

## Warkworth Sands Woodland Integrated Management Plan

This Plan is a compliance requirement under Condition 34 of the Warkworth Mining Limited's NSW Project Approval (SSD-6464) granted under the *Environmental Planning & Assessment Act 1979*.

15 February 2017



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Cover photo – Warkworth Sands Woodland, Northern Biodiversity Area 2015

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Document Title	Version	Date effective	Comment
Warkworth Sands Woodland Integration Management Plan	1	February 2017	For approval by regulators

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# 1 Introduction

On 5 May 2016, Warkworth Sands Woodland (WSW) was listed as Critically Endangered (CE) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It has been listed as an Endangered Ecological Community (EEC) under the New South Wales (NSW) *Threatened Species Conservation Act 1995* (TSC Act) since 2002.

This Plan has been prepared to satisfy the conditions of NSW environmental approval held by Warkworth Mining Limited for the Warkworth Coal Mine located in the Hunter Valley NSW. The Warkworth Mine forms part of the Mount Thorley Warkworth complex managed by Coal & Allied Operations Limited (Coal & Allied).

Condition 34 of the Warkworth Mining Limited's NSW Project Approval (SSD-6464) granted under the *Environmental Planning & Assessment Act 1979* that states '*the applicant to prepare an Integrated Management Plan for WSW to the satisfaction of OEH. This plan must be prepared in consultation with the owners of the Wambo and Bulga mines, and outline the measures that would be implemented to co-ordinate management and recovery efforts for the EEC*'.

WSW is a unique vegetation community due to the presence of sand substrate and its confined distribution across Aeolian sand deposits in the vicinity of Warkworth, south-east of Singleton in the mid Hunter Valley, NSW. Aeolian sands are windblown, and it is believed that these sand deposits were formed during the Pleistocene epoch, some 18,000 to 15,000 years, from windblown grains of sand originating from the sandy alluvium of Wollombi Brook, and erosion from the nearby Wollemi and Yengo National Parks.

This document constitutes an Integrated Management Plan (Plan) for WSW, and as such, considers the requirements of the community across its known range, identifies key elements influencing the long-term viability of the community and stakeholders.

There has been some conjecture regarding the range of this community and to inform this Plan, Coal & Allied engaged environmental consultants, EMM, to verify the mapping across Coal & Allied owned land, and assess the vegetation for consistency against the Commonwealth and NSW listings for WSW. As described in the *Approved Conservation Advice (including listing advice) for Warkworth Sands Woodland of the Hunter Valley*, by the Threatened Species Scientific Committee issued in 2016, and the *Final Determinations for the Warkworth Sands Woodland in the Sydney Basin Bioregion*, by the NSW Scientific Committee published in 2011. The purpose of this was to provide a consolidated map of the current extent of the community. It also contributes to the first of the 18 Priority Actions published by NSW Office of Environment and Heritage (OEH), which is to "Accurately survey and map the extent and condition of all remnants", the full list of action is provided in Section 4.

The key action of this Plan is to establish a WSW Exchange Forum to enable integration of management actions and knowledge exchange between the following landowners:

- Bulga Coal Complex, Glencore;
- Wambo Coal Mine, Peabody Energy; and
- Mount Thorley Warkworth, Coal & Allied.

The Forum is to be held annually, with invitations extended to representatives from the Commonwealth Department of Environment and Energy (DoEE), NSW Department of Planning and Environment (DPE) and OEH.

Consultation on this Plan was undertaken throughout 2016, this included meetings with representative from Bulga Coal Complex and Wambo Coal Mine in April and discussed at meetings with representative from OEH.

## 2 Biological Information

### 2.1 Description

WSW is a unique low woodland vegetation community due to the presence of a sand substrate. The sand substrate is believed to have formed during the Pleistocene epoch, some 18,000-15,000 years ago, from the sandy alluvium of the Wollombi Brook, possibly from erosion in Wollemi and Yengo National Parks (Galloway 1963).

The presence of a relatively deep sand substrate has allowed for the development of a plant community that is characterised by species that usually occur on coastal, Aeolian dunes. These include the Coast Banksia (*Banksia integrifolia*), Slender Rice Flower (*Pimelea linifolia*) and Rough Barked Apple (*Angophora floribunda*). Other tree species may be present such as Forest Red Gum (*Eucalyptus tereticornis*) and Slaty Red Gum (*E. glaucina*). Shrub and ground layer species commonly present include Fern-leaved Wattle (*Acacia filicifolia*), Thyme Honey-myrtle (*Melaleuca thymifolia*), Daphne Heath (*Brachyloma daphnoides*), Bracken (*Pteridium esculentum*), Blady Grass (*Imperata cylindrica* var. *major*), Common Everlasting (*Chrysocephalum apiculatum*) and *Glycine clandestina*. Small drainage lines within the area occupied by this community may support the presence or higher abundance of certain species (such as Thyme Honey-myrtle) and the absence or lower abundance of others (such as Coast Banksia).

While sandmass plant communities do occur elsewhere in New South Wales, only the Agnes Banks sandmass and subsequent vegetation communities from Western Sydney are of a similar age (Ryan et al. 1996). This makes the WSW community unique in this region.

Other sandmass plant communities that occur in the lower Hunter Valley include Kurri Sand Swamp Woodland (NSW NPWS 2008) and Quorrobolong Scribbly Gum Woodland (NSW NPWS 2002), however each of these communities occur on deeply weathered sandstone (Peake et al. 2002), rather than the river sediments that occur at Warkworth.

#### 2.1.1 EPBC Act listing

The *Approved Conservation Advice (including listing advice) for Warkworth Sands Woodland of the Hunter Valley* (TSSC 2016) describes Warkworth Sands Woodland as:

- a medium to low woodland typically dominated by Rough-barked Apple in the canopy and Coast Banksia and/or Fern-leaved Wattle in the sub-canopy;
- containing a small tree layer, shrubs and groundcover species typical of sandy soils in the Hunter Valley region;
- typically occurring on sand dunes between 1-6 m in height, on river terraces on the undulating valley floor;
- also occurring on shallow veneers of sand, separated from the main sand deposit by areas of clay soils;
- characterised by a sparse to dense woodland on deeper sand deposits that are typically dominated by Rough-barked Apple;
- dominated by a Red Gum hybrid (*Eucalyptus blakelyi* x *E. tereticornis*) and Narrow-leaved Ironbark (*E. crebra*) on shallower sand deposits. These areas may also contain grasses and herbs typical of the surrounding clay landscapes.
- inclusive of disturbed woodland areas that contain a higher abundance of Bulloak and Black Cypress-Pine (*Callitris endlicheri*).

#### 2.1.2 TSC Act listing

The *Final determination for Warkworth Sands Woodland in the Sydney Basin Bioregion* (NSWSC 2011) describes the listed community as:

- occurring on Aeolian sand deposits south east of Singleton in the Hunter Valley, in the local government area of Singleton;

- generally comprising woodland to low woodland structure that contains Rough-barked Apple (*Angophora floribunda*), Coast Banksia (*Banksia integrifolia*), Fern-leaved Wattle (*Acacia filicifolia*), Bracken (*Pteridium esculentum*), Blady Grass (*Imperata cylindrica*), Daphne Heath (*Brachyloma daphnoides*) and Thyme Honeymyrtle (*Melaleuca thymifolia*); and
- typically associated with sand dunes generally 1-6 m in height, aligned in a north west to south east direction, and rest on a river terrace.

The *Final determination for Warkworth Sands Woodland in the Sydney Basin Bioregion* (NSWSC 2011) also notes some variations in landscape position and floristics to that described above, that are included in the listed community. Such areas comprise small drainage lines that support a higher abundance of Thyme Honeymyrtle and are less dominated by Coast Banksia. In addition, adjacent areas, where woodland occurs on a shallow horizon of sand, are included within this community.

Woodlands occurring adjacent to the sand dunes on Permian clays share many species with Warkworth Sands Woodland but also have a higher abundance of Permian substrate species, such as Spotted Gum (*Corymbia maculata*), Grey Box (*Eucalyptus moluccana*), Buloke (*Allocasuarina luehmannii*) and Narrow-leaved Ironbark (*Eucalyptus crebra*). Such areas are excluded from the listed community, except in ecotones where there is a dominant abundance of the representative species of the Warkworth Sands Woodland described in the final determination. This generally occurs where a thin sandy layer overlies the Permian substrate.

Table 1 provides the species assemblage listed by the NSW determination.

**Table 1 Species assemblage listed in the NSW Scientific Committee final determination (2002) to characterise Warkworth Sand Woodland**

Scientific Name	Common Name	Strata
<i>Acacia falcata</i>	Hickory Wattle	Shrub
<i>Acacia filicifolia</i>	Fern-leaved wattle	Canopy / Mid storey
<i>Ajuga australis</i>	Austral Bugle	Ground cover
<i>Allocasuarina littoralis</i>	Black She-oak	Canopy / Mid storey
<i>Allocasuarina luehmannii</i>	Bulloak	Canopy / Mid storey
<i>Amyema pendulum</i>	Mistletoe	Shrub
<i>Angophora floribunda</i>	Rough-barked Apple	Canopy / Mid storey
<i>Aristida calycina</i>		Ground cover
<i>Aristida ramosa</i>	Purple Wiregrass	Ground cover
<i>Aristida vagans</i>	Threeawn Speargrass	Ground cover
<i>Aristida warburgii</i>		Ground cover
<i>Banksia integrifolia</i>	Coast Banksia	Canopy / Mid storey
<i>Brachyloma daphnoides</i>	Daphne Heath	Shrub
<i>Breynia oblongifolia</i>	Coffee Bush	Shrub
<i>Callitris endlicheri</i>	Black Cypress Pine	Canopy / Mid storey
<i>Calotis cuneifolia</i>	Purple Burr-daisy	Ground cover
<i>Cheilanthes sieberi</i>	Poison Rock Fern	Ground cover
<i>Chrysocephalum apiculatum</i>	Common Everlasting	Ground cover
<i>Desmodium varians</i>		Ground cover
<i>Dianella revoluta</i>	Blue Flax Lily	Ground cover
<i>Dichondra species A</i>	Kidney Grass	Ground cover
<i>Echinopogon caespitosus</i>	Bushy Hedgehog-grass	Ground cover
<i>Echinopogon intermedius</i>	Erect Hedgehog Grass	Ground cover
<i>Einadia trigonos</i>	Fishweed	Ground cover
<i>Entolasia stricta</i>	Wiry Panic	Ground cover
<i>Eucalyptus blakelyi/tereticornis</i>	Forest Red Gum	Canopy / Mid storey
<i>Eucalyptus crebra</i>	Narrow-leaved Ironbark	Canopy / Mid storey

