Coastal Sandplain Vegetation at Brisbane Water and Broken Bay – reconstructing the past to plan for the future

Robert Payne[1], Ross Wellington[2] & Michael Somerville[3]

[1]15 Mountain Ash Way Umina Beach 2257 NSW AUSTRALIA, email: ecolsurvey@netspace.net.au
[2]email: rossw@ecoaus.com.au; [3] email: flora@huntercouncils.com.au

***Abstract*:** The vegetation and floristics of the coastal sandplains on the Umina-Woy Woy Peninsula on the northern foreshores of Broken Bay (lat 33° 30' S, long 151° 15' E), 40 km north of Sydney, are described from historical records, sampling of remnants and analysis of regional scale vegetation.

Of the seven vegetation communities described, Umina Coastal Sandplain Woodland (UCSW) was originally the most extensive type of vegetation over the Umina-Woy Woy sandplain and on the seaward side of the Pearl Beach sandplain, and possibly on the sandplains at Patonga and Little Patonga. Characteristic tree species are *Angophora floribunda* and *Eucalyptus botryoides*; the latter appears to be more common at foreshore sites. Close to the sea and in swales at the base of hillslopes, littoral rainforest elements can be present. Patonga may have had significant inclusions of this vegetation.

As a result of clearing for suburban development and its reduction to small remnants, UCSW and Freshwater Wetlands have been listed as an Endangered Ecological Communities under the *NSW Threatened Species Conservation Act*.

A form of the closely-related Sydney Red Gum (SRG) complex occurs on a different SLU on the south-west side of Pearl Beach. A characteristic tree is *Angophora costata.* Site environmental differences between UCSW and the Sydney Red Gum Complex include their occurrence on iron podsols and humus podsols respectively. Regional vegetation classification and analysis shows that these vegetation units are distinctly different from each other. This is supported by historical evidence from surveyor notation on Crown Survey and land subdivision plans.

Originally the Bangalay – Rough-barked Apple Woodland vegetation component of the Umina Woy Woy sandplain was defined by the NSW Scientific Committee for Umina Coastal Sandplain Woodland. Regional analysis now reveals the Red Gum-Red Bloodwood (RGBW) component now merges with this former community. The Pearl Beach vegetation remains separate. A re-definition of UCSW is now required.

Management, particularly of UCSW, currently involves revegetation and regeneration works in the vicinity of existing reserves. However, because the depletion has been so extensive there is further opportunity to decrease the loss by utilising the wide riparian reserves and laneways where mature trees still exist.

A major conservation concern is the modification and loss of the sandplain vegetation, particularly the wetlands. The historical Crown Survey plans highlight the extent of wetlands as an important ecological feature of the original sandplain landscape. The current study estimated that 83% of wetlands and 79% of riparian vegetation has been lost on the Umina-Woy Woy sandplain since European settlement.

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Introduction

Extensive coastal sandplains are major landform features behind the main beaches on the northern foreshores of Broken Bay (the estuary of the Hawkesbury-Nepean River) and at the southern end of Brisbane Water. The area is on the Central Coast of New South Wales about 40 km north of Sydney.

Before European settlement began in the 19th Century the sandplains supported a variety of sclerophyll vegetation types including woodlands, wetlands, palm forest, and riparian elements associated with slow flowing stream systems and alluvial fans.

The largest sandplain area, the Umina-Woy Woy sandplain (bounded by Brisbane Water and Blackwall Mountain to the

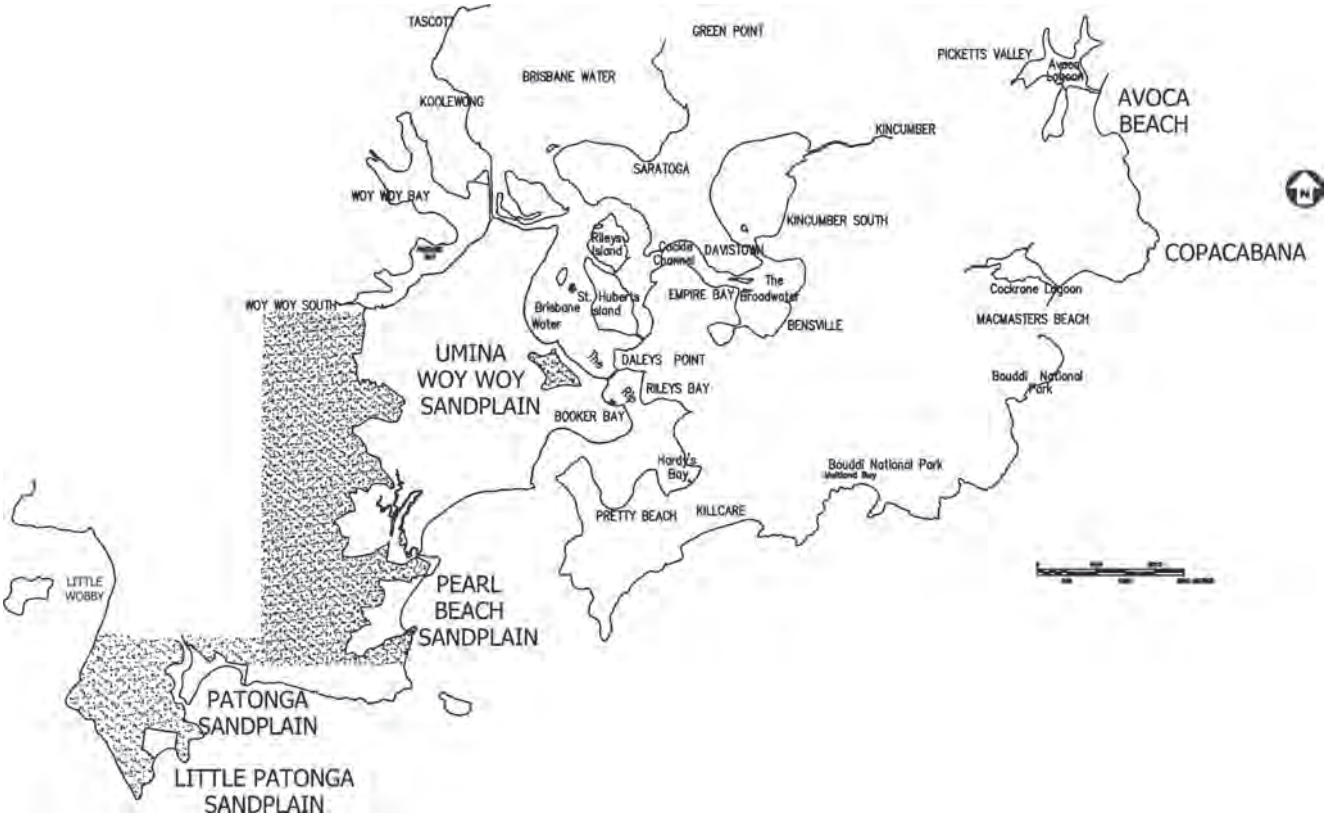

Fig. 1 Location of Brisbane Water sandplain areas to the north of Broken Bay.

north, the Brisbane Water National Park escarpment to the west and Mt Ettalong to the south) once supported more than 1 200 ha of native vegetation (Figure 1). Separate patches of similar habitat occurred at Patonga, Little Patonga and Pearl Beach, and evidence of similar but smaller areas of sandplain vegetation is present at Avoca, Copacabana and Koolewong.

Since European settlement, clearing of vegetation for rural and suburban development, particularly since the 1950s, has left only fragmented and disconnected remnants as 'refugia' scattered through the area. The Umina Coastal Sandplain Woodland Endangered Ecological Community and Sydney Freshwater Wetlands in the Sydney Basin Bioregion Endangered Ecological Community, listed under the NSW *Threatened Species Conservation Act, 1995* provide some legislative cover for some of the *s*mall remaining areas of sandplain vegetation. Brisbane Water National Park and some public reserve areas provide additional protection.

Except for brief mentions in the soils-oriented work of Burges & Drover (1953) and Hails (1969), the nature and floristic composition of the Central Coast sandplain vegetation are poorly known**.** Sandplain vegetation was not recorded adequately in the initial inventory for the Lower Hunter – Central Coast regional mapping (House 2003) and Gosford local government area mapping (Bell 2004), though it has been included in a recent update by Hunter Councils (Somerville 2008)**.**

Griffith et.al. (2000, 2003, 2007) have described the sandplain or 'wallum' vegetation of the NSW North Coast. The sandplain vegetation at Brisbane Water is related to the 'wallum' but does not qualify in the original sense because of the absence of *Banksia aemula* heathlands (it may fit a revised definition, see Griffith et. al. 2003).

Because of the potential changes associated with future developments proposed for the Brisbane Water area coastal sandplains, the few remaining patches of threatened vegetation will require intensive ecological management if they are to survive in the long-term (see Rackham (2006) for similar comments on woodland in Britain). As a basis for management strategies the current study aims to determine the previous vegetation patterns for areas where sandplain vegetation has been almost totally lost, and to identify species and strategies appropriate for restoration projects applicable for areas of cleared land, where rehabilitation of habitat and connection of remnants of native vegetation is required.

Methods

Study Area

The coastal sandplain study area (lat 33° 30' S, long 151° 15' E) encompasses sandplain areas at Umina-Woy Woy, Pearl Beach, Patonga and Little Patonga Beach (in ancient

times, all tributaries of the same catchment), and Avoca, Copacabana and Koolewong. Almost all the sandplain vegetation at Patonga, Little Patonga and Avoca has been removed for urban development. At Copacabana and Koolewong only tiny littoral remnants in a very small area of coastal sandplain remain (the Koolewong remnant may be regrowth on redeposited sands from railway construction). At Umina-Woy Woy and Pearl Beach there are more substantial remnants on what were much more extensive and well developed inner and outer beach ridge systems (Figure 1).

The Umina-Woy Woy sandplain is now characterised by a regular pattern of dunes and swales oriented parallel to the beach, which were created by the prevailing south east swell waves. Historically, dune crests were 5–7 m above sea level with swales 1–1.5 m below that level (Hails 1969). These characteristic geomorphic features are evident on historical air photos (Figure 2) and although highly altered by urban development, in some places can still be discerned at groundlevel.

The sandplains of Umina-Woy Woy began to form about 6000 years b.p. as sea levels began to rise (Thom et. al. 1978). The Hawkesbury River system's shelf sand deposits, created by siltation and the presence of the volcanic rock bar off Barrenjoey (White 1999), resulted in the extensive beach dune ridge complex contemporaneous with aggrading of the lower reaches of the Hawkesbury Broken Bay estuary (Albani et al. 1991, 1992).

Radiocarbon dating of shell detritus shows that the Umina-Woy Woy sandplain formed over a period of 4000 years (Thom et. al. 1981). The Umina-Woy Woy Sandplain is the widest in New South Wales, up to 3.7 km wide with an average height of 4 m above sea level. Shoreline displacement per year averaged 0.8 m, although the innermost barrier of 1600 m may have prograded at a rate of 4 m per year. Aeolian reworking of the beach barrier rather than seaward progradation also occurred and parts of the sandplain, where there is a shallow nearshore gradient, probably experienced such a phase (Thom et. al. 1978).

Unleached ridges (i.e. those with iron podzols) are recent (Holocene), which began to form as early as 7000 years BP and older dunes (ie those with humus podzols) are of Pleistocene age. These latter dunes could be recognised by the presence of *Banksia serrata* and *Angophora costata* (Hails, 1969). Referring to the investigations of Burges & Drover (1953) and Hails (1969), Thom et. al. (1978) stated that the whole Woy Woy sandplain is of Holocene age dating from 6240–1380 years BP.

Soil landscape maps by Chapman & Murphy (1989) and Murphy (1993) show the southern part of the Umina-Woy Woy sandplain as part of the Woy Woy Soil Landscape Unit (SLU) (of Recent age) and the north as Tuggerah SLU (aeolian, of Recent and older age). Sandplains at Avoca and Copacabana are also mapped as Woy Woy SLU. Pearl Beach sandplains are mapped as Warriewood SLU (humus podzol soils) and Little Patonga as Cockle Bay SLU (marine and aeolian sands and sandy loams).

