Vegetation of the Worimi Conservation Lands Port Stephens, New South Wales:

Worimi NP, Worimi SCA & Worimi RP



November 2010

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Report to

Dept. of Environment, Climate Change & Water
Hunter Region
Parks & Wildlife Group (NPWS)

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EXECUTIVE SUMMARY

A vegetation survey and mapping program of the Worimi Conservation Lands (near Newcastle) was carried out during 2009-2010. The Worimi Conservation Lands comprise Worimi National Park (1835 ha), Worimi State Conservation Area (882 ha), and Worimi Regional Park (1329 ha) and collectively occupy approximately 4200 ha of coastal sand ecosystems, stretching from Fern Bay to Anna Bay and along Stockton Bight. The most extensive area of native vegetation is found in Worimi National Park, while Worimi Regional Park is predominantly unvegetated and comprises the sand dunes of Stockton Bight.

Survey and mapping of the native vegetation was undertaken to assist in managing the area for conservation and use by recreational vehicles, but also to document significant botanical and cultural aspects of the reserves. A targeted sampling methodology using 0.04ha survey plots was employed on the vegetation, and numerical classification of collected data undertaken using the *Primer v6* software, defining vegetation communities at the ~35% level of similarity. This classification was also informed by a regional data analysis, which showed the sandbeds-defined communities to be robust. Mapping of vegetation communities incorporated the resultant analysis groupings with aerial photographic interpretation and extensive ground truthing.

Collectively, the three reserves support over 190 plant taxa across 9 vegetation communities, generally displaying low levels of diversity in communities and plant species as may be expected in ecosystems developed on relatively recent sand substrates. Three of these taxa are considered of significance within the region, and are currently listed on the Commonwealth *EPBC Act 1999* or the NSW *TSC Act 1995* (*Diuris arenaria*: Endangered, *Diuris praecox*: Vulnerable, *Senecio spathulatus* var. *attenuatus*: Endangered). *Senecio spathulatus* was formerly considered extinct in the Newcastle region, and the population of >1200 plants recorded during the current study updates the status of this species.

The vegetation communities present encompass the structural range from grassland, heath and scrub to open forest, and include various forms of swamp forest. In the most part, community definition allowed broad comparisons with regional vegetation classifications undertaken in the Lower Hunter and Central Coast bioregion, and consequently statements of conservation significance for each community have been made. Only one of the communities defined for Worimi equate to an Endangered Ecological Community, as listed in the NSW *TSC Act 1995*: Beach Wetlands broadly align with Sydney Freshwater wetlands EEC.

Recommendations have been made towards management of the Worimi Conservation Lands, specifically in regard to weed species, significant taxa, unauthorised access, and fire management.

Acknowledgements

Many thanks to Hunter Region staff for assistance during the course of this project, in particular Ruth Armstrong for overseeing the work, and Rangers Warren Mayer and Tony DeMamiel. Aerial photographs used in the study are © Department of Lands 2000, and have been used under licence. All other photographs within this report are those of the authors.

Document cover shows (L to R) *Spinifex sericeus* grassland on Stockton Bight; *Senecio spathulatus, Melichrus procumbens, Eucalyptus parramattensis* subsp*. decadens X Eucalyptus robusta* buds [photographs © S. Bell & C. Driscoll]

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1. INTRODUCTION

1.1 Background

The Worimi Conservation Lands (WCL) cover an area of 4,200 hectares and comprise three reserves: Worimi National Park, Worimi State Conservation Area and Worimi Regional Park. The WCL have been identified as a significant cultural landscape and are managed through a board of management by registered Aboriginal Owners and the Department of Environment, Climate Change & Water (DECCW).

A number of broad vegetation surveys and reports have been compiled for the Stockton Bight area in recent decades, including the Newcastle Bight Strategy (Department of Environment & Planning 1983) and the Port Stephens Shire Vegetation Mapping (Enviros ciences and Shortland Wetlands Centre Ltd 1992). A later study completed by HLA Enviros ciences (1995) included a flora list and basic vegetation community profile mapping, and the Lower Hunter and Central Coast Regional Biodiversity Conservation Strategy (NPWS 2000) modeled the WCL vegetation, but at a local scale is unreliable. Coastal dune plants along the southern end of Stockton Beach, including weed species, have been detailed in Heyligers (2008).

A more detailed assessment of the vegetation communities, including the identification of threatened species and endangered ecological communities, has been requested by the DECCW to assist in the future management of the WCL. One aspect of this study will also involve working with Aboriginal Traditional Owners to capture those flora species and vegetation communities of important cultural landscape linkages.

Eastcoast Flora Survey has been commissioned by the DECCW to complete the survey and mapping project of the WCL.

Objectives

The following objectives have been identified as core components of the study:

- Undertake a floristic survey of the Worimi Conservation lands (WCL) which identifies flora species, vegetation communities, significant species including threatened species and endangered ecological communities;
- Map the location of vegetation communities and any significant species or isolated weed infestations and prepare this information as spatial data layers;
- Identify known cultural associations with flora species and vegetation communities;
- Identify key management issues impacting on vegetation communities within the WCL;
- Prepare a report of the results which includes a separate appendix with a vegetation community map, species list and vegetation community profiles.

1.2 The Study Area and Study Region

The Worimi Conservation Lands lie approximately 7km north-east of Newcastle on the New South Wales North Coast (Figure 1). Biogeographically, it occurs within the NSW North Coast region of Thackway and Cresswell (1995), and the North Coast botanical division of Anderson (1961). The NSW North Coast biogeographical region stretches from around Newcastle in the south, north to the Queensland border, and generally west to the New England Tablelands. The region covers approximately 61000 km^2, and is composed of hills, coastal plains and sand dunes, supporting *Eucalyptus* - *Lophostemon confertus* tall open forests, *Eucalyptus* open forests and woodlands, rainforests (complex notophyll and microphyll vine forest,

often with *Araucaria cunninghamii*), *Melaleuca quinquenervia* wetlands, and heaths (Thackway & Cresswell 1995). The North Coast botanical region generally occupies an equivalent area, and is bounded to the west by the Northern Tablelands and Central Western Slopes, and in the south by the Central Coast botanical regions (Anderson 1961).

The WCL are well vegetated across the majority of their 4 200 ha. Some sections in the south-west have been previously mined for beach sands, and support simple rehabilitated ecosystems. Other sand extraction ventures are current adjacent to some parts of the WCL. Much of the seaward side of the WCL comprise the mobile transgressive dune system of Stockton Bight, and support relatively little vegetation. Stockton Bight is a registered and policed outdoor recreational area for 4WD use, and access to the beach can be made formally at Anna Bay in the north-east and off Lavis Lane (Salt Ash) towards the south, and at several other informal locations.

In the central and south-west sections of the WCL, a small number of water extraction bores have been installed and are maintained by Hunter Water. Hunter Water has maintained an interest in the area as a source of potable water since the 1920s when portions of Crown land were reserved for water supply purposes. A number of minor investigations into groundwater quality and piezometric surface characterisation have occurred in the years since, generally as a precursor to an envisaged jump in demand, drought, or augmentation to an existing source.

Climatic data is available predominantly from the nearby Williamtown Meteorological Station ~8km west of the WCL. This data shows that there is generally no seasonality in rainfall for the district, with approximately 60% falling in the period from January to June, and 40% from July to December, while the mean annual rainfall for the area is 1120mm (Fox *et al.* 1996). December to February are typically the hottest months, with mean daily maximum temperatures of 27^{o}C and mean daily minimum temperatures of 17.5^{o}C. June-to-August represent the coldest months, with a mean daily maximum temperature of 17.5^{o}C and a mean daily minimum of 7^{o}C.

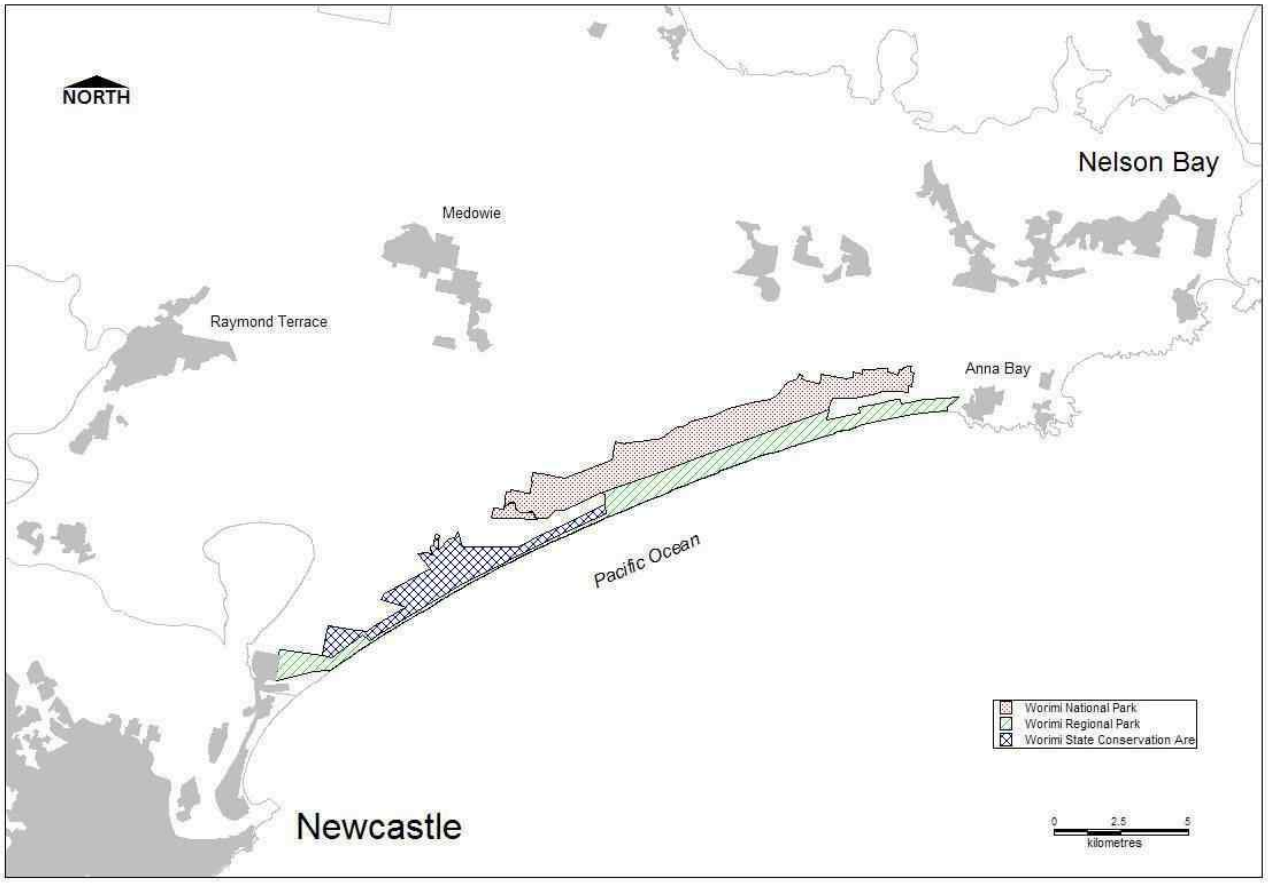

Figure 1 Location of the Worimi Conservation Lands.

Data on rainfall patterns from the Anna Bay Meteorological Station (maintained by Hunter Water Corporation staff) for the period between 1972-1984 shows the average annual rainfall to be 1251mm. The wettest months for the Tomaree Peninsula as a whole are February and March, with August and September the driest.

1.3 Geology and Geomorphology

In the broad sense, Engel (1962) and Rose, Jones & Kennedy (1966) showed that Quaternary Sands comprised all of the lands now conserved in the WCL. Within the Quaternary, sand deposition of Holocene (recent) and Pleistocene origin are distinguished, the latter occurring outside of the WCL on the Tomago Sandbeds. Soils of the Pleistocene deposits are predominantly white-to-grey, well-drained and highly podzolised sands (Thom, Shepherd, Ly, Roy, Bowman, & Hesp 1992), while those of the Holocene frontal and transgressive dunes have little or no podzolisation.

Thom *et al* (1992) have examined the geomorphology of the district (Figure 2), indicating that during the late Pleistocene period, the Inner Barrier of the Newcastle Bight embayment and nearby areas was formed following a rise in sea level. As sea levels dropped, deposited sands formed what are now the Tomago and Tomaree Sandbeds. At Tomaree, low volcanic hills occurring as islands during this time facilitated the development of a sand plain (the Anna Bay Sandbeds). Recent dune formation along the current coastline (the outer barrier) has resulted in both mobile and stationary dune systems of sandy material. To the north, the much more extensive Eurunderee Sandmass forms part of Myall Lakes National Park.

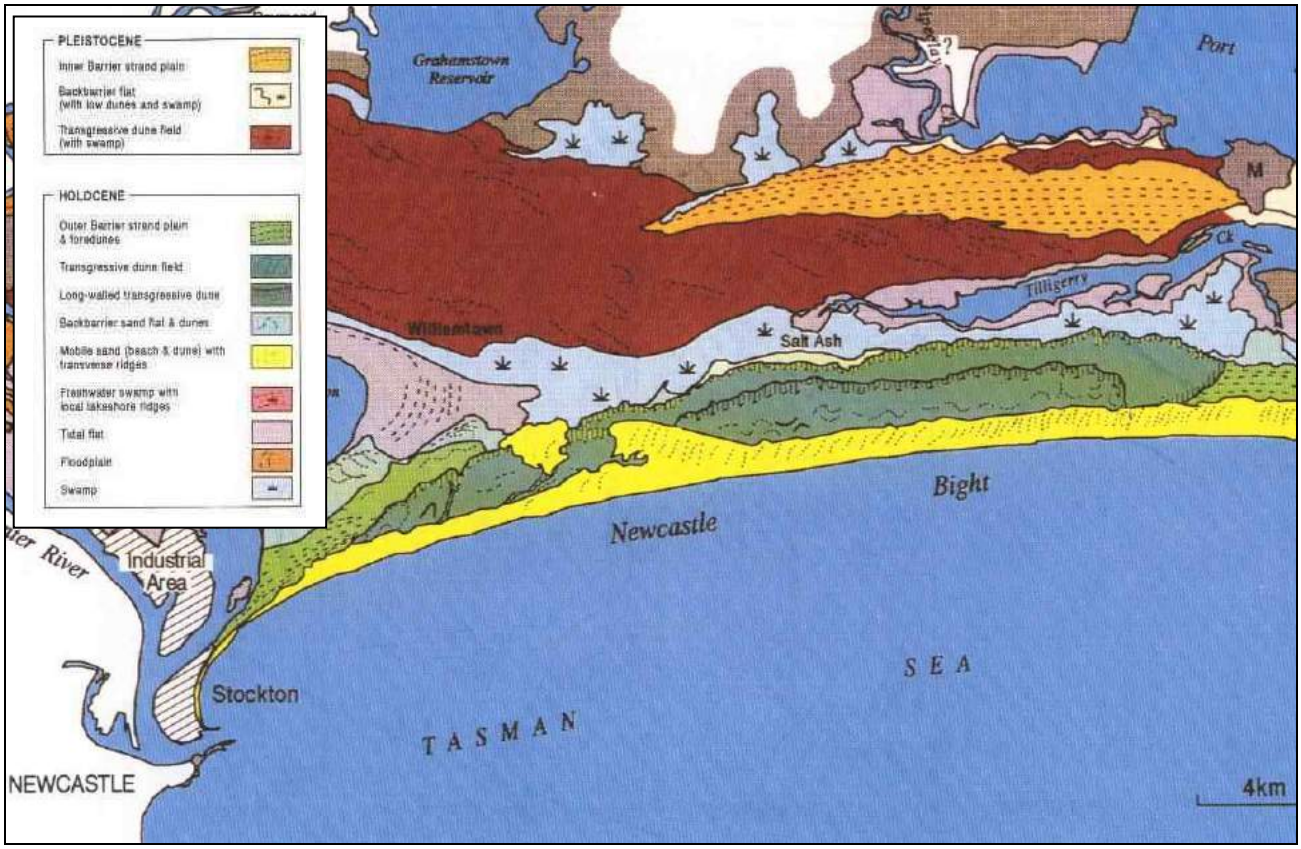

Figure 2 Summarised geomorphological map of the Newcastle Bight Embayment (from Thom et al 1992).

Matthei (1995a; 1995b) has reported on and mapped in detail the soil landscapes of the Newcastle 1: 100 000 map sheet, which includes the majority of the WCL. The eastern portions near Anna Bay are included in Murphy (1995) for the Port Stephens 1: 100 000 map sheet. Such mapping is of value in vegetation studies,

since soil type is often a major contributing factor to the distribution of differing vegetation types. Two sand-based landscape types and four landscape units have been mapped for the WCL, and are summarised in Table 1.

Table 1 Soil landscapes present within the Worimi Conservation Lands, from Matthei (1995a) and Murphy (1995).

Aeolian Landscapes	
Boyces Track (bt)	Steep Quaternary Holocene transgressive Aeolian dunes consisting of deep, well-drained weakly developed Podzol soils.
Hawks Nest (hn)	Low Holocene sand sheets and low transgressive dunes. Deep, well-drained Podzol and Siliceous sands on dunes, deep, poorly drained Humus Podzols on sandsheets.
Shoal Bay (sb)	Gentle-inclined well drained Pleistocene sand sheets, to rolling very low dunes. Deep, well-drained Podzol soils. (13ha only)
Beach Landscapes	
Stockton Beach (sk)	Beaches, foredunes and often extensive unstable dunes and blowouts on Holocene marine and aeolian sand. Deep, very poorly drained Solonchaks/ Calcareous Sands on beaches, with very well-drained Calcareous Sands on the dunes.

1.4 Previous Vegetation Studies

Regional Studies

At a broad scale, a comprehensive study of the vegetation occurring in the Port Stephens and Myall Lakes region has been completed by McNair (1997). This study provides important information on the high floristic diversity of the general Port Stephens area, when compared against other floristically rich regions across the country. More recently, NPWS (2000) surveyed and mapped the vegetation of the Lower Hunter and Central Coast on behalf of Hunter Councils. Knott *et al*. (1998) examined the history of vegetation in the Port Stephens area in relation to Koala habitat.

Mapping of vegetation within the Port Stephens Local Government Area was completed for a Koala Habitat Atlas by Phillips, Callaghan & Thompson (1996). This mapping involved aerial photographic interpretation and floristic sampling at selected sites of $20m^2$. Forty such sites were completed across the whole of Port Stephens Shire (an area of some 97800ha: PSC 1999), with the broad level of detail depicted in the resultant map reflecting this relatively small number of sample sites.