Scientific Name	Common Name	Strata
<i>Eucalyptus glaucina</i>	Slaty Red Gum	Canopy / Mid storey
<i>Exocarpos cupressiformis</i>	Cherry Ballart / Native Cherry	Canopy / Mid storey
<i>Exocarpos strictus</i>	Pale-fruit Ballart / Dwarf Cherry	Canopy / Mid storey
<i>Hardenbergia violacea</i>	Purple Coral Pea	Ground cover
<i>Hibbertia linearis</i>	Showy Guinea-flower	Shrub
<i>Hovea linearis</i>	-	Shrub
<i>Hypoxis hygrometrica</i>	Golden Weather-grass	Ground cover
<i>Imperata cylindrical</i>	Blady grass	Ground cover
<i>Indigofera australis</i>	Australian Indigo	Shrub
<i>Jacksonia scoparia</i>	Winged Broom-pea	Shrub
<i>Lomandra glauca</i>	Pale Mat-rush	Ground cover
<i>Lomandra leucocephala</i>	Woolly Mat-rush	Ground cover
<i>Lomandra muticus</i>		Ground cover
<i>Melaleuca decora</i>	White Feather Honey-myrtle	Shrub
<i>Melaleuca thymifolia</i>	Thyme Honey-myrtle	Shrub
<i>Persoonia linearis</i>	Narrow-leaved Geebung	Shrub
<i>Pimelea linifolia</i>	Wedding Bush / Slender Rice-flower	Shrub
<i>Pomax umbellata</i>		Ground cover
<i>Pteridium esculentum</i>	Common Bracken	Ground cover
<i>Solanum prinophyllum</i>	Forest Nightshade	Ground cover
<i>Vittadina sulcata</i>		Ground cover

## 2.2 Distribution

The community is confined to Aeolian sand deposits in the vicinity of Warkworth, south-east of Singleton in the mid Hunter Valley. Due to the extent of vegetation clearing and modification in other areas, the original extent is now difficult to estimate, though assuming the community occurred on most of the other occurrences of the Warkworth Land System (Story et al. 2010), it is estimated that the WSW had a pre-European distribution of between 3,038 ha (Peake 2011) and 6,000 ha (NSW Scientific Committee 2002).

In 2011, the NSW Scientific Committee estimated the current Warkworth Sands Woodland extent to be 13% of its pre-settlement extent. Other estimates have ranged from 400 ha (Bell 2012); 464.8 ha (Peake 2011); 800 ha (NSW Scientific Committee 2002); and 1,133.4 ha (Peake 2006). In the NSW Land and Environment Court case of *Bulga Milbrodale Progress Association Inc v The Minister for Planning and Infrastructure and Warkworth Mining Limited* (LEC judgment) the chief judge estimated the WSW extent to be 465ha. Coal & Allied used this distribution for their impact assessments and offset management plans for the Northern and Southern Biodiversity Areas. The LEC judgment also identified an additional 275ha of Warkworth Sands Grassland (WSG). WSG refers to grassland with a native species component occurring on Aeolian sand derived from the clearing of the original WSW canopy and mid-storey. This vegetation community does not conform to the Commonwealth and State listing for WSW. Importantly, restoration of WSG, through activities such as removal of grazing stock, weed and feral animal control and assisted regeneration, has the capacity to increase the extent of WSW. The details of the regeneration works is contained within the Management Plans for the Northern and Southern Biodiversity Areas.

In 2016, Coal & Allied engaged environmental consultants, EEM, to complete a review and verification of the distribution of WSW across their land. This work assessed the three existing mapping sources that define the known extent of Warkworth Sands Woodland:

- crest and swale mapping (Cumberland Ecology 2013), which is based on the TSC Act listing advice;
- mapping completed for Wambo Mine (Wambo 2014); and

- the vegetation of the Central Hunter Valley NSW (Peake 2006).

A copy of the full study is included at Appendix A.

The study also assessed the consistency of the mapped areas with the:

- Approved Conservation Advice (including listing advice) for Warkworth Sands Woodland of the Hunter Valley, by the Threatened Species Scientific Committee issued in 2016; and
- Final Determinations for the Warkworth Sands Woodland in the Sydney Basin Bioregion, by the NSW Scientific Committee published in 2011.

The consolidated map of the distribution of WSW, is shown in Figure 2. The map was developed using the sources listed above and the plot data collected during the study. Noting, the map excludes areas of WSW within a current NSW development consent approval.

Figure 1 represents the areas that meet the description of the TSC Act listed community. All areas covered by the map sources assessed were classified as representing the TSC Act listed community. Areas mapped by EMM also represent the TSC Act listed community. These areas also represent the EPBC Act listed community as:

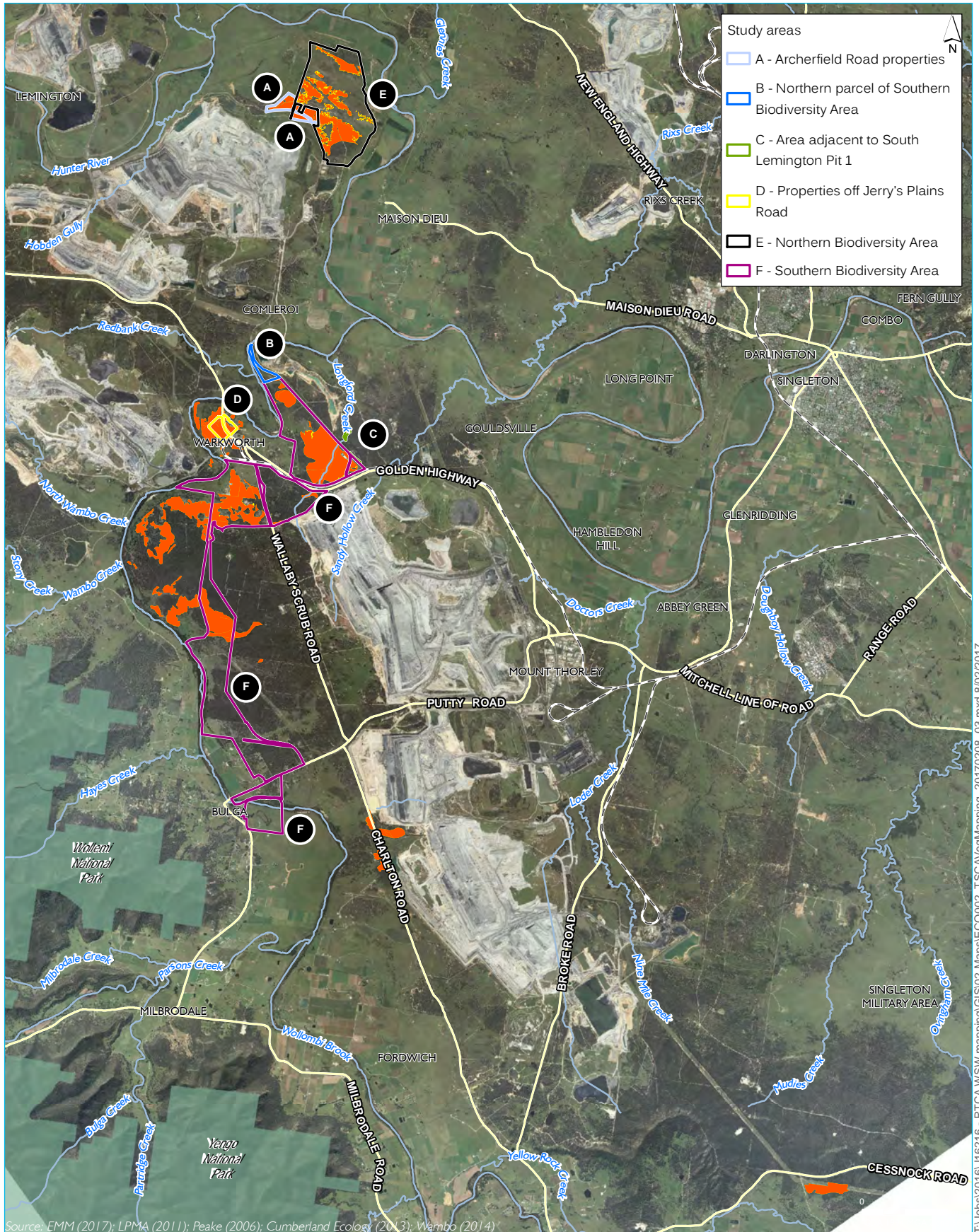
- the plot comparison with the TSC Act and EPBC Act listings were identical;
- the Cumberland Ecology mapping (based on the TSC Act listing) was found to be consistent with the EPBC Act listing; and
- the Wambo (2014) and Peake (2006) mapping was found to be consistent with both listing advices.

Figure 1 also represents additional areas that represent the EPBC Act listed community. Such areas include derived native grasslands that are in a gap, in or at the edge of a patch of WSW; or connecting two patches across a short distance (i.e. 30 m), as described by the EPBC Act listing.

The additional extent of the EPBC Act listed community was determined by reviewing the Cumberland Ecology (2013) maps and the maps prepared for this study to determine where Warkworth Sands Grassland occurred adjacent to areas mapped as Warkworth Sands Woodland and measuring the distances between connecting patches. If the connecting patch was 30 m or less, the boundary of the Warkworth Sands Woodland was adjusted such that the patch of grassland was included.

A total of 599ha of WSW that represents the TSC and EPBC Act listed communities occurs in the study area. An additional 20.9ha of EPBC Act listed Warkworth Sands Woodland is also present in the form of derived native grasslands that occur in gaps of 30 m or less between patches of woodland, increasing the total of the EPBC Act listed community to 619.9ha. A breakdown of the areas is provided in Table 2.





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Warkworth Sands Woodland – TSC Act and EPBC Act listings  
 Warkworth Continuation Project  
 Warkworth Sands Woodland Integrated Management Plan

Figure 1

**Table 2 Extent of Warkworth Sands Woodland in the study area**

Location	Landowner	TSC Act extent (ha)	EPBC Act extent (ha)
A. Archerfield Road properties	Coal & Allied	32.6	32.6
B. Northern parcel of Southern Biodiversity Area	Coal & Allied	4.7	4.7
C. Area adjacent to South Lemington Pit 1	Coal & Allied	91.6	110.5
D. Properties off Jerry's Plains Road	Coal & Allied	0.6	0.6
E. Northern Biodiversity Area	Coal & Allied	17.9	17.9
F. Southern Biodiversity Area	Coal & Allied	252.6	254.7
Isolated patches	Privately owned	198.9	199.0
Total		599.0	619.9

*Notes*

1. All areas of the mapped TSC Act extent also represent the EPBC Act listed community
2. This represents the entire extent of the EPBC Act listed community, which comprises the TSC Act extent, and the additional areas of derived native grasslands that occur in gaps of 30 m or less between patches of woodland.

The impact of this mapping on the areas contained within the Northern and Southern Biodiversity Areas is shown below in Table 3. The Biodiversity Areas contain the offset areas to be protected in perpetuity as part of the requirement for the continued mining at Warkworth under the Commonwealth and State environmental approvals.