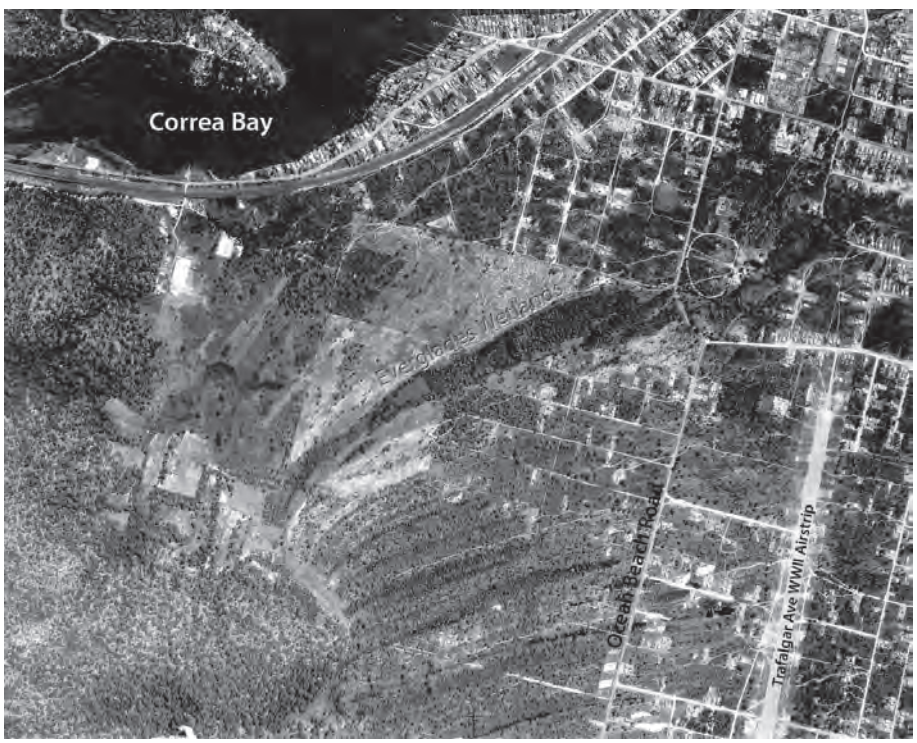

Fig. 2. 1941 aerial photo showing the northern part of the Woy Woy-Umina sandplain in the vicinity of the Everglades Wetland. Note the parallel transgressive dunes supporting woodland vegetation to the south and the more forested vegetation on Aeolian dunes to the north.

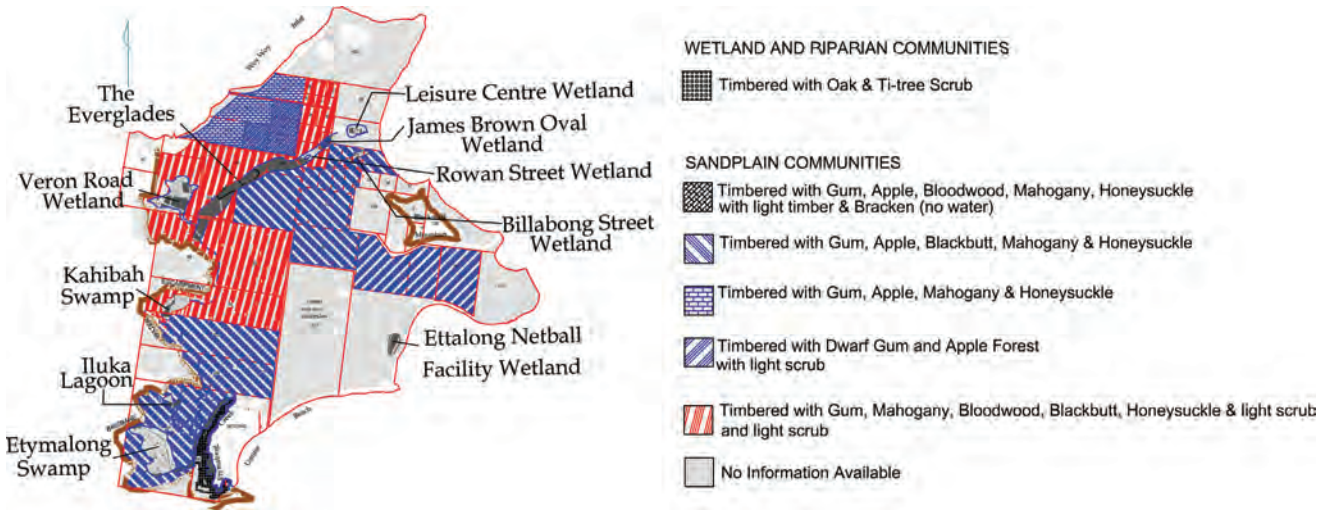

Fig. 3. Map showing the drainage of the umina Woy Woy sandplain with reference sites cited in the text.

Drainage systems and wetlands

On the Umina-Woy Woy sandplain, the major creek systems, Etymalong Creek, Kahibah Creek and Iluka Creek, drained southward from extensive wetland areas at the base of the Brisbane Water sandstone escarpment to Umina Beach at the foot of Mt Ettalong. These wetlands included those in the southern vicinity of the present day Everglades Golf Course, the Kahibah Swamps (present day remnants near McEvoy Oval and Umina High School), Iluka Lagoon further to the south and the previously extensive Etymalong Swamp wetlands (the last is no longer present to-day). Minor drainage occurred at Ettalong and entered the Brisbane Water estuary almost opposite Half Tide Rocks (today the Ettalong Netball facility). Woy Woy Creek drained northeast and entered Brisbane Water (the head of the creek was probably somewhere near the Community Leisure Centre).

Freshwater wetlands formed the sandplain headwaters of these creeks and were formerly much more extensive. The swamps and lagoons at Woy Woy, near Umina High School, Ettalong and Etymalong are not evident to-day (Figure 3). They have been incrementally reduced or totally destroyed as urbanisation and drainage pressures have occurred over the years.

The Pearl Beach sandplain is dissected by three creeks, one known locally as Green Point Creek, (originally Patonga Creek-see Crown Plan 00092-$_{0719}$) (Figure 8). Pearl Beach Lagoon, the current major water body, lies behind the frontal dune but does not generally support vegetation due to saltwater ingress. In earlier times this lagoon was a much smaller wetland (Crown Plan 00694-$_{2111}$). A swampy area at the rear of the tennis courts near Opal Close shown on early Portion plans (Crown Plan 9822 $_{158}$) no longer exists (Figure 8).

Patonga does not have any drainage line dissecting the sandplain although the sand plain lies alongside Patonga Creek, a major drainage line entering Brisbane Water. There is a small drainage line, which was part of the swale and dune system, at the base of the escarpment. At Little Patonga Beach there are two tributaries that enter the sandplain from the escarpment and in historical times drained into and formed a small wetland. This area was previously known as Spring Bay (Crown Plan 00694 $_{2111}$).

Historical Research

Historical Crown Portion plans, often annotated with surveyor's field notes, are a valuable source of historical information on the pre-European soils, geology and the general vegetation type in an area. Reference trees (ie trees with an offset distance and bearing in order that crown portion corners can be re-established) can be useful because trees are also identified by common name and accurately located.

Crown Portion plans for the Umina-Woy Woy, Pearl Beach and Little Patonga sandplains dating between 1836 and 1943 were examined for vegetation details, reference trees and portion boundaries (no crown plans are available for Patonga). Information from these plans was tabulated and plotted on a cadastral map base, and initial vegetation and reference tree maps were compiled. These vegetation maps showed roughly what type of vegetation occurred in each Crown Portion over the sandplain (Figure 3).

Historical photos at the Gosford City Library and State Library of NSW were examined for supporting information on sandplain and wetland vegetation. Broken Bay 1941 series commonwealth aerial photography was used to identify and confirm vegetation patterns over the sandplain areas, as

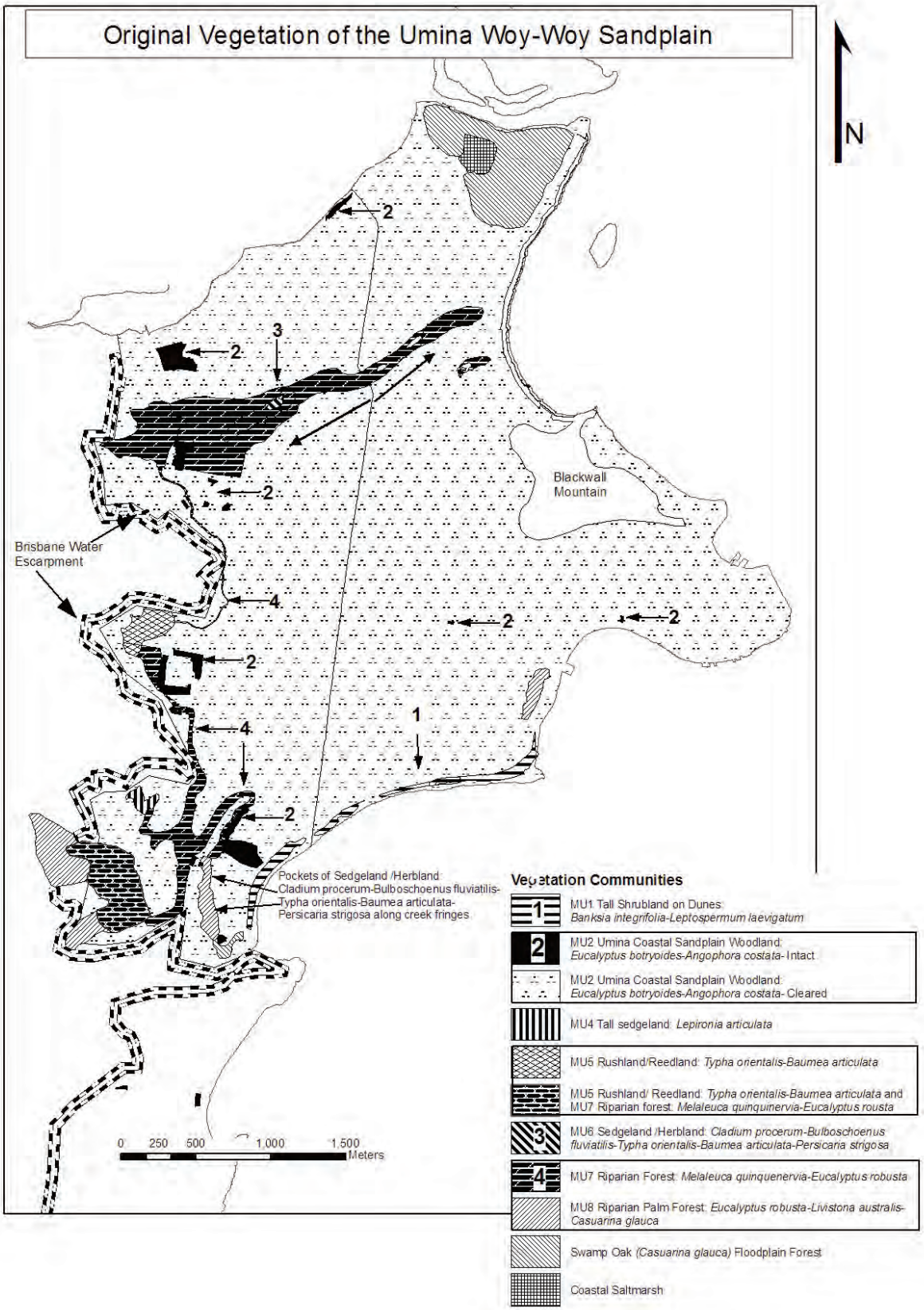

Fig. 4. Map of the original vegetation of the Umina Woy Woy sandplain compiled from various sources including early crown survey plans (vegetation for most of the eastern section was not recorded by the early surveyors). Note the extensive wetland systems that have now been almost completely destroyed.

Fig. 5. The vegetation at the mouth of the creek draining the Pearl Beach lagoon showing Swamp Oak, *Casuarina glauca* and saltmarsh, and b) Green Point Creek with Green Point Headland in the background with Spotted Gum, *Corymbia maculata*. Photos taken in 1925. (Reproduced with permission from Gosford City Council).

well as the numerous wetlands that became obvious from the investigation of the historical Portion Plans. Wetlands and drainage lines on each portion were digitised to show location and checked using historical aerial photography.

Field Mapping and Description

The small vegetation remnants that occur throughout Umina-Woy Woy, Patonga and Copacabana were mapped using a GPS or measuring directly from cadastral boundaries. The Pearl Beach sandplain has substantial vegetation cover, and existing remnants were mapped directly using GPS traversing. In all cases the data gathered was tied to the cadastral database using property boundary corners to improve accuracy.

Current floristic data was recorded between 2006–2009 in 400m^2 quadrats in relatively undisturbed vegetation remnants. Descriptions of forest/woodland vegetation communities were prepared following the Sydney Natural Vegetation Study, which includes Little Patonga, Patonga and part of the Umina Woy Woy sandplain (Benson & Howell 1994). All of the vegetation units fit into the Coastal Swamp Forest complex unit (Map Unit 27a) of Benson & Howell (1994). Wetland and riparian vegetation types are based on those of Griffith et al. (2000) for the North Coast. For each description, the common name, structure, main species in each strata level, geomorphology/soil landscape unit and occurrence were identified. The descriptions follow Specht (1981) structure classes and for wetlands (Briggs 1981) with supplementary information from Watts (2007).