Directly to the north of Port Stephens, Myall Lakes National Park conserves vegetation from a similar environment to that occurring in the WCL. Myerscough & Carolin (1986) examined the vegetation of the Eurunderee Sandmass and associated headlands within the south-eastern sections of the Park, delineating seventeen vegetation communities, thirteen of which occurred solely on sand deposits. Cropper (1997) surveyed some western sections of the Park not covered by Myerscough & Carolin (1986), while Hunter & Alexander (2000) re-surveyed and mapped the entire Park, including the new additions to the west. Clements (1988) also investigated the vegetation patterns occurring in the Fens Embayment area. In addition, a small number of small-scale and unpublished surveys (eg: Osborne & Robertson 1939; Anderson 1973) are noted in Myerscough & Carolin (1986).

Experimental ecological studies conducted within the Myall Lakes region have included those of Clark (1975), Dodkin & Floyd (1978), Fox, Fox & McKay (1979), Fox & Fox (1986), Fox (1988), Brockoff & Allaway (1989), Buckney & Morrison (1992, 1993), Lewis & Clements (1993), Clark, Myerscough & Skelton (1996), and Myerscough, Clarke & Skelton (1995, 1996). Such studies provide further understanding on why certain

vegetation types and species occur where they do, and can be extrapolated to similar environments elsewhere.

Several other works have examined similar habitats in both New South Wales and other States. Such studies provide useful information on the vegetation patterns occurring in these habitats, and are beneficial in determining the conservation significance of the vegetation on coastal sand masses. These studies include Groves & Specht (1965); Conner & Wilson (1968); Siddiqi, Carolin & Anderson (1972); Siddiqi & Carolin (1975); Siddiqi, Carolin & Myerscough (1976); Specht, Conner & Clifford (1977); Specht (1979); Buchanan (1980); Clemens & Franklin (1980); Groves & Specht (1981); Jehne & Thompson (1981); Posamentier, Clark, Hain & Recher (1981); Walker, Thompson, Fergus & Tunstall (1981); Bridge, Ross & Thompson (1984); Adam, Stricker & Anderson (1989); Adam, Stricker, Wiecek & Anderson (1989); Specht & Specht (1989); Pressey & Griffith (1992); and Keith & Bradstock (1994).

Tomago & Tomaree Sandbeds

Bell & Driscoll (2006a) detail a vegetation survey and mapping program undertaken on the Tomago and Tomaree Sandbeds, updating all previous studies undertaken there. A targeted sampling methodology using 0.04ha survey plots and numerical classification delineated 43 vegetation communities, with the distribution of each being mapped through aerial photographic interpretation and extensive ground truthing. Collectively, the two sandbeds were found to support over 400 plant taxa. Over twenty of these taxa are considered of significance within the region, seven of which are currently listed on the Commonwealth *EPBC Act 1999* or the NSW *TSC Act 1995* (*Diuris arenaria, Eucalyptus camfieldii, Eucalyptus parramattensis* subsp*. decadens, Grevillea parviflora* subsp*. parviflora, Melaleuca groveana, Prostanthera densa, Rulingia prostrata*), and one is considered to be nationally rare (*Gonocarpus salsoloides*).

The 43 vegetation communities present on both the Tomago and Tomaree Sandbeds encompass the structural range from simple sedgeland to open forest, and include various forms of swamp and swamp forest. In the most part, community definition allowed broad comparisons with regional vegetation classifications recently undertaken in the Lower Hunter and Central Coast bioregion, and consequently statements of conservation significance for each community were made. Three Endangered Ecological Communities, as listed in the NSW *TSC Act 1995*, occur within the sandbeds.

Significant Species

Searches of relevant databases and the literature have revealed eighteen threatened or rare plant species as potentially occurring within a radius of 10km from the WCL. Threatened species are as listed on the Commonwealth *EPBC Act 1999* or the NSW *TSC Act 1995*, while rare species are listed in Briggs and Leigh (1996). Table 2 summarises these species.

Table 2 Summary of significant plant species previously recorded within the locality. [E = Endangered; V = Vulnerable]

Species	EPBC Act	TSC Act	Comment/ Source
Nationally Threatened species (legislative support)			
Angophora inopina	V	V	Bell & Driscoll (2006b)
Chamaesyce psammogeton	-	E	NPWS Wildlife Atlas
Corybas dowlingii	-	E	NPWS Wildlife Atlas
Cryptostylis hunteriana	V	V	NPWS Wildlife Atlas
Diuris arenaria	E	E	NPWS Wildlife Atlas
Diuris praecox	V	V	NPWS Wildlife Atlas
Eucalyptus camfieldii	V	V	NPWS Wildlife Atlas (Tomago Sandbeds)
Eucalyptus parramattensis subsp. *decadens*	V	V	NPWS Wildlife Atlas (Tomago Sandbeds)
Melaleuca biconvexa	V	V	NPWS Wildlife Atlas
Melaleuca groveana	-	V	Bell & Driscoll (2006a)
Persicaria elatior	V	V	NPWS Wildlife Atlas
Prostanthera densa	V	V	NPWS Wildlife Atlas
Rulingia prostrata	E	E	Bell & Driscoll (2006a)

Species	EPBC Act	TSC Act	Comment/ Source
Tetratheca juncea	V	V	NPWS Wildlife Atlas
Nationally Rare species (no legislative support)			
Eucalyptus sp. (Fern Bay)	-	-	pers. obs. (taxonomic status uncertain)
Gonocarpus salsoloides	-	-	Oyster Cove (Bell 1997b)
Lomandra fluviatilis	-	-	Reported by Melehan (1997), but suitable habitat is not present anywhere in Port Stephens LGA.
Macrozamia flexuosa	-	-	pers. obs. (Lilies Point; 1999)

2. METHODS

Four separate but related tasks were undertaken in order to meet the objectives of this project:

- Collection of Rapid Data Points to assist classification and mapping
- Systematic flora survey to sample all observable variations
- Analysis of floristic data to classify the vegetation
- Mapping the distribution of defined vegetation communities or their variants

2.1 Rapid Data Points

The collection of Rapid Data Points (RDPs) is a new method of vegetation mapping being developed by the authors for accurate spatial depiction of vegetation biodiversity. Central to this method is the recognition that variability in vegetation distribution cannot yet be predicted using computer GIS programs, and that simply documenting what actually occurs on the ground is the simplest yet most important fact to be reflected in a final map. Many recent mapping programs have relied heavily on GIS capabilities to predict where certain vegetation communities occur, with disappointing results. Bell and Driscoll (2006a), DECC (2008) and Bell (2009a) have all used this mapping technique successfully.

RDPs are essentially summaries of floristic information recorded at specific points in the field. A live feed to a laptop computer, running Manifold © GIS, records locational information in real-time. At specific and regular locations, summaries of the vegetation are entered onto a spreadsheet linked to the GIS. Information recorded includes:

- Canopy layer dominant species
- Shrub layer dominant species
- Ground layer dominant species
- Draft vegetation unit
- Miscellaneous notes

Initially, all trafficable paths across the study areas are driven in 4WD vehicle recording RDPs. Those areas lacking extensive trail networks are then walked on foot with hand-held GPS units, recording the same information which is later added to the main database. In this way, a large dataset of summary information can be rapidly collected to use in modeling and vegetation mapping procedures. The data also proves invaluable as a ground-truthing mechanism for the final vegetation map.

2.2 Systematic Flora Survey

Systematic flora survey conducted in the two areas consisted of the following steps:

1. Data audit – an audit of existing floristic data within or immediately adjacent to the WCL was undertaken to identify which data was suitable for use in the current project. This audit was based on information contained in Bell (2000), and resulted in data from 4 plots from the Comprehensive Regional Assessments (conducted in 1998-99 by the National Parks and Wildlife Service) and 6 plots from the Lower Hunter and Central Coast Regional Environmental Management Strategy (NPWS 2000) as being suitable. Only the latter 6 plots could be easily located for use in this project. In addition, six additional plots conducted in lands now part of the Fern Bay residential area by one of us (SB) were available.

2. New plot selection – new plots completed for the current project were located with reference to the variations observed during the Rapid Data Point collection phase, to ensure that as much variation as possible was sampled. This process recognised the fact that environmental stratification of the area was not adequately highlighting many floristic variations which were evident in the field. Other workers have

also recognised the problems of stratification in some environments (eg: Griffith, Wilson & Maryott-Brown 2000), and this process of expert intuition is one of the central themes in the Braun-Blanquet system of plant classification (Braun-Blanquet 1928). Recent work completed by us on the Tomago Sandbeds encountered the same issues (Bell & Driscoll 2006a).

3. Plot Sampling - Within areas considered to be representative of the major floristic variations present, detailed survey within 0.04ha quadrats was completed. Methods used were those adopted as standard by the National Parks and Wildlife Service for national parks and nature reserves in New South Wales (Wilson, Gott & Schofield, 1997), State Forests for land under their control (York, Binns & Shields 1991), and the Department of Natural Resources for other areas (DLWC 1999). The same methods are also consistent with the large body of existing data in the region (Bell 2000). The draft Native Vegetation Interim Standard (Sivertsen 2009) also recommends these same methods of vegetation survey. Benson (1999) provides an overview of how important consistent survey methods are for vegetation management across the State.

   Within each 0.04ha site (nominally 20 X 20m, but can be 40 X 10m, etc), all vascular plant species present are recorded and given an abundance rating, based on a modified 1-6 point Braun-Blanquet scale (1 = few individuals, <5% cover; 2 = many individuals, <5% cover; 3 = 5-25% cover; 4 = 26-50% cover; 5 = 51-75% cover; 6 = 76-100% cover). Physical attributes of the site (vegetation structure, soil type, elevation, slope, aspect, physiographical position, etc) are also recorded, and photographs taken of the site for later reference. Plant specimens of unknown or significant status are collected for later identification or lodgement with the National Herbarium in Sydney.

4. Significant Species – Significant plant species where encountered during full floristic plot surveys were noted and their positions recorded. General reconnaissance undertaken as part of the mapping process (see below) validated trends observed in the floristic data. During such reconnaissance, searches for rare or threatened Australian plants were also made, using random and targeted meanders (Cropper 1993; Keith 2000). Other plant species known or thought to represent culturally significant species were also recorded, however those that were abundant were not recorded individually.

2.3 Data Analysis

Taxonomic Review

Given the inclusion of pre-existing plot data from within or adjacent to the WCL, a review of plant taxonomy was undertaken for all taxa included in the final dataset to ensure consistency of nomenclature. Nomenclature according to Harden (1990a-1993; 2002) and Harden and Murray (2000) was used as the standard, except where more recent revisions have been published in recognised scientific journals and accepted by the National Herbarium of New South Wales.

Floristic Data Exploration

Cluster analysis and non-metric multidimensional scaling (nMDS) on the combined WCL dataset (including previously collected data) was performed using *Primer* V6 (Clarke & Gorley 2006). This program was chosen over PATN (Belbin 1995a; 1995b) for analyses because of its greater flexibility in data presentation and the greater range of analysis options and procedures. Both programs run similar algorithms and produce identical results.

Two data analyses were undertaken with the WCL data.

- *Analysis 1: Worimi Conservation Lands only* – using only the existing and newly-collected data, an analysis was completed to ascertain the relationships existing within the data at a local scale.

- *Analysis 2: Worimi Conservation Lands & Tomago/ Tomaree Sandbeds* – new and existing WCL data was combined to investigate the relationships evident between the vegetation of the WCL and the Tomago/ Tomaree Sandbeds (Bell & Driscoll 2006a).

Both analyses utilised the group averaging strategy, the Bray-Curtis association measure and a Beta value of –0.1. The SIMPER routine in Primer was used to generate diagnostic species lists for each defined floristic group. Analysis of similarity within and between pre-defined floristic groups was undertaken with the ANOSIM routine.

Structural Data Exploration

Information on the structure of vegetation within each community has been calculated and averaged from data collected at each of the floristic data plots. Estimates of height and percentage cover for each of the emergent, tallest layer, mid layer, and lowest layers have been used.

2.4 Vegetation Mapping

The vegetation mapping process began with a preliminary interpretation of digital orthorectified aerial photographs (API: images supplied by Lands & Property Information LPI: 2007), extracting out observable structural differences in the vegetation (eg: swamp forests, heathlands, etc) and constructing structural polygons. Following this, community-coded RDP data was used to generate a raw community layer in Manifold © GIS, using the Voronoi algorithm to extrapolate data across the landscape, but constrained by structural API boundaries. Within Mapinfo © GIS, this linework was then overlaid onto digital orthorectified aerial photographs, and each polygon edited where necessary. Subsequent to this, additional interpretation of the areas was undertaken on-screen to highlight potentially different areas of vegetation for later ground-truthing.

At all times in the vegetation mapping process, reference was made to the data collected during the RDP phase to confirm specific vegetation units. In some cases, perimeters of certain vegetation types were walked to further refine the map.

3. RESULTS

3.1 Rapid Data Points

A total of 1190 Rapid Data Points (RDPs) were collected during field reconnaissance for the Worimi Conservation Lands. For Worimi NP, data from 713 RDPs were recorded, 204 were collected in Worimi SCA, and 145 in Worimi RP (the balance occurred outside WCL boundaries). Large areas of Worimi RP & SCA comprise beach sands, so it is to be expected that fewer RDPs would be collected there. At each of these points, information on dominant plant species was noted and could be imported directly into the vegetation mapping process. Figure 3 shows the distribution of RDPs within the three reserves.

Figure 3 Distribution of Rapid Data Points (RDPs), Worimi Conservation Lands.

3.2 Floristic Survey

Available Data & Sampling Intensity

A total of 70 full floristic survey plots were analysed for the WCL project (Table 3), including 58 new plots completed under the current contract. Figure 4 shows the distribution of all plots analysed for the WCL.

Table 3 Full floristic plot data available for numerical classification analysis of the Worimi Conservation Lands.

	Project	No. of Plots	Source	Comment
Project	NPWS CRA	-	NPWS (1999)	data not sourced
	LHCCREMS	6	NPWS (2000)	-
	S.Bell data	6	unpubl. data	Fern Bay development
	WCL	58	current	-
	Total	70		

Figure 4 Distribution of floristic survey sites, Worimi Conservation Lands.

Floristic Diversity

A total of 194 plant taxa (26 weed species) have been recorded through systematic plot surveys for the Worimi Conservation Lands (Appendix 1). The most common species recorded across all sampling plots were the trees *Banksia serrata, Angophora costata,* and *Eucalyptus pilularis*; the grasses *Imperata cylindrica* var. *major* and *Themeda australis;* the shrubs *Bossiaea rhombifolia* subsp. *rhombifolia, Monotoca elliptica, Acacia longifolia* subsp. *longifolia, Acacia ulicifolia, Aotus ericoides, Leucopogon lanceolatus* var. *gracilis*, and *Dillwynia retorta*; and the herbs *Gonocarpus teucrioides, Pomax umbellata* and *Hibbertia linearis*. *Pteridium esculentum* was the most commonly recorded fern.

Significant plant species recorded in the three reserves, including those of cultural significance, are discussed further in Section 4.

3.3 Data Analysis & Community Definition

Vegetation Community Diversity

Prior to any analysis, a full taxonomic review was undertaken on all datasets. This process ensured that a consistent nomenclature is applied across all current and previous surveys, and eliminates potential errors through mis-identification or duplicate entries. For example, the shrub *Hakea dactyloides* has in recent years been split into two species; a single-stemmed, forest form lacking a lignotuber (*H. dactyloides*), and a multi-stemmed, resprouting taxon (*H. laevipes*). Surveys undertaken prior to the late-1990's would not have recognised the latter species.

Exploration of floristic data using *Primer* was carried out on several datasets. Separate analyses were undertaken on the WCL data alone, the WCL – Tomago/Tomaree Sandbeds data combined, as well as a regional analysis using all available data from the Lower Hunter and Central Coast. This enabled floristic relationships to be examined both individually (WCL), as well as in a more regional sandbeds context. In addition, this process allowed for the examination of apparently similar vegetation types from the Tomago and Tomaree sandbeds to be directly compared.

Analysis 1: Worimi Conservation Lands

Multivariate cluster analysis of 70 sample plots and 161 native plant taxa resulted in the definition of 13 groups at 34% similarity, or 0.66 dissimilarity (Figure 5). For the purposes of this study, these 13 groups have been reduced to 9 communities in recognition of the high diversity shown in the Beach Wetlands and some swamp communities. The vast majority of the 70 samples comprise the Frontal Dune Blackbutt-Apple Forest, the most common vegetation type within the three reserves. Despite targeted sampling of observed variations within this type (eg: stunted canopy, understorey dominated by grasses, relatively long unburnt patches), little further subdivision could be maintained with confidence. The next most populous community was the Paperbark-Mahogany Dry Swamp Forest with 11 samples, representing areas where small, shallow depressions in the sand sheets occur within a wider landscape of Frontal Dune Blackbutt-Apple Forest. The remaining seven defined communities are represented by five or less samples, and are in general of very restricted distribution across the study area.

Non-metric multidimensional scaling strongly supported the groupings evident in the cluster analysis, with a low stress level of 0.1 and strong congruence with the cluster analysis groups (Figure 6). All defined groups are well separated in 2-dimensional space.

The analysis of similarity of species composition between defined groups of sample plots (ANOSIM) revealed an overall Global R value of 0.972 ($p = 0.001$). Significant differences were also evident between all defined communities in the pairwise analysis (Table 4). Comparisons from most groups returned R values at or close to unity, indicating within group similarity to be greater than between group similarity. Exceptions here were values of 0.400 (Beach Wetlands & Paperbark-Mahogany Sedge Swamp Forest) and 0.640 (Beach Wetlands & Paperbark-Mahogany Wet Swamp Forest), which both reflect the sharing of sedge and wetland species in these communities. A value of 0.662 was also obtained for Beach Wetlands & Foredune Spinifex, and probably reflects the sharing of beach dune plants in these two communities. Unrecognised floristic variation in the Beach Wetlands (see later) is likely to be the root cause of these low R values.

