Warkworth Sands Woodland - An Endangered Ecological Community
Distribution, Ecological Significance and Conservation Status

Authors: Travis Peake, Stephen Bell, Terry Tame, John Simpson and Tim Curran
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Preamble

In October 2002, the NSW Scientific Committee made a preliminary determination to list Warkworth Sands Woodland as an Endangered Ecological Community on the NSW Threatened Species Conservation Act 1995, and on 13th December 2002, a final determination was made to list the community as endangered. This listing follows a long history of reports and statements recognising the geomorphological and botanical significance of the area, starting as early as the 1960's (eg: Galloway 1963; Story et al 1963; Benson 1981a). The Hunter Rare Plants Committee has prepared this statement in response to the preliminary and final determinations to provide interested individuals and organisations with further information on the community. This technical note aims to provide information on the distribution, ecological significance and conservation status of Warkworth Sands Woodland for use by researchers, land managers, consultants and the general public.

Background

During regional vegetation surveys recently undertaken in the Hunter Valley, a small area of remnant vegetation near Warkworth was identified and classified as a regionally significant community (Peake 2000). It was also recognised that the area was under significant and immediate threat. Since then, the NSW Scientific Committee has made a determination to list the community as endangered.

As a component of other vegetation surveys (eg. Bell 2000; NSW NPWS 1999; Peake in prep.) literature review, aerial photograph interpretation and field reconnaissance were undertaken to ascertain the spatial distribution of the Warkworth Sands Woodland. Subsequently, it was revealed that this vegetation type is highly restricted, currently occupying an area of approximately 800ha in a largely agricultural and mining landscape within Singleton LGA in the Sydney Basin Bioregion. While regional survey and classification of the vegetation in the lower Hunter and Central Coast region has recently been completed (NSW NPWS 1999), it was realised that the Warkworth Sands Woodland did not readily conform to any of the units described therein. Consequently, follow-up investigations as part of other surveys were directed at determining the significance of this community at a local and regional level.

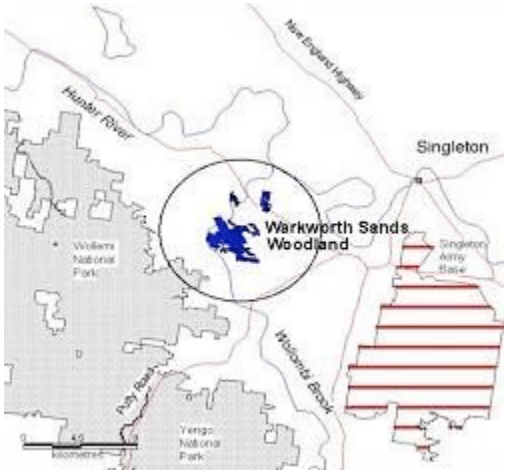

Figure 1: Location of Warkworth Sands Woodland

Location & general description

Warkworth Sands Woodland occupies a small area in the Hunter Valley near Warkworth, between Singleton and Bulga, in the Singleton LGA of the mid Hunter Valley (see Figure 1). The vegetation type is distinct in the local area due to the dominance of coast banksia (*Banksia integrifolia* subsp. *integrifolia*), rough-barked apple (*Angophora floribunda*), fern-leaved wattle (*Acacia filicifolia*), bracken (*Pteridium esculentum*) and blady grass (*Imperata cylindrica* var. *major*) within a largely grey box (*Eucalyptus moluccana*) - narrow-leaved ironbark (*E. crebra*) and spotted gum (*Corymbia maculata*) woodland landscape. Understorey vegetation in Warkworth Sands Woodland supports species more typical of sand or sandstone-based environments, and include blunt beard-heath (*Leucopogon muticus*), *Brachyloma daphnoides* subsp. *daphnoides*, Guinea flower (*Hibbertia linearis*), slender rice flower (*Pimelea linifolia* subsp. *linifolia*), blady grass, bracken and thyme-leaved paperbark (*Melaleuca thymifolia*). Plates 1 & 2 illustrate the community.

It has been estimated that approximately 800ha of an original 6020ha of this vegetation type remains, with the majority having been cleared for agricultural development.

Plate 1: Acacia filicifolia, Banksia integrifolia subsp. integrifolia and Pteridium esculentum are the most characteristic dominant species in Warkworth Sands Woodland.