**Table 3 Warkworth Sands Woodland within the Biodiversity Areas**

Biodiversity Area	Warkworth Sands Woodland 2014 extent (ha)	Warkworth Sands Woodland 2017 TSC Act extent (ha)
Northern	19.5	17.9
Southern	137	252.6
Total	156.5	270.5

## 2.3 Land tenure and zoning

The remnant areas of WSW occur on private land. The majority of these occur on lands managed by coal mining companies, with a small portion occurring on agricultural land.

No areas of WSW are contained within the public conservation reserve system.

Coal & Allied is to secure and protect 270.5ha as part of their environmental approval. Bulga Coal and Wambo Mine also have area to be protected in perpetuity as part of the environmental approval conditions.

## 2.4 Habitat and ecology

WSW occurs on Aeolian sand deposits generally 1-6 m high, resting on a river terrace. The main dune deposit is aligned NW-SE. The sand deposit is thought to be of Pleistocene age (Story et al. 2010).

Cohen and Nanson (2009, 179) describe the Warkworth Sands as most likely falling into the Warkworth soils group. This soils group is characterised by two types of Aeolian silicious sand deposits; sand dunes and thin sandsheets with gentle undulations, reflecting the underlying rock surface. The dunes are distributed on high river terraces of either Wollombi Brook or the Hunter River and range in height from 1 – 6 m and are generally aligned NW SE. This is consistent with Story *et al.* (1963) description, which described two land units associated within the Warkworth land system in the central lowlands of the Hunter Valley. They provided a description of the plant community associated with the two types of Aeolian silicious sand deposits, as shown in Table 4.

**Table 4 Description of two land units within the Warkworth Land system (Story *et al.* 1963)**

Unit	Land Forms	Soil	Vegetation
1	Linear sand dunes 3-20 ft high [1 to 7 m], resting on high river terrace; aligned NWSE; generally stable but subject to blowouts; swamp seepage zones at margins	Sandy aeolian regosols (Warkworth) of single grain structure; very little organic matter in surface.	Anomalous woodland, trees usually scattered, 12-40 ft. high [4-13 meters], <i>Banksia integrifolia</i> , <i>Angophora floribunda</i> , <i>E. tereticornis</i> , <i>Callitris enlicheri</i> , much cleared and under grassland of <i>Aristida</i> and <i>Eragrostis</i> spp, with <i>Imperata cylindrica</i> , <i>Pteridium aquilinum</i> [now <i>P. esculentum</i> ] and <i>Stenotaphrum secundatum</i> where damp: shrubs uncommon.
2	Low long linear dunes; less than 3ft. high [1 m], 100-200 yd apart and up to 0.5 mile long, aligned NW-SE; thin sand sheets with gentle undulations, reflecting the underlying rock surface.	Sandy aeolian regosols (Warkworth) over shallow clay at shallow to moderate depth.	Dense heath 5 ft. high [about 1.5 m], of many species; scanty grasses; trees scattered, up to 40 ft high [12.5 meters], <i>E. agglomerata</i> , <i>E. crebra</i> , <i>E. tereticornis</i> .

WSW provides habitat for a range of flora, fauna and habitat, which appear to be associated with vegetation of different regrowth age and structure, reflecting past disturbance regimes. These provide particular habitat resources, including hollow-bearing trees in woodland and a mosaic of regrowth woodland and open grassland areas.

The community provides known habitat for affected species including woodland birds (including speckled warbler (*Pyrrholaemus saggitata*), brown treecreeper (*Climacteris picumnus subsp. victoriae*) and grey-crowned babbler (*Pomatosomus temporalis subsp. temporalis*), which are all listed as Vulnerable under the TSC Act), the Squirrel Glider (*Petaurus norfolcensis*) and insectivorous bats. WSW EEC also provides potential habitat for threatened amphibians and reptiles, as well as a high frequency of winter flowering plants, providing a potential food resource for nectivorous fauna including the Critically Endangered regent honeyeater (*Anthochaera phrygia*) and Endangered swift parrot (*Lathamus discolor*).

#### 2.4.1 Ecological processes

The species composition of a site will be influenced by the size of the site, recent rainfall or drought condition, and by its disturbance (including fire) history.

To effectively manage and conserve WSW it is important to have an understanding of the ecological processes that influence the ability of WSW to respond to disturbance. The frequency of disturbance, particularly fire, is of vital importance for the management and conservation of WSW. It is likely that too frequent disturbance, and also potentially a long term absence of disturbance, may be detrimental to the persistence of WSW.

The number of species, and the above ground relative abundance of species will change with time since fire, and may also change in response to changes in fire regime (including changes in fire frequency). At any one time, above ground individuals of some species may be absent, but the species may be represented below ground in the soil seed banks or as dormant structures such as bulbs, corms, rhizomes, rootstocks or lignotubers. The list of species in Table 1 is of vascular plant species, the community also includes micro-organisms, fungi, cryptogamic plants and a diverse fauna, both vertebrate and invertebrate. These components of the community are poorly documented (NSW Scientific Committee 2011).

## 3 Threats and Management Issues

### 3.1 Threats

The WSW have been intensively used and managed, since the mid-1830s. Historically, WSW were managed variously for agricultural and forestry outcomes. Depending on the prevailing social and economic setting over this period, a land manager would have used land management practices to change the ecological function of an area to deliver a selected mix of ecosystem services over time.

The NSW Scientific Committee 2011 identified the ongoing threats to WSW include open-cut coalmining, sandmining and the construction of mining infrastructure, as well as habitat degradation from causes such as:

- inappropriate fire regimes, particularly altered fire frequency;
- changes to drainage conditions and nutrient levels due to clearing of adjacent lands.
- localised weed invasion; and
- grazing.

### 3.2 Limits to current knowledge

Since 2002, there have been numerous WSW research studies undertaken. Coal & Allied developed a commercial agreement with the University of New England (UNE) to develop and implement a comprehensive research programme on the distribution, ecology and restoration of WSW. The UNE research is comprehensive and highly valuable to the understanding of the restoration ecology of WSW, and early indications suggest that there is a high likelihood that WSW can be re-established providing adequate resources and an appropriate monitoring programme.

Past and current research has not addressed other knowledge gaps such as appropriate fire regime, including fire frequency, intervals, and seasonality and intensity.

Further research would provide land managers and consent and determining authorities with more detailed recommendations for appropriate fire management, as well as provide greater insight into the degree fire threatens WSW and hence assist in identifying how much effort should be placed on fire suppression activities.

### 3.3 Regeneration

The development of long-term ecological linkages and conservation areas integrating existing vegetation and rehabilitated WSW would be beneficial for the recovery of WSW (Peake 2011). Overall, the likely long-term chance of recovery of WSW is regarded as good, subject to ongoing works (establishment, maintenance, monitoring and research) (Peake 2011). Research into the life history attributes of key floristic elements of WSW suggests that the community is likely to re-establish well over time, and it is also anticipated that ecosystem function will be restored in a reasonable time period (Peake 2011).

The time required for a full recovery is unknown. It is likely that a thorough assessment of performance measures after 10 years post-establishment would reveal likely recovery trends (Peake 2011); however, it is likely to be at least 50 years before there is absolute certainty of full recovery (Peake 2011).

Coal & Allied has a committed to demonstrating regeneration of the WSW in the Northern Biodiversity Area within 15 years. Regeneration has been defined as “the process of restoration and growth that makes an ecosystem resilient to natural fluctuations or events that cause disturbance or damage. It can be demonstrated by the new growth of seedlings, community assembly and absence of weeds”. Specific performance criteria have been developed to demonstrate that the community is on a regeneration trajectory, by measuring the convergence of transition (grassland) toward reference (woodland) sites and the benchmark values for WSW.

## 4 Existing management priorities and actions

### 4.1 Priority Actions

The OEH identified 18 Priority Actions to guide the recovery of WSW EEC (OEH 2014) and these are listed in Table 5.

**Table 5 Priority Action for Warkworth Sands Woodland Endangered Ecological Community**

Action Title	Priority
1. Accurately survey and map the extent and condition of all remnants	High
2. Undertake an assessment of the conservation significance of remnants and prioritise sites for protection and active management on this basis of this assessment	High
3. Nominate WSW as an EEC under the EPBC Act	High
4. Notify landowners/managers and other stakeholders of the presence of WSW remnants under their care and/or control	High
5. Determine the tenure of all remnants of the EEC and identify relevant stakeholders	High
6. Prepare community profile and EIA guidelines and provide to Singleton Council, the DoP and any other bodies that have a consent or approval role	High
7. Seek to increase the level of legislative protection for sites through landuse planning mechanisms and conservation agreements	High
8. Undertake rehabilitation works at priority sites using approved bush regeneration techniques	Medium
9. Undertake regeneration works to maintain or improve connectivity between remnants	Medium
10. Fence remnants to exclude livestock and encourage regeneration	Medium
11. [Guidelines] Prepare best practice management guidelines for remnants and provide to landowners/managers as well as other stakeholders (consent/determining authorities)	Medium
12. Establish incentives programs to promote and encourage best practice management of remnants on private land	Medium
13. Determine location, species composition and threats to remaining remnants to assist with prioritising restoration works	Medium
14. Collect seed for NSW Seedbank. Develop collection program in collaboration with BGT - all known provenances (conservation collection)	Medium
15. Investigate seed viability, germination, dormancy and longevity (in natural environment and in storage)	Medium
16. Undertake management-focused research (including investigation of an appropriate fire regime, population viability analysis )	Medium
17. Prepare a recommendation for the identification of critical habitat on the basis of the outcomes of extent, condition and tenure assessment	Medium
18. Assess opportunities for incorporating land supporting WSW into the reserve estate (biobanking)	Low

### 4.2 In-situ protection and habitat management action

#### 4.2.1 Mount Thorley Warkworth

Coal & Allied have a number of consent conditions related to the management of WSW, as part of the Warkworth Continuation Project Approval (SSD-6464). This project approval requires completion of the following actions that are relevant to WSW:

- the restoration of 235ha of Warkworth Sands grassland, which is expected to deliver a net long term conservation gain for WSW community by increasing its extent by 30%;
- develop suitable performance criteria to the satisfaction of the OEH for determining the successful regeneration of WSW in the Northern Biodiversity Area within 15 years from the commencement of the project (before 2031);
- lodgement of a \$1million restoration bond with OEH for the regeneration of WSW in the Northern Biodiversity Area; and
- preparation of an Integrated Management Plan for WSW in consultation with Wambo and Bulga Mines, both mines own and manage significant areas of WSW.

Coal & Allied has prepared Management Plan (MP) for the Northern and Southern Biodiversity Areas to manage offsets areas within the Northern and Southern Biodiversity Areas. As indicated in Section 2.2 this includes 270.5ha of WSW.

#### **4.2.2 Bulga Coal Complex**

A small area of WSW occurs in the north-west section of the Bulga Complex.

Bulga Coal have several environmental approval conditions related to the management of WSW, as part of the development consent for the open cut (SSD-4960) and underground (DA 376-8-2003) operations. These relate to the ongoing management of WSW within the Wollombi Brook Conservation Area. In 2016, a management plan for the area was prepared which identified 17.5ha of WSW and 2.8ha of Warkworth Sands Disturbed Grassland and 7ha of Warkworth Sands Derived Native Grassland.