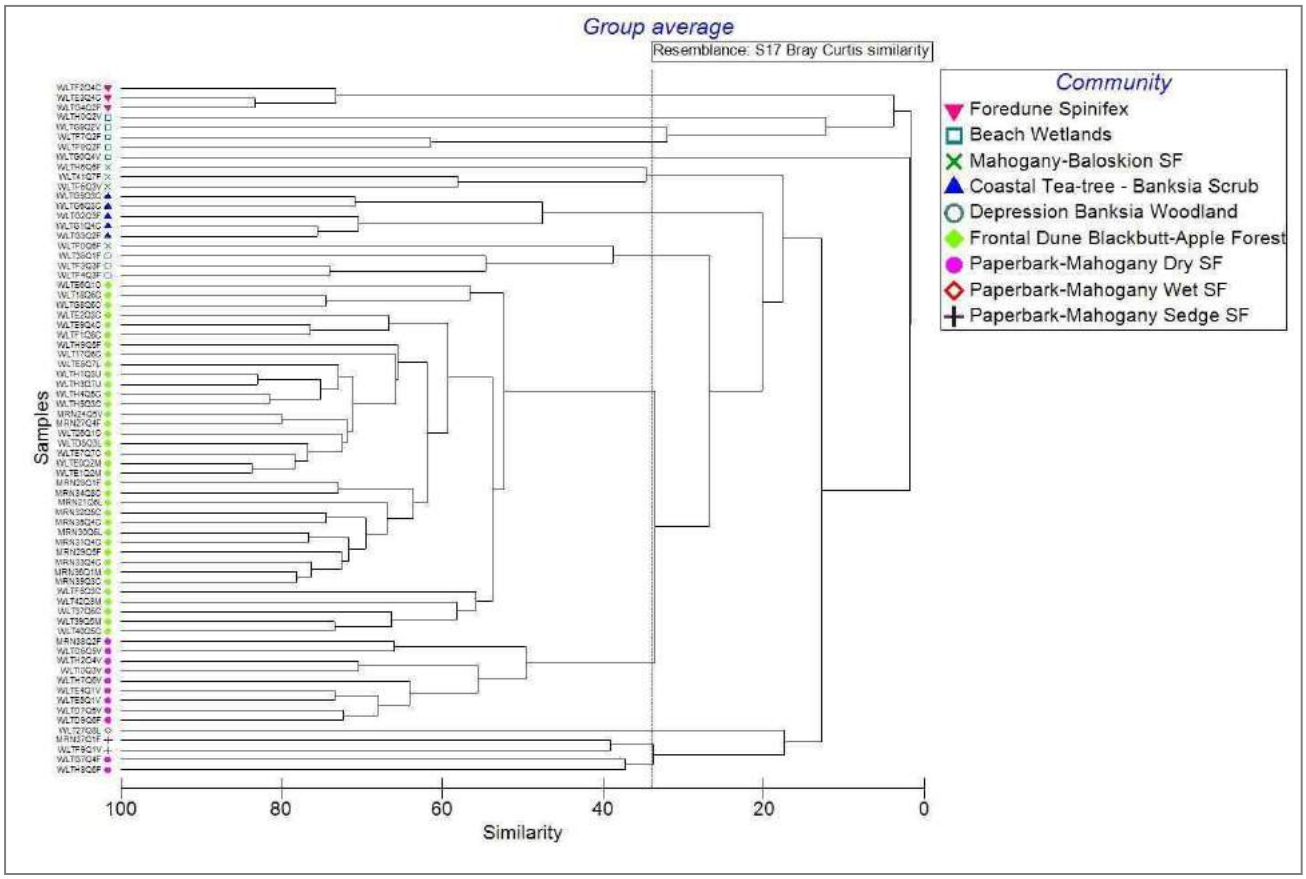

Figure 5 Cluster dendrogram for Worimi Conservation Lands.

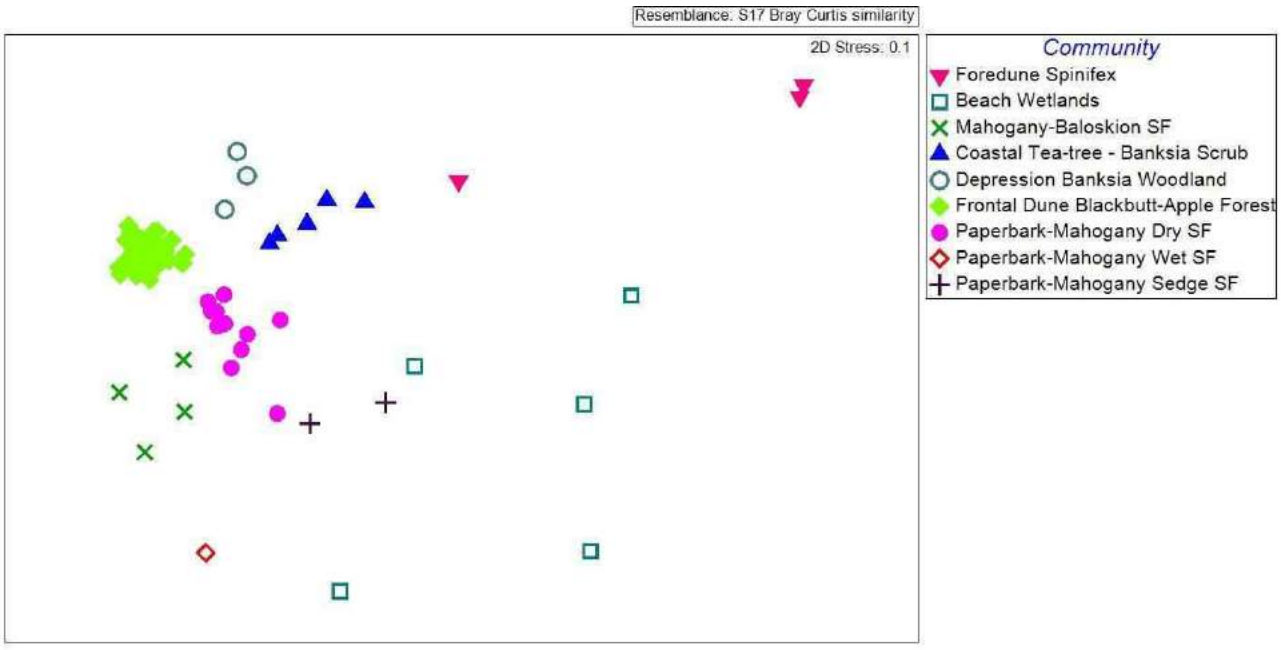

Figure 6 nMDS ordination plot for Worimi Conservation Lands. Stress = 0.1.

Table 4 ANOSIM results (Global R values) for pair-wise comparisons of *aprior* vegetation groups.

	FDBAF	PMSSF	PMDSF	PMWSF	DBW	MBSF	FS	BW	CTTBS
FDBAF									
PMSSF	1								
PMDSF	0.962	0.814							
PMWSF	1	1	1						
DBW	0.998	1	0.839	1					
MBSF	0.999	1	0.808	1	0.870				
FS	1	1	1	1	1	1			
BW	0.996	0.400	0.928	0.640	0.836	0.844	0.662		
CTTBS	0.995	1	0.906	1	1	1	1	0.884	

FDBAF = Frontal Dune Blackbutt-Apple Forest
PMSSF = Paperbark-Mahogany Sedge Swamp Forest
PMDSF = Paperbark-Mahogany Dry Swamp Forest
PMWSF = Paperbark-Mahogany Wet Swamp Forest
DBW = Depression Banksia Woodland
MBSF = Mahogany-Baloskion Swamp Forest
FS = Foredune Spinifex
BW = Beach Wetlands
CTTBS = Coastal Tea-tree – Banksia Scrub

Table 5 presents brief descriptions of the nine WCL vegetation communities defined in this study; Appendix 8.3 contains detailed information on each community.

Table 5 Summary of key species for each defined vegetation community, Worimi Conservation Lands.

Canopy	Mid	Ground
1. Foredune Spinifex	-	*Spinifex sericeus*
2. Depression Banksia Woodland		
Banksia serrata	*Calytrix tetragona* *Leucopogon ericoides* *Platysace lanceolata* *Dillwynia retorta* *Melaleuca nodosa* *Ricinocarpos pinifolius* *Conospermum taxifolium* *Leptospermum laevigatum* *Olax stricta*	*Dianella caerulea* *Schoenus ericetorum* *Amperea xiphoclada var. xiphoclada*
3. Frontal Dune Blackbutt-Apple Forest		
Angophora costata *Eucalyptus pilularis* *Banksia serrata*	*Pteridium esculentum* *Bossiaea rhombifolia* *Leucopogon lanceolatus var. gracilis* *Aotus ericoides* *Acacia ulicifolia* *Monotoca elliptica* *Acacia suaveolens* *Persoonia levis* *Acacia longifolia subsp. longifolia*	*Gonocarpus teucrioides* *Imperata cylindrical var. major* *Hibbertia linearis* *Themeda australis* *Lomandra longifolia* *Dianella caerulea*
4. Paperbark-Mahogany Sedge Swamp Forest		
Eucalyptus robusta	*Leptospermum polygalifolium* *Acacia longifolia subsp. longifolia* *Dodonaea triquetra*	*Baumea articulata* *Baumea juncea* *Hemarthria uncinata var. uncinata*
5. Paperbark-Mahogany Dry Swamp Forest		
Melaleuca quinquenervia *Eucalyptus robusta* *Banksia serrata*	*Dodonaea triquetra* *Platysace lanceolata* *Dillwynia retorta* *Acacia ulicifolia* *Acacia longifolia subsp. longifolia*	*Imperata cylindrical var. major* *Hemarthria uncinata var. uncinata* *Pomax umbellate* *Gonocarpus teucrioides* *Lomandra longifolia* *Panicum simile* *Eragrostis brownii* *Setaria distans* *Dianella caerulea*
6. Paperbark-Mahogany Wet Swamp Forest		
Eucalyptus robusta *Melaleuca quinquenervia* *Casuarina glauca*	*Livistona australis* *Glochidion ferdinandii*	*Blechnum indicum* *Cyclosorus interuptus* *Commelina cyanea* *Gahnia clarkei*

Canopy	Mid	Ground
		Oplismenus imbecillus
7. Mahogany-Baloskion Swamp Forest		
Eucalyptus robusta	*Leptospermum polygalifolium* *Aotus ericoides* *Melaleuca nodosa*	*Baloskion tetraphyllous subsp. meiostachys* *Lomandra longifolia*
8. Coastal Tea-tree – Banksia Scrub		
Leptospermum laevigatum *Banksia serrata* *Banksia integrifolia*	*Monotoca elliptica*	*Imperata cylindrical var. major*
9. Beach Wetlands		
-	*Ficinia nodosa* *Juncus acutus*	*Hydrocotyle bonariensis*
-	*Phragmites australis* *Philydrum lanuginosum*	*Hydrocotyle bonariensis* *Fimbristylis velata* *Epaltes australis* *Gratiola pedunculata*
-	*Typha domingensis*	*Hydrocotyle bonariensis* *Lachnagrostis filiformis*
-	-	*Carex pumila* *Hydrocotyle bonariensis*

Analysis 2: Worimi Conservation Lands & Tomago/ Tomaree Sandbeds

When combined with the Tomago/ Tomaree sandbeds dataset (244 samples), most Worimi communities maintained their distinctiveness separate from that area at the ~40% similarity level. The Frontal Dune Blackbutt-Apple Forest is floristically similar to the same vegetation type present at Tomago, and the 36 samples from Worimi formed a sub-group within the much larger Frontal Dune Blackbutt-Apple Forest. As in the Tomago-Tomaree study, similar Blackbutt-Apple forests from Tomaree on the Anna Bay Sandbeds remained distinct from the Tomago-Worimi group, perhaps attributable to differing understorey species due to slightly higher rainfall closer to Nelson Bay. In essence, Analysis 2 illustrated that the Worimi vegetation is sufficiently different from that occurring on both the Tomago and Tomaree sand beds, and the three areas combined are critical in conserving sand-based communities in the region.

The relationship of all nine Worimi communities relative to those at Tomago and Tomaree are depicted in Table 6.

Table 6 Comparison of Worimi communities with those at Tomago and Tomaree.

Worimi Community	Tomago	Tomaree
1 Foredune Spinifex	-	-
2 Depression Banksia Woodland	-	-
3 Frontal Dune Blackbutt-Apple Forest	Tomago Blackbutt-Apple-Banksia Forest	-
4 Paperbark-Mahogany Sedge Swamp Forest	Paperbark Swamp Forest	Paperbark Swamp Forest
5 Paperbark-Mahogany Dry Swamp Forest	-	-
6 Paperbark-Mahogany Wet Swamp Forest	-	-
7 Mahogany-Baloskion Swamp Forest	-	-
8 Coastal Tea-tree – Banksia Scrub	-	-
9 Beach Wetlands	-	-

3.4 Vegetation Community Map

A vegetation community map of the Worimi Conservation Lands has been created as a major component of this project (Figure 8). Map layers will be submitted to DECCW as separate map files, and are best viewed and examined on a GIS program.

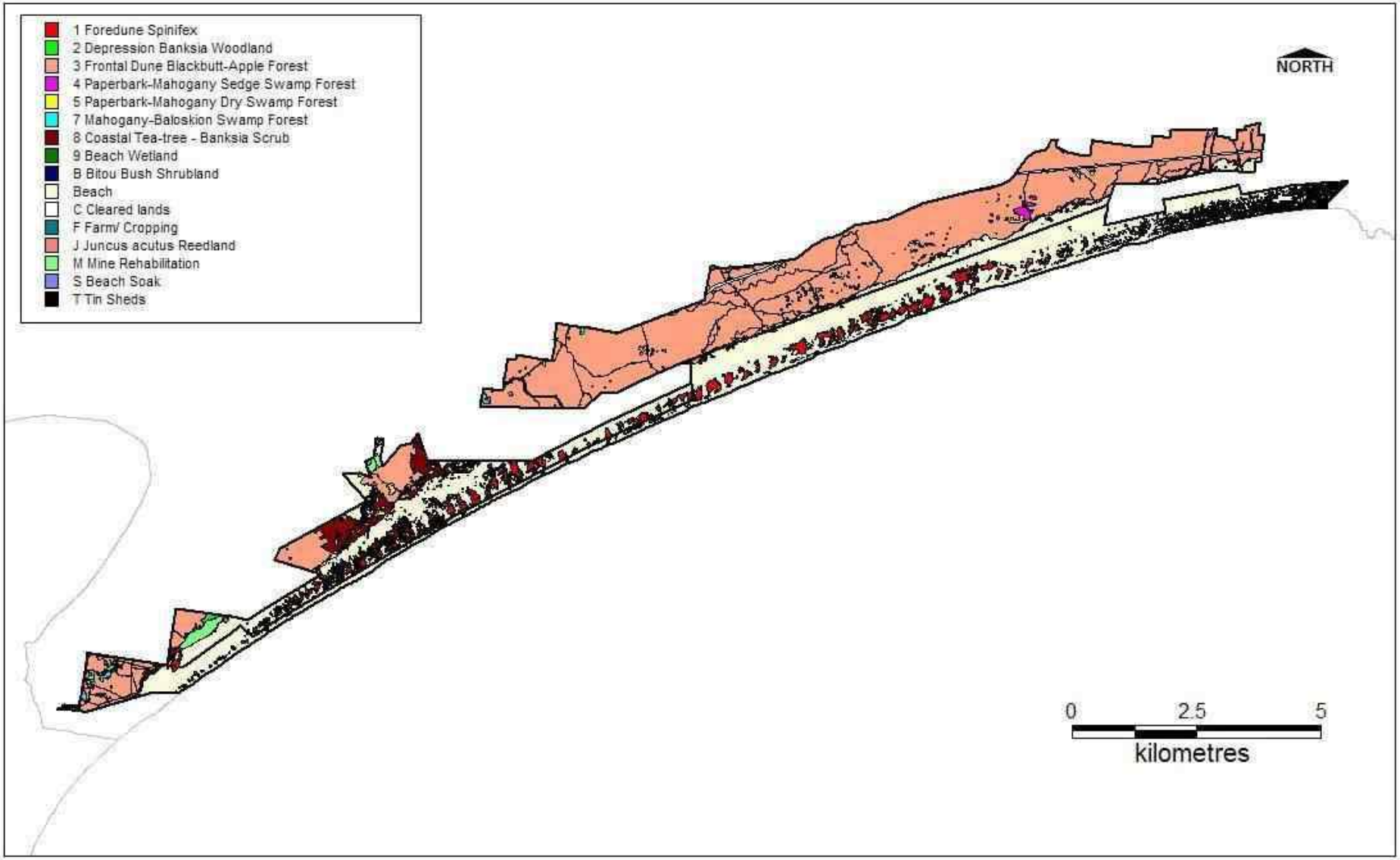

Figure 8 Vegetation map of the Worimi Conservation Lands.

4. CONSERVATION SIGNIFICANCE

The conservation significance of vegetation diversity within the Worimi Conservation Lands comprises an assessment of both vegetation communities present, and individual species. At the highest level, communities and species listed on the relevant threatened species legislation require active consideration and management wherever possible. In addition, the potential impacts of groundwater extraction necessitate careful management of threatened entities, should the water reserves within the North Stockton Sandbeds be targeted at some time in the future.

4.1 Vegetation Communities

Commonwealth

At present, there are no Threatened Ecological Communities listed on the *Environment Protection & Biodiversity Conservation Act 1999* that apply to vegetation within the Worimi Conservation Lands. However, this situation may change in the future should nominations for relevant communities be received and accepted by the Commonwealth.

State

A number of Endangered Ecological Communities potentially occur within the Worimi Conservation Lands, each of which is listed in the *Threatened Species Conservation Act 1995*. These include:

- River Flat Eucalypt Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South-East Corner bioregions (RFEFCF)
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South-East Corner bioregions (SSFCF)
- Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South-East Corner bioregions (FWCF)
- Sydney Freshwater Wetlands in the Sydney Basin bioregion (SFW)
- Subtropical Coastal Floodplain Forest of the NSW North Coast, Sydney Basin and South-East Corner bioregions (SCFF)
- Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South-East Corner bioregions (SOFF)
- Coastal Saltmarsh in the NSW North Coast, Sydney Basin and South-East Corner bioregions (CS)
- Littoral Rainforest in the NSW North Coast, Sydney Basin and South-East Corner bioregions (LR)

Six of these eight EEC's relate to vegetation occurring on the coastal floodplains of New South Wales, and originate from work completed by Keith and Scott (2005). The seventh EEC recognises the sensitive nature of saltmarsh vegetation, particularly in regard to anthropogenic impacts. Although this community lies in close proximity to the Tomago Sandbeds, (such as at Tilligerry Wetland), it does not occur on coastal sand deposits.

Only one of the eight EECs listed above is considered to be present within the WCL. Vegetation described in this study as Beach Wetlands (Unit 9) may broadly fit within Sydney Freshwater Wetlands EEC, given their occurrence on coastal sand dunes and the dominance of sedge species supported there. Swamp Sclerophyll Forest on Coastal Floodplains EEC has in the past been considered to include any swamp vegetation where

Eucalyptus robusta is characteristic in the canopy (D. Benson pers. comm.; Bell & Driscoll 2006a), but recent judgements in the Land and Environment Court have determined otherwise (eg: NSW LEC 209: Gales Holdings Pty Ltd v Tweed Shire Council 2008).

Regional

To assist in the regional assessment of vegetation from particular areas, the Lower Hunter and Central Coast Regional Environmental Management Strategy (LHCCREMS) undertook a vegetation survey and mapping project of the seven local government areas from Port Stephens to Gosford, and west to Cessnock. The original survey (incorporating stratified random sampling) and mapping (GIS modelling) was documented in NPWS (2000), and updated mapping was completed in 2002 (Eco Logical Australia 2002). Hunter Councils are currently in the process of revising this mapping for the much larger Hunter-Central Rivers Catchment Management Area.

