.42	<5

### 10.2.3 Rill assessment

No rills were observed within the monitoring quadrat in any monitoring year.

### 10.2.4 Tree density and health condition

No trees were present within this monitoring plot.



### 10.2.5 Shrubs and regeneration

This year 15 *Callitris glaucophylla* seedlings were found and have been the result of natural recruitment event probably initiated during high rainfall activity in March 2012 (Table 10-13). All seedlings remained less than 0.5m in height and at the time of monitoring were approximately 10 - 20cm tall. Many other juvenile *C. glaucophylla*, *E. microcarpa* and *E. populnea* were now visible within the larger paddock areas a result of natural recruitment stimulated by the good summer rainfall over the past two years.

Table 10-13. Shrubs and young trees occurring within the monitoring site.

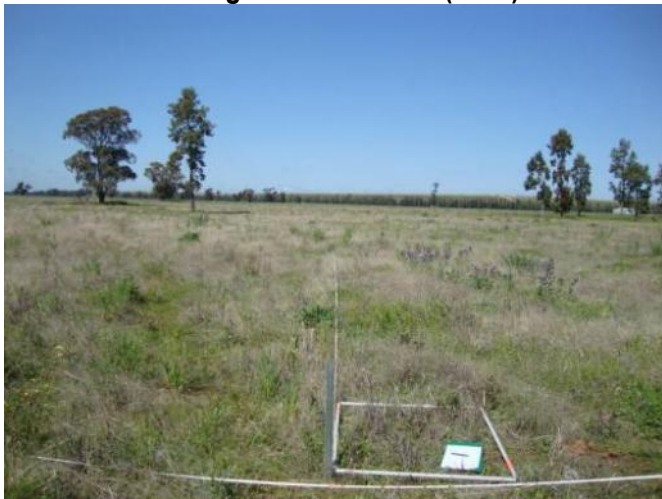
Species	0 - 0.5m	0.5 - 1.0m	1.0 - 1.5m	1.5 - 2.0m	>2.0m	Total	endemic	not endemic
<i>Callitris glaucophylla</i>	15					15	15	
<b>Total</b>	<b>15</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>15</b>	<b>15</b>	<b>0</b>
<b>% endemic species</b>							<b>100</b>	<b>0</b>

### 10.2.6 Structural diversity and habitat complexity

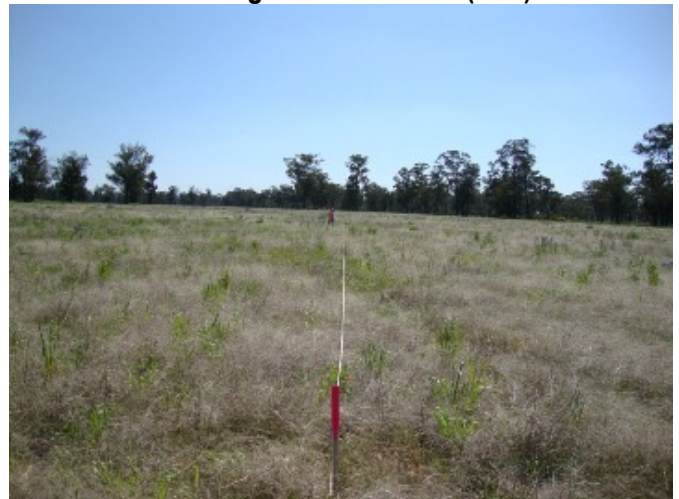
There has been very little change in the overall structure of this recovering native grassland which remains devoid of a shrub and canopy layer (Figure 10-8). This year there continued to be 100% total ground cover but there has been a further decline 20.0 – 16.5% perennial plant cover due to the dry spring weather conditions. Subsequently there have been marginal increases in dead litter and annual plant cover which provided 53.5% and 30% cover this year respectively (Figure 10-9).

No other habitat features such as rocks or logs were recorded. With the relatively dry spring weather combined with some macropod grazing the vegetative cover had been kept quite low, apart from some a few scattered weed which provide limited cover >0.5m in height on two occasions. Table 10-14 provides the average and minimum and maximum values obtained along the vegetation transect in 2013.

2010 Vegetation transect (front)



2010 Vegetation transect (rear)



**2011 Vegetation transect (front)**



**2011 Vegetation transect (rear)**



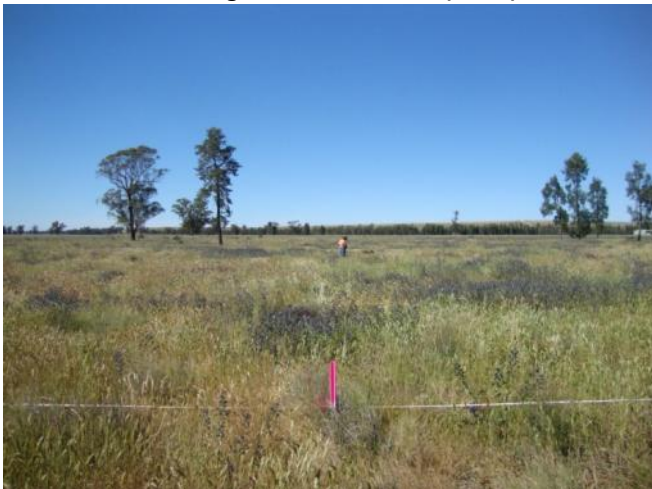
**2012 Vegetation transect (front)**



**2012 Vegetation transect (rear)**



**2013 Vegetation transect (front)**



**2013 Vegetation transect (rear)**



**Figure 10-8. Permanent photo points taken from the front (left) and rear (right) of the vegetation transect.**

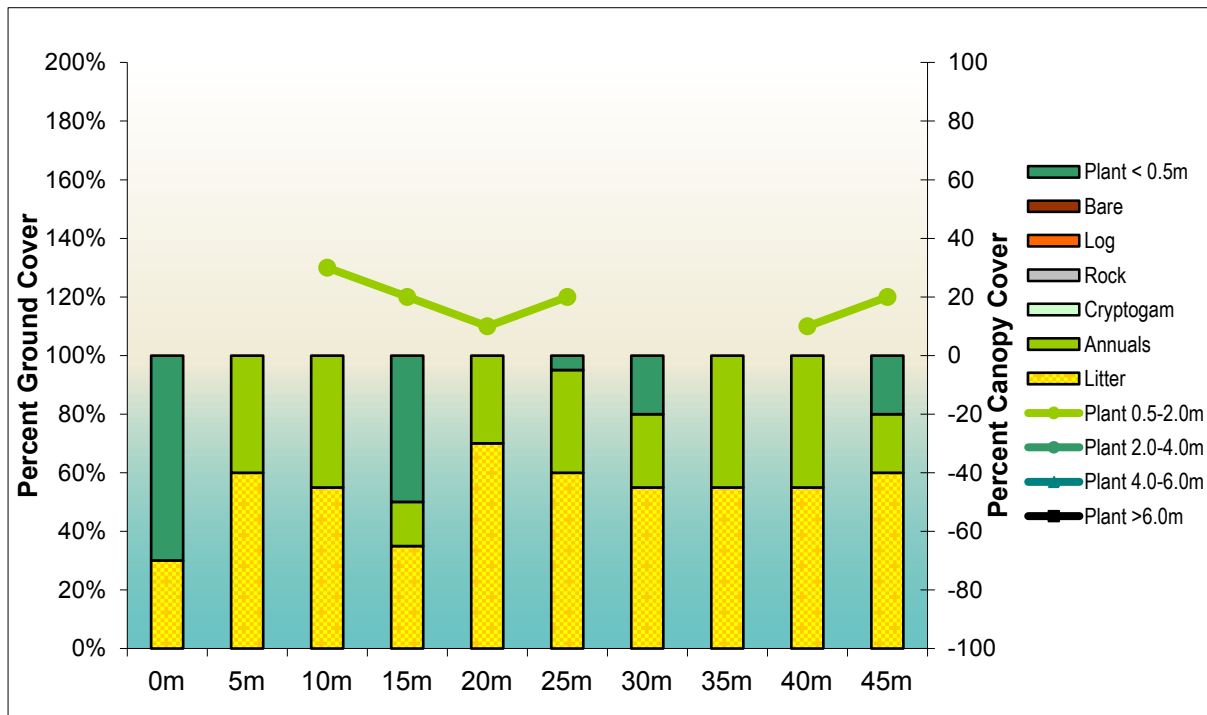


Figure 10-9. Graph illustrating the structural diversity and habitat complexity of the monitoring site.

Table 10-14. Average and minimum and maximum values of the structural diversity of the monitoring site.

Vegetation structure	0m	5m	10m	15m	20m	25m	30m	35m	40m	45m	Average	Min	Max
Litter	30	60	55	35	70	60	55	55	55	60	53.5	30	70
Annuals	0	40	45	15	30	35	25	45	45	20	30	0	45
Cryptogam	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock	0	0	0	0	0	0	0	0	0	0	0	0	0
Log	0	0	0	0	0	0	0	0	0	0	0	0	0
Bare	0	0	0	0	0	0	0	0	0	0	0	0	0
Perennial <0.5m	70	0	0	50	0	5	20	0	0	20	16.5	0	70
Total Ground Cover	100	100	100	100	100	100	100	100	100	100	100	100	100
0.5-2.0m	0	0	30	20	10	20	0	0	10	20	11	0	30
2.0-4.0m	0	0	0	0	0	0	0	0	0	0	0	0	0
4.0-6.0m	0	0	0	0	0	0	0	0	0	0	0	0	0
>6.0m	0	0	0	0	0	0	0	0	0	0	0	0	0

## 10.2.7 Species cover abundance

In 2013 there were 19 different species recorded in the five 1m<sup>2</sup> quadrats on the permanent vegetation transect line including 13 exotic species. Using the Braun-blauquet scale, the highest possible cover score that can be obtained is 30 and cover abundance is illustrated as a sum of scores (class values) obtained along the five 1m<sup>2</sup> quadrats.

In previous years most ground cover was provided by the native forb *Wahlenbergia gracilis* and the exotic annuals *Trifolium subterranean*, *Medicago truncatula*, *Lactuca saligna* and *Bromus molliformis*. This year *Bromus molliformis* was by far the most common and abundant species with others including *Echium plantagineum*, *Chloris truncata*, *Trifolium campestre*, *Vulpia* spp., *Carex inversa* and *Walwhalleya proluta* also being relatively common (Figure 10-10, Table 10-15). The remaining species were less common with many being recorded on only one occasion and/or provided low cover values. Of the live plant cover scores recorded 29.5% was provided by native species, a reduction from 33.3% recorded last year.



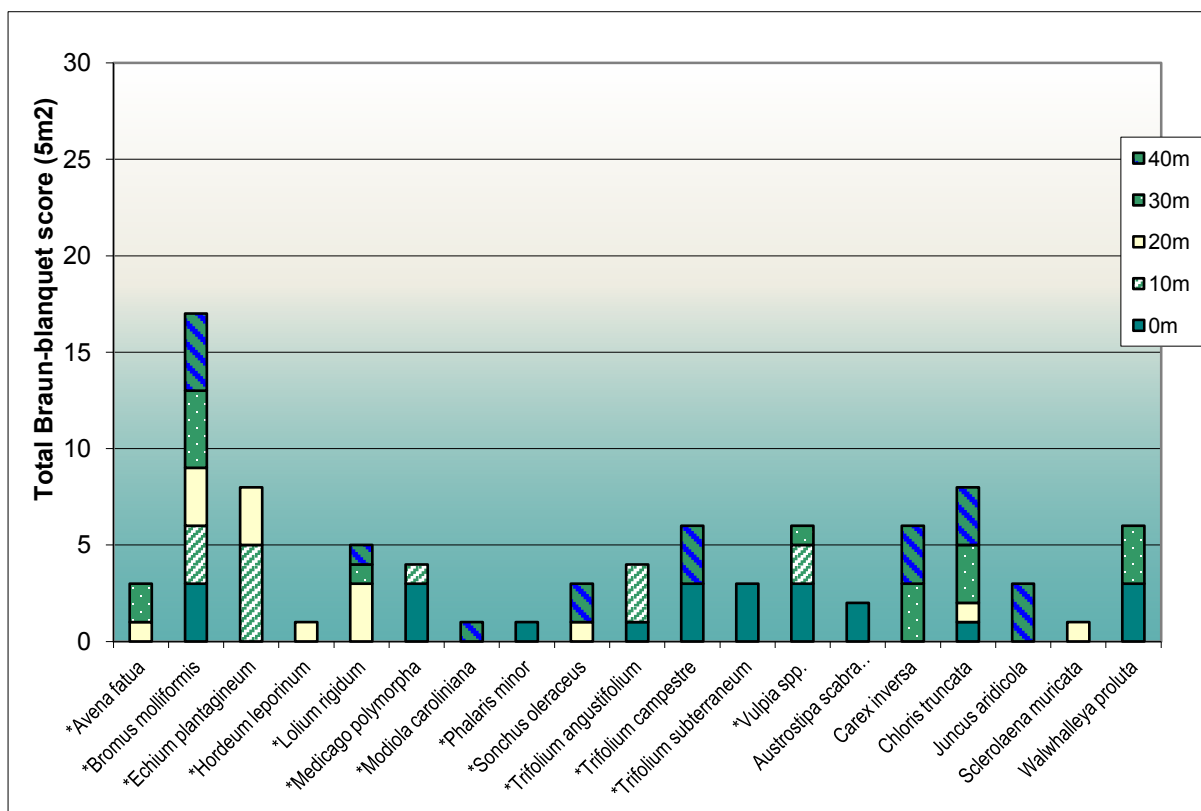


Figure 10-10. Total species recorded across the five, 1m<sup>2</sup> quadrats using the Braun-blauquet scale (max possible score is 30) as a measure of cover abundance.

Table 10-15. List of species and their average cover abundance score across the five, 1m<sup>2</sup> monitoring quadrats.

Species	0m	10m	20m	30m	40m	Total
*Avena fatua			1	2		3
*Bromus molliformis	3	3	3	4	4	17
*Echium plantagineum		5	3			8
*Hordeum leporinum			1			1
*Lolium rigidum			3	1	1	5
*Medicago polymorpha	3	1				4
*Modiola caroliniana					1	1
*Phalaris minor	1					1
*Sonchus oleraceus			1		2	3
*Trifolium angustifolium	1	3				4
*Trifolium campestre	3				3	6
*Trifolium subterraneum	3					3
*Vulpia spp.	3	2		1		6
Austrostipa scabra subsp. falcata	2					2
Carex inversa				3	3	6
Chloris truncata	1		1	3	3	8
Juncus aridicola					3	3
Sclerolaena muricata			1			1
Walwhalleya proluta	3			3		6
<b>Total cover</b>						<b>88</b>
<b>Sum of cover of native species</b>						<b>26</b>
<b>Percent endemic species cover</b>						<b>29.5</b>



## 10.2.8 Floristic diversity

The floristic diversity of the sites was measured using two different methods. One provides an assessment of the average number of species within five, one square metre (m<sup>2</sup>) sub-quadrats along the vegetation transect, while the other provides the total number of species within the entire 50x20m monitoring plot.

### 10.2.8.1 Species diversity per m<sup>2</sup>

With the drier season compared to the previous monitoring years there were fewer native and exotic species on average within the five replicates sub-plots. Native diversity has declined from 4.0 – 2.2 species per m<sup>2</sup> while the number of exotics also declined from 6.6 – 5.4 exotic species per m<sup>2</sup> (Table 10-16). The number of native species ranged between 0 – 3 species per m<sup>2</sup>, while the number of exotic species ranged between 5 – 10 species per m<sup>2</sup>.

Table 10-16. Species diversity per 1m<sup>2</sup>.

Species /m2	0m	10m	20m	30m	40m	Avg/m2	SD
Native	3	0	2	3	3	2.2	1.3
Exotic	7	5	6	4	5	5.4	1.1
Total	10	5	8	7	8	7.6	1.8

### 10.2.8.2 Total species diversity

There continued to be 44 species in the 50 x 20m monitoring quadrat, however this year there were 22 exotic species (Figure 10-11, Table 10-17). The gradual and relatively low shape of the species area curve indicates the site was relatively homogenous, with new species recorded at a relatively low rate. A patch of native species was recorded 500m<sup>2</sup>. A full list of species recorded within the monitoring site is provided in Appendix 1.

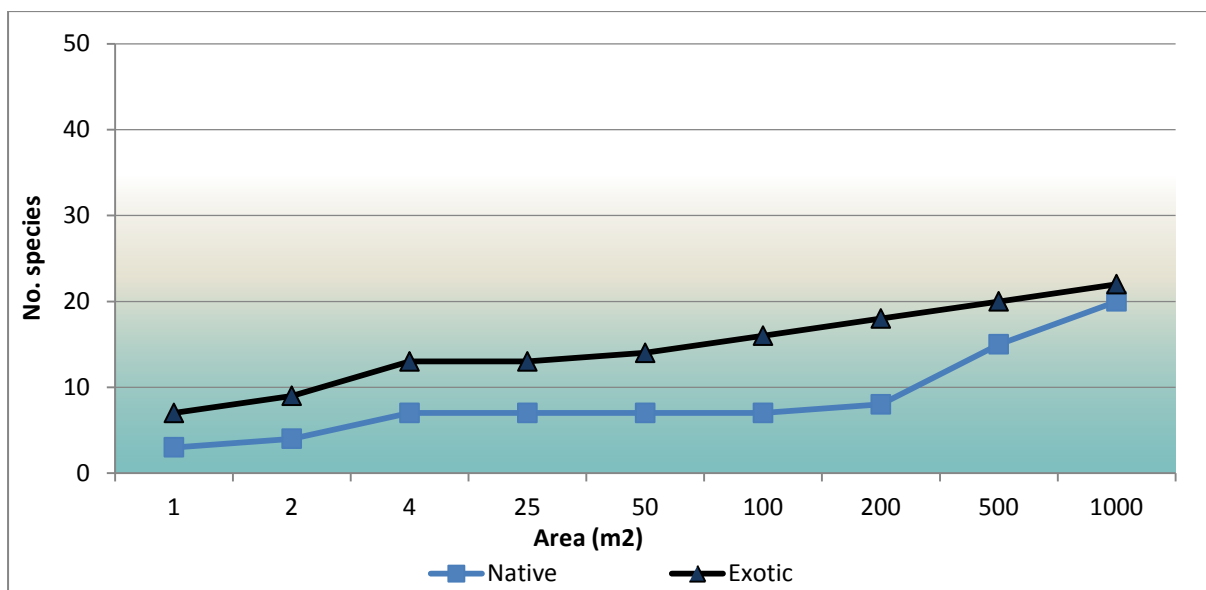


Figure 10-11. Cumulative species in the 50m x 20m (1000m<sup>2</sup>) monitoring quadrat.

Table 10-17. Cumulative species diversity.

Area (m2)	1	2	4	25	50	100	200	500	1000
Native	3	4	7	7	7	7	8	15	20
Exotic	7	9	13	13	14	16	18	20	22

### 10.2.9 Growth forms

Figure 10-12 is a summary of species in each growth form that were recorded in EOA-02. Herbs continued to be the most dominant plant type with 21 species including 16 exotic species. There were 14 grasses and this included six exotic species. There was one tree species, three native sub-shrubs and three species of reed. No shrub or fern representatives were recorded. Compared to the woodland reference sites, there was a lack of tree (and shrub) species and a low number of herbs.

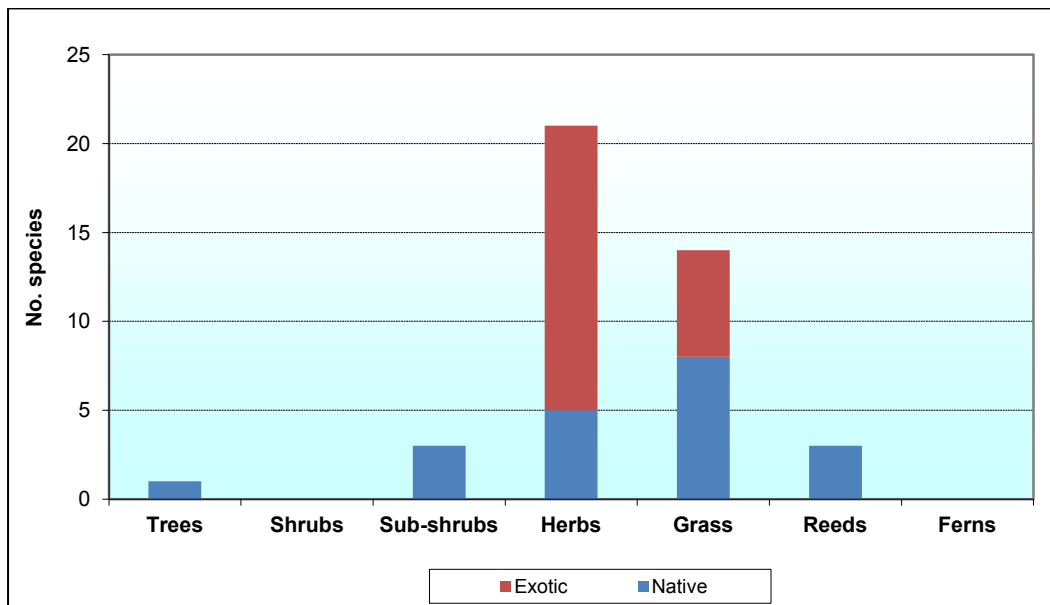


Figure 10-12. Graph illustrating the growth forms of species recorded in the 50m x 20m monitoring quadrat.

## 10.2.10 Comparison of rehabilitation data with key performance indicators

Table 10-18 indicates the performance of the monitoring site against the Completion and Desirable Performance Indicators developed for woodland sites during the 2013 monitoring period. The selection of criteria have been presented in order of ecosystem successional processes, beginning with landform establishment and stability (orange) for example and ending with indicators of ecosystem and landuse development (blue). The range values will be amended annually.

Rehabilitation sites meeting or exceeding the range values of their representative community type have 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 2013. 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 10-18. Comparison of key performance Indicators recorded at site EOA-02 compared to lower and upper limits recorded in the woodland reference sites.**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-02			
Performance indicators are quantified by the range of values obtained from replicated reference sites							Lower	Upper	2010	2011	2012	2013
Phase2: 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°)	0	5	1	1	1	1
	Landform function	Landform is functional and performing as it was designed to do	LFA Stability	Based on key physical, biological and chemical characteristics the LFA stability index provides an indication of the sites stability and that it is comparable to or trending towards that of the local remnant vegetation		%	62.9	69.0	71.0	73.5	74.5	71.0
			LFA Infiltration	Based on key physical, biological and chemical characteristics the LFA infiltration index provides an indication of the sites infiltration capacity and that it is comparable to or trending towards that of the local remnant vegetation		%	41.1	55.7	41.5	45.4	40.7	45.0
			LFA Nutrient recycling	Based on key physical, biological and chemical characteristics the LFA nutrient recycling index provides an indication of the sites ability to recycle nutrient and that it is comparable to or trending towards that of the local remnant vegetation		%	36.2	53.0	40.9	42.7	42.3	44.3
			LFA Landscape organisation	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and that it is comparable to that of the local remnant vegetation		%	100	100	100	100	100	100
	Active erosion	Areas of active erosion are limited	No. Rills/Gullies	Provides an assessment of the number of gullies or rills occurring in a 50m transect and that these are limited and stabilising		No.	0	0	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-02			
			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
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)	6.0	7.1	6.17	6.11	6.24	6.0
			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)	0.038	0.191	0.032	0.070	0.084	0.040
			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)	3.0	4.6	3.7	3.7	3.9	3.3
			Phosphorous		Available Phosphorus is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	ppm (50)	6.4	17.3	54.1	48.5	44.3	38.7
			Nitrate	Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		ppm (>12.5)	1.2	1.9	1.6	2.2	2.3	1.4
			CEC		Cation Exchange Capacity is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	Cmol+/kg (>14)	12.0	22.9	11.56	10.70	11.43	10.17
			ESP		Exchangeable Sodium Percentage (a measure of sodicity) is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	% (<5)	0.3	2.4	1.93	1.98	2.88	2.8
Phase 4: Ecosystem & Landuse Establishment	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	6	0	0	1	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	na	NA	100	100
			Total species richness		The total number of live plant species provides an indication of the floristic diversity of the site and is comparable to the local remnant vegetation	No./area	53	76	48	41	46	42
			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	33	53	26	22	27	20



Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-02			
			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	13	27	22	19	19	22
	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	29	110	0	0	24	15
	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	2	4	0	0	1	1
			Shrubs	The number of shrub species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	0	3	0	0	0	0
			Sub-shrubs		The number of sub-shrub species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	1	5	1	4	3	3
			Herbs	The number of herbs or forb species comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	33	46	36	26	25	21
			Grasses		The number of grass species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	9	22	10	9	15	14
			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	1	2	2	3
			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
			Ferns		The number of ferns comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	1	0	0	0	0
Phase 5: Ecosystem & Landuse Development	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	%	47	77	14.5	26.5	52.5	53.5
			Annual plants		Percent ground cover provided by live annual plants is comparable to that of the local remnant vegetation	<%	2	22	50.0	24.0	27.5	30.0
			Cryptogam cover		Percent ground cover provided by cryptogams (eg mosses, lichens) is comparable to that of the local remnant vegetation	%	0	8	4.5	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-02			
			Rock		Percent ground cover provided by stones or rocks (> 5cm diameter) is comparable to that of the local remnant vegetation	%	0	1	0	0	0	0
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	0	3	0.0	0	0	0
			Bare ground		Percentage of bare ground is less than or comparable to that of the local remnant vegetation	< %	6	11	2	0	0	0
			Perennial plant cover (< 0.5m)	Percent ground cover provided by live perennial vegetation (< 0.5m in height) is comparable to that of the local remnant vegetation		%	7	25	29	49.5	20	16.5
			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		%	89	95	98	100	100	100
	Ground cover diversity	Vegetation contains a diversity of species per square meter comparable to that of the local remnant vegetation	Native understorey abundance		The abundance of native species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it has more than or an equal number of native species as the local remnant vegetation	> species/m <sup>2</sup>	7	8	8.4	4.6	4	2.2
			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 has less than or an equal number of exotic species as the local remnant vegetation	< species/m <sup>2</sup>	1	4	8.4	6.8	6.6	5.4
	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		%	63	87	54.2	34.7	33.3	29.5
	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	7	89	0	0	24	15
			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	2	15	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-02			
			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	13	0	0	0	0
			shrubs and juvenile trees 1.5 - 2m in height	The number of shrubs or juvenile trees 1.5-2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation		No./area	0	18	0	0	0	0
			shrubs and juvenile trees >2m in height		The number of shrubs or juvenile trees > 2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	0	48	0	0	0	0
	Ecosystem structure	The vegetation is developing in structure and complexity comparable to that of the local remnant vegetation	Foliage cover 0.5 - 2 m	Projected foliage cover provided by perennial plants in the 0.5 - 2m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation		% cover	1	9	0	1	7.5	11
			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	6	0	0	0	0
			Foliage cover 4 - 6m		Projected foliage cover provided by perennial plants in the 4 -6m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation	% cover	0	9	0	0	0	0
			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	17	42	0	0	0	0
	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	0	0	0	0
				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	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-02			
	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	6	19	0	0	0	0
			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	18	54	0	0	0	0
	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	83	100	0	0	0	0
			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	7	47	0	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	44	57	0	0	0	0
			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	0	36	0	0	0	0
			Dead Trees		The percentage of the tree population which are dead (stags) and that the percentage is comparable to the local remnant vegetation	% population	0	17	0	0	0	0
			Mistletoe		The percentage of the tree population which have mistletoe provides an indication of community health and habitat value and that the percentage is comparable to the local remnant vegetation	% population	0	7	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	50	83	0	0	0	0



### 10.3 EOA-03 site description

EOA-03 was an open grassy clearing situated in the centre of the southern woodland area on top of the hill. It was dominated by native grasses particularly *Austrostipa scabra subsp. falcata* and contained a very high diversity of native (43) and introduced species (18) including many Asteraceae and Poaceae species. There was good ground cover provided by perennial plants (59%) and annual (30%) and there was small quantities of cover provided by leaf litter and cryptogams. There were sparse occurrences of *Carthamus lanatus*, *Echium plantagineum*, *Salvia verbenaca*, *Erodium cicutarium* and a variety of *Medicago* and *Trifolium* species. On the fringing woodland (photo point 2 GHD 2010), there was a diverse range of additional native species including *Arthropodium minus*, *Stackhousia monogyna*, *Pterostylis* sp, *Dichopogon stricta*, *Bulbine bulbosa*, *Goodenia pinnatifida* and *Calotis cuneifolia* to name a few. In 2011 and 2012 the site was very dry, with macropod grazing maintaining low grass cover. There was a significant decline in floral diversity but the site retained good ground cover. In 2012 seven *C. glaucophylla* seedlings were found within the site. In 2013 there continued to be moderate abundance of native grasses and scattered *Xerochrysum bracteatum* and *Dichopogon stricta* but *Echium plantagineum* was also quite abundant. Twelve *C. glaucophylla* seedlings were recorded.

#### 10.3.1 Landscape Function Analysis

##### 10.3.1.1 Landscape organisation

EOA-03 continued to be characterised as a grassland patch and with excellent ground cover scored a Landscape Organisation Index of 100% with little to no leakage of resources (Figure 10-13, Table 10-19). There has continued to be a marginal decline in the ecological function of the site largely due to a reduction in perennial plant cover as a result of the prolonged dry conditions.

The resultant LFA indices for stability, infiltration and nutrient recycling were 70.0, 50.3 and 47.3 respectively. Compared to the minimum range provided by the woodland reference sites this site was 7.1, 9.2 and 11.1 LFA units higher.



Figure 10-13. Permanent photo point taken from the top of the LFA transect in 2012 (left) and 2013 (right).