Plate 2: Here Angophora floribunda forms the canopy, with Breynia oblongifolia occurring in the shrub layer above Pteridium esculentum.

Geomorphological Setting

It is believed that the sand dunes at Warkworth formed some 18,000 to 15,000 years ago from the sandy alluvium of Wollombi Brook (Galloway 1963). Currently, linear sand dunes between 1 and 6 m high, rest on a high river terrace (Story et al. 1963). The main dune deposit is aligned NW-SE; Story et

al. (1963) note that it is generally stable but is subject to blow-outs. A further two small deposits are located east of Watts trig and another near the village of Warkworth itself, both of which have been largely cleared. Benson (1981a) notes that as well as the deeper sand deposits, there is a shallow "veneer" of sand continuing southward from the north-west end of the main sand deposit, which is separated from the main deposit by an area of clay soils developed on Permian sediments. An area of similar "sandy veneer" occurs to the north of the intersection between the Golden Highway and Long Point Road, about 2 km north-east of the main deposit. Both areas of sandy veneer were included in the community described by the preliminary determination, due to the presence of characteristic species such as *Banksia integrifolia* subsp. *integrifolia, Acacia filicifolia and Angophora floribunda,* albeit in reduced abundance.

Soil landscape mapping published for the Singleton 1:250 000 map sheet shows three occurrences of the Warkworth soil landscape (SS-ww) (Kovac and Lawrie 1991); however, none of these three coincides with the main sand deposit described by Story et al. (1963), Benson (1981a) and Peake (in prep.). The Warkworth soil landscape is therein described as one of linear sand dunes 1-3 m high on old river terraces, generally aligned north-west to south-west (sic) (Kovac and Lawrie 1991).

Description

In defining Warkworth Sands Woodland the following common species were listed in the preliminary and final determinations, and are here listed according to whether or not they are abundant and/or characteristic, or less common:

Abundant and/or Characteristic Taxa	**Less Common Taxa**
Acacia filicifolia	*Acacia falcata*
Allocasuarina littoralis	*Ajuga australis*
Amyema pendulum subsp. *pendulum*	*Allocasuarina luehmannii*
Angophora floribunda	*Aristida ramosa* var. *speciosa*
Aristida calycina var. *calycina*	*Aristida warburgii*
Aristida vagans	*Calotis cuneifolia*
Banksia integrifolia subsp. *integrifolia*	*Cheilanthes sieberi* subsp. *sieberi*
Brachyloma daphnoides subsp. *daphnoides*	*Chrysocephalum apiculatum*
Breynia oblongifolia	*Desmodium varians*
Callitris endlicheri	*Dichondra* species A
Dianella revolute var. *revoluta*	*Echinopogon caespitosus* var. *caespitosus*
Entolasia stricta	*Echinopogon intermedius*
Eucalyptus blakelyi/tereticornis	*Einadia trigonos*

Exocarpos cupressiformis	*Eucalyptus crebra*
Exocarpos strictus	*Eucalyptus glaucina*
Hardenbergia violacea	*Hovea linearis*
Hibbertia linearis	*Hypoxis hygrometrica* var. *hygrometrica*
Imperata cylindrica var. *major*	*Indigofera australis*
Jacksonia scoparia	*Melaleuca decora*
Leucopogon muticus	*Solanum prinophyllum*
Lomandra glauca	*Vittadinia sulcata*
Lomandra leucocephala subsp. *leucocephala*	
Melaleuca thymifolia	
Persoonia linearis	
Pimelea linifolia subsp. *linifolia*	
Pomax umbellata	
Pteridium esculentum	

As noted by the NSW Scientific Committee preliminary and final determinations, not all species are present in every single stand, and the total species list from all stands of the community is considerably larger than that listed above, with some 99 species being recorded to date. At any one time, seeds of some species may only be present in the soil seed bank with no above ground individuals present. The species composition of a stand will be influenced by the size of the stand and by its recent disturbance history. The number of species and the above-ground composition of species will change with time since fire, and may also change in response to altered fire frequencies.

Whilst the species listed above are found regularly in Warkworth Sands Woodland, many also occur in other communities. Small drainage lines within the community may support a higher abundance of certain species (such as *Melaleuca thymifolia*) and less of others (such as *Banksia integrifolia* subsp. *integrifolia*). Such areas are included as part of this community. In addition, adjacent areas where woodland occurs on a thin "veneer" of sand are included with this community description, despite the presence of other species more typical of surrounding communities.