The LHCCREMS classification and mapping was of necessity broad in nature, given budget limitations and the large study area involved. However, it is an important baseline for placing a site into a regional perspective, and hence the Worimi vegetation has been assessed against this regional classification (Table 7). Where necessary, community names applied to the Worimi vegetation have been kept distinct from the LHCCREMS names to avoid confusion with those broader units, particularly where direct comparisons are difficult. One consequence of the broad nature of the regional communities and the conservation planning that stems from it is that unique communities of restricted occurrence are not acknowledged and hence are prone to extinction. Some of the WCL communities are floristically and structurally distinct, yet when placed within the regional LHCCREMS framework bear little resemblance to their adoptive community.

Table 7 Comparison of vegetation communities in the Worimi Conservation Lands with the regional LHCCREMS classification.

Worimi Community	LHCCREMS Community
1 Foredune Spinifex	Beach Spinifex
2 Depression Banksia Woodland	Tomago Sand Swamp Woodland (?)
3 Frontal Dune Blackbutt-Apple Forest	Coastal Sand Apple-Blackbutt Forest
4 Paperbark-Mahogany Sedge Swamp Forest	Swamp Mahogany – Paperbark Swamp Forest
5 Paperbark-Mahogany Dry Swamp Forest	Swamp Mahogany – Paperbark Swamp Forest
6 Paperbark-Mahogany Wet Swamp Forest	Swamp Mahogany – Paperbark Swamp Forest
7 Mahogany-Baloskion Swamp Forest	Swamp Mahogany – Paperbark Swamp Forest
8 Coastal Tea-tree – Banksia Scrub	Coastal Sand Scrub
9 Beach Wetlands	-

Relative to the nearby Tomago and Tomaree Sandbeds (Bell & Driscoll 2006a), the vegetation of the Worimi Conservation Lands exhibits low community diversity. Combined, those two sandbeds (and associated hard rock 'islands') support 43 vegetation communities and contrast well against the 9 communities defined for Worimi. The principle reasons for this dichotomy relate to the age of the associated sand masses and the presence of volcanic or Carboniferous sediments within or adjacent to the sandbeds themselves.

It is difficult to make further comment on the regional significance of the Worimi vegetation, given that the available LHCCREMS regional information is limited in its application (Nicholls, Doherty & Newsome 2002). However, looking farther afield interesting comparisons can be made with vegetation occurring on other coastal sand bodies, particularly on the North Coast. Griffith, Bale, Adam and Wilson (2003) have published a very detailed account of wallum and related vegetation on older sands between Taree and Lennox Head, largely based on the PhD studies of Steve Griffith. Their study defined 42 vegetation communities and, as may be expected, few of these correlate with those in the much younger sands of the Worimi Conservation Lands (Table 8).

Table 8 Comparison of wallum, sedgeland, and heathland vegetation communities in the Worimi Conservation Lands with the classification of Griffith et al. (2003).

Worimi Community	Griffith et al. (2003) Community
1 Foredune Spinifex	-
2 Depression Banksia Woodland	*Banksia – Leptospermum – Melaleuca* Wet Heathland (Unit 23) (?)
3 Frontal Dune Blackbutt-Apple Forest	-
4 Paperbark-Mahogany Sedge Swamp Forest	-
5 Paperbark-Mahogany Dry Swamp Forest	-
6 Paperbark-Mahogany Wet Swamp Forest	-
7 Mahogany-Baloskion Swamp Forest	-
8 Coastal Tea-tree – Banksia Scrub	-
9 Beach Wetlands	-

Similarly, the vegetation occurring on the Myall Lakes sand mass has been studied by a number of authors, principally Myerscough and Carolin (1986), Clements (1988), Cropper (1997) and Hunter and Alexander (2000). Although some of these studies were less rigorous than that completed by Griffith et al. (2003), they never-the-less provide useful insights into the types of vegetation present on the Eurunderee sandmass and nearby areas. Most of the vegetation communities defined for the Worimi Conservation Lands are also present within Myall Lakes NP. To the south, knowledge of the limited sand-based landscapes between Newcastle and Sydney gained through many vegetation studies on the Central Coast (eg: Bell 1998b, 2002c, 2009b), together with examination of reports of other authors (eg: Payne 1997; McRae 1990) suggests that nearly all of the Worimi vegetation communities are also present to the south, although in considerably smaller amounts.

4.2 Species Diversity

One hundred & ninety-four plant taxa (including 26 weeds) have been recorded to date from the Worimi Conservation Lands (Appendix 1). Prominent families represented include the Fabaceae, Ericaceae, Myrtaceae, and Mimosoidacea. Significant plant species are discussed in detail in Section 4.3. Table 9 provides a comparative analysis of the Worimi flora in relation to existing conservation reserves in the region. Note that several of the reserves in this region are relatively new and have not had detailed survey yet undertaken in them. Many are also small offshore island reserves gazetted for specific purposes (such as providing seabird habitat). The vegetation diversity present within the Worimi Conservation Lands is relatively low compared to several other reserves of comparable size, but may be attributable to the young age of the coastal sand mass on which it occurs.

4.3 Significant Species

Relatively few significant plant species have been detected within the Worimi Conservation Lands. Table 10 summarises those that are known, and includes previously recorded locations. Three of these species are contained within the Schedules of the Commonwealth *EPBC Act 1999* or the NSW *TSC Act 1995*. The vulnerable saprophytic orchid *Cryptostylis hunteriana* is known from the Gan Gan Hill and Tomaree Headland areas (Bell 2001), and may occur within the Worimi Conservation Lands. Populations of this species in south-eastern Queensland occur in coastal Wallum habitat (Logan 1998; pers. obs.), but use of such habitat has not yet been confirmed in NSW (de Lacey, Bell & Chamberlain in prep). *Rulingia hermannifolia*, a rare prostrate shrub, occurs on coastal headlands at Boat Harbour (Bell 1997a), but is not expected to be present on the sandmass of the Worimi CL.

Plant species of cultural significance are included in Appendix 8.2.

Table 9 Floristic diversity indexes of conservation reserves within the Lower North Coast and Upper Central Coast Region, listed in decreasing order of relative species diversity (expressed as taxa/ ha x 100).

Reserve	Major Geology	Diversity	Size (ha)	Index [1]	Source
Tingira Heights NR	Permian	80	16	500	Bell (1998a)
Pambalong NR	Alluvial	86	35	245	Eco Logical (2003)
Awabakal NR	Quaternary	470	200	235	Bell (1998b)
Blackbutt Reserve	Permian	350	200	175	Winning (1992)
Pulbah Island NR	Permian	99	69	143	Bell (1998a)
Glenrock SCA	Permian/ Quaternary	349	483	72	Bell (1998b)
Lake Macquarie SCA	Permian	346	696	50	Bell (1998a)
Columbey NP	Carboniferous	386	1126	34	Bell (2009a)
Tomaree NP	Quaternary/ Carboniferous	350	2266	15	Bell (1997a)
Salt Ash Weapons Range	Permian/ Quaternary	337	2824	12	Bell & Driscoll (2006b)
Werakata NP	Permian	190	2145	9	Bell (2004)
Karuah NR [3]	Carboniferous	269	2738	9	Bell (2002a)
Wallaroo NR [3]	Carboniferous	192	2786	7	Bell (2002a)
Manobalai NR	Triassic	246	4500	5	Bell (1997c)
Watagan NP [3]	Triassic	350	7765	5	Bell (2002b)
Tomaree Sandbeds	Quaternary/ Carboniferous	207	4500	4.6	Bell & Driscoll (2006a)
Worimi CL	**Quaternary (Holocene)**	**163**	**4200**	**3.9**	**current study**
Tomago Sandbeds	Quaternary	343	10000	3.4	Bell & Driscoll (2006a)
Jilliby SCA [3]	Triassic	340	12140	3	Bell & Driscoll (2006c)
Myall Lakes NR	Carboniferous/ Quaternary	946	44742	2	Hunter & Alexander (2000)
Goulburn River NP [2]	Triassic	~600	74411	0.8	Hill (1999)
Yengo NP	Triassic	701	189073	0.4	Bell, Vollmer & Gellie (1993)
Wollemi NP	Triassic	1360	492220	0.3	Bell (1998c)
Boondelbah NR	Carboniferous	no data	17	-	-
Corrie Island NR	Carboniferous (?)	no data	164	-	-
Hexham Swamp NR	Quaternary	no data	906	-	-
John Gould NR	Carboniferous	no data	31	-	-
Kooragang Island NR	Quaternary	no data	3353	-	-
Moffats Swamp NR	Quaternary	no data	143	-	-
Moon Island NR	Permian	no data	3.6	-	-
Munmorah SCA	Quaternary/ Triassic	no data	1463	-	-
Seaham Swamp NR	Quaternary	no data	11	-	-
Seal Rocks NR	Carboniferous	no data	1.6	-	-
Snapper Island NR	Carboniferous	no data	11	-	-
Stormpetrel NR	Carboniferous	no data	4	-	-
Tilligerry NR	Quaternary	no data	116	-	-
Worimi NR	Quaternary	no data	530	-	-

Note: 1 Index is calculated by dividing the number of taxa recorded in a reserve by the area of that reserve, then multiplying by 100. In the case of the WCL, 163 native taxa / 4200ha X 100 = 3.9.
2 includes Munghorn Gap Nature Reserve.
3 survey not yet complete for these reserves.

Diuris arenaria (Sand Doubletail)

Diuris arenaria was first described in 1999 for a terrestrial orchid species discovered by local orchid enthusiast George Hillman (Jones 1999). It is listed as endangered, and is endemic to the Tomaree Peninsula where it grows on coastal sand deposits in heathy forest and woodland dominated by *Corymbia gummifera* and *Angophora costata*. This species is being included in a study of the storage of selected threatened orchid seeds and their associated mycorrhizae being conducted by the Botanic Gardens Trust, with funding from the Herman Slade Foundation (Siemon & Offord, in prog.). Populations are known from a few locations along a powerline easement within Worimi NP (Figure 9: NPWS pers. comm.).

Table 10 Summary of significant plant species recorded within the Worimi Conservation Lands. [E = Endangered; V = Vulnerable]

Species	EPBC Act	TSC Act	Location
Nationally Threatened species (legislative support)			
Diuris arenaria	E	E	Worimi NP
Diuris praecox	V	V	Worimi NP
Senecio spathulatus var. *attenuatus*	-	E	Worimi SCA, Worimi RP
Nationally Rare species (no legislative support)			
-	-	-	-
Taxa of uncertain status (no legislative support)			
Eucalyptus sp. (Fern Bay)	-	-	Worimi RP, Worimi SCA
Species at or near distributional limits (no legislative support)			
Aotus lanigera	-	-	Sth limit Tomago Sandbeds
Leucopogon lanceolatus var. *gracilis*	-	-	Sth limit Nelson Bay

Diuris praecox (Rough Doubletail)

Diuris praecox is endemic to the lower Hunter Valley and Central Coast region, extending from the Gosford district north to the Hawks Nest area, predominantly along the coastal zone (Jones 1991). Records exist for the Glenrock State Conservation Area (from where the Type was collected in 1989), Hawks Nest, Anna Bay, Swansea, and parts of Wyong and Gosford LGAs (Bell 2009b). *Diuris praecox* is listed as Vulnerable in both State and Commonwealth legislation. Little detailed information is available on the preferred habitat of this species, however a project currently underway is examining known habitat from throughout the species' range (Bell & Cockerill in prog.). Within the WCL, this species is known along and near to a powerline easement within Worimi NP (Figure 9).

Senecio spathulatus var. *attenuatus* (Coast Grounsel)

Senecio spathulatus var. *attenuatus* is a poorly known species inhabiting coastal dune systems from Forster to Jervis Bay (Thompson 2005), and which was thought to be extinct in the Newcastle region. Over 1200 hundred plants of this species were recorded during the current study along two sections of Stockton Beach (Worimi SCA & Worimi RP), confirming its presence in the Newcastle area. This population within the Worimi CL is threatened by permitted 4WD access to Stockton Beach, and monitoring of populations should be undertaken to ensure their long-term survival. Figure 9 shows the locations of this species within the Worimi CLs.

Eucalyptus sp. (Fern Bay)

Previous vegetation surveys in the Fern Bay area of Worimi Conservation Lands uncovered several locations of a small eucalypt of unknown taxonomy (Bell 2006). Specimens lodged with the National Herbarium of NSW determined these specimens as a possible hybrid between the threatened *Eucalyptus parramattensis* subsp. *decadens* and either *Eucalyptus resinifera, E. scias* or *E. punctata*. Further examination of the brown cuboid seed from some of these plants put them closest to *Eucalyptus parramattensis* subsp. *decadens*, as the seed of *E. punctata* are dark brown to black, cuboid or obliquely pyramidal, with toothed margins; *E. resinifera* are brown, pyramidal to cuboid, sometimes flattened; and *E. scias* are brown, cuboid to pyramidal and with slightly toothed margins (Brooker, Slee, Conners & Duffy 2002). These hybrids are characterised by their often mallee habit, their large campanulate fruit with exert valves, and their mostly smooth bark. Interestingly, none of the putative parents of these hybrids are known to occur within the local area.

New occurrences and collections of these putative hybrids made during the current study confirm the hybrid nature of these specimens, albeit with different assumed parentage. There is high variability between specimens in both fruit/ bud morphology and leaf size and shape. Several new collections were made and examined in detail, and they are considered now to probably represent hybrid forms of *Eucalyptus robusta*

(common in the area, though restricted) and *Eucalyptus parramattensis* subsp. *decadens* (absent from the immediate area, but within ~10km), much like the well documented hybrids between the former species and *Eucalyptus tereticornis* (also present in Worimi). Most specimens appear closest to *Eucalyptus robusta*, and this parent seems to be the more dominant, resulting in a hybrid swarm of specimens very difficult to identify to species level. Digital images and scans were relayed to Dean Nicolle (Eucalypt taxonomist, Currency Creek Arboretum, South Australia), and he agreed with the diagnosis presented here.

As most specimens present within Worimi (and surrounds) exhibit stronger characteristics of *Eucalyptus robusta* rather than *Eucalyptus parramattensis* subsp. *decadens*, it is unlikely that the population could be included within the Vulnerable species listing of the latter species. As mentioned, character traits vary widely from tree to tree, and such inconsistency is typical of unstable hybrids.

Figure 9 Records of *Diuris arenaria, Diuris praecox* and *Senecio spathulatus* var. *attenuatus* from the Worimi Conservation Lands.

5. MANAGEMENT ISSUES

In view of the high quality of the vegetation present within the Worimi Conservation Lands, the preferred management strategy for both areas should be a passive one. However, a relatively small number of management issues are apparent in relation to maintaining the diversity of vegetation present. Principal among these is the potential impact that groundwater extraction may have on vegetation species and communities should extraction rates increase on current levels. Secondary to this issue are the actual and potential impacts of exotic plants, fire management and rationalisation of the existing trail networks.

5.1 Exotic Plants

In general terms, exotic plants within the Worimi CL are uncommon. However, there are exceptions to the rule, and efforts should be made in these areas to redress the problem of ongoing weed invasion. The following areas and species are the most pressing:

- *Chrysanthemoides monilifera* (Bitou Bush) – Bitou Bush is widespread and common along the entire coastal fringe of the reserves, where it is invading the coastal open Blackbutt forests from established stands on Stockton Beach. Many areas were encountered within forests where this species has dramatically replaced the native shrub layer. It is understood that the NPWS is undertaking controlled management of Bitou Bush within the reserves, and active replacement of the shrub layer may be necessary in some beach areas (see Bakewell, Raman, Hodgkins & Nicol 2009 for an example of the use of long-stem planting of *Acacia sophorae* on beach sands).

- *Eragrostis curvula* (African Love Grass) – a perennial grass weed associated with utility easements and mining rehabilitation. While this species is not abundant, its presence along utility corridors should be eradicated wherever possible. Slashing of easements in the traditional way tends to promote the spread of this grass, and alternatives have been documented (eg: Murdoch 1994).

- *Juncus acutus* subsp*. acutus* (Sharp Rush) – a perennial rush occurring in moist depressions along parts of Stockton Beach, specifically in the south-west and north-east of the Worimi CLs. This species is likely to have invaded after past sand mining operations, and has colonised several of the beach wetlands, often forming monospecific stands. The delicate ecology of the beach wetlands is threatened by this invasive species, displacing native sedges and rushes such as *Ficinia nodosa* and *Typha domingensis*, and attempts at eradication should be considered (see Paul & Young 2006).

5.2 Fire Management

Much of the Worimi Conservation Land is regularly used by visitors, or traversed en route to Stockton Beach by fisherman and 4WDs. With increasing visitor pressures come the increased risk of wildfire, and increases in fire frequency should be avoided as far as possible through sensitive asset protection and fire management. High frequency fire has the potential to reduce biodiversity through the simplification of habitat, and is a listed Key Threatening Process on the NSW *Threatened Species Conservation Act 1995*.

The nine vegetation communities identified during the current project are shown in Table 11 against suggested fire regimes. These regimes are based on basic knowledge of component plant species within each community, not on detailed scientific evidence. In all cases, mosaic burning of each community is the preferred management, so that differing age-classes remain throughout the reserves.

Table 11 Suggested fire regimes for WCL vegetation communities.

Worimi Community	Suggested Fire Regime
1 Foredune Spinifex	fire exclusion; unlikely to burn
2 Depression Banksia Woodland	7-25 years
3 Frontal Dune Blackbutt-Apple Forest	7-20 years
4 Paperbark-Mahogany Sedge Swamp Forest	10-30 years
5 Paperbark-Mahogany Dry Swamp Forest	7-15 years
6 Paperbark-Mahogany Wet Swamp Forest	10-30 years
7 Mahogany-Baloskion Swamp Forest	7-25 years
8 Coastal Tea-tree – Banksia Scrub	7-25 years
9 Beach Wetlands	fire exclusion; unlikely to burn

5.3 Trail Rationalisation

The Worimi Conservation Lands currently support a network of tracks and easements which fragment the natural landscapes. High densities of trails encourage weed invasion, and tend to serve as corridors for vertebrate pests such as cats, dogs and foxes. If possible, it is suggested that rationalisation of trails be undertaken to reduce this fragmentation, and active rehabilitation of some of these be undertaken.

5.4 Beach Access

Stockton Beach is one of the few licensed 4WD beach driving locations in New South Wales. Wherever, possible, 4WD users should be directed away from the fragile beach ecosystems (Spinifex, wetland depressions) and mobile dune systems. Known populations of the endangered *Senecio spathulatus* var. *attentuatus* should also be monitored for damage through 4WDs.

6. CONCLUSIONS & RECOMMENDATIONS

The Worimi Conservation Lands protect a moderately diverse array of coastal vegetation taxa and communities, most of which are currently in very good to exceptional condition. Disturbance across the site is negligible, although extensive outbreaks of weeds (Bitou Bush, Spiny Rush) are evident along the immediate coastline.

Over 180 plant taxa across 9 vegetation communities are protected within the Worimi Conservation Lands. Three of these taxa are considered of significance within the region, and are currently listed on the Commonwealth *EBPC Act 1999* or the NSW *TSC Act 1995* (*Diuris arenaria, Diuris praecox, Senecio spathulatus var. attenuatus*). *Senecio spathulatus* was formerly considered extinct in the Newcastle region, and the population of >1200 plants recorded during the current study updates the status of this species.

