

## THE VEGETATION OF THE GOSFORD AND LAKE MACQUARIE 1:100 000 VEGETATION MAP SHEET

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### ABSTRACT

Benson, D. H. (*National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, New South Wales, Australia* 2000) 1986. *The vegetation of the Gosford and Lake Macquarie 1:100 000 vegetation map sheet. Cunninghamia* 1(4):467-489. The composition and extent of the present natural vegetation on the Gosford and Lake Macquarie 1:100 000 map sheet (lat. 33° 00'-33° 30'S, long. 151° 00'-151° 45'E) is described and mapped in terms of structure, characteristic species and associated environmental factors. The area encompasses examples of almost all the structural and floristic vegetation types to be encountered in any area of coastal New South Wales. Twelve (12) map units are recognized, including estuarine communities, heaths, woodlands, open-forests and rainforests. The lack of adequate conservation reserves for some of the communities is discussed.

### INTRODUCTION

The Gosford and Lake Macquarie Vegetation Map Sheet is the first in the Sydney Region Vegetation Map Series, a series of vegetation maps being prepared by the Ecology Section of the Royal Botanic Gardens, Sydney. The Series consists of vegetation maps at a scale of 1:100 000, corresponding to the Division of Natural Mapping 1:100 000 topographic sheets. The first sheets to be produced will be those within the Sydney 1:250 000 map area: Gosford and Lake Macquarie, Sydney, Penrith, St Albans, Wallerawang and Katoomba. These will be followed by the Wollongong map area, and ultimately the Newcastle and Singleton 1:250 000 map areas. Draft dyeline maps and explanatory notes are generally available for comment several years prior to publication.

### METHODS

Areas of vegetation with similar structural and floristic characteristics were grouped on the basis of aerial photo-pattern, geology and landform to form the map units. Black and white aerial photography from the New South Wales Department of Lands (Gosford and Lake Macquarie 1:60 500 scale, flown in August 1980) was used. Only present-day natural vegetation is mapped. Field work involved checking of particular areas and recording notes on structure, characteristic species of major strata and associated environmental factors. Extensive species lists have not been presented though such data are being gradually compiled by the National Herbarium and are available either through Pickard (1972) and Bryant & Benson (1981) or on request.

The vegetation has been classified into the structural forms of Specht (1970). The structural forms (Table 1) are further subdivided by the dominant or characteristic species. An alpha-numeric code is used to identify map units. The numeric code represents the predominant structural form of the plant community (from Table 1) and the alphabetic code represents the characteristic species. Missing numbers are units that do not occur on this sheet area. This system has been used in Queensland for the Moreton Region Vegetation Map Series (McDonald & Whiteman, 1979).

The map units recognized are not all of equivalent rank. This is because some are essentially land-units made up of several plant communities associated with a particular geological or physiographic type (for example, map units 4a, 10a) whereas others are more clearly plant associations (*sensu* Beadle & Costin, 1952; for example, map units 9k, 12b).

TABLE 1  
Structural classification of the vegetation based on Specht (1970)\*

Life form and height of predominant stratum	Projective foliage cover of predominant stratum			
	70-100%	30-70%	10-30%	< 10%
Trees 30 m + . . . . .	5. Tall closed-forests	6. Tall open-forests	7. Tall Woodlands	..
Trees 10-30 m . . . .	8. Closed-forests	9. Open-forests	10. Woodlands	11. Open-woodlands
Trees 6-10 m . . . . .	12. Low closed-forests	13. Low open-forests	14. Low Woodlands	15. Low open-woodlands
Shrubs 2-8 m . . . . .	16. Closed-scrubs	17. Open-scrubs	18. Tall shrublands	19. Tall open-shrublands
Shrubs 1-2 m . . . . .	20. Closed-heaths	21. Open-heaths	22. Low shrublands	23. Low open-shrublands
Hummock grasses	..	..	24. Hummock grassland	25. Open hummock grassland
Herbaceous plants	26. Closed-herbland	27. Herbland	28. Open-herbland	29. Sparse-herbland

\* Table from McDonald and Whiteman (1979).

Other units on map:

4. Littoral vegetation.

C. Disturbed areas—partly or wholly cleared for agriculture, forestry or urban use.

The vegetation map is a diagrammatic attempt to simplify the distributional patterns of an often rich and varied flora, over an extensive region. It is scale-dependent and map units will almost invariably include unmapped areas of other map units too small to be shown separately. Similarly, most plant communities do not have clear-cut boundaries but grade into each other, often over a broad ecotone. For mapping purposes such boundaries have to be approximated to a line.

Botanical names used are those currently recognized at the National Herbarium of New South Wales. Recent nomenclatural changes since the latest edition of Beadle, Evans & Carolin (1982), the relevant Flora, include a revision of *Tristania* (Wilson & Waterhouse, 1982) and the separation of *Allocasuarina* from *Casuarina* (Johnson, 1982).

#### GENERAL DESCRIPTION OF AREA

The Gosford and Lake Macquarie 1:100 000 Vegetation Sheet (based on the Gosford 1:100 000 Topographic Sheet 9131 and Lake Macquarie 1:100 000 Topographic Sheet 9231, Division of National Mapping, Canberra) is bounded by latitudes 33°00' and 33°30'S and longitudes 151°00' and 151°45'E. This area extends from Redhead, just south of Newcastle, southward along the coast to Terrigal near Gosford, and westward almost to Wollombi and Wisemans Ferry. The major coastal lake systems of Lake Macquarie and Tuggerah Lake are included, together with the urban centres of Gosford and Wyong. Much of the western half of the sheet is State Forest or National Park.

### Climate

The area lies on the Subtropical East Coast (Gentili, 1972) and experiences a generally mild climate. Average maximum temperatures for January, the hottest month, are about 28° C whilst average minimum temperatures for July, the coldest, range from 8° C on the coast to 3° C on the western edge (Bureau of Meteorology, 1979). Rainfall is highest in the Watagan Mountains in the north central part of the map sheet (average annual rainfall for Olney State Forest, lat. 33° 06'S, long. 151° 15'E, altitude 152 m, is 1614 mm). Average annual rainfall decreases to about 1000 mm on the western edge of the area and to about 1000 mm over Lake Macquarie. There is a slight increase along the coast. Gosford, on the southern edge of the sheet area, has an average annual rainfall of 1282 mm. March is generally the wettest month and October the driest. Summer winds are predominantly south to southeasterly with a tendency for onshore afternoon northeasterlies on the coast. Winter winds are predominantly west to southwesterly (Bureau of Meteorology, 1979).

### Geology and Geomorphology

The sheet area lies at the northeastern corner of the Hornsby Plateau, which is a subdivision of the Sydney Basin, the large structural basin extending from Muswellbrook to Batemans Bay (Bembrick *et al.*, 1980). Several major north/south geological folds give rise to a series of major north/south ridge systems. One of these, the Hunter Range, divides the catchment of the Hawkesbury River, here essentially that of Mangrove Creek, from those of the other coastal creeks, Dora and Wyong Creeks. West of the Hunter Range is an extensive and deeply dissected plateau of Triassic Hawkesbury Sandstone which continues further westward as far as the Blue Mountains. In this area the plateau surface ranges between 200 and 300 m high. Softer sandstones and shales of the underlying Triassic Narrabeen Group are exposed in the gullies and narrow valleys cut through the Hawkesbury Sandstone. East of the Hunter Range most of the Hawkesbury Sandstone capping has disappeared, except for residuals on the Watagan Mountains (up to 400 m high), and steep, hilly country is formed from the Narrabeen Group sediments, here subdivided into the Gosford Formation Sandstone and the underlying Clifton Sub-group sandstone, claystones and shales (Figure 1). On the northeast corner are the Newcastle Coal Measures of Permian age, comprising shale, sandstone, conglomerate, tuff, chert and coal seams. In the Swansea-Redhead region these are covered with Quaternary sand. River and creek valleys contain deep deposits of Quaternary alluvium, and the coastal lakes are formed behind Quaternary barrier systems. Creeks entering these lakes (e.g., Dora Creek) have often built up characteristic 'silt jetties'. Around Woy Woy and Wyong-Tuggerah are extensive floodplains. Mount Warrawolong, a prominent dome-shaped hill of Tertiary-aged basalt, is the highest point of the area (640 m elevation). About a dozen small volcanic necks or diatremes also occur.