Woodland occurring adjacent to the sand dunes on Permian clays shares many species with Warkworth Sands Woodland, but also has a higher abundance of Permian substrate species, such as *Corymbia maculata, Eucalyptus moluccana, Allocasuarina luehmannii* and *Eucalyptus crebra*. These areas are not considered to be part of this community, except in ecotones where there is a dominant abundance of the common and characteristic species listed above, particularly where a thin, "sandy veneer" overlies the Permian substrate.

Warkworth Sands Woodland was not described in NSW NPWS (1999). However, comparisons of species present and relative abundances with other communities defined in that document confirm that Warkworth Sands Woodland represents a distinct assemblage.

Distribution and Condition

Warkworth Sands Woodland is known only from Singleton Local Government Area, where it currently occupies an area of approximately 800ha. Mapping of land systems by Story et al. (1963) includes a further 10 locations (in addition to the two occurrences at Warkworth) with similar soils, landform and vegetation, all termed the "Warkworth Land System". Two of these at Kurri Kurri can now be confirmed to be floristically quite different (Benson 1981a). Due to the extent of vegetation clearing and alteration at the remaining eight other sites, they do not now support a similar vegetation community. It is likely, however, that at least some of the other occurrences of the Warkworth Land System supported a similar vegetation community, some being now simply dominated by *Acacia filicifolia* and *Pteridium esculentum* while others now are totally cleared. Indeed, the location of all occurrences, except two near Kurri Kurri, adjacent or close to existing or former river channels suggests that most may well have supported a broadly similar vegetation community to that occurring at Warkworth.

Currently, the Warkworth Sands Woodland comprises some 77% of the extant vegetation (Peake in prep.) on the ten occurrences of the land system that are considered to have similar attributes (ie. excluding the two occurrences of the Warkworth Land System near Kurri Kurri). Assuming that the ten relevant occurrences of the land system were fully vegetated prior to European settlement, it is estimated that only 13% of the former distribution of this vegetation community remains. None of the known community occurs within conservation reserves. A large proportion could be regarded to be threatened by proposed open cut coal mine extensions and a recently-approved sand mine, together with the associated infrastructure necessary to support these projects.

Conservation Status and Threats

Based on aerial photographic interpretation, GIS mapping and field reconnaissance, approximately 800ha of Warkworth Sands Woodland remains. Of this, approximately half is made up of Warkworth Sands Woodland (as described in the preliminary determination), while the other half contains dominant and characteristic species of surrounding *Eucalyptus crebra - Eucalyptus moluccana - Corymbia maculata* forests and woodlands. Both expressions of the community were included in the preliminary determination. None of the community occurs within any conservation reserve, and a substantial proportion of it is threatened by proposed developments.

Of the remaining Warkworth Sands Woodland, there is a high potential for vegetation clearing for open cut coal mining and sand mining due to the tenure of the land on which it occurs and based on recent proposed developments, one of which (a sand mine) has already been approved (eg. ERM 2002, HLA-Envirosciences 2000). In addition, a railway line associated with an existing open cut coal mine is proposed to pass through the middle sand mass.

Warkworth Sands Woodland is currently subject to threats from clearing associated with the proposed extension of an open-cut coal mine to the east of Wallaby Scrub Road (ERM 2002), and by a recently-approved sand mine adjacent to Wollombi Brook which will require the mining of the very substrate that the community occurs on (HLA-Envirosciences 2000). It is also considered that Warkworth Sands Woodland is likely to be subject to pressures from agricultural clearing, and from threats to the community's structure and composition associated with fire frequency, weed invasion and grazing.

Previous Work - CSIRO General Report on the Lands of the Hunter Valley

The landmark 1963 report by CSIRO subdivided the Hunter Valley (including Lake Macquarie) into 43 land systems (Story et al. 1963). Land systems were defined as "areas each with its own characteristic combination of land forms, soils, and vegetation, and consequently its own potential and own reaction under any given set of conditions" based on work by Christian and Stewart (1953). Of these, the Warkworth land system is described as "low dunes or thin sand sheets; brown single-grained sandy Aeolian regosols; anomalous woodland, mostly cleared, with wiry grasses, or heath; wooded or shrubby area 50%; rainfall 24-28 in" (Story et al. 1963).