The vegetation communities present range from grassland to open forest, and include various forms of swamp and swamp forest. In the most part, community definition allowed reasonable comparisons with regional vegetation classifications recently undertaken in the Lower Hunter and Central Coast, and consequently statements of conservation significance for each community could be made.

From a vegetation management point of view, it is recommended that;

- consideration be given to the rationalisation of trails present throughout the reserves, and restricting unauthorised access to the more remote parts, particularly from trail bikes;

- weed control and monitoring be undertaken on those problem species identified in this report, with particular regard to obligations under the *Noxious Weeds Act 1993*.

Project Limitations

As comprehensive as this project has been, there is still some scope for improving upon the work presented here. In particular, further traverses and data collection on foot could be made into those areas where access has been limited to date, which will improve the vegetation map already prepared. While it is not envisaged that additional full floristic plot sampling is required, these should be done if potentially new community variations are encountered in the more remote areas. Further sampling of Beach Wetlands could also be undertaken to increase knowledge on these poorly studied ecosystems.

The majority of field survey completed for this project was undertaken outside of the known flowering periods of several threatened and common orchid species. Consequently, it is likely that the orchid flora presented in this report under-represents the diversity present.

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8. APPENDICIES

Appendix 8.1 Plant species list – Worimi Conservation Lands

Family	Scientific Name	Common Name
Aizoaceae	*Carpobrotus glaucescens*	Pigface
Anthericaceae	*Thysanotus tuberosus subsp. tuberosus*	
	Tricoryne elatior	Yellow Autumn-lily
Apiaceae	*Actinotus helianthi*	Flannel Flower
	Centella asiatica	Indian Pennywort
	** Hydrocotyle bonariensis*	
	Hydrocotyle verticillata	Shield Pennywort
	Platysace ericoides	
	Platysace lanceolata	Shrubby Platysace
Apocynaceae	*Parsonsia straminea*	Common Silkpod
Araliaceae	*Polyscias sambucifolia subsp. sambucifolia*	
Arecaceae	*Livistona australis*	Cabbage Palm
Asteraceae	**Acanthospermum australe*	
	**Aster subulatus*	Wild Aster
	**Arctotheca populifolia*	Beach Daisy
	**Chrysanthemoides monilifera subsp. rotundata*	Bitou Bush
	**Conyza parva*	Fleabane
	**Conyza spp.*	A Fleabane
	Epaltes australis	Spreading Nut-heads
	Ozothamnus diosmifolius	White Dogwood
	Senecio crassiflorus	
	Senecio hispidulus	Hill Fireweed
	**Senecio madagascariensis*	Fireweed
	Senecio pinnatifolius var. pinnatifolius	
	Senecio spathulatus var. attenuatus	Coast Groundsel
	Sigesbeckia orientalis subsp. orientalis	Indian Weed
	**Taraxacum officinale*	Dandelion
Bignoniaceae	*Pandorea pandorana*	Wonga Wonga Vine
Blechnaceae	*Blechnum indicum*	Swamp Water Fern
Brassicaceae	**Cakile edentula*	American Sea Rocket
Campanulaceae	*Wahlenbergia stricta subsp. stricta*	Tall Bluebell
Casuarinaceae	*Allocasuarina littoralis*	Black She-Oak
	Casuarina glauca	Swamp Oak
Commelinaceae	*Commelina cyanea*	Native Wandering Jew
Convolvulaceae	*Calystegia marginata*	
Cyperaceae	*Baumea articulata*	Jointed Twig-rush

Family	Scientific Name	Common Name
	Baumea juncea	
	Carex appressa	Tall Sedge
	Carex pumila	
	**Cyperus aggregates*	Umbrella Sedge
	Ficinia nodosa	Knobby Club-rush
	Fimbristylis velata	
	Gahnia clarkei	Tall Saw-sedge
	Isolepis cernua	Nodding Club-rush
	Isolepis hookeriana	
	Isolepis inundata	Club-rush
	Schoenoplectus mucronatus	
	Schoenus brevifolius	
	Schoenus ericetorum	
Dennstaedtiaceae	*Pteridium esculentum*	Bracken
Dilleniaceae	*Hibbertia acicularis*	
	Hibbertia fasciculata	
	Hibbertia linearis	
Dioscoreaceae	*Dioscorea transversa*	Native Yam
Elaeocarpaceae	*Elaeocarpus reticulatus*	Blueberry Ash
	Tetratheca thymifolia	Black-eyed Susan
Ericaceae	*Astroloma humifusum*	Native Cranberry
	Astroloma pinifolium	Pine Heath
	Brachyloma daphnoides subsp. daphnoides	
	Leucopogon ericoides	Pink Beard-heath
	Leucopogon lanceolatus var. gracilis	
	Leucopogon margarodes	
	Leucopogon parviflorus	Coastal Beard-heath
	Monotoca elliptica	Tree Broom-heath
	Monotoca scoparia	
	Styphelia viridis subsp. viridis	
Euphorbiaceae	*Amperea xiphoclada var. xiphoclada*	
	Homalanthus populifolius	
	Ricinocarpos pinifolius	Wedding Bush
Fabaceae (Faboideae)	*Aotus ericoides*	
	Aotus lanigera	
	Bossiaea ensata	Sword Bossiaea
	Bossiaea heterophylla	Variable Bossiaea
	Bossiaea rhombifolia subsp. rhombifolia	
	Desmodium gunnii	Slender Tick-trefoil
	Desmodium rhytidophyllum	
	Desmodium varians	Slender Tick-trefoil
	Dillwynia glaberrima	
	Dillwynia retorta	
	Glycine clandestina	Twining glycine
	Gompholobium latifolium	Golden Glory Pea
	Hardenbergia violacea	False Sarsaparilla
	Kennedia rubicunda	Dusky Coral Pea
	Acacia implexa	Hickory Wattle

Family	Scientific Name	Common Name
Fabaceae (Mimosoideae)		
	Acacia irrorata subsp. irrorata	Green Wattle
	Acacia longifolia subsp. longifolia	Sydney Golden Wattle
	Acacia suaveolens	Sweet Wattle
	Acacia ulicifolia	Prickly Moses
Goodeniaceae	*Goodenia bellidifolia subsp. bellidifolia*	
	Goodenia paniculata	
Haloragaceae	*Gonocarpus micranthus subsp. ramosissimus*	
	Gonocarpus teucrioides	Germander Raspwort
Iridaceae	**Gladiolus gueinzii*	
Juncaceae	** Juncus acutus subsp. acutus*	Sharp Rush
	Juncus continuus	
Juncaginaceae	*Triglochin striatum*	
Lamiaceae	*Lycopus australis*	Australian Gipsywort
Lauraceae	*Cassytha glabella f. glabella*	
	Cassytha pubescens	Downy Dodder-laurel
	Endiandra sieberi	Hard Corkwood
Lobeliaceae	*Lobelia anceps*	
Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat-rush
Loranthaceae	*Dendrophthoe vitellina*	
Menispermaceae	*Stephania japonica var. discolor*	Snake Vine
Myrsinaceae	*Myrsine howittiana*	Brush Muttonwood
Myrtaceae	*Angophora costata*	Sydney Red Gum
	Calytrix tetragona	Common Fringe-myrtle
	Corymbia gummifera	Red Bloodwood
	Eucalyptus parramattensis subsp. decadens X robusta	
	Eucalyptus pilularis	Blackbutt
	Eucalyptus robusta	Swamp Mahogany
	Eucalyptus x kirtoniana (robusta x tereticornis)	
	Leptospermum juniperinum	Prickly Tea-tree
	Leptospermum laevigatum	Coast Teatree
	Leptospermum polygalifolium subsp. cismontanum	
	Leptospermum trinervium	Slender Tea-tree
	Melaleuca nodosa	
	Melaleuca quinquenervia	Broad-leaved Paperbark
	Melaleuca styphelioides	Prickly-leaved Tea Tree
Olacaceae	*Olax stricta*	
Onagraceae	**Oenothera drummondii*	
Orchidaceae	*Chiloglottis spp.*	
	Diuris arenaria	Sandhill Double-tail
	Diuris praecox	Rough Double-tail
	Pterostylis concinna	Trim Greenhood

Family	Scientific Name	Common Name
	Pterostylis longifolia	Tall Greenhood
Philydraceae	*Philydrum lanuginosum*	Frogsmouth
Phormiaceae	*Dianella caerulea var. assera*	
	Dianella caerulea var. caerulea	
Phyllanthaceae	*Breynia oblongifolia*	Coffee Bush
	Glochidion ferdinandi var. ferdinandi	Cheese Tree
	Glochidion ferdinandi var. pubens	Hairy Cheese Tree
	Poranthera microphylla	Small Poranthera
Pinaceae	**Pinus elliottii*	Slash Pine
Pittosporaceae	*Billardiera scandens*	Appleberry
Poaceae	**Andropogon virginicus*	Whisky Grass
	**Axonopus fissifolius*	Narrow-leaved Carpet Grass
	Cynodon dactylon	Common Couch
	Dichelachne micrantha	Shorthair Plumegrass
	Digitaria parviflora	Small-flowered Finger Grass
	Digitaria ramularis	Finger Panic Grass
	**Ehrhart erecta*	Panic Veldtgrass
	Entolasia marginata	Bordered Panic
	Entolasia stricta	Wiry Panic
	Eragrostis brownii	Brown's Lovegrass
	**Eragrostis curvula*	African Lovegrass
	Hemarthria uncinata var. uncinata	
	Imperata cylindrica var. major	Blady Grass
	Lachnagrostis filiformis	
	Microlaena stipoides var. stipoides	Weeping Grass
	Oplismenus imbecillis	
	Panicum simile	Two-colour Panic
	Paspalidium distans	
	Phragmites australis	Common Reed
	Pseudoraphis paradoxa	Slender Mudgrass
	Setaria distans	
	Spinifex sericeus	Hairy Spinifex
	Themeda australis	Kangaroo Grass
Polygalaceae	*Comesperma ericinum*	
Polygonaceae	*Persicaria decipiens*	
	Persicaria strigosa	
Proteaceae	*Banksia integrifolia subsp. integrifolia*	Coastal Banksia
	Banksia serrata	Old-man Banksia
	Conospermum taxifolium	
	Persoonia lanceolata	Lance Leaf Geebung
	Persoonia levis	Broad-leaved Geebung
Restionaceae	*Baloskion pallens*	
	Baloskion tetraphyllum subsp. meiostachyum	
Rubiaceae	*Opercularia aspera*	Coarse Stinkweed
	Opercularia diphylla	Stinkweed

Family	Scientific Name	Common Name
	Pomax umbellata	Pomax
Rutaceae	*Nematolepis squamea subsp. squamea* *Eriostemon australasius*	Satinwood
Santalaceae	*Leptomeria acida* *Exocarpos cupressiformis*	Sour Currant Bush Cherry Ballart
Sapindaceae	*Dodonaea triquetra*	Large-leaf Hop-bush
Schizaeaceae	*Schizaea bifida*	Forked Comb Fern
Scrophulariaceae	*Gratiola pedunculata*	
Selaginaceae	*Hebenstretia dentata*	
Smilacaceae	*Smilax glyciphylla*	Sweet Sarsparilla
Solanaceae	**Solanum nigrum*	Black-berry Nightshade
Thelypteridaceae	*Cyclosorus interruptus*	
Thymelaeaceae	*Pimelea linifolia subsp. linifolia*	
Typhaceae	*Typha domingensis*	Narrow-leaved Cumbungi
Verbenaceae	**Lantana camara*	Lantana
Violaceae	*Hybanthus monopetalus* *Viola banksii* *Viola hederacea*	Slender Violet-bush Ivy-leaved Violet
Zamiaceae	*Macrozamia communis*	Burrawang

* introduced species

Appendix 8.2 Culturally Significant Plant Species, Worimi CL

Species	Common Name	Weaving	Implements	Adhesives	Food/ Cooking	Seeds	Nectar	Medicine	Other
Acacia implexa	Hickory		√						
Acacia spp.	Wattles					√			√
Actinotus helianthi	Flannel Flower								√
Allocasuarina spp	She-oaks		√						
Angophora costata	Smooth-barked Apple		√	√				√	
Angophora floribunda	Rough-barked Apple							√	
Astroloma humifusum	Native Cranberry								√
Banksia integrifolia	Coast Banksia					√	√	√	
Banksia spp.	Banksia						√		
Billardiera scandens	Apple Berry				√				√
Blechnum indicum	Bungwahl Fern								√
Callistemon spp.	Bottlebrushes						√		
Canavalia marina									√
Carpobrotus glaucescens	Pig Face				√				√
Cassytha glabella	Devils Twine								√
Cassytha pubescens	Devils Twine								√
Casuarina glauca	Swamp Oak								√
Casuarina spp	Oaks		√						
Ceratopetalum gummiferum	NSW Christmas Bush							√	
Choretrum spp.	Sour Bush								√
Clematis glycinoides	Headache Vine								√
Corymbia gummifera	Red Bloodwood			√					
Diuris spp.	Donkey orchids								√
Dodonaea spp.	Hop Bushes								√
Duboisia myoporoides	Corkwood								√
Endiander sieberi	Corkwood							√	
Eucalyptus pilularis	Blackbutt		√						
Eucalyptus spp.	Gum Trees								√
Eucalyptus tereticornis	Forest Red Gum		√						
Exocarpus cupressiformis	Native Cherry				√				√
Glycine clandestina	Twining Glycine								√
Goodenia spp.	-				√			√	
Juncus spp	Rush	√							
Kennedia rubicunda	Dusky Coral Pea								√
Leptomeria acida	Native Currant								√
Leucopogon spp.	Beard-heaths								√
Lissanthe spp.	Native Cranberry								√

Species	Common Name	Weaving	Implements	Adhesives	Food/ Cooking	Seeds	Nectar	Medicine	Other
Livistona australis	Cabbage Tree Palm				√			√	
Lomandra longifolia	Spiny-headed Mat-rush	√				√			√
Macrozamia communis	Burrawang								√
Melaleuca quinquenervia	Broad-leaved Paperbark				√			√	
Melaleuca styphelioides	Prickly-leaved Paperbark							√	
Monotoca elliptica	Tea Tree Heath								√
Persoonia linearis	Geebung				√				
Phragmites australis	Common Reed								√
Pteridium esculentum	Bracken Fern							√	√
Scaevola calandulacea	Fan Flower								√
Themeda australis	Kangaroo Grass					√			
Thysanotus tuberosus	Fringe lily				√				√
Typha spp	Bull Rush	√			√				√
Xanthorrhoea spp	Grass Trees			√					

Note: Information in this table provided predominantly from Warren Mayers, Ranger (Worimi).

Appendix 8.3 Vegetation Community Profiles

Community profiles of each vegetation community present within the Worimi Conservation Lands have been developed using the available floristic and structural information. The rationale behind the profiles is to assist end-users in the interpretation of delineated map units, and to allow the general reader with at least some basic knowledge of common plant species to identify the different vegetation types. A summary map showing the distribution of each community within the reserve is provided with each profile. For each vegetation community, a summary of the basic structural makeup of that unit is given. The accuracy of structural information presented with each profile is governed by the sample size of each community (shown as "n" in the structural tables). Where possible, the equivalent vegetation classification unit within other regional assessments have been provided under the community name, to assist in regional comparisons and significance assessments.

The derivation of diagnostic species for each community has been defined using the SIMPER routine in *Primer*. SIMPER analysis provides the relative contributions of each species to the Bray-Curtis similarity within each of the defined vegetation communities. Only those species contributing to a total cumulative contribution of 99% of the average similarity for each community are listed. These species can be described of as *typical* of that community, and have a consistently large presence within the data as reflected in the ratio of their contribution to the standard deviation (the Sim/SD field in each table) across the within-group similarities (the average similarity). Community groups with less than two samples (ie: Paperbark-Mahogany Sedge Swamp Forest, Paperbark-Mahogany Wet Swamp Forest) cannot be analysed in this way. Instead, the full species list from the single plot in each community is shown.

In the *Key Diagnostic Species* tables in each profile:

- Average similarity — is the within-group similarity for all pairs of sample plots comprising the community. Higher average similarity indicates a better defined community.
- Av.Abund — is the average cover abundance of that species within sample plots comprising the community
- Av.Sim — is the average similarity (contribution) made by each species to the within-group similarity (the overall average similarity).
- Sim/SD — is the ratio of average similarity to standard deviation for each species across all pairs of samples. A high ratio represents a good discriminating species. At least three samples are required for this ratio to be calculated.
- Contrib % — is the percentage contribution of each species to the overall average similarity for the community.
- Cum % — is the cumulative percentage contribution for all species for that community.

Profiles for the following communities have been prepared:

1. Foredune Spinifex Unit 1

Beach Spinifex REMS Unit 53

General Description:

Foredune Spinifex occurs sporadically along the mobile sands of Stockton Bight, and are characterised by the colonising, sand-stabling grass *Spinifex sericeus*. Lower in the topographical profile towards open depressions, *Carex pumila* also occurs with *Spinifex*, and grades into Beach Wetlands (Unit 9). A number of other species may also be present within these areas, including several weed species. In some areas, Bitou Bush (*Chrysanthemoides monilifera*) has become established and is threatening the long-term survival of this community. This community is also prone to over-use by recreational 4WD vehicles, which may impact on its sand-binding capabilities.

Known Floristic/ Structural Variations:

Variations within this simple community relate mainly to the age of the stand relative to mass movement of sand, and to the extent of weed species present. The latter may be influenced by proximity to sand extraction sites, or use by recreational 4WD vehicles. Progressive dominance by *Carex pumila* also occurs as Foredune Spinifex grades into Beach Wetlands (Unit 9).

Distribution:

Scattered along most of the mobile dune sands of Stockton Bight.