#### **4.2.3 Wambo Coal Mine**

WSW occurs in the south-east section of the Wambo Coal Mine, in the vicinity of Wollombi Brook.

Wambo Coal environmental approval includes several conditions related to the management of WSW, as part of the development consent DA 305-7-2013.

Peabody Energy has prepared a *Flora and Fauna Management Plan* (FFMP) that describes the management of Remnant Woodland Enhancement Areas. There is a significant area of WSW located within Remnant Woodland Enhancement Area A. This area adjoins the Coal & Allied Southern Biodiversity Area to the west.

## 5 WSW Exchange Forum

There is currently no co-ordinated management of WSW, with each landholder managing WSW independently. It is therefore proposed to establish a WSW the landowners meet on an annual basis to enable the integration of management and exchange knowledge.

### 5.1 Scope

To enable integration of management actions and knowledge exchange between the following landowners:

- Bulga Coal Complex, Glencore;
- Wambo Coal Mine, Peabody Energy; and
- Mount Thorley Warkworth, Coal & Allied.

The Forum is to be held annually from 2017 to 2020 (3 years), with invitations extended to representatives from DoEE, DPE and OEH.

This Plan and the draft Terms of Reference are to be endorsed at the first meeting on **Friday 5 May 2017**, and the first Friday of May for the following years.

### 5.2 Forum agenda

The following agenda items are to be addressed at each meeting, and were informed by the threats identified in Section 3.

1. Health, Safety and Environment Share and introductions
2. Landowners overview of management actions to include:
  - a. Active restoration – tree planting;
  - b. Passive restoration – weed and feral animal control; and
  - c. Fire Management.
3. Research findings
4. Monitoring results
5. Identification / review of integration actions
6. Meeting summary and close

Meeting agendas will be submitted to the Forum by Coal & Allied in a timely fashion prior to any meeting. Meetings are to be held at Warkworth Mine and may include field visits; it is expected meeting to take up between 2 to 4 hours, depending on the inclusion of a field trip.

### 5.3 Forum membership

The list of proposed Forum members is shown in Table 6. Representatives from DoEE, DPE and OEH will be invited to attend.

**Table 6 Forum members**

Landowner	Representative
Bulga Coal Complex, Glencore	Environment & Community Manager and Environmental Advisor
Wambo Coal, Peabody	Environment & Community Manager and Environmental Advisor
Warkworth Mine, Coal & Allied	Environment & Community Manager, Environmental Specialist and Environmental Advisor

The Forum members can request additional members or invite guests, to provide further explanation of the operations, research such as contractors, researchers, or consultants. The Forum member must provide prior notice of the proposed additional member or guests to the all of the member listed in Table 6. If any Forum member provides a written objection then the additional member or guest will not be able to attend.

A Coal & Allied representative is to hold the position of Chair and Secretary for the Forum meetings.

#### **5.4 Confidentiality**

Information prepared and discussed by the Forum will not necessarily be confidential in nature. However, any release or discussion of Forum matters should be agreed to by the members prior to any disclosure.

#### **5.5 Meeting arrangements**

The Forum quorum is 3, however if members are unable to attend, a written response to the agenda items will be accepted as adequate and render meetings quorate. A quorum must include the Coal & Allied member.

Membership will lapse if a member fails to attend three consecutive meetings or send comment without apology or reasonable excuse. The Secretary will notify the member in writing accordingly.

#### **5.6 Reporting**

Coal & Allied will be responsible for preparing a summary of outcomes to be circulated to all members.

#### **5.7 Funding**

Membership of the Forum is voluntary and members will not be reimbursed for any costs associated with their participation by Coal & Allied.



## 6 References

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<http://www.publish.csiro.au/paper/LRS08.htm> [accessed on 15 December 2013]

## 7 Appendix A – Warkworth Sands Woodland Mapping

8 February 2017

Ground Floor, Suite 01, 20 Chandos Street  
St Leonards, NSW, 2065  
PO Box 21  
St Leonards, NSW, 1590

T +61 2 9493 9500

F +61 2 9493 9599

E [info@emmconsulting.com.au](mailto:info@emmconsulting.com.au)

[www.emmconsulting.com.au](http://www.emmconsulting.com.au)

Re: Warkworth Sands Woodland mapping

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Dear Nel,

## 1 Introduction

Coal & Allied manages the Mount Thorley Warkworth mine complex (the mine) at Putty Rd, Mt Thorley. Development consent for the Warkworth Continuation Project (SSD 6464) was granted in November 2015 and development commenced in February 2016.

The mine contains Warkworth Sands Woodland, listed as an endangered ecological community (EEC) under the NSW *Threatened Species Conservation Act 1995* (TSC Act). On 5 May 2016, Warkworth Sands Woodland of the Hunter Valley, a similar community to that which is listed under the TSC Act, was listed as a critically endangered ecological community (CEEC) under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Coal & Allied is required to complete an Integrated Management Plan for Warkworth Sands Woodland in accordance with Condition 34 of the development consent. Condition 34 is reproduced below.

34. Within 12 months of the commencement of development under this consent, the Applicant shall prepare an Integrated Management Plan for the Warkworth Sands Woodland EEC to the satisfaction of OEH. This plan must be prepared in consultation with the owners of the Wambo and Bulga mines, and outline the measures that would be implemented to co-ordinate management and recovery efforts for the EEC.

Prior to preparation of the Integrated Management Plan, the extent of Warkworth Sands Woodland was required to be clarified. There are three existing mapping sources (shown in Figure 1) that define the known extent of Warkworth Sands Woodland proximal to the mine, comprising:

1. crest and swale mapping (Cumberland Ecology 2013), which is based on the TSC Act listing advice;
2. mapping completed for Wambo Mine (Wambo 2014); and
3. the vegetation of the Central Hunter Valley NSW (Peake 2006).

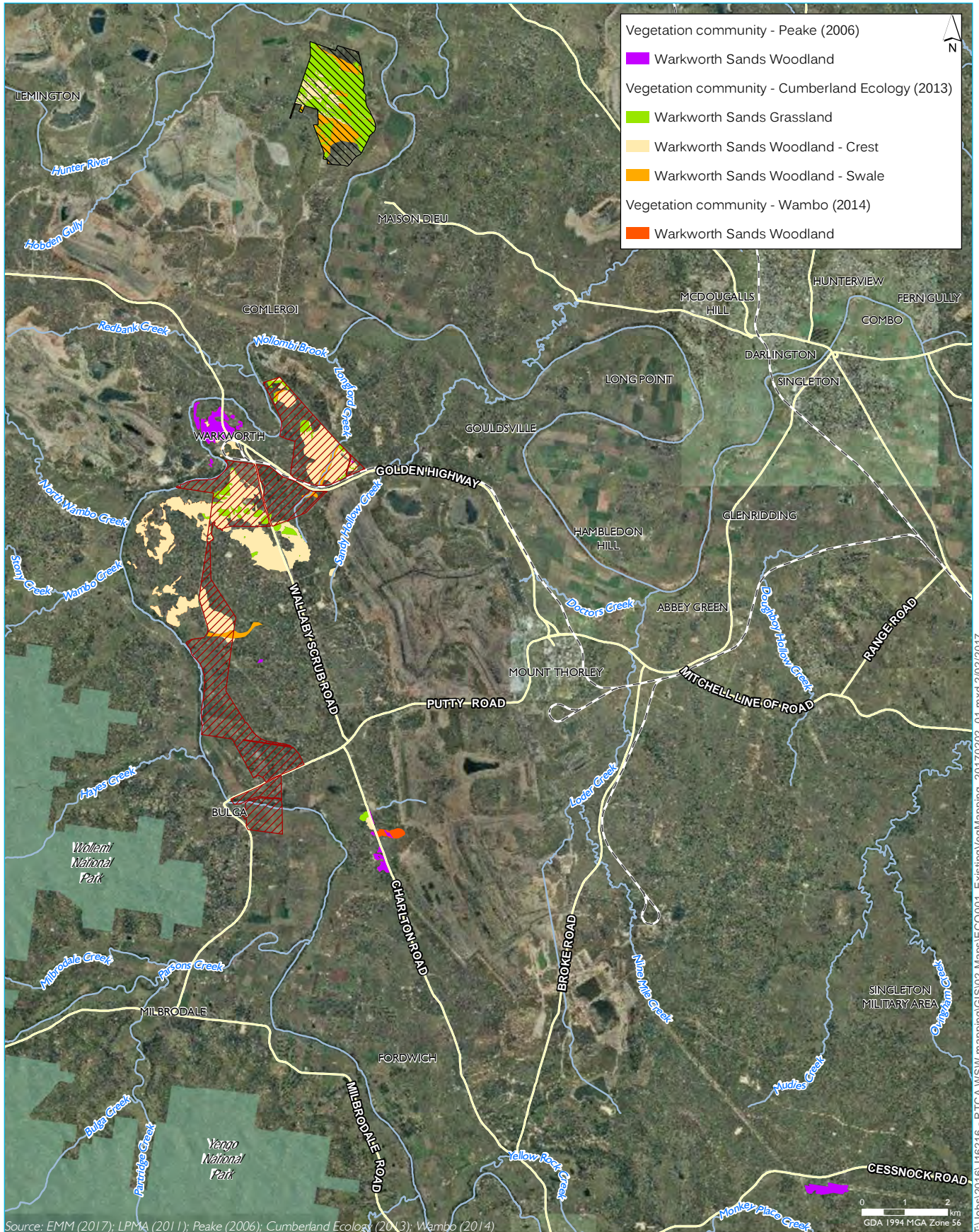
These mapping sources each describe the community using different nomenclature. In addition, there were areas adjacent to the mapped occurrences of Warkworth Sands Woodland that had not been surveyed and were likely to contain the listed community. Accordingly, Coal & Allied required a consolidated vegetation map for Warkworth Sands Woodland to inform preparation of the Integrated Management Plan.

## 2 Scope

Coal & Allied engaged EMM Consulting Pty Limited to undertake:

- a desktop review to consolidate the mapping sources listed above (shown in Figure 1);
- field surveys to verify mapping accuracy;
- data analysis to assess the mapped areas for consistency with the *Final Determination for Warkworth Sands Woodland in the Sydney Basin Bioregion* (NSWSC 2011) and the *Approved Conservation Advice (including listing advice) for Warkworth Sands Woodland of the Hunter Valley* (TSSC 2016);
- preparation of a consolidated vegetation map for Warkworth Sands Woodland; and
- a brief report summarising the method and results of the study and the associated maps to assist in the development of the Integrated Management Plan that Coal & Allied is currently developing.

This letter report describes the method and results of the study. It is intended that the information in this report will be used by Coal & Allied to develop of the Integrated Management Plan, in accordance with the requirements of the development consent.