The 400m^2 quadrat data were also included in the regional analysis for the Central Coast Hunter Great Lakes Region. The dataset used in the final classification results utilised only native species. Braun Blanquet cover/ abundance scores

Table 1. Vernacular names used by surveyors on historical Crown Portion Plans for subdivisions on the Umina-Woy Woy sandplain (Maiden =Maiden 1889)

Common Name	Botanical Name	Source
'Apple'	*Angophora floribunda*	Maiden, local context
'Banksia'	*Banksia serrata*	Maiden
'Blackbutt'	*Eucalyptus pilularis*	Maiden, local context
'Bloodwood'	*Corymbia gummifera*	Maiden, local context
'Bracken'	*Pteridium esculentum*	Maiden, local context
'Burrawang'	*Macrozamia communis*	Aboriginal
'Mahogany'	*Eucalyptus robusta, Eucalyptus botryoides*	Maiden
'Honeysuckle'	*Banksia serrata*	Maiden
'Gum'	*Angophora costata*	Local context
'Ti Tree'	*Melaleuca quinquenervia Leptospermum polygalifolium*	Maiden, local context

Fig. 6. An early 20th century photo taken between Nelson Street and Britannia Avenue, Umina, showing the sandplain dunes with woodland with thick scrub; *Macrozamia communis* & *Banksia integrifolia* are reasonably identifiable. This vegetation fits descriptions in early Crown surveys. (reproduced with permission from Gosford City Council).

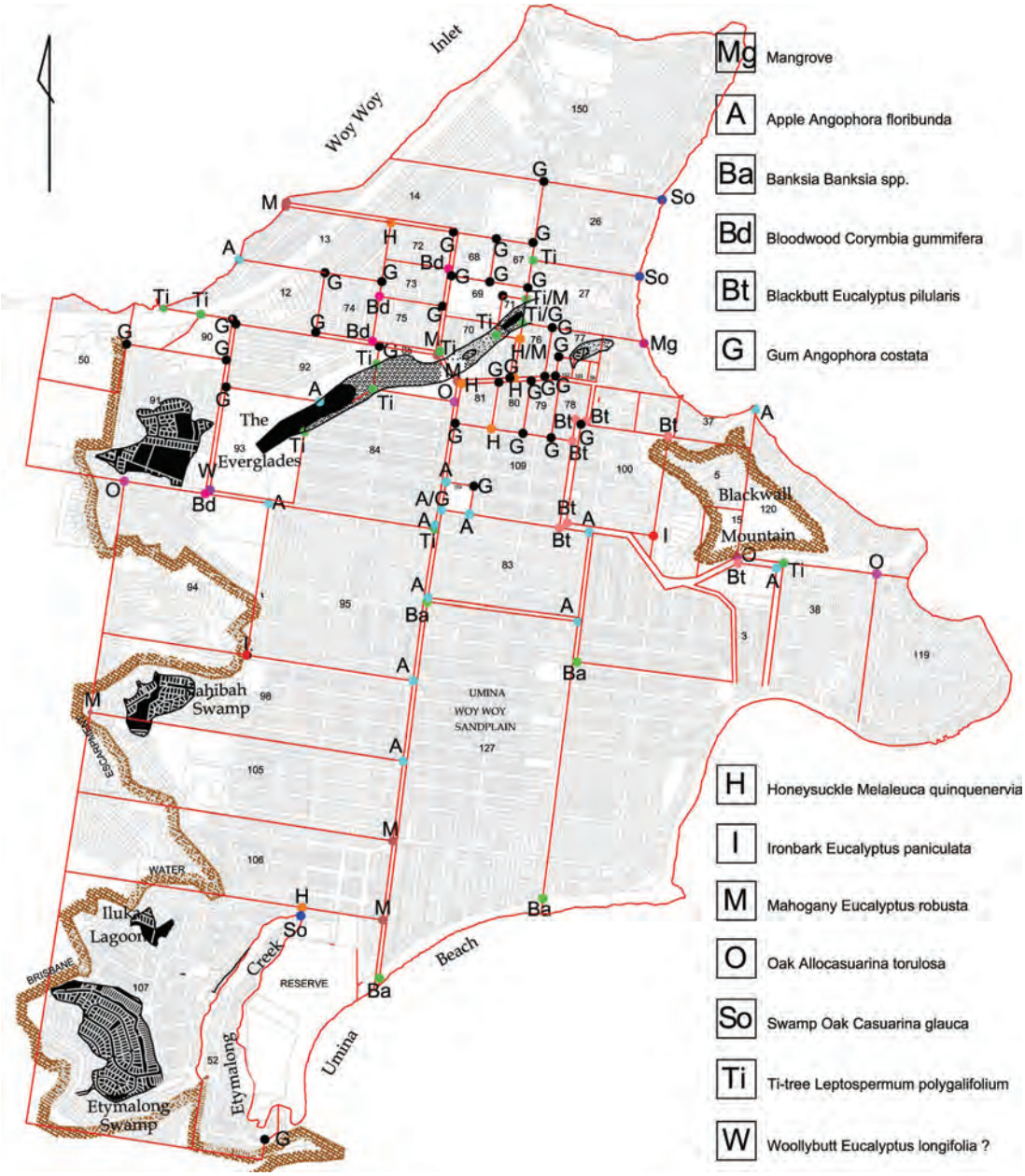

Fig. 7. The location of original surveyor reference trees used to relocate portion corners on the Umina Woy Woy sandplain.

were used and the final classification was undertaken using the DOS version of the PATN software package (Somerville 2008).

While it does not support large tracts of natural vegetation, the Umina-Woy Woy sandplain still supports a large number of remnant native trees that have over the years been protected within the large number of public laneways that still exist behind residential properties. Such trees can be used as indicators for the compilation or ground-truthing of vegetation maps. The locations of many of these indicator trees were recorded using a Magellan global positioning system (GPS).

Soil analysis was undertaken using standard laboratory techniques to determine iron, organic matter and pH. Two soil samples from the soil profile of iron podzols on the Umina Woy Woy sandplain and two samples of humus podzols on the Pearl Beach sandplain were taken. Each soil sample was collected using a hand auger and was measured in the laboratory for pH, iron and organic matter.

The pH was measured by placing 100mL of wet soil into measuring cylinders with deionised water and, after vigorous shaking, measured with a water analyser.

Organic matter was calculated using the percent organic matter and combustion method. Approximately 10g of soil

Table 2. Reference trees and vegetation details shown on Crown Grants – Parish Of Patonga

Portion No.	Date	Plan	Reference Trees	Description
UMINA- WOY WOY SANDPLAIN				
3,4 & 5	1881	717 $_{2111}$	Gum, Apple, Ti-tree, Oak, Blackbutt & Banksia	Dwarf Gum & Apple Forest with scrub
12, 13 & l4	1892	3322 $_{2111}$	Ti-tree, Gum, Apple, Honeysuckle, Mahogany and Oak	Gum, Apple, Mahogany, Honeysuckle, Bloodwood & Scrub
26	1837	95 $_{719}$	Gum, Oak & Ti-tree	No details provided
27	1839	105A $_{719}$	Oak	No details provided
28, 29, 30, 31, 32 & 33	1895	3424 $_{2111}$	Gum & Bloodwood	Timbered with Gum, Mahogany, Bloodwood, Honeysuckle & light scrub.
34, 35, 36, 37	1867	124 $_{719}$	No detail provided	No detail provided
38	1835	65 $_{719}$	No detail provided	No detail provided
50	1871	979 $_{1501}$	Ironbark, Apple & Oak	No detail provided
52	1872	33 $_{2111}$	Gum, Ti-tree, Woollybutt, Swamp Oak	Thick scrub. Timbered with Oak and Ti-tree.
66	1894	3360 $_{2111}$	Apple & Blackbutt	Swamp
67, 68, 69 & 70	1875	3423 $_{2111}$	Gum, Mahogany & Ti-tree	Timbered with Gum, Mahogany, Bloodwood, Blackbutt, Honeysuckle & light scrub. Lagoon & Ti-tree swamp. (Wetlands on Pts. 70 & 71)
71	1875	3425 $_{2111}$	Gum, Ti-tree & Honeysuckle	Timbered with Gum, Mahogany, Bloodwood, Blackbutt, Honeysuckle & light scrub. Lagoon & Ti-tree swamp.
72, 73, 74 & 75	1895	3422 $_{2111}$	Gum, Mahogany, Bloodwood & Honeysuckle	Timbered with Gum, Apple, Mahogany, Bloodwood, Honeysuckle & light scrub.
76, 77, 78, 79, 80 & 81	1895	3426 $_{2111}$	Gum, Ti-tree, Blackbutt & Honeysuckle	Part Pt. 77 shows a swamp with Ti-tree. The remainder shows timbered with Gum, Apple, Blackbutt, Mahogany and Honeysuckle. Part Pt. 78 with Honeysuckle & thick scrub. (Wetland shown on Pt. 77)
83, 84 & 109	1895	3428 $_{2111}$	Gum, Blackbutt, Apple, Ti-tree & Oak	Timbered with Gum, Apple, Blackbutt, Mahogany and Honeysuckle. Light scrub. Part Pt. 84 shows lagoon.
85	1895	3429 $_{2111}$	Oak, Ti-tree, Gum & Mahogany	Most of Pt. swampy surrounded by Gum, Apple, Ti-tree Mahogany, Blackbutt & Honeysuckle. (Wetland shown).
90	1895	3431 $_{2111}$	Gum, Ti-tree, Honeysuckle, Mahogany, Gum, Apple & Turpentine	Timbered with Gum, Mahogany, Blackbutt, Bloodwood, Ti-tree & Honeysuckle
91,92 & 93	1895	3430 $_{2111}$	Ti-tree, Apple, Gum, Woollybutt, Bloodwood, Mahogany & Oak	Timbered with Gum, Bloodwood, Blackbutt, Mahogany & Honeysuckle. Part Pt. 91 has Swampy Ti-tree and Pt. 93 has creek & lagoon with Ti-tree & light scrub.
94, 95 & 98	1896	3432 $_{2111}$	Apple & Ironbark	Timbered with Gum, Mahogany, Blackbutt, Honeysuckle & Ti-tree with Banksia scrub. Part Pt. 94 with Ti-tree watercourse. Pt. 98 shows Kahibah Lagoon.
100	1876	318 $_{2111}$	Gum, Blackbutt and Ironbark	No details provided
104	1895	3360 $_{2111}$	Blackbutt & Ironbark	
105,106 & 107	1895	3433 $_{2111}$	Apple, Mahogany & Honeysuckle	Thick Honeysuckle & Banksia scrub; Honeysuckle & Ti-tree. Creek shown as swampy watercourse. Timbered with Gum, Apple, Mahogany & Blackbutt just west of Ettymalong Creek. Ettymalong Ck. Shown as swampy watercourse AND Etymalong Swamp shown.
119		B 648 old roll		missing
121	1836	93 $_{719}$	Banksia and Apple	No details provided
125	1831	43 $_{719}$	No details provided	Mangrove flat on Pelican Island only
154	1908	4392 $_{2111}$	Apple & Gum	Timbered with Apple, Gum, Blackbutt, Mahogany & Honeysuckle
496	1977	N9063 $_{2111}$	No detail provided	No detail provided

PEARL BEACH				
8	1837	92 $_{719}$	No details provided	No details provided
9	1840	158 $_{645}$	No detail provided	No detail provided
96	1873	79 $_{2111}$	Gum & Bloodwood	No detail provided
97	1873	79 $_{2111}$	Gum & Bloodwood	No detail provided
101	1876	N319 $_{2111}$	Bangalow & Gum	Wetland shown.
132 & 152	1932	9822 $_{158}$	Gum & Bloodwood	Heavily timbered with gum, Bloodwood, Honeysuckle, Peppermint, Mahogany, Ironbark & thick scrub. Wetland shown.
159		6493 $_{2111}$	No detail provided	Heavily timbered with gum, Bloodwood, Honeysuckle, Peppermint, Mahogany, Ironbark & thick scrub.
172		6693 $_{2111}$	No detail provided	Heavily timbered with gum, Bloodwood, Honeysuckle, Peppermint, Mahogany, Ironbark & thick scrub.
179	1921	5884 $_{2111}$	Oak stump & Apple stump	No detail provided
215 & 216	1932		Mahogany, Gum & Peppermint	Heavily timbered with gum, Bloodwood, Honeysuckle, Peppermint, Mahogany, Ironbark & thick scrub.
337	1943	N7569 $_{2111}$	Ironbark, Turpentine & Gum	Timbered with Gum, Bloodwood, Blackbutt, Honeysuckle, Oak & undergrowth.
PATONGA				
Public Reserve and lots		No details provided	No details provided	No details provided
LITTLE PATONGA				
1 & 2	1880	694 $_{2111}$	Apple, Bloodwood, Honeysuckle, Oak. Gum & Turpentine	Moderately timbered with gum and apple tree. Wetland shown.

was placed into crucibles, which had been cleaned, dried and weighed. Each crucible was placed in a muffle surface on a stainless steel tray and heated to 550°C and allowed to stay in the furnace for 1.5 hours. After combustion the crucibles were removed from the furnace and allowed to cool before they were reweighed. The weight loss, due to combustion, was used to calculate the percentage organic matter in the soil.

Iron was tested using the DTPA method. Ten grams of air dried soil was shaken with with 20Ml of DTPA extractant for two hours. The leachate was filtered and iron measured in the filtrate by atomic absorption spectrophotometry (Lindsay & Norvell 1978).

Results

Historical Research and Field Mapping

Most historical sources give common or vernacular names rather than scientific names to vegetation and plant species. For example early Crown Portion plan vegetation notes refer to "Honeysuckle, Ti-tree Swamp" or "Ti-tree Scrub". Individual reference trees are variously described as "Honeysuckle, Ti-tree" and "Banksia".