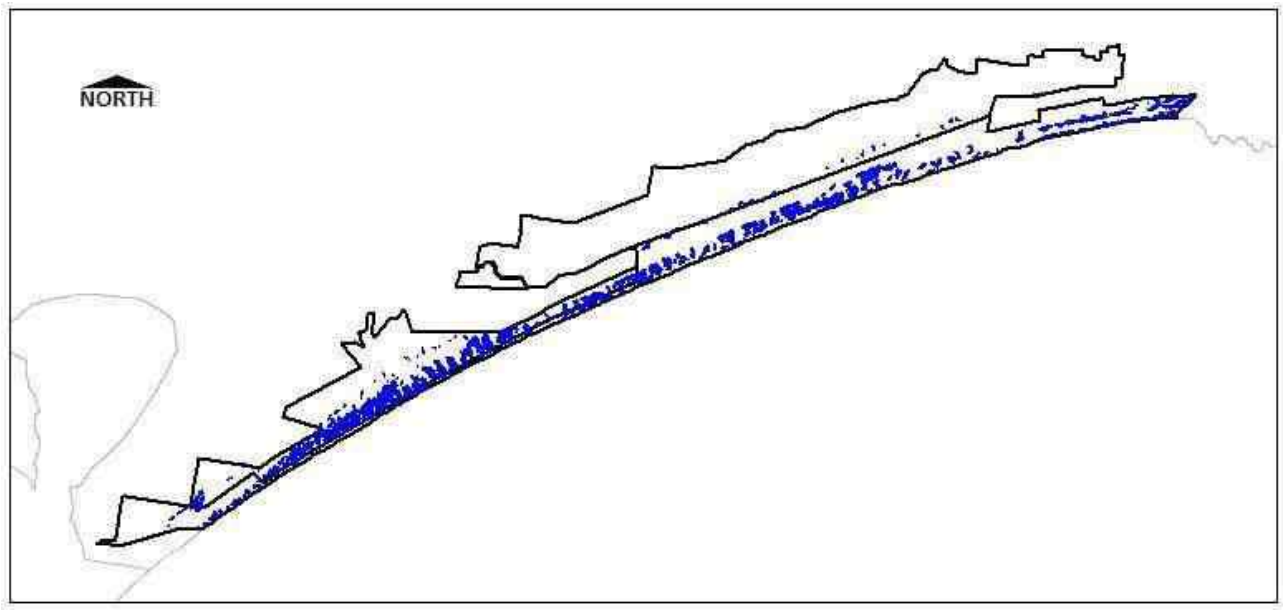
Extent: Worimi NP = 3.0 ha Worimi SCA = 108.7 ha Worimi RP = 115.8 ha Total = 227.5 ha

Relationship to Other Communities:

Foredune Spinifex is distinct from all other vegetation communities present within the WCL, and can be distinguished by the dominance of *Spinifex sericeus*. No other community occurs only as grassland.

Significant Species:

- Undescribed species – *none recorded*
- Threatened (TSC Act) – *Senecio spathulatus* (Endangered); possibly *Chamaesyce psammogeton* (Endangered)
- Rare (ROTAP) – *none recorded*



Community Conservation Status:

Reserve Representation - within the region, this vegetation type is present in a number of coastal reserves, but nowhere is it extensive.

TSC Act (1995) Status - not currently listed.

Vegetation Structure [based on 3 plots]:

Stratum	Mean height (m)	Min height (m)	Max height (m)	Mean cover (%)	Sdev	n
Emergent	-	-	-	-	-	-
Tallest	0.47	0.10	0.50	78	10.4	3
Middle 1	-	-	-	-	-	-
Middle 2	-	-	-	-	-	-
Lowest	-	-	-	-	-	-

Key Diagnostic Species [based on 3 plots]:

Species	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Spinifex sericeus	5.67	76.59	12.54	100	100

2. Depression Banksia Woodland Unit 2

Tomago Sand Swamp Woodland (?) REMS Unit 36

General Description:

Depression Banksia Woodland occurs only in a few restricted locations, principally in the Worimi SCA and Worimi RP areas in the west. It is characterised by the general absence of large canopy trees, but with *Banksia serrata* occurring as a low, widely spaced canopy. Small tree species, such as *Eucalyptus pilularis* or *Angophora costata*, may occur rarely as stunted specimens. The hybrid *Eucalyptus parramattensis X robusta* is also common in this community. Areas supporting this vegetation type occur on gentle sand sheets, with a range of understorey shrub and herb species which are uncommon or rare from other parts of the WCL. Several of these (eg: *Olax stricta, Calytrix tetragona, Conospermum taxifolium*) are considerably more common on the older Pleistocene sand sheets of the Tomago Sandbeds, suggesting that these areas within the WCL occur on older sand deposits than that which surround them.

Known Floristic/ Structural Variations:

Fire history may influence the general appearance and floristic composition of this community. Those areas subjected to more frequent and regular fire support a low heath, while those with longer fire-free periods tend towards a tall heath or scrub. Varying depths to the water table may also be influencing these differences.

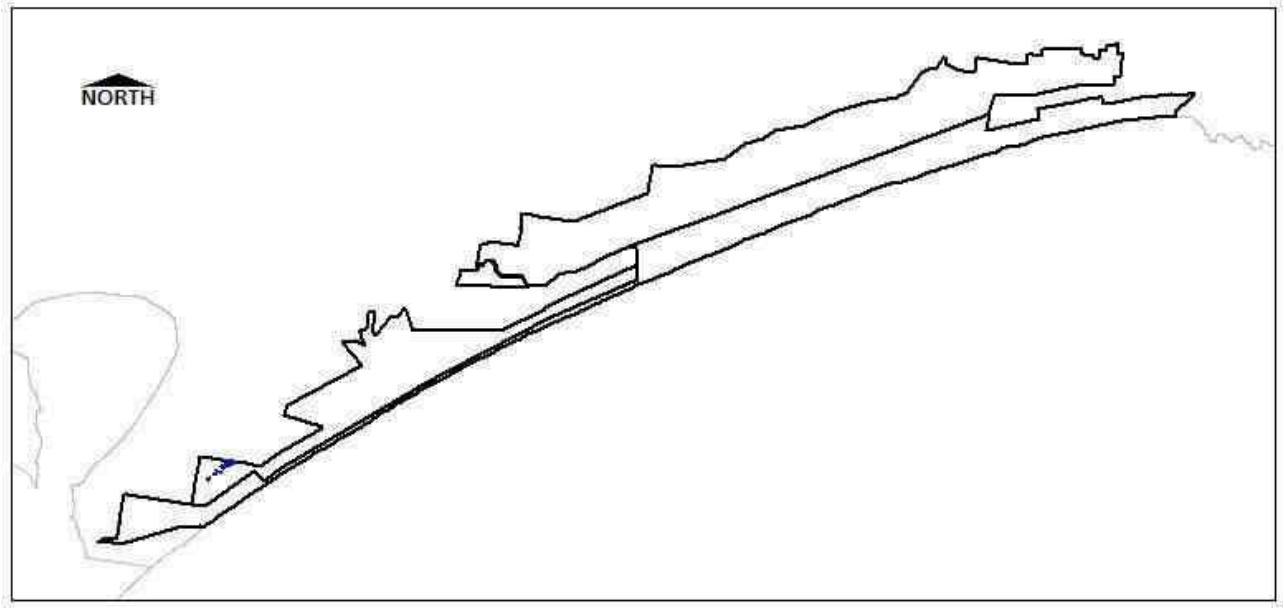
Distribution:

Known with certainty only from the western parts of the WCL near Fern Bay, within Worimi SCA. There may be additional small occurrences in the western parts of Worimi NP, but none have been verified.

Extent: Worimi NP = 0.0 ha Worimi SCA = 4.2 ha Worimi RP = 0.0 ha Total = 4.2 ha

Relationship to Other Communities:

Depression Banksia Woodland is the only open woodland or heath vegetation community present in the WCL, and consequently it is unlikely to be confused with other communities. The presence of a widely scattered low canopy of *Banksia serrata* is not repeated elsewhere, and many of the species comprising the understorey are absent from other communities. This community also occurs on flat sand sheets at lower elevations to the dunes of higher relief, which support Frontal Dune Blackbutt-Apple Forest. Coastal Tea-tree – Banksia Scrub is superficially similar to this community, however the co-dominance of *Leptospermum laevigatum* in that community, and the lack of a well developed shrub layer, s=distinguishes the two.



Significant Species:

- Undescribed species – *Eucalyptus* sp. (Fern Bay) [hybrid *E.robusta* X *E. parramattensis* subsp. *decadens*]
- Threatened (TSC Act) – *none recorded*
- Rare (ROTAP) – *none recorded*

Community Conservation Status:

Reserve Representation - this vegetation type is not known from any other conservation reserve in the region.

TSC Act (1995) Status - not currently listed.

Vegetation Structure [based on 3 plots]:

Stratum	Mean height (m)	Min height (m)	Max height (m)	Mean cover (%)	Sdev	n
Emergent	-	-	-	-	-	-
Tallest	8.00	3.00	10.00	24.33	21.01	3
Middle 1	2.07	1.00	2.50	66.67	40.41	3
Middle 2	-	-	-	-	-	-
Lowest	0.97	0.10	1.50	13.00	19.05	3

Key Diagnostic Species [based on 3 plots]:

Species	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Calytrix tetragona	3.33	6.37	7.10	10.43	10.43
Leucopogon ericoides	3.00	6.37	7.10	10.43	20.85
Platysace lanceolata	3.00	6.37	7.10	10.43	31.28
Banksia serrata	3.33	5.55	2.71	9.09	40.37
Dillwynia retorta	2.67	4.90	4.90	8.02	48.39
Dianella caerulea var. assera	2.00	4.25	7.10	6.95	55.34
Schoenus ericetorum	2.00	4.25	7.10	6.95	62.29
Melaleuca nodosa	2.67	3.29	0.58	5.39	67.67
Ricinocarpos pinifolius	1.67	2.95	1.71	4.82	72.50
Brachyloma daphnoides subsp. daphnoides	1.67	2.77	2.78	4.53	77.03
Conospermum taxifolium	1.67	2.77	2.78	4.53	81.56

Species	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Leptospermum laevigatum	1.33	2.12	7.10	3.48	85.04
Cassytha glabella f. glabella	1.33	1.65	0.58	2.69	87.73
Olax stricta	1.33	1.65	0.58	2.69	90.43
Amperea xiphoclada var. xiphoclada	1.33	1.29	0.58	2.12	92.54
Leptospermum trinervium	1.67	1.29	0.58	2.12	94.66
Acacia longifolia	0.67	0.65	0.58	1.07	95.73
Acacia ulicifolia	1.00	0.65	0.58	1.07	96.80
Leptospermum polygalifolium subsp. cismontanum	1.00	0.65	0.58	1.07	97.87
Monotoca elliptica	0.67	0.65	0.58	1.07	98.94
Lomandra longifolia	2.00	0.65	0.58	1.06	100.00

3. Frontal Dune Blackbutt-Apple Forest Unit 3

Coastal Sand Apple – Blackbutt Forest REMS Unit 33

General Description:

Frontal Dune Blackbutt-Apple Forest occurs on freely draining Quaternary Sand deposits. In general terms, this vegetation type is characteristic of the NSW North Coast, and becomes disjunct in the Central Coast area south from Newcastle. In most locations, Blackbutt (*Eucalyptus pilularis*), and Smooth-barked Apple (*Angophora costata*) dominate the tree layer, often with *Banksia serrata*. Understorey vegetation typically includes several Fabaceae species, together with *Monotoca elliptica, Monotoca scoparia, Pteridium esculentum, Themeda australis, Imperata cylindrical var. major, Gonocarpus teucrioides,* and *Amperea xiphoclada* var. *xiphoclada*. Frontal Dune Blackbutt-Apple Forest is the most widespread community within the WCL.

Known Floristic/ Structural Variations:

Variations within this community relate predominantly to structure, which is influenced by proximity to the sea and fire history. The typical form occurs away from the immediate coastline, and supports a moderately tall canopy over a well developed understorey. Closer to the sea, such as in the eastern parts of Worimi NP, canopy height is much reduced and understorey diversity is low, perhaps exacerbated by regular fire events. In other areas, a dense shrub layer of *Dodonaea triquetra* and *Acacia longifolia* subsp. *longifolia* can occur. Targeted sampling within all of these observable variations failed to detect a consistent pattern in the numerical classification, hence all are considered as the one community.

Distribution:

Frontal Dune Blackbutt-Apple Forest is abundant in all three reserves, particularly in Worimi NP.

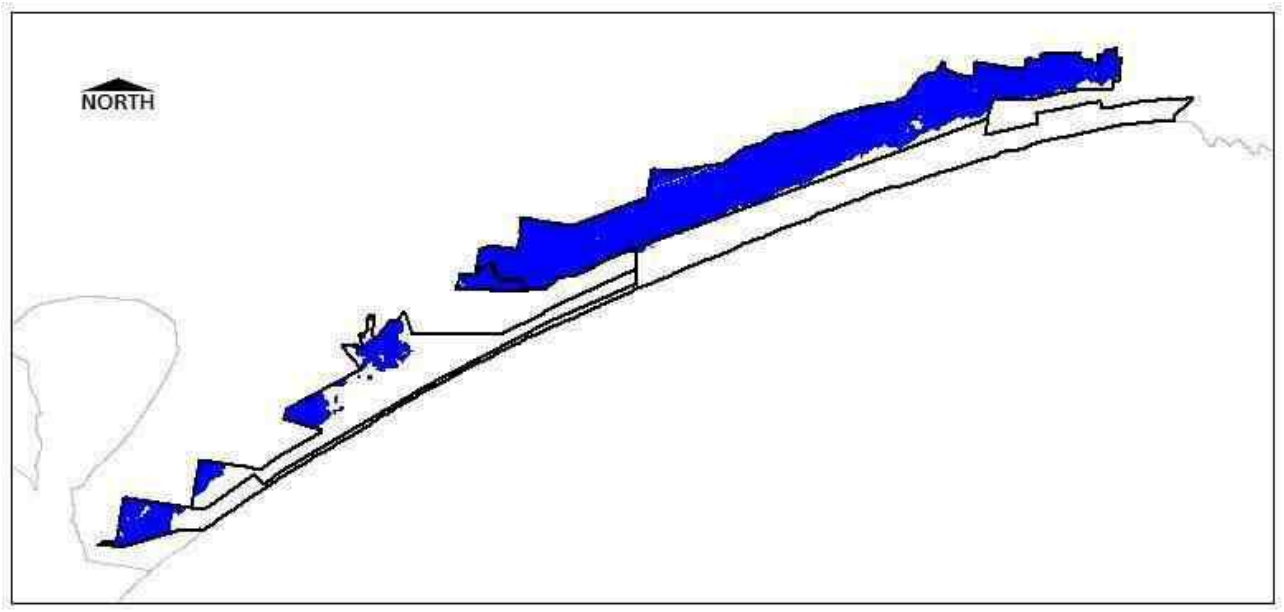
Extent: Worimi NP = 1656.0 ha Worimi SCA = 164.8 ha Worimi RP = 103.3 ha Total = 1924.1 ha

Relationship to Other Communities:

The co-dominance of *Eucalyptus pilularis, Angophora costata* and *Banksia serrata*, over a relatively diverse understorey, distinguish this community from all others in the WCL. Any of these three canopy species may also occur in the Paperbark-Mahogany Dry Swamp Forest, but the normally dominant stands of *Melaleuca quinquenervia* in that community, and areas of bare, compacted ground with little understorey development, separate the two.

Significant Species:

- Undescribed species – *none recorded*
- Threatened (TSC Act) – *Diuris arenaria* (Endangered)*; Diuris praecox* (Vulnerable)
- Rare (ROTAP) – *none recorded*



Community Conservation Status:

Reserve Representation - well represented in the region and beyond in a number of coastal conservation reserves.

TSC Act (1995) Status - not currently listed.

Vegetation Structure [based on 36 plots]:

Stratum	Mean height (m)	Min height (m)	Max height (m)	Mean cover (%)	Sdev	n
Emergent	-	-	-	-	-	-
Tallest	12.38	5.00	30.00	39.61	22.96	36
Middle 1	5.95	0.10	15.00	24.38	28.33	29
Middle 2	4.54	0.70	12.00	35.00	32.93	36
Lowest	0.84	0.01	1.70	40.22	35.24	36

Key Diagnostic Species [based on 36 plots]:

Species	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Pteridium esculentum	4.75	8.24	3.77	13.69	13.69
Angophora costata	3.11	5.38	4.58	8.94	22.63
Banksia serrata	2.61	4.21	2.83	6.99	29.62
Eucalyptus pilularis	2.72	3.89	1.50	6.46	36.08
Gonocarpus teucrioides	2.17	3.84	6.29	6.39	42.47
Imperata cylindrica var. major	2.22	3.30	1.84	5.49	47.96
Hibbertia linearis	1.78	3.09	2.61	5.13	53.09
Lomandra longifolia	2.06	3.02	1.91	5.03	58.11
Themeda australis	2.00	2.81	1.59	4.68	62.79
Bossiaea rhombifolia subsp. rhombifolia	2.19	2.76	1.19	4.58	67.37
Dianella caerulea var. assera	1.83	2.38	1.14	3.96	71.33
Leucopogon lanceolatus var. gracilis	1.42	1.72	0.95	2.86	74.19
Aotus ericoides	1.44	1.42	0.84	2.36	76.55
Acacia longifolia subsp. longifolia	1.11	1.38	1.22	2.29	78.84
Acacia ulicifolia	1.19	1.28	1.02	2.12	80.96

Species	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Monotoca elliptica	1.08	1.22	1.00	2.03	82.98
Acacia suaveolens	1.06	1.19	0.92	1.98	84.97
Persoonia levis	0.78	1.15	1.21	1.92	86.88
Hardenbergia violacea	0.97	1.11	0.97	1.84	88.72
Ricinocarpos pinifolius	0.92	0.78	0.61	1.30	90.02
Glycine clandestina	0.81	0.77	0.72	1.28	91.30
Dillwynia retorta	1.14	0.72	0.48	1.20	92.51
Pomax umbellata	0.81	0.64	0.53	1.06	93.56
Brachyloma daphnoides subsp. daphnoides	0.78	0.55	0.53	0.91	94.47
Platysace lanceolata	0.83	0.53	0.42	0.88	95.35
Pandorea pandorana	0.58	0.37	0.42	0.61	95.96
Billardiera scandens	0.44	0.33	0.45	0.54	96.51
Bossiaea heterophylla	0.58	0.30	0.32	0.50	97.00
Cassytha glabella f. glabella	0.39	0.24	0.37	0.41	97.41
Tetratheca thymifolia	0.53	0.22	0.29	0.36	97.77
Eragrostis brownii	0.39	0.17	0.26	0.28	98.05
Platysace ericoides	0.36	0.11	0.20	0.19	98.24
Dillwynia glaberrima	0.33	0.10	0.20	0.17	98.41
Dodonaea triquetra	0.36	0.10	0.21	0.17	98.58
Kennedia rubicunda	0.31	0.10	0.20	0.16	98.74
Leucopogon margarodes	0.33	0.10	0.18	0.16	98.90
Acianthus fornicatus	0.36	0.09	0.16	0.15	99.05

4. Paperbark-Mahogany Sedge Swamp Forest Unit 4

Swamp Mahogany – Paperbark Swamp Forest REMS Unit 37

General Description:

Swamp forests dominated by paperbarks are relatively common along the eastern seaboard of New South Wales, and are particularly associated with coastal sand masses. In WCL, Paperbark-Mahogany Sedge Swamp Forest is typified by a canopy of *Melaleuca quinquenervia* with occasional *Eucalyptus robusta*, over an understorey dominated by sedges. In some places, *Eucalyptus tereticornis* also occurs in the canopy. This community represents the 'wettest' of the four swamp forest communities present in the WCL, although at the time of survey there was little surface water evident.