Table 10-19. Summary of landscape organisation and LFA indices in 2010, 2011, 2012 and 2013.

EOA-03		24/09/2010		20/10/2011		18/10/2012		16/10/2013	
Number of Patches/10m		0.5		0.5		0.5		0.5	
Total Patch Area (m2)		200		200		200		200.00	
Patch Area Index		1		1		1		1.00	
Landscape Organisation Index		1		1		1		1.00	
Average Interpatch Length (m)		NA		NA		NA		NA	
Range Interpatch length (m)		NA		NA		NA		NA	
Patch or Interpatch Type		Grassland Patch		Grassland Patch		Grassland Patch		Grassland Patch	
Patch or Interpatch Proportion (%)		100	100	100	100	100	100	100.0	100
Soil Surface Assessment									
Within Individual Zones	Stability	77.5		77.5		73		70.0	
	Infiltration	45.4		51.7		52		50.3	
	Nutrients	43.7		48.8		49.6		47.3	
			Total		Total		Total		Total
Individual zones contribution to the whole of Landscape	Stability	77.5	77.5	77.5	77.5	73	73	70.0	70.0
	Infiltration	45.4	45.4	51.7	51.7	52	52	50.3	50.3
	Nutrients	43.7	43.7	48.8	48.8	49.6	49.6	47.3	47.3

### 10.3.1.2 Soil Surface Assessment

There continued to be a decline in perennial plant cover and as a result there was a lower level of rain splash protection and perennial basal cover (Table 10-20). The level of litter cover remained high and continued to accumulate to some depth and this year moderate decomposition was now observed across all replicates within the site indicating a positive increase in microbial and fungal activity. The soil surface remained crusted but due to the high vegetative cover there continued to be an absence of cryptogams. The grass tussocks continued to provide moderate to high soil surface relief and there was little to no evidence of erosion or decomposition. The loam soils continued to be moderately hard and very stable.

**Table 10-20 . Results of the Soils Surface Assessment for the Grassland patch.**

Features	Max score	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Soil Cover	5	3	2	2	3	2
Per. basal / canopy cover	4	3	2	2	3	2
Litter cover, orig & incorp.	10	6lm	6lm	5lm	5lm	6lm
Cryptogam cover	4	1	1	1	1	1
Crust broken-ness	4	4	4	4	4	4
Erosion type & severity	4	4	4	4	4	4
Deposited materials	4	4	4	4	4	4
Soil surface roughness	5	4	3	3	3	2
Surface resist. to disturb.	5	3	3	3	3	3
Slake test	4	4	4	4	4	4
Texture	4	2	2	2	2	2

### 10.3.2 Soil analyses

The result of the soil analyses indicates there have only been minor changes in the soil characteristics since 2010 and this year minor reductions in numerous attributes were recorded and were likely to have been due to the prolonged dry conditions and inherent site and sampling variability. The soil pH was borderline slightly to moderately acidic but remained just within local ranges (Table 10-21). The Electrical Conductivity continued to be low indicating low levels of soluble salts and the presence of non saline soils. Organic Matter, phosphorous and nitrates had also declined but remained typical of the local area and CEC levels were low. There was little change in ESP and while it remained higher than the reference sites it was below the desirable level indicating that the soils are non sodic.

**Table 10-21. Results of the soil analysis for EOA-03 compared to the upper and lower values for the woodland reference sites and desirable levels in 2010, 2011, 2012 and 2013.**

Nutrient	Units	EOA-03				Lower KPI	Upper KPI	Desirable Level
		2010	2011	2012	2013			
pH (1:5 water)	units	5.68	6.22	6.40	6.04	5.99	7.10	5.6 – 7.3
Conductivity (1:5 water)	dS/m	0.176	0.075	0.070	0.037	0.04	0.19	0.150
Organic Matter	%	5.5	6.3	5.2	3.6	3.01	4.61	>4.5
Phosphorus (Colwell)	mg/kg	23	16	15	8	6.41	17.29	50
Nitrate	mg/kg	42.1	2.2	3.8	1.2	1.20	1.88	13.0
Cation Exchange Capacity	cmol+/Kg	10.74	11.90	11.14	7.94	12.05	22.87	14.00
Exchangeable Sodium Percentage	%	0.92	0.32	0.38	0.34	0.29	2.42	<5

### 10.3.3 Rill assessment

No rills were observed within the monitoring quadrat in any monitoring year.

### 10.3.4 Tree density and health condition

No trees or shrubs with a dbh >5cm were present within this monitoring plot.

### 10.3.5 Shrubs and regeneration



This year 12 *Callitris glaucophylla* seedlings were found and have been the result of natural recruitment event probably initiated during high rainfall activity in March 2012 (Table 10-22). All seedlings remained less than 0.5m in height and at the time of monitoring were approximately 10 - 20cm tall. Many other juvenile *C. glaucophylla*, *E. microcarpa* and *E. populnea* were now visible within the larger paddock areas a result of natural recruitment stimulated by the good summer rainfall over the past two years.

**Table 10-22. Shrubs and young trees occurring within the monitoring site.**

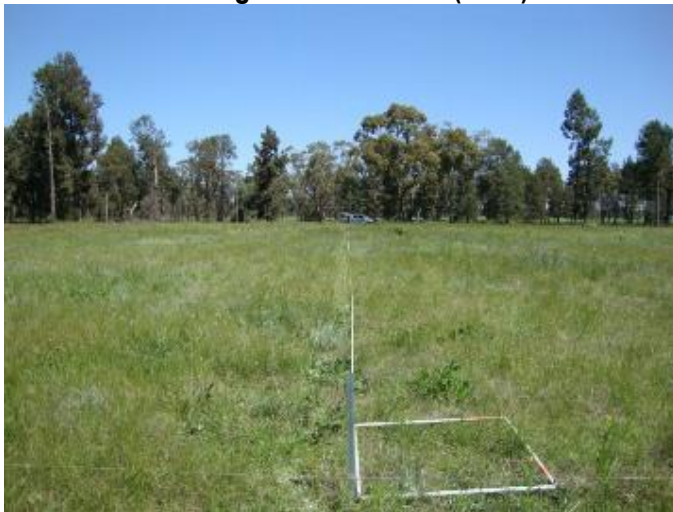
Species	0 - 0.5m	0.5 - 1.0m	1.0 - 1.5m	1.5 - 2.0m	>2.0m	Total	endemic	not endemic
<i>Callitris glaucophylla</i>	12					12	12	
<b>Total</b>	<b>12</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>12</b>	<b>12</b>	<b>0</b>
<b>% endemic species</b>							<b>100</b>	<b>0</b>

### 10.3.6 Structural diversity and habitat complexity

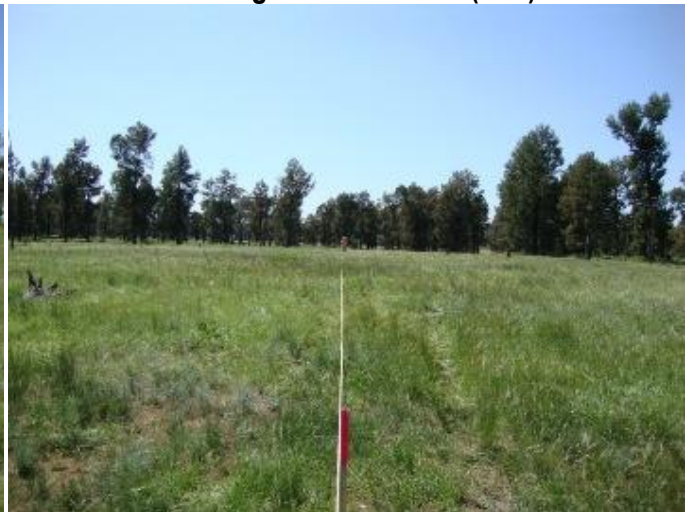
There has been very little change in the overall structure of this open grassy clearing which remains devoid of a shrub and canopy layer (Figure 10-14 and Figure 10-15). There continued to 100% total ground cover and this remained dominated by dead leaf litter which has slightly declined from 54.5% to 50% cover and there was a reduction from 43.5 – 31% cover provided by perennial plants. There was however a significant increase in annual plant covers which has increased from 2 – 19%.

There continued to be an absence of cryptogams due to the high ground cover. The dry conditions combined with macropod grazing have maintained a low grass cover however a few taller grasses provided a small amount (4%) of cover >0.5m in height. Table 10-5 provides the average and minimum and maximum values obtained along the vegetation transect.

**2010 Vegetation transect (front)**



**2010 Vegetation transect (rear)**



**2011 Vegetation transect (front)**



**2011 Vegetation transect (rear)**





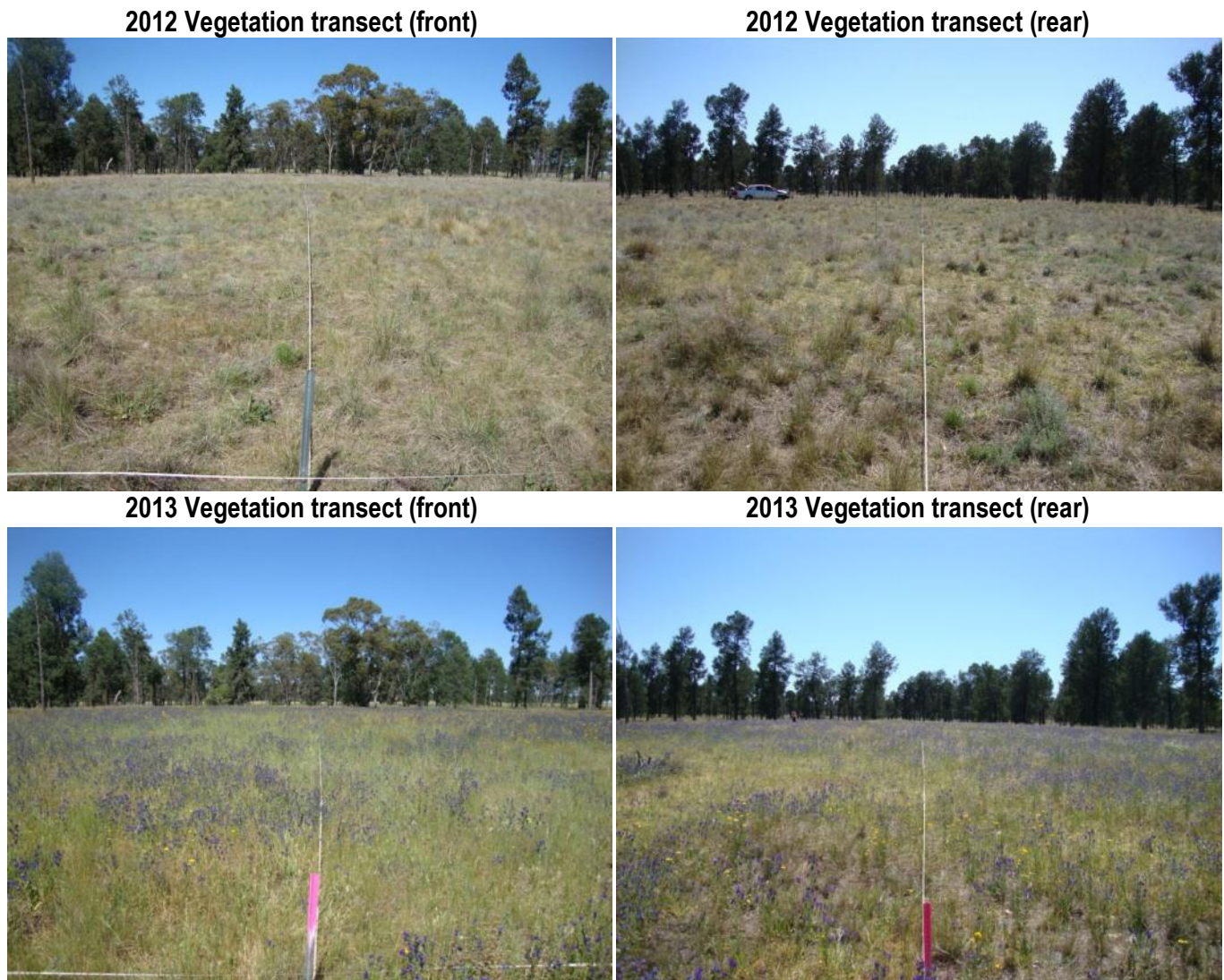


Figure 10-14. Permanent photo points taken from the front (left) and rear (right) of the vegetation transect.

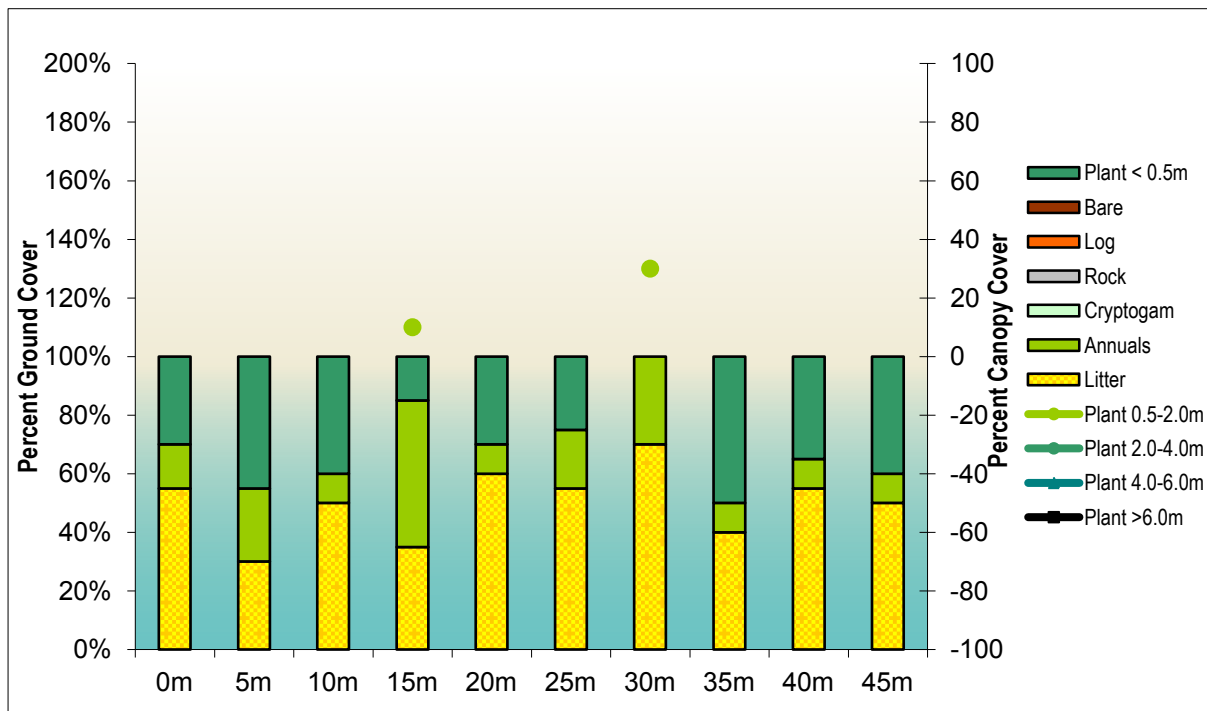


Figure 10-15. Graph illustrating the structural diversity and habitat complexity of the monitoring site.

**Table 10-23. Average and minimum and maximum values of the structural diversity of the monitoring site.**

Vegetation structure	0m	5m	10m	15m	20m	25m	30m	35m	40m	45m	Average	Min	Max
Litter	55	30	50	35	60	55	70	40	55	50	50	30	70
Annuals	15	25	10	50	10	20	30	10	10	10	19	10	50
Cryptogam	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock	0	0	0	0	0	0	0	0	0	0	0	0	0
Log	0	0	0	0	0	0	0	0	0	0	0	0	0
Bare	0	0	0	0	0	0	0	0	0	0	0	0	0
Perennial <0.5m	30	45	40	15	30	25	0	50	35	40	31	0	50
Total Ground Cover	100	100	100	100	100	100	100	100	100	100	100	100	100
0.5-2.0m	0	0	0	10	0	0	30	0	0	0	4	0	30
2.0-4.0m	0	0	0	0	0	0	0	0	0	0	0	0	0
4.0-6.0m	0	0	0	0	0	0	0	0	0	0	0	0	0
>6.0m	0	0	0	0	0	0	0	0	0	0	0	0	0

### 10.3.7 Species cover abundance

This year a total of 30 species, 11 of which were exotic species were found in the five 1m<sup>2</sup> quadrats on the permanent vegetation transect line. Using the Braun-blauquet scale, the highest possible cover score that can be obtained is 30 and cover abundance is illustrated as a sum of scores (class values) obtained along the five 1m<sup>2</sup> quadrats.

Figure 10-16 and Table 10-24 show that native species remained dominant within this site but this year there was an increased abundance of the exotics *Echium plantagineum*, *Salvia verbenaca* and various *Trifolium* species.

The most common and abundant species were *Austrodanthonia eriantha*, *Austrostipa nodosa*, *Austrostipa scabra subsp. falcata* and *Elymus scaber*. Other common native species included *Sida corrugata*, *Wahlenbergia gracilis* and *Xerochrysum bracteatum*. There continued to be a large patch of *Dichopogon*. The remaining species were fewer in number and/or provided lower cover values. Of the live plant cover scores recorded 62.9% was provided by native species which was a reduction from 81.3% recorded last year.

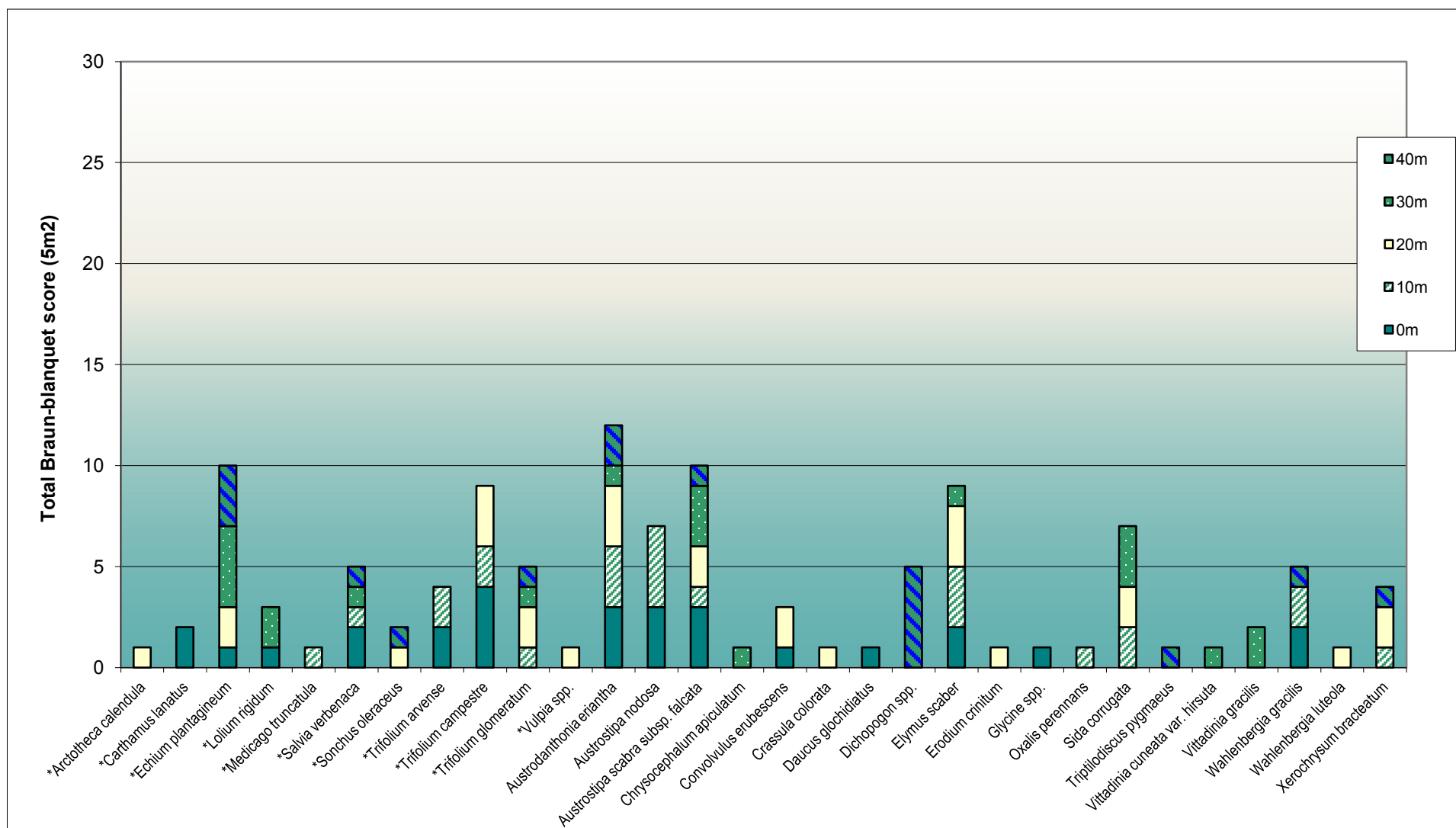


Figure 10-16. Total species recorded across the five, 1m<sup>2</sup> quadrats using the Braun-blanket scale (max possible score is 30) as a measure of cover abundance.

**Table 10-24. List of species and their average cover abundance score across the five, 1m<sup>2</sup> monitoring quadrats.**

Species	0m	10m	20m	30m	40m	Total
* <i>Arctotheca calendula</i>			1			1
* <i>Carthamus lanatus</i>	2					2
* <i>Echium plantagineum</i>	1		2	4	3	10
* <i>Lolium rigidum</i>	1			2		3
* <i>Medicago truncatula</i>		1				1
* <i>Salvia verbenaca</i>	2	1		1	1	5
* <i>Sonchus oleraceus</i>			1		1	2
* <i>Trifolium arvense</i>	2	2				4
* <i>Trifolium campestre</i>	4	2	3			9
* <i>Trifolium glomeratum</i>		1	2	1	1	5
* <i>Vulpia</i> spp.			1			1
<i>Austrodanthonia eriantha</i>	3	3	3	1	2	12
<i>Austrostipa nodosa</i>	3	4				7
<i>Austrostipa scabra</i> subsp. <i>falcata</i>	3	1	2	3	1	10
<i>Chrysocephalum apiculatum</i>				1		1
<i>Convolvulus erubescens</i>	1		2			3
<i>Crassula colorata</i>			1			1
<i>Daucus glochidiatus</i>	1					1
<i>Dichopogon</i> spp.					5	5
<i>Elymus scaber</i>	2	3	3	1		9
<i>Erodium crinitum</i>			1			1
<i>Glycine</i> spp.	1					1
<i>Oxalis perennans</i>		1				1
<i>Sida corrugata</i>		2	2	3		7
<i>Triptilodiscus pygmaeus</i>					1	1
<i>Vittadinia cuneata</i> var. <i>hirsuta</i>				1		1
<i>Vittadinia gracilis</i>				2		2
<i>Wahlenbergia gracilis</i>	2	2			1	5
<i>Wahlenbergia luteola</i>			1			1
<i>Xerochrysum bracteatum</i>		1	2		1	4
<b>Total cover</b>						116
<b>Sum of cover of native species</b>						73
<b>Percent endemic species cover</b>						62.9

### 10.3.8 Floristic diversity

The floristic diversity of the sites was measured using two different methods. One provides an assessment of the average number of species within five, one square metre (m<sup>2</sup>) sub-quadrats along the vegetation transect, while the other provides the total number of species within the entire 50x20m monitoring plot.

#### 10.3.8.1 Species diversity per m<sup>2</sup>

There has been a further decline in the number of native species per m<sup>2</sup> this year which have declined from 8.6 to 7.6 species, while exotic species have increased slightly from 3.0 - 5.0 species per m<sup>2</sup> (Table 10-25). The number of native species ranged between 6 - 9 species per m<sup>2</sup>, while the number of exotic species ranged between 4 – 6 species per m<sup>2</sup>.



Table 10-25. Species diversity per 1m<sup>2</sup>.

Species /m2	0m	10m	20m	30m	40m	Avg/m2	SD
Native	8	8	9	7	6	7.6	1.1
Exotic	6	5	6	4	4	5	1.0
Total	14	13	15	11	10	12.6	2.1

### 10.3.8.2 Total species diversity

The overall total floristic diversity recorded in the 50 x 20m monitoring quadrat has increased from 49 - 52, however this year there were 21 exotic species (Figure 10-17, Table 10-26). The series of small sharp increases in the species area curve indicate the diversity within the site was rather patchy. A full list of species recorded within the monitoring site is provided in Appendix 1.

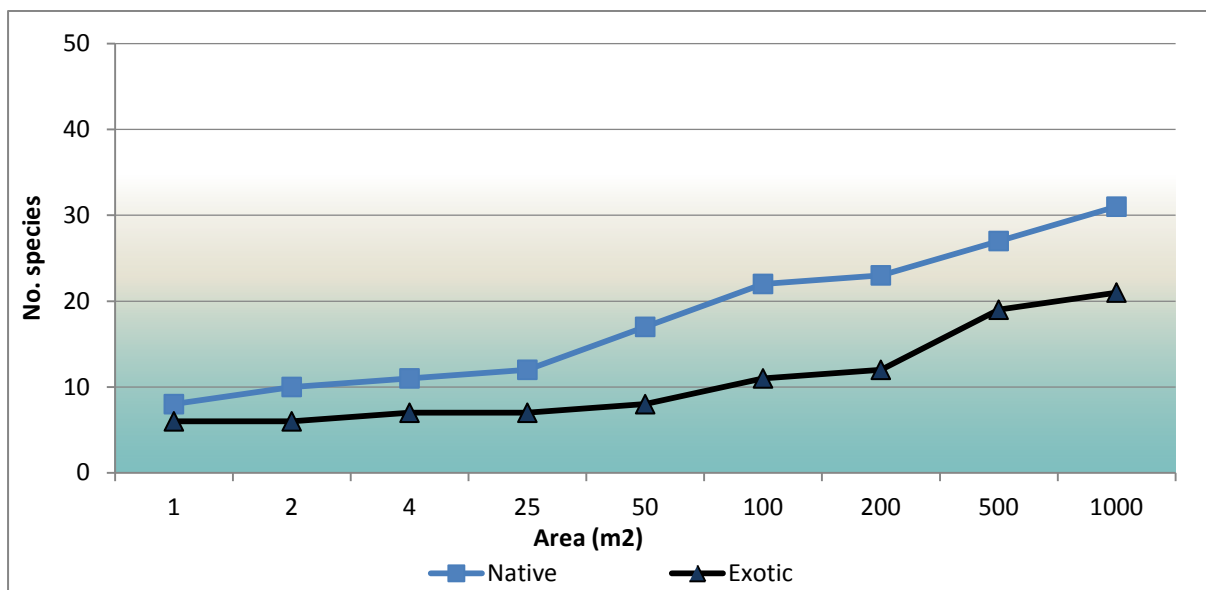
Figure 10-17. Cumulative species in the 50m x 20m (1000m<sup>2</sup>) monitoring quadrat.

Table 10-26. Cumulative species diversity.

Area (m2)	1	2	4	25	50	100	200	500	1000
Native	8	10	11	12	17	22	23	27	31
Exotic	6	6	7	7	8	11	12	19	21

### 10.3.9 Growth forms

Figure 10-18 is a summary of species in each growth form that were recorded in EOA-03. Herbs continued to be the most dominant growth with 37 species including 16 exotic species. There were 13 grass species and only five of these were exotic. There continued to be one tree species and this year there was one sub-shrub which was recorded for the first time. There were no reed species this year and no ferns were present this year. Compared to the composition of the reference sites this site lacked the diversity of tree species.

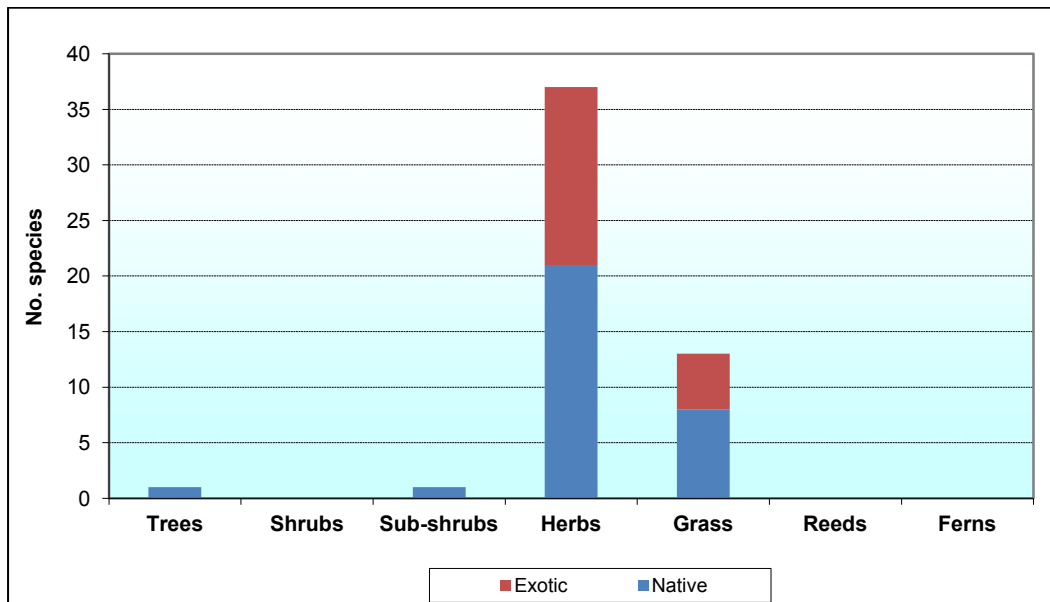


Figure 10-18. Graph illustrating the growth forms of species recorded in the 50m x 20m monitoring quadrat.