The botanical identity of these names was confirmed as far as possible using 19th Century literature together with likelihood of occurrence in the sandplain ecological context (Table 1). Maiden (1889) indicates Honeysuckle referred to *Banksia serrata* whilst Ti-tree referred to either *Melaleuca quinquenervia* or *Leptospermum polygalifolium*. Field checking of notes on the early plans for the Everglades, Billabong Street (Portion 77) and within the lower reaches of Etymalong Creek suggests both "Ti-tree Swamp" and "Ti-tree scrub" refer to *Melaleuca quinquenervia* even though the latter community does not occur as a "scrub". Wetlands are variously described either as "lagoon", Ti-tree swamp, Ti-tree watercourse or swampy watercourse.

Umina – Woy Woy Sandplain

The pattern of distribution of vegetation over the Umina – Woy Woy sandplain compiled from surveyor's field notes on historical Crown plans (Table 2) indicates a number of variants with different combinations of canopy species, as well as previously unrecognised areas of riparian and wetland vegetation. "Gum, Apple, Blackbutt, Mahogany and Honeysuckle" (interpreted respectively as *Angophora costata, Angophora floribunda, Eucalyptus pilularis, Eucalyptus robusta* and *Banksia serrata*) covered extensive areas of the sandplain. This was associated with an

understorey of thick or light scrub or a "Honeysuckle" and "Banksia scrub".

The original historical reference trees used to locate portion corners on the Umina Woy Woy sandplain (Figure 7) include 13 species, the most common being Gum (assumed to be *Angophora costata)* followed by Apple (*Angophora floribunda)*, Blackbutt (*Eucalyptus pilularis)* and Bloodwood (*Corymbia gummifera)*. The clustering of historical reference trees indicated as "Gum" (presumably *Angophora costata*) north-west, north and south of Everglades (Figure 7), suggest this area supported *Angophora costata – Corymbia gummifera* Red Gum-Red Bloodwood (RGRB) forest (part of Coastal Dune forest of Benson & Howell 1994). The surveyor records also indicate that this area supported "Gum, Bloodwood, Blackbutt, Mahogany and Honeysuckle" (*Angophora costata, Corymbia gummifera, Eucalyptus pilularis, Eucalyptus robusta, Banksia serrata).* The understorey comprised "Ti-tree" (probably in swales) and "Banksia scrub" (probably on ridges).

A general view of the sandplain vegetation along a transect running inland from Umina Beach is provided in Burges and Drover's (1952) work on soil podzol development, done before the extensive suburban development of the 1960s and 70s. They reported that *Leptospermum laevigatum – Banksia integrifolia* occurred as a frontal dune community about 90 m wide behind Umina Beach. Behind this *Eucalyptus botryoides* was present, gradually merging with *Angophora floribunda* at 140 m from the beach where iron podzol soils occur. This vegetation is readily observed on historical 1941 aerial photographs as open woodland. Hails (1969) recorded that unleached sands of the Umina-Woy Woy Sand plain (i.e. iron podzols) were dominated by a scrub of *Leptospermum laevigatum*, *Angophora floribunda* and *Banksia integrifolia* with "woodland of Bangalay *Eucalyptus botryoides* and dominated by ferns and Bracken"".

Burges and Drover (1953) report that around Woy Woy and Ettalong *Eucalyptus pilularis* (Blackbutt) was common (large remnant trees can still be seen today), and that *Corymbia gummifera* Red Bloodwood and *Eucalyptus botryoides* Bangalay occurred in the vicinity of Woy Woy, Ettalong, and Blackwall. *Angophora floribunda* (Rough-barked Apple) was more common at the southern end of Umina Beach.

Changes in soil type are correlated with the change in vegetation. Where soils change to humus podzols *Angophora costata* replaced *Angophora floribunda*. The change occurred between 1800–2700 m from the beach where the soil B-horizon becomes well developed (Burges & Drover 1953). Hails (1969) recorded that the humus podsolized ridges of the Umina-Woy Woy Sand plain supported a "dune heath and scrub dominated by *Banksia* and *Angophora.* The Red Gum Red Bloodwood Forest, *Angophora costata – Corymbia gummifera* dominates this latter soil habitat.

Burges & Drover (1953) and Hails (1969) postulated that the difference between the iron podzols and humus podzol soil types on the Umina Woy Sand plain can be attributed to the age and consequently the development of the soil profile and the height of the watertable. Watertable depths, at least on humus podzols at Pearl Beach are variable and localised and being sometimes only found at depth. Those on the Umina Woy Woy sandplain tend to be found at a shallower depth.

Comparison with current vegetation

Descriptions of current Sandplain Vegetation Communities and component species based on data from existing vegetation remnants are given in Appendices 1 and 2.

Overall the early vegetation descriptions and remnant vegetation suggests that dune vegetation on the Woy Woy-Umina sandplain commonly included a range of canopy trees. The combination of *Angophora floribunda* (Rough-barked Apple), with *Eucalyptus botryoides* (Bangalay) in foreshore sites, as described in the Final Determination of the NSW Scientific Committee and listed as the Umina Coastal Sandplain Woodland EEC (UCSW) appears to have been predominant over the south east half of the sandplain.

Vegetation on the northern half of the sandplain appears to have been Red Gum-Red Bloodwood forest, (areas at Hillview St are now regarded as included within UCSW). Red Gum-Red Bloodwood forest RGRB with *Angophora costata*, *Corymbia gummifera*, *Eucalyptus pilularis* and *Banksia serrata* occurred between Kahibah Swamp and the Everglades Golf Course, and on aeolian soils north of the Everglades (Figure 3). Part of this vegetation type was recorded as "Dwarf Gum and Apple Forest" on Portions 3, 4 & 38 and probably extended further south into Portion 126**,** where windswept conditions predominate**.**

Fieldwork indicates that the UCSW includes more littoral species than previously recognised. At Umina Beach there are two very large *Ficus rubiginosa* at the rear of the foredune with stands of *Livistona australis* Cabbage Tree Palm, *Ficus coronata* Sandpaper Fig and *Alphitonia excelsa* Red Ash; other littoral species in remnants are found along the foreshore from Woy Woy to Blackwall. Early photos of the Woy Woy foreshore support this view (Government Tourist Bureau 1907, p. 17). Similar littoral elements are also present at Patonga and Copacabana.

Soil differences between UCSW and RGBW communities on the Umina – Woy Woy sandplain

Identification between these two vegetation types UCSW and RGBW may be difficult because of the floristic continuity across the sandplain, and the small size and degraded condition of existing remnants mean that the characteristic species diversity is not well represented at any particular site.

The vegetation patterns on the Umina-Woy Woy sandplain, as indicated in the historical survey plans, support Burges and Drover's (1953) vegetation types related to soil leaching processes and height above sea level. Both Burges & Drover

(1953) and Hails (1969) recognised that the transgressive dunes gradually progress from an iron podzol to a humus podzol as dune age increases across the sandplain. Iron podzols are related to the younger Holocene dunes and humus podzols to the older Holocene dunes.

Humus podzols develop as humus leaches down through the soil profile and consolidates just above a water table, where a dense organic pan (Coffee Rock) can form. As the humic acids increase and move down through the soil profile, the calcium carbonate, derived from shells and other crustacean material are dissolved over time. This leaching results in the older sands having iron 'B' horizons at a greater depth and a deeper 'A' horizon of pale grey sand. Where the water table is encountered the iron goes into solution and the organic matter accumulates as "Coffee Rock".

Table 3. Comparison of iron (Fe) and pH values for soil types with UCSW vegetation (on iron podzols) and SRG vegetation (on humus podzols) using Paired T-Test.

	Results	Mean	SD	t	Sig
UCSW pH	5.85; 5.82	5.84	0.02	8.7	0.07
SRG pH	4.8; 5.11	5.43	0.36		
UCSW Fe (ppm)	507; 331	419	124.5	5.2	0.12
SRG Fe (ppm)	51; 21	36	21.2		
UCSW om (%)	0.23; 0.12	0.18	0.07	-2.8	0.22
SRG om (%)	0.42; 0.21	3.27	2.42		

Chemical analysis of the soils associated with the two vegetation types (UCSW & Pearl Beach SRGF) show that the iron content (mean= 419 ppm v 36 ppm) may be used to define the difference. There may be a possibility of using percent organic matter (0.17% v 3.26 %), but the number of readings available are too low to make a significant comparison. A paired T-Test (Table 3) showed no significant difference between the means of the available results at this stage.

Although the soil types differ, there is a high degree of floristic continuity between the two sandplain vegetation types, where small remnants are involved. This situation is also observed at Copacabana where the UCSW vegetation variant (Bell 2004) extends up onto the Narrabeen countryrock. Similarly at Pearl Beach the SRG Complex occurs on Warriewood, Erina and Watagan SLU's. The floristic variation over the Umina-Woy Woy and Pearl Beach sandplains is perhaps not unusual; similar trends have also been shown in the "Kwongan" sandplain area of Western Australia (Pate & Beard 1984) suggesting that sandy soils have a low level of edaphic control over understorey plant species distribution.

Pearl Beach Sandplain

In 1906 Minard Crommelin *"sailed down to Pearl Beach in a cedar boat…. The beach was so beautiful with a great number of Cabbage Tree palms, growing along the little creeks and up the valleys and hillsides"* (Webb 1994). Timber-getting was a working enterprise in the early 20th Century. One visitor remembers her father removing Turpentine from Pearl Beach. Logs were stacked and left floating in the water, attached to piles from the beach (P. Westlake pers. com. 2005)

The Pearl Beach sandplain is still densely treed and partly densely vegetated. The vegetation map (Figure 8) is based primarily on existing vegetation remnants, as historical surveyor reference trees and vegetation descriptions are poorly documented except for the south western corner of the sandplain. The lagoon at Pearl Beach was originally only a small soak (crown plan 319 $_{2111}$) but was greatly enlarged, prior to 1941, as landowners removed sediment to raise the levels of their adjoining land (P. Westlake, pers comm.). In the 1960s a resident remembered the boulder-strewn section of the creek at the rear of the Pearl Beach sandplain colonised with large colonies of *Pyrrosia rupestris* (Rock Felt Fern) and pockets of *Livistona australis* (Cabbage Tree Palm).

There are differences between vegetation at Pearl Beach and Umina-Woy Woy. Riparian vegetation at Pearl Beach is mainly palm- dominated; at Umina-Woy Woy although isolated areas of similar vegetation occurred (eg at the rear of Etymalong Swamp, the downstream section of Etymalong Creek and the Ettalong Netball Facility) riparian vegetation was mainly Ti-Tree *(Melaleuca quinquenervia)*. The main type of sandplain vegetation at Pearl Beach is similar to Sydney Red Gum complex but with *Xanthorrhoea arborea* (Grass Tree) dominated understorey. This type of vegetation is not found at Umina-Woy Woy except in Burrawang Reserve where Murphy (1993) suggests that sands are Aeolian (Tuggerah SLU).

Patonga, Avoca, Copacobana and Koolewong sandplains

Historically neither vegetation nor reference trees were recorded for the Patonga sandplain. Most of the original vegetation had been cleared by the 1940s (Anon 1945). The littoral form of UCSW is still present as a tiny remnant at the southern end of Patonga; it appears to extend to the dune foreshore in historical photos. At Little Patonga Beach, the extent of vegetation clearance is evident on the 1941 air photos.

The Avoca Beach UCSW vegetation has been cleared. Copacabana still supports a narrow remnant dominated by littoral rainforest elements with *Angophora floribunda* and *Eucalyptus botryoides*. The sandplain remnant at Koolewong railway station appears to have re-established on sand altered during railway construction in the 1880s. It is dominated by *Angophora floribunda* and currently (2009) supports a Bandicoot population.