Known Floristic/ Structural Variations:

Variation in this community relates directly to depth to the water table. In areas regularly inundated with water, sedges predominate. However, where the water table is slightly deeper, shrubs (*Dodonaea triquetra, Acacia longifolia* subsp. *longifolia, Acacia irrorata* subsp. *irrorata*) become more prominent.

Distribution:

Restricted to one main area towards the eastern end of Worimi NP.

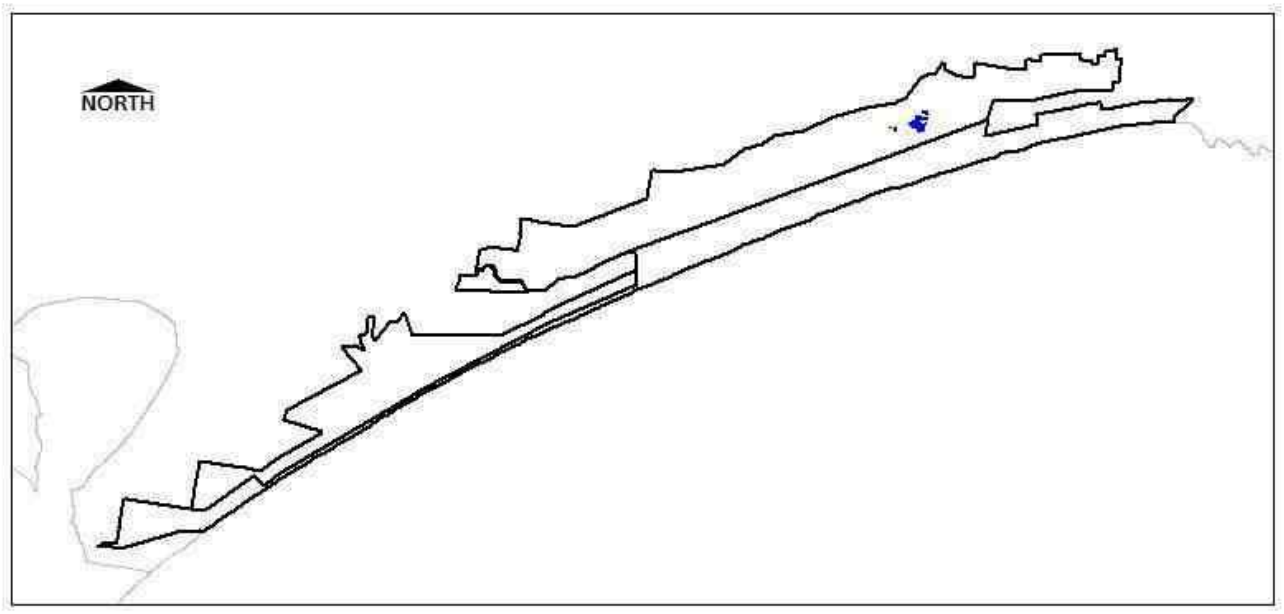
Extent: Worimi NP = 8.3 ha Worimi SCA = 0.0 ha Worimi RP = 0.0 ha Total = 8.3 ha

Relationship to Other Communities:

Paperbark-Mahogany Sedge Swamp Forest is closely related to other swamp forest types through a sharing of *Melaleuca quinquenervia* in the canopy layer. However, the dominance of sedge species (*Baumea articulata, Baumea juncea*) in the understorey distinguishes this community from the others.

Significant Species:

- Undescribed species – *none recorded*
- Threatened (TSC Act) – *none recorded*
- Rare (ROTAP) – *none recorded*



Community Conservation Status:

Reserve Representation - likely to be well represented within regional conservation reserves along the coastal zone, although rarely occurring as extensive stands.

TSC Act (1995) Status - not currently listed. Occurrence of this community on a coastal sand body without the presence of alluvial soils precludes inclusion in the Swamp Sclerophyll Forest on Coastal Floodplains EEC.

Vegetation Structure [based on 2 plots]:

Stratum	Mean height (m)	Min height (m)	Max height (m)	Mean cover (%)	Sdev	n
Emergent	-	-	-	-	-	-
Tallest	12.00	8.00	12.00	80.00	7.07	2
Middle 1	-	2.00	3.00	5.00	-	1
Middle 2	-	-	-	-	-	-
Lowest	0.75	0.01	1.30	45.50	62.93	2

Key Diagnostic Species [based on 2 plots]:

Species	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Melaleuca quinquenervia	6.00	29.27	-	75.00	75.00
Acacia longifolia subsp. longifolia	1.50	4.88	-	12.50	87.50
Kennedia rubicunda	1.00	4.88	-	12.50	100.00

5. Paperbark-Mahogany Dry Swamp Forest Unit 5

Swamp Mahogany – Paperbark Swamp Forest REMS Unit 37

General Description:

Paperbark-Mahogany Dry Swamp Forest occurs characteristically as small, open depressions in level to slightly undulating sand sheets within WCL. The canopy is dominated by *Melaleuca quinquenervia*, and occasionally *Eucalyptus robusta*, and the shrub layer is sparse or completely absent. The depressions in which this community occurs are close to the underlying water table, and are periodically subject to waterlogging during wet periods. As a consequence, ground layer vegetation composition is dynamic, with species turnover high as local conditions alternate between wet and dry. During the current survey period, this layer of vegetation tended to be dominated by grasses and graminoids, with occasional shrub and sedge species.

Known Floristic/ Structural Variations:

No variations are recognised for this community, although the floristic composition present at any one time or in any one stand is dependent on depth to the water table. When these areas are dry (such as during the current survey period), ground layer vegetation is sparse with grasses and graminoids dominating, and often with large bare areas where water would pool during wetter periods. The extent of *Melaleuca quinquenervia* or *Eucalyptus robusta* stands tends to be related to the size of the depression involved.

Distribution:

Scattered throughout the WCL, but predominantly within Worimi NP. Many stands are very small in size (10-20m across), and hence complete mapping of this community at an appropriate scale may not have been achieved.

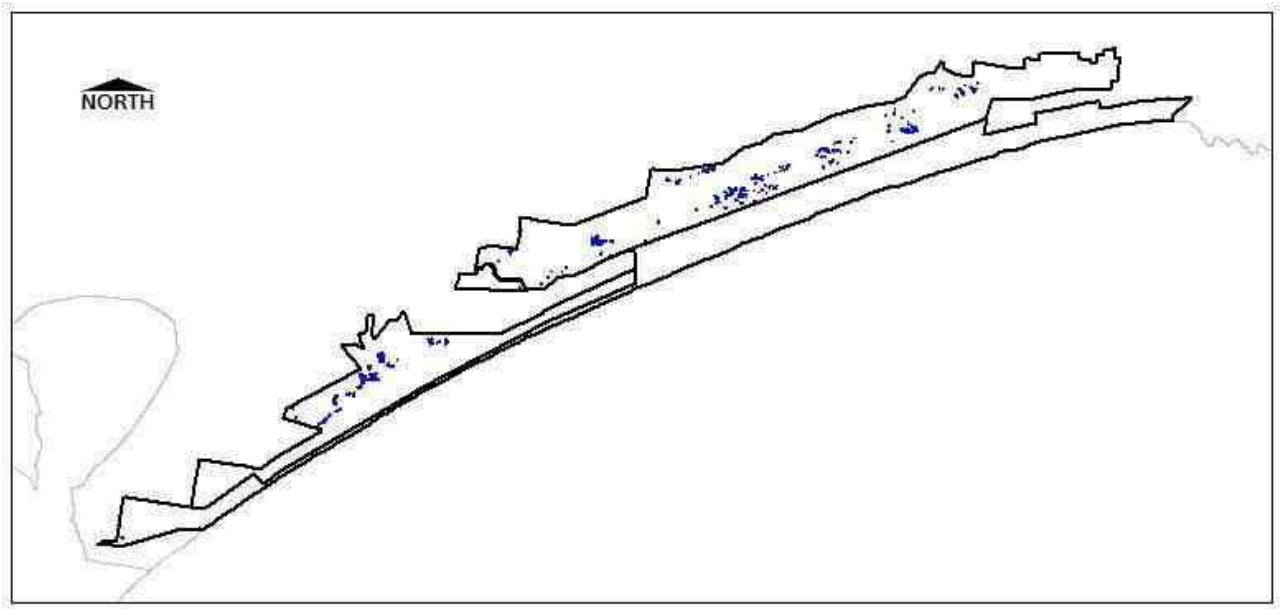
Extent: Worimi NP = 22.0 ha Worimi SCA = 14.4 ha Worimi RP = 0.12 ha Total = 36.5 ha

Relationship to Other Communities:

In common with three other communities, Paperbark-Mahogany Dry Swamp Forest shares *Melaleuca quinquenervia* and *Eucalyptus robusta* in the canopy layer. However, the grassy nature of the ground layer in this community, coupled with the open bare areas on the ground, distinguish this community from all others. Mahogany-Paperbark Sedge Swamp Forest is dominated in the ground layer by sedges (*Baumea articulata, Baumea juncea*), while Paperbark-Mahogany Wet Swamp Forest supports *Gahnia clarkei* and *Livistona australis* as notable components. Mahogany-Baloskion Swamp Forest, perhaps the mostly similar of the three swamp forest types, is characterised by the presence of *Baloskion tetraphyllum* in the ground layer, and often dense stands of *Melaleuca nodosa* and *Leptospermum* spp. in the shrub layer.

Significant Species:

- Undescribed species – *none recorded*
- Threatened (TSC Act) – *none recorded*
- Rare (ROTAP) – *none recorded*



Community Conservation Status:

Reserve Representation - representation in other regional reserves is unknown, however it is to be expected in coastal sand bodies north from Newcastle.

TSC Act (1995) Status - not currently listed. Occurrence of this community on a coastal sand body without the presence of alluvial soils precludes inclusion in the Swamp Sclerophyll Forest on Coastal Floodplains EEC.

Vegetation Structure [based on 11 plots]:

Stratum	Mean height (m)	Min height (m)	Max height (m)	Mean cover (%)	Sdev	n
Emergent	-	-	-	-	-	-
Tallest	14.00	8.00	18.00	39.09	23.43	11
Middle 1	4.27	1.00	10.00	25.27	21.70	11
Middle 2	-	-	-	-	-	-
Lowest	1.02	0.01	2.50	49.09	33.45	11

Key Diagnostic Species [based on 11 plots]:

Species	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Melaleuca quinquenervia	3.91	6.95	2.80	14.16	14.16
Imperata cylindrica var. major	3.09	5.22	2.42	10.63	24.80
Pomax umbellata	2.55	4.32	3.69	8.81	33.61
Lomandra longifolia	1.64	2.77	3.01	5.65	39.25
Acacia longifolia subsp. longifolia	1.91	2.54	1.46	5.17	44.43
Platysace lanceolata	1.64	2.51	1.26	5.12	49.55
Gonocarpus teucrioides	1.45	2.22	1.01	4.52	54.07
Dillwynia retorta	1.55	1.94	0.94	3.95	58.02
Kennedia rubicunda	1.09	1.81	1.99	3.69	61.72
Hemarthria uncinata var. uncinata	1.64	1.74	0.76	3.55	65.27

Species	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Dianella caerulea var. assera	1.27	1.67	1.20	3.40	68.67
Eucalyptus robusta	1.64	1.62	0.70	3.31	71.97
Banksia serrata	1.09	1.53	1.22	3.11	75.09
Acacia ulicifolia	0.91	1.41	1.36	2.88	77.97
Dodonaea triquetra	1.55	1.41	0.59	2.87	80.83
Panicum simile	1.09	1.32	0.92	2.68	83.51
Pteridium esculentum	1.00	1.21	0.95	2.47	85.98
Monotoca elliptica	0.91	1.14	0.98	2.32	88.30
Baloskion pallens	1.18	1.01	0.58	2.06	90.36
Eragrostis brownii	0.91	0.81	0.56	1.65	92.01
Setaria distans	0.82	0.61	0.44	1.25	93.26
Juncus continuus	0.73	0.51	0.43	1.04	94.30
Leucopogon lanceolatus var. gracilis	0.45	0.40	0.47	0.81	95.11
Acacia irrorata subsp. irrorata	0.55	0.39	0.47	0.79	95.90
Conospermum taxifolium	0.64	0.34	0.33	0.70	96.60
Aotus ericoides	0.55	0.28	0.32	0.58	97.18
Banksia integrifolia subsp. integrifolia	0.36	0.24	0.35	0.49	97.66
Blechnum indicum	0.55	0.17	0.22	0.34	98.01
Cassytha glabella forma glabella	0.45	0.16	0.23	0.32	98.32
Actinotus helianthi	0.36	0.12	0.24	0.25	98.57
Persoonia levis	0.27	0.12	0.24	0.24	98.81
Goodenia paniculata	0.36	0.07	0.13	0.15	98.96
Baloskion tetraphyllum subsp. meiostachyum	0.27	0.04	0.13	0.09	99.05

6. Paperbark-Mahogany Wet Swamp Forest Unit 6

Swamp Mahogany – Paperbark Swamp Forest REMS Unit 37

General Description:

Paperbark-Mahogany Wet Swamp Forest is currently known from lands adjacent to the WCL, although it is possible that small occurrences may also occur within the reserves. Like similar swamp forests elsewhere in the reserves, this community is dominated by *Melaleuca quinquenervia* and *Eucalyptus robusta*, but also with the addition of occasional *Casuarina glauca* and *Livistona australis*. Ground layer vegetation is dominated by the large sedge *Gahnia clarkei*, indicating a high water table and ready access to relatively permanent water. Ground ferns *Blechnum indicum* and *Cyclosorus interuptus* are also prominent.

Known Floristic/ Structural Variations:

No floristic or structural variations have been delineated for this community.

Distribution:

Currently known with certainty only from lands adjacent to WCL north of Fern Bay.

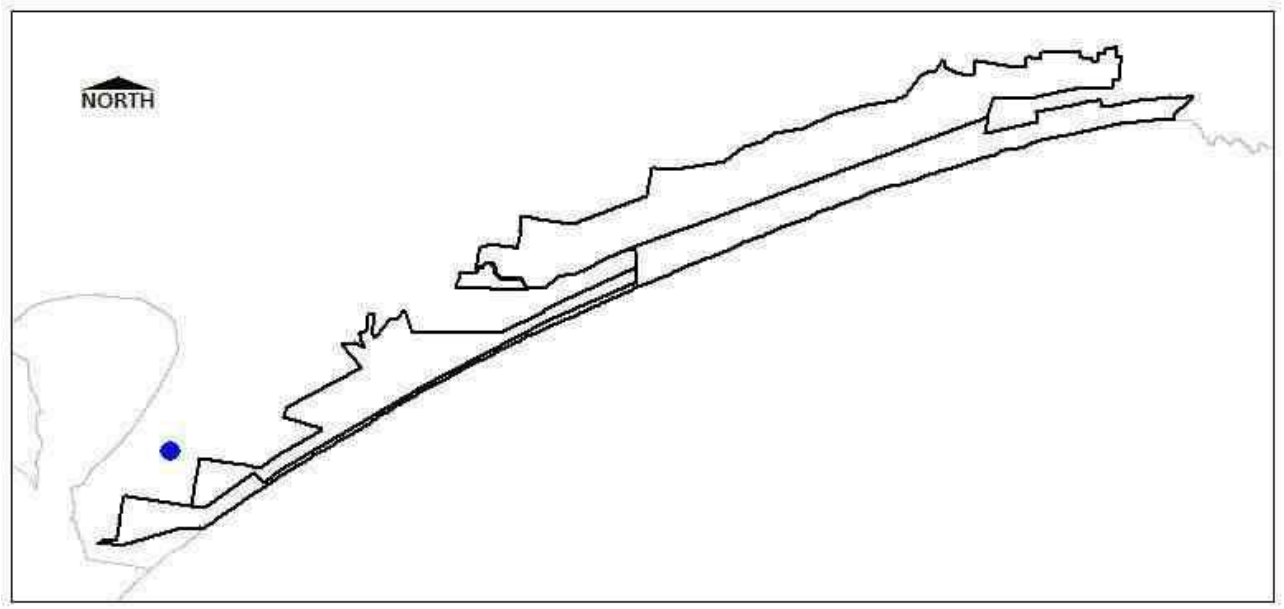
Extent: Worimi NP = 0.0 ha Worimi SCA = 0.0 ha Worimi RP = 0.0 ha Total = 0.0 ha

Relationship to Other Communities:

The dominance of *Gahnia clarkei* in the ground layer, together with *Livistona australis, Blechnum indicum* and *Cyclosorus interuptus*, distinguish this community from others supporting *Melaleuca quinquenervia* and *Eucalyptus robusta* in the canopy. Paperbark-Mahogany Sedge Swamp Forest is dominated by *Baumea articulata* and *Baumea juncea*, with only occasional *Gahnia clarkei*; Paperbark-Mahogany Dry Swamp Forest has a depauperate or non-existent ground layer and supports open grassy bare areas subject to irregular inundation; and Mahogany-Baloskion Swamp Forest supports *Baloskion tetraphyllum* and a shrub layer of *Melaleuca nodosa* and *Leptospermum* spp.

Significant Species:

- Undescribed species – *none recorded*
- Threatened (TSC Act) – *none recorded*
- Rare (ROTAP) – *none recorded*



Community Conservation Status:

Reserve Representation - unknown if this community is present within the regional reserve system, although closely related forms are present in several reserves on the North Coast.

TSC Act (1995) Status - not currently listed. Occurrence of this community on a coastal sand body without the presence of alluvial soils precludes inclusion in the Swamp Sclerophyll Forest on Coastal Floodplains EEC.

Vegetation Structure [based on 1 plot]:

Stratum	Mean height (m)	Min height (m)	Max height (m)	Mean cover (%)	Sdev	n
Emergent	-	-	-	-	-	-
Tallest	-	18.00	22.00	80.00	-	1
Middle 1	-	2.00	4.00	20.00	-	1
Middle 2	-	-	-	-	-	-
Lowest	-	0.10	1.00	100.00	-	1

Key Diagnostic Species [based on 1 plot]:

Species	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Blechnum indicum	-	-	-	-	-
Calystegia marginata	-	-	-	-	-
Carex appressa	-	-	-	-	-
Casuarina glauca	-	-	-	-	-
Centella asiatica	-	-	-	-	-
Commelina cyanea	-	-	-	-	-
Cyclosorus interruptus	-	-	-	-	-
Dianella caerulea var. caerulea	-	-	-	-	-
Dioscorea transversa	-	-	-	-	-
Entolasia marginata	-	-	-	-	-
Eucalyptus robusta	-	-	-	-	-
Gahnia clarkei	-	-	-	-	-
Glochidion ferdinandi var. pubens	-	-	-	-	-
Homalanthus populifolius	-	-	-	-	-

Species	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Hydrocotyle verticillata	-	-	-	-	-
Lantana camara	-	-	-	-	-
Livistona australis	-	-	-	-	-
Lobelia anceps	-	-	-	-	-
Lycopus australis	-	-	-	-	-
Melaleuca quinquenervia	-	-	-	-	-
Melaleuca styphelioides	-	-	-	-	-
Oplismenus imbecillis	-	-	-	-	-
Parsonsia straminea	-	-	-	-	-
Persicaria strigosa	-	-	-	-	-
Phragmites australis	-	-	-	-	-
Solanum nigrum	-	-	-	-	-
Viola hederacea	-	-	-	-	-

7. Mahogany-Baloskion Swamp Forest Unit 7

Swamp Mahogany – Paperbark Swamp Forest REMS Unit 37

General Description:

Mahogany-Baloskion Swamp Forest occurs principally in the western parts of WCL, with best representation near Fern Bay. This community is characterised by low trees of *Eucalyptus robusta*, and only occasional *Melaleuca quinquenervia*. *Eucalyptus robusta x parramattensis* is also reasonably common in this community. More typical is the presence of a tall and often dense shrub layer of *Melaleuca nodosa* and *Leptospermum polygalifolium*, and a ground layer dominated by *Baloskion tetraphyllum* and *Lomandra longifolia*. This community occurs only in open depressions and drainage lines where a clay influence in the sand impedes free drainage and promotes the growth of species such as *Melaleuca nodosa*.