The Triassic sediments weather to grey and yellow-brown uniform sands on, or adjacent to, areas of strong relief, and sandy yellow leached gradational soils, often with ironstone gravels, on areas of gentle to moderate relief, particularly around Somersby (Hamilton, 1976). On steep slopes the high rate of erosion leaves a shallow soil that may contain fragments of parent material. On ridges and upper slopes in the Watagan Mountains are loose brown to dark grey sands and sandy loams. Fertility on these soils is low (Soil Conservation Service of New South Wales, in prep.). The Narrabeen Group sediments weather to loams and clays of moderate to high fertility. Floodplains and valley flats may have deep earthy yellow and brown alluvial sands and loams of low to moderate fertility. The fine-textured soils formed from the Clifton Sub-group have a high potential for deep gully erosion. The alluvial deposits are derived from the sandy material of the higher slopes and are prone to erosion once the vegetation cover has been removed. Erosion is increased by frequent fire.

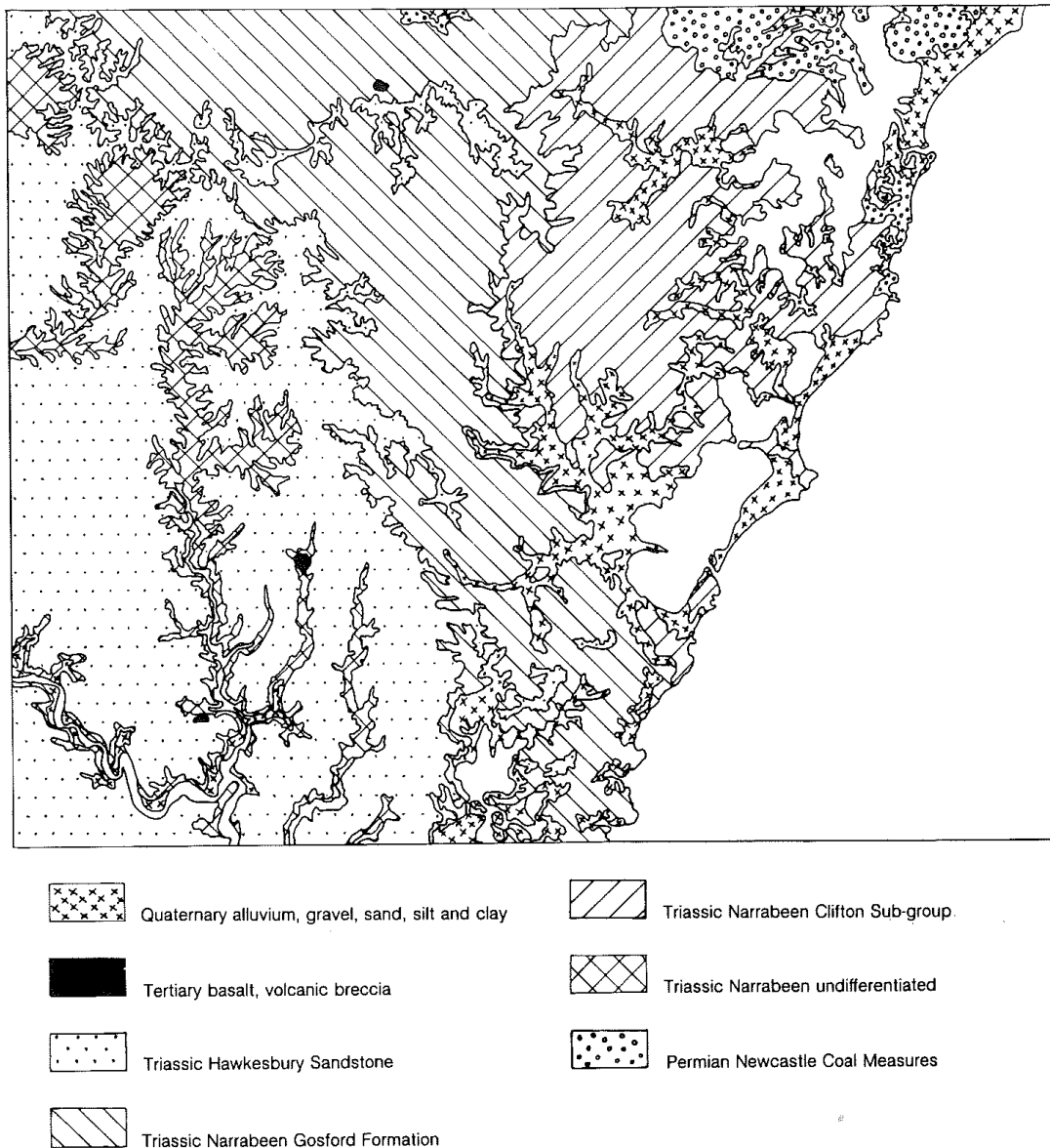


Figure 1. Geological map of the Gosford-Lake Macquarie map sheet area (adapted from New South Wales Department of Mines, 1966).

### Land-use

The Wyong district was first exploited by Europeans early last century as the cedar-cutters moved through. "The whole of this country, from Wyong to the Myall, and from Warrewolong to the Lakes, is very heavily timbered, particularly in the gullies; great quantities of cedar and other valuable woods abound, but are fast disappearing under the hands of the sawyers" wrote Raymond in 1832. As this timber was cut out settlers cleared land for farming. Wyong remained an important timber town well into the 20th century because of the large amount of hardwood timber in the mountains to the west, though, by 1916, with the first dedication of state forests, only the comparatively infertile and/or steep slopes remained forested.

Today, most of the more fertile soils particularly on the alluvial flats, has been cleared of native vegetation and replaced with improved pastures or citrus orchards. The resulting landscape is a mosaic of natural vegetation dissected

by strips of agricultural or urban development. Important land-uses include citrus or stone fruit orchards, poultry, beef cattle, dairying, tomato and other cash crops (e.g., passionfruit) and plant nurseries. State forests cover large areas of uncleared rugged country in the centre and north of the map sheet. These include Ourimbah, Wyong, Watagan and Olney State Forests and are managed for the production of sawlogs and mining timbers.

The Gosford–Wyong region has been extensively developed for urban and associated recreational use, especially around Tuggerah Lake and Brisbane Water, and along the coast, particularly north of Swansea. Coal-mining occurs on the Newcastle Coal Measures and a number of major power stations are sited on the coastal lake margins.

The rugged country to the south of the map sheet, round the Hawkesbury River, is mainly National Park: Dharug, Brisbane Water and the recently gazetted Marramarra National Park in the far southwest. There are a number of small parks and reserves along the coast, including Munmorah State Recreation Area and Wyong Shire Council's North Entrance Nature Reserve.

## VEGETATION

Apart from the specialized habitats such as mangroves and freshwater swamp, the vegetation of the map sheet belongs either to Beadle's (1981) eastern coastal lowlands tall *Eucalyptus* forests mostly on soils of higher fertility, or his *Eucalyptus* woodlands and forests on soils of low fertility. The vegetation of the Hawkesbury Sandstone of the Gosford region was included in Pidgeon's (1937, 1938, 1940, 1941) vegetation study of the Central Coastal area of New South Wales. Detailed descriptions of the vegetation of Brisbane Water National Park have been prepared by J. S. Benson & Fallding (1981) and for Mangrove Creek by D. H. Benson (1981). A vegetation survey of Dharug National Park is currently (1986) being undertaken at the Royal Botanic Gardens, Sydney. There are also a series of dyeline 1: 25 000 scale "Forest Type" maps covering Olney, Ourimbah, Watagan and Wyong State Forests available from the Forestry Commission of New South Wales. Further information is limited to species lists for local areas, references to which are given in the appropriate plant community descriptions.

A summary of the map units recognized here, their structural formations, main canopy species and geological substrates are given in Table 2. Species of particular conservation importance are listed in Table 3, major conservation areas in Table 4 (see p. 486). The vegetation map sheet is located inside the back cover.

### Plant community descriptions

#### 4a *Estuarine complex*

Estuarine vegetation is found on alluvial mudflats along the Hawkesbury River, its tributaries, Mangrove Creek and Mooney Mooney Creek, and in the bays of Brisbane Water, especially around The Rip, and Ripleys and Pelican Islands. Extensive clearing and reclamation for foreshore development has taken place around Gosford and Woy Woy. For example, St Huberts Island, at the entrance to Brisbane Water, has been completely cleared for canal-estate housing. In the Lake Macquarie and Tuggerah Lake areas estuarine vegetation is found at the head of Lake Eraring, around the shores of Muddy Lake, at the tips of the Dora Creek silt jetties, Whiteheads Lagoon and at the entrance to Lake Macquarie at Swansea.