The authors mapped 12 occurrences of the Warkworth land system, with ten of these occurring close to the Hunter River or Wollombi Brook, and the other two being well away from any major creek in the Kurri Kurri area. Two occurring at Warkworth include Warkworth Sands Woodland. They describe two distinct units for the land system, one dominated by woodland, making up about 75% of the land system's area, and the other dominated by dense heath, making up the remaining 25%. In total the land system is recorded to cover 31 square miles (about 8,030 ha). In the supporting technical report on the vegetation of the land systems, Story (1963, p. 42) notes that "most of the trees have been cleared from the woodland and a grassland with scattered trees remains."

Previous Work - The Hunter Remnant Vegetation Project

The Hunter Catchment Management Trust is currently finalising its report on this 6 year project. The study aimed to map the distribution of vegetation communities in the mid Hunter Valley, and to undertake botanical surveys of their composition and structure (Peake in prep.). The purpose of the project was to determine the conservation status of each vegetation community, and to assess their relative threats and degree of reservation.

20x20 metre floristic plots were sampled in and around the Warkworth Sands Woodland area in 1999 as part of this project and also by NSW NPWS (NSW NPWS 1999) as part of the Comprehensive Regional Assessment (CRA) process. The Hunter Trust's remnant vegetation study has found that Warkworth Sands Woodland is the most restricted vegetation community in the 3,200 km^2 study area, and is most likely to be under the highest threat of extinction in the next 50 years (Peake in prep.).

Comparison with Potentially Similar Communities

Warkworth Sands Woodland occurs on a sand-based soil landscape unique in the Hunter Valley. Several other vegetation communities have been described in the scientific literature which bear some resemblance to the Warkworth Sands Woodland (including ten Endangered Ecological Communities). First hand experience of most of those in the Sydney Basin bioregion has been obtained by the members of the Hunter Rare Plants Committee which has aided them in the preparation of this technical note.

Table 1 outlines the floristic composition of Sydney Basin sand-based vegetation in the literature, based on published and unpublished reports, as well as one further sand deposit in the Brigalow Belt South, which bears some resemblance to Warkworth Sands Woodland. Where possible, published accounts of vegetation have been cited. Standard vegetation survey has yet to occur across all sand-based vegetation types, and consequently analysis cannot yet be undertaken to clarify relationships. Nevertheless, the information provided in Table 1 indicates basic differences in the floristic composition of each vegetation type. The Warkworth Sands Woodland has a suite of dominant

species that is distinctly different to the other sand-based vegetation types listed in Table 1 and does not match any other Endangered Ecological Communities.

Also of relevance is an examination of the geological history of each of these sand deposits (Table 2). The Warkworth Sands Woodland is one of four vegetation types that are grouped as "inland Aeolian sand deposits." It is certain that both Agnes Banks and Warkworth Sands Woodland are of Pleistocene age, while it is speculated that the Mendooran deposit about 16 km west of Mendooran is of similar age as well. The Maroota sandmass complex appears to be possibly of Tertiary age (Ryan et al. 1996). Of the two other communities which occur on Pleistocene inland Aeolian sands, (Mendooran Sands and Agnes Banks), only 14% and 23% of plant species respectively are shared between these sites and the 99 native plant species recorded in Warkworth Sands Woodland to date.

The Ecological Significance of Warkworth Sands Woodland

Warkworth Sands Woodland occurs on a highly restricted, aeolian sandmass derived from sand deposits along the nearby Wollombi Brook. Consequently, it is floristically distinct from other vegetation in the local area which is predominantly various associations of grey box (*Eucalyptus moluccana*), narrow-leaved ironbark (*E. crebra*) and spotted gum (*Corymbia maculata*) (Peake in prep.). Warkworth Sands Woodland has also been shown to have a different floristic composition, particularly as regards the dominant species, to other sand-based communities of the Sydney Basin Bioregion (Table 1). The highly restricted nature of both the sandy substrate and the Warkworth Sands Woodland it supports is further evidenced by the fact that neither were delineated or described in recent regional vegetation mapping (NSW NPWS 1999).

The NSW Scientific Committee has made a final determination to list Warkworth Sands Woodland as an Endangered Ecological Community on the NSW *Threatened Species Conservation Act* 1995.