### 10.3.10 Comparison of rehabilitation data with key performance indicators

Table 10-27 indicates the performance of the monitoring site against the Completion and Desirable Performance Indicators developed for woodland sites during the 2013 monitoring period. The selection of criteria have been presented in order of ecosystem successional processes, beginning with landform establishment and stability (orange) for example and ending with indicators of ecosystem and landuse development (blue). The range values will be amended annually.

Rehabilitation sites meeting or exceeding the range values of their representative community type have 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 2013. 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 10-27. Comparison of key performance Indicators recorded site EOA-03 compared to lower and upper limits recorded in the woodland reference sites.**

Table 10-27: Comparison of key performance indicators recorded site EOA-03 compared to lower and upper limits recorded in the woodland reference sites.												
Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-03			
Performance indicators are quantified by the range of values obtained from replicated reference sites							Lower	Upper	2010	2011	2012	2013
Phase2: 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°)	0	5	0	0	0	0
	Landform function	Landform is functional and performing as it was designed to do	LFA Stability	Based on key physical, biological and chemical characteristics the LFA stability index provides an indication of the sites stability and that it is comparable to or trending towards that of the local remnant vegetation		%	62.9	69.0	77.5	77.5	73.0	70.0
			LFA Infiltration	Based on key physical, biological and chemical characteristics the LFA infiltration index provides an indication of the sites infiltration capacity and that it is comparable to or trending towards that of the local remnant vegetation		%	41.1	55.7	45.4	51.7	52.0	50.3
			LFA Nutrient recycling	Based on key physical, biological and chemical characteristics the LFA nutrient recycling index provides an indication of the sites ability to recycle nutrient and that it is comparable to or trending towards that of the local remnant vegetation		%	36.2	53.0	43.7	48.8	49.6	47.3
			LFA Landscape organisation	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and that it is comparable to that of the local remnant vegetation		%	100	100	100	100	100	100
	Active erosion	Areas of active erosion are limited	No. Rills/Gullies	Provides an assessment of the number of gullies or rills occurring in a 50m transect and that these are limited and stabilising		No.	0	0	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-03			
			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
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)	6.0	7.1	5.68	6.22	6.48	6.0
			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)	0.038	0.191	0.176	0.075	0.070	0.037
			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)	3.0	4.6	3.5	6.3	5.2	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)	6.4	17.3	23.0	16.4	15.4	8.4
			Nitrate	Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		ppm (>12.5)	1.2	1.9	42.1	2.2	3.8	1.2
			CEC		Cation Exchange Capacity is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	Cmol+/kg (>14)	12.0	22.9	10.74	11.90	11.14	7.94
			ESP		Exchangeable Sodium Percentage (a measure of sodicity) is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	% (<5)	0.3	2.4	0.92	0.32	0.38	0.3
Phase 4: Ecosystem & Landuse Establishment	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	6	0	0	1	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	na	NA	100	100
			Total species richness		The total number of live plant species provides an indication of the floristic diversity of the site and is comparable to the local remnant vegetation	No./area	53	76	61	50	49	52
			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	33	53	43	33	32	31



Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-03			
			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	13	27	18	17	17	21
	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	29	110	0	0	7	12
	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	2	4	0	0	1	1
			Shrubs	The number of shrub species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	0	3	0	0	0	0
			Sub-shrubs		The number of sub-shrub species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	1	5	0	0	0	1
			Herbs	The number of herbs or forb species comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	33	46	48	35	35	37
			Grasses		The number of grass species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	9	22	12	14	12	13
			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
			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
			Ferns		The number of ferns comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	1	1	1	0	0
Phase 5: Ecosystem & Landuse Development	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	%	47	77	6.5	43.0	54.5	50
			Annual plants		Percent ground cover provided by live annual plants is comparable to that of the local remnant vegetation	<%	2	22	30	7	2.0	19
			Cryptogam cover		Percent ground cover provided by cryptogams (eg mosses, lichens) is comparable to that of the local remnant vegetation	%	0	8	2.5	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-03			
			Rock		Percent ground cover provided by stones or rocks (> 5cm diameter) is comparable to that of the local remnant vegetation	%	0	1	0	0	0	0
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	0	3	0.0	0	0	0
			Bare ground		Percentage of bare ground is less than or comparable to that of the local remnant vegetation	< %	6	11	2	0	0	0
			Perennial plant cover (< 0.5m)	Percent ground cover provided by live perennial vegetation (< 0.5m in height) is comparable to that of the local remnant vegetation		%	7	25	59	50	43.5	31
			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		%	89	95	98	100	100	100
	Ground cover diversity	Vegetation contains a diversity of species per square meter comparable to that of the local remnant vegetation	Native understorey abundance		The abundance of native species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it has more than or an equal number of native species as the local remnant vegetation	> species/m <sup>2</sup>	7	8	12.8	10.2	8.6	7.6
			Exotic understorey abundance		The abundance of exotic species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it has less than or an equal number of exotic species as the local remnant vegetation	< species/m <sup>2</sup>	1	4	3.4	2.2	3.0	5.0
	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		%	63	87	81.1	85.6	81.3	62.9
	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	7	89	0	0	7	12
			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	2	15	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-03			
			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	13	0	0	0	0
			shrubs and juvenile trees 1.5 - 2m in height	The number of shrubs or juvenile trees 1.5-2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation		No./area	0	18	0	0	0	0
			shrubs and juvenile trees >2m in height		The number of shrubs or juvenile trees > 2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	0	48	0	0	0	0
	Ecosystem structure	The vegetation is developing in structure and complexity comparable to that of the local remnant vegetation	Foliage cover 0.5 - 2 m	Projected foliage cover provided by perennial plants in the 0.5 - 2m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation		% cover	1	9	0	1	0	4
			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	6	0	0	0	0
			Foliage cover 4 - 6m		Projected foliage cover provided by perennial plants in the 4 -6m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation	% cover	0	9	0	0	0	0
			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	17	42	0	0	0	0
	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	0	0	0	0
				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	0	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-03			
	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	6	19	0	0	0	0
			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	18	54	0	0	0	0
	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	83	100	0	0	0	0
			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	7	47	0	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	44	57	0	0	0	0
			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	0	36	0	0	0	0
			Dead Trees		The percentage of the tree population which are dead (stags) and that the percentage is comparable to the local remnant vegetation	% population	0	17	0	0	0	0
			Mistletoe		The percentage of the tree population which have mistletoe provides an indication of community health and habitat value and that the percentage is comparable to the local remnant vegetation	% population	0	7	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	50	83	0	0	0	0



## 10.4 EOA-04 site description

Estcourt Offset Area 04 (EOA-04) is situated on the edge of a woodland stand which contains a moderate canopy of *Callitris glaucophylla* trees of varying health, including numerous dead stags. The transect extended into an area of open grassland, which contained a higher diversity of native ground cover species than beneath the tree canopies. There was no *C. glaucophylla* recruitment but numerous trees were flowering or contained fruit. The site contained numerous fallen logs and branches. The understorey was relatively weedy with *Lolium sp* and *Trifolium* species being very common, but it retained high native species diversity and native perennial grasses were particularly dominant. There were no shrubs and no tree hollows were observed. The site had very high species diversity. In 2011, later monitoring and drier seasonal conditions has resulted in a reduction in floristic diversity. In 2012, there were 7 *Dodonaea* and two *Callitris* seedlings. In 2013 there continued to be good cover of native grasses but there were patches of *Echium plantagineum*. Only one seedling each of *Dodonaea* and *Callitris* were found this year.

### 10.4.1 Landscape Function Analysis

#### 10.4.1.1 Landscape organisation

EOA-04 continued to be characterised as a woodland patch and resulted in a Landscape Organisation Index of 100% indicating there is little to no leakage of resources from the site (Figure 10-19, Table 10-28). The woodland continued to have a high abundance of native perennial species, dead leaf litter and fallen branches which collectively provided high levels of soil surface cover resulting in a highly stable and functional community.

In 2010 and 2011 the site has demonstrated improved ecological function largely due to significant increase in depth of litter cover and higher states of decomposition. Since then however there was a marginal decline in ecological function largely due to the decline in active perennial grass growth but there was also less litter cover this year and cryptogams were scarce. The resultant LFA indices for stability, infiltration and nutrient recycling were 70.5, 49.4 and 44.3 respectively. Compared to the minimum range provided by other local woodland sites, the LFA indices were 7.6, 8.3 and 8.1 units higher.



Figure 10-19. Permanent photo point taken from the top of the LFA transect in 2012 (left) and 2013 (right).

Table 10-28. Summary of landscape organisation and LFA indices in 2010, 2011, 2012 and 2013.

EOA-04		24/09/2010		20/10/2011		18/10/2012		16/10/2013	
Number of Patches/10m		0.5		0.5		0.5		0.5	
Total Patch Area (m2)		200		200		200		200.00	
Patch Area Index		1		1		1		1.00	
Landscape Organisation Index		1		1		1		1.00	
Average Interpatch Length (m)		NA		NA		NA		NA	
Range Interpatch length (m)		NA		NA		NA		NA	
Patch or Interpatch Type		Woodland Patch		Woodland Patch		Woodland Patch		Woodland Patch	
Patch or Interpatch Proportion (%)		100	100	100	100	100	100	100.0	100
Soil Surface Assessment									
Within Individual Zones	Stability	70		76		73.5		70.5	
	Infiltration	43.7		49.9		52.7		49.4	
	Nutrients	37.6		46		48.3		44.3	
			Total		Total		Total		Total
Individual zones contribution to the whole of Landscape	Stability	70	70	76	76	73.5	73.5	70.5	70.5
	Infiltration	43.7	43.7	49.9	49.9	52.7	52.7	49.4	49.4
	Nutrients	37.6	37.6	46	46	48.3	48.3	44.3	44.3

#### 10.4.1.2 Soil Surface Assessment

There continued to be a decline in perennial plant cover and as a result there was a lower level of rain splash protection and perennial basal cover but these typically provided moderate levels of cover, while the mature *Callitris glaucophylla* trees continued to provide high canopy cover (Table 10-29). There was a slight decline in litter cover and while this remained high there appeared to be less evidence of decomposition with slight decomposition being more typical this year, even within the more open grassland area. The soil surface remained crusted and due to the high vegetative cover there continued to be an absence of cryptogams. The grass tussocks continued to provide moderate surface relief and there was little to no evidence of erosion or decomposition. The loam soils remained moderately hard and very stable, due to the high levels of organic matter and humus.

**Table 10-29 . Results of the Soils Surface Assessment for the Woodland patch.**

Features	Max score	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Soil Cover	5	2	3	3	3	3
Per. basal / canopy cover	4	4	4	3	4	4
Litter cover, orig & incorp.	10	5ls	6ls	6ls	5lm	5ls
Cryptogam cover	4	2	1	1	1	1
Crust broken-ness	4	4	4	4	4	4
Erosion type & severity	4	4	4	4	4	4
Deposited materials	4	3	4	4	4	4
Soil surface roughness	5	2	3	3	3	3
Surface resist. to disturb.	5	3	3	3	3	3
Slake test	4	4	4	4	4	4
Texture	4	3	3	3	3	3

## 10.4.2 Soil analyses

The result of the soil analyses indicates there have only been minor changes in the soil characteristics since 2010 and this year minor reductions in numerous attributes were recorded and were likely to have been due to inherent site and sampling variability and the prolonged dry conditions. The soil pH has slightly declined to moderately acidic levels and this year these were lower than local levels but remained within the desirable range (Table 10-30). The Electrical Conductivity continued to be low indicating low levels of soluble salts and the presence of non saline soils. Organic Matter, phosphorous and nitrates had also declined but these were typical of the local area. CEC levels were low and there has been little change in ESP and these low levels indicate that the soils are non sodic.

**Table 10-30. Results of the soil analysis for EOA-04 compared to the upper and lower values for the woodland reference sites and desirable levels in 2010, 2011, 2012 and 2013.**

Nutrient	Units	EOA-04				Lower KPI	Upper KPI	Desirable Level
		2010	2011	2012	2013			
pH (1:5 water)	units	6.07	6.07	6.16	5.62	5.99	7.10	5.6 – 7.3
Conductivity (1:5 water)	dS/m	0.063	0.079	0.078	0.030	0.04	0.19	0.150
Organic Matter	%	9.1	7.5	7.8	5.1	3.01	4.61	>4.5
Phosphorus (Colwell)	mg/kg	33	18	16	9	6.41	17.29	50
Nitrate	mg/kg	3.2	4.8	5.6	1.4	1.20	1.88	13.0
Cation Exchange Capacity	cmol*/Kg	16.82	14.87	16.61	10.59	12.05	22.87	14.00
Exchangeable Sodium Percentage	%	0.18	0.22	0.20	0.37	0.29	2.42	<5

## 10.4.3 Rill assessment

No rills were observed within the monitoring quadrat in any monitoring year

## 10.4.4 Tree density and health condition

There has been little change within this mature *Callitris glaucophylla* woodland patch which consists of 14 *Callitris glaucophylla* trees and seven dead stags. They had an average dbh of 28cm but they ranged from 12 – 43cm in diameter. The majority of the live trees remained in medium health, but three were healthy and two were considered to be in a state of advanced dieback, possibly due to the prolonged drought conditions increasing competition levels between the trees. Eight individuals were in flower or were bearing cones. No mistletoe or tree hollows were observed.

Table 10-31. Summary of tree health and density.

Dominant species	<i>Callitris glaucophylla</i> (14)
Average dbh (Cm)	28
Max dbh (cm)	43
Min dbh (cm)	12
Total trees	21
No. with multiple limbs	2
No. Live trees	14
No. Healthy	3
No. Medium Health	9
No. Advanced Dieback	2
No. Dead	7
Mistletoe	0
Flowers / fruit	8

### 10.4.5 Shrubs and regeneration

Last year two *Callitris glaucophylla* and eight *Dodonaea viscosa subsp. cuneata* seedlings were recorded with two *Dodonaea viscosa subsp. cuneata* up to 1m in height. This year however only one seedlings of each were relocated and these had been heavily browsed (Figure 10-20, Table 10-32).

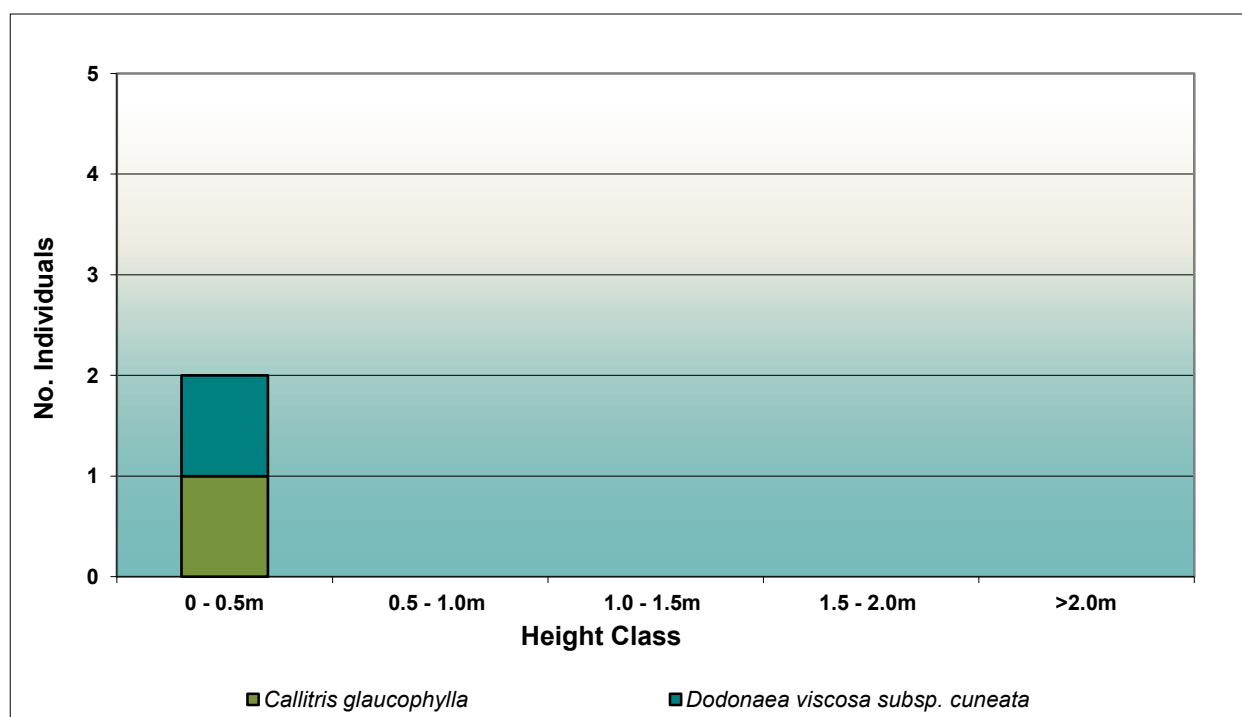


Figure 10-20. Shrubs and young trees occurring within the monitoring site.

Table 10-32. Shrubs and young trees occurring within the monitoring site.

Species	0 - 0.5m	0.5 - 1.0m	1.0 - 1.5m	1.5 - 2.0m	>2.0m	Total	endemic	not endemic
<i>Callitris glaucophylla</i>	1					1	1	
<i>Dodonaea viscosa subsp. cuneata</i>	1					1	1	
<b>Total</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>2</b>	<b>2</b>	<b>0</b>
<b>% endemic species</b>							<b>100</b>	<b>0</b>



#### 10.4.6 Structural diversity and habitat complexity

The structural composition of site EOA-04 has changed very little over the past few years and retains a high total ground cover of 100% (Figure 10-21, Figure 10-22). Dead leaf litter continues to be a dominant form of cover and this year has increased from 62 –56.5% with annual plants also providing 7% cover this year. There has been a small reduction in perennial vegetation cover but this provided 36.5% cover and there continued to be an absence of cryptogams. No logs and fallen branches were recorded along the vegetation transect but they were scattered across the larger remnant area.

The *Callitris glaucophylla* stand provided some canopy cover <6.0m in the first half of the transect, with one tree providing some lower canopy cover 2.0 – 4.9 and 4.0 – 6.0m vertical height categories. Beyond 25m, the site transforms into an open grassland area. Overall the site lacked projected foliage cover within the 0.5 – 2.0m height category. Average and minimum and maximum values of the structural diversity are recorded in Table 10-33.

2010 Vegetation transect (front)



2010 Vegetation transect (rear)



2011 Vegetation transect (front)



2011 Vegetation transect (rear)





2012 Vegetation transect (front)



2012 Vegetation transect (rear)



2013 Vegetation transect (front)



2013 Vegetation transect (rear)

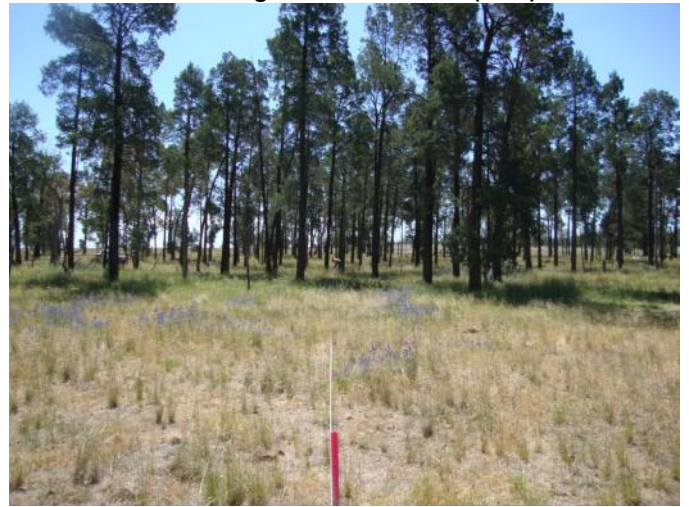


Figure 10-21. Permanent photo points taken from the front (left) and rear (right) of the vegetation transect.

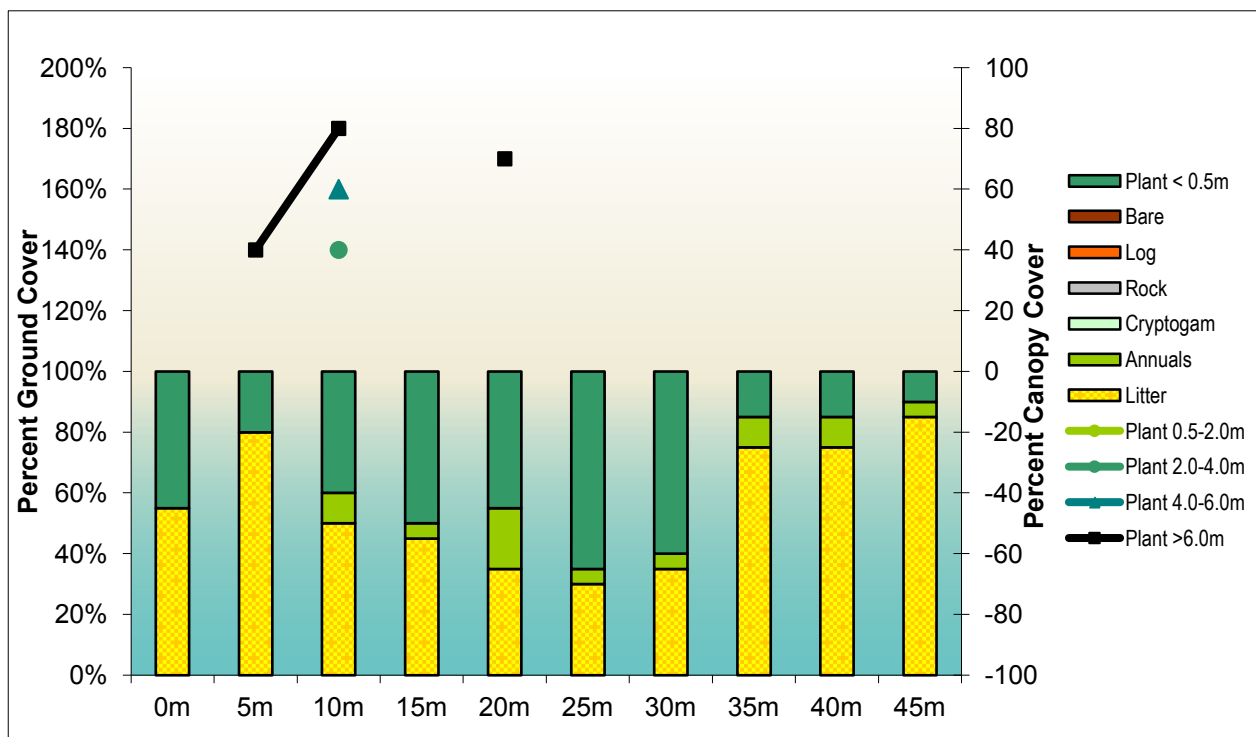


Figure 10-22. Graph illustrating the structural diversity and habitat complexity of the monitoring site.

Table 10-33. Average and minimum and maximum values of the structural diversity of the monitoring site.

Vegetation structure	0m	5m	10m	15m	20m	25m	30m	35m	40m	45m	Average	Min	Max
Litter	55	80	50	45	35	30	35	75	75	85	56.5	30	85
Annuals	0	0	10	5	20	5	5	10	10	5	7	0	20
Cryptogam	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock	0	0	0	0	0	0	0	0	0	0	0	0	0
Log	0	0	0	0	0	0	0	0	0	0	0	0	0
Bare	0	0	0	0	0	0	0	0	0	0	0	0	0
Perennial <0.5m	45	20	40	50	45	65	60	15	15	10	36.5	10	65
Total Ground Cover	100	100	100	100	100	100	100	100	100	100	100	100	100
0.5-2.0m	0	0	0	0	0	0	0	0	0	0	0	0	0
2.0-4.0m	0	0	40	0	0	0	0	0	0	0	4	0	40
4.0-6.0m	0	0	60	0	0	0	0	0	0	0	6	0	60
>6.0m	0	40	80	0	70	0	0	0	0	0	19	0	80

### 10.4.7 Species cover abundance

This year there were 22 species recorded in the five 1m<sup>2</sup> quadrats on the permanent vegetation transect line, with eight species being exotic species. Using the Braun-blauquet scale, the highest possible cover score that can be obtained is 30. Cover abundance is illustrated as a sum of scores (class values) obtained along the five 1m<sup>2</sup> quadrats.

*Austrodanthonia eriantha* continued to be the most dominant species, followed by *Austrostipa scabra* subsp. *falcata* and *Glycine* spp., a native twining forb was also very common. Other common native species included *Sida corrugata* and *Daucus glochidiatus*. The exotic species *Lolium rigidum* and a variety of *Trifolium* species were also quite common (Figure 10-23, Table 10-34). The remaining species were recorded on less than two occasions or provided low cover values. Of the live plant cover scores recorded 73.4% was provided by native species which was a reduction from 96.4% recorded last year.

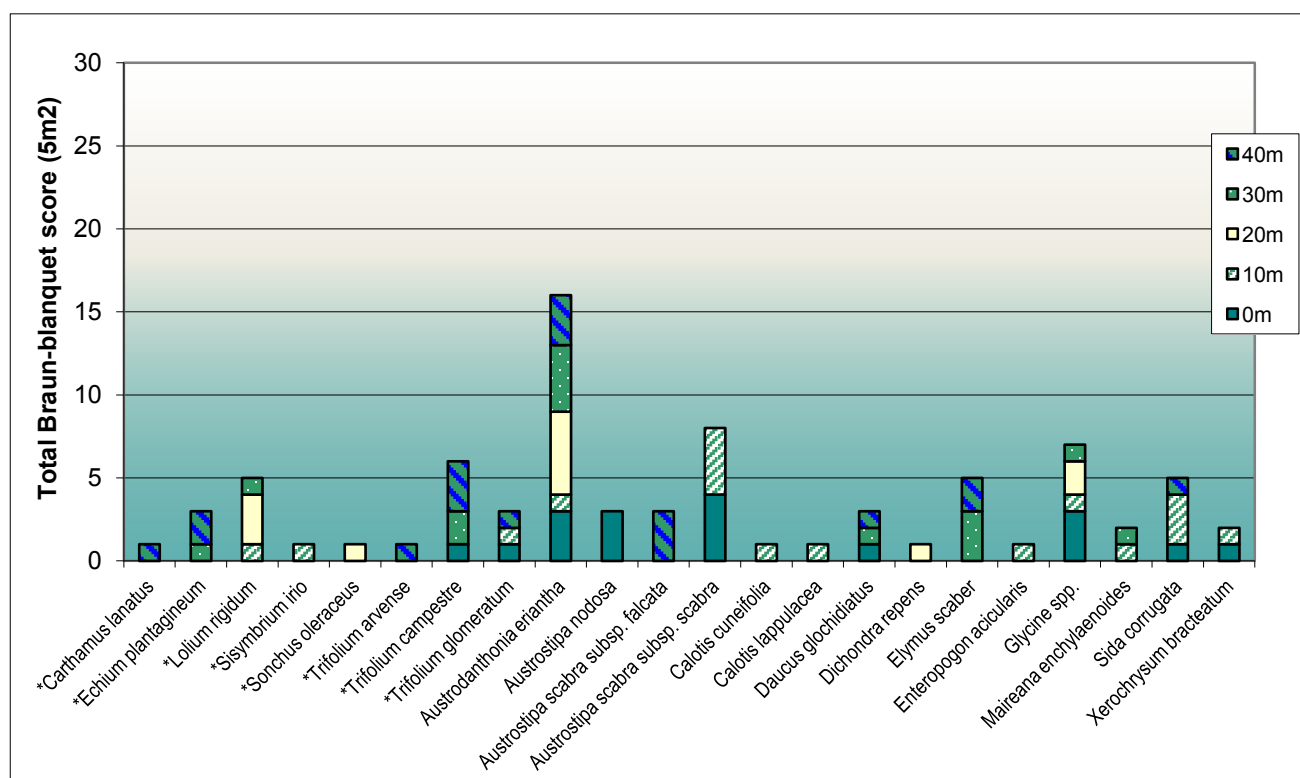


Figure 10-23. Total species recorded across the five, 1m<sup>2</sup> quadrats using the Braun-blauquet scale (max possible score is 30) as a measure of cover abundance.

**Table 10-34. List of species and their average cover abundance score across the five, 1m<sup>2</sup> monitoring quadrats.**

Species	0m	10m	20m	30m	40m	Total
* <i>Carthamus lanatus</i>					1	1
* <i>Echium plantagineum</i>				1	2	3
* <i>Lolium rigidum</i>		1	3	1		5
* <i>Sisymbrium irio</i>		1				1
* <i>Sonchus oleraceus</i>			1			1
* <i>Trifolium arvense</i>					1	1
* <i>Trifolium campestre</i>	1			2	3	6
* <i>Trifolium glomeratum</i>	1	1			1	3
<i>Austrodanthonia eriantha</i>	3	1	5	4	3	16
<i>Austrostipa nodosa</i>	3					3
<i>Austrostipa scabra</i> subsp. <i>falcata</i>					3	3
<i>Austrostipa scabra</i> subsp. <i>scabra</i>	4	4				8
<i>Calotis cuneifolia</i>		1				1
<i>Calotis lappulacea</i>		1				1
<i>Daucus glochidiatus</i>	1			1	1	3
<i>Dichondra repens</i>			1			1
<i>Elymus scaber</i>				3	2	5
<i>Enteropogon acicularis</i>		1				1
<i>Glycine</i> spp.	3	1	2	1		7
<i>Maireana enchylaenoides</i>		1		1		2
<i>Sida corrugata</i>	1	3			1	5
<i>Xerochrysum bracteatum</i>	1	1				2
<b>Total cover</b>						79
<b>Sum of cover of native species</b>						58
<b>Percent endemic species cover</b>						73.4

### 10.4.8 Floristic diversity

The floristic diversity of the sites was measured using two different methods. One provides an assessment of the average number of species within five, one square metre (m<sup>2</sup>) sub-quadrats along the vegetation transect, while the other provides the total number of species within the entire 50x20m monitoring plot.