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KEY

- - Rail line
- Main road
- Watercourse
- NPWS reserve
- ▨ Northern biodiversity area
- ▧ Southern biodiversity area

Warkworth Sands Woodland mapping sources  
Warkworth Continuation Project  
Warkworth Sands Woodland Integrated Management Plan  
Figure 1

## 3 Community description

### 3.1 TSC Act listing

The *Final determination for Warkworth Sands Woodland in the Sydney Basin Bioregion* (NSWSC 2011) describes the listed community as:

- occurring on aeolian sand deposits south east of Singleton in the Hunter Valley, in the local government area of Singleton;
- generally comprising woodland to low woodland structure that contains Rough-barked Apple (*Angophora floribunda*), Coast Banksia (*Banksia integrifolia*), Fern-leaved Wattle (*Acacia filicifolia*), Bracken (*Pteridium esculentum*), Blady Grass (*Imperata cylindrica*), Daphne Heath (*Brachyloma daphnoides*) and Thyme Honeymyrtle (*Melaleuca thymifolia*); and
- typically associated with sand dunes generally 1-6 m in height, aligned in a north west to south east direction, and rest on a river terrace.

The *Final determination for Warkworth Sands Woodland in the Sydney Basin Bioregion* (NSWSC 2011) also notes some variations in landscape position and floristics to that described above, that are included in the listed community. Such areas comprise small drainage lines that support a higher abundance of Thyme Honeymyrtle and are less dominated by Coast Banksia. In addition, adjacent areas, where woodland occurs on a shallow horizon of sand, are included within this community.

Woodlands occurring adjacent to the sand dunes on Permian clays share many species with Warkworth Sands Woodland but also have a higher abundance of Permian substrate species, such as Spotted Gum (*Corymbia maculata*), Grey Box (*Eucalyptus moluccana*), Buloke (*Allocasuarina luehmannii*) and Narrow-leaved Ironbark (*Eucalyptus crebra*). Such areas are excluded from the listed community, except in ecotones where there is a dominant abundance of the representative species of the Warkworth Sands Woodland described in the final determination. This generally occurs where a thin sandy layer overlies the Permian substrate.

### 3.2 EPBC Act listing

The *Approved Conservation Advice (including listing advice) for Warkworth Sands Woodland of the Hunter Valley* (TSSC 2016) describes Warkworth Sands Woodland as:

- a medium to low woodland typically dominated by Rough-barked Apple in the canopy and Coast Banksia and/or Fern-leaved Wattle in the sub-canopy;
- containing a small tree layer, shrubs and groundcover species typical of sandy soils in the Hunter Valley region;
- typically occurring on sand dunes between 1-6 m in height, on river terraces on the undulating valley floor;
- also occurring on shallow veneers of sand, separated from the main sand deposit by areas of clay soils;
- characterised by a sparse to dense woodland on deeper sand deposits that are typically dominated by Rough-barked Apple;
- dominated by a Red Gum hybrid (*Eucalyptus blakelyi* x *E. tereticornis*) and Narrow-leaved Ironbark (*E. crebra*) on shallower sand deposits. These areas may also contain grasses and herbs typical of the surrounding clay landscapes.

- inclusive of disturbed woodland areas that contain a higher abundance of Bulloak and Black Cypress-Pine (*Callitris endlicheri*).

## 4 Method

### 4.1 Desktop review

A detailed review was conducted of the mapping sources described in Section 1, the final determination for Warkworth Sands Woodland in the Sydney Basin Bioregion (NSWSC 2011) and the *Approved Conservation Advice (including listing advice) for Warkworth Sands Woodland of the Hunter Valley* (TSSC 2016, described in Section 2).

The study area was defined during the desktop review, which consists of all mapped occurrences of Warkworth Sands Woodland in the mapping sources identified in Section 1 (Figure 1) and the six additional areas and several isolated patches of mapped Warkworth Sands Woodland (Figure 2).

### 4.2 Field surveys

Field surveys were conducted at six main locations on Coal & Allied property and selected offset areas. Ten vegetation plots and transects were completed in these areas, in accordance with the *BioBanking Assessment Methodology* on Coal & Allied-owned land.

Rapid assessments were conducted in the Northern and Southern Biodiversity Areas to verify previous vegetation mapping and plot data prepared by Cumberland Ecology, which was based on the community described in the TSC Act listing advice. Rapid assessments were completed by walking around or driving through the Northern and Southern Biodiversity Areas and comparing the dominant canopy species and landscape position with the existing maps. Verification of these areas was also completed to determine if they were also consistent with the Commonwealth Conservation Advice, as the EPBC Act listing occurred following the Cumberland Ecology Surveys and development consent.

### 4.3 Data analysis

Plot data recorded during surveys, the Cumberland Ecology (2013), Wambo (2014) and Peake (2006) mapping were analysed to determine the extent of Warkworth Sands Woodland in Coal & Allied-owned land and offset areas. A consolidated vegetation map was generated for inclusion in the Integrated Management Plan.

### 4.4 Mapping

Vegetation polygons were digitised for the study areas using data collected during plots and rapid assessments. The three other mapping sources were checked in a geographic information system (GIS) to determine if additional areas of derived native grassland were required to be included in the mapped polygons of Warkworth Sands Woodland, in accordance with the EPBC Act listing. The EPBC Act listing includes grasslands derived from Warkworth Sands Woodland where they are located in a gap, in or at the edge of a patch, or connecting two patches across a short distance of 30 m.

## 5 Results

### 5.1 Plot data

A detailed analysis of the plot data collected is presented in the following tables. Table 1 provides a comparison of the plot data with the TSC Act listing (NSWSC 2011). Table 2 provides a comparison of the plot data with the key diagnostic characteristics in Section 1.5.1 of the EPBC Act listing (TSSC 2016), while Table 3 provides a comparison of the plot data with the other diagnostic characteristics in Section 1.5.2 of the EPBC Act listing.

Plots 1 and 8 were inconsistent with the TSC and EPBC Act listings. Plot 1 is likely to be a derived native grassland of Warkworth Sands Woodland, however contained few species representative of the community. In addition, Plot 1 was not located in a gap, in or at the edge of a patch; or connecting two patches across a short distance (ie 30 m), as described by the EPBC Act listing. Plot 8 was dominated by introduced grasses, contained few representative species of the community, and was not located in a gap or at the edge of a patch connecting two patches across a short distance, as described in the EPBC Act listing.

The two landscapes upon which Warkworth Sands Woodland occurs (as described in the TSC and EPBC Act listing advices) were recorded in the plots. Plots 5 to 7 and 9 to 10 occurred on sand dunes between 1-6 m in height, on river terraces on the undulating valley floor. Plots 2 to 4 occurred on shallow veneers of sand.



**Table 1 Comparison of plot data with the TSC Act listing<sup>1</sup>**

Key diagnostic characteristics	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10
Characterised by species listed in Warkworth Sands Woodland in the Sydney Basin Bioregion (WSW) - Determination to make a minor amendment to Part 3 of Schedule 1 of the <i>Threatened Species Conservation Act</i>	Contains 1 WSW characteristic species which represents 7% of the community (n = 15).	Contains 7 WSW characteristic species which represents 28% of the community (n = 25).	Contains 10 WSW characteristic species which represents 42% of the community (n = 24).	Contains 5 WSW characteristic species which represents 63% of the community (n = 8).	Contains 12 WSW characteristic species which represents 40% of the community (n = 30).	Contains 17 WSW characteristic species which represents 42% of the community (n = 41).	Contains 8 WSW characteristic species which represents 32% of the community (n = 25).	Contains 2 WSW characteristic species which represents 12% of the community (n = 17).	Contains 10 WSW characteristic species which represents 37% of the community (n = 27).	Contains 11 WSW characteristic species which represents 58% of the community (n = 19).
Generally woodland to low woodland structure containing Rough-barked Apple, Coast Banksia, Fern-leaved Wattle, Bracken, Blady Grass, Daphne Heath and Thyme Honeymyrtle	Plot lies in grassland and does not contain any of these species.	Plot lies in low woodland and contains Rough-barked Apple, but does not contain any of the other associated species.	Plot lies in low woodland and contains Rough-barked Apple, but does not contain any of the other associated species.	Plot lies in low woodland and contains Rough-barked Apple, but does not contain any of the other associated species.	Plot lies in low woodland and contains Coast Banksia and Fern-leaved Wattle but does not contain any of the other associated species.	Plot lies in low woodland and contains Fern-leaved Wattle and Thyme Honeymyrtle but does not contain any of the other associated species.	Plot lies in low woodland and contains Fern-leaved Wattle and Thyme Honeymyrtle but does not contain any of the other associated species.	Plot lies in exotic grassland and does not contain any of the other associated species.	Plot lies in low woodland and contains Coast Banksia and Fern-leaved Wattle but does not contain any of the other associated species.	Plot lies in low woodland and contains Coast Banksia, Fern-leaved Wattle and Thyme Honeymyrtle but does not contain any of the other associated species.
Small drainage lines may support a higher abundance of certain species such as Thyme Honeymyrtle and less of others such as Coast Banksia	Neither species were observed in this plot.	Neither species were observed in this plot.	Neither species were observed in this plot.	Neither species were observed in this plot.	Neither species were observed in this plot.	Thyme Honeymyrtle is the second most dominant tree species.	Few Thyme Honeymyrtle present.	Neither species were observed in this plot.	Coast Banksia is the most dominant tree species.	Coast Banksia is the most dominant tree species and Thyme Honeymyrtle is the second most dominant tree species.
Occupies sand dunes generally 1-6 m high, resting on a river terrace. The main dune deposit is aligned north west to south east.	The plot meets this description.	The plot meets this description.	The plot meets this description.	The plot meets this description.	The plot meets this description.	The plot meets this description.	The plot meets this description.	The plot meets this description.	The plot meets this description.	The plot meets this description.

**Table 1 Comparison of plot data with the TSC Act listing<sup>1</sup>**

Key diagnostic characteristics	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10
Conclusion	Plot 1 is not representative of Warkworth Sands Woodland as it contains only one characteristic species and has a of a derived native grassland structure.	Plot 2 is representative of Warkworth Sands Woodland due to its geographic location, vegetation structure and characteristic flora species.	Plot 3 is representative of Warkworth Sands Woodland due to its geographic location, vegetation structure and characteristic flora species.	Plot 4 is representative of Warkworth Sands Woodland due to its geographic location, vegetation structure and characteristic flora species.	Plot 5 is representative of Warkworth Sands Woodland due to its geographic location, vegetation structure and characteristic flora species.	Plot 6 is representative of Warkworth Sands Woodland due to its geographic location, vegetation structure and characteristic flora species.	Plot 7 is representative of Warkworth Sands Woodland due to its geographic location, vegetation structure and characteristic flora species.	Plot 8 is not representative of Warkworth Sands Woodland as it contains only two characteristic species and is reflective of an exotic dominated grassland.	Plot 9 is representative of Warkworth Sands Woodland due to its geographic location, vegetation structure and characteristic flora species.	Plot 10 is representative of Warkworth Sands Woodland due to its geographic location, vegetation structure and characteristic flora species.