Estuarine vegetation generally consists of zones of vegetation, often of different structural formations. The main factor in the explanation of plant distribution is the influence of tide and elevation on salinity in relation to the environmental requirements and tolerance ranges of the plant species. Plant zonation is closely associated with elevation above mean sea level, and very small differences in microtopography are involved (Clarke & Hannon, 1969).

TABLE 2

Map unit, structure, main canopy species, geology and occurrence of plant communities on the Gosford and Lake Macquarie 1:100 000 vegetation map sheet

Map unit	Structural formation	Main canopy species	Geology	Occurrence
4a	OPEN-SCRUB	<i>Avicennia marina</i>	Quaternary alluvium	Estuarine mudflats, regular tidal inundation
	HERBLAND	<i>Sarcocornia quinqueflora</i>		Occasional tidal inundation
	RUSHLAND	<i>Juncus kraussii</i>		Infrequent tidal inundation
	LOW OPEN-FOREST	<i>Casuarina glauca</i> , <i>Baumea juncea</i>		Poorly drained, some saline influence
6e	TALL OPEN-FOREST	<i>Eucalyptus saligna</i> , <i>Syncarpia glomulifera</i> , <i>Angophora costata</i> , <i>E. pellita</i>	Clifton Sub-group Gosford	Deep, sheltered gullies, southeast aspects
8a	CLOSED-FOREST	<i>Ceratopetalum apetalum</i> , <i>Doryphora sassafras</i> , <i>Acmena smithii</i> , <i>Livistona australis</i> , Emergents— <i>Eucalyptus deanei</i> , <i>Syncarpia glomulifera</i>	Narrabeen Group	Sheltered gullies, fertile soils
8b	CLOSED-FOREST	<i>Melaleuca linariifolia</i> , <i>M. styphelioides</i> , Emergents— <i>Eucalyptus robusta</i> , <i>E. longifolia</i>	Quaternary alluvium	Poorly-drained creek flats
	SCRUB	<i>Melaleuca ericifolia</i> , <i>M. sieberi</i> , <i>M. decora</i> , <i>M. nodosa</i> , <i>M. linariifolia</i> , <i>M. thymifolia</i>		Poorly-drained flats often on poor soils
9g	OPEN-FOREST	<i>Angophora costata</i> , <i>Eucalyptus gummifera</i> , <i>E. capitellata</i> , <i>E. pilularis</i> , <i>E. maculata</i> , <i>E. umbra</i> , <i>E. siderophloia</i> , <i>E. punctata</i>	Narrabeen Group and Permian sandstones	Gentle slopes, ridge tops and valley floors  Steeper slopes on ridge sides

Map unit	Structural formation	Main canopy species	Geology	Occurrence
9h	OPEN-FOREST	<i>Eucalyptus deanei</i> , <i>E. acmenoides</i> , <i>Angophora floribunda</i> , <i>Syncarpia glomulifera</i>	Narrabeen Group	Valleys, or lower valley slopes, sheltered aspects
		<i>Angophora floribunda</i> , <i>E. punctata</i> , <i>E. tereticornis</i> , <i>E. eugenioides</i> , <i>Allocasuarina torulosa</i>		Dry northern or western aspects
9k	OPEN-FOREST	<i>Angophora costata</i>	Quaternary sand dunes	Sheltered coastal dunes, North Entrance
10a	OPEN-FOREST/ WOODLAND	<i>Eucalyptus piperita</i> , <i>Angophora costata</i>	Hawkesbury Sandstone	Sheltered hillsides, gullies
	LOW WOODLAND	<i>E. gummifera</i> , <i>E. eximia</i> , <i>E. punctata</i> , <i>E. haemastoma</i>		Ridges, plateaux and dry exposed hillsides
	OPEN-SCRUB	<i>Banksia ericifolia</i> , <i>Hakea teretifolia</i>		Poorly-drained situations
		<i>Angophora hispida</i> , <i>Lambertia formosa</i> , <i>Banksia serrata</i>		Dry rocky ridges, shallow soil
	OPEN-HEATH	<i>Allocasuarina distyla</i> , <i>Baeckea spp.</i> , <i>Darwinia spp.</i>		Patches in isolated depressions on rock platforms
	SEDGELAND	Cyperaceae and Restionaceae, <i>Banksia robur</i>	Swampy organic soils with impeded drainage	
10e	WOODLAND	<i>Eucalyptus haemastoma</i>	Clifton Sub-group	Broad low ridges with poor soils
21a	OPEN-HEATH	<i>Melaleuca nodosa</i> , <i>Allocasuarina distyla</i> , <i>Lambertia formosa</i> , <i>Banksia oblongifolia</i> , <i>Hakea teretifolia</i>	Clifton Sub-group/ Permian coal measures	Shallow soils or exposed situations, generally coastal
	GRASSLAND SEDGELAND	<i>Themeda australis</i> <i>Melaleuca thymifolia</i> , <i>Leptospermum juniperinum</i> , <i>Callistemon citrinus</i>		Headlands Poorly-drained sites

Map unit	Structural formation	Main canopy species	Geology	Occurrence
21b	OPEN-HEATH	<i>Banksia aemula</i>	Quaternary aeolian sand (Pleistocene)	Coastal headlands
	CLOSED-SCRUB	<i>Leptospermum laevigatum</i> , <i>Banksia integrifolia</i> , <i>Acacia longifolia</i>	Aeolian sand (Recent)	Coastal dunes
	LOW CLOSED-FOREST	<i>Cupaniopsis anacardioides</i> , <i>Livistona australis</i>		Lee side of larger dunes
27a	SEDGELAND	<i>Eleocharis spp.</i> , <i>Baumea spp.</i> , <i>Juncus spp.</i> , <i>Alisma plantago-aquatica</i> , <i>Philydrum lanuginosum</i> , <i>Phragmites australis</i>	Quaternary alluvium	Floodplains or behind dune systems where soils are periodically waterlogged  Brackish water
	CLOSED-SCRUB	<i>Melaleuca ericifolia</i> , <i>Gahnia clarkei</i>		Shorter periods of inundation and waterlogging
	OPEN-FOREST	<i>Melaleuca quinquenervia</i> , <i>Casuarina glauca</i> , <i>Eucalyptus robusta</i> , <i>E. amplifolia</i>		
C	CLEARED	Native vegetation has been largely removed for agricultural or suburban development but remnant vegetation of varying size and condition may remain.		

The zonation is broadly as follows. On the outermost side of the mudflat is a zone of mangrove open-scrub, commonly 1 to 5 m high and dominated by *Avicennia marina*. The other mangrove species that may be found is *Aegiceras corniculatum*, a smaller, less abundant plant generally confined to the inner edges of the mangrove zone. The mangrove zone is subjected to a relatively high number of high tides (Clarke & Hannon, 1969). Behind the mangrove zone may be a zone of saltmarsh, a herbland dominated by succulent members of the Chenopodiaceae, *Sarcocornia quinqueflora* and *Suaeda australis*. These plants are less than 0.5 m high and are inundated by sea water only during very high tides or at flood periods. These areas are often waterlogged and have a high salinity. Behind this may be a zone of rushland with *Juncus kraussii* and *Sporobolus virginicus*. These areas receive infrequent inundation. Finally there is a zone of swamp forest with *Casuarina glauca* or *Eucalyptus robusta*, often with an understorey of *J. kraussii* or *Phragmites australis*, the latter indicating a brackish rather than saline environment. This zone is not directly flooded. Where sandstone hillsides abut the water's edge and there is no accumulated alluvium, the zonation may be reduced to a line of mangroves and a few trees of *C. glauca*.

The estuarine wetlands of Brisbane Water are significant within the context of the Sydney Region, with mangroves representing approximately 14 per cent and saltmarshes approximately 28 per cent of the Sydney Region resources.



Reasonably large areas of mangroves still survive—indeed the area of mangroves in Brisbane Water increased overall by 25 ha between 1954 and 1979, as a result of increased siltation resulting from clearing and disturbance in catchment areas. In contrast the area of saltmarsh has been substantially reduced (by 60 per cent since 1954) by reclamation (New South Wales Department of Environment and Planning, 1983). Important areas of saltmarsh include Cockle Bay, Rileys Island, lower Mangrove Creek and near Singletons Mill on the Hawkesbury (Benson, 1974). Rushland and *Casuarina glauca* are still fairly common, though *Eucalyptus robusta* communities are rare and inadequately conserved.