#### 10.4.8.1 Species diversity per m<sup>2</sup>

There has been a slight increase from 5.0 – 5.8 native species per m<sup>2</sup> and the number of exotics species also increased from 0.4 – 3.0 species per m<sup>2</sup> (Table 10-35). The number of native species ranged between 3 – 7 species per m<sup>2</sup>, while exotic species ranged from 2 - 5.

**Table 10-35. Species diversity per 1m<sup>2</sup>.**

Species /m2	0m	10m	20m	30m	40m	Avg/m2	SD
Native	7	9	3	5	5	5.8	2.3
Exotic	2	3	2	3	5	3	1.2
<b>Total</b>	<b>9</b>	<b>12</b>	<b>5</b>	<b>8</b>	<b>10</b>	<b>8.8</b>	<b>2.6</b>

#### 10.4.8.2 Total species diversity

The overall floristic diversity has also increased from 47 - 54 species in the 50 x 20m monitoring quadrat and this included 18 exotic species (Figure 10-24, Table 10-36). The series of small sharp increases in the species area curve indicate the diversity within the site was rather patchy. A full list of species recorded within the monitoring site is provided in Appendix 1.

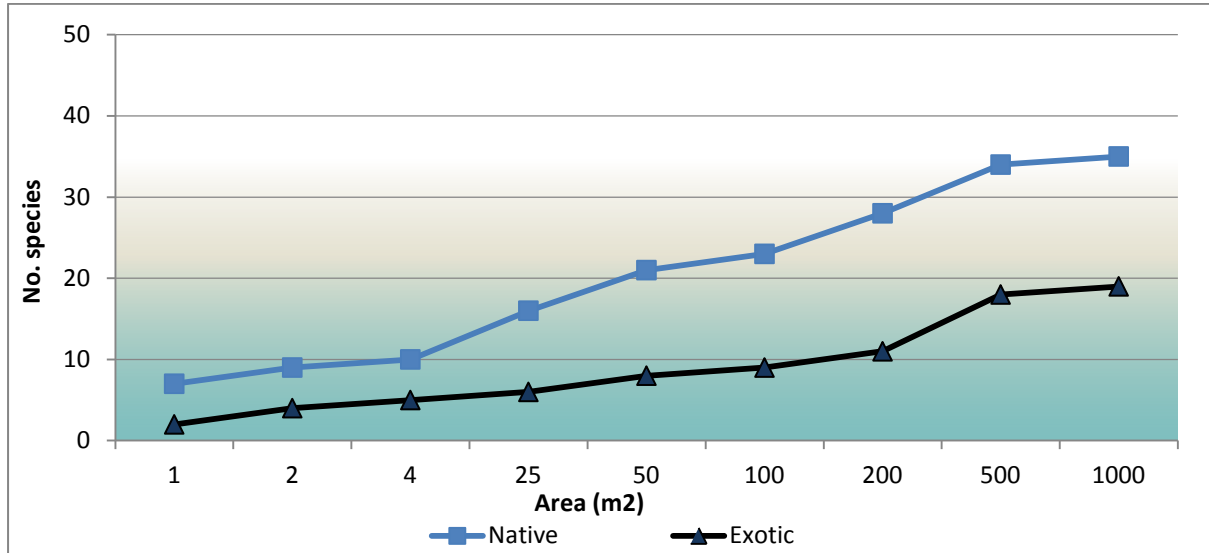


Figure 10-24. Cumulative species in the 50m x 20m (1000m²) monitoring quadrat.

Table 10-36. Cumulative species diversity.

Area (m2)	1	2	4	25	50	100	200	500	1000
Native	7	9	10	16	21	23	28	34	35
Exotic	2	4	5	6	8	9	11	18	19

#### 10.4.9 Growth forms

Figure 10-25 is a summary of species in each growth form that were recorded in EOA-04. The site continued to be dominated by herbs, with 38 different species including 16 exotic species and there were 13 different grass species including three exotic species. There was one shrub and one sub-shrub but no reed or fern species were recorded this year. Compared to the composition of the reference sites the site lacked the diversity of tree species.

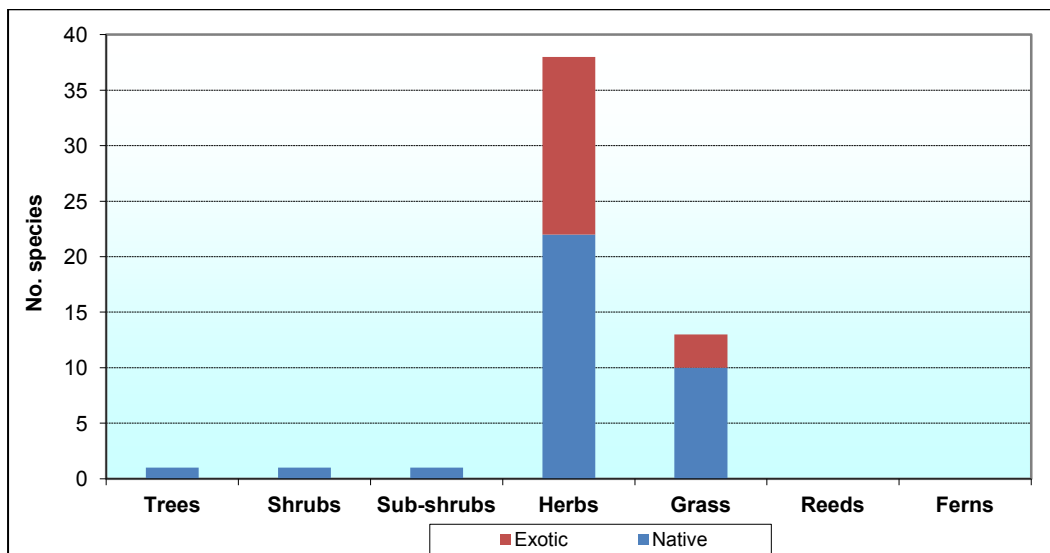


Figure 10-25. Graph illustrating the growth forms of species recorded in the 50m x 20m monitoring quadrat.



#### 10.4.10 Comparison of rehabilitation data with key performance indicators

Table 10-37 indicates the performance of the monitoring site against the Completion and Desirable Performance Indicators developed for woodland sites during the 2013 monitoring period. The selection of criteria have been presented in order of ecosystem successional processes, beginning with landform establishment and stability (orange) for example and ending with indicators of ecosystem and landuse development (blue). The range values will be amended annually.

Rehabilitation sites meeting or exceeding the range values of their representative community type have 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 2013. 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 10-37. Comparison of key performance Indicators recorded at site EOA-04 compared to lower and upper limits recorded in the woodland reference sites.**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-04			
Performance indicators are quantified by the range of values obtained from replicated reference sites							Lower	Upper	2010	2011	2012	2013
Phase2: 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°)	0	5	1	1	1	1
	Landform function	Landform is functional and performing as it was designed to do	LFA Stability	Based on key physical, biological and chemical characteristics the LFA stability index provides an indication of the sites stability and that it is comparable to or trending towards that of the local remnant vegetation		%	62.9	69.0	70.0	76.0	73.5	70.5
			LFA Infiltration	Based on key physical, biological and chemical characteristics the LFA infiltration index provides an indication of the sites infiltration capacity and that it is comparable to or trending towards that of the local remnant vegetation		%	41.1	55.7	43.7	49.9	52.7	49.4
			LFA Nutrient recycling	Based on key physical, biological and chemical characteristics the LFA nutrient recycling index provides an indication of the sites ability to recycle nutrient and that it is comparable to or trending towards that of the local remnant vegetation		%	36.2	53.0	37.6	46.0	48.3	44.3
			LFA Landscape organisation	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and that it is comparable to that of the local remnant vegetation		%	100	100	100	100	100	100
	Active erosion	Areas of active erosion are limited	No. Rills/Gullies	Provides an assessment of the number of gullies or rills occurring in a 50m transect and that these are limited and stabilising		No.	0	0	0	0	0	0



Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-04			
			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
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)	6.0	7.1	8.07	8.07	8.16	8.02
			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)	0.038	0.191	0.063	0.079	0.078	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)	3.0	4.6	9.1	7.5	7.8	5.1
			Phosphorous		Available Phosphorus is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	ppm (50)	6.4	17.3	32.8	17.8	15.6	9.2
			Nitrate	Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		ppm (>12.5)	1.2	1.9	3.2	4.8	5.6	1.4
			CEC		Cation Exchange Capacity is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	Cmol+/kg (>14)	12.0	22.9	16.8	14.87	16.61	10.59
			ESP		Exchangeable Sodium Percentage (a measure of sodicity) is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	% (<5)	0.3	2.4	0.18	0.22	0.20	0.4
Phase 4: Ecosystem & Landuse Establishment	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	6	0	1	2	2
				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	na	100	100	100
			Total species richness		The total number of live plant species provides an indication of the floristic diversity of the site and is comparable to the local remnant vegetation	No./area	53	76	71	54	47	54
			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	33	53	51	39	38	35

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-04			
			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	13	27	20	15	9	19
	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	29	110	0	4	10	2
	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	2	4	1	1	1	1
			Shrubs	The number of shrub species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	0	3	0	1	1	1
			Sub-shrubs		The number of sub-shrub species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	1	5	0	2	3	1
			Herbs	The number of herbs or forb species comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	33	46	53	35	26	38
			Grasses		The number of grass species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	9	22	16	14	14	13
			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	1	1	0
			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
			Ferns		The number of ferns comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	1	1	0	1	0
Phase 5: Ecosystem & Landuse Development	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	%	47	77	11	57.5	62	56.5
			Annual plants		Percent ground cover provided by live annual plants is comparable to that of the local remnant vegetation	<%	2	22	24.5	0	0	7
			Cryptogam cover		Percent ground cover provided by cryptogams (eg mosses, lichens) is comparable to that of the local remnant vegetation	%	0	8	6	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-04			
			Rock		Percent ground cover provided by stones or rocks (> 5cm diameter) is comparable to that of the local remnant vegetation	%	0	1	0	0	0	0
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	0	3	0.0	0	0	0
			Bare ground		Percentage of bare ground is less than or comparable to that of the local remnant vegetation	< %	6	11	3	0	0.5	0
			Perennial plant cover (< 0.5m)	Percent ground cover provided by live perennial vegetation (< 0.5m in height) is comparable to that of the local remnant vegetation		%	7	25	55.5	42.5	37.5	36.5
			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		%	89	95	97	100	99.5	100
	Ground cover diversity	Vegetation contains a diversity of species per square meter comparable to that of the local remnant vegetation	Native understorey abundance		The abundance of native species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it is has more than or an equal number of native species as the local remnant vegetation	> species/m <sup>2</sup>	7	8	10.2	7.6	5	5.8
			Exotic understorey abundance		The abundance of exotic species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it is has less than or an equal number of exotic species as the local remnant vegetation	< species/m <sup>2</sup>	1	4	3.8	0.2	0.4	3
	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		%	63	87	75.4	98.6	96.4	73.4
	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	7	89	0	4	8	2
			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	2	15	0	0	2	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-04			
			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	13	0	0	0	0
			shrubs and juvenile trees 1.5 - 2m in height	The number of shrubs or juvenile trees 1.5-2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation		No./area	0	18	0	0	0	0
			shrubs and juvenile trees >2m in height		The number of shrubs or juvenile trees > 2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	0	48	0	0	0	0
	Ecosystem structure	The vegetation is developing in structure and complexity comparable to that of the local remnant vegetation	Foliage cover 0.5 - 2 m	Projected foliage cover provided by perennial plants in the 0.5 - 2m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation		% cover	1	9	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	6	0	3	3	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	0	9	4	7	5	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	17	42	22	18	24	19
	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	1	1	1	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	100

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-04			
	<b>Tree density</b>	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	6	19	21	21	21	21
			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	18	54	28	28	28	28
	<b>Ecosystem health</b>	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	83	100	67	66.7	66.7	66.7
			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	7	47	14.0	9.5	9.5	14.3
			Medium health		The percentage of the tree population which are in a medium health condition and that the percentage is comparable to the local remnant vegetation	% population	44	57	38	38.1	47.6	42.9
			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	0	36	14.0	9.5	9.5	9.5
			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	17	33	33.3	33.3	33.3
			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	7	0.0	0	0	0
			Flowers/fruit: Trees	The percentage of the tree population with reproductive structures such as buds, flowers or fruit provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources comparable to that of the local remnant vegetation		% population	50	83	48.0	47.6	52.4	38.1



## 10.5 EOA-05 site description

Estcourt Offset Area 05 (EOA-05) is situated to the north east of the site within a sparse woodland stand of *Callitris glaucophylla* trees, including two dead stags. In 2010 there was no *C. glaucophylla* recruitment but the trees were flowering or contained fruit. The understorey was relatively weedy (23 exotic species) especially beneath the trees where there were remnant stockcamps, with *Lolium* and *Trifolium* species being very common, but it retained high native species diversity (49 species) and native perennial grasses were particularly dominant. There were no shrubs and one tree hollow was observed in one of the dead stags. The site had very high species diversity (72 species). In 2011, later monitoring and drier seasonal conditions has resulted in a reduction in floristic diversity. In 2012, 11 *C. glaucophylla* seedlings were found. In 2013 there continued to be good cover of native grasses but there were patches of *Echium plantagineum*. Fourteen *C. glaucophylla* seedlings were recorded. An echidna had destroyed a large ant nest.

### 10.5.1 Landscape Function Analysis

#### 10.5.1.1 Landscape organisation

EOA-05 continued to be characterised as a woodland patch with no interpatch areas leaking resources from the site (Figure 10-26, Table 10-38), which subsequently resulted in a Landscape Organisation Index of 100%. Between 2010 and 2011 this site had had little change in stability but a marked improvement in infiltration and nutrient recycling has occurred largely due to increased extent and depth of litter cover, higher states of litter decomposition and reduced surface crusting and soil hardness. In 2012 and 2013 however there has been a declining trend in ecological function, largely due to the combination of reduced perennial plant and cryptogam covers, and this year there was a decline in litter cover.

The resultant LFA indices for stability, infiltration and nutrient recycling were 70.5, 47.8 and 44.1 respectively. Compared to the minimum KPI target provided by the woodland reference sites, this site had LFA indices which were 7.6, 6.7 and 7.9 units higher respectively.



Figure 10-26. Permanent photo point taken from the top of the LFA transect in 2012 (left) and 2013 (right).

Table 10-38. Summary of landscape organisation and LFA indices in 2010 - 2013.

EOA-05		24/09/2010		20/10/2011		18/10/2012		16/10/2013	
Number of Patches/10m		0.5		0.5		0.5		0.5	
Total Patch Area (m2)		200		200		200		200.00	
Patch Area Index		1		1		1		1.00	
Landscape Organisation Index		1		1		1		1.00	
Average Interpatch Length (m)		NA		NA		NA		NA	
Range Interpatch length (m)		NA		NA		NA		NA	
Patch or Interpatch Type		Grassy Woodland Patch		Grassy Woodland Patch		Grassy Woodland Patch		Grassy Woodland Patch	
Patch or Interpatch Proportion (%)		100	100	100	100	100	100	100.0	100
Soil Surface Assessment									
Within Individual Zones	Stability	78		78.5		73.5		70.5	
	Infiltration	38.4		48.5		48.9		47.8	
	Nutrients	40		48.8		46		44.1	
			Total		Total		Total		Total
Individual zones contribution to the whole of Landscape	Stability	78	78	78.5	78.5	73.5	73.5	70.5	70.5
	Infiltration	38.4	38.4	48.5	48.5	48.9	48.9	47.8	47.8
	Nutrients	40	40	48.8	48.8	46	46	44.1	44.1

### 10.5.1.2 Soil Surface Assessment

There has been a further reduction in perennial plant cover this year which provided low to moderate levels of protective ground cover and was largely provided by the native perennial grasses as the tree cover was limited (Table 10-39). There continued to be high cover of dead leaf litter and annual plants which had accumulated to some depth across the site and slight to moderate states of decomposition were observed indicating improved levels of microbial and fungal activity.

The soils remained crusted and this year there was an absence of cryptogams probably due to the increasing levels of ground cover. The vegetation and heavy litter covers continued to provide moderate soil surface relief and there was little to no evidence of erosion or deposition despite the high rainfall activity during June. The clay loam soils continued to be moderately hard across the site and due to the developing humus layer they remained very stable.

**Table 10-39 . Results of the Soils Surface Assessment for the Grassy Woodland patch.**

Features	Max score	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Soil Cover	5	3	3	3	2	2
Per. basal / canopy cover	4	2	3	3	2	3
Litter cover, orig & incorp.	10	5ls	6ls	6lm	5ls	6lm
Cryptogam cover	4	1	1	1	1	1
Crust broken-ness	4	4	4	4	4	4
Erosion type & severity	4	4	4	4	4	4
Deposited materials	4	4	4	4	4	4
Soil surface roughness	5	3	3	3	3	3
Surface resist. to disturb.	5	3	3	3	3	3
Slake test	4	4	4	4	4	4
Texture	4	2	2	2	2	2

### 10.5.2 Soil analyses

The result of the soil analyses indicates there have only been minor changes in the soil characteristics since 2010 and this year minor reductions in numerous attributes were recorded and were likely to have been due to a combination of the prolonged dry conditions and inherent site and sampling variability. The soil pH was moderately acidic this but while it was lower than local levels it remained within the desirable range (Table 10-40). There was little change in the Electrical Conductivity and this continued to be low indicating low levels of soluble salts and the presence of non saline soils. Organic matter and phosphorous had also declined but these remained typical of the local area. There was a slight increase in nitrates these were within desirable levels despite being higher than the local woodlands. CEC levels were normal and the low ESP indicates that the soils are non sodic.

**Table 10-40. Results of the soil analysis for EOA-05 compared to the upper and lower values for the woodland reference sites and desirable levels 2010 - 2013.**

Nutrient	Units	EOA-05				Lower KPI	Upper KPI	Desirable Level
		2010	2011	2012	2013			
pH (1:5 water)	units	5.87	6.24	6.14	5.76	5.99	7.10	5.6 – 7.3
Conductivity (1:5 water)	dS/m	0.093	0.091	0.057	0.054	0.04	0.19	0.150
Organic Matter	%	4.8	6.1	4.8	3.2	3.01	4.61	>4.5
Phosphorus (Colwell)	mg/kg	18	15	16	8	6.41	17.29	50
Nitrate	mg/kg	22.0	6.2	4.5	5.0	1.20	1.88	13.0
Cation Exchange Capacity	cmol+/Kg	12.73	13.67	12.15	13.86	12.05	22.87	14.00
Exchangeable Sodium Percentage	%	0.79	0.86	0.62	1.27	0.29	2.42	<5

### 10.5.3 Rill assessment

No rills were observed within the monitoring quadrat in any monitoring year.

### 10.5.4 Tree density and health condition

There was little change observed among the mature trees (>5cm dbh) with three live *Callitris glaucophylla* and two dead stags recorded within the 50 x 20m monitoring plot, equating to a tree density of 50 trees per hectare (Table 10-41). This year all three of the live trees were considered to be in a healthy condition and contained fruits and/or flowers. The average dbh was 46cm and ranged from 18 – 67 cm. One of the stags contained tree hollows.

Table 10-41. Summary of tree health and density.

Dominant species	<i>Callitris glaucophylla</i> (3)
Average dbh (Cm)	46
Max dbh (cm)	67
Min dbh (cm)	18
Total trees	5
No. with multiple limbs	0
No. Live trees	3
No. Healthy	3
No. Medium Health	0
No. Advanced Dieback	0
No. Dead	2
Mistletoe	0
Flowers / fruit	3

### 10.5.5 Shrubs and regeneration

This year 14 *Callitris glaucophylla* seedlings were counted within site as a result of a natural recruitment event probably initiated over summer 2011/12. All individuals continued to be less than 0.5m in height and at the time of monitoring were approximately 10 - 20cm tall. Many other juvenile *C. glaucophylla*, *E. microcarpa* and *E. populnea* were now visible within the larger paddock areas as a result of natural recruitment.

Table 10-42. Shrubs and young trees occurring within the monitoring site.

Species	0 - 0.5m	0.5 - 1.0m	1.0 - 1.5m	1.5 - 2.0m	>2.0m	Total	endemic	not endemic
<i>Callitris glaucophylla</i>	14					14	14	
Total	14	0	0	0	0	14	14	0
% endemic species							100	0

### 10.5.6 Structural diversity and habitat complexity

Site EOA-05 remains to be relatively simple in structure and continues to have high levels of ground cover and this year there was 99.5% total ground cover (Figure 10-27, Figure 10-28). While dead leaf litter continued to be the most dominant form of cover this has declined from 72 – 50.5% cover, and this year annual plants had become quite abundant and provided 16.5% cover. There was a minor increase in perennial plant cover and there continued to be an absence of cryptogams along the transect this year. A small branch, which presumably fell from the tree above continued to provide a small amount of cover at the 15m mark on the transect.

The mature *Callitris* trees were sparsely distributed in this area but one provided some canopy cover in the 4 - 6m and >6.0m vertical height categories at 15m along the transect. No other vertical foliage cover was recorded and the site typically lacked vertical complexity. Average and minimum and maximum values of the structural diversity are recorded in Table 10-43.



**2010 Vegetation transect (front)**



**2010 Vegetation transect (rear)**



**2011 Vegetation transect (front)**



**2011 Vegetation transect (rear)**



**2012 Vegetation transect (front)**



**2012 Vegetation transect (rear)**





2013 Vegetation transect (front)



2013 Vegetation transect (rear)



Figure 10-27. Permanent photo points taken from the front (left) and rear (right) of the vegetation transect.

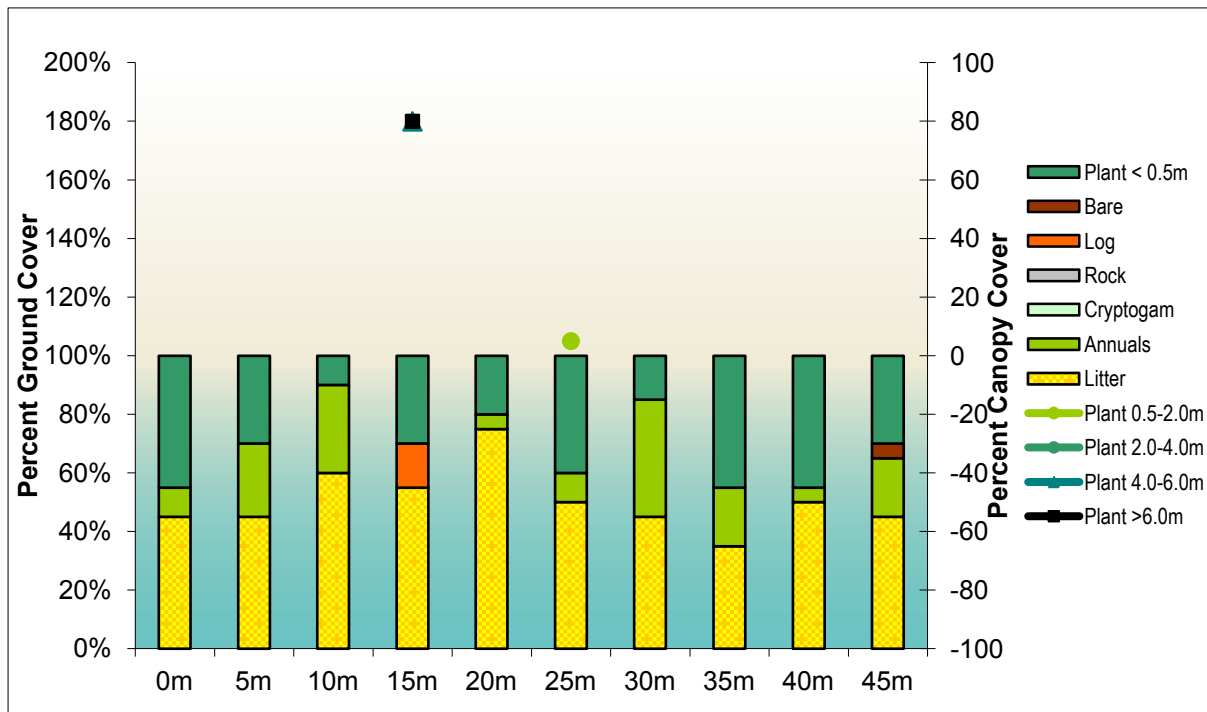


Figure 10-28. Graph illustrating the structural diversity and habitat complexity of the monitoring site.

Table 10-43. Average and minimum and maximum values of the structural diversity of the monitoring site.

Vegetation structure	0m	5m	10m	15m	20m	25m	30m	35m	40m	45m	Average	Min	Max
Litter	45	45	60	55	75	50	45	35	50	45	50.5	35	75
Annuals	10	25	30	0	5	10	40	20	5	20	16.5	0	40
Cryptogam	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock	0	0	0	0	0	0	0	0	0	0	0	0	0
Log	0	0	0	15	0	0	0	0	0	0	1.5	0	15
Bare	0	0	0	0	0	0	0	0	0	5	0.5	0	5
Perennial <0.5m	45	30	10	30	20	40	15	45	45	30	31	10	45
Total Ground Cover	100	100	100	100	100	100	100	100	100	95	99.5	95	100
0.5-2.0m	0	0	0	0	0	5	0	0	0	0	0.5	0	5
2.0-4.0m	0	0	0	0	0	0	0	0	0	0	0	0	0
4.0-6.0m	0	0	0	80	0	0	0	0	0	0	8	0	80
>6.0m	0	0	0	80	0	0	0	0	0	0	8	0	80

### 10.5.7 Species cover abundance

This year there were 33 species recorded in the five 1m<sup>2</sup> quadrats on the permanent vegetation transect line and this included eight exotic species. Using the Braun-blauquet scale, the highest possible cover score that can be obtained is 30. Cover abundance is illustrated as a sum of scores (class values) obtained along the five 1m<sup>2</sup> quadrats.

This year the native grass *Austrodanthonia eriantha* was the most dominant however so too were the exotic annuals *Lolium rigidum* and *Trifolium glomeratum* (Figure 10-29, Table 10-44). *Austrostipa nodosa* and *Austrostipa scabra subsp. falcata* were also relatively common and so was *Maireana enchylaenoides*. The remaining species were recorded less frequently and/or provided low cover values. Of the live plant cover scores recorded, 66.3% was provided by native species which was a reduction from 96.3% recorded last year.

**Table 10-44. List of species and their average cover abundance score across the five, 1m<sup>2</sup> monitoring quadrats.**

Species	0m	10m	20m	30m	40m	Total
* <i>Arctotheca calendula</i>				1		1
* <i>Lolium rigidum</i>	2	3	2	2	2	11
* <i>Medicago minima</i>		1				1
* <i>Sonchus oleraceus</i>	1				1	2
* <i>Trifolium arvense</i>				2		2
* <i>Trifolium campestre</i>	3				2	5
* <i>Trifolium glomeratum</i>	1	2	2	3	2	10
* <i>Vulpia spp.</i>	2			1		3
<i>Austrodanthonia eriantha</i>	1	3	3	2	3	12
<i>Austrostipa nodosa</i>	3		3	3		9
<i>Austrostipa scabra subsp. falcata</i>	3	3				6
<i>Austrostipa setacea</i>					4	4
<i>Callitris glaucophylla</i>			1			1
<i>Calotis lappulacea</i>		1				1
<i>Chloris truncata</i>				2		2
<i>Convolvulus erubescens</i>				1		1
<i>Daucus glochidiatus</i>				1		1
<i>Dichondra repens</i>	1	1				2
<i>Elymus scaber</i>	3					3
<i>Enteropogon acicularis</i>		1				1
<i>Erodium crinitum</i>		1				1
<i>Glycine spp.</i>			1	1	2	4
<i>Maireana enchylaenoides</i>		2	1	1	1	5
<i>Oxalis perennans</i>				1	1	2
<i>Paspalidium constrictum</i>			1			1
<i>Sida corrugata</i>		1	2		1	4
<i>Solanum esuriale</i>	1	1		1		3
<i>Sporobolus caroli</i>				1		1
<i>Vittadinia cuneata</i>		1				1
<i>Vittadinia tenuissima</i>		1				1
<i>Wahlenbergia gracilis</i>			1			1
<i>Wahlenbergia luteola</i>				1		1
<i>Xerochrysum bracteatum</i>		1				1
<b>Total cover</b>						104
<b>Sum of cover of native species</b>						69
<b>Percent endemic species cover</b>						66.3

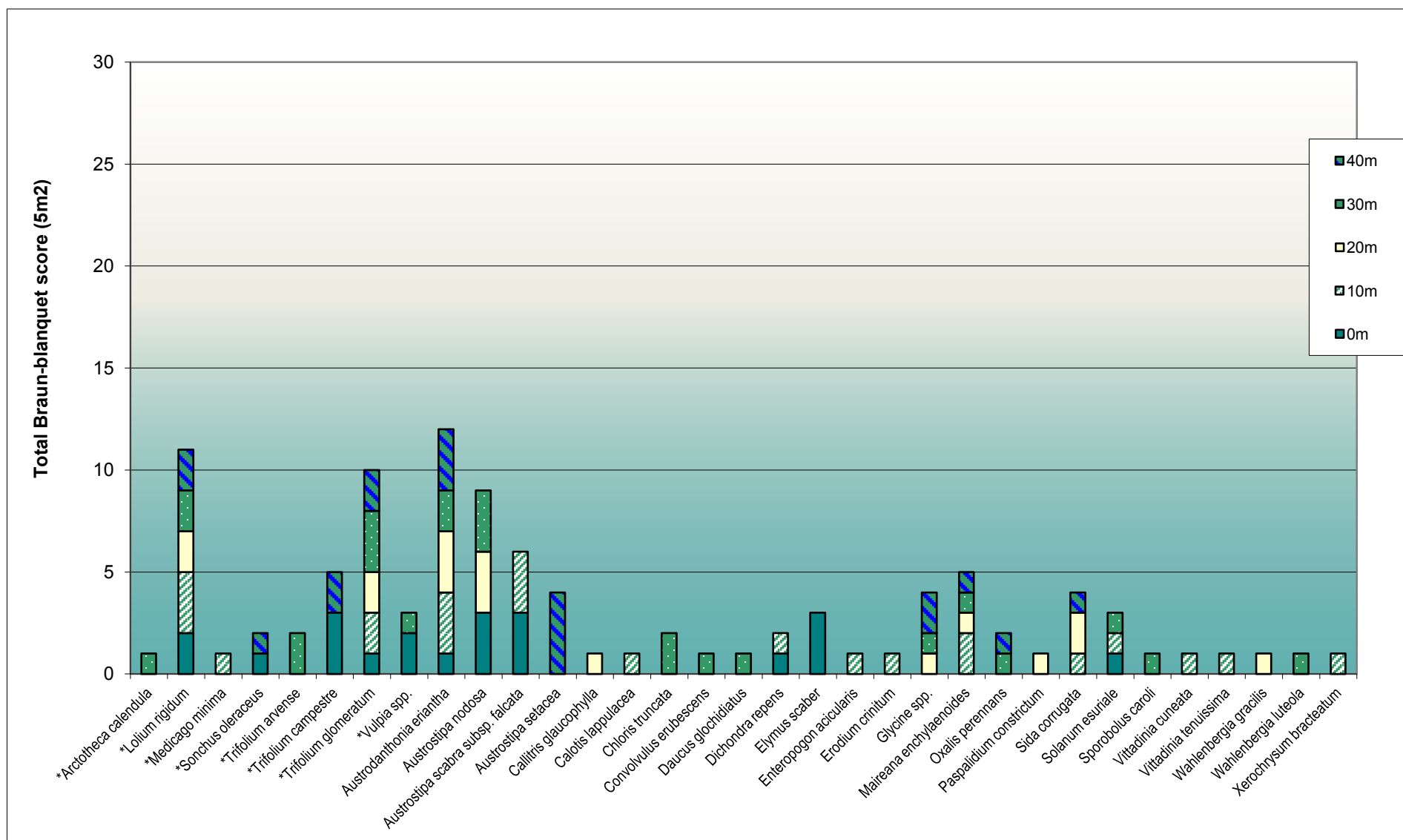


Figure 10-29. Total species recorded across the five, 1m<sup>2</sup> quadrats using the Braun-blanket scale (max possible score is 30) as a measure of cover abundance.