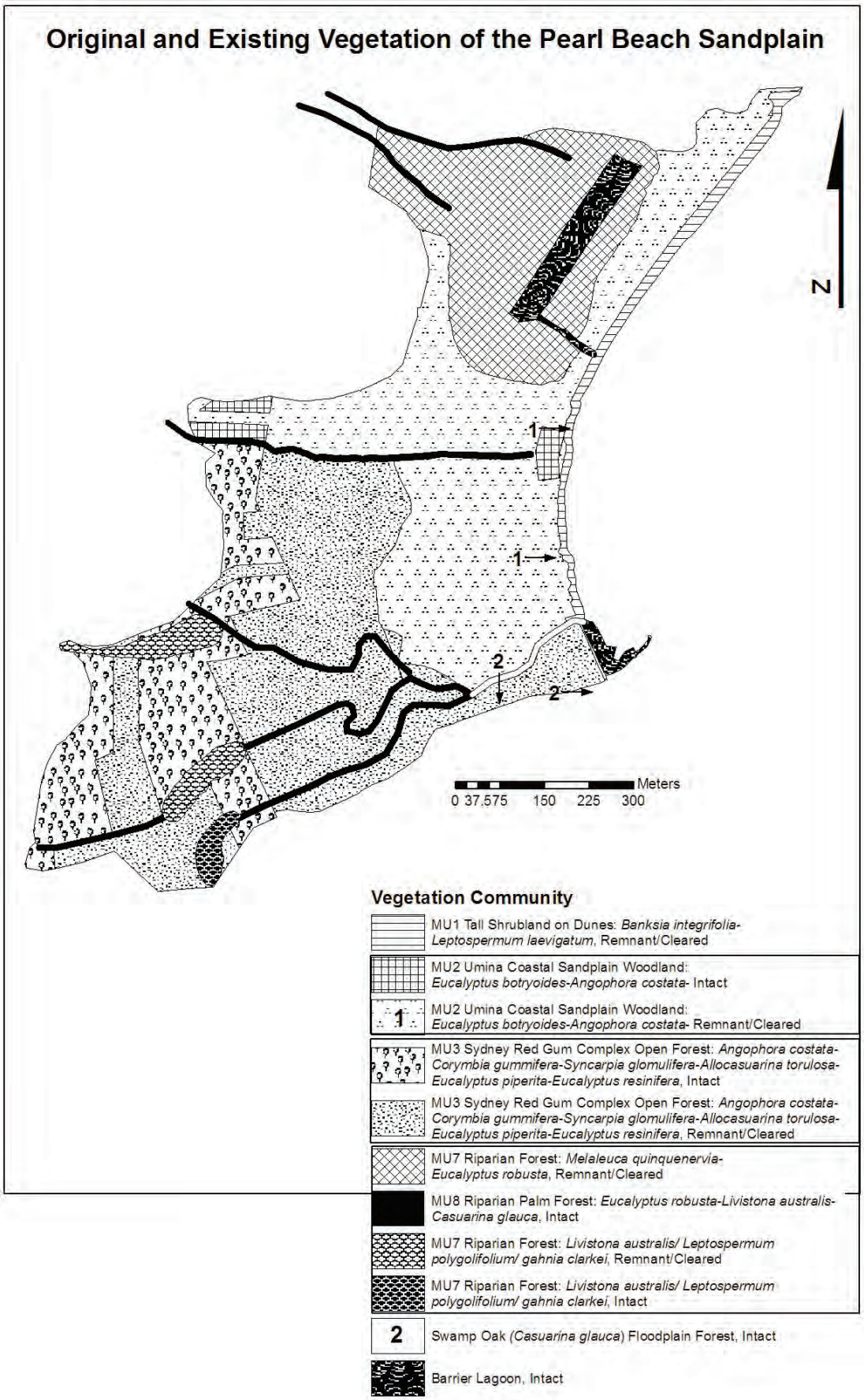

Fig. 8. Map of Pearl Beach showing original and existing vegetation compiled primarily from field survey of existing remnants.

Loss of Wetland areas

Early survey records show extensive natural swamp vegetation once existed along the drainage lines on the Umina-Woy Woy sandplain. The innermost beach ridges enclosed swamps with *Phragmites australis* reeds, sedges and *Melaleuca* (Swamp Paperbark or Ti-tree), *Eucalyptus robusta* (Swamp Mahogany) and *Casuarina glauca* (Swamp Oak).

Prior to 1990 Iluka Lagoon was mostly dominated by *Lepironia articulata*, whilst *Baumea articulata* covered the majority of Kahibah Swamp and much of Etymalong Swamp and Etymalong Creek with patches in the Pearl Beach Lagoon (pers. obs). Etymalong Swamp also supported pockets of Swamp Mahogany *Eucalyptus robusta* and Broad-leaved Paperbark *Melaleuca quinquenervia*. Up until 2000 the Everglades Lagoon supported more diverse wetland vegetation with *Melaleuca quinquenervia* forest and sedgelands/herblands *of Bolboschoenus fluviatilis, Cladium procerum* and *Persicaria strigosa (*Swamp Dock) (pers. obs.).

Table 4. Estimated extent of loss of Coastal Freshwater Wetlands and Riparian Forest on the Umina Woy Woy sandplain since European settlement
?=Losses likely but difficult to determine

Location	Original Area (ha)	Area lost	Percent Lost
COASTAL FRESHWATER WETLANDS			
Etymalong Swamp	18.07	18.07	100
Iluka Lagoon	1.89	0.58	31
Veron Road Wetlands	12.17	11.73	96
Kahibah Swamp	6.33	4.36	69
The Everglades	4.71	?0	? 0
James Brown Oval Wetland	0.30	0.30	100
Rowan Street Wetland	0.30	0.30	100
Billabong Street Wetlands	0.31	0.31	100
Ettalong Netball Facility	2.50	2.50	100
Woy Woy Leisure Centre	2.63	2.63	100
Total	49.21	40.78	83
RIPARIAN FOREST			
Etymalong Creek	9.82	3.12	32
Iluka Creek	1.11	1.11	100
Kahibah Creek	1.91	1.91	100
Kahibah Swamp/Veron Road Wetlands	3.49	3.49	100
The Everglades/Roberts Park	17.60	15.84	90
Rowan Street/Woy Woy Community Centre	2.60	2.60	100
James Brown Oval	0.98	0.98	100
Woy Woy Leisure Centre	2.15	2.15	100
Total	39.76	31.20	78

Most of the natural swamp vegetation has been destroyed by extensive drainage alteration and reclamation works (Table 4). For example the Veron Road (Kahibah Swamp) and Ettalong Wetlands had been mostly reclaimed by 1941, and during the 1960s the drainage lines were deepened, widened and straightened with a cut-off channel constructed on Etymalong Creek (McLauren Road), with the beginning of residential influx. Reclamation of remaining wetlands occurred in 1985–95 despite many local residents and Gosford City Council making a strong stand against the residential development over the Etymalong Swamp (Bruce Kerr Pty Ltd vs Gosford City Council, 1985; 1988).

Although Iluka Lagoon has not been reclaimed, it has suffered dramatically from the effects of upstream development through siltation, which has virtually caused the local extinction of *Lepironia articulata*. In the 1980s, prior to upstream development, this wetland was more or less a pristine tall sedgeland (and the only wetland of its type on these sandplains), but today (2009) this freshwater wetland supports mostly weeds, and needs recovery action.

Within drainage lines and Kahibah Swamp, changes in local hydrology caused by reclamation are causing Cumbungi, *Typha orientalis*, to displace *Baumea articulata* and *Blechnum indicum*. Some of these changes have coincided with excavation of creeks to remove the aquatic vegetation and move storm runoff away more quickly to reduce the risk of flooding to private property. About 83% of wetlands and 79% of riparian vegetation has been lost on the Woy Woy Umina Peninsula alone (Table 4).

Regional floristic analyses

Whilst it may be difficult to determine the difference between these two main vegetation types, UCSW and RGBW described above, based on visual assessment and analysis at a local scale, statistical analyses was used at a more regional scale.

In a recent regional vegetation classification based on an analysis of over 4600 sites across the Hunter, Central and Lower North Coast region, a total of 21 sites in of the Umina community and 9 in the Pearl Beach community were included. (Somerville 2008). Sites on the Umina -Woy Woy sandplain all merge together as one unit but are separate from those at Pearl Beach. These units lie within a broader group of sclerophyllous open forest, woodland and heath communities mostly occurring on coastal sands and sandstones, but the dendrogram (Figure 9) shows these communities are relatively widely separated based on floristics sampled at the regional scale. It should be noted here that not all sites included in the original classification of the Umina and Pearl Beach communities were used in the regional classification due to the process used to include or exclude sites from that analysis.

The Umina -Woy Woy sandplain community is equivalent to the Old Man Banksia/ Rough-barked Apple/ Bangalay

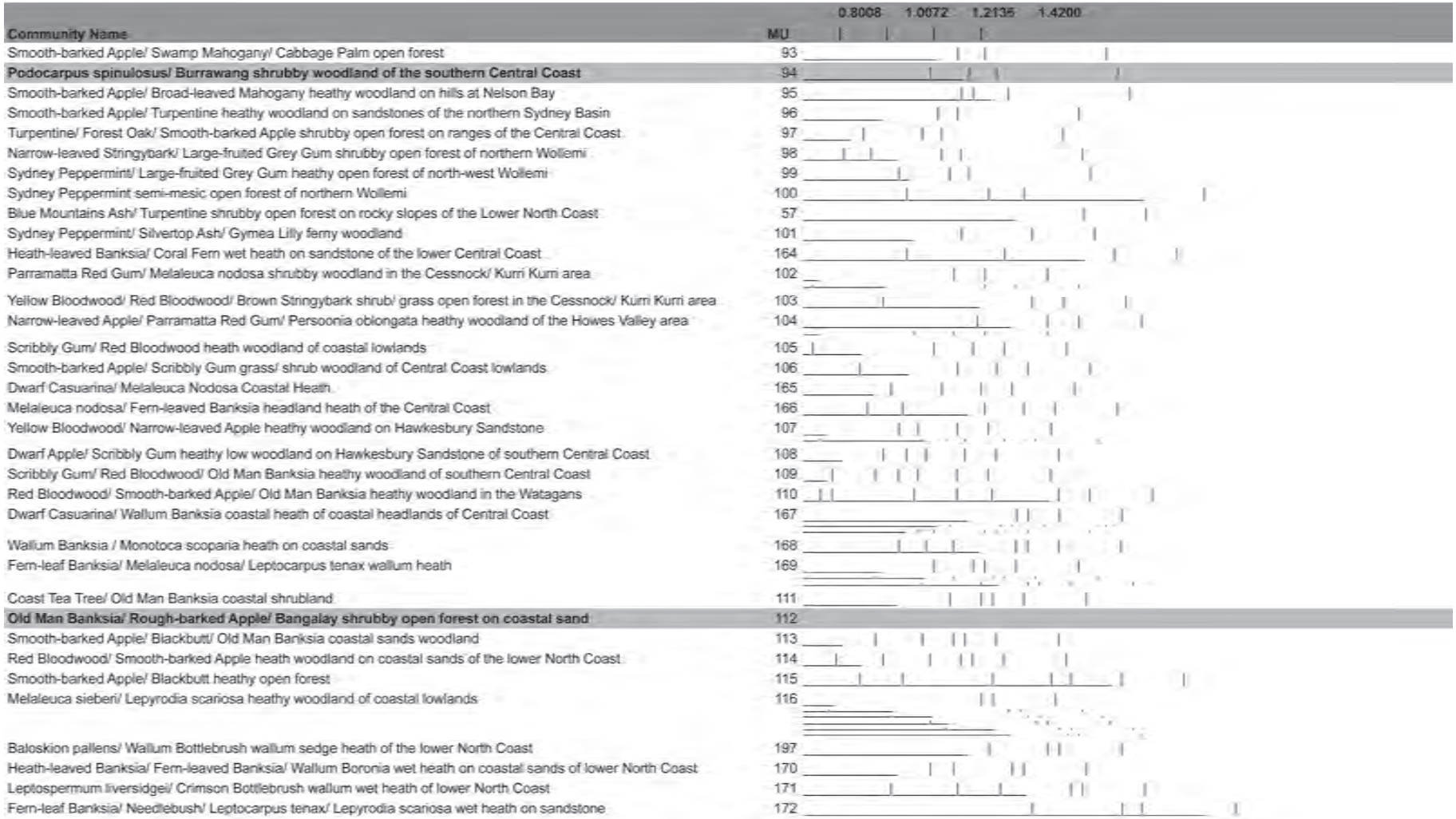

Fig. 9. Dendrogram showing regional vegetation units recognised in PATN analyses.

shrubby open forest on coastal sand (MU 112) identified in the regional classification. The UCSW sites occur mainly on the Umina sandplain on Quaternary (on both Tuggerah and Woy Woy SLUs) sands at an average elevation of 2 m. The diagnostic canopy species of MU 112 were *Angophora floribunda* (67% of 21 sites), *Eucalyptus botryoides* (43%), *Corymbia gummifera* (33%), with *Allocasuarina littoralis* occurring at over 85% of sites. Diagnostic understorey species included *Banksia serrata* (95%) and *Macrozamia communis* (91%), along with *Glochidion ferdinandi* and *Monotoca elliptica*.

The Pearl Beach SRG community equates to *Podocarpus spinulosus*/ Burrawang shrubby woodland of the southern Central Coast (MU 94), which is also rare at the regional scale. The Pearl Beach SRG community is restricted within the regional classification to a group of sites at the rear of the Pearl Beach sandplain on both Quaternary sands (Warriewood SLU) and Triassic sandstones (Erina and Watagan SLU's) at an average elevation of 31 m. The diagnostic canopy species of MU94 were *Angophora costata* (78% of 8 sites), *Corymbia gummifera* (78%), *Livistona australis* (78%), *Syncarpia gummifera* (67%), *Eucalyptus piperita* (44%) and *Allocasuarina torulosa* (33%). *Macrozamia communis* (100%) and *B. serrata* (67%) are again prominent in the understorey; however *Elaeocarpus reticulatus* (100%), *Podocarpus spinulosus* (89%), *Pultenaea flexilis* (89%) and *Xanthorrhoea arborea* (78%) are also diagnostic features of this community.