Detailed studies of similar mangrove and saltmarsh communities and the requirements of individual species have been carried out by Clarke & Hannon (1967, 1969, 1970, 1971) at Towra Point on the southern shore of Sydney's Botany Bay. Descriptions of estuarine communities within the area have been compiled for Brisbane Water National Park (J. S. Benson & Fallding, 1981), Lake Eraring (Waterhouse & Quinn, 1974), Kincumber (Thorvaldson, 1975) and Wyee Creek (Pickard, 1973).

#### 6e Tall open-forest: *Eucalyptus saligna*

This community is associated with deep, sheltered gullies with southeasterly aspects on the Gosford Formation and the Clifton Sub-group. Such sites occur below the escarpments of the Watagan Mountains and other ridges in the catchment of Dora Creek. There are numerous small patches in the steep headwater sections of gullies though these are too small to be shown on the map sheet. The species present at any site vary according to micro-relief. Common large trees are *Eucalyptus saligna*, *Syncarpia glomulifera*, *E. pellita*, *Angophora costata* and *E. acmenoides*. Smaller trees include *E. umbra*, *Melaleuca styphelioides* and *Allocasuarina torulosa*. Shrubs include *Acacia binervata*, *A. irrorata* and *Rhodamnia rubescens*, and vines are common, including *Ripogonum fawcettianum*, *Pandorea pandorana*, *Eustrephus latifolius* and *Dioscorea transversa*. The ground cover is mainly ferns, *Blechnum cartilagineum* and *Pteridium esculentum* and graminoids, *Gahnia melanocarpa* and *Gymnostarchys anceps*.

On slightly drier sites are *Eucalyptus maculata*, *E. siderophloia*, *E. umbra* subsp. *umbra*, *E. punctata*, *E. paniculata* and *Allocasuarina torulosa*. Here the understorey is dominated by grasses, mainly *Imperata cylindrica*, *Entolasia stricta* and *Poa affinis*. Other species include the small tree *Pittosporum revolutum* and the vine *Eustrephus latifolius*. Extensive logging has been carried out in most areas.

There were once extensive tall open-forests of *Eucalyptus saligna* on the alluvial flats of Wyong, Ourimbah and Jilliby Jilliby Creeks, though these have been cleared for agriculture.

#### 8a Closed-forest: rainforest

Closed-forest dominated by rainforest species is found in deep, sheltered valleys on cool, southern to eastern aspects of varying geology but most commonly on the Narrabeen Group or on alluvium. An extensive occurrence is in Strickland State Forest near Somersby and smaller patches are common around Ourimbah. Rainforest species generally form a closed-forest canopy up to 12 m high though there may be emergent eucalypts up to 30 m high. The main rainforest species are *Ceratopetalum apetalum*, *Doryphora sassafras*, *Acmena smithii*, *Livistona australis* and occasionally *Archontophoenix cunninghamiana*, the palms being in poorly-drained sites. This canopy tends to be continuous with the tall shrub layer of species such as *Backhousia myrtifolia*, *Trochocarpa laurina*, *Tristaniopsis collina* and *T. laurina*, *Notelaea* spp., *Wilkiea huegeliana* and *Eupomatia laurina*. The ground cover is usually dominated by

ferns such as *Blechnum cartilagineum*, *Culcita dubia*, *Asplenium* spp. and *Doodia aspera*. Other understorey species include the climbers *Smilax* and *Cissus*, orchids and other monocotyledons. Emergent tree species include *Eucalyptus deanei* and *Syncarpia glomulifera* (J. S. Benson & Fallding, 1981). There are also a number of planted specimens of *Araucaria cunninghamii* and *A. bidwillii* in Strickland State Forest.

Small pockets of rainforest are also found in sheltered gullies in the Watagan Mountains further north, associated with tall open-forest (community 6e) and open-forest (community 9g).

Remnant rainforest also survives as a gallery forest along the banks of creeks such as Ourimbah and Wyong Creeks, though often heavily infested with exotic weeds. It rarely extends more than 20 m from the creek edges, the surrounding country being generally cleared for grazing or agricultural land. Originally such sites carried large trees of *Toona australis* which were exploited by the cedar-cutters early last century. Common tree species now include *Livistona australis*, *Tristaniopsis laurina*, *Cryptocarya glaucescens*, *Lomatia myricoides*, *Backhousia myrtifolia*, *Ceratopetalum apetalum* and *Acmena smithii*. Vines and lianes include *Smilax australis*, *Morinda jasminoides*, *Malaisia scandens* and *Ripogonum album*. *Eucalyptus saligna* is a common emergent tree, this community frequently grading into tall open-forest (community 6e). Invasion by exotic weed species such as *Ligustrum sinense*, *Cinnamomum camphora* and *Tradescantia albiflora* is a major threat to the survival of rainforest remnants.

A number of rainforest species reach their southern distributional limit in the Gosford-Wyong region: *Elaeocarpus obovatus* (Elaeocarpaceae) *Dysoxylum fraserianum* (Meliaceae) and *Ripogonum fawcettianum* (Smilacaceae) and *Tetrastigma nitens* (Vitidaceae) (Williams, 1979).

#### 8b *Melaleuca* swamp forest

This community occurs on poorly-drained alluvial swamp flats in small to medium-sized valleys of streams flowing into Lake Macquarie or Tuggerah Lake.

The main component of the community is a layer of small trees from 10 to 15 m high forming a closed canopy (90 per cent or more canopy cover). Stem density is very high. The characteristic species are *Melaleuca linariifolia*, *M. styphelioides* and occasionally *M. sieberi*. Frequently there are scattered emergent *Eucalyptus robusta* or *E. longifolia* trees up to 20 m tall. In some places the *Melaleuca* canopy is lower and forms a scrub or heath structure. Predominant species may be *Melaleuca ericifolia*, *M. sieberi*, *M. decora*, *M. nodosa*, *M. linariifolia* and occasionally *M. thymifolia*.

The groundcover in the closed-forest is variable, but generally includes *Entolasia* spp., *Imperata cylindrica*, *Viola hederacea*, *Pratia purpurascens*, *Glycine clandestina* and *Eustrephus latifolius*. Associated with the scrub may be sedges such as *Schoenus brevifolius* and herbs such as species of *Hydrocotyle* and *Gonocarpus*, and *Selaginella uliginosa*. Near watercourses are larger graminoids, *Gahnia clarkei*, *Baumea juncea* and *B. articulata*. Many of the *Melaleuca* swamps in the larger valleys have been cleared for agriculture, and burning and grazing, and trampling, often associated with paper-bark collection for the horticulture trade, frequently leads to understorey deterioration. However, there is only limited knowledge of the flora of these swamps and, because very few are in conservation areas, further study should be directed towards them.

#### 9g Open-forest: *Eucalyptus gummifera*-*E. maculata*-*E. pilularis*

This community is very widespread on claystones, sandstones and shales of the Clifton Sub-group, the Gosford Formation and the Newcastle Coal Measures. Soils range from podzolized sands to deep sandy loams. Species

composition is very variable and changes from the coastal lowlands to the higher country to the west.

The trees are about 20 m high and crowns are separate and readily distinguished. The canopy is more open on north-facing slopes than on those facing south. In coastal areas particularly on the Clifton Sub-group, there are two sub-communities that tend to form a mosaic. Characteristic species of the first group are *Eucalyptus gummifera*, *E. capitellata*, *Angophora costata* and *Allocasuarina littoralis* which are found on shallow slopes, such as on ridges and spurs, or in valleys. On wetter sites, *E. pilularis* occurs. Common shrubs are *Lambertia formosa*, *Leptospermum attenuatum*, *Epacris microphylla* and *Dillwynia retorta*. The ground cover is dominated by grasses such as *Imperata cylindrica*, *Entolasia stricta* and *Themeda australis*. On steeper slopes, where talus material is present and colluvial soil is mainly found trapped by boulders, the second sub-community occurs: *Eucalyptus maculata* is the most characteristic species, with other common species being *E. umbra* subsp. *umbra*, *E. siderophloia*, *E. punctata* and *Allocasuarina torulosa*. Common shrubs are *Daviesia ulicifolia*, *Bursaria longisepala*, *Oxylobium scandens* and the exotic weed *Lantana camara*. The ground cover is dominated by the grasses *Themeda australis*, *Imperata cylindrica* and *Entolasia stricta*, but also common is the grass *Poa affinis*, the herb *Pseuderanthemum variabile* and the vine *Eustrephus latifolius*.