### 10.5.8 Floristic diversity

The floristic diversity of the sites was measured using two different methods. One provides an assessment of the average number of species within five, one square metre ( $m^2$ ) sub-quadrats along the vegetation transect, while the other provides the total number of species within the entire 50x20m monitoring plot.

#### 10.5.8.1 Species diversity per $m^2$

There has been a slight reduction in native diversity which has declined from 9 – 8.6 native species per  $m^2$  while the number of exotic species has increased from 0.6 – 3.8 exotic species per  $m^2$  (Table 10-45). The number of native species ranged between 6 – 12 species per  $m^2$ , while the number of exotic species ranged between 2 – 5 species per  $m^2$ .

Table 10-45. Species diversity per  $1m^2$ .

Species / $m^2$	0m	10m	20m	30m	40m	Avg/ $m^2$	SD
Native	6	12	8	11	6	8.6	2.8
Exotic	5	3	2	5	4	3.8	1.3
Total	11	15	10	16	10	12.4	2.9

#### 10.5.8.2 Total species diversity

This year total floristic diversity has increased from 48 - 58 species recorded in the 50 x 20m monitoring quadrat with 20 of these being exotic species n(Figure 10-30, Table 10-46). The sharp increase in the native species diversity curves indicates the site began rather homogenous but became quite variable after 50 $m^2$ . A list of species recorded within the monitoring site is provided in Appendix 1.

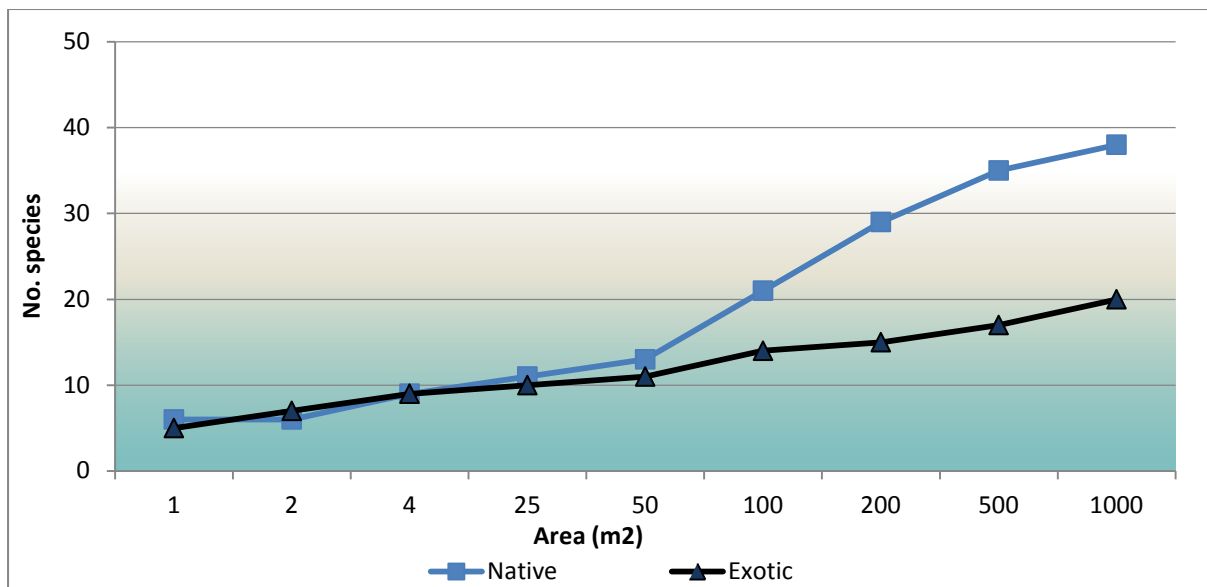


Figure 10-30. Cumulative species in the 50m x 20m (1000 $m^2$ ) monitoring quadrat.

Table 10-46. Cumulative species diversity.

Area ( $m^2$ )	1	2	4	25	50	100	200	500	1000
Native	6	6	9	11	13	21	29	35	38
Exotic	5	7	9	10	11	14	15	17	20

### 10.5.9 Growth forms

Figure 10-31 is a summary of species in each growth form that were recorded in EOA-05. The site continued to be dominated by herbs with 41 native including 16 exotic species followed by 15 different grass species and of these four were exotic species. There was one species of tree and one sub-shrub however this year there was an absence reeds and ferns. There continued to be a lack of shrub species. Compared to the composition of the reference sites the site was low in tree diversity.

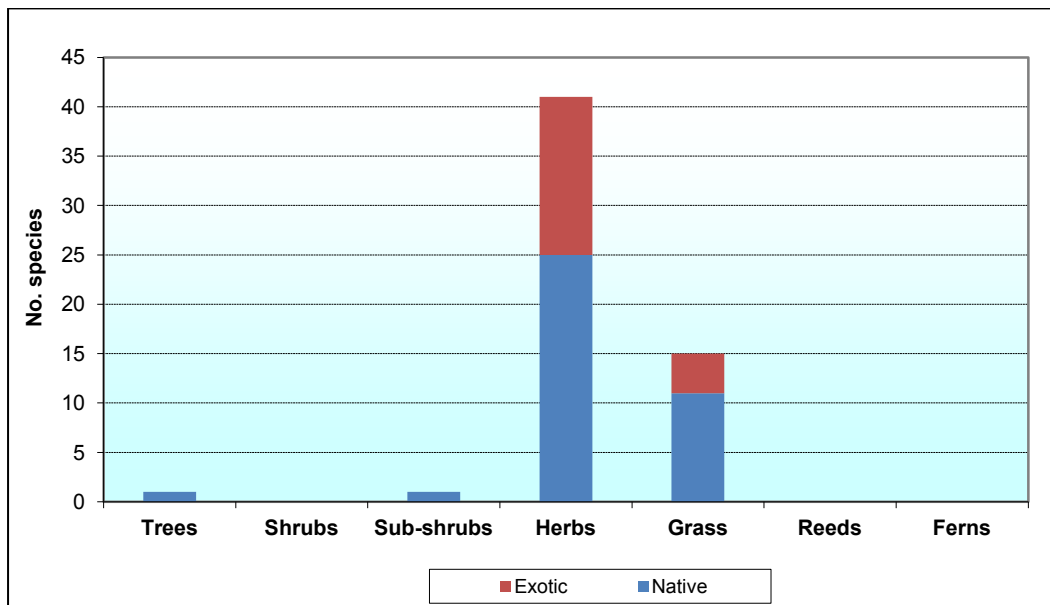


Figure 10-31. Graph illustrating the growth forms of species recorded in the 50m x 20m monitoring quadrat.



## 10.5.10 Comparison of rehabilitation data with key performance indicators

Table 10-47 indicates the performance of the monitoring site against the Completion and Desirable Performance Indicators developed for woodland sites during the 2013 monitoring period. The selection of criteria have been presented in order of ecosystem successional processes, beginning with landform establishment and stability (orange) for example and ending with indicators of ecosystem and landuse development (blue). The range values will be amended annually.

Rehabilitation sites meeting or exceeding the range values of their representative community type have 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 2013. 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 10-47. Comparison of key performance Indicators recorded at siteEOA-05 compared to lower and upper limits recorded in the woodland reference sites.**

Table 10-47: Comparison of key performance indicators recorded at site EOA-05 compared to lower and upper limits recorded in the woodland reference sites.													
Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-05				
Performance indicators are quantified by the range of values obtained from replicated reference sites								Lower	Upper	2010	2011	2012	2013
Phase2: 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°)	0	5	1	1	1	1	
	Landform function	Landform is functional and performing as it was designed to do	LFA Stability	Based on key physical, biological and chemical characteristics the LFA stability index provides an indication of the sites stability and that it is comparable to or trending towards that of the local remnant vegetation		%	62.9	69.0	78.0	78.5	73.5	70.5	
			LFA Infiltration	Based on key physical, biological and chemical characteristics the LFA infiltration index provides an indication of the sites infiltration capacity and that it is comparable to or trending towards that of the local remnant vegetation		%	41.1	55.7	38.4	48.5	48.9	47.8	
			LFA Nutrient recycling	Based on key physical, biological and chemical characteristics the LFA nutrient recycling index provides an indication of the sites ability to recycle nutrient and that it is comparable to or trending towards that of the local remnant vegetation		%	36.2	53.0	40.0	48.8	46.0	44.1	
			LFA Landscape organisation	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and that it is comparable to that of the local remnant vegetation		%	100	100	100	100	100	100	

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-05			
	<b>Active erosion</b>	Areas of active erosion are limited	No. Rills/Gullies	Provides an assessment of the number of gullies or rills occurring in a 50m transect and that these are limited and stabilising		No.	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
<b>Phase 3: Growth medium development</b>	<b>Soil chemical, physical properties and amelioration</b>	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)	6.0	7.1	5.87	5.24	6.14	5.76
			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)	0.038	0.191	0.093	0.091	0.057	0.054
			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)	3.0	4.6	4.8	6.1	4.8	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)	6.4	17.3	18.4	15.3	15.9	8.4
			Nitrate	Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		ppm (>12.5)	1.2	1.9	22.0	6.2	4.5	5.0
			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)	12.0	22.9	12.73	13.67	12.15	13.9
			ESP		Exchangeable Sodium Percentage (a measure of sodicity) is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	% (<5)	0.3	2.4	0.79	0.86	0.62	1.3
<b>Phase 4: Ecosystem &amp; Landuse Establishment</b>	<b>Vegetation diversity</b>	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	6	0	0	1	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	na	NA	100	100
			Total species richness		The total number of live plant species provides an indication of the floristic diversity of the site and is comparable to the local remnant vegetation	No./area	53	76	72	48	51	58

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-05			
			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	33	53	49	35	39	38
			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	13	27	23	13	12	20
	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	29	110	0	0	11	14
	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	2	4	1	1	1	1
			Shrubs	The number of shrub species regardless of age comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	0	3	0	0	0	0
			Sub-shrubs		The number of sub-shrub species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	1	5	1	2	1	1
			Herbs	The number of herbs or forb species comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	33	46	55	28	31	41
			Grasses		The number of grass species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	9	22	13	15	16	15
			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	1	1	1	0
			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
			Ferns		The number of ferns comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	1	1	1	1	0
Phase 5: Ecosystem & Landuse Development	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	%	47	77	10	58.5	72	50.5
			Annual plants		Percent ground cover provided by live annual plants is comparable to that of the local remnant vegetation	<%	2	22	27	1	0	16.5

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-05			
			Cryptogam cover		Percent ground cover provided by cryptogams (eg mosses, lichens) is comparable to that of the local remnant vegetation	%	0	8	7	0	0	0
			Rock		Percent ground cover provided by stones or rocks (> 5cm diameter) is comparable to that of the local remnant vegetation	%	0	1	0	0	0	0
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	0	3	0.5	0	1	1.5
			Bare ground		Percentage of bare ground is less than or comparable to that of the local remnant vegetation	< %	6	11	3.5	0	0	0.5
			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		%	7	25	52	40.5	27	31
			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		%	89	95	96.5	100	100	99.5
	Ground cover diversity	Vegetation contains a diversity of species per square meter comparable to that of the local remnant vegetation	Native understorey abundance		The abundance of native species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it has more than or an equal number of native species as the local remnant vegetation	> species/m <sup>2</sup>	7	8	13	9.2	9	8.6
			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 has less than or an equal number of exotic species as the local remnant vegetation	< species/m <sup>2</sup>	1	4	4	1.2	0.6	3.8
	Native ground cover abundance	Native ground cover abundance is comparable to that of the local remnant vegetation	Percent ground cover provided by native vegetation <0.5m tall	The percent ground cover abundance of native species (<0.5m height) compared to exotic species is comparable to that of the local remnant vegetation		%	63	87	78.7	91.8	96.3	66.3
	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	7	89	0	0	11	14

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-05			
			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	2	15	0	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	13	0	0	0	0
			shrubs and juvenile trees 1.5 - 2m in height	The number of shrubs or juvenile trees 1.5-2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation		No./area	0	18	0	0	0	0
			shrubs and juvenile trees >2m in height		The number of shrubs or juvenile trees > 2m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	0	48	0	0	0	0
	<b>Ecosystem structure</b>	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	1	9	0	0	0	0.5
			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	6	0	0	0	0
			Foliage cover 4 - 6m		Projected foliage cover provided by perennial plants in the 4 -6m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation	% cover	0	9	0	0	6	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	17	42	8	7	8	8
	<b>Tree diversity</b>	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	1	1	1	1



Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-05			
	Tree density	Vegetation contains a density of maturing tree and shrubs species comparable to that of the local remnant vegetation		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
			Tree density		The density of shrubs or trees with a stem diameter > 5cm is comparable to that of the local remnant vegetation	No./area	6	19	5	5	5	5
			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	18	54	46	46	46	46
	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	83	100	60	60	60	60
			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	7	47	60.0	40.0	60.0	60.0
			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	44	57	0	20	0	0
			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	0	36	0.0	0	0	0
			Dead Trees		The percentage of the tree population which are dead (stags) and that the percentage is comparable to the local remnant vegetation	% population	0	17	40	40	40	40
			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	7	0.0	0	0	0
			Flowers/fruit: Trees	The percentage of the tree population with reproductive structures such as buds, flowers or fruit provides evidence that the ecosystem is maturing, capable of recruitment and can provide habitat resources comparable to that of the local remnant vegetation		% population	50	83	60.0	60.0	60	60

## 10.6 EOA-06 site description

This site was established in 2013 after a grass fire in November 2012 which was initiated by harvesting machinery in adjacent cropland and burnt approximately 1ha within the EOA. The LFA transect = vegetation transect. There were log patches and fallen trees which had caught fire and continued to burn at high temperatures leaving scorched tree canopies and charred blackened coals and bare scorched earth in these immediate areas. Much of the remaining burnt area however appears to have recovered with a very high diversity of scattered native grasses and wild flowers, however total ground cover was patchy. Exotic species tended to dominate areas beneath the tree canopies.

### 10.6.1 Landscape Function Analysis

#### 10.6.1.1 Landscape organisation

Despite the patchiness of the site, EOA-06 was characterised as 100% woodland patch which had no interpatch areas leaking resources along the transect (Figure 10-32, Table 10-48), which subsequently resulted in a Landscape Organisation Index of 1.0 (100% woodland patch).

The resultant LFA indices for stability, infiltration and nutrient recycling were 65.5, 40.5 and 36.2 respectively. Compared to the minimum KPI target provided by the woodland reference sites, this site had a stability index which was 2.6 LFA units higher and the nutrient recycling index was equivalent. The infiltration capacity was 0.6 LFA units lower.



Figure 10-32. Permanent photo point taken from the top of the LFA transect in 2013 (left) and a young *E. populneus* growing in the burnt area (right).

Table 10-48. Summary of landscape organisation and LFA indices in 2013.

EOA-06		16/10/2013	
Number of Patches/10m		0.5	
Total Patch Area (m <sup>2</sup> )		200.00	
Patch Area Index		1.00	
Landscape Organisation Index		1.00	
Average Interpatch Length (m)		NA	
Range Interpatch length (m)		NA	
Patch or Interpatch Type		Burnt Woodland patch	
Patch or Interpatch Proportion (%)		100.0	100
Soil Surface Assessment			
Within Individual Zones	Stability	65.5	
	Infiltration	40.5	
	Nutrients	36.2	
			Total
Individual zones contribution to the whole of Landscape	Stability	65.5	65.5
	Infiltration	40.5	40.5
	Nutrients	36.2	36.2

### 10.6.1.2 Soil Surface Assessment

There were variable levels of perennial ground cover plants which typically provided low to moderate levels of protective ground and basal cover and scattered trees provided some canopy cover (Table 10-49). While the cover of dead leaf litter was patchy, typically there were moderate to high levels of cover with evidence of slight decomposition indicating microbial and fungal activity but the litter had not yet accumulated any depth since the fire.

The soils were crusted and cryptogams were only found in small abundance on one occasion. Where vegetative cover was limited, some erosion was observed however the scattered vegetation and litter cover typically provided moderate soil surface relief and most mobilised resources were contained within the woodland and slight levels of deposition commonly observed. The loam soils were hard to very hard which would limit the infiltration capacity of the site, however they were typically very stable when immersed in water.

Table 10-49 . Results of the Soils Surface Assessment for the Grassy Woodland patch.

Features	Max score	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5
Soil Cover	5	2	4	3	2	3
Per. basal / canopy cover	4	2	4	3	2	3
Litter cover, orig & incorp.	10	4ln	5ls	5ls	5ls	4ls
Cryptogam cover	4	1	2	1	1	1
Crust broken-ness	4	4	4	4	4	3
Erosion type & severity	4	2	4	4	4	3
Deposited materials	4	3	3	2	3	4
Soil surface roughness	5	2	3	3	3	3
Surface resist. to disturb.	5	4	4	4	3	3
Slake test	4	3	4	4	4	4
Texture	4	3	3	3	3	3

## 10.6.2 Soil analyses

The soils were borderline slightly to moderately acidic and while these were lower than local levels they were within the desirable range and similar to those recorded in other EOA sites (Table 10-50). The Electrical Conductivity was very low indicating low levels of soluble salts and non saline soils typical of the local area. Despite the recent fire there were acceptable levels of Organic Matter, phosphorous and nitrates, however CEC was low. The low ESP indicates that that the soils are non sodic.

**Table 10-50. Results of the soil analysis for EOA-05 compared to the upper and lower values for the woodland reference sites and desirable levels in 2013.**

Nutrient	Units	EOA-06	Lower KPI	Upper KPI	Desirable Level
		2013			
pH (1:5 water)	units	5.65	5.99	7.10	5.6 – 7.3
Conductivity (1:5 water)	dS/m	0.051	0.04	0.19	0.150
Organic Matter	%	3.6	3.01	4.61	>4.5
Phosphorus (Colwell)	mg/kg	7	6.41	17.29	50
Nitrate	mg/kg	3.2	1.20	1.88	13.0
Cation Exchange Capacity	cmol+/Kg	10.48	12.05	22.87	14.00
Exchangeable Sodium Percentage	%	0.64	0.29	2.42	<5

## 10.6.3 Rill assessment

No rills were observed.

## 10.6.4 Tree density and health condition

There were 13 live mature trees recorded within the 50 x 20m monitoring plot including eight *Callitris glaucophylla* and five *Eucalyptus populnea* and there were four dead stags. One individual had recently died apparently as a result of the fire and eight trees had charring on the lower tree trunks (Table 10-51). Most of the live trees were considered to be in moderate health and eight contained fruits and/or flowers. The average dbh was 25cm and ranged from 11 – 40 cm. No tree hollows were observed.

**Table 10-51. Summary of tree health and density.**

<b>Dominant species</b>	<i>Callitris glaucophylla</i> (8), <i>Eucalyptus populnea</i> (5)
<b>Average dbh (Cm)</b>	25
<b>Max dbh (cm)</b>	40
<b>Min dbh (cm)</b>	11
<b>Total trees</b>	17
<b>No. with multiple limbs</b>	0
<b>No. Live trees</b>	13
<b>No. Healthy</b>	4
<b>No. Medium Health</b>	7
<b>No. Advanced Dieback</b>	2
<b>No. Dead</b>	4
<b>Mistletoe</b>	0
<b>Flowers / fruit</b>	8



### 10.6.5 Shrubs and regeneration

There were nine *E. populnea* saplings which were less than 1.0m in height. The majority of these appeared to be established saplings rather than new recruits but they have been stunted via browsing and were probably affected by the grass fire. Nonetheless all individuals contained healthy new leaf growth.

Table 10-52. Shrubs and young trees occurring within the monitoring site.

Species	0 - 0.5m	0.5 - 1.0m	1.0 - 1.5m	1.5 - 2.0m	>2.0m	Total	endemic	not endemic
<i>Eucalyptus populnea</i>	6	3				9	9	
<b>Total</b>	<b>6</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>9</b>	<b>9</b>	<b>0</b>
<b>% endemic species</b>							<b>100</b>	<b>0</b>

### 10.6.6 Structural diversity and habitat complexity

The ground cover at this site was patchy but overall there was 98.5% total ground cover and this was dominated by dead leaf litter which provided an average 61.5% of this cover (Figure 10-33, Figure 10-34). There was 25% perennial plant cover and also some limited cover provided by annual plants (6%), cryptogams (1%) and logs (5%).

The mature trees were scattered but provided some canopy cover exceeding 6m in height at 15m and 40m along the transect. There was some limited cover 4 - 6m in height but otherwise vertical foliage cover was limited and the site overall lacked vertical complexity which was typical of the Offset Area. Average and minimum and maximum values of the structural diversity are recorded in Table 10-53.

2013 Vegetation transect (front)



2013 Vegetation transect (rear)



Figure 10-33. Permanent photo points taken from the front (left) and rear (right) of the vegetation transect.



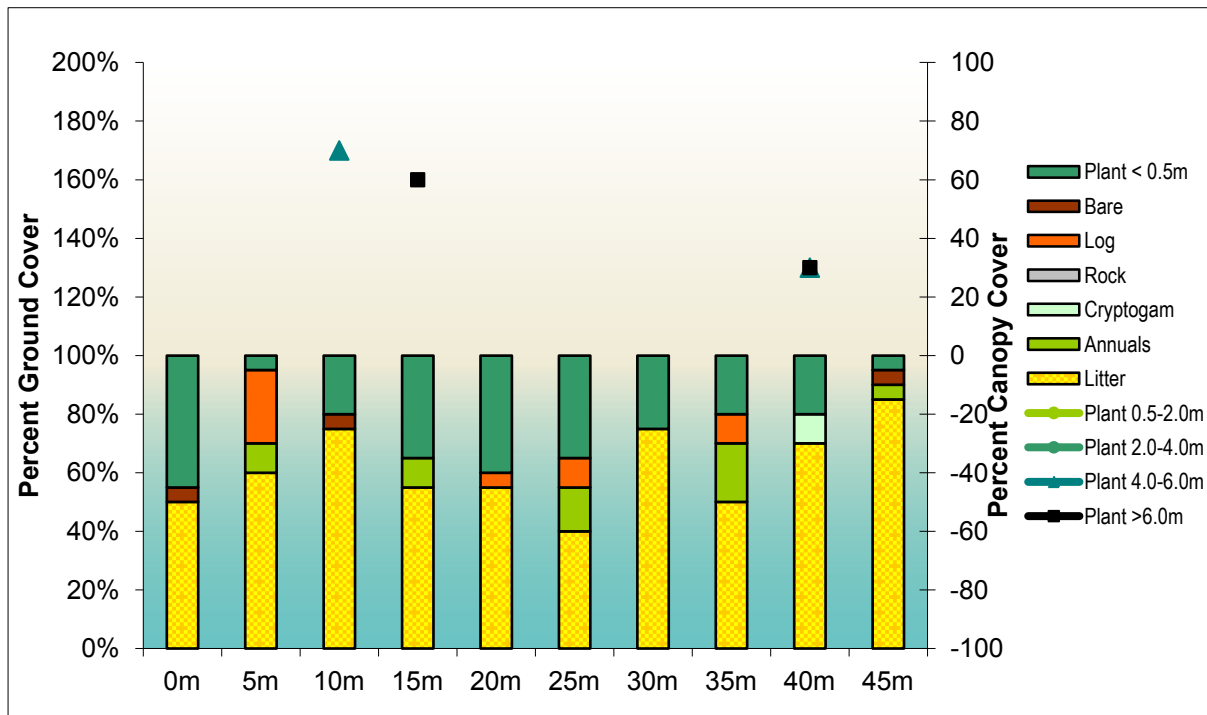


Figure 10-34. Graph illustrating the structural diversity and habitat complexity of the monitoring site.

Table 10-53. Average and minimum and maximum values of the structural diversity of the monitoring site.

Vegetation structure	0m	5m	10m	15m	20m	25m	30m	35m	40m	45m	Average	Min	Max
Litter	50	60	75	55	55	40	75	50	70	85	61.5	40	85
Annuals	0	10	0	10	0	15	0	20	0	5	6	0	20
Cryptogam	0	0	0	0	0	0	0	0	10	0	1	0	10
Rock	0	0	0	0	0	0	0	0	0	0	0	0	0
Log	0	25	0	0	5	10	0	10	0	0	5	0	25
Bare	5	0	5	0	0	0	0	0	0	5	1.5	0	5
Perennial <0.5m	45	5	20	35	40	35	25	20	20	5	25	5	45
Total Ground Cover	95	100	95	100	100	100	100	100	100	95	98.5	95	100
0.5-2.0m	0	0	0	0	0	0	0	0	0	0	0	0	0
2.0-4.0m	0	0	0	0	0	0	0	0	0	0	0	0	0
4.0-6.0m	0	0	70	0	0	0	0	0	30	0	10	0	70
>6.0m	0	0	0	60	0	0	0	0	30	0	9	0	60

### 10.6.7 Species cover abundance

There were 37 species recorded in the five 1m<sup>2</sup> quadrats on the permanent vegetation transect line, and this included nine exotic species. Using the Braun-blauquet scale, the highest possible cover score that can be obtained is 30. Cover abundance is illustrated as a sum of scores (class values) obtained along the five 1m<sup>2</sup> quadrats.

Figure 10-35 and Table 10-54 illustrate that the site was particularly diverse with no single species being exceptionally dominant, but the most common and abundant species include the natives *Sida corrugata* and *Austrostipa scabra* subsp. *scabra*. *Austrodanthonia eriantha*, *Calotis cuneifolia*, *Dichopogon* spp., *Glycine* spp. and *Vittadinia pterochaeta* were also relatively common. *Trifolium glomeratum* was the most common exotic species and was recorded in four of the five replicates but only provided low cover scores. The remaining species were recorded less frequently and/or provided low cover values. Of the live plant cover scores recorded, 87.1% was provided by native species.