Beyond the Umina Woy Woy sandplain the nearest communities in the regional classification are those typically occurring on Quaternary sands, mainly coastal shrubland, woodland and heath communities, including Wallum communities found further north near Newcastle and the lower North Coast. All the related communities have a number of factors in common, including the occurrence on low lying sands and the presence of *Banksia aemula.* On the other hand, the Pearl Beach SRG community appears to have affinities to more hinterland communities of woodland and open forests, on Triassic sandstones of the Sydney Basin.

Discussion

Historical Crown Portion plans, early aerial photography and early photos were found to be useful in determining pre-settlement patterns in sandplain vegetation. Although not all Crown plans could be located, an overall picture of the original vegetation pattern emerged combining current remnants with historical data.

Before being cleared for suburban development, vegetation over the Umina-Woy Woy sandplain was Umina Coastal Sandplain Woodland (UCSW) in the south merging with Red Gum Red Bloodwood (RGBW). Similar vegetation extended onto the seaward side of the Pearl Beach sandplain and possibly on the sandplains at Patonga and Little Patonga. Within UCSW, littoral elements are present adjacent to the sea; Patonga may have had significant inclusions of this vegetation. Swale vegetation also has mesophyllous elements such as *Ceratopetalum apetalum* and *Callicoma serratifolia.*

The Bangalay- Rough-barked Apple Woodland is the vegetation component defined originally by the NSW Scientific Committee for Umina Coastal Sandplain Woodland. Regional analysis now reveals the RGBW component, located north of the Everglades, merges with this former community, but the Pearl Beach vegetation will always be separate. A re-definition of UCSW is now required.

Given the very large extent of vegetation loss on these sandplains (Table 4), this is a good reason for re-establishing increased areas of Sandplain Woodland and riparian and wetland vegetation on the Umina-Woy Woy sandplain. The species lists and descriptions provided in this paper will assist the re-establishment programs. A particular effort should be made to re-establish some areas of lost UCSW vegetation; there are many remnant trees that once formed part of this vegetation community that could be incorporated into and re-established as a viable reserve, in line with the new proposed re-development strategy currently under review by the NSW Government. For example the early records show *Eucalyptus pilularis* (Blackbutt) was previously widespread on the sandplains, but is now almost locally extinct. It requires re-establishing in areas where it used to grow using seed from the few existing over mature trees that still survive near Blackwall Mountain. Since many of drainage reserves are very wide and the numerous rear laneways still exist there is capacity for further restoration. Identifying areas along the wide drainage reserves and any laneways as connecting corridors for wildlife, should be part of the planning process during redevelopments on the Umina Woy Woy sandplain areas.

Management issues for sandplain vegetation include continued revegetation and regeneration of the existing wetlands, including the small remnant in Billabong Street Woy Woy . Priority projects should be

(1) the recovery of *Lepironia articulata* at Iluka Lagoon because this species has almost but disappeared locally.

(2) to increase the extent of UCSW vegetation at the reserve in Dulkara Avenue by placing additional mulch from UCSW trees, 300 mm thick, over the existing grass to allow the UCSW vegetation to expand

(3) Undertake weed removal/bush regeneration at the McEvoy Oval UCSW remnant

(4) Cover the exotic grass cover at Umina Oval with 300 mm thick UCSW mulch to allow expansion of the native vegetation.

Improvements to riparian management began when management practices changed in the late 1990s. The introduction of 'threatened' species legislation such as the *NSW Threatened Species Conservation Act* and the listing of

Freshwater Wetland and Umina Coastal Sandplain Woodland as "endangered ecological communities" has played a major role in highlighting vegetation in need of restoration. Local Land Care groups and professional bush regeneration companies under the direction of Gosford City Council began to restore these vegetation communities. Mechanical excavation of riparian aquatic vegetation has ceased and only selected trees are now removed from banks to reduce the flood risk to private property. There is now a concentrated effort to restore and manage vegetation at Etymalong Creek, Iluka Lagoon, Umina Oval, Kahibah Creek, the Everglades, Umina High School, Blackwall, Pearl Beach and the Hillview Street and Burrawang Reserves. Management plans are available for most of these sites. Some small billabong areas, left isolated by the previous straightening of Etymalong and Iluka Creeks, have also been protected and are being restored. This invaluable work has had a major impact in restoring native vegetation and eradicating weeds.

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Appendix 1

Descriptions of current Sandplain Vegetation Communities based on data from existing vegetation remnants, observations and historical sources

Coastal Holocene Dunes

Tall Shrubland: *Banksia integrifolia – Leptospermum laevigatum*

Structure: Tall shrubland

Habitat: Holocene foredunes exposed to strong sea borne winds.

Distribution**:** The best example is at Patonga but also occurs behind Ocean Beach, Umina Beach and Ettalong.

Floristic composition**:** *Banksia integrifolia* Coast Banksia and *Leptospermum laevigatum* Coastal Ti-tree are the main canopy species with a subcanopy of *Monotocca elliptica*, *Pittosporum undulatum*, *Clerodendrum tomentosum*, *Alphitonia excelsa* and *Breynia oblongifolia*. Understorey species include *Lomandra longifolia*, *Hydrocotyle bonariensis* and *Hibbertia scandens*.

Related mapping units**:** MU 34 Coastal Sand Wallum Woodland Heath (House 2003); E50a Coastal Sand Foredune Scrub (Bell 2004).

Umina Coastal Sandplain Woodland (UCSW) Woodland: *Eucalyptus botryoides – Angophora floribunda* (Fig. 10)

Structure: Woodland with shrubby and cycad understorey

Habitat**:** Holocene Sands (Woy Woy SLU) on soils with iron podzols.

This is Umina Coastal Sandplain Woodland and for the purpose of this study includes littoral elements found in swales, because they are not able to be mapped across a disturbed landscape. It also includes the vegetation on aeolian sands (Tuggerah SLU).

Distribution**:** Mostly cleared, now only found as remnants at Umina Oval, Pearl Beach, Blackwall, Patonga and Copacabana. Mostly on Holocene sediments (Woy Woy SLU). On Aeolian sand (Tuggerah SLU) in Burrawang Reserve (Hillview Street, Woy Woy).

Floristic composition**:** The canopy is dominated by *Angophora floribunda* (Rough-barked Apple) and *Eucalyptus botryoides* (Bangalay) with a low tree layer of *Allocasuarina littoralis* and *Banksia integrifolia subsp. integrifolia* close to the foreshore. On foreshore sites and in swales at the base of hillslopes, littoral rainforest elements with *Ficus rubiginosa* as a canopy tree with sub canopy trees such as *Acmena smithii*, *Callicoma serratifolia*, *Ceratopetalum apetalum*, *Clerodendrum tomentosum*, *Elaeocarpus reticulatus*, *Euroschinus falcata*, *Glochidion ferdinandi*, *Guioa semiglauca*, *Livistona australis*, *Schizomera ovata* and *Leptospermum polygalifolium*. can be present.

In other locations *Eucalyptus botryoides* and *Angophora floribunda* extended almost to the foreshore along with *Casuarina glauca* (Herfort, no date). *Banksia integrifolia*, *Breynia oblongifolia* and *Exocarpus cupressiformis* make up a second mid stratum layer together with other littoral species such as *Pittosporum revolutum*, *Synoum glandulosum*, *Acronychia oblongifolia*, *Rapanaea variabilis, Rhodomyrtus psidioides* and *Pittosporum multiflorum* (prev. Citriobatus pauciflorus) at Copacabana. The groundlayer is generally comprised of *Macrozamia communis, Lepidosperma longitudinale,* regenerating littoral species and ferns such as *Pteridium esculentum*, *Pellaea falcata*, *Doodia aspera* and *Adiantum hispidulum. Cissus antarctica* and *Eustrephus latifolius* are the main climbers.

Aeolian dune ridges on the Tuggerah SLU occur at the northern end of the sandplain in Woy Woy. These sand ridges have more of a forest vegetation (see Fig. 2) dominated by *Angophora costata* and *Corymbia gummifera (*RGBW). Understorey trees are *Banksia serrata, Allocasuarina littoralis* and groundplants include *Acacia suaveolens, Banksia serrata, Breynia oblongifolia, Lomandra longifolia* and *Pteridium esculentum.*

In the sand dune swales here, woodland is dominated by *Angophora floribunda, Banksia serrata, Eucalyptus robusta,* and *Melaleuca quinquenervia*. The understorey plants mainly comprise *Banksia serrata, Monotocca elliptica, Exocarpus cupressiformis, Angophora floribunda, Allocasuarina littoralis, Dodonaea triquetra, Acacia longifolia* subsp. *longifolia, Macrozamia communis, Lomandra longifolia* and *Pteridium esculentum.*

The only area on the Umina-Woy Woy sandplain where this aeolian dune and swale vegetation remains is the Burrawang Reserve (Hillview Street, Woy Woy). It is the most important reserve on the sandplains for this reason. Although floristically and visually this vegetation looks similar to the Sydney Red Gum complex at Pearl Beach, it lacks the distinctive *Xanthorrhoea* Grass Tree understorey and the co-dominants of *Eucalyptus resinifera* and *Syncarpia glomulifera.*

Vegetation on coastal aeolian dunes is incorporated with Umina Coastal Sandplain Woodland in the regional PATN analysis.

Related mapping units**:** MU 33 Coastal Sand Apple Blackbutt Forest (House, 2003); Umina Sands Coastal Woodland E 33bi (Bell, 2004)

Fig. 10. Woodland dominated by *Angophora floribunda* and *Eucalyptus botryoides* with *Banksia serrata* as a sub-dominant. *Macrozamia communis* is conspicuous in the ground layer

Sydney Red Gum Complex (SRGC)

Open Forest: ***Angophora costata – Corymbia gummifera – Syncarpia glomulifera – Allocasuarina torulosa – Eucalyptus piperita – Eucalyptus resinifera*** (Fig.11)

Structure: Forest with a shrubby, cycad and grass tree understorey

Habitat**:** found on humus podzols on Holocene Sands (Warriewood SLU). Riparian elements along narrow riparian habitats or alluvial fans occur on both humus podzols and iron podzols on Holocene Sands (Warriewood and Woy Woy SLUs). The sandplain sites merge with those found on the Triassic Hawkesbury Sandstones.

Distribution**:** Pearl Beach in Brisbane Water National Park, the Crommelin Native Arboretum and the Crommelin Biological Research Station.

Riparian remnants only found as small pockets at the rear of Pearl Beach, at the rear of the Pearl North Estate (which was previously part of the Etymalong Swamp) and at the Crommelin Native Arboretum and Crommelin Research Station. It once also occurred at the Ettalong Netball Facility Wetland

Floristic Composition**:** *Angophora costata* Sydney Red Gum, *Corymbia gummifera* Red Bloodwood, *Syncarpia glomulifera* Turpentine, *Allocasuarina torulosa* Forest Oak, *Eucalyptus piperita* Sydney Peppermint *and Eucalyptus resinifera* Red Mahogany are all canopy dominants. The lower tree layer is made up of *Allocasuarina torulosa, Syncarpia glomulifera and Banksia serrata.* A number of species make up the mid stratum layers such as *Synoum glandulosum, Leptospermum polygalifolium, Pultenaea daphnoides, Persoonia levis, Elaeocarpus reticulatus, Dillwynia floribunda, Pultenaea flexilis, Dodonaea triquetra* and *Podocarpus spinulosus.* The ground layer is always distinctive and dominated by *Macrozamia communis* and *Xanthorrhoea arborea. Lomandra longifolia, Themeda australis* and *Entolasia stricta* also occur.

In riparian locations remnant palms suggest *Livistona australis,* Cabbage Tree Palm was a tall emergent with canopy trees of *Eucalyptus piperita, Sydney* Peppermint, *Syncarpia glomulifera* Turpentine and *Eucalyptus paniculata* Grey Ironbark. Understorey trees included *Ceratopetalum apetalum, Trochocarpa laurina, Persoonia pinifolia, Livistona australis, Omalanthus populneus* and *Leptospermum polygalifolium*. Where swampy conditions occurred large trees of *Leptospermum polygalifolium* were present with a dense canopy and with an equally dense sedgeland of *Gahnia clarkei* beneath. Ferns included *Hypolepis muelleri* and *Calochlaena dubia*. At the rear of the previous Ettymalong Swamp pockets of dense palm forest occur with little or no understorey.

Related mapping units**:** Not shown by House (2003); Hawkesbury Apple Peppermint Forest e25 of Bell (2004)

Coastal Freshwater Swamps

Tall Sedgeland: *Lepironia articulata*

Structure: Dense cover of tall sedges up to 2 m high.

Habitat: Deep acid waters over Holocene sands (Woy Woy SLU).

Distribution: This type of reedland was found only in Iluka Lagoon. Prior to the 1990s the lagoon was in fairly good condition but since the development around Homan Close, it has become degraded through siltation. Despite concentrated efforts by the Iluka Landcare Group to revive the vegetation, it has almost become locally extinct.

Floristic composition: Mainly occurs as a monospecific stand of *Lepironia articulata.* Currently very disturbed and in need of recovery.