Notes 1. Source - NSWSC 2011

**Table 2 Comparison with key diagnostic characteristics of Commonwealth Conservation Advice<sup>1</sup>**

Key diagnostic characteristics	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10
Occurs in the Central Hunter Valley, in the Hunter Valley IBRA subregion of the Sydney Basin Bioregion in New South Wales	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
It occurs on aeolian sands of the Warkworth Land System	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is a mid to low woodland (occasionally forest), with a projected crown cover of at least 10%	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
A ground layer is present (although it may vary in	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

**Table 2 Comparison with key diagnostic characteristics of Commonwealth Conservation Advice<sup>1</sup>**

Key diagnostic characteristics	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10
development and composition), as a sparse to thick layer of native shrubs, bracken, grasses and/or other native herbs										
Is characterised by multiple flora species listed in Table 1 of the Approved Conservation Advice: Warkworth Sands Woodland of the Hunter Valley, although not all species need be present	Contains 1 WSW characteristic species which represents 7% of the community (n = 15).	Contains 7 WSW characteristic species which represents 28% of the community (n = 25).	Contains 10 WSW characteristic species which represents 42% of the community (n = 24).	Contains 4 WSW characteristic species which represents 50% of the community (n = 8).	Contains 11 WSW characteristic species which represents 37% of the community (n = 30).	Contains 17 WSW characteristic species which represents 42% of the community (n = 41).	Contains 7 WSW characteristic species which represents 27% of the community (n = 26).	Contains 2 WSW characteristic species which represents 12% of the community (n = 17).	Contains 11 WSW characteristic species which represents 41% of the community (n = 27).	Contains 10 WSW characteristic species which represents 53% of the community (n = 19).
Conclusion	Plot 1 is not representative of Warkworth Sands Woodland as it is a grassland. It represents a derived native grassland that would likely regenerate to WSW.	Plot 2 is representative of Warkworth Sands Woodland as it adequately meets all "key diagnostic characteristics" and 50% of the "other diagnostic considerations".	Plot 3 is representative of Warkworth Sands Woodland as it adequately meets all "key diagnostic characteristics" and 70% of the "other diagnostic considerations".	Plot 4 is representative of Warkworth Sands Woodland as it adequately meets all "key diagnostic characteristics" and 60% of the "other diagnostic considerations".	Plot 5 is representative of Warkworth Sands Woodland as it adequately meets all "key diagnostic characteristics" and 80% of the "other diagnostic considerations".	Plot 6 is representative of Warkworth Sands Woodland as it adequately meets all "key diagnostic characteristics" and 70% of the "other diagnostic considerations".	Plot 7 is representative of Warkworth Sands Woodland as it adequately meets all "key diagnostic characteristics" and 80% of the "other diagnostic considerations".	Plot 8 is not representative of Warkworth Sands Woodland as it contains only two characteristic species and is reflective of an exotic dominated grassland.	Plot 9 is representative of Warkworth Sands Woodland as it adequately meets all "key diagnostic characteristics" and 90% of the "other diagnostic considerations".	Plot 10 is representative of Warkworth Sands Woodland as it adequately meets all "key diagnostic characteristics" and 60% of the "other diagnostic considerations".

Notes 1. Source - TSSC 2016

**Table 3 Comparison with other diagnostic characteristics of the Commonwealth Conservation Advice<sup>1</sup>**

<b>Other diagnostic considerations</b>	<b>Plot 1</b>	<b>Plot 2</b>	<b>Plot 3</b>	<b>Plot 4</b>	<b>Plot 5</b>	<b>Plot 6</b>	<b>Plot 7</b>	<b>Plot 8</b>	<b>Plot 9</b>	<b>Plot 10</b>
Mostly occupies linear sand dunes, which are generally between one and six metres high, typically resting on a river terrace, on the undulating valley floor.	The plot occurs on River	The plot occurs on River	The plot occurs on River	The plot occurs on River	The plot occurs on River	The plot occurs on River	The plot occurs on River	The plot occurs on River	The plot occurs on River	The plot occurs on River
As well as deeper sand deposits, the ecological community also occurs on shallow “veneers” of sand separated from the main sand deposit by areas of clay soils developed on Permian sediments.	Dominated - Lower Delta Plain (ie a river terrace).	Dominated - Lower Delta Plain (ie a river terrace).	Dominated - Lower Delta Plain (ie a river terrace).	Dominated - Lower Delta Plain (ie a river terrace).	Dominated - Lower Delta Plain (ie a river terrace).	Dominated - Lower Delta Plain (ie a river terrace).	Dominated - Lower Delta Plain (ie a river terrace).	Dominated - Lower Delta Plain (ie a river terrace).	Dominated - Lower Delta Plain (ie a river terrace).	Dominated - Lower Delta Plain (ie a river terrace).
Does not occur on clay soils on Permian sediments, nor does it occur on the sandy colluviums of the widespread Triassic Sandstone plateaus.	The plot lies on a shallow sand veneer adjacent to the main sand deposit.	The plot lies on a shallow sand veneer adjacent to the main sand deposit.	The plot lies on a shallow sand veneer adjacent to the main sand deposit.	The plot lies on a shallow sand veneer adjacent to the main sand deposit.	The plot lies on deeper sand deposit.	The plot lies on deeper sand deposit.	The plot lies on deeper sand deposit.	The plot lies on deeper sand deposit.	The plot lies on deeper sand deposit.	The plot lies on deeper sand deposit.
The canopy is typically dominated by Rough-barked Apple on deeper sands.	The plot occurs on Late Permian lithic sandstone.	The plot occurs on Late Permian lithic sandstone.	The plot occurs on Late Permian lithic sandstone.	The plot occurs on Late Permian lithic sandstone.	The plot occurs on Late Permian lithic sandstone.	The plot occurs on Late Permian lithic sandstone.	The plot occurs on Late Permian lithic sandstone.	The plot occurs on Late Permian lithic sandstone.	The plot occurs on Late Permian lithic sandstone.	The plot occurs on Late Permian lithic sandstone.
On the shallower sands (e.g.in swales) Blakely’s Red Gum-Forest Red Gum hybrid and sometimes Narrow-leaved Ironbark may be more numerous. There may be more grasses and herbs typical of the surrounding clay landscapes, but they are not dominant in the understorey.	The plot does not contain Rough-barked Apple.	The plot meets this description.	Rough-barked Apple is the second most abundant canopy species in the plot.	Rough-barked Apple is the second most abundant canopy species in the plot.	The plot does not contain Rough-barked Apple.	The plot does not contain Rough-barked Apple.	The plot does not contain Rough-barked Apple.	The plot does not contain Rough-barked Apple.	The plot does not contain Rough-barked Apple.	The plot does not contain Rough-barked Apple.
	The plot does not contain the Red Gum hybrid or Narrow-leaved Ironbark. It is dominated by native grass and exotic groundcover.	The plot does not contain the Red Gum hybrid or Narrow-leaved Ironbark. It does not contain grasses and herbs typical of the surrounding	The plot contains Narrow-leaved Ironbark. The Red Gum hybrid is not present. It does not contain grasses and herbs typical of the surrounding	The plot contains Narrow-leaved Ironbark. The Red Gum hybrid is not present. It does not contain grasses and herbs typical of the surrounding	The plot contains Narrow-leaved Ironbark. The Red Gum hybrid is not present. It does not contain grasses and herbs typical of the surrounding	The plot contains Narrow-leaved Ironbark. The Red Gum hybrid is not present. It does not contain grasses and herbs typical of the surrounding	The plot contains Narrow-leaved Ironbark. The Red Gum hybrid is not present. It does not contain grasses and herbs typical of the surrounding	The plot does not contain the Red Gum hybrid or Narrow-leaved Ironbark. It does not contain grasses and herbs typical of the surrounding	The plot contains the Red Gum hybrid. Narrow-leaved Ironbark. It does not contain grasses and herbs typical of the surrounding	The plot does not contain the Red Gum hybrid or Narrow-leaved Ironbark. It does not contain grasses and herbs typical of the surrounding

**Table 3 Comparison with other diagnostic characteristics of the Commonwealth Conservation Advice<sup>1</sup>**

Other diagnostic considerations	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10
		clay landscapes.	clay landscapes.	clay landscapes.	clay landscapes.	clay landscapes.	clay landscapes.	clay landscapes.		
In more disturbed areas, other canopy trees such as Bullock, and Black Cypress Pine may be more numerous.	The plot does not contain Bull Oak or Black Cypress Pine.	The plot does not contain Bull Oak or Black Cypress Pine.	The plot contains Bull Oak and is indicative of a more disturbed area. Black Cypress Pine is not absent.	The plot contains Bull Oak and is indicative of a more disturbed area. Black Cypress Pine is not absent.	The plot contains Bull Oak and is indicative of a more disturbed area. Black Cypress Pine is not absent.	The plot contains Bull Oak and is indicative of a more disturbed area. Black Cypress Pine is not absent.	The plot contains Bull Oak and is indicative of a more disturbed area. Black Cypress Pine is not absent.	The plot does not contain Bull Oak or Black Cypress Pine.	The plot contains Bull Oak and is indicative of a more disturbed area. Black Cypress Pine is not absent.	The plot contains Bull Oak and is indicative of a more disturbed area. Black Cypress Pine is not absent.
Other tree species may include Blakely's Red Gum as well as Kurrajong ( <i>Brachychiton populneus subsp. populneus</i> ) in some areas.	The plot does not contain Blakely's Red Gum or Kurrajong.	The plot does not contain Blakely's Red Gum or Kurrajong.	The plot is dominated by Blakely's Red Gum, while Kurrajong is absent.	The plot does not contain Blakely's Red Gum or Kurrajong.	The plot is dominated by Blakely's Red Gum, while Kurrajong is absent.	The plot does not contain Blakely's Red Gum or Kurrajong.	The plot is dominated by Blakely's Red Gum, while Kurrajong is absent.	The plot does not contain Blakely's Red Gum or Kurrajong.	The plot is dominated by Blakely's Red Gum, while Kurrajong is absent.	The plot does not contain Blakely's Red Gum or Kurrajong.
Patches with hybrid eucalypt species are included in the ecological community (i.e. areas should not be excluded on the basis of hybridisation).	The plot does not contain hybrid eucalypt species.	The plot does not contain hybrid eucalypt species.	The plot does not contain hybrid eucalypt species.	The plot does not contain hybrid eucalypt species.	The plot does not contain hybrid eucalypt species.	The plot does not contain hybrid eucalypt species.	The plot does not contain hybrid eucalypt species.	The plot does not contain hybrid eucalypt species.	The plot contains a Red Gum hybrid (Eucalyptus blakelyi x E. tereticornis).	The plot does not contain hybrid eucalypt species.
A sparse, sub-canopy layer is likely to be dominated by Coast Banksia) and/or Fern-leaved Wattle.	The plot does not contain Coast Banksia or Fern-leaved Wattle.	The plot does not contain Coast Banksia or Fern-leaved Wattle.	The plot does not contain Coast Banksia or Fern-leaved Wattle.	The plot does not contain Coast Banksia or Fern-leaved Wattle.	The plot contains Fern-leaved Wattle in a sparse sub canopy however, it is not the dominant sub-canopy species. Coast Banksia is absent.	The plot contains Fern-leaved Wattle in a sparse sub canopy however, it is not the dominant sub-canopy species. Coast Banksia is absent.	The plot contains Fern-leaved Wattle in a sparse sub canopy however, it is not the dominant sub-canopy species. Coast Banksia is absent.	The plot does not contain Coast Banksia or Fern-leaved Wattle.	The plot is dominated by Coast Banksia and Fern-leaved Wattle in a sparse sub canopy.	The plot is dominated by Coast Banksia and Fern-leaved Wattle in a sparse sub canopy.