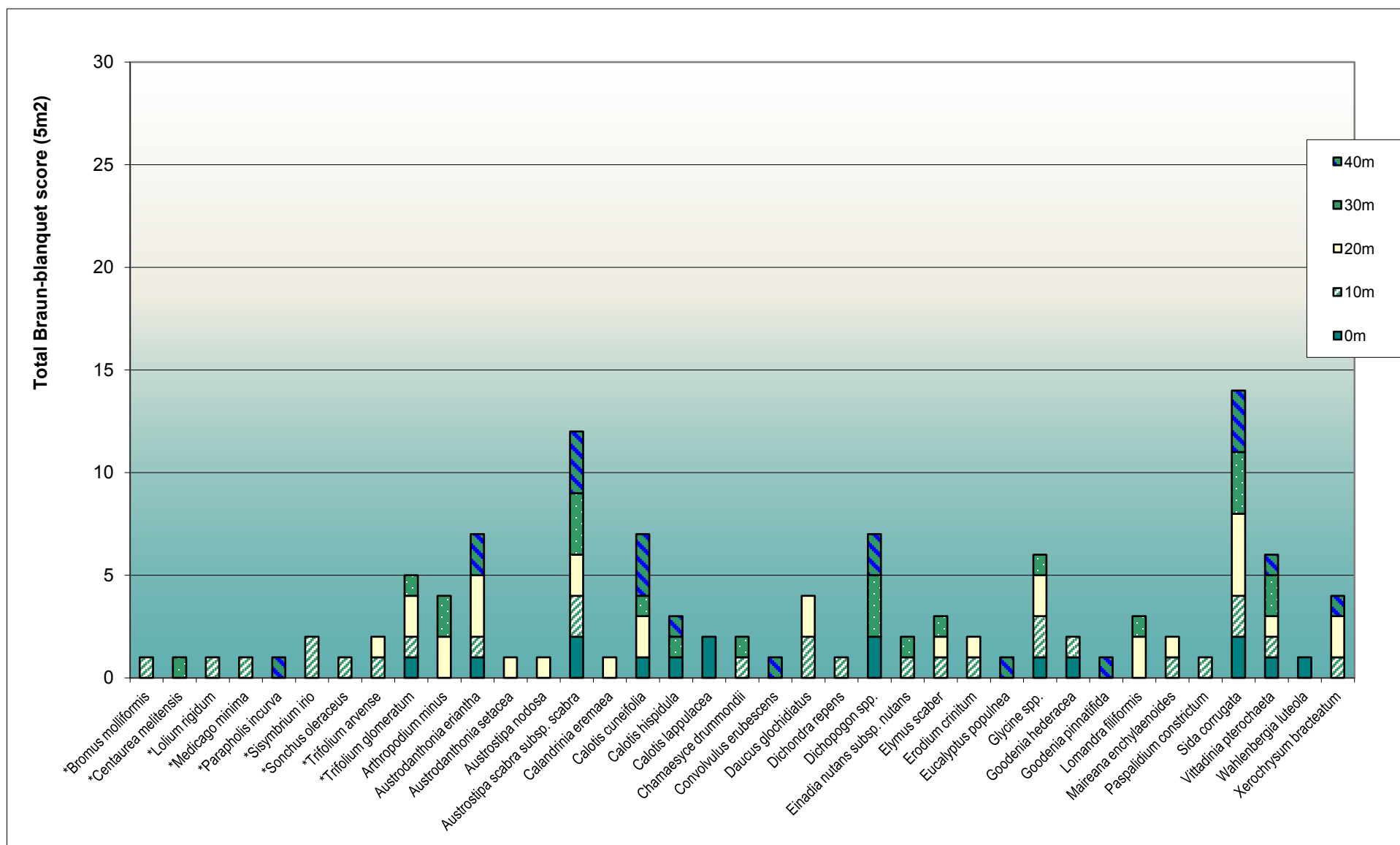


Figure 10-35. Total species recorded across the five, 1m<sup>2</sup> quadrats using the Braun-blauquet scale (max possible score is 30) as a measure of cover abundance.

**Table 10-54. List of species and their average cover abundance score across the five, 1m<sup>2</sup> monitoring quadrats.**

Species	0m	10m	20m	30m	40m	Total
* <i>Bromus molliformis</i>		1				1
* <i>Centaurea melitensis</i>				1		1
* <i>Lolium rigidum</i>		1				1
* <i>Medicago minima</i>		1				1
* <i>Parapholis incurva</i>					1	1
* <i>Sisymbrium irio</i>		2				2
* <i>Sonchus oleraceus</i>		1				1
* <i>Trifolium arvense</i>		1	1			2
* <i>Trifolium glomeratum</i>	1	1	2	1		5
<i>Arthropodium minus</i>			2	2		4
<i>Austrodanthonia eriantha</i>	1	1	3		2	7
<i>Austrodanthonia setacea</i>			1			1
<i>Austrostipa nodosa</i>			1			1
<i>Austrostipa scabra</i> subsp. <i>scabra</i>	2	2	2	3	3	12
<i>Calandrinia eremaea</i>			1			1
<i>Calotis cuneifolia</i>	1		2	1	3	7
<i>Calotis hispidula</i>	1			1	1	3
<i>Calotis lappulacea</i>	2					2
<i>Chamaesyce drummondii</i>		1		1		2
<i>Convolvulus erubescens</i>					1	1
<i>Daucus glochidiatus</i>		2	2			4
<i>Dichondra repens</i>		1				1
<i>Dichopogon</i> spp.	2			3	2	7
<i>Einadia nutans</i> subsp. <i>nutans</i>		1		1		2
<i>Elymus scaber</i>		1	1	1		3
<i>Erodium crinitum</i>		1	1			2
<i>Eucalyptus populnea</i>					1	1
<i>Glycine</i> spp.	1	2	2	1		6
<i>Goodenia hederacea</i>	1	1				2
<i>Goodenia pinnatifida</i>					1	1
<i>Lomandra filiformis</i>			2	1		3
<i>Maireana enchylaenoides</i>		1	1			2
<i>Paspalidium constrictum</i>		1				1
<i>Sida corrugata</i>	2	2	4	3	3	14
<i>Vittadinia pterochaeta</i>	1	1	1	2	1	6
<i>Wahlenbergia luteola</i>	1					1
<i>Xerochrysum bracteatum</i>		1	2		1	4
<b>Total cover</b>						116
<b>Sum of cover of native species</b>						101
<b>Percent endemic species cover</b>						87.1

### 10.6.8 Floristic diversity

The floristic diversity of the sites was measured using two different methods. One provides an assessment of the average number of species within five, one square metre (m<sup>2</sup>) sub-quadrats along the vegetation transect, while the other provides the total number of species within the entire 50x20m monitoring plot.

### 10.6.8.1 Species diversity per m<sup>2</sup>

This site was floristically very diverse and had an average of 13 native and 2.6 exotic species per m<sup>2</sup> (Table 10-55). The number of native species ranged between 11– 16 species per m<sup>2</sup>, while the number of exotic species ranged between 1 – 7 species per m<sup>2</sup>.

Table 10-55. Species diversity per 1m<sup>2</sup>.

Species /m2	0m	10m	20m	30m	40m	Avg/m2	SD
Native	11	15	16	12	11	13	2.3
Exotic	1	7	2	2	1	2.6	2.5
Total	12	22	18	14	12	15.6	4.3

### 10.6.8.2 Total species diversity

The number of native species recorded in the 50 x 20m monitoring quadrat far exceeded the number of exotic species with a total of 55 native species being recorded amongst a total of 72 different species of plant. The sharp regular increases in the native species diversity curve indicates the site was heterogeneous (Figure 10-36, Table 10-56). A list of species recorded within the monitoring site is provided in Appendix 1.

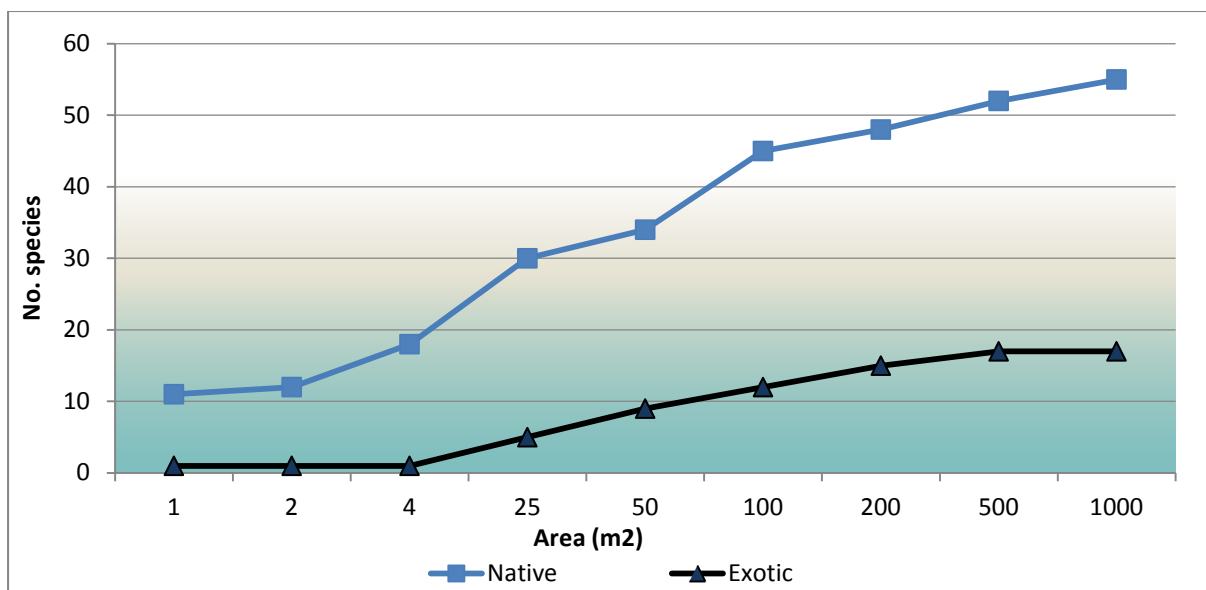


Figure 10-36. Cumulative species in the 50m x 20m (1000m<sup>2</sup>) monitoring quadrat.

Table 10-56. Cumulative species diversity.

Area (m2)	1	2	4	25	50	100	200	500	1000
Native	11	12	18	30	34	45	48	52	55
Exotic	1	1	1	5	9	12	15	17	17

### 10.6.9 Growth forms

Figure 10-37 is a summary of species in each growth form that were recorded in EOA-06. The site was dominated by herbs with 53 native and 14 exotic species. There were 15 different grass species and of these three were exotic species. There were two tree species and two sub-shrubs.

There was no shrub, reed or fern representatives found. This site contained an appropriate diversity and composition and was similar to the local woodland reference sites.

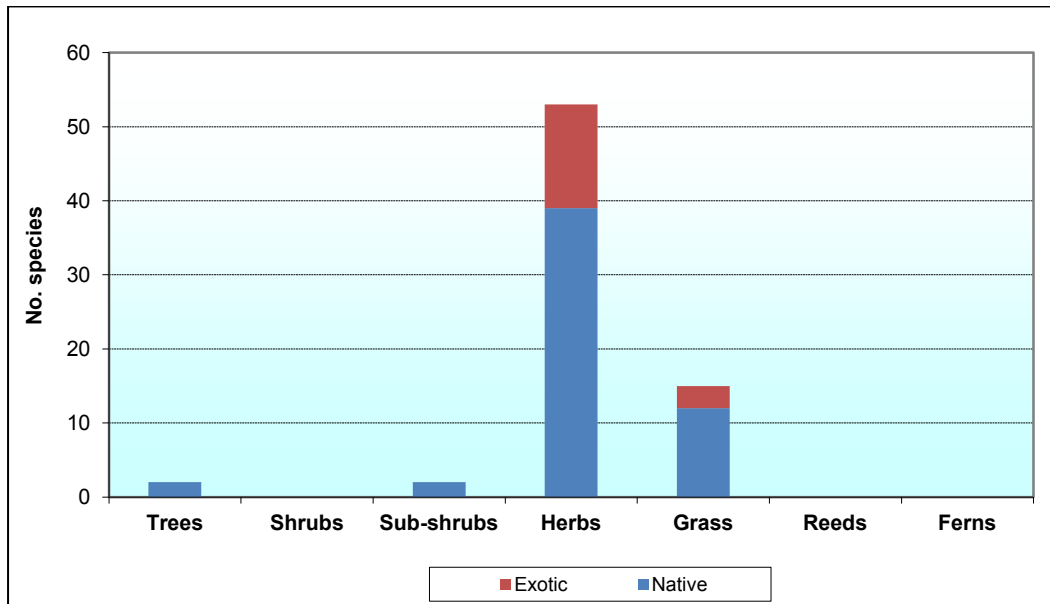


Figure 10-37. Graph illustrating the growth forms of species recorded in the 50m x 20m monitoring quadrat.



## 10.6.10 Comparison of rehabilitation data with key performance indicators

Table 10-57 indicates the performance of the monitoring site against the Completion and Desirable Performance Indicators developed for woodland sites during the 2013 monitoring period. The selection of criteria have been presented in order of ecosystem successional processes, beginning with landform establishment and stability (orange) for example and ending with indicators of ecosystem and landuse development (blue). The range values will be amended annually.

Rehabilitation sites meeting or exceeding the range values of their representative community type have 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 2013. 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 10-57. Comparison of key performance Indicators recorded at site EOA-06 compared to lower and upper limits recorded in the woodland reference sites.**

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-06
Performance indicators are quantified by the range of values obtained from replicated reference sites							Lower	Upper	2013
Phase2: 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°)	0	5	2
	Landform function	Landform is functional and performing as it was designed to do	LFA Stability	Based on key physical, biological and chemical characteristics the LFA stability index provides an indication of the sites stability and that it is comparable to or trending towards that of the local remnant vegetation		%	62.9	69.0	65.5
			LFA Infiltration	Based on key physical, biological and chemical characteristics the LFA infiltration index provides an indication of the sites infiltration capacity and that it is comparable to or trending towards that of the local remnant vegetation		%	41.1	55.7	40.5
			LFA Nutrient recycling	Based on key physical, biological and chemical characteristics the LFA nutrient recycling index provides an indication of the sites ability to recycle nutrient and that it is comparable to or trending towards that of the local remnant vegetation		%	36.2	53.0	36.2
			LFA Landscape organisation	The Landscape Organisation Index provides a measure of the ability of the site to retain resources and that it is comparable to that of the local remnant vegetation		%	100	100	100
	Active erosion	Areas of active erosion are limited	No. Rills/Gullies	Provides an assessment of the number of gullies or rills occurring in a 50m transect and that these are limited and stabilising		No.	0	0	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-06
			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
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)	6.0	7.1	5.65
			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)	0.038	0.191	0.051
			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)	3.0	4.6	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)	6.4	17.3	7.0
			Nitrate	Nitrate levels are typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry		ppm (>12.5)	1.2	1.9	5.2
			CEC		Cation Exchange Capacity is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	Cmol+/kg (>14)	12.0	22.9	10.5
			ESP		Exchangeable Sodium Percentage (a measure of sodicity) is typical of that of the surrounding landscape or fall within desirable ranges provided by the agricultural industry	% (<5)	0.3	2.4	0.6
Phase 4: Ecosystem & Landuse Establishment	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	6	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
			Total species richness		The total number of live plant species provides an indication of the floristic diversity of the site and is comparable to the local remnant vegetation	No./area	53	76	72
			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	33	53	55
			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	13	27	17
	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	29	110	9

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-06
	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	2	4	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	0	3	0
			Sub-shrubs		The number of sub-shrub species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	1	5	2
			Herbs	The number of herbs or forb species comprising the vegetation community is comparable to that of the local remnant vegetation		No./area	33	46	53
			Grasses		The number of grass species comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	9	22	15
			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
			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
			Ferns		The number of ferns comprising the vegetation community is comparable to that of the local remnant vegetation	No./area	0	1	0
Phase 5: Ecosystem & Landuse Development	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	%	47	77	61.5
			Annual plants		Percent ground cover provided by live annual plants is comparable to that of the local remnant vegetation	<%	2	22	6
			Cryptogam cover		Percent ground cover provided by cryptogams (eg mosses, lichens) is comparable to that of the local remnant vegetation	%	0	8	1
			Rock		Percent ground cover provided by stones or rocks (> 5cm diameter) is comparable to that of the local remnant vegetation	%	0	1	0
			Log		Percent ground cover provided by fallen branches and logs (>5cm) is comparable to that of the local remnant vegetation	%	0	3	5
			Bare ground		Percentage of bare ground is less than or comparable to that of the local remnant vegetation	< %	6	11	1.5
			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		%	7	25	25

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-06
			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		%	89	95	98.5
	Ground cover diversity	Vegetation contains a diversity of species per square meter comparable to that of the local remnant vegetation	Native understorey abundance		The abundance of native species per square metre averaged across the site provides an indication of the heterogeneity of the site and that it has more than or an equal number of native species as the local remnant vegetation	> species/m <sup>2</sup>	7	8	13
			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 has less than or an equal number of exotic species as the local remnant vegetation	< species/m <sup>2</sup>	1	4	2.6
	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		%	63	87	87.1
	Ecosystem growth and natural recruitment	The vegetation is maturing and/or natural recruitment is occurring at rates similar to those of the local remnant vegetation	shrubs and juvenile trees 0 - 0.5m in height	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	7	89	6
			shrubs and juvenile trees 0.5 - 1m in height		The number of shrubs or juvenile trees 0.5-1m in height provides an indication of establishment success, growth and/or natural ecosystem recruitment and that it is comparable to that of the local remnant vegetation	No./area	2	15	3
			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	13	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	18	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	48	0
	Ecosystem structure	The vegetation is developing in structure and complexity comparable to that of the local remnant vegetation	Foliage cover 0.5 - 2 m	Projected foliage cover provided by perennial plants in the 0.5 - 2m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation		% cover	1	9	0

Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-06
			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	6	0
			Foliage cover 4 - 6m		Projected foliage cover provided by perennial plants in the 4 - 6m vertical height stratum indicates the community structure is comparable to that of the local remnant vegetation	% cover	0	9	10
			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	17	42	9
	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	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
	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	6	19	17
			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	18	54	25
	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	83	100	76.5
			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	7	47	23.5
			Medium health		The percentage of the tree population which are in a medium health condition and that the percentage is comparable to the local remnant vegetation	% population	44	57	41.2
			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	0	36	11.8
			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	17	23.5
			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	7	0



Rehabilitation Phase	Aspect or ecosystem component	Completion criteria	Performance Indicators	Completion Performance Indicators Description	Desirable Performance Indicators Description	Unit of measurement	Woodland ecosystem range 2013		EOA-06
			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	50	83	47.1

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## Appendix 1. List of flora species recorded in the EOA and the woodland reference sites in 2013

Group	Family	exotic	Scientific Name	Common Name	Habit	EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06	RWood01	RWood02	RWood03	RWood04
Coniferopsida	Cupressaceae		<i>Callitris glaucophylla</i>	White Cypress Pine	t	1	1	1	1	1	1	1	1		1
Dicotyledon	Acanthaceae		<i>Rostellularia adscendens</i> var. <i>Pogonanthera</i>	Pink Tongues	h							1			
Dicotyledon	Amaranthaceae		<i>Ptilotus exaltatus</i>	Lambs Tails	h							1		1	
Dicotyledon	Amaranthaceae		<i>Ptilotus spathulatus</i>	Pussy Tails	h						1				1
Dicotyledon	Apiaceae		<i>Daucus glochidiatus</i>	Australian Carrot	h			1	1	1	1		1		1
Dicotyledon	Asteraceae	*	<i>Arctotheca calendula</i>	Capeweed	h	1	1	1	1	1					1
Dicotyledon	Asteraceae		<i>Brachyscome curvicalpa</i>	Curved-seed Daisy	h							1		1	
Dicotyledon	Asteraceae		<i>Calotis anthemoides</i>	Cut-leaved Burr-daisy	h							1	1	1	
Dicotyledon	Asteraceae		<i>Calotis cuneifolia</i>	Purple Burr Daisy	h		1		1	1	1	1	1	1	
Dicotyledon	Asteraceae		<i>Calotis hispidula</i>	Bogan Flea	h				1		1				
Dicotyledon	Asteraceae		<i>Calotis lappulacea</i>	Yellow Burr Daisy	h			1	1	1	1	1	1	1	
Dicotyledon	Asteraceae	*	<i>Carthamus lanatus</i>	Saffron Thistle	h	1	1	1	1	1	1	1	1		1
Dicotyledon	Asteraceae	*	<i>Centaurea melitensis</i>	Maltese Cockspur	h	1	1	1	1	1	1				1
Dicotyledon	Asteraceae	*	<i>Centaurea solstitialis</i>	St Barnaby's Thistle	h								1	1	
Dicotyledon	Asteraceae	*	<i>Chondrilla juncea</i>	Skeleton Weed	h			1							
Dicotyledon	Asteraceae		<i>Chrysocephalum apiculatum</i>	Common Everlasting	h			1							
Dicotyledon	Asteraceae	*	<i>Cirsium vulgare</i>	Spear Thistle	h	1		1		1	1		1		
Dicotyledon	Asteraceae	*	<i>Conyza bonariensis</i>	Fleabane	h						1				
Dicotyledon	Asteraceae		<i>Cymbonotus lawsonianus</i>	Bear's Ear	h					1	1		1	1	
Dicotyledon	Asteraceae		<i>Euchiton sphaericus</i>	Japanese Cudweed	h						1			1	1
Dicotyledon	Asteraceae	*	<i>Gamochaeta americana</i>	Cudweed	h								1		
Dicotyledon	Asteraceae	*	<i>Hedypnois rhagadioloides</i> subsp. <i>cretica</i>	Cretan Weed	h				1					1	1
Dicotyledon	Asteraceae	*	<i>Hypochaeris glabra</i>	Smooth Catsear	h	1									
Dicotyledon	Asteraceae	*	<i>Hypochaeris radicata</i>	Flatweed	h			1	1						
Dicotyledon	Asteraceae	*	<i>Hypochaeris</i> spp.	Flatweed	h									1	
Dicotyledon	Asteraceae	*	<i>Lactuca saligna</i>	Wild Lettuce	h	1			1						
Dicotyledon	Asteraceae	*	<i>Lactuca serriola</i>	Prickly Lettuce	h			1	1	1	1	1	1	1	1
Dicotyledon	Asteraceae		<i>Leiocarpa panaetioides</i>	Woolly Buttons	h									1	
Dicotyledon	Asteraceae		<i>Minuria leptophylla</i>	Minnie Daisy	h							1		1	
Dicotyledon	Asteraceae		<i>Rhodanthe corymbiflora</i>	Small White Sunray	h				1	1		1			
Dicotyledon	Asteraceae		<i>Rhodanthe pygmaea</i>	Pigmy Sunray	h								1		

Group	Family	exotic	Scientific Name	Common Name	Habit	EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06	RWood01	RWood02	RWood03	RWood04
Dicotyledon	Asteraceae		<i>Senecio quadridentatus</i>	Cotton Fireweed	h						1				
Dicotyledon	Asteraceae		<i>Solenogyne bellioides</i>		h				1		1				
Dicotyledon	Asteraceae	*	<i>Sonchus oleraceus</i>	Milk Thistle	h	1	1	1	1	1	1	1	1	1	1
Dicotyledon	Asteraceae		<i>Triptilodiscus pygmaeus</i>	Austral Sunray	h			1	1	1	1		1		1
Dicotyledon	Asteraceae		<i>Vittadinia cuneata</i>	Fuzzweed	h	1	1			1		1	1	1	1
Dicotyledon	Asteraceae		<i>Vittadinia cuneata</i> var. <i>cuneata</i>	Fuzzweed	h						1				
Dicotyledon	Asteraceae		<i>Vittadinia cuneata</i> var. <i>hirsuta</i>	Fuzzweed	h			1							1
Dicotyledon	Asteraceae		<i>Vittadinia gracilis</i>	A Fuzzweed	h		1	1							1
Dicotyledon	Asteraceae		<i>Vittadinia muelleri</i>	Fuzzweed	h								1		
Dicotyledon	Asteraceae		<i>Vittadinia pterochaeta</i>	Rough Fuzzweed	h			1			1	1			
Dicotyledon	Asteraceae		<i>Vittadinia sulcata</i>	A Fuzzweed	h		1					1			
Dicotyledon	Asteraceae		<i>Vittadinia tenuissima</i>	Western New Holland Daisy	h					1	1		1		
Dicotyledon	Asteraceae		<i>Xerochrysum bracteatum</i>	Golden Everlasting	h			1	1	1	1		1		1
Dicotyledon	Boraginaceae	*	<i>Buglossoides arvensis</i>	Corn Gromwell	h										1
Dicotyledon	Boraginaceae		<i>Cynoglossum australe</i>	Forget-me-not	h			1							
Dicotyledon	Brassicaceae	*	<i>Capsella bursa-pastoris</i>	Shepherd's Purse	h										1
Dicotyledon	Brassicaceae	*	<i>Lepidium africanum</i>	Peppergrass	h	1	1		1	1	1	1		1	1
Dicotyledon	Brassicaceae	*	<i>Rapistrum rugosum</i>	Turnip Weed	h							1			
Dicotyledon	Brassicaceae	*	<i>Sisymbrium irio</i>	London Rocket	h				1	1	1	1	1		1
Dicotyledon	Campanulaceae		<i>Wahlenbergia gracilis</i>	Sprawling Bluebell	h	1		1		1	1				
Dicotyledon	Campanulaceae		<i>Wahlenbergia luteola</i>	Australian Bluebell	h			1	1	1	1		1		
Dicotyledon	Campanulaceae		<i>Wahlenbergia</i> spp.	Bluebell	h									1	1
Dicotyledon	Caryophyllaceae	*	<i>Petrorhagia nanteuillii</i>	Proliferous Pink	h								1		1
Dicotyledon	Caryophyllaceae	*	<i>Spergularia rubra</i>	Sandspurry	h	1	1			1				1	
Dicotyledon	Casuarinaceae		<i>Allocasuarina luehmannii</i>	Bulloak	t							1		1	
Dicotyledon	Chenopodiaceae		<i>Atriplex semibaccata</i>	Creeping Saltbush	ss	1	1				1		1		
Dicotyledon	Chenopodiaceae		<i>Atriplex spinibractea</i>	Spiny-fruit Saltbush	ss							1			1
Dicotyledon	Chenopodiaceae		<i>Chenopodium desertorum</i> subsp. <i>anidiophyllum</i>	Mallee Goosefoot	ss								1	1	
Dicotyledon	Chenopodiaceae		<i>Einadia nutans</i> subsp. <i>linifolia</i>	Climbing Saltbush	h							1		1	
Dicotyledon	Chenopodiaceae		<i>Einadia nutans</i> subsp. <i>nutans</i>	Climbing Saltbush	h				1	1	1		1		1
Dicotyledon	Chenopodiaceae		<i>Maireana enchylaenoides</i>	Wingless Fissure Weed	h				1	1	1	1	1	1	1
Dicotyledon	Chenopodiaceae		<i>Maireana microphylla</i>	Eastern Cottonbush	ss		1					1		1	
Dicotyledon	Chenopodiaceae		<i>Maireana</i> spp.		ss			1							



Group	Family	exotic	Scientific Name	Common Name	Habit	EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06	RWood01	RWood02	RWood03	RWood04
Dicotyledon	Chenopodiaceae		<i>Salsola kali</i>	Buckbush	ss							1		1	
Dicotyledon	Chenopodiaceae		<i>Sclerolaena diacantha</i>	Grey Copperburr	ss							1		1	
Dicotyledon	Chenopodiaceae		<i>Sclerolaena muricata</i>	Black Roly Poly	ss	1	1			1					
Dicotyledon	Convolvulaceae		<i>Convolvulus erubescens</i>	Australian Bindweed	h	1		1	1	1	1	1	1	1	1
Dicotyledon	Convolvulaceae		<i>Dichondra repens</i>	Kidney Weed	h				1	1	1		1	1	1
Dicotyledon	Crassulaceae		<i>Crassula colorata</i>	Dense Stonecrop	h			1		1	1		1		
Dicotyledon	Euphorbiaceae		<i>Chamaesyce drummondii</i>	Caustic Weed	h						1				
Dicotyledon	Fabaceae (Caesalpinoideae)		<i>Senna artemisioides subsp. filifolia</i>	Punty Bush	s									1	
Dicotyledon	Fabaceae (Faboideae)		<i>Glycine clandestina</i>	Climbing Glycine	h				1		1	1		1	
Dicotyledon	Fabaceae (Faboideae)		<i>Glycine spp.</i>	Glycine	h			1	1	1	1				
Dicotyledon	Fabaceae (Faboideae)		<i>Glycine tabacina</i>	Variable Glycine	h							1	1		1
Dicotyledon	Fabaceae (Faboideae)	*	<i>Medicago minima</i>	Small Woolly Burr Medic	h			1		1	1	1	1	1	1
Dicotyledon	Fabaceae (Faboideae)	*	<i>Medicago polymorpha</i>	Burr Medic	h	1	1						1	1	1
Dicotyledon	Fabaceae (Faboideae)	*	<i>Medicago truncatula</i>	Barrel Medic	h	1	1	1							
Dicotyledon	Fabaceae (Faboideae)	*	<i>Trifolium angustifolium</i>	Narrow-leaf Clover	h	1	1			1			1		
Dicotyledon	Fabaceae (Faboideae)	*	<i>Trifolium arvense</i>	Haresfoot Clover	h	1	1	1	1	1	1		1		1
Dicotyledon	Fabaceae (Faboideae)	*	<i>Trifolium campestre</i>	Hop Clover	h	1	1	1	1	1	1		1		1
Dicotyledon	Fabaceae (Faboideae)	*	<i>Trifolium glomeratum</i>	Clustered Clover	h	1	1	1	1	1	1	1	1	1	1
Dicotyledon	Fabaceae (Faboideae)	*	<i>Trifolium scabrum</i>	Rough Clover	h								1		
Dicotyledon	Fabaceae (Faboideae)	*	<i>Trifolium subterraneum</i>	Subterranean Clover	h	1	1	1						1	1
Dicotyledon	Fabaceae (Faboideae)	*	<i>Trifolium tomentosum</i>	Woolly Clover	h				1		1				
Dicotyledon	Fabaceae (Mimosoideae)		<i>Acacia deanei</i>	Green Wattle	s								1		
Dicotyledon	Fabaceae (Mimosoideae)		<i>Acacia hakeoides</i>	Hakea Wattle	s							1		1	
Dicotyledon	Geraniaceae	*	<i>Erodium cicutarium</i>	Common Crowsfoot	h										1
Dicotyledon	Geraniaceae		<i>Erodium crinitum</i>	Blue Storksbill	h			1	1	1	1				1
Dicotyledon	Goodeniaceae		<i>Goodenia hederacea</i>	Forest Goodenia	h						1				
Dicotyledon	Goodeniaceae		<i>Goodenia pinnatifida</i>	Scrambled Eggs	h					1	1	1	1	1	
Dicotyledon	Lamiaceae	*	<i>Marrubium vulgare</i>	Horehound	h							1	1		1
Dicotyledon	Lamiaceae	*	<i>Salvia verbenaca</i>	Wild Sage	h	1		1	1	1		1	1		1
Dicotyledon	Malvaceae	*	<i>Modiola caroliniana</i>	Red-flowered Mallow	h		1								
Dicotyledon	Malvaceae		<i>Sida corrugata</i>	Corrugated Sida	h			1	1	1	1	1	1	1	1
Dicotyledon	Malvaceae		<i>Sida fibulifera</i>	Pin Sida	h										1
Dicotyledon	Malvaceae		<i>Sida platycalyx</i>	Lifesaver Burr	h										1

