Vegetation of Bouddi Peninsula, New South Wales

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Abstract

McRae, R.H.D. (National Herbarium of New South Wales, Royal Botanic Gardens, Sydney, Australia 2000) 1990. Vegetation of Bouddi Peninsula, New South Wales. Cunninghamia 2(2): 263–293. The results of an ecological survey of the Bouddi Peninsula, New South Wales (latitude 33°30′ S, longitude 151°20′ E), are presented. The area lies in the Central Coast botanical subdivision and includes Bouddi National Park (1160 ha). Fifteen vegetation communities are mapped, and related to habitat elements such as geology, geomorphology, climate and soil. A species list and a vegetation map (at a scale of 1:25 000) are also given. The implications of the results of the survey for the management of fire effects, weed invasion and rare or restricted species are discussed.

Introduction

The Bouddi Peninsula is situated on the northern headland of Broken Bay, 45 km north of Sydney and 10 km south-east of Gosford (Figure 1). It is near the towns of Killcare, Kincumber, MacMasters Beach and Woy Woy (Figure 1). A large portion of the Peninsula is occupied by Bouddi National Park.

The climate is typical of that of the Central Coast. Mean temperature and rainfall data (Bureau of Meteorology 1979) are shown in Table 1. The local climatic effects that influence the vegetation on the Peninsula are: (1) proximity to the coast exposes vegetation to coastal winds and salt-spray; and (2) high areas with a coastal aspect receive the most rainfall.

The geology of the area has been described in Herbert & Helby (1980; especially articles 10 and 12) and in Strom, Goldstein & Strom (1979). The main components are two nearly level-bedded Triassic sedimentary series: the Hawkesbury Sandstone and the Narrabeen Series. The former is largely cross-bedded sandstone, with frequent interbedded shale lenses. The latter contains a wide range of sedimentary rock types, from massive sandstone to shale. The other components of the surface geology are deposits of transported material, weathered from the above rock types or deposited from the coastal longshore drift system, and thus of variable origin. The surface geology is shown in Figure 2.

The Peninsula contains a number of landforms (Figure 3) that are important for understanding the vegetation patterns. Mount Bouddi (166 m altitude), Wards Hill and Box Head are erosional remnants of a plateau of Hawkesbury Sandstone, each generally from 0.5 km to 2.0 km across. The thickness of the cliff-lined Hawkesbury Sandstone caps ranges from about 50 m in the south to about 15 m in the north. A ridgeline capped by Hawkesbury Sandstone, 1.5 km long and 0.5 km wide, joins Wards Hill and Mount Bouddi, and is also edged

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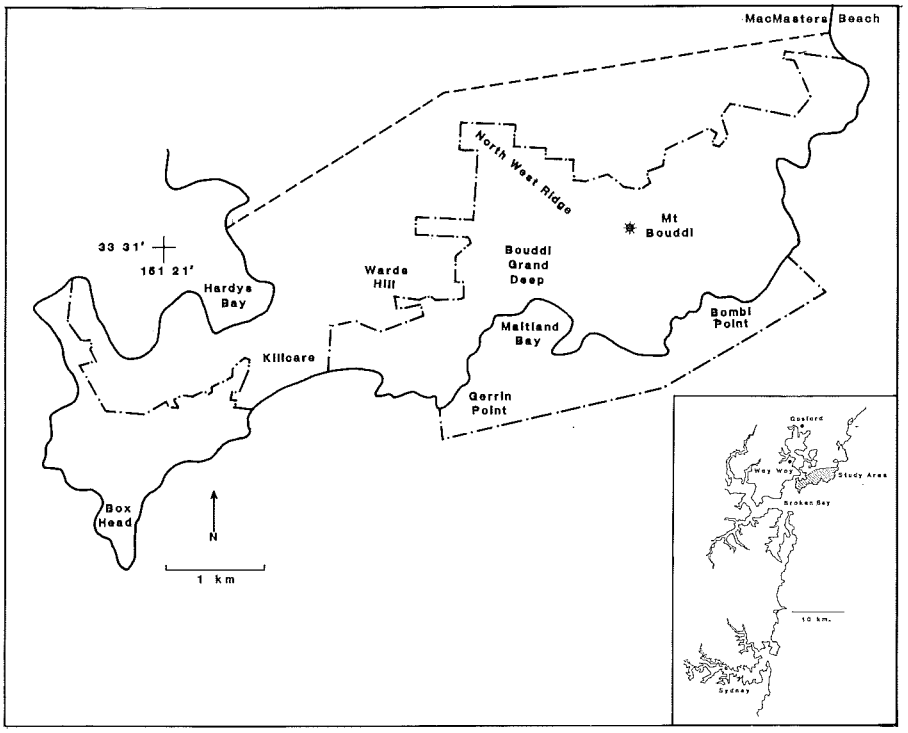


Figure 1. Location maps, showing the locations of sites and localities mentioned in the text.

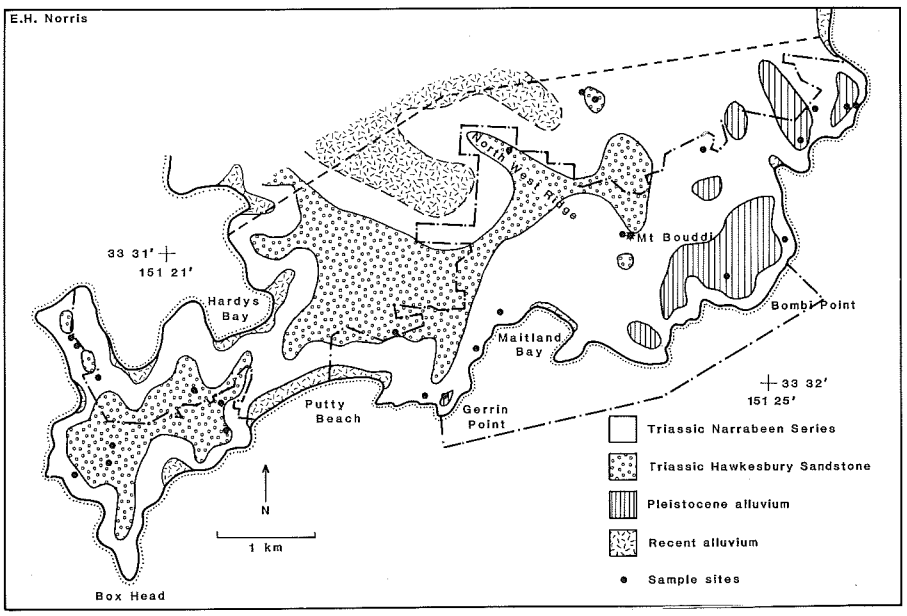


Figure 2. Surface geology of the Bouddi Peninsula and the locations of the sample sites (dots).

Table 1. Approximate mean temperature and rainfall data for Bouddi Peninsula.

Mean seasonal and annual rainfall data (mm)

Summer	Autumn	Winter	Spring	Annual
350	380	300	240	1270

Mean monthly temperature for selected months and mean annual temperature (°C)

	January	April	July	October	Annual
Maximum	26.5	22.5	17	22	22
Minimum	18	13	7.5	13	13

by small cliffs. Where the sandstone is thinnest, such as around the top of the Bouddi Grand Deep, it is broken up by undercutting and often forms a colluvial layer above the rocks downslope.

The Box Head and Wards Hill plateaus are fringed by steep slopes on the Narrabeen Series strata. The slope varies with local rock type, but frequently exceeds 30°. No true gullies have developed here, and drainage basins tend to have an amphitheatre shape, a width of about 0.5 km and numerous drainage lines. There are also steep slopes to the