**Table 3 Comparison with other diagnostic characteristics of the Commonwealth Conservation Advice<sup>1</sup>**

<b>Other diagnostic considerations</b>	<b>Plot 1</b>	<b>Plot 2</b>	<b>Plot 3</b>	<b>Plot 4</b>	<b>Plot 5</b>	<b>Plot 6</b>	<b>Plot 7</b>	<b>Plot 8</b>	<b>Plot 9</b>	<b>Plot 10</b>
Derived native grasslands are not included in patches of this nationally protected ecological community, except where there is a gap, in or at the edge of a patch; or connecting two patches across a short distance (i.e. 30 m).	The plot is a derived native grassland that has a gap over greater than 30 m to Warkworth Sands Woodland.	The plot is not a derived native grassland as it is characterized as woodland.	The plot is not a derived native grassland as it is characterized as woodland.	The plot is not a derived native grassland as it is characterized as woodland.	The plot is not a derived native grassland as it is characterized as woodland.	The plot is not a derived native grassland as it is characterized as woodland.	The plot is not a derived native grassland as it is characterized as woodland.	The plot is not a derived native grassland as it is characterized as woodland.	The plot is not a derived native grassland as it is characterized as woodland.	The plot is not a derived native grassland as it is characterized as woodland.

Notes 1. Source - TSSC 2016

## 5.2 Rapid assessments

The rapid assessments in the Northern and Southern Biodiversity Areas confirmed that the previous mapping completed by Cumberland Ecology (2013), Wambo (2014) and Peake (2006) for these areas was correct, and was consistent with the TSC Act listing advice as above.

It is noted that the Cumberland Ecology (2013) mapping for Warkworth Sands Woodland is separated into two different landscapes, namely crest and swale. The areas mapped as crest were consistent with those found in the plots (Section 4.1) on deeper sands, that were typically dominated by Rough-barked Apple and Coast Banksia. The areas marked as swale were also consistent with those found in the plots (Section 4.1) on a shallow veneer of sand, that contained Rough-barked Apple, however had a higher dominance of Thyme Honey myrtle, Blakelys Red Gum and/or the Red Gum hybrid.

## 5.3 Consolidated vegetation maps for Warkworth Sands Woodland

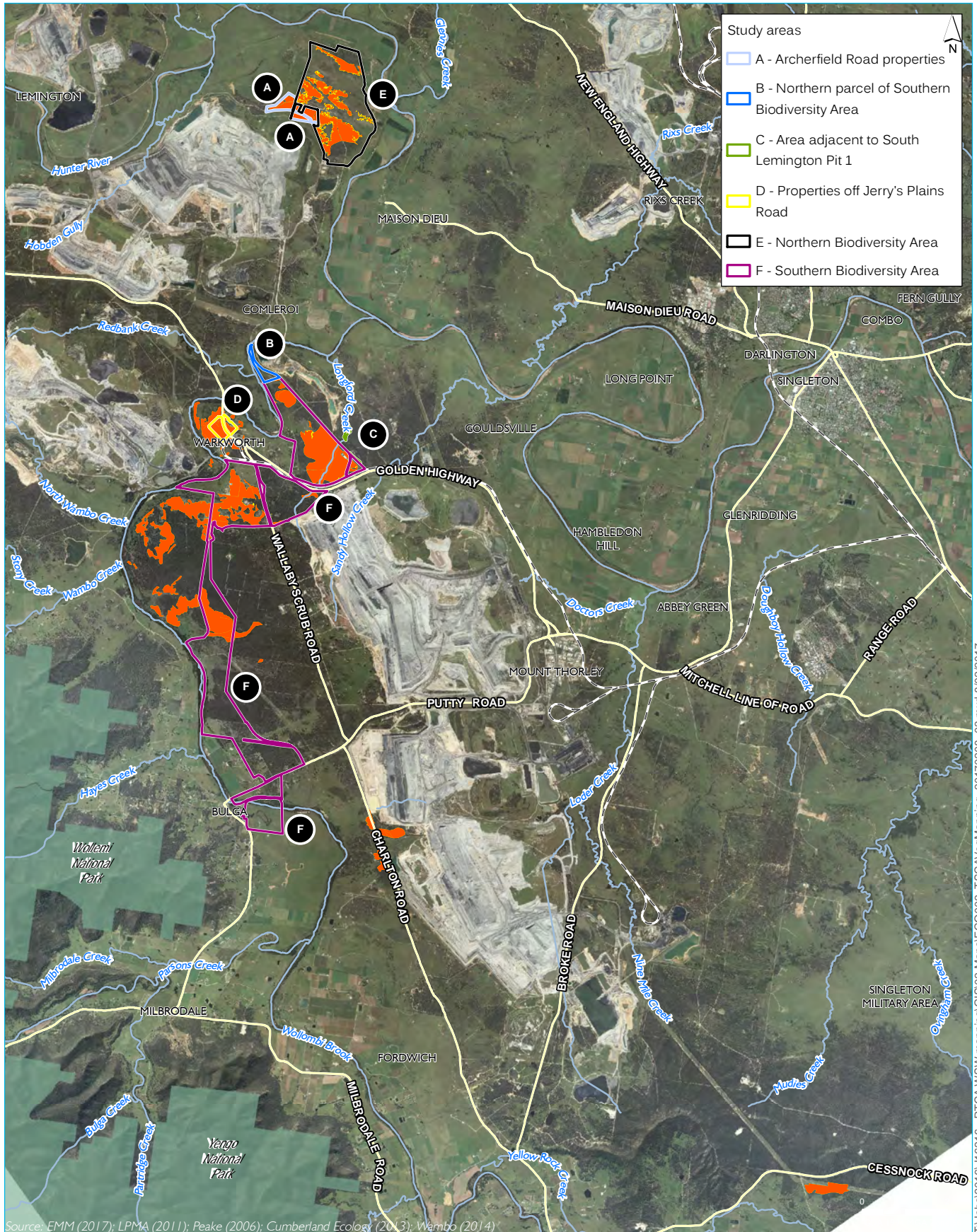
A consolidated vegetation map has been prepared for Warkworth Sands Woodland. The map was developed using the sources listed in Section 1 and the plot data collected during this study. The map excludes Warkworth Sands Woodland within the approved disturbance boundary of the Warkworth Continuation Project.

Figure 2 represents the areas that meet the description of the TSC Act listed community, All areas covered by the map sources listed in Section 1 were classified as representing the TSC Act listed community. Areas mapped by EMM also represent the TSC Act listed community. These areas also represent the EPBC Act listed community as:

- the plot comparison with the TSC Act and EPBC Act listings were identical (ie Plot 1 and 8 did not represent the listed communities, while Plot 2-7 and 9-10 represented the listed community);
- the Cumberland Ecology mapping (based on the TSC Act listing) was found to be consistent with the EPBC Act listing; and
- the Wambo (2014) and Peake (2006) mapping was found to be consistent with both listing advices.

Figure 2 also represents additional areas that represent the EPBC Act listed community. Such areas include derived native grasslands that are in a gap, in or at the edge of a patch of Warkworth Sands Woodland; or connecting two patches across a short distance (i.e. 30 m), as described by the EPBC Act listing.

The additional extent of the EPBC Act listed community was determined by reviewing the Cumberland Ecology (2013) maps and the maps prepared for this study to determine where Warkworth Sands Grassland occurred adjacent to areas mapped as Warkworth Sands Woodland and measuring the distances between connecting patches. If the connecting patch was 30 m or less, the boundary of the Warkworth Sands Woodland was adjusted such that the patch of grassland was included.



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**Warkworth Sands Woodland – TSC Act and EPBC Act listings**

**Warkworth Continuation Project**

**Warkworth Sands Woodland Integrated Management Plan**

**Figure 2**



A total of 599 ha of Warkworth Sands Woodland that represents the TSC and EPBC Act listed communities occurs in the study area. An additional 20.9 ha of EPBC Act listed Warkworth Sands Woodland is also present in the form of derived native grasslands that occur in gaps of 30 m or less between patches of woodland, increasing the total of the EPBC Act listed community 619.9 ha. A breakdown of the areas is provided in Table 4.

**Table 4**            **Extent of Warkworth Sands Woodland in the study area**

Location	Landowner	TSC Act extent (ha) <sup>1</sup>	EPBC Act extent (ha) <sup>2</sup>
A. Archerfield Road properties	Coal & Allied	32.6	32.6
B. Northern parcel of Southern Biodiversity Area	Coal & Allied	4.7	4.7
C. Area adjacent to South Lemington Pit 1	Coal & Allied	91.6	110.5
D. Properties off Jerry's Plains Road	Coal & Allied	0.6	0.6
E. Northern Biodiversity Area	Coal & Allied	17.9	17.9
F. Southern Biodiversity Area	Coal & Allied	252.6	254.7
Isolated patches	Privately owned	198.9	199.0
<b>Total</b>		<b>599.0</b>	<b>619.9</b>

*Notes*    1. All areas of the mapped TSC Act extent also represent the EPBC Act listed community  
 2. This represents the entire extent of the EPBC Act listed community, which comprises the TSC Act extent, and the additional areas of derived native grasslands that occur in gaps of 30 m or less between patches of woodland.

## 6 Conclusion

This study has been completed to consolidate existing mapping for Warkworth Sands Woodland into a single dataset and supplement this dataset with additional survey on Coal 599 ha for the TSC and EPBC Act listed communities, with an additional 20.9 ha of the EPBC Act listed community recorded in the form of derived native grasslands that occur in gaps of 30 m or less between patches of Warkworth Sands Woodland.

This information will be used by Coal & Allied to inform the preparation of the Integrated Management Plan for Warkworth Sands Woodland, in accordance with Condition 34 of the Warkworth Continuation Project approval (SSD 6464).