Under the draft national criteria used for assessing the level of threat to ecological communities (Landsberg 2000), the Warkworth Sands Woodland is rated as Critically Endangered under criteria A & B. This status is achieved on the basis of criterion "A" (very severe decline in geographic distribution) and "B" (small geographic distribution coupled with demonstrable threat). The total pre-1750 area of occupancy is estimated at 6020ha, of which approximately 800ha (13%) remains. There is currently no representation of this community within dedicated reserves, despite previous consideration by NPWS for dedication as a nature reserve (Pavich 1992).

Four threatened fauna species were located by ERM (2002) on the land proposed for the extension of the Warkworth open-cut coal mine, including squirrel glider (*Petaurus norfolcensis*), speckled warbler (*Pyrrholaemus saggitata*), brown treecreeper (*Climacteris picumnus* subsp. *victoriae*) and grey-crowned babbler (*Pomatosomus temporalis* subsp. *temporalis*). All of these are listed as Vulnerable on the NSW *Threatened Species Conservation Act* 1995. O'Brien (1999) recorded the Vulnerable turquoise parrot (*Neophema pulchella*) at the site of the proposed sand mine, and considered that the Endangered regent honeyeater (*Xanthomyza phrygia*) is likely to be present on occasion during migration. In addition it is highly likely that the Vulnerable (TSC Act 1995) glossy black cockatoo (*Calyptorhynchus lathami*) is present in Warkworth Sands Woodland.

The Vulnerable tree *Eucalyptus glaucina* has been recorded within the community during CRA surveys by NPWS (NPWS 1999), however this may require confirmation.

Finally, a 1992 reference statement by NPWS indicated that the Service had since at least 1978 "been considering the long term protection of …… Warkworth Sands, preferably by dedication as a

Nature Reserve if this proved possible" (Pavich 1992, p. 1). However, no formal protection of the Warkworth Sands Woodland has been attained in that time.

Conclusion

Warkworth Sands Woodland is a naturally restricted vegetation community presently occurring in only about 13% of its former pre-European distribution. It is currently threatened by a number of land management practices, and has been recognised by the NSW Scientific Committee as an Endangered Ecological Community. In order to secure the long-term viability of this community, the retention of existing patches coupled with the restoration of degraded components of the land system on which it occurs will be crucial.

Warkworth Sands Woodland - An Endangered Ecological Community

Table 1 Floristic Composition of Recognised Sand-based Vegetation Communities

Community / Location	Floristic Composition
Subject	
Warkworth Sands Woodland	*Angophora floribunda, Banksia integrifolia, Allocasuarina littoralis, Melaleuca thymifolia, Acacia filicifolia, Pteridium esculentum, Imperata cylindrica* var. *major, Hibbertia linearis, Brachyloma daphnoides subsp. daphnoides, Exocarpus cupressiformis, Callitris endlicheri, Jacksonia scoparia, Leucopogon muticus, Pimelea linifolia* subsp. *linifolia*
Endangered Ecological Communities (TSC Act 1995)	
Agnes Banks Woodland (Benson 1981b)	*Eucalyptus sclerophylla, Eucalyptus parramattensis* subsp. *parramattensis, Angophora bakeri, Banksia serrata, Banksia aemula, Ricinocarpus pinifolius, Dillwynia glaberrima, Leptospermum trinervium, Conospermum taxifolium, Philotheca salsolifolia, Acacia brownii, Leptospermum polygalifolium, Isopogon anemonifolius, Kunzea capitata, Persoonia nutans, Melaleuca thymifolia, Monotoca scoparia, Pteridium esculentum, Callistemon citrinus*
Eastern Suburbs Banksia Scrub (NSW Scientific Committee)	*Banksia aemula, Banksia serrata, Banksia integrifolia, Banksia ericifolia, Pteridium esculentum, Corymbia gummifera, Acacia suaveolens, Acacia terminalis, Allocasuarina distyla, Brachyloma daphnoides, Bossiaea heterophylla, Hakea teretifolia, Kunzea ambigua, Lambertia formosa, Leptospermum trinervium, Leptospermum laevigatum, Monotoca scoparia, Ricinocarpus pinifolius, Persoonia lanceolata, Pimelea linifolia*