On country of stronger relief further west are extensive state forests. Here, on soils on the Gosford Formation, *Eucalyptus pilularis* is a characteristic species, sometimes forming pure stands, but often associated with *E. paniculata*, *E. propinqua*, *E. umbra*, *E. agglomerata*, *E. acmenoides* or *Angophora floribunda*. On moister sites, species include *E. saligna*, *E. deanei* and *Syncarpia glomulifera*.

Understoreys are typically grassy and open in the drier places, commonly with much *Imperata cylindrica*. In more sheltered gully sites with deeper, more fertile soils the understorey is very tall and denser with "rainforest" trees and shrubs such as *Ceratopetalum apetalum*, *Callicoma serratifolia*, *Tristaniopsis collina* and *Acacia elata*, and vines such as *Cissus hypoglauca* and *C. antarctica*. In some places a fern stratum with *Culcita dubia* and *Blechnum cartilagineum* predominates.

An isolated stand of *Eucalyptus fastigata* is found on the slopes of Mt Warrawolong, a basalt-capped mountain. A number of major ridges east and south of Mt Warrawolong are shown on the geological map (New South Wales Department of Mines, 1966) as Hawkesbury Sandstone. There is some *Eucalyptus piperita*, a common sandstone species, but the characteristic sclerophyllous shrub understorey of the Hawkesbury Sandstone Complex (community 10a) is absent. Generally the vegetation has *Angophora floribunda* and *Syncarpia glomulifera* and is more similar to the varied eucalypt open-forest (community 9g).

These forests have been extensively logged in the past and are very much altered from their original pre-settlement structure, though floristically they may be essentially unaltered except where cleared or frequently burnt. Extensive areas have been cleared for plantations of *Eucalyptus pilularis* and *E. agglomerata*.

Species lists have been compiled for Pulbah Island Nature Reserve (Messmer, Bryce & Rupp, 1941), Eraring (Waterhouse & Quinn, 1974), Gwandalan and Charmhaven (New South Wales Department of Public Works, 1978), Kincumber (Thorvaldson, 1975), Wye Creek (Pickard, 1973), Redhead district (McDonald *et al.*, 1971) and Newcastle district, south to Swansea (Morris, 1969).

### 9h Open-forest: *Eucalyptus deanei*-*Angophora floribunda*

This community is found on sediments of the Narrabeen Group that commonly outcrop in valleys or on lower hillsides below cliffs and ridges of Hawkesbury Sandstone, particularly in the valleys of the Hawkesbury River and its tributaries, Mangrove and Mooney Mooney Creeks. Slopes are steep and the soils are clayey. There are two recognizable subunits:

- (i) The first occurs on more sheltered sites, closer to the coast, and is often associated with rainforest gullies (community 8a). The main tree species are *E. deanei*, *E. acmenoides*, *Angophora floribunda*, *Syncarpia glomulifera* and *Allocasuarina torulosa*. Common species in the tall shrub layer are *Acmena smithii*, *Backhousia myrtifolia*, *Acacia prominens* and *Ficus rubiginosa*. The ground cover is mainly of ferns such as *Doodia aspera* and *Culcita dubia*, graminoids such as *Imperata cylindrica* and *Themeda australis*, and *Lomandra* spp., herbs and climbers.
- (ii) The second subunit occurs on drier, often westerly facing sites. Around Brisbane Water National Park, for example, common tree species are *Angophora floribunda* and *Allocasuarina torulosa* with other species including *E. paniculata*, *E. punctata*, *E. resinifera* and *Callitris muelleri*. Further west, species such as *E. tereticornis* and *E. eugenioides* become common. The diverse shrub layer contains species such as *Dodonaea triquetra*, *Oxylobium ilicifolium*, *Persoonia* spp. and *Jacksonia scoparia*. The ground cover is mainly grasses and herbs. This community grades into the varied eucalypt open-forest community 9g. Published descriptions are available for upper Mangrove Creek (D. H. Benson, 1981) and Brisbane Water National Park (J. S. Benson & Fallding, 1981).

### 9k Open-forest: *Angophora costata*

Open-forest of *Angophora costata* is found on the North Entrance Peninsula on a series of Quaternary sand ridges and swales, the largest undisturbed area of coastal sand-dunes between Sydney and Newcastle. The vegetation on the eastern side of the Peninsula and on similar sand dunes further north has been destroyed by mineral-sand mining but an area known as the "Red Gum Forest" has been saved by Wyong Shire Council and is now managed as a Nature Reserve. Here then are trees of *Angophora costata* (locally called Red Gum), 10 to 15 m high often with smaller trees of *Banksia serrata*. Occasional trees of *Allocasuarina torulosa*, *Eucalyptus botryoides* and *E. gummifera* may be found (Figure 2). There is a dense shrub layer from 0.75 to 2 m in height. The ground is typically covered with leaf litter; low herbs and grasses are uncommon. *Dillwynia glaberrima* is the most common shrub species in many areas. In some places *Macrozamia communis* predominates but in others there may be a variety of shrub species including *Ricinocarpos pinifolius*, *Leucopogon ericoides* and *Pimelea linifolia*. Timms (1975) gives a description of this vegetation together with an analysis of flowering times. Small patches of littoral rainforest (of low closed-forest structure) are associated with sheltered swales at the southern end of the North Entrance open-forest. Rainforest species include *Cupaniopsis anacardioides*, *Livistona australis*, *Acmena smithii* and *Alphitonia excelsa*. Small, often degraded littoral rainforest patches may also be found further north.

### 10a Open-forest/Low Woodland/Open-scrub (Hawkesbury Sandstone Complex)

This is the widespread vegetation complex found on the Hawkesbury Sandstone areas of the map sheet. It contains considerable local structural and floristic variation depending particularly on topographic position, drainage and aspect. Various sub-units and topographic sequences can be recognized but because of the large area involved, and the scale of mapping, it has been



Figure 2. *Angophora costata* with understorey of sclerophyllous shrubs including *Macrozamia communis* (community 9k).

practical to map only a very broad unit. An idea of the variation to be expected within this unit can be obtained from the larger scale (1:50 000) vegetation map of J. S. Benson & Fallding (1981) who have mapped seven plant communities for the Hawkesbury Sandstone of the northern half of the Brisbane Water National Park.

Structurally, the vegetation ranges from open-forest to woodland and low woodland, and to open-scrub and sedgeland. In sheltered sites, with southerly or easterly aspects, on hillsides or in shallow valleys, is open-forest dominated by *Eucalyptus piperita* subsp. *piperita* and *Angophora costata*. Other tree species vary with situation, and include *E. oblonga*, *E. umbra* subsp. *umbra*, *E. gummifera* and *E. haemastoma* near Brisbane Water National Park, and *Syncarpia glomulifera*, *Allocasuarina torulosa* and *Acacia elata* near Mangrove Creek. The understorey is very diverse, a mixture of sclerophyllous shrubs forming a layer up to 1 m high, and a ground cover of *Pteridium esculentum* and graminoids including sclerophyllous grasses and sedges. *Doryanthes excelsa* may be locally abundant.

Similar vegetation is found on the Hunter Plateau, on deep, sandy, yellow, leached, gradational soils from Kariong through Peats Ridge towards Bucketty. The vegetation on these sites is normally an open-forest to low open-forest with

*Angophora costata*, *Eucalyptus haemastoma* and *E. sieberi* and a large number of proteaceous shrubs, such as *Petrophile pulchella*, *Hakea* spp., *Lambertia formosa*, *Banksia spinulosa*, *Persoonia* spp., *Telopea speciosissima*, *Xylomelum pyriforme* and *Grevillea* spp. *Doryanthes excelsa* may be conspicuous. Mixed with these species are those of nearby communities, including *Syncarpia glomulifera*, *E. gummifera*, *E. punctata*, *E. oblonga*, *E. capitellata* and *Banksia serrata*. Shrubs include *Leptospermum* spp., *Acacia* spp., *Bossiaea* spp. and *Gompholobium* spp. and the ground species such as *Actinotus minor*, *Dampiera stricta* and *Gonocarpus teucroides*. Because they tend to be deeper and more amenable to agriculture than most of the sandstone-derived soils, the yellow-earth soils here have been actively sought and cleared, particularly in recent years.