## 7 References

Cumberland Ecology 2013, *Warkworth Sands Woodland Vegetation Map*

New South Wales Scientific Committee (NSWSC) 2011, *Final Determination for Warkworth Sands Woodland in the Sydney Basin Bioregion*, [www.environment.nsw.gov.au](http://www.environment.nsw.gov.au), viewed February 2017

Peake T 2006, *The vegetation of the Central Hunter Valley NSW*, Hunter Central Rivers Catchment Management Authority

Threatened Species Scientific Committee (TSSC) 2016, *Approved Conservation Advice (including listing advice) for Warkworth Sands Woodland of the Hunter Valley*, [www.environment.gov.au](http://www.environment.gov.au), viewed February 2017

Wambo 2014, *Warkworth Sands Woodland Vegetation Map*

## Appendix A

### Plot and transect data

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**Table 5** EMM plot data

Family	Common name	Scientific name	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10
<b>Trees</b>												
CASUARINACEAE	Black She-oak	<i>Allocasuarina littoralis</i>									2	
CASUARINACEAE	Bull Oak	<i>Allocasuarina luehmannii</i>			3	5	4	4	3		3	4
FABACEAE - MIMOSOIDEAE	Fan Wattle	<i>Acacia amblygona</i>		1	1			2				
FABACEAE - MIMOSOIDEAE	Coastal Myall	<i>Acacia binervia</i>		4								
FABACEAE - MIMOSOIDEAE	Sickle Wattle	<i>Acacia falcata</i>						1				
FABACEAE - MIMOSOIDEAE	Fern-leaved Wattle	<i>Acacia filicifolia</i>					2	3	2		2	1
FABACEAE - MIMOSOIDEAE	Hickory Wattle	<i>Acacia implexa</i>						1				
FABACEAE - MIMOSOIDEAE	Kangaroo Thorn	<i>Acacia paradoxa</i>					2					
FABACEAE - MIMOSOIDEAE	Silver-stemmed Wattle	<i>Acacia parvipinnula</i>						1				
FABACEAE - MIMOSOIDEAE	Native Willow	<i>Acacia salicina</i>							1			
MYRTACEAE	Rough-barked Apple	<i>Angophora floribunda</i>		4	3	2						3
MYRTACEAE	Blakely's Red Gum	<i>Eucalyptus blakelyi</i>			4		4		3			
MYRTACEAE	Red Gum	<i>Eucalyptus blakelyi</i> x <i>E. tereticornis</i>									4	
MYRTACEAE	Narrow-leaved Ironbark	<i>Eucalyptus crebra</i>			2	3	3	4	3			
MYRTACEAE	White Feather Honey-myrtle	<i>Melaleuca decora</i>						1				
MYRTACEAE	Thyme Honey-myrtle	<i>Melaleuca thymifolia</i>						3	1			3
PROTEACEAE	Coast Banksia	<i>Banksia integrifolia</i>									4	4
RHAMNACEAE	Soap Tree	<i>Alphitonia excelsa</i>					1					
<b>Shrubs</b>												
ASTERACEAE	Dolly Bush	<i>Cassinia aculeata</i>			1		1		1			
DILLENIACEAE	Hoary Guinea Flower	<i>Hibbertia obtusifolia</i>		2			1	2	2			2
ERICACEAE	Daphne Heath	<i>Brachyloma daphnoides</i>										5
FABACEAE - FABOIDEAE	Narrow leaf Hovea	<i>Hovea linearis</i>		1								

**Table 5** EMM plot data

Family	Common name	Scientific name	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10
FABACEAE - FABOIDEAE	Dogwood	<i>Jacksonia scoparia</i>						3	2			
MYRTACEAE		<i>Kunzea sp. (hybrid)</i>						2	3		3	
MYRTACEAE	Slender Tea-tree	<i>Leptospermum polyanthum</i>									2	
PHYLLANTHACEAE	Coffee Bush	<i>Breynia oblongifolia</i>					3	1			3	
PROTEACEAE	Finger Hakea	<i>Hakea dactyloides</i>		3								
<b>Groundcovers</b>												
ANTHERICACEAE	Slender Wire Lily	<i>Laxmannia gracilis</i>		3	2				1		1	
ASTERACEAE	Bogan Flea	<i>Calotis hispidula</i>					3	2	4			
ASTERACEAE	Yellow Burr-daisy	<i>Calotis lappulacea</i>					2	1				
ASTERACEAE	Yellow Buttons	<i>Chrysocephalum apiculatum</i>		1			1	1		2		3
ASTERACEAE	Cudweed	<i>Euchiton japonicus</i>	1									
CAMPANULACEAE	Tufted Bluebell	<i>Wahlenbergia communis</i>						1				
CAMPANULACEAE		<i>Wahlenbergia sp.</i>									1	
CHENOPODIACEAE	Climbing Saltbush	<i>Einadia nutans</i>							1			
CHENOPODIACEAE	Fishweed	<i>Einadia trigonos</i>			1	1	1	1	1			
COMMELINACEAE	Scurvy Weed	<i>Commelina cyanea</i>		2	1	2	2	1	1			1
CONVOLVULACEAE	Kidney Weed	<i>Dichondra repens</i>						2				
FABACEAE - FABOIDEAE	Gorse Bitter Pea	<i>Daviesia ulicifolia</i>						1				
FABACEAE - FABOIDEAE	Slender Tick Trefoil	<i>Desmodium varians</i>		2	2		1					
FABACEAE - FABOIDEAE	Twirling Glycine	<i>Glycine clandestina</i>						1				
FABACEAE - FABOIDEAE	Small-leaf Glycine	<i>Glycine microphylla</i>					2	1			1	1
FABACEAE - FABOIDEAE	Variable Glycine	<i>Glycine tabacina</i>		1	1			1				
LAMIACEAE	Austral Bugle	<i>Ajuga australis</i>										1
LOMANDRACEAE	Mat-rush	<i>Lomandra confertifolia</i>			1				3		3	

**Table 5** EMM plot data

Family	Common name	Scientific name	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10
LOMANDRACEAE	Wattle Mat-rush	<i>Lomandra filiformis</i>										3
LOMANDRACEAE	Spiny-headed Mat-rush	<i>Lomandra longifolia</i>		1							2	2
OXALIDACEAE	Yellow Wood-sorrel	<i>Oxalis perennans</i>			1		1	2	1	1	1	2
PHORMIACEAE	Blue Flax-Lily	<i>Dianella longifolia</i>			2		3	3				
PLANTAGINACEAE	Trailing Speedwell	<i>Veronica plebeia</i>					1	2			1	
POACEAE	Purple Wiregrass	<i>Aristida ramosa</i>		1	3	2	2	3				
POACEAE	Three-awn Speargrass	<i>Aristida vagans</i>		4								
POACEAE	Barbed Wire Grass	<i>Cymbopogon refractus</i>	4	2	3		2	3	3	3		
POACEAE	Couch	<i>Cynodon dactylon</i>	4		3		4	3	4		4	
POACEAE	Plumegrass	<i>Dichelachne sp. (sterile)</i>						1				
POACEAE	Queensland Blue Couch	<i>Digitaria didactyla</i>									1	
POACEAE	Bushy Hedgehog-grass	<i>Echinopogon caespitosus</i>					1				1	1
POACEAE	Wiry Panic	<i>Entolasia stricta</i>			1			2			5	
POACEAE	Hairy Panic	<i>Panicum effusum</i>	1	1								
POACEAE		<i>Poa sp. (sterile)</i>			1		1					
POACEAE		<i>Rytidosperma sp. (sterile)</i>		1								
PTERIDACEAE	Rock Fern	<i>Cheilanthes austrotenuifolia</i>							1			
PTERIDACEAE	Narrow Rock fern	<i>Cheilanthes sieberi</i>	3	3	2		3	3	3	3	2	2
RUBIACEAE		<i>Pomax umbellata</i>			3			2				
SCROPHULARIACEAE	Winter Apple	<i>Eremophila debilis</i>						1				
SOLANACEAE	Forest Nightshade	<i>Solanum prinophyllum</i>						1				
THYMELAEACEAE	Slender Rice Flower	<i>Pimelea linifolia</i>					2	1			2	3
<b>Introduced species</b>												
APOCYNACEAE	Cottonbush	<i>Gomphocarpus physocarpus</i>	2									

**Table 5**      **EMM plot data**

Family	Common name	Scientific name	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10
ASTERACEAE	Fleabane	<i>Conyza sp.*</i>								1		
ASTERACEAE	Catsear	<i>Hypochaeris radicata</i>	3	2				1		2	1	
ASTERACEAE	Fireweed	<i>Senecio madagascariensis</i>	3	2	2			1				
CACTACEAE	Tiger Pear	<i>Opuntia aurantiaca</i>			3	2			2	2	1	
CACTACEAE	Common Prickly Pear	<i>Opuntia stricta</i>	4	3	3	2	2	2	3	3	2	2
CARYOPHYLLACEAE	Hairy Pink	<i>Petrorhagia dubia</i>	3							3		
CARYOPHYLLACEAE	Proliferous Pink	<i>Petrorhagia nanteullii</i>								3		
CRASSULACEAE	Mother of Millions	<i>Bryophyllum delagoense</i>					3					
FABACEAE - MIMOSOIDEAE	Black Wattle	<i>Acacia decurrens*</i>					1			3		
MALVACEAE	Paddy's Lucerne	<i>Sida rhombifolia</i>	2						2			
OLEACEAE	African Olive	<i>Olea europaea subsp. cuspidata</i>					1					
PLANTAGINACEAE	Plantain	<i>Plantago lanceolata</i>	4									
POACEAE		<i>Aira sp. (sterile)</i>		2								
POACEAE	Rhodes Grass	<i>Chloris gayana</i>	1									
POACEAE	African Lovegrass	<i>Eragrostis curvula</i>		1						2	3	
POACEAE	Red Natal Grass	<i>Melinis repens</i>	1	2				2		2	1	5
POLYGONACEAE	Sheep Sorell	<i>Acetosella vulgaris</i>								1		
RUBIACEAE	Field Madder	<i>Richardia stellaris</i>		1					4	3		
SCROPHULARIACEAE	Twiggy Mullein	<i>Verbascum virgatum</i>								3		
VERBENACEAE	Lantana	<i>Lantana camara</i>									1	
VERBENACEAE	Purpletop	<i>Verbena bonariensis</i>								6		

Note      \* denotes a naturalised species

**Table 6**      **Transect data**

Transect	Native plant species richness	Native canopy cover (%)	Native midstorey cover (%)	Native groundcover (shrubs) (%)	Native groundcover (grasses) (%)	Native groundcover (other) (%)	Exotic plant cover (%)	Number of trees with hollows	Overstorey regeneration	Total length of fallen logs
1	6	0	0	2	54	6	32	0	0	0
2	18	15	4	0	48	8	0	0	0.2	24
3	21	19	3	0	24	8	4	0	0.4	18
4	6	6	27.5	0	4	0	0	0	0.4	35
5	26	10	7.5	0	58	22	10	0	0.4	0
6	36	10.5	13	4	30	6	2	0	0.2	12
7	22	25	0	8	34	30	12	0	0.4	10
8	6	0	8	0	0	6	45	0	0	5
9	20	6.5	17.5	16	62	12	2	4	0	90
10	17	9.5	11.5	8	40	8	4	0	0.4	60