Elderslie Banksia Scrub Forest (NPWS 1997)	*Eucalyptus botryoides, Eucalyptus baueriana, Banksia integrifolia, Melaleuca decora, Acacia decurrens, Angophora subvelutina, Aotus ericoides, Dillwynia glaberrima, Acacia implexa, Duboisia myoporoides, Ozothamnus diosmifolius, Platysace lanceolata, Pteridium esculentum, Hibbertia diffusa, Clerodendrum tomentosum, Ricinocarpus pinifolius*
Castlereagh Scribbly Gum Woodland (NPWS 2000a)	*Eucalyptus parramattensis* subsp. *parramattensis, Angophora bakeri, Eucalyptus sclerophylla, Melaleuca decora, Banksia spinulosa* var. *spinulosa, Melaleuca nodosa, Hakea sericea, Hakea dactyloides, Themeda australis, Entolasia stricta, Cyathochaeta diander, Dianella revoluta subsp. revoluta, Stylidium graminifolium, Platysace ericoides, Laxmannia gracilis, Aristida warburgii*
Castlereagh Swamp Woodland (NPWS 2000a; NSW Scientific Commit.)	*Eucalyptus parramattensis* subsp. *parramattensis, Melaleuca decora, Eucalyptus sclerophylla, Angophora bakeri, Eucalyptus sideroxylon, Melaleuca nodosa, Baumea articulata, Callistemon linearis, Kunzea capitata, Leptospermum polygalifolium, Banksia oblongifolia, Melaleuca thymifolia, Melaleuca erubescens, Pultenaea villosa, Lepyrodia muelleri*
Kurnell Dune Forest (NSW Scientific Committee)	*Eucalyptus botryoides, Eucalyptus robusta, Endiandra sieberi, Angophora costata, Banksia serrata, Elaeocarpus reticulatus, Monotoca elliptica, Leptospermum laevigatum, Cupaniopsis anacardioides, Glochidion ferdinandi, Banksia ericifolia, Aotus ericoides, Clerodendrum tomentosum, Breynia oblongifolia, Leucopogon parviflorus, Pimelea linifolia*
Kurri Sand Swamp Woodland (NPWS 2000b)	*Eucalyptus parramattensis* subsp. *decadens, Angophora bakeri, Eucalyptus signata,*

	Eucalyptus sparsifolia, Melaleuca nodosa, Banksia spinulosa, Jacksonia scoparia, Hakea dactyloides, Acacia ulicifolia, Lambertia formosa, Pimelea linifolia, Dillwynia retorta, Lissanthe strigosa, Melaleuca thymifolia
Low Woodland - Heathland, Norah Head (Payne 1997)	*Eucalyptus camfieldii, Corymbia gummifera, Melaleuca sieberi, Melaleuca quinquenervia, Acacia longifolia, Acacia suaveolens, Allocasuarina distyla, Callistemon citrinus, Banksia oblongifolia, Grevillea sericea, Hakea teretifolia, Lambertia formosa, Isopogon anemonifolius, Bossiaea ensata, Leptocarpus tenax, Epacris microphylla, Melaleuca thymifolia, Pimelea linifolia, Persoonia levis, Xanthorrhoea fulva, Themeda australis*
Quorrobolong Scribbly Gum Woodland (Bell and Murray 2001)	*Eucalyptus racemosa, Eucalyptus piperita, Angophora costata, Eucalyptus resinifera* subsp. *resinifera, Eucalyptus punctata, Syncarpia glomulifera, Banksia spinulosa, Leptospermum trinervium, Xylomelum pyriforme, Melaleuca nodosa, Persoonia linearis, Acacia ulicifolia, Melaleuca sieberi, Callistemon pinifolius, Leucopogon juniperinus, Breynia oblongifolia, Daviesia ulicifolia, Zieria smithii subsp. smithii, Lomatia silaifolia, Correa reflexa*
Umina Coastal Sandplain Woodland (NSW Scientific Committee)	*Angophora floribunda, Banksia integrifolia, Eucalyptus botryoides, Eucalyptus paniculata, Melaleuca quinquenervia, Monotoca elliptica, Banksia serrata, Allocasuarina torulosa, Banksia ericifolia, Macrozamia communis, Aotus ericoides, Duboisia myoporoides, Dodonaea triquetra, Elaeocarpus reticulatus, Eriostemon australasius, Xanthorrhoea arborea, Pteridium esculentum, Leptospermum trinervium, Leptospermum polygalifolium, Lomandra longifolia,*