Group	Family	exotic	Scientific Name	Common Name	Habit	EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06	RWood01	RWood02	RWood03	RWood04
Dicotyledon	Myoporaceae		<i>Eremophila debilis</i>	Amulla	ss				1		1	1		1	
Dicotyledon	Myrtaceae		<i>Eucalyptus albens</i>	White Box	t								1		
Dicotyledon	Myrtaceae		<i>Eucalyptus melliodora</i>	Yellow Box	t										1
Dicotyledon	Myrtaceae		<i>Eucalyptus microcarpa</i>	Grey Box	t							1		1	
Dicotyledon	Myrtaceae		<i>Eucalyptus populnea</i>	Bimble Box	t						1		1		1
Dicotyledon	Nyctaginaceae		<i>Boerhavia dominii</i>	Tar Vine	h							1			1
Dicotyledon	Oxalidaceae		<i>Oxalis perennans</i>	Yellow Wood-sorrel	h	1	1	1		1		1	1	1	
Dicotyledon	Papaveraceae	*	<i>Papaver hybridum</i>	Rough Poppy	h										1
Dicotyledon	Papaveraceae	*	<i>Papaver somniferum</i>	Opium Poppy	h										1
Dicotyledon	Plantaginaceae	*	<i>Echium plantagineum</i>	Paterson's Curse	h	1	1	1	1	1	1	1	1		1
Dicotyledon	Plantaginaceae		<i>Plantago debilis</i>	Plantain	h					1	1	1	1	1	
Dicotyledon	Polygonaceae	*	<i>Polygonum aviculare</i>	Wireweed	h		1								
Dicotyledon	Polygonaceae		<i>Rumex brownii</i>	Swamp Dock	h	1				1	1				1
Dicotyledon	Portulacaceae		<i>Calandrinia eremaea</i>	Purslane	h				1		1				
Dicotyledon	Rubiaceae		<i>Asperula conferta</i>	Common Woodruff	h			1	1						
Dicotyledon	Sapindaceae		<i>Alectryon oleifolius</i>	Rosewood	t							1			
Dicotyledon	Sapindaceae		<i>Dodonaea viscosa subsp. cuneata</i>	Wedge-leaf Hopbush	s				1			1		1	
Dicotyledon	Schrophulariaceae		<i>Brunoniella australis</i>	Blue Trumpet	h						1	1		1	
Dicotyledon	Solanaceae		<i>Solanum esuriale</i>	Quena	h	1		1		1	1		1		1
Dicotyledon	Stackhousiaceae		<i>Stackhousia monogyna</i>	Creamy Candles	h						1				
Dicotyledon	Sterculiaceae		<i>Brachychiton populneus</i>	Kurrajong	t								1		
Monocotyledon	Anthericaceae		<i>Arthropodium minus</i>	Small Vanilla Lily	h				1		1		1	1	
Monocotyledon	Anthericaceae		<i>Dichopogon spp.</i>	Chocolate Lily	h			1	1	1	1		1		1
Monocotyledon	Asphodelaceae		<i>Bulbine bulbosa</i>	Bulbine Lily	h			1							
Monocotyledon	Asphodelaceae		<i>Bulbine semibarbata</i>	Leek Lily	h									1	
Monocotyledon	Colchicaceae		<i>Wurmbea dioica</i>	Early Nancy	h									1	
Monocotyledon	Cyperaceae		<i>Carex inversa</i>	Knob Sedge	r	1	1						1		
Monocotyledon	Iridaceae	*	<i>Romulea rosea</i>	Onion Grass	h										
Monocotyledon	Juncaceae		<i>Juncus aridicola</i>	Tussock Rush	r	1	1								
Monocotyledon	Juncaceae		<i>Juncus usitatus</i>		r	1	1								
Monocotyledon	Lomandraceae		<i>Lomandra filiformis</i>	Wattle Mat-rush	h				1		1				
Monocotyledon	Lomandraceae		<i>Lomandra glauca</i>	Pale Mat-rush	h								1		
Monocotyledon	Lomandraceae		<i>Lomandra multiflora</i>	Many-flowered Mat-rush	h									1	

Group	Family	exotic	Scientific Name	Common Name	Habit	EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06	RWood01	RWood02	RWood03	RWood04
Monocotyledon	Lomandraceae		<i>Lomandra spp.</i>		h										1
Monocotyledon	Orchidaceae		<i>Pterostylis spp.</i>	Greenhood Orchid	h						1				
Monocotyledon	Phormiaceae		<i>Dianella longifolia</i> var. <i>longifolia</i>	Smooth Flax-lily	h						1				
Monocotyledon	Phormiaceae		<i>Dianella revoluta</i>	Native Flax Lily	h								1		
Monocotyledon	Poaceae	*	<i>Aira caryophyllea</i>	Silvery Hairgrass	g			1							
Monocotyledon	Poaceae		<i>Aristida behriana</i>	Bunch Wiregrass	g			1	1		1		1		1
Monocotyledon	Poaceae		<i>Aristida jerichoensis</i> var. <i>jerichoensis</i>	Jericho Wiregrass	g								1		
Monocotyledon	Poaceae		<i>Austrodanthonia bipartita</i>	Wallaby Grass	g				1		1	1		1	
Monocotyledon	Poaceae		<i>Austrodanthonia caespitosa</i>	Wallaby Grass	g						1	1	1	1	
Monocotyledon	Poaceae		<i>Austrodanthonia eriantha</i>	Hill Wallaby Grass	g	1	1	1	1	1	1		1	1	1
Monocotyledon	Poaceae		<i>Austrodanthonia racemosa</i>	Wallaby Grass	g				1						
Monocotyledon	Poaceae		<i>Austrodanthonia setacea</i>	Small-flowered Wallaby Grass	g		1				1	1	1		
Monocotyledon	Poaceae		<i>Austrodanthonia sp.</i>	Wallaby Grass	g						1				
Monocotyledon	Poaceae		<i>Austrostipa bigeniculata</i>	Tall Speargrass	g								1		
Monocotyledon	Poaceae		<i>Austrostipa nodosa</i>	A Speargrass	g	1	1	1	1	1	1	1	1	1	1
Monocotyledon	Poaceae		<i>Austrostipa scabra</i> subsp. <i>falcata</i>	Speargrass	g	1	1	1	1	1	1		1	1	1
Monocotyledon	Poaceae		<i>Austrostipa scabra</i> subsp. <i>scabra</i>	Rough Speargrass	g			1	1	1	1	1	1	1	1
Monocotyledon	Poaceae		<i>Austrostipa setacea</i>	Corkscrew Grass	g	1				1					
Monocotyledon	Poaceae	*	<i>Avena fatua</i>	Wild Oats	g	1	1	1					1	1	
Monocotyledon	Poaceae		<i>Bothriochloa macra</i>	Red-leg Grass	g			1					1		
Monocotyledon	Poaceae	*	<i>Bromus diandrus</i>	Great Brome	g	1							1		
Monocotyledon	Poaceae	*	<i>Bromus molliformis</i>	Soft Brome	g	1	1			1	1				1
Monocotyledon	Poaceae		<i>Chloris truncata</i>	Windmill Grass	g	1	1			1				1	
Monocotyledon	Poaceae		<i>Dichanthium sericeum</i>	Queensland Bluegrass	g								1		
Monocotyledon	Poaceae		<i>Digitaria divaricatissima</i>	Umbrella Grass	g					1					
Monocotyledon	Poaceae		<i>Digitaria spp.</i>		g								1		
Monocotyledon	Poaceae		<i>Elymus scaber</i>	Common Wheatgrass	g	1		1	1	1	1		1	1	1
Monocotyledon	Poaceae		<i>Enteropogon acicularis</i>	Curly Windmill Grass	g	1	1		1	1		1	1	1	
Monocotyledon	Poaceae	*	<i>Hordeum leporinum</i>	Barley Grass	g	1	1	1	1	1		1			1
Monocotyledon	Poaceae	*	<i>Lamarckia aurea</i>	Golden-Top	g								1		
Monocotyledon	Poaceae	*	<i>Lolium rigidum</i>	Wimmera Ryegrass	g	1	1	1	1	1	1	1	1	1	1
Monocotyledon	Poaceae		<i>Panicum spp.</i>		g								1		
Monocotyledon	Poaceae	*	<i>Parapholis incurva</i>	Curly Rye Grass	g						1				

Group	Family	exotic	Scientific Name	Common Name	Habit	EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06	RWood01	RWood02	RWood03	RWood04
Monocotyledon	Poaceae		<i>Paspalidium constrictum</i>	Knottybutt Grass	g	1	1			1	1	1	1	1	
Monocotyledon	Poaceae	*	<i>Phalaris minor</i>	Lesser Canary Grass	g		1								
Monocotyledon	Poaceae		<i>Poa sieberiana</i>	Fine-leaf Tussock	g				1		1		1		
Monocotyledon	Poaceae		<i>Sporobolus caroli</i>	Fairy Grass	g	1				1				1	
Monocotyledon	Poaceae	*	<i>Vulpia spp.</i>		g	1	1	1	1	1			1		1
Monocotyledon	Poaceae		<i>Walwhalleya proluta</i>	Rigid Panic	g	1	1	1						1	
Pteridophyta	Adiantaceae		<i>Cheilanthes sieberi subsp. sieberi</i>	Rock Fern	f								1		

## Appendix 2. ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT– Estcourt Offset Sites

Soil samples supplied by DNA Environmental on 23rd October, 2013 - Lab Job No. C9596

Site				EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06	Heavy Soil e.g Clay	Medium Soil e.g Clay Loam	Light Soil e.g Loam	Sandy Soil e.g Loamy Sand
Method	Nutrient		Units	C9596/22	C9596/23	C9596/24	C9596/25	C9596/26	C9596/27	Indicative guidelines only- refer Note 6			
Morgan 1	Calcium	Ca	mg/kg	514	540	543	786	569	697	1150	750	375	175
	Magnesium	Mg		277	247	128	171	220	218	160	105	60	25
	Potassium	K		222	260	225	150	227	175	113	75	60	50
	Phosphorus	P		2.6	2.2	2.0	1.4	1.5	1.5	15	12	10	5.0
Bray1	Phosphorus	P	mg/kg	14.2	11.7	4.8	4.0	3.9	2.5	45 <sup>note 8</sup>	30 <sup>note 8</sup>	24 <sup>note 8</sup>	20 <sup>note 8</sup>
Colwell				41	34	8	9	8	7	80	50	45	35
Bray2				25	20	6	8	6	4	90 <sup>note 8</sup>	60 <sup>note 8</sup>	48 <sup>note 8</sup>	40 <sup>note 8</sup>
KCl	Nitrate Nitrogen	N	mg/kg	0.6	1.4	1.2	1.4	5.0	3.2	15	13	10	10
	Ammonium Nitrogen			8.4	10.6	8.7	11.6	17.3	13.6	20	18	15	12
	Sulfur	S		1.9	5.3	2.7	7.6	8.4	9.8	10.0	8.0	8.0	7.0
1:5 Water	pH		units	6.04	6.03	6.04	5.62	5.76	5.65	6.5	6.5	6.3	6.3
	Conductivity		dS/m	0.039	0.040	0.037	0.030	0.054	0.051	0.200	0.150	0.120	0.100
Calculation	Organic Matter		% OM	3.2	3.3	3.6	5.1	3.2	3.6	>5.5	>4.5	>3.5	>2.5
Ammonium Acetate + Calculations	Calcium	Ca	cmol+/Kg	4.60	5.04	5.17	7.31	7.45	6.35				
			kg/ha	2067	2260	2321	3282	3345	2851				
			mg/kg	923	1009	1036	1465	1493	1273	3125	2150	1000	375
	Magnesium	Mg	cmol+/Kg	3.52	3.15	1.53	2.14	4.10	2.80				
			kg/ha	959	856	418	583	1117	761				
			mg/kg	428	382	186	260	499	340	290	200	145	75



Site				EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06	Heavy Soil e.g Clay	Medium Soil e.g Clay Loam	Light Soil e.g Loam	Sandy Soil e.g Loamy Sand
	Potassium	K	cmol <sup>+</sup> /Kg	1.36	1.59	1.12	0.92	1.96	1.12				
			kg/ha	1192	1391	981	805	1715	982				
			mg/kg	532	621	438	359	765	439	235	190	150	100
	Sodium	Na	cmol <sup>+</sup> /Kg	0.41	0.28	0.03	0.04	0.18	0.07				
			kg/ha	209	145	14	20	91	35				
			mg/kg	93	65	6	9	40	15	69	60	51	25
	KCl	Aluminium	cmol <sup>+</sup> /Kg	0.02	0.01	0.01	0.02	0.03	0.03				
			kg/ha	4	2	2	3	5	6				
			mg/kg	2	1	1	1	2	3	54	45	41	14
	Acidity Titration	Hydrogen	cmol <sup>+</sup> /Kg	0.19	0.11	0.08	0.16	0.14	0.12				
			kg/ha	4	2	2	4	3	3				
			mg/kg	2	1	1	2	1	1	6	5	5	2
	Calculation	Effective Cation Exchange Capacity (ECEC)	cmol <sup>+</sup> /Kg	10.10	10.17	7.94	10.59	13.86	10.48	20	14	7	4
	Base Saturation Calculations	Calcium	Ca	45.6	49.5	65.1	69.1	53.8	60.6	77	76	69	60
		Magnesium	Mg	34.9	30.9	19.3	20.2	29.6	26.7	12	12	16	20
		Potassium	K	13.5	15.6	14.1	8.7	14.1	10.7	3	4	5	8
		Sodium - ESP	Na	4.0	2.8	0.3	0.4	1.3	0.6	2	2	3	3
		Aluminium	Al	0.2	0.1	0.1	0.1	0.2	0.3	7	7	7	9
		Hydrogen	H <sup>+</sup>	1.9	1.1	1.0	1.5	1.0	1.1				
	Calculation	Calcium/ Magnesium Ratio	ratio	1.3	1.6	3.4	3.4	1.8	2.3	6.4	6.3	4.3	3.0
	DTPA	Zinc	Zn	0.9	1.2	0.7	1.7	0.7	1.5	6.0	5.0	4.0	3.0
		Manganese	Mn	76	63	25	136	86	98	25	22	18	15
		Iron	Fe	122	117	90	91	87	59	25	22	18	15

Site				EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06	Heavy Soil e.g Clay	Medium Soil e.g Clay Loam	Light Soil e.g Loam	Sandy Soil e.g Loamy Sand	
		Copper	Cu		4.2	5.5	4.0	7.1	3.8	7.1	2.4	2.0	1.6	1.2
	CaCl <sub>2</sub>	Boron	B	mg/kg	0.89	0.90	0.48	0.60	0.82	0.99	2.0	1.7	1.4	1.0
		Silicon	Si		69	71	34	56	50	72	50	45	40	35
	LECO IR Analyser	Total Carbon	C	%	1.81	1.87	2.08	2.94	1.84	2.04	>3.1	>2.6	>2.0	>1.4
		Total Nitrogen	N	%	0.15	0.18	0.21	0.15	0.16	0.16	>0.30	>0.25	>0.20	>0.15
	Calculation	Carbon/ Nitrogen Ratio		ratio	11.7	10.6	9.8	19.0	11.4	12.7	10-12	10-12	10-12	10-12
		Basic Texture			Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	Clay Loam	..	..	..	..
		Basic Colour			Brownish	Brownish	Brownish	Red	Red	Red	..	..	..	..
	Calculation	Chloride Estimate	equiv. ppm		25	26	23	19	34	32	..	..	..	..
	Total Acid Extractable	Calcium	Ca	mg/kg	1,284	1,312	1,407	1,914	1,549	1,595	1,000 - 10,000 Ca			
		Magnesium	Mg		1,273	1,281	750	1,234	1,042	1,376	500 - 5,000 Mg			
		Potassium	K		1,901	2,026	1,632	1,888	1,679	2,140	200 - 2,000 K			
		Sodium	Na		141	109	<50	<50	<50	<50	100 - 500 Na			
		Sulfur	S		127	125	151	136	123	141	100 - 1,000 S			
	Total Acid Extractable	Phosphorus	P	mg/kg	332	357	421	322	274	226	400 - 1,500 P			
	Total Acid Extractable	Zinc	Zn	mg/kg	20	27	18	46	21	51	20 - 50 Zn			
		Manganese	Mn		955	930	331	1,590	972	1,328	200 - 2,000 Mn			
		Iron	Fe		18,548	18,869	31,554	33,135	21,922	27,695	1,000 - 50,000 Fe			
		Copper	Cu		29.9	39.9	60.3	70.4	31.0	73.3	20 - 50 Cu			
		Boron	B		3	2	<2	<2	2	<2	2 - 50 B			
		Silicon	Si		1,031	708	591	545	512	697	1,000 - 3,000 Si			
		Aluminium	Al		12,016	12,315	8,358	13,493	11,141	15,314	2,000 - 50,000 Al			
	Total Acid Extractable	Molybdenum	Mo	mg/kg	0.6	0.9	1.8	1.1	0.7	1.3	0.5 - 3 Mo			

Site				EOA-01	EOA-02	EOA-03	EOA-04	EOA-05	EOA-06	Heavy Soil e.g. Clay	Medium Soil e.g. Clay Loam	Light Soil e.g. Loam	Sandy Soil e.g. Loamy Sand
		Cobalt	Co		10	10	4	14	8	12	5 - 50 Co		
		Selenium	Se		<0.5	<0.5	1.6	0.7	<0.5	0.5	0.1 - 2.0 Se		
	Total Acid Extractable	Cadmium	Cd	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	< 5 Cd		
		Lead	Pb		11	10	7	16	11	19	< 75 Pb		
		Arsenic	As		3	3	7	4	3	4	< 25 As		
		Chromium	Cr		20	24	14	29	26	22	<25 Cr		
		Nickel	Ni		8	8	5	11	8	9	<150 Ni		
		Mercury	Hg		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	< 3.75 Hg		
		Silver	Ag		<1	<1	<1	<1	<1	<1	.. Ag		

**EAL Soil Testing Notes**

1. All results as dry weight - 40°C oven dried soil crushed to <2mm
2. Methods from Rayment and Lyons, 2011. *Soil Chemical Methods*
3. Soluble Salts included in Exchangeable Cations - NO PRE-WASH
4. 'Morgan 1 Extract' adapted from 'Science in Agriculture', 'Non-Toxic Farming' and Lamonte 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. Contaminant Guides based on 'Residential with gardens and accessible soil including childrens daycare centres, preschools, primary schools, town houses or villas' (NSW EPA 1998).
9. Information relating to testing colour codes is available on Sheet 2 - "*Understanding you soil results*"

**Calculations**

1. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm
2. 1 cmol<sup>+</sup>/Kg = 1 meq/100g; 1 Lb/Acre = 2 ppm (parts per million); kg/ha = 2.24 x ppm; mg/kg = ppm
3. Conversions for 1 cmol<sup>+</sup>/Kg = 230 Kg/Hectare Sodium, 780 Kg/Ha Potassium, 240 Kg/Ha Magnesium, 400 Kg/Ha Calcium
4. Organic Matter = %C x 1.75
5. Chloride Estimate = EC x 640 (most likely over-estimate)
6. ECEC = sum of the exchangeable cations cmol<sup>+</sup>/Kg
7. Base saturation calculations = (cation cmol<sup>+</sup>/Kg) / ECEC x 100
8. Ca/Mg ratio from the exchangeable cmol<sup>+</sup>/Kg results

**Understanding your EAL soil results**

**Soil Acidity** - Is the water pH >6.5 or CaCl<sub>2</sub> pH >5.5 – hence no major problem. >7pH indicates alkaline soil. Soil with pH below 4.5 often has high kg/ha exchangeable hydrogen and aluminium (and likely high % exchangeable H and Al).

**Cation Exchange Capacity** - Using the ECEC or CEC is the soil heavy, medium, light or sandy? In particular, compare the exchangeable Calcium and Potassium in kg/ha to suggested guidelines.

**Soil Salinity** - Is the electrical conductivity (EC) above texture guidelines (ie. > 0.2dS/m heavy soil) – hence indicates possible salinity issue. If the Exchangeable Sodium Percentage or % Exchangeable Sodium > 5% then possible salt issue. With high EC the chloride is also likely to be elevated.

**Ca/Mg Ratio** - Above 5 indicates good soil structure. Ratio 1 – 5 suggests addition of calcium to assist soil structure. Ratio <1 (ie. far higher magnesium) often indicates high clay soil and possibly a sub-soil. Compaction and poor water infiltration is a likely indication of the cation imbalance.

**Organic Matter** - Refer to guidelines - >5.5% indicates good organic carbon and organic matter in the soil. Total Carbon to Total Nitrogen ratio should be around 12:1 – If higher then suggests depletion of organic nitrogen.

**Phosphorus** - Are the levels of Bray I (plant available)/Bray II (exchangeable P) below or above the guidelines. At, above or near guidelines suggests no need for P addition.

**Solubles** - Nitrate, ammonium and sulfur – compare to guidelines for soil type. Leachable nutrients hence may be further down soil profile.

**Micronutrients** - Plant available Iron, Manganese, Copper and Zinc – compare to guidelines to assess if relatively low or high. Iron and manganese availability is significantly influenced by soil pH (acid soils often have very high soluble iron). Leaf testing is ideal for confirming potential issues with micronutrients.

**Boron** - A micronutrient extracted as plant available – compare to guidelines but be aware boron is very leachable and could be elevated down the soil profile.

**Acid Extractable Nutrients** - If total available nutrients were analysed then use numbers as a guide to compare to assess store of nutrients.

## Appendix 3. ROUTINE AGRICULTURAL SOIL ANALYSIS REPORT– Reference Sites

Soil samples supplied by DNA Environmental on 23rd October, 2013 - Lab Job No. C9596

Site				RWood01	RWood02	RWood03	RWood04	Heavy Soil e.g Clay	Medium Soil e.g Clay Loam	Light Soil e.g Loam	Sandy Soil e.g Loamy Sand
Method	Nutrient		Units	C9596/15	C9596/16	C9596/17	C9596/18	Indicative guidelines only- refer Note 6			
Morgan 1	Calcium	Ca	mg/kg	1508	1183	2118	796	1150	750	375	175
	Magnesium	Mg		458	520	682	228	160	105	60	25
	Potassium	K		256	181	134	242	113	75	60	50
	Phosphorus	P		2.9	2.8	2.4	2.0	15	12	10	5.0
Bray1	Phosphorus	P	mg/kg	6.3	2.9	2.5	3.0	45 <sup>note 8</sup>	30 <sup>note 8</sup>	24 <sup>note 8</sup>	20 <sup>note 8</sup>
Colwell				17	9	6	8	80	50	45	35
Bray2				11	6	5	9	90 <sup>note 8</sup>	60 <sup>note 8</sup>	48 <sup>note 8</sup>	40 <sup>note 8</sup>
KCl	Nitrate Nitrogen	N	mg/kg	1.7	1.4	1.2	1.9	15	13	10	10
	Ammonium Nitrogen			11.7	7.5	7.1	8.1	20	18	15	12
	Sulfur	S		7.1	4.3	8.0	10.1	10.0	8.0	8.0	7.0
1:5 Water	pH		units	6.89	6.88	7.10	5.99	6.5	6.5	6.3	6.3
	Conductivity		dS/m	0.148	0.053	0.191	0.038	0.200	0.150	0.120	0.100
Calculation	Organic Matter		% OM	4.6	3.5	3.7	3.0	>5.5	>4.5	>3.5	>2.5
Ammonium Acetate + Calculations	Calcium	Ca	cmol <sup>+</sup> /Kg	11.43	11.48	13.73	7.34				
			kg/ha	5131	5153	6165	3294				
			mg/kg	2291	2301	2752	1471	3125	2150	1000	375
	Magnesium	Mg	cmol <sup>+</sup> /Kg	5.40	6.98	7.65	2.98				
			kg/ha	1469	1899	2081	810				
			mg/kg	656	848	929	362	290	200	145	75
	Potassium	K	cmol <sup>+</sup> /Kg	1.65	1.25	0.93	1.56				









Site				RWood01	RWood02	RWood03	RWood04	Heavy Soil e.g Clay	Medium Soil e.g Clay Loam	Light Soil e.g Loam	Sandy Soil e.g Loamy Sand
			kg/ha	1447	1097	819	1364				
			mg/kg	646	490	365	609	235	190	150	100
		Sodium Na	cmol <sup>+</sup> /Kg	0.35	0.25	0.55	0.04				
			kg/ha	179	129	285	18				
			mg/kg	80	58	127	8	69	60	51	25
	KCl	Aluminium Al	cmol <sup>+</sup> /Kg	0.01	0.01	0.01	0.00				
			kg/ha	3	2	1	1				
			mg/kg	1	1	1	0	54	45	41	14
	Acidity Titration	Hydrogen H <sup>+</sup>	cmol <sup>+</sup> /Kg	0.00	0.00	0.00	0.14				
			kg/ha	0	0	0	3				
			mg/kg	0	0	0	1	6	5	5	2
	Calculation	Effective Cation Exchange Capacity (ECEC)	cmol <sup>+</sup> /Kg	18.84	19.97	22.87	12.05	20	14	7	4
	Base Saturation Calculations	Calcium Ca	%	60.7	57.5	60.0	60.9	77	76	69	60
		Magnesium Mg		28.6	34.9	33.4	24.7	12	12	16	20
		Potassium K		8.8	6.3	4.1	12.9	3	4	5	8
		Sodium - ESP Na		1.8	1.3	2.4	0.3	2	2	3	3
		Aluminium Al		0.1	0.0	0.0	0.0	7	7	7	9
		Hydrogen H <sup>+</sup>		0.0	0.0	0.0	1.1				
	Calculation	Calcium/ Magnesium Ratio	ratio	2.1	1.6	1.8	2.5	6.4	6.3	4.3	3.0
	DTPA	Zinc Zn	mg/kg	1.4	0.7	0.5	6.9	6.0	5.0	4.0	3.0
		Manganese Mn		108	37	46	92	25	22	18	15
		Iron Fe		40	30	36	61	25	22	18	15
		Copper Cu		3.5	5.5	3.0	15.8	2.4	2.0	1.6	1.2

Site				RWood01	RWood02	RWood03	RWood04	Heavy Soil e.g Clay	Medium Soil e.g Clay Loam	Light Soil e.g Loam	Sandy Soil e.g Loamy Sand
	CaCl <sub>2</sub>	Boron B	mg/kg	1.51	1.32	1.57	1.02	2.0	1.7	1.4	1.0
		Silicon Si		32	108	34	66	50	45	40	35
	LECO IR Analyser	Total Carbon C	%	2.63	2.01	2.13	1.72	>3.1	>2.6	>2.0	>1.4
		Total Nitrogen N	%	0.19	0.14	0.13	0.16	>0.30	>0.25	>0.20	>0.15
	Calculation	Carbon/ Nitrogen Ratio		ratio	13.5	14.2	16.7	10.6	10-12	10-12	10-12
	Basic Texture			Clay Loam	Clay Loam	Clay Loam	Clay Loam	..	..	..	..
	Basic Colour			Brownish	Red	Red	Red	..	..	..	..
	Calculation	Chloride Estimate	equiv. ppm	95	34	122	24	..	..	..	..
	Total Acid Extractable	Calcium Ca	mg/kg	3,365	3,267	3,953	2,066	1,000 - 10,000 Ca			
		Magnesium Mg		1,743	3,216	2,433	2,944	500 - 5,000 Mg			
		Potassium K		2,161	2,226	1,600	2,603	200 - 2,000 K			
		Sodium Na		133	130	203	<50	100 - 500 Na			
		Sulfur S		168	149	167	143	100 - 1,000 S			
	Total Acid Extractable	Phosphorus P	mg/kg	319	252	191	360	400 - 1,500 P			
	Total Acid Extractable	Zinc Zn	mg/kg	31	41	23	209	20 - 50 Zn			
		Manganese Mn		3,206	1,203	694	2,193	200 - 2,000 Mn			
		Iron Fe		19,272	46,449	20,614	42,489	1,000 - 50,000 Fe			
		Copper Cu		32.8	69.8	29.7	142.3	20 - 50 Cu			
		Boron B		3	3	3	<2	2 - 50 B			
		Silicon Si		850	548	610	558	1,000 - 3,000 Si			
		Aluminium Al		13,829	17,763	15,363	18,505	2,000 - 50,000 Al			
	Total Acid Extractable	Molybdenum Mo	mg/kg	0.5	0.4	0.5	1.0	0.5 - 3 Mo			
		Cobalt Co		14	19	8	17	5 - 50 Co			
		Selenium Se		0.5	0.5	<0.5	0.6	0.1 - 2.0 Se			