Low woodland or low open-woodland occurs on drier ridgetops and spurs, with shallow skeletal soils. The main trees are *Angophora costata*, *E. gummifera*, *E. eximia*, *E. umbra* subsp. *umbra*, *E. haemastoma* and *E. punctata*. *Eucalyptus racemosa* and *Angophora bakeri* are common on the western side of the area. Shrubs are common in the very diverse understorey. Common families (and genera) are Proteaceae (*Banksia* spp., *Hakea* spp.), Fabaceae (*Pultenaea* spp., *Dillwynia* spp.), Epacridaceae (*Epacris* spp., *Leucopogon* spp.), Rutaceae (*Boronia* spp., *Eriostemon australasius*), Myrtaceae (*Leptospermum* spp., *Angophora hispida*) and *Acacia* spp. The ground cover is mainly sclerophyllous monocotyledons, such as *Entolasia stricta*, *Lepidosperma* spp., *Lepyrodia scariosa*, *Lomandra* spp., *Schoenus* spp. and *Xanthorrhoea media*.

On ridgetops, valley heads and drainage lines where drainage is locally impeded, closed-scrub or open-scrub is found. There are occasional scattered trees, such as *E. haemastoma*, *E. umbra* and *E. gummifera*, but the main structural feature is the shrub layer. This is 2 to 5 m high and composed of densely packed large shrubs in wetter situations, but is more open in drier places. The most common species are *Banksia ericifolia* and *Hakea teretifolia*. Interspersed are species of *Grevillea* and *Leptospermum*. The ground cover is mainly sclerophyllous monocotyledons, such as *Restio* spp., *Lepyrodia scariosa*, *Xanthorrhoea resinosa* and *Lomandra* spp.

At the northern end of the Judge Dowling Range, south of Bucketty, is a broad, relatively undissected ridge with distinctive patches of open-scrub vegetation. These contrast with the typical low open-woodland of the surrounding ridges. The soil is very shallow and skeletal, with patches of sand. Common shrub species include *Banksia serrata*, *B. ericifolia*, *Lambertia formosa*, *Angophora hispida* and *Persoonia lanceolata*. Two scribbly gum species, *Eucalyptus haemastoma* and *E. racemosa*, grow together though *E. haemastoma* is generally absent from the adjacent ridges particularly to the west and south.

In depressions on sandstone rock shelves there may be pockets of heath interspersed with scattered small trees, mainly *Eucalyptus haemastoma* and *E. eximia*. Shrubs species include *Allocasuarina distyla*, *Baeckea* spp., *Darwinia fascicularis*, *Eriostemon australasius*, *Kunzea* spp., *Leptospermum* spp., *Angophora hispida* and various epacridaceous species. Graminoids are common, especially on the shallower soils on the peripheries of the pockets. Species found here include *Caustis pentandra*, *Lepidosperma* spp. and *Restio* spp.

On swampy organic soils, particularly in the area covered by the southern half of the map sheet where rainfall is higher, are patches of sedgeland. These are usually on plateaux or in shallow basins where impervious shale layers direct the water-table to the surface. The dominant vegetation cover is a layer of graminoids, including *Restio* spp., *Chorizandra* spp., *Cyathochaeta diandra*, *Gymnoschoenus sphaerocephalus*, *Lepidosperma* spp. and *Leptocarpus tenax*. Associated shrub species include *Banksia robur*, *Sprengelia incarnata* and *Leptospermum juniperinum*. Scattered shrubs of *Banksia oblongifolia* and *Hakea teretifolia* are frequent on drier sandy soils. Throughout are herbs such as

*Drosera* spp., *Dampiera stricta*, *Goodenia bellidifolia* and *Selaginella uliginosa*. Creeks are commonly fringed with *Tristaniopsis laurina*, *Leptospermum flavescens* and *Callicoma serratifolia*.

The greatest diversity in the Hawkesbury Sandstone complex is found in the southeast of the area especially within Brisbane Water National Park (J. S. Benson & Fallding, 1981). Here, there appears to be a high frequency in the number of outcropping shale bands within the sandstone. This, together with a high rainfall, results in numerous localized soaks and extensive variation in soil water distribution, leading to mosaics of scrub, heath and sedgeland. To the northwest the diversity decreases, especially in the shrub-layer. West of Mangrove Creek only open-forest and low open-woodland are common, with heath infrequent (Benson, 1981).

The Hawkesbury Sandstone Complex is included within the Mixed *Eucalyptus* Forest Association of Pidgeon (1937, 1938, 1940, 1941), and the *Eucalyptus gummifera*-*E. racemosa*-*E. sieberi* Alliance of Beadle (1981). Floristic lists for Dharug National Park are given by the Linnean Society (1971) and Matthew (1973).

#### 10e Woodland: *Eucalyptus haemastoma*

This community is restricted to the tops of low broad ridges with a northerly aspect to easterly aspect on poor sandy soils derived from the Clifton Sub-group of the Narrabeen Group. Occurrences range from Wyong northwards on both sides of Lake Macquarie. The structure of the community varies from open-forest to very scattered woodland. Tree height is less than 20 m and species are *Eucalyptus haemastoma* or less commonly *E. racemosa*. A dense shrub layer, about 0.5 m high overlies a variable, but usually open, ground cover. Shrub species include *Leucopogon microphyllus*, *Leptospermum attenuatum*, *Epacris microphylla* and *Banksia oblongifolia*. The ground cover is dominated by sedges and sclerophyllous graminoids. The main species are *Ptilanthelium deustum*, *Xanthorrhoea macronema* and *Entolasia stricta*.

#### 21a Open-heath/Grassland/Sedgeland

This is coastal vegetation which is low, scrubby and treeless, both because of the low nutrient status of its soils and because it is exposed to onshore winds that restrict tree growth. It is found on soils developed from Narrabeen and Permian claystone, sandstone and shales and Quaternary alluvium from Lake Munmorah to Redhead. Height ranges from open-heath 1-2 m high, down to grassland 30 cm high. Soils are generally clayey or sandy, and exposure ranges from reasonably sheltered to very exposed. Common shrubs in the open-heath include *Melaleuca nodosa*, *Allocasuarina distyla*, *Lambertia formosa*, *Banksia oblongifolia*, *Hakea teretifolia* with clumps of mallee *Eucalyptus capitellata* or *E. umbra*. On exposed headlands, particularly around Catherine Hill Bay are extensive grasslands of *Themeda australis*. Local species composition depends on soil depth and drainage. In poorly-drained sites particularly in broad valleys, sedgeland develops. Species here include the graminoids, *Lepyrodia scariosa*, *Leptocarpus tenax* and *Schoenus brevifolius* and the shrubs *Melaleuca thymifolia*, *Leptospermum juniperinum*, *Callistemon citrinus* and *Viminaria juncea* as well as sedges and grasses.

Coastal vegetation has been described at Fraser Park (now Munmorah State Recreation Area) (New South Wales Department of Public Works, 1978) and Redhead (McDonald *et al.*, 1970, 1971).

#### 21b Open-heath: *Banksia aemula*

This community is found on coastal headlands on deposits of highly leached white sand of Pleistocene age (P. Myerscough pers. comm.) that overlie the Triassic and Permian sediments. It forms a closed to open-heath



Figure 3. Open-heath with *Banksia aemula* on Pleistocene sand deposits on Wybung Head near Swansea (community 21b).

characterized by the shrub *Banksia aemula* (formerly *B. serratifolia*) (Figure 3). Common smaller shrubs include *Ricinocarpus pinifolius*, *Brachyloma daphnoides*, *Dillwynia glaberrima*, *D. retorta*, *Allocasuarina distyla*, *Bossiaea ensata*, *Aotus ericoides* and *Phyllota phyllicoides*. The graminoid *Empodisma minus* is generally present. The community is found sporadically northward along the coast of New South Wales from as far south as La Perouse, near Sydney, and is common in the Myall Lakes district. Within the area of the map sheet it is found in Munmorah State Recreation Area, and around Redhead (McDonald *et al.*, 1970) though much of this has been destroyed by sand-mining.

On younger, yellow, less leached sands, the open-heath is replaced by scrub with *Acacia longifolia*, *Banksia integrifolia*, *B. serrata* and *Leptospermum laevigatum*, species that appear to need the higher nutrient conditions. There may be occasional emergent trees of *Eucalyptus gummifera* and *Angophora costata*. Many of these areas have been sand-mined. *Acacia longifolia* and *Persoonia lanceolata* are conspicuous species in recolonizing areas.