Related mapping units: MU 33 Coastal Sand Apple Blackbutt Forest (House 2003; Umina Lepironia Sedgeland E45 of Bell (2004).

Rushland/Reedland: *Typha orientalis – Baumea articulata*

Typha orientalis is now dominant in part of the Kahibah Swamp wetland with pockets of *Hypolepis muelleri* and *Persicaria strigosa,* with occasional trees of *Melaleuca quinquenervia* and *Glochidion ferdinandi*. This vegetation has recently colonised the northern end of the wetland. Residential subdivision has caused silt to enter which was later colonised by *Typha orientalis*. Although a native species Typha is not retained by the Authorities because it increases the risk of flooding.

Prior to 1990 this wetland was dominated by *Baumea articulata* with *Blechnum indicum* and *Hypolepis muelleri* and the previous vegetation persists at the southern end of the wetland where the impacts are less, although originally this area appeared to be mainly open water **(Figure 12).** Small pockets of *Melaleuca quinquenervia* and *Eucalyptus robusta* are now colonising the western edge on silt entering the wetland through drainage pipes.

This type of vegetation along with Common Reed, *Phragmites australis,* was also present in the meandering Etymalong, Kahibah and Iluka Creeks.

Related mapping units: MU 40 Swamp Oak Rushland Forest by House (2003) and Coastal Sand Swamp Forest E37ai of Bell (2004).

Fig. 11. Sydney Red Gum Forest with *Xanthorrhoea arborea* as a conspicuous element amongst thick scrub in the understorey

Fig. 12. Wetlands were a significant feature of the vegetation on the Umina-Woy Woy sandplain. This is Kahibah Swamp (part of Portion 98) in 1956. (Reproduced with permission from Gosford City Council).

Sedgeland /Herbland: *Cladium procerum – Bolboschoenus fluviatilis – Typha orientalis – Baumea articulata – Persicaria strigosa*

The Everglades Lagoon supports a more mixed type of wetland vegetation although it is heavily modified (Figure 13). The sedges comprise *Cladium procerum*, *Bolboschoenus fluviatilis, Typha orientalis* Cumbungi, *Baumea articulata* with herbs of *Persicaria strigosa.* Drainage works have changed the water levels at the lagoon leaving the large root systems of *Melaleuca quinquenervia* trees exposed. This wetland is now invaded by the exotic *Alternanthera philoxeroides* Alligator Weed.

Related mapping units: MU 40 Swamp Oak Rushland Forest of House (2003) and Freshwater Typha Wetland E46a of Bell 2004)

Riparian Forest: *Melaleuca quinquenervia – Eucalyptus robusta*

On the eastern edge of the Everglades Lagoon is a remnant forest of *Melaleuca quinquenervia* Broad-leaved Paperbark but around the fringes of this and other wetlands and along the drainage lines the species occurs with *Eucalyptus robusta* Swamp Mahogany. Smaller understorey trees are *Omalanthus populneus, Ficus coronata* and *Glochidion ferdinandi.* The understorey vegetation comprises *Carex appressa* and *Carex fasicularis.*

Riparian Forest with an understorey of *Baumea articulata* was once present in Etymalong Swamp but now only occurs as a narrow fringe beside residential properties.

Related mapping units: MU 33 Coastal Sand Apple Blackbutt Forest and MU 40 Swamp Oak Rushland Forest (House 2003) and Coastal Sand Swamp Forest of Bell (2004).

Riparian Palm Forest: *Eucalyptus robusta – Livistona australis – Casuarina glauca*

Along the lower reaches of Etymalong Creek a palm dominated riparian forest is found. This is the Coastal Sand Swamp Forest variant of Bell (2004). The forest type occurs at three sites on the Umina Woy Woy sandplain but originally may have occurred along drainage lines in some areas of the Pearl Beach sandplain. The Palm Forest on the alluvial fan behind Burdett Place Umina Beach (Figure 14) is included with this description.

Structure: Palm forest with a fern, sedge and reed understorey.

Habitat: Holocene sands (Woy Woy SLU) and subject to inundation. Ponds and soaks obvious. The vegetation community behind Burdett Place Umina was burnt out in the 2007 wildfire and has recovered.

Floristic Composition: The canopy is dominated by *Eucalyptus robusta* (Swamp Mahogany), *Livistona australis* (Cabbage Tree Palm) and *Casuarina glauca* (Swamp Oak) and occasionally *Angophora floribunda* (Rough-barked Apple). Sub-dominant trees include *Glochidion ferdinandi* (Cheese Tree), *Pittosporum undulatum* (Pittosporum), *Ficus coronata* (Sandpaper Fig) and *Alphitonia excelsa* (Red Ash). Dense pockets of small Cabbage Tree Palms and Sandpaper Fig trees make up part of the ground layer. The fern and sedge ground layer includes *Hypolepis muelleri* (Harsh Ground Fern), *Calochlaena dubia* (Common Ground Fern), *Blechnum indicum* (Swamp Water Fern) and *Cyclosorus interruptus*, whilst the sedges and reeds comprise *Cladium procerum*, *Schoenus imberbis, Gahnia clarkei* and *Phragmites australis* the Common Reed. Upslope of soaks the ground layer is mainly *Viola hederacea* (Native Violet), *Commelina*

Figure 13 Sedgeland/Reedland/Herbland at the Everglades showing *Persicaria strigosa* with *Bolboschoenus fluviatilis* behind. Pockets of *Cladium procerum* and *Baumea articulata* are sporadic.

Figure 14 Burnt palms, *Livistona australis* at the rear of Burdett Place, Umina (rear of Old Etymalong Swamp).

cyanea, Oplismenus aemulus (Basket Grass) and *Entolasia marginata*. Regenerating plants of *Astrotricha floccosa* and *Alphitonia excelsa* are common behind Burdett Place.

Related mapping units: MU 37 Swamp Mahogany-Paperbark Swamp Forest of House (2003) and MU 37eii Coastal Sand Swamp Forest-Cabbage Tree variant of Bell (2004).

No description for the Coast Banksia shrubland along the frontal dunes is provided. Whilst the canopy is still intact, most of the area is either weedy or has been replaced by plantings with some areas undergoing bush regeneration. This community extended along Umina and Ocean Beaches, Pearl Beach and Patonga Beach, although at Patonga the shrubland tended to be mixed with UCSW. Historical photos show UCSW, along with species such as *Casuarina glauca* Swamp Oak, extended along the foreshore of Woy Woy Channel.

There are still large remnant trees of *Ficus rubiginosa* along the public foreshore of the Woy Woy Channel and Brisbane Water, suggesting pockets of littoral rainforest may once have been present but as no evidence of associated vegetation remains, no description can be provided.

Appendix 2

Plant species recorded from sandplain remnants at Umina and Pearl Beach showing Vegetation communities (mapunits), together with occurrence in area burnt in 1992 wildfire at Pearl Beach in 1988 (pre-fire) and 2004 (post–fire)

Coastal Holocene Dunes

1) Tall Shrubland: *Banksia integrifolia – Leptospermum laevigatum*

2) Umina Coastal Sandplain Woodland (UCSW)

Woodland: *Eucalyptus botryoides – Angophora floribunda*

3) Sydney Red Gum Complex (SRC)

Open Forest: *Angophora costata – Corymbia gummifera – Syncarpia glomulifera – Allocasuarina torulosa –Eucalyptus piperita – Eucalyptus resinifera*

Coastal Freshwater Swamps

4) Tall Sedgeland: *Lepironia articulata*

5) Rushland/Reedland: *Typha orientalis – Baumea articulata*

6) Sedgeland /Herbland: *Cladium procerum – Bolboschoenus fluviatilis – Typha orientalis – Baumea articulata – Persicaria strigosa*

7) Riparian Forest: *Melaleuca quinquenervia – Eucalyptus robusta*

8) Riparian Palm Forest *Eucalyptus robusta – Livistona australis – Casuarina glauca*

Species	Family	Map unit	Pearl Beach Prefire (1988) Postfire (2004
Abrophyllum ornans	Escalloniaceae	2	
Acacia elata	Fabaceae	6	
Acacia floribunda	Fabaceae	2, 3	
Acacia irrorata subsp. *irrorata*	Fabaceae	5	
Acacia longifolia subsp. *longifolia*	Fabaceae	1, 2, 3, 7	88,04
Acacia oxycedrus	Fabaceae	2, 3	88
Acacia prominens	Fabaceae	5	
Acacia suaveolens	Fabaceae	2, 3	88,04
Acacia terminalis	Fabaceae	2, 3	88
Acacia ulicifolia	Fabaceae	2, 3	88,04
Acmena smithii	Myrtaceae	1,2, 3	88
Acronychia oblongifolia	Rutaceae	2	
Adiantum aethiopicum	Adiantaceae	2, 3, 5	88,04
Adiantum hispidulum	Adiantaceae	2	
Allocasuarina littoralis	Casuarinaceae	2	
Allocasuarina torulosa	Casuarinaceae	3, 5	88,04
Alocasia brisbanensis	Araceae	5	
Alphitonia excelsa	Rhamnaceae	1, 2,8	
Amperea xiphoclada	Euphorbiaceae	3	88
Angophora costata	Myrtaceae	2, 3	88,04
Angophora floribunda	Myrtaceae	2, 3, 7,8	88,04
Anisopogon avenaceus	Poaceae	3	88,04
Astroloma humifusum	Ericaceae	3	88,04
Astrotricha floccosa	Araliaceae	3	
Azolla filiculoides	Azollaceae	6	
Baloskion tetraphyllum subsp. *meiostachyum*	Restionaceae	2, 3	88,04
Banksia ericifolia	Proteaceae	5	
Banksia integrifolia	Proteaceae	2, 3	
Banksia serrata	Proteaceae	2, 3	88,04
Bauera rubioides	Baueraceae	3	88
Baumea articulata	Cyperaceae	5, 6	
Baumea teretifolia	Cyperaceae	5	
Billardiera scandens	Pittosporaceae	2, 3	88,04
Blechnum camfieldii	Blechnaceae	3	88,04
Blechnum cartilagineum	Blechnaceae	2, 3	88,04
Blechnum indicum	Blechnaceae	5,8	
Blechnum wattsii	Blechnaceae	3	88
Bolboschoenus fluviatilis	Cyperaceae	5, 6.7	
Bossiaea ensata	Fabaceae	3	88
Bossiaea heterophylla	Fabaceae	3	88,04
Breynia oblongifolia	Euphorbiaceae	2, 3	88,04
Bursaria spinosa	Pittosporaceae	3	88,04
Caesia parviflora	Anthericaceae	5	
Caladenia capillata	Orchidaceae	3	88
Callicoma serratifolia	Cunoniaceae	2	
Callistemon citrinus	Myrtaceae	3	88,04
Callistemon linearifolius	Myrtaceae	3	88
Calochilus gracillimus	Orchidaceae	3	88
Calochlaena dubia	Dicksoniaceae	3, 5,8	88
Carex appressa	Cyperaceae	5, 6, 7	
Carex fascicularis	Cyperaceae	7	
Carpobrotus glaucescens	Aizoaceae	1	
Cassytha pubescens	Lauraceae	2, 3, 5	88,04
Cassytha spp.	Lauraceae	3	
Casuarina glauca	Casuarinaceae	2, 5, 7	
Cayratia clematidea	Vitaceae	2, 5	
Centella asiatica	Apiaceae	5	
Ceratopetalum apetalum	Cunoniaceae	2, 3, 4, 5	88,04
Ceratopetalum gummiferum	Cunoniaceae	3	88,04
Chiloglottis spp.	Orchidaceae	3	
Christella dentata	Thelypteridaceae	3	88
Cissus antarctica	Vitaceae	2	
Cissus hypoglauca	Vitaceae	1, 2, 3, 5	88,04
Cladium procerum	Cyperaceae	5, 6, 7	
Clematis glycinoides	Ranunculaceae	2, 3	88,04
Clerodendrum tomentosum	Verbenaceae	2, 3	88,04
Comesperma ericinum	Polygalaceae	2	
Commelina cyanea	Commelinaceae	1, 2, 3, 5	88,04
Correa reflexa var. reflexa	Rutaceae	3	88
Corymbia gummifera	Myrtaceae	2, 3	88,04
Cotula australis	Asteraceae	5	
Crinum pedunculatum	Amaryllidaceae	7	
Crowea exalata subsp. *exalata*	Rutaceae	3	88
Cyathea australis	Cyatheaceae	3	88,04
Cyathea leichhardtiana	Cyatheaceae	3	88
Cyathochaeta diandra	Cyperaceae	3	
Cymbidium suave	Orchidaceae	3	88
Cymbopogon refractus	Poaceae	3	88
Cynodon dactylon	Poaceae	3, 6	88
Cyperus difformis	Cyperaceae	5	
Cyperus exaltatus	Cyperaceae	5	
Cyperus polystachyos	Cyperaceae	5	
Dampiera stricta	Goodeniaceae	3	88,04
Desmodium brachypodum	Fabaceae	3, 5	88
Dianella caerulea var. caerulea	Phormiaceae	2	88,04
Dianella caerulea var. *producta*	Phormiaceae	3	
Dianella congesta	Phormiaceae	1, 2	
Dianella longifolia	Phormiaceae	2	
Dichelachne crinita	Poaceae	5	
Dichondra repens	Convolvulaceae	3	88
Digitaria breviglumis	Poaceae	2	
Dillwynia floribunda	Fabaceae	3	88,04
Dioscorea transversa	Dioscoreaceae	3	88
Dipodium punctatum	Orchidaceae	3	88
Dodonaea triquetra	Sapindaceae	2, 3, 5	88,04
Doodia aspera	Blechnaceae	2	
Elaeocarpus reticulatus	Elaeocarpaceae	2, 3	88,04
Eleocharis sphacelata	Cyperaceae	3, 5	88
Empodisma minus	Restionaceae	3	
Entolasia marginata	Poaceae	3, 5	
Entolasia stricta	Poaceae	2, 3	88
Epacris longiflora	Ericaceae	3	88
Epacris microphylla	Ericaceae	3	88
Eriostemon australasius	Rutaceae	2	
Eucalyptus botryoides	Myrtaceae	2, 7	
Eucalyptus paniculata	Myrtaceae	2, 3, 7	88,04
Eucalyptus piperita	Myrtaceae	3	88,04