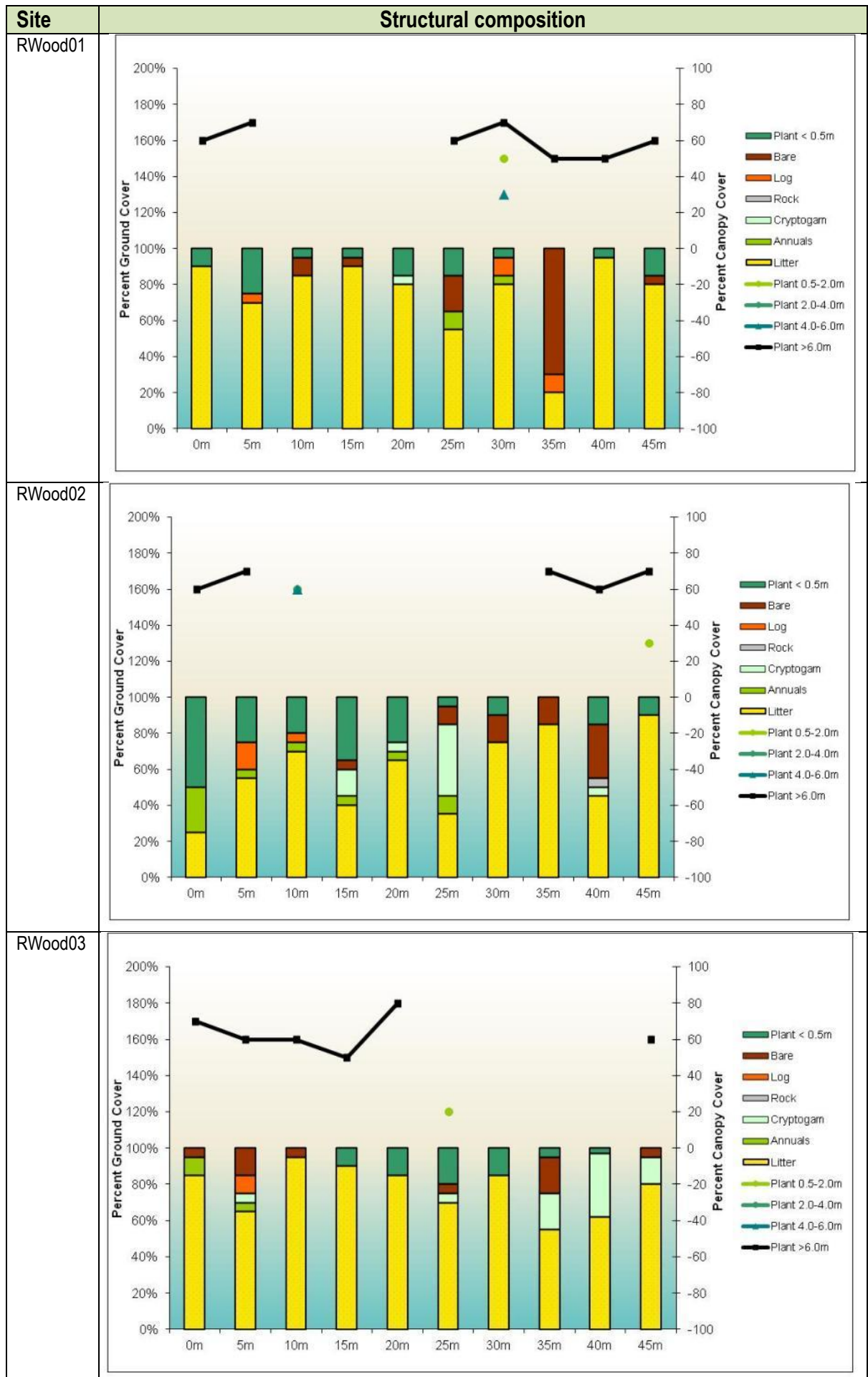
Site				RWood01	RWood02	RWood03	RWood04	Heavy Soil e.g Clay	Medium Soil e.g Clay Loam	Light Soil e.g Loam	Sandy Soil e.g Loamy Sand
Total Acid Extractable	Cadmium	Cd	mg/kg	<0.5	<0.5	<0.5	<0.5	< 5 Cd			
	Lead	Pb		13	8	13	17	< 75 Pb			
	Arsenic	As		3	4	3	8	< 25 As			
	Chromium	Cr		21	73	21	20	<25 Cr			
	Nickel	Ni		10	20	9	10	<150 Ni			
	Mercury	Hg		<0.1	<0.1	<0.1	<0.1	< 3.75 Hg			
	Silver	Ag		<1	<1	<1	<1	.. Ag			



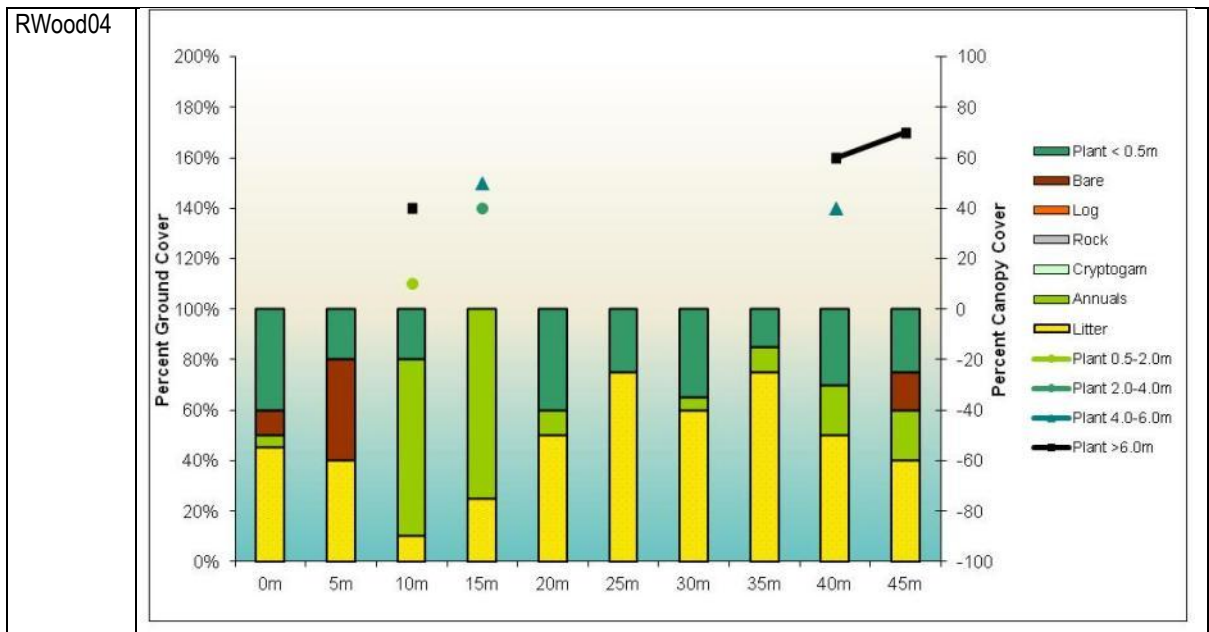
## Appendix 4. Data obtained from the woodland reference sites in 2013

Site	Vegetation transect (front)	Vegetation transect (rear)
RWood01		
RWood02		
RWood03		
RWood04		







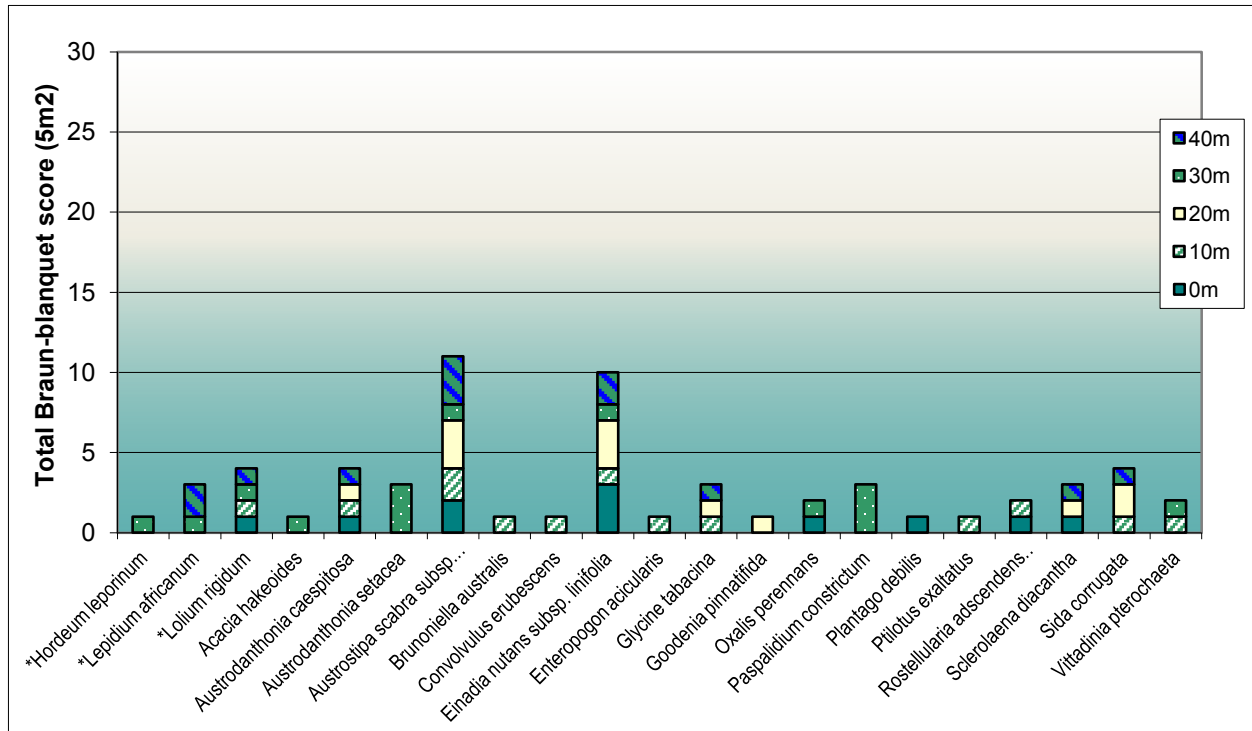


## Landscape Function Analysis

Site		RWood01		RWood02		RWood03		RWood04	
Number of Patches/10m		0.5		0.5		0.5		0.5	
Total Patch Area (m2)		200.00		200.00		200.00		200.00	
Patch Area Index		1.00		1.00		1.00		1.00	
Landscape Organisation Index		1.00		1.00		1.00		1.00	
Average Interpatch Length (m)		NA		NA		NA		NA	
Range Interpatch length (m)		NA		NA		NA		NA	
Patch or Interpatch Type		Woodland Patch		Woodland Patch		Woodland Patch		Woodland Patch	
Patch or Interpatch Proportion (%)		100.0	100	100.0	100	100.0	100	100.0	100
Soil Surface Assessment									
Within Individual Zones	Stability	62.9		68.1		69.0		67.5	
	Infiltration	50.3		55.7		42.8		41.1	
	Nutrients	45.8		53.0		42.7		36.2	
			Total		Total		Total		Total
Individual zones contribution to the whole of Landscape	Stability	62.9	62.9	68.1	68.1	69.0	69.0	67.5	67.5
	Infiltration	50.3	50.3	55.7	55.7	42.8	42.8	41.1	41.1
	Nutrients	45.8	45.8	53.0	53.0	42.7	42.7	36.2	36.2

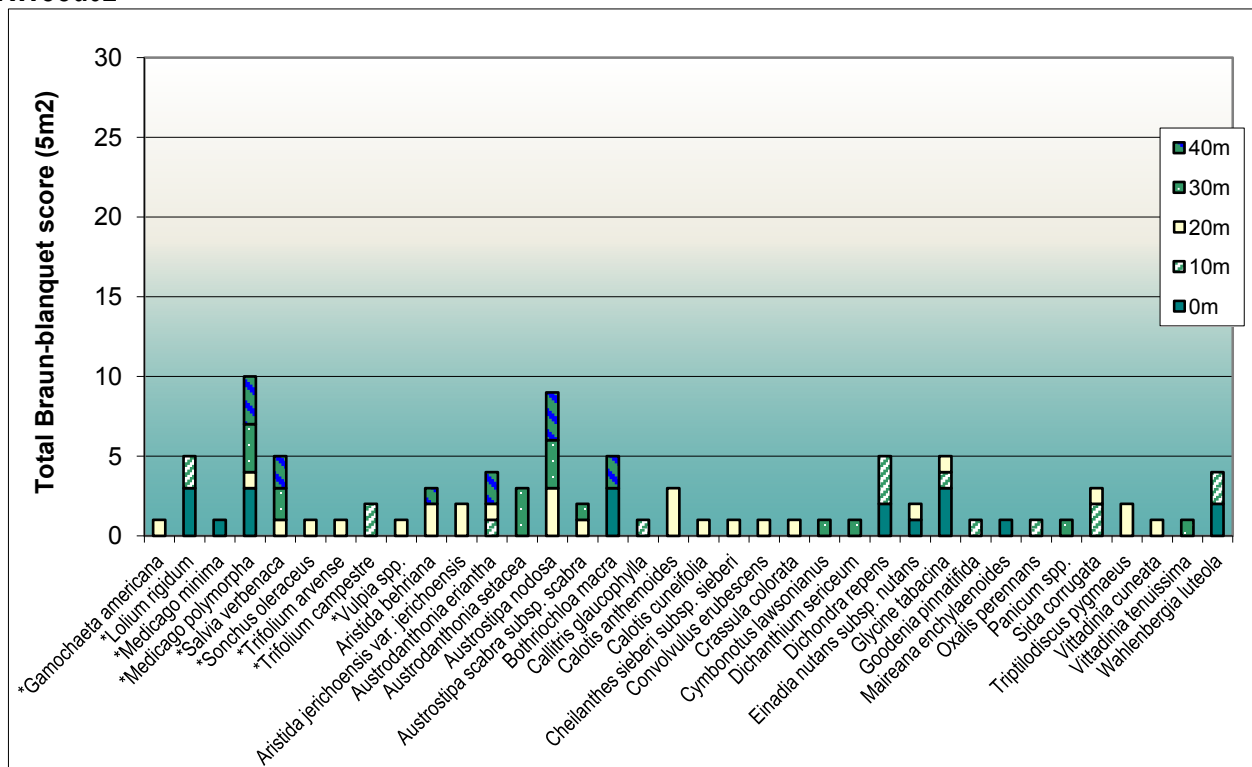
## Species cover abundance

### RWood01



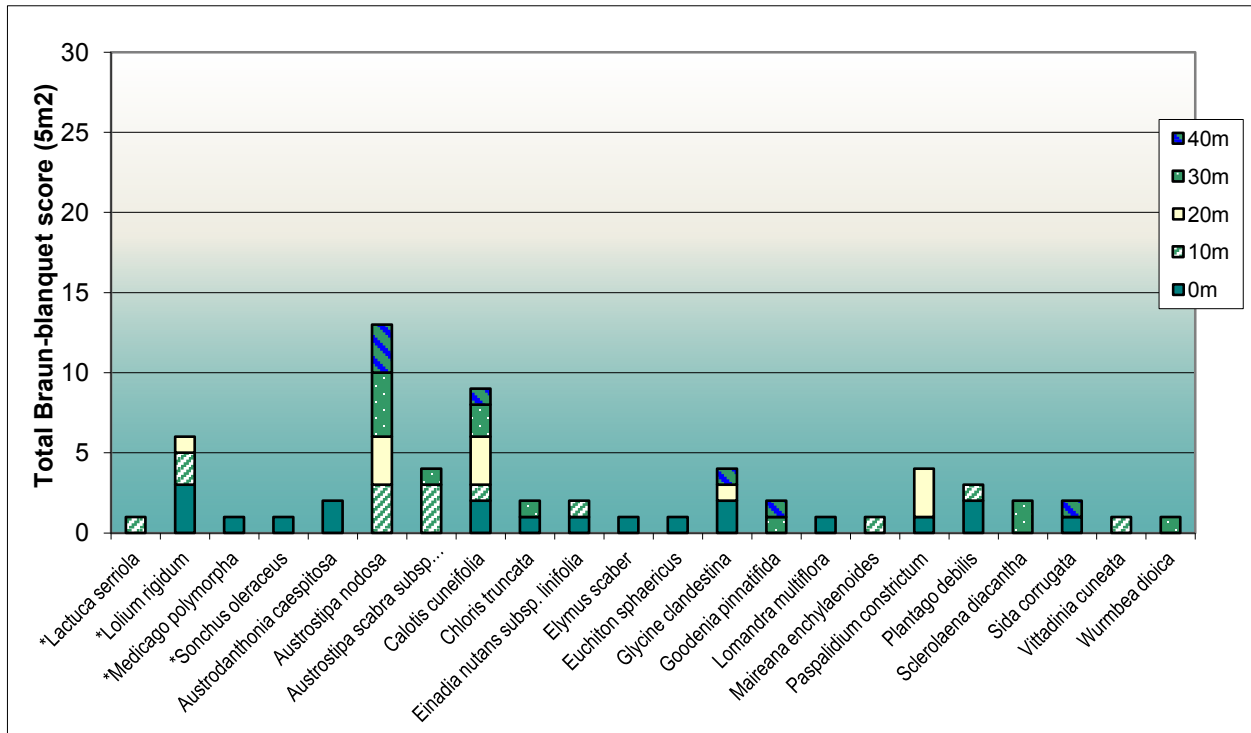
Species /m2	0m	10m	20m	30m	40m	Avg/m2	SD
Native	7	11	7	7	6	7.6	1.9
Exotic	1	1	0	3	2	1.4	1.1
<b>Total</b>	<b>8</b>	<b>12</b>	<b>7</b>	<b>10</b>	<b>8</b>	<b>9</b>	<b>2.0</b>

### RWood02



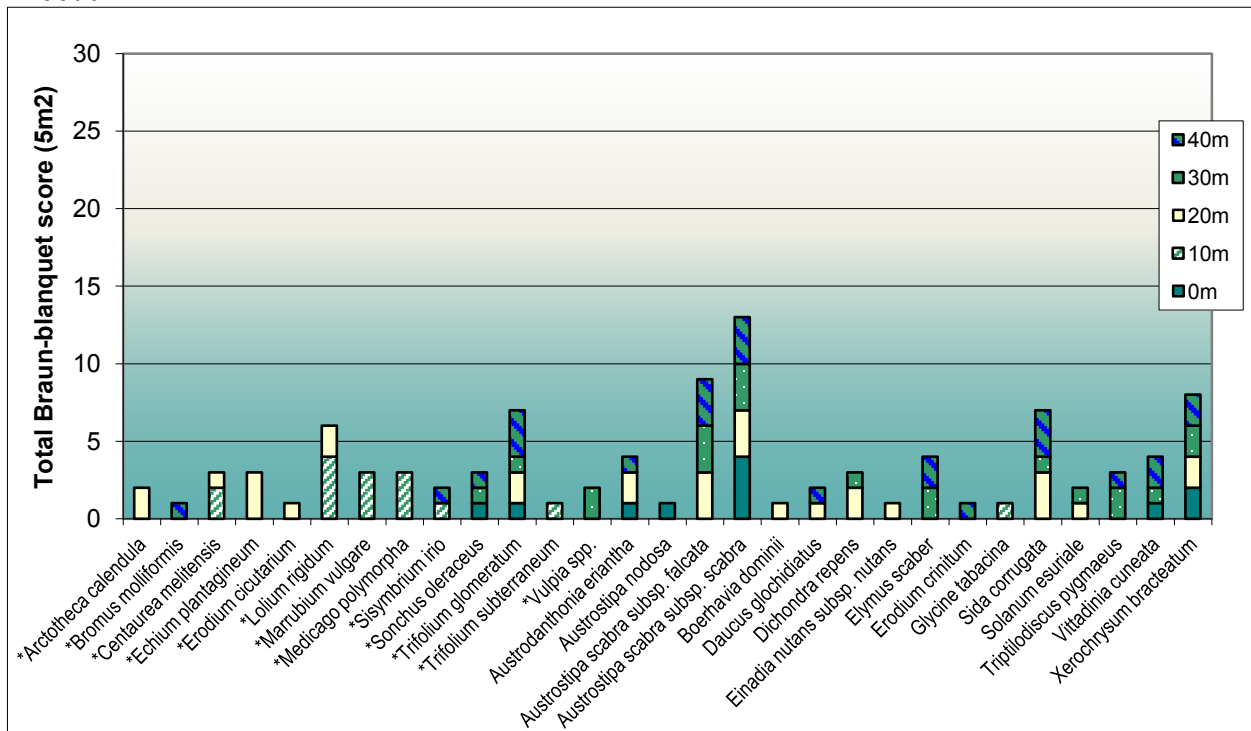
Species /m2	0m	10m	20m	30m	40m	Avg/m2	SD
Native	6	8	15	7	4	8	4.2
Exotic	3	2	6	2	2	3	1.7
<b>Total</b>	<b>9</b>	<b>10</b>	<b>21</b>	<b>9</b>	<b>6</b>	<b>11</b>	<b>5.8</b>

## RWood03



Species /m2	0m	10m	20m	30m	40m	Avg/m2	SD
Native	11	7	4	7	5	6.8	2.7
Exotic	3	1	1	0	0	1	1.2
<b>Total</b>	<b>14</b>	<b>8</b>	<b>5</b>	<b>7</b>	<b>5</b>	<b>7.8</b>	<b>3.7</b>

## RWood04

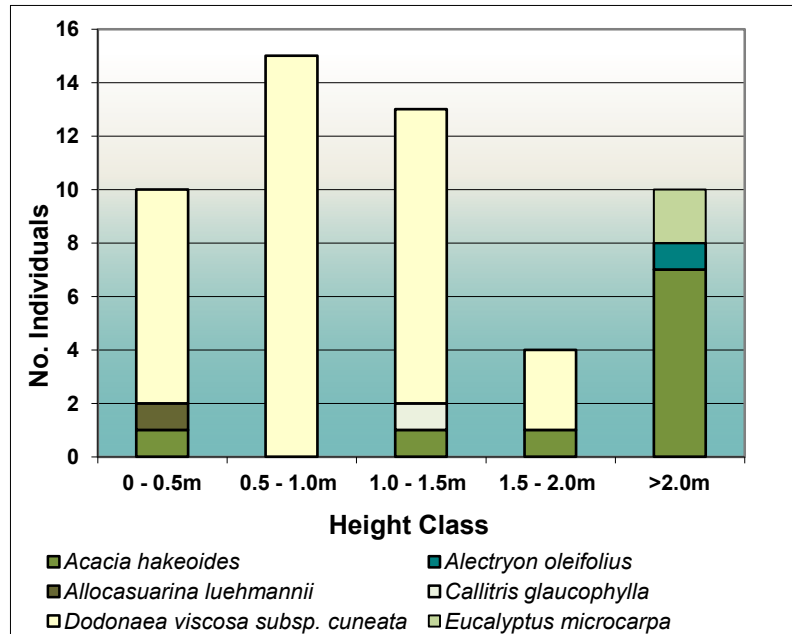


Species /m2	0m	10m	20m	30m	40m	Avg/m2	SD
Native	5	1	10	9	10	7	3.9
Exotic	2	6	6	3	4	4.2	1.8
<b>Total</b>	<b>7</b>	<b>7</b>	<b>16</b>	<b>12</b>	<b>14</b>	<b>11.2</b>	<b>4.1</b>

## Trees and Shrubs

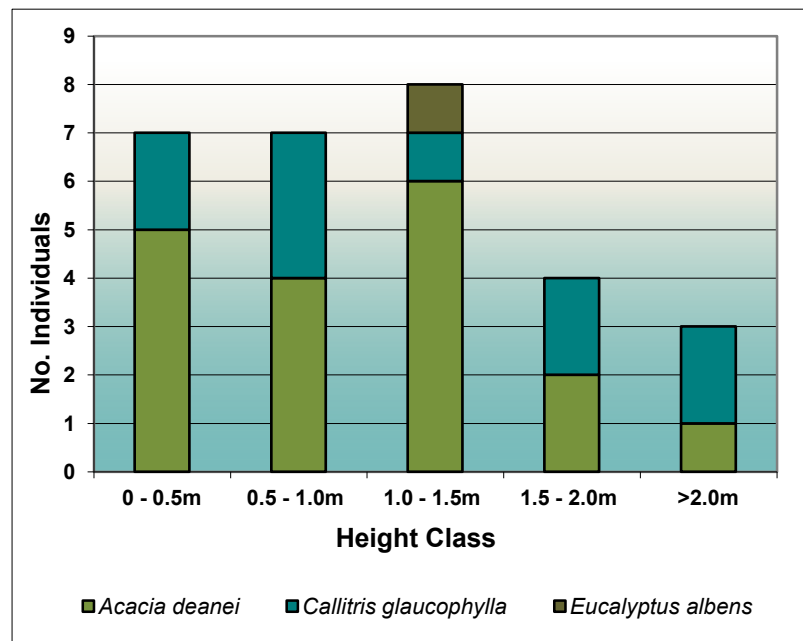
### RWood01

Dominant species	<i>Allocasuarina luehmannii</i> (7), <i>Eucalyptus microcarpa</i> (6), <i>Acacia hakeoides</i> (1)
Average dbh (Cm)	36
Max dbh (cm)	76
Min dbh (cm)	12
Total trees	14
No. with multiple limbs	0
No. Live trees	14
No. Healthy	1
No. Medium Health	8
No. Advanced Dieback	5
No. Dead	0
Mistletoe	1
Flowers / fruit	7



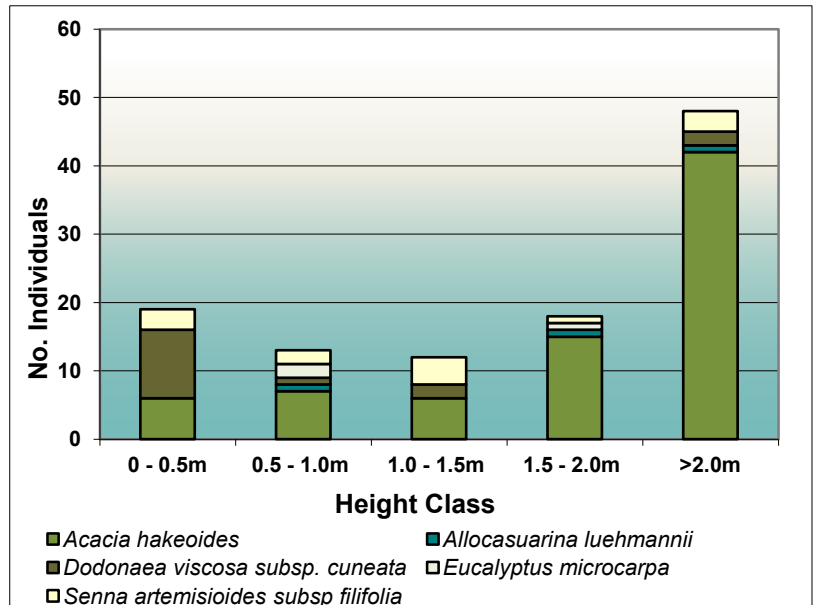
### RWood02

Dominant species	<i>Callitris glaucophylla</i> (13), <i>Eucalyptus albens</i> (5), <i>Eucalyptus populnea</i> (1)
Average dbh (Cm)	18
Max dbh (cm)	49
Min dbh (cm)	5
Total trees	19
No. with multiple limbs	1
No. Live trees	19
No. Healthy	9
No. Medium Health	10
No. Advanced Dieback	0
No. Dead	0
Mistletoe	0
Flowers / fruit	10



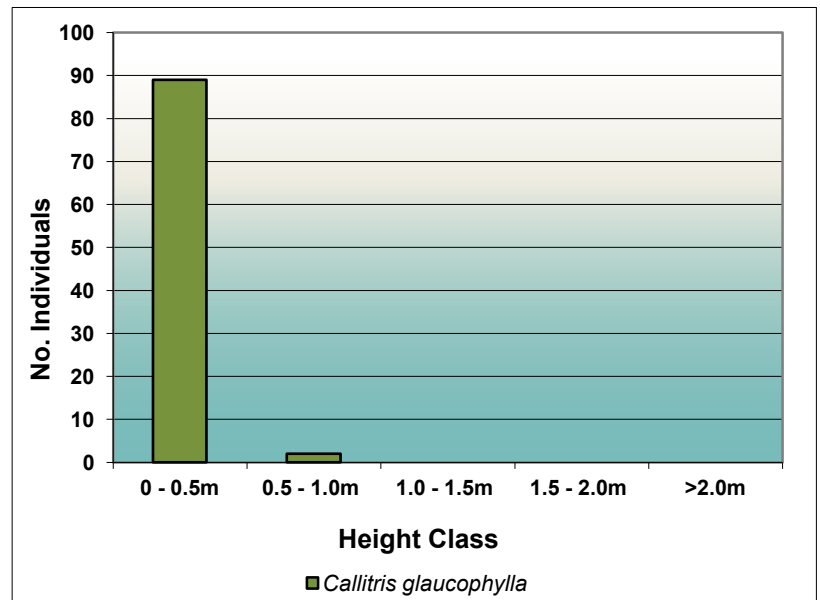
## RWood03

<b>Dominant species</b>	<i>Eucalyptus microcarpa</i> (5), <i>Acacia hakeoides</i> (2), <i>Allocasuarina luehmannii</i> (1)
<b>Average dbh (Cm)</b>	35
<b>Max dbh (cm)</b>	66
<b>Min dbh (cm)</b>	5
<b>Total trees</b>	9
<b>No. with multiple limbs</b>	1
<b>No. Live trees</b>	9
<b>No. Healthy</b>	3
<b>No. Medium Health</b>	4
<b>No. Advanced Dieback</b>	2
<b>No. Dead</b>	0
<b>Mistletoe</b>	0
<b>Flowers / fruit</b>	5



## RWood04

<b>Dominant species</b>	<i>Callitris glaucophylla</i> (2), <i>Eucalyptus populnea</i> (2), <i>Eucalyptus melliodora</i> (1)
<b>Average dbh (Cm)</b>	54
<b>Max dbh (cm)</b>	82
<b>Min dbh (cm)</b>	35
<b>Total trees</b>	6
<b>No. with multiple limbs</b>	0
<b>No. Live trees</b>	5
<b>No. Healthy</b>	2
<b>No. Medium Health</b>	3
<b>No. Advanced Dieback</b>	0
<b>No. Dead</b>	1
<b>Mistletoe</b>	0
<b>Flowers / fruit</b>	5





## Species diversity and community composition