	Platysace lanceolata, Persoonia linearis, Pomax umbellata
Other Communities Occurring on Sand Bodies	
Mellong Woodland (Ryan et al. 1996)	*Angophora bakeri, Eucalyptus sclerophylla, Leptospermum trinervium, Isopogon anemonifolius, Bossiaea heterophylla, Hakea dactyloides, Banksia spinulosa, Cryptandra spinescens, Monotoca scoparia, Pteridium esculentum, Platysace ericoides, Haemodorum planifolium, Gompholobium latifolium, Lindsaea linearis*
Mendooran Sand Deposit (Benson 1979)	*Angophora floribunda, Eucalyptus macrorhyncha, Callitris endlicheri, Hovea lanceolata, Brachyloma daphnoides, Calytrix tetragona, Acacia brownii, Dianella revoluta, Lepidosperma laterale, Schoenus ericetorum, Melaleuca thymifolia, Pultenaea microphylla, Allocasuarina luehmannii, Acacia gladiiformis, Gahnia aspera, Imperata cylindrica* var. *major*
Upper Cudgegong Sandslope Woodland (Bell 1998)	*Eucalyptus rossii, Eucalyptus mannifera, Eucalyptua macrorhyncha, Angophora floribunda, Eucalyptus blakelyi, Eucalyptus punctata, Eucalyptus cannonii, Persoonia myrtilloides, Monotoca scoparia, Leucopogon virgatus, Boronia microphylla, Dillwynia phylicoides, Brachyloma daphnoides, Acacia buxifolia, Petrophile pulchella, Hakea dactyloides, Mirbelia platyloboides, Caustis pentandra, Acacia echinula, Petrophile canescens*
Maroota Sandmass Complex (Ryan et al. 1996)	*Eucalyptus haemastoma, Eucalyptus squamosa, Corymbia gummifera, Angophora bakeri, Eucalyptus globoidea, Eucalyptus punctata, Angophora costata*

Tomago Sand Swamp Woodland (NPWS 2000b)	*Eucalyptus paramattensis* subsp. *decadens, Eucalyptus signata, Leptospermum polygalifolium, Melaleuca nodosa, Persoonia lanceolata, Hakea teretifolia, Melaleuca sieberi, Banksia oblongifolia, Dillwynia retorta, Melaleuca thymifolia, Aotus ericoides, Leucopogon ericoides, Lepyrodia scariosa*
Wilpinjong Scribbly Gum Woodland (Bell 1995; Hill 1999)	*Eucalyptus rossii, Eucalyptus crebra, Callitris endlicheri, Corymbia trachyphloia* subsp. *amphistomatica, Eucalyptus dwyeri, Brachyloma daphnoides, Calytrix tetragona, Persoonia myrtilloides subsp. cunninghamii, Bossiaea rhombifolia subsp. rhombifolia, Styphelia triflora, Grevillea sericea, Persoonia linearis, Patersonia sericea, Pomax umbellata, Macrozamia spiralis, Melichrus urceolatus, Leucopogon virgatus, Xanthorrhoea johnsonii*

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Table 2 Geological History of Sandmass Vegetation

Community	Geological History
Warkworth Sands Woodland	Inland Aeolian Sands (Pleistocene)
Agnes Banks Woodland	Inland Aeolian Sands (Pleistocene)
Maroota Sandmass Complex	Inland Aeolian Sands (Tertiary?)
Mendooran Sand Deposit	Inland Aeolian Sands (Pleistocene?)
Quorrobolong Scribbly Gum Woodland	Deeply Weathered Sandstone (Permian Maitland Group)
Kurri Sand Swamp Woodland	Deeply Weathered Sandstone (Permian Maitland Group)
Upper Cudgegong Sandslope Woodland	Deeply Weathered Sandstone (Triassic Narrabeen)
Wilpinjong Scribbly Gum Woodland	Deeply Weathered Sandstone (Triassic Narrabeen)
Mellong Woodland	Deeply Weathered Sandstone (Triassic Narrabeen)
Tomago Sand Swamp Woodland	Coastal Aeolian Sands (Pleistocene)
Low Woodland - Heathland, Norah Head	Coastal Aeolian Sands (Pleistocene)
Eastern Suburbs Banksia Scrub	Coastal Aeolian Sands (Pleistocene)
Umina Coastal Sandplain Woodland	Coastal Aeolian Sands (Holocene)
Kurnell Dune Forest	Coastal Aeolian Sands (?Holocene)
Elderslie Banksia Scrub Forest	Tertiary Alluvium
Castlereagh Scribbly Gum Woodland	Tertiary Alluvium
Castlereagh Swamp Woodland	Tertiary Alluvium