Small pockets of littoral rainforest of low closed-forest structure may be found on the lee side of some of the larger dunes. Tree species here may include *Cupaniopsis anacardioides*, *Livistona australis* and *Syzygium* spp.

#### 27a Freshwater Swamp Complex

This complex of communities occurs on low-lying Quaternary sediments, on floodplains or behind dune systems, and generally adjacent to areas of open water. Though essentially freshwater communities they often occur near estuarine communities (community 4a) and there may be some localized saline or brackish influence. Plant composition depends on degree of waterlogging. Permanently wet sites with standing water may have submerged or floating water plants such as *Vallisneria* and *Potamogeton* with a fringe of emergent sedges and rushes including species of *Eleocharis*, *Baumea* and *Juncus* often with *Philydrum lanuginosum*, *Alisma plantago-aquatica* and *Villarsia exalata*.





Figure 4. *Melaleuca quinquenervia* low open-forest with herbaceous understorey in Munmorah State Recreation Area (community 27a).

Brackish sites may have *Phragmites australis*. These may be surrounded by extensive open-forest with *Melaleuca quinquenervia* (Figure 4) or *Casuarina glauca*, the latter indicating brackish conditions, with an understorey of species from the wetter zones.

On adjacent drier areas may be bands of closed-heath or closed-scrub with *Melaleuca* species, *Viminaria juncea*, *Gahnia clarkei* and *Acacia longifolia*, or swamp forest with *Eucalyptus robusta*, *E. longifolia* or *E. amplifolia*.

Occasionally an open-heath community occurs on the boundary with the surrounding dry-land open-forest. Where a sizeable watercourse crosses a swamp there may be levee banks on which may be remnants of the now almost totally cleared riparian forests of *Eucalyptus pilularis*, *E. saligna* and *Angophora floribunda*. *Casuarina glauca* may form a narrow band along the edge of the levee bank adjacent to the swamp.

Freshwater swamps have been described at Toukley, Charmhaven and Fraser Park (New South Wales Department of Public Works, 1978) and Redhead, Jewels Swamp (Baxter & McDonald, undated; McDonald *et al.*, 1970; McDonald, 1971).

## CONSERVATION

### Species of particular conservation importance

Table 3 lists species from the Gosford/Lake Macquarie Vegetation Sheet area that are known to be rare or endangered (Leigh, Briggs & Hartley, 1981) or of significance in terms of geographic distribution of localized populations. Its purpose is to alert workers preparing environmental impact statements, plans of management, conservation studies etc., that populations of these species may be significant if they are found in their study area.

### Conservation of plant communities

The major conservation areas, Dharug, Marramarra and Brisbane Water National Parks (Table 4; Figure 5) are in the south of the sheet area and mainly restricted to the vegetation of the Hawkesbury Sandstone (community 10a).

TABLE 3

**Species of particular conservation importance within the Gosford and Lake Macquarie Vegetation map sheet**

Species listed here are either rare or threatened (from Leigh *et al.*, 1981), or of significance in terms of geographic distribution, or localized populations disjunct from other occurrences.

pop. = population, Sth = southern, Nth = northern, NP = national park, SRA = state recreation area, NR = nature reserve.

Species	Locality/habitat	Significance (codings as in 2EC, 2V, 3V, 2RC, 3RC, Leigh <i>et al.</i> , 1981)
<b>DICOTYLEDONS</b>		
<b>AIZOACEAE</b>		
<i>Macarthuria neocambrica</i>	Munmorah SRA	Sth limit
<b>ARALIACEAE</b>		
<i>Astrotricha crassifolia</i>	Patonga	local pop., rare
<b>ASTERACEAE</b>		
<i>Olearia cordata</i>	Wisemans Ferry, Fernances Trig.	2V, local endemic, only 2 pop. known.
<i>O. nernstii</i>	Gosford	Sth limit
<b>CONVOLVULACEAE</b>		
<i>Wilsonia backhousei</i>	Saltmarsh, Wamberal Lagoon N.R.	Nth limit
<b>CUNONIACEAE</b>		
<i>Caldcluvia paniculosa</i>	Ourimbah, rainforest	Sth limit
<b>ELAEOCARPACEAE</b>		
<i>Elaeocarpus obovatus</i>	Wyong, rainforest	Sth limit
<b>EPACRIDACEAE</b>		
<i>Leucopogon amplexicaulis</i>	Brisbane Water NP	3RC, Nth limit
<i>L. margarodes</i>	Brisbane Water NP	Sth limit
<i>L. pleiospermus</i>	Woy Woy	Sth limit
<i>Styphelia laeta</i> var. <i>latifolia</i>	Brisbane Water NP	local pop.
<b>FABACEAE</b>		
<i>Acacia bynoeana</i>	Dora Creek, Morisset, Kulnura	rare
<i>A. quadrilateralis</i>	Redhead district	rare
<i>A. prominens</i>	Gosford district	local pop.
<b>GOODENIACEAE</b>		
<i>Velleia perfoliata</i>	Hawkesbury district	3RC
<b>HALORAGACEAE</b>		
<i>Gonocarpus chinensis</i> subsp. <i>verrucosa</i>	Hawkesbury River	rare
<b>LAMIACEAE</b>		
<i>Prostanthera incisa</i> var. <i>pubescens</i>	Kendall's Glen, Gosford	rare, possibly endemic taxon
<b>LAURACEAE</b>		
<i>Endiandra discolor</i>	Gosford district	Sth limit
<b>MELIACEAE</b>		
<i>Dysoxylum fraseranum</i>	rainforest	Sth limit
<b>MYRSINACEAE</b>		
<i>Embelia australiana</i>	Wyong District	Sth limit
<b>MYRTACEAE</b>		
<i>Darwinia glaucophylla</i>	Brisbane Water NP	2RC
<i>D. procera</i>	Brisbane Water NP	2RC
<i>Decaspermum paniculatum</i>	Ourimbah, rainforest	Sth limit

Species	Locality/habitat	Significance (codings as in 2EC, 2V, 3V, 2RC, 3RC, Leigh <i>et al.</i> , 1981)
<i>Eucalyptus multicaulis</i>	Brisbane Water NP	local pop.
<i>E. luehmanniana</i>	Brisbane Water NP	2RC Nth limit
<i>Melaleuca deanei</i>	Brisbane Water NP	3RC, Nth limit
<i>Rhodomyrtus psidioides</i>	rainforest	Sth limit
<i>Syzigium paniculatum</i>	littoral rainforest, Wamberal Lagoon NR	local pop.
<b>PROTEACEAE</b>		
<i>Banksia paludosa</i>	Doyalson	Nth limit
<i>Grevillea shiressii</i>	Brisbane Water NP	2EC
<i>Grevillea</i> sp. aff. <i>capitellata</i>	Brisbane Water NP	local pop.
<i>Grevillea</i> sp. nov.	sandstone scarp, Somersby-Narara	local endemic pop.
<i>Hakea bakerana</i>	Lake Macquarie district, Doyalson-Wyee, Dharug NP	uncommon
<b>RUTACEAE</b>		
<i>Acronychia wilcoxiana</i>	Gosford district	rare
<i>Boronia fraseri</i>	Brisbane Water NP	2RC
<b>SAPINDACEAE</b>		
<i>Dodonaea megazyga</i>	Olney State Forest	3RC, Sth limit
<b>TREMANDRACEAE</b>		
<i>Tetratheca glandulosa</i>	Mangrove Mtn-Wisemans Ferry	2RC, local pop. Nth limit.
<i>Tetratheca juncea</i>	Lake Macquarie district	3V, local pop.
<b>VITIDACEAE</b>		
<i>Tetrastigma nitens</i>	rainforest	Sth limit
<b>MONOCOTYLEDONS</b>		
<b>JUNCAGINACEAE</b>		
<i>Maundia triglochinosoides</i>	Swamp, Wyong	Sth limit
<b>LILIACEAE</b>		
<i>Allania endlicheri</i>	Brisbane Water NP	3RC, local pop.
<i>Blandfordia grandiflora</i>	Gosford northwards	Sth limit
<b>POACEAE</b>		
<i>Ancistrachne maidenii</i>	Hawkesbury River	2RC, rare
<b>SMILACACEAE</b>		
<i>Ripogonum fawcettianum</i>	rainforest	Sth limit
<b>XANTHORRHOEACEAE</b>		
<i>Xanthorrhoea resinosa</i> subsp. <i>fulva</i>	Coastal sand systems	Sth limit
<b>ZINGIBERACEAE</b>		
<i>Alpina caerulea</i>	Martinsville	Sth limit
<b>FERNS</b>		
<b>ASPLENIACEAE</b>		
<i>Asplenium aethiopicum</i>	Watagan Mtns	rare
<b>BLECHNACEAE</b>		
<i>Blechnum ambiguum</i>	Brisbane Water NP	Nth limit
<b>LINDSAEACEAE</b>		
<i>Lindsaea dimorpha</i>	Brisbane Water NP	local pop., rare
<b>OPHIOGLOSSACEAE</b>		
<i>Botrychium australe</i>	Martinsville	uncommon