Eucalyptus punctata	Myrtaceae	3	88,04
Eucalyptus resinifera	Myrtaceae	3	
Eucalyptus robusta	Myrtaceae	2, 5, 6,8	
Eucalyptus umbra	Myrtaceae	3	88,04
Eupomatia laurina	Eupomatiaceae	2	
Euroschinus falcata var *falcata*	Anacardiaceae	2	
Eustrephus latifolius	Luzuriagaceae	1, 2, 3, 5	88,04
Exocarpos cupressiformis	Santalaceae	2	
Ficus coronata	Moraceae	6, 7	
Ficus rubiginosa	Moraceae	2, 7	
Gahnia clarkei	Cyperaceae	3, 5	88,04
Geitonoplesium cymosum	Luzuriagaceae	1, 3	88
Geranium homeanum	Geraniaceae	5	
Gleichenia dicarpa	Gleicheniaceae	3, 5	88,04
Glochidion ferdinandi var. *ferdinandi*	Euphorbiaceae	2, 3, 5, 6, 7	88,04
Glycine clandestina	Fabaceae	2, 3	88,04
Gompholobium latifolium	Fabaceae	2, 3	88
Gonocarpus tetragynus	Haloragaceae	2	
Gonocarpus teucrioides	Haloragaceae	3	88
Grevillea linearifolia	Proteaceae	5	
Guioa semiglauca	Sapindaceae	2	
Gymnostachys anceps	Araceae	2, 3	88,04
Hardenbergia violacea	Fabaceae	2, 3	88
Hemarthria uncinata	Poaceae	3	
Hibbertia aspera	Dilleniaceae	3	88
Hibbertia dentata	Dilleniaceae	3,8	88,04
Hibbertia diffusa	Dilleniaceae	2, 3	88
Hibbertia empetrifolia subsp. *empetrifolia*	Dilleniaceae	3	88
Hibbertia fasciculata	Dilleniaceae	2	
Hibbertia obtusifolia	Dilleniaceae	2	
Hibbertia scandens	Dilleniaceae	1, 2, 3	88
Histiopteris incisa	Dennstaedtiaceae	4	88,04
Homalanthus populifolius	Euphorbiaceae	3, 5, 6,7	88
Hovea lanceolata	Fabaceae	2	
Hybanthus monopetalus	Violaceae	2, 3	88,04
Hydrocotyle laxiflora	Apiaceae	2	
Hydrocotyle peduncularis	Apiaceae	2, 5	
Hydrocotyle tripartita	Apiaceae	5	
Hydrocotyle verticillata	Apiaceae	5	
Hypolepis muelleri	Dennstaedtiaceae	3, 5	88,04
Imperata cylindrica var. *major*	Poaceae	1, 2, 3,8	
Indigofera australis	Fabaceae	3	88
Isachne globosa	Poaceae	5	
Isolepis cernua	Cyperaceae	5, 6	
Isolepis nodosa	Cyperaceae	1, 2	88
Juncus planifolius	Juncaceae	3, 5	88
Juncus prismatocarpus	Juncaceae	5	
Juncus usitatus	Juncaceae	6	
Kennedia rubicunda	Fabaceae	2, 3	88,04
Lasiopetalum ferrugineum var. *ferrugineum*	Sterculiaceae	3	88
Lastreopsis microsora subsp. *microsora*	Dryopteridaceae	3	88
Lepidosperma elatius	Cyperaceae	3	
Lepidosperma laterale	Cyperaceae	3	88,04
Lepidosperma longitudinale	Cyperaceae	2	
Lepironia articulata	Cyperaceae	4	
Leptomeria acida	Santalaceae	3	88,04
Leptospermum laevigatum	Myrtaceae	2, 3, 5	
Leptospermum polygalifolium	Myrtaceae	2, 3,5,7	88,04
Leptospermum trinervium	Myrtaceae	2	
Livistona australis	Arecaceae	3, 5, 7,8	88,04
Lobelia anceps	Lobeliaceae	5	
Lobelia dentata	Lobeliaceae	2	
Logania albiflora	Loganiaceae	3	88,04
Lomandra filiformis subsp. *coriacea*	Lomandraceae	2	
Lomandra longifolia	Lomandraceae	1, 2, 3	88,04
Lomandra multiflora subsp. *multiflora*	Lomandraceae	3	88,04
Lomandra obliqua	Lomandraceae	3	88,04
Ludwigia peploides subsp. *montevidensis*	Onagraceae	6	
Macrozamia communis	Zamiaceae	2, 3, 5, 6	88,04
Maytenus silvestris	Celastraceae	3	
Melaleuca linariifolia	Myrtaceae	5,8	
Melaleuca quinquenervia	Myrtaceae	2, 5, 6	
Melia azedarach	Meliaceae	7	
Microlaena stipoides	Poaceae	1, 3, 5	88
Mitrasacme polymorpha	Loganiaceae	2, 3	88
Monotoca elliptica	Ericaceae	2, 3	88,04
Morinda jasminoides	Rubiaceae	2, 5	
Myoporum acuminatum	Myoporaceae	5	
Myrsine variabilis	Myrsinaceae	2, 3	88,04
Notelaea longifolia	Oleaceae	3	88
Opercularia aspera	Rubiaceae	2	
Opercularia hispida	Rubiaceae	2	
Oplismenus aemulus	Poaceae	2	
Oxalis perennans	Oxalidaceae	1	
Pandorea pandorana	Bignoniaceae	1,2, 3	88,04
Panicum effusum	Poaceae	3	
Parsonsia straminea	Apocynaceae	2, 3, 5, 7	88
Paspalum distichum	Poaceae	6	
Patersonia sericea	Iridaceae	3	88,04
Pellaea falcata	Adiantaceae	1, 2, 7	
Persicaria decipiens	Polygonaceae	5, 6	
Persicaria strigosa	Polygonaceae	3, 5, 6, 7	88,04
Persoonia lanceolata	Proteaceae	3	
Persoonia levis	Proteaceae	3	88
Persoonia linearis	Proteaceae	1, 3	88
Persoonia pinifolia	Proteaceae	3	88,04
Philydrum lanuginosum	Philydraceae	3, 5	88
Phragmites australis	Poaceae	4, 6	
Phyllanthus hirtellus	Euphorbiaceae	2, 3	88,04
Pittosporum multiflorum	Pittosporaceae	2, 3	88,04
Pittosporum revolutum	Pittosporaceae	1, 2	
Pittosporum undulatum	Pittosporaceae	1, 2, 3, 5 ,7	88,04
Platylobium formosum subsp. *formosum*	Fabaceae	2, 3	88,04
Platysace lanceolata	Apiaceae	2, 3	
Platysace linearifolia	Apiaceae	3	88,04
Poa affinis	Poaceae	5	
Podocarpus spinulosus	Podocarpaceae	3	88,04

Pomaderris ferruginea	Rhamnaceae	3	88,04
Pomaderris intermedia	Rhamnaceae	2	88
Pomax umbellata	Rubiaceae	2, 3	88,04
Pratia purpurascens	Lobeliaceae	3	88
Prostanthera linearis	Lamiaceae	3	88,04
Pseuderanthemum variabile	Acanthaceae	2, 3, 5	88,04
Pseudognaphalium luteo-album	Asteraceae	5	
Psychotria loniceroides	Rubiaceae	3	88
Pteridium esculentum	Dennstaedtiaceae	1, 2, 3	88,04
Pterostylis nutans	Orchidaceae	3	88
Pultenaea daphnoides	Fabaceae	3	88,04
Pultenaea flexilis	Fabaceae	3, 5	88,04
Pultenaea linophylla	Fabaceae	5	
Ranunculus inundatus	Ranunculaceae	5	
Rhodamnia rubescens	Myrtaceae	2	
Rhodomyrtus psidioides	Myrtaceae	2	
Ricinocarpos pinifolius	Euphorbiaceae	2, 3	88,04
Rubus moluccanus var. *trilobus*	Rosaceae	2, 5	
Sarcopetalum harveyanum	Menispermaceae	3	88
Scaevola ramosissima	Goodeniaceae	3	88
Schelhammera undulata	Uvulariaceae	3	88,04
Schizaea bifida	Schizaeaceae	3	88,04
Schizaea dichotoma	Schizaeaceae	3	
Schizomeria ovata	Cunoniaceae	2, 5	88,04
Schoenus apogon	Cyperaceae	6	
Schoenus brevifolius	Cyperaceae	2, 3	88,04
Selaginella uliginosa	Selaginellaceae	2, 3	88,04
Senecio diaschides	Asteraceae	2	
Senecio lautus subsp. *lanceolatus*	Asteraceae	2	
Sigesbeckia orientalis subsp. *orientalis*	Asteraceae	5	
Smilax australis	Smilacaceae	3	88
Smilax glyciphylla	Smilacaceae	1, 2, 3	88,04
Solanum elegans	Solanaceae	3, 5	
Solanum mauritianum	Solanaceae	3	
Stephania japonica var. *discolor*	Menispermaceae	1, 2, 5	
Sticherus flabellatus var. *flabellatus*	Gleicheniaceae	3	88,04
Stylidium graminifolium	Stylidiaceae	3	88
Syncarpia glomulifera	Myrtaceae	3	88,04
Synoum glandulosum subsp. *glandulosum*	Meliaceae	2, 3	88,04
Syzygium oleosum	Myrtaceae	3, 7	88
Tetragonia tetragonioides	Aizoaceae	1	
Tetratheca ericifolia	Tremandraceae	2	
Themeda australis	Poaceae	2, 3	88,04
Todea barbara	Osmundaceae	3	88
Trema tomentosa var. *viridis*	Ulmaceae	4, 6	
Triglochin procerum	Juncaginaceae	6, 7	
Triglochin striatum	Juncaginaceae	8	
Trochocarpa laurina	Ericaceae	1, 2, 3	
Typha orientalis	Typhaceae	5, 6	
Villarsia exaltata	Menyanthaceae	5	
Viminaria juncea	Fabaceae	3	88,04
Viola caleyana	Violaceae	6	
Viola hederacea	Violaceae	3, 6	88,04
Wahlenbergia gracilis	Campanulaceae	3, 6	88
Wilkiea huegeliana	Monimiaceae	1, 2	88
Woollsia pungens	Ericaceae	3	88,04
Xanthorrhoea arborea	Xanthorrhoeaceae	3	88,04
Xanthorrhoea media	Xanthorrhoeaceae	3	88,04
Xanthosia pilosa	Apiaceae	3	88,04
Xylomelum pyriforme	Proteaceae	3	88,04

INTRODUCED SPECIES

**Ageratina adenophora*	Asteraceae	88
**Aira caryophyllea*	Poaceae	88
**Andropogon virginicus*	Poaceae	88,04
**Asparagus officianalis*	Asparagaceae	
Brachychiton acerifolius	Sterculiaceae	
**Cinnamomum camphora*	Lauraceae	88,04
**Ehrharta erecta*	Poaceae	
**Erechtites valerianifolia*	Asteraceae	
**Geranium molle* subsp. *molle*	Geraniaceae	
**Hydrocotyle bonariensis*	Apiaceae	
**Hypochaeris radicata*	Asteraceae	88,04
**Lantana camara*	Verbenaceae	88,04
**Ligustrum sinense*	Oleaceae	
**Lonicera japonica*	Caprifoliaceae	88,04
**Melastoma affine*	Melastomaceae	
**Nephrolepis cordifolia*	Davalliaceae	88,04
**Ochna serrulata*	Ochnaceae	88,04
**Panicum effusum*	Poaceae	88
**Paspalum urvillei*	Poaceae	88
**Passiflora edulis*	Passifloraceae	88,04
**Poa annua*	Poaceae	88
**Senna pendula* var. *glabrata*	Fabaceae (Caesalpinioideae)	88,04
**Setaria sp.*	Poaceae	88
**Sida rhombifolia*	Malvaceae	88
**Tradescantia fluminensis*	Commelinaceae	88