Known Floristic/ Structural Variations:

No variations have been delineated for this community.

Distribution:

Predominantly occurs in the Fern Bay area of Worimi RP, with smaller stands in Worimi NP.

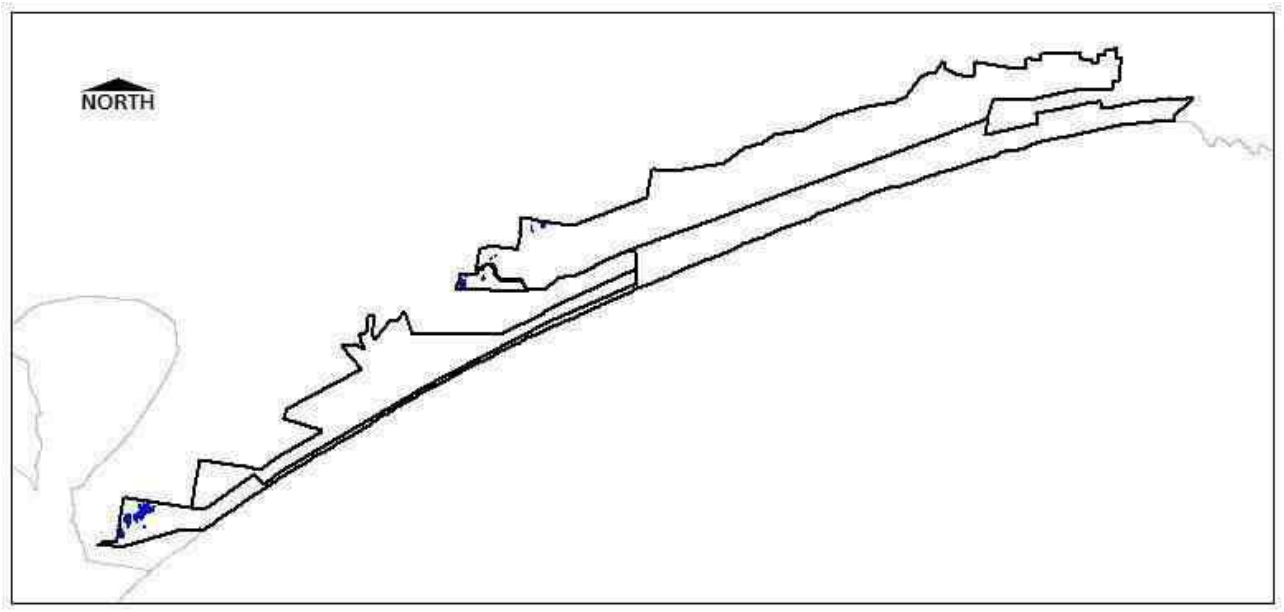
Extent: Worimi NP = 4.4 ha Worimi SCA = 0.0 ha Worimi RP = 11.1 ha Total = 15.5 ha

Relationship to Other Communities:

Mahogany-Baloskion Swamp Forest is distinguishable from the three other swamp forest types present in the WCL by the low abundance or absence of *Melaleuca quinquinervia*, the dominance of *Melaleuca nodosa* and *Leptospermum polygalifolium* in the shrub layer, and the dominance of *Baloskion tetraphyllum* and *Lomandra longifolia* in the ground layer. Paperbark-Mahogany Sedge Swamp Forest is dominated by *Baumea articulata* and *Baumea juncea* in the ground layer; Paperbark-Mahogany Wet Swamp Forest supports dense stands of *Gahnia clarkei* and *Livistona australis*; and Paperbark-Mahogany Dry Swamp Forest has a depauperate or non-existent ground layer and supports open grassy bare areas subject to irregular inundation.

Significant Species:

- Undescribed species – *Eucalyptus* sp. (Fern Bay) [hybrid *E.robusta* X *E. parramattensis* subsp. *decadens*]
- Threatened (TSC Act) – *none recorded*
- Rare (ROTAP) – *none recorded*



Community Conservation Status:

Reserve Representation - this vegetation type is likely to be present in several regional reserves along the coastal zone north from Newcastle.

TSC Act (1995) Status - not currently listed. Occurrence of this community on a coastal sand body without the presence of alluvial soils precludes inclusion in the Swamp Sclerophyll Forest on Coastal Floodplains EEC.

Vegetation Structure [based on 4 plots]:

Stratum	Mean height (m)	Min height (m)	Max height (m)	Mean cover (%)	Sdev	n
Emergent	-	-	-	-	-	-
Tallest	10.00	4.00	14.00	23.75	8.54	4
Middle 1	3.63	0.50	6.00	71.25	20.16	4
Middle 2	-	-	-	-	-	-
Lowest	1.02	0.10	1.70	50.00	38.94	4

Key Diagnostic Species [based on 4 plots]:

Species	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Leptospermum polygalifolium subsp. cismontanum	4.50	10.33	3.05	26.18	26.18
Eucalyptus robusta	3.50	8.84	4.00	22.39	48.56
Baloskion tetraphyllum subsp. meiostachyum	3.75	5.70	0.75	14.44	63.00
Aotus ericoides	2.00	4.32	2.08	10.94	73.94
Lomandra longifolia	2.25	2.72	0.90	6.90	80.84
Dillwynia retorta	1.25	1.35	0.90	3.42	84.26
Acacia longifolia subsp. longifolia	0.75	1.27	0.90	3.22	87.48
Melaleuca nodosa	1.75	1.19	0.41	3.02	90.50
Baloskion pallens	1.75	0.78	0.41	1.99	92.48
Dianella caerulea var. assera	1.00	0.78	0.41	1.99	94.47
Gahnia clarkei	0.75	0.48	0.41	1.22	95.69
Schoenus brevifolius	0.75	0.48	0.41	1.22	96.92
Gonocarpus teucrioides	0.75	0.43	0.41	1.08	98.00
Pomax umbellata	0.75	0.40	0.41	1.01	99.01

8. Coastal Tea-tree – Banksia Scrub Unit 8

Coastal Sand Scrub REMS Unit 50

General Description:

Coastal Tea-tree – Banksia Scrub occurs principally in the Worimi SCA and Worimi RP areas off Lavis Lane, on low dune rises and slopes. It is typified by often dense stands of *Leptospermum laevigatum* with *Banksia serrata* and occasional *Banksia integrifolia* subsp. *integrifolia*. Understorey species include *Acacia longifolia* subsp. *sophorae* and *Monotoca elliptica*, and ground layer species are sparse but often include *Imperata cylindrica* var. *major* and *Lomandra longifolia*. Parts of the area mapped as this community may include small areas of previously mined land that have now been revegetated with *Leptospermum laevigatum* dominant.

Known Floristic/ Structural Variations:

No variations have been delineated for this community.

Distribution:

Occurs predominantly in the Worimi SCA and Worimi RP areas off Lavis Lane.

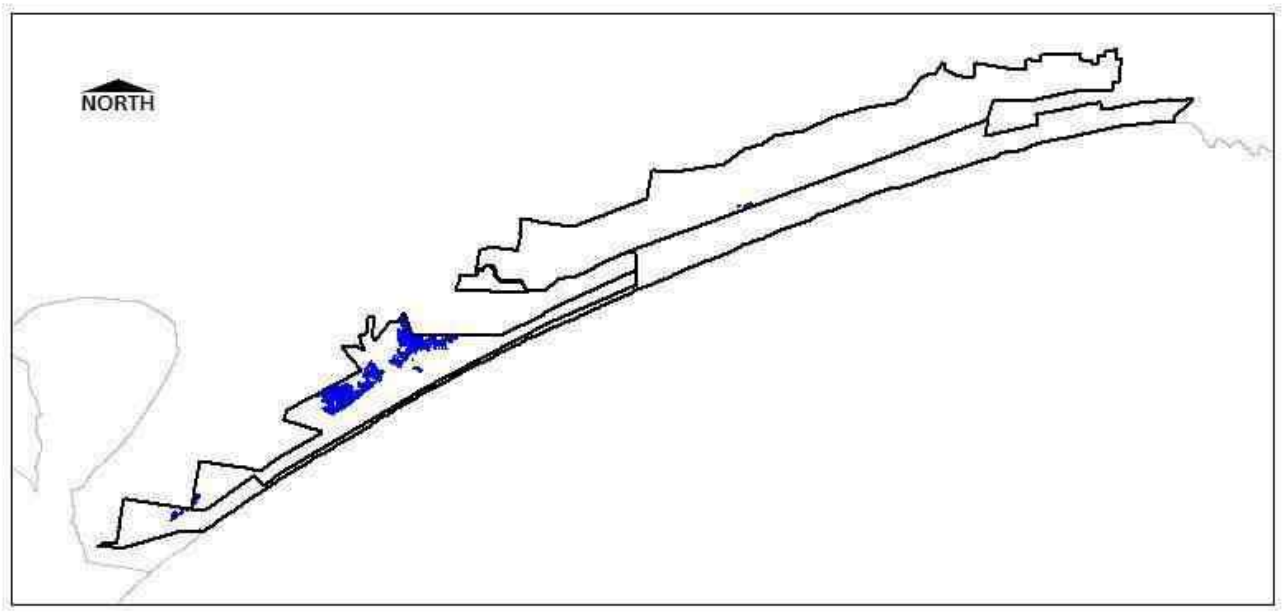
Extent: Worimi NP = 0.4 ha Worimi SCA = 95.5 ha Worimi RP = 2.3 ha Total = 98.2 ha

Relationship to Other Communities:

Coastal Tea-tree – Banksia Scrub is the only community within the WCL that is dominated by dense stands of *Leptospermum laevigatum*, together with *Banksia serrata* and *Banksia integrifolia* subsp. *integrifolia*. Depression Banksia Woodland may approach this type in some parts, however that community supports a larger number of understorey species not present in Coastal Tea-tree – Banksia Scrub, and it occurs on flat sand sheets.

Significant Species:

- Undescribed species – *none recorded*
- Threatened (TSC Act) – *none recorded*
- Rare (ROTAP) – *none recorded*



Community Conservation Status:

Reserve Representation - it is unknown how extensive this vegetation type is elsewhere in the region. Broadly similar vegetation was present in the Wyrrabalong NP area near Norah Head on the Central Coast, but much of this has now been lost to development.

TSC Act (1995) Status - not currently listed.

Vegetation Structure [based on 5 plots]:

Stratum	Mean height (m)	Min height (m)	Max height (m)	Mean cover (%)	Sdev	n
Emergent	-	-	-	-	-	-
Tallest	9.20	5.00	10.00	16.00	10.84	5
Middle 1	4.00	1.00	5.00	82.00	5.70	5
Middle 2	-	-	-	-	-	-
Lowest	0.74	0.01	1.50	7.60	9.79	5

Key Diagnostic Species [based on 5 plots]:

Species	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Leptospermum laevigatum	4.80	15.53	7.51	27.11	27.11
Monotoca elliptica	3.20	9.45	2.46	16.50	43.60
Acacia longifolia subsp. longifolia	2.80	8.67	7.02	15.14	58.74
Banksia integrifolia subsp. integrifolia	2.60	8.12	2.49	14.17	72.91
Dianella caerulea var. caerulea	1.40	3.43	5.00	5.98	78.90
Banksia serrata	2.00	2.92	1.01	5.09	83.99
Carpobrotus glaucescens	1.00	1.71	0.56	2.98	86.97
Pterostylis concinna	1.00	1.33	0.58	2.32	89.29
Conospermum taxifolium	0.80	1.26	0.62	2.20	91.49
Cassytha pubescens	1.00	1.10	0.59	1.92	93.41
Lomandra longifolia	1.00	1.10	0.59	1.92	95.34
Acianthus fornicatus	0.80	0.51	0.32	0.88	96.22
Platysace lanceolata	1.00	0.51	0.32	0.88	97.11
Persoonia lanceolata	0.60	0.36	0.32	0.63	97.74
Digitaria parviflora	0.60	0.28	0.32	0.49	98.23

Species	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Allocasuarina littoralis	0.60	0.25	0.32	0.44	98.67
Imperata cylindrical var. major	0.60	0.25	0.32	0.44	99.12

9. Beach Wetlands Unit 9

n/a REMS Unit n/a

General Description:

Along the length of Stockton Beach. depressions within the dune systems commonly support one of several forms of Beach Wetlands. These wetlands form where fresh groundwater meets the surface, typically at the foot of larger sand dunes, and allow simple ecosystems of perennial and ephemeral wetland species to survive. Past disturbance through mining of beach sands and 4WD activities has allowed the invasion of these wetlands by several weed species, the most notable of which is Spiny Rush (*Juncus acutus*). Extensive swathes of this species are present in the wetlands towards the southern section of Stockton Beach, and have completely transformed the wetlands there.

Known Floristic/ Structural Variations:

Five floristic variations have been recognised in this study, and are referred to collectively as Beach Wetlands:

- *Ficinia* Reedlands (dominated by *Ficinia nodosa*)
- *Typha* Reedlands (dominated by *Typha domingensis*)
- *Phragmites* Grasslands (dominated by *Phragmites australis*)
- *Carex* Meadows (dominated by *Carex pumila*)
- *Juncus* Reedlands (dominated by *Juncus acutus*)

Many wetlands support the invasive *Juncus acutus* to varying degrees; those dominated by this species have been mapped separately as few native species persist in these environments. Beach Soaks have also been mapped separately, and comprise mostly wet sand where the groundwater table meets the surface after rain events. It is these areas where new Beach Wetlands may develop over time.

Distribution:

Occur along the entire length of Stockton Beach, generally behind the immediate foredune.

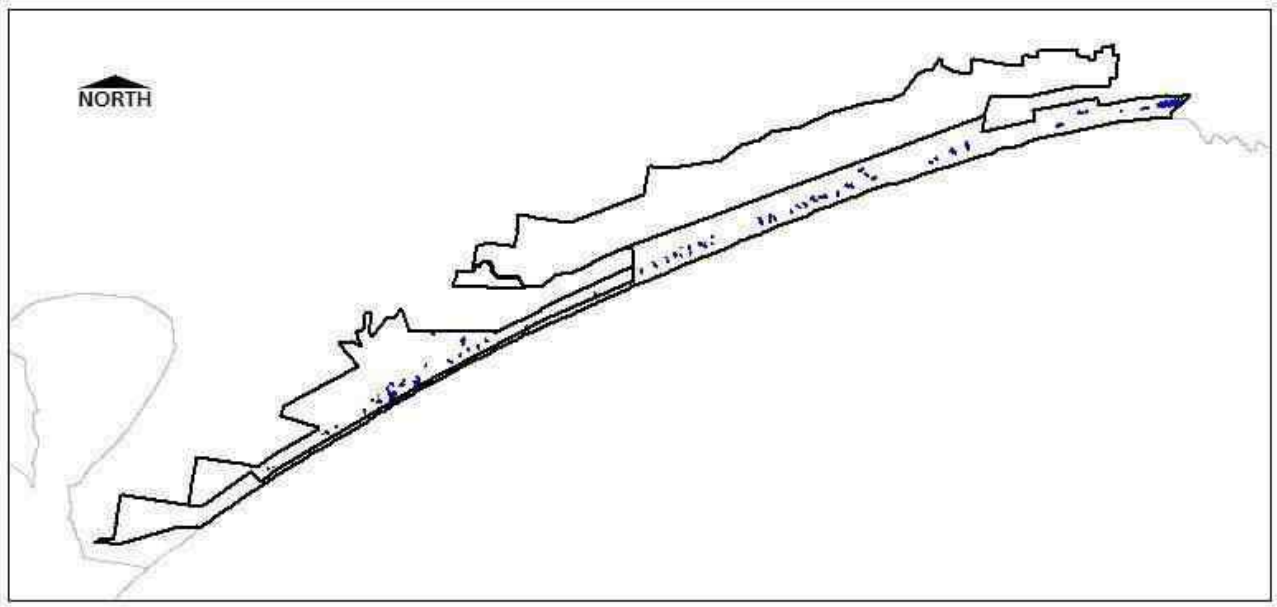
Extent: Worimi NP = 0.0 ha Worimi SCA = 6.4 ha Worimi RP = 15.1 ha Total = 21.5 ha

Relationship to Other Communities:

Structurally, the Beach Wetlands differ from all other described communities for the Worimi CLs. However, several of the component species (eg: *Phragmites australis, Ficinia nodosa, Baumea juncea*) do occur in some swamp forest communities.

Significant Species:

- Undescribed species – *none recorded*
- Threatened (TSC Act) – *Senecio spathulatus* (Endangered) may occur around wetland edges
- Rare (ROTAP) – *none recorded*



Community Conservation Status:

Reserve Representation - it is unknown how extensive this vegetation type is elsewhere in the region, however it is likely that other coastal reserves with sizeable beach frontages (eg: Myall Lakes NP, Wyrrabalong NP) will support similar vegetation.

TSC Act (1995) Status - possibly forms a component of *Sydney Freshwater Wetlands* EEC.

Vegetation Structure [based on 5 plots]:

Stratum	Mean height (m)	Min height (m)	Max height (m)	Mean cover (%)	Sdev	n
Emergent	-	-	-	-	-	-
Tallest	1.30	0.70	1.90	90.00	8.66	5
Middle 1	-	-	-	-	-	-
Middle 2	-	-	-	-	-	-
Lowest	0.26	0.10	0.30	26.00	38.63	5

Key Diagnostic Species [based on 5 plots]:

Species	Av. Abund	Av. Sim	Sim/SD	Contrib%	Cum.%
Ficinia nodosa	2.60	16.24	0.81	92.73	92.73
Melaleuca quinquenervia	0.60	0.67	0.32	3.81	96.54
Typha domingensis	1.40	0.61	0.32	3.46	100.00

A range of additional wetland species are also present within the Beach Wetlands, however these have not been determined as diagnostic during the analysis due to limited plot data. *Carex pumila*, in particular, is a consistent species in many wetlands, but this has not been borne out in sampling.