**TABLE 4**  
**Major conservation reserves for Gosford and Lake Macquarie 1:100 000 vegetation map sheet**

Reserve	Administered by	Area (ha)	Map units included
<b>National Parks</b>			
Dharug NP .....	NP & WS	14 728	9h, 10a
Marramarra NP .....	NP & WS	11 503*	4a, 10a
Brisbane Water NP .....	NP & WS	11 151*	4a, 8a, 9h, 10a
<b>Nature Reserves</b>			
1. Awabakal NR .....	NP & WS	200	21a, 21b
2. Wamberal Lagoon NR .....	NP & WS	102	21b, 27a
3. Pulbah Island NR .....	NP & WS	69	9g
<b>Forest Reserves</b>			
4. Bar Forest (now a Flora Reserve) .....	FC	73	9g
5. Warrawolong .....	FC	48	6e, 9g
6. Little Jilliby Creek .....	FC	25	8a, 9g
7. Richters Caves .....	FC	24	9g
<b>Others</b>			
8. Munmorah State Recreation Area .....	NP & WS	1008	10e, 21a, 21b, 27a
9. North Entrance Nature Reserve .....	Wyong Shire	c800	9k

Plant community map units not conserved—8b.

\* only part of this area is within the map sheet.

NP & WS = National Parks & Wildlife Service.

FC = Forestry Commission of NSW.

There are only small reserves for the conservation of other plant communities. Community 9g, a mixed eucalypt forest community, which covers approximately 80 000 ha (30% of the area covered by the map sheet) is particularly poorly protected. Apart from Pulbah Island Nature Reserve (69 ha), all other reserves are Forestry Commission Forest Preserves, with a tenure that has no legislative backing, though it is intended that these areas will eventually be declared Flora Reserves (Baur, 1981), and together total a mere 170 ha in area. As this community is particularly rich and diverse floristically, and includes significant habitat variation, these reserves are inadequate and should be increased. Increased reserves are particularly important as current forestry practices of clearing and replanting with a limited range of species, together with frequent prescribed burning, are reducing the numbers of species represented in the understorey of these forests. Indeed, one of the main requirements of the Native Forest Preservation Programme (Baur, 1981) is that Forest Preserves preferably cover an area in excess of 40 ha, though two of the four Preserves within the map area, Little Jilliby Creek (25 ha) and Richters Caves (24 ha) are considerably smaller, and a third, Warrawolong (48 ha) only just exceeds this size (Table 4). Enlargement of these forest preserves is desirable (even if the additions have been partially logged in the past) and quite possible because they are all within State Forest boundaries. Part of Little Jilliby Creek and Warrawolong Forest Preserve have already been logged, but an increase in size will help to retain a diversity of understorey species. This diversity is particularly threatened by the long-term prescribed burning programme used elsewhere in the Forests.

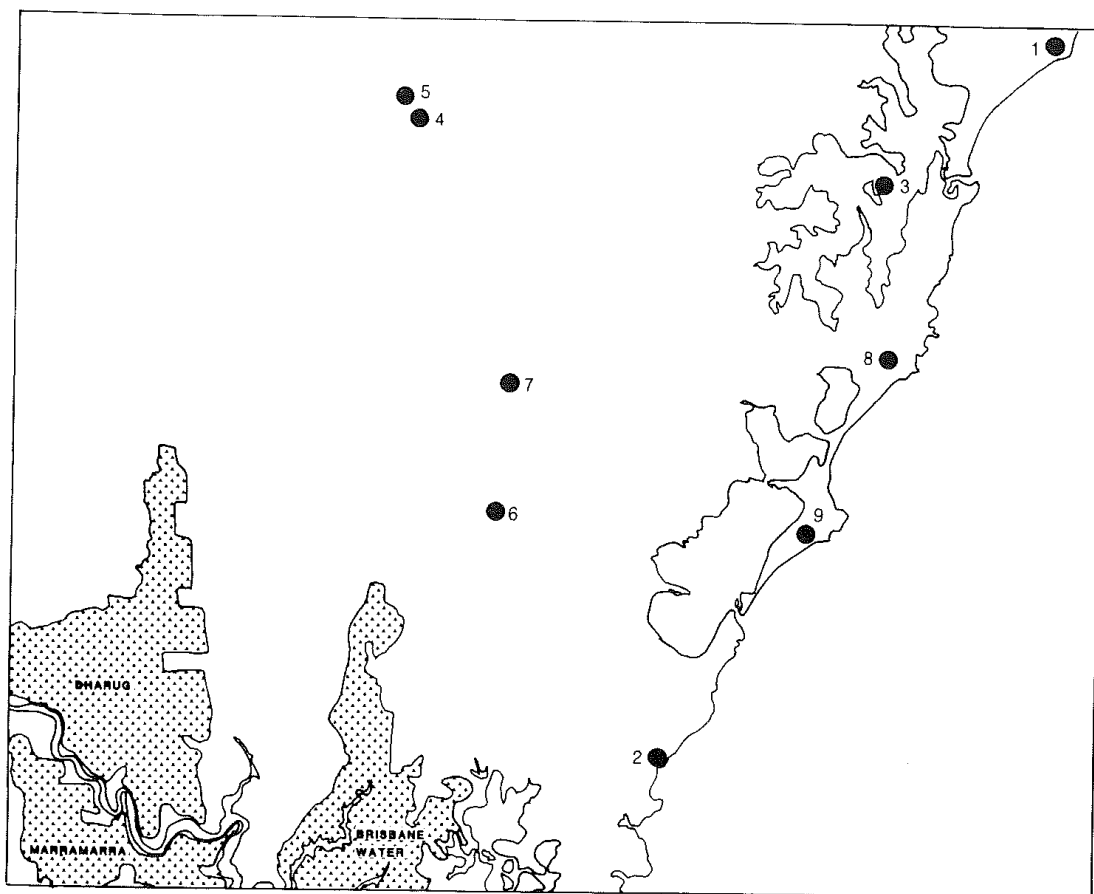


Figure 5. Location of conservation reserves mentioned in Table 4.

The conservation of some of the *Melaleuca* swamps (community 8b) is also desirable; most of these are privately owned and threatened with draining for pasture use. Similar threats face estuarine communities (community 4a) in Mangrove and Popran creeks. The National Trust of Australia (New South Wales, 1983) has proposed a Mt Olive National Park to include some of these estuarine communities as well as areas of communities 8a, 9g and 10a. The Trust has also proposed Nature Reserves for the estuarine islands, Pelican and Rileys islands, and for Mt Avoca, behind Terigal.

The New South Wales Department of Environment and Planning (1983) indicates that Rileys Island and the mainland wetlands at Empire Bay, Cockle Bay and Bensville are the most important wetland areas in Brisbane Water, the mainland ones being especially important as they are mostly privately owned and subject to potential pressures for filling and development in the longer term.

Much of the pattern of past and present land usage in the Gosford-Lake Macquarie map area can be related to the original pattern of landform and vegetation. For example, farming activities were concentrated on the wet eucalypt and rainforests of the alluvial soils, and fishing and tourist towns are associated with the estuaries. It will be a great loss if all evidence of these landform/landuse associations are destroyed. Examples of characteristic species associated with landform types are *Casuarina glauca* of the estuarine lakes, *Melaleuca* spp. of swamps, *Eucalyptus saligna* of the rich alluvial flats, *Livistona* of swamps and littoral rainforest, and *Eucalyptus maculata* of forests on poorer, dry ridges. The retention of small natural remnants of these and their associated species by the roadside, in paddocks or parks, etc., should be an important local conservation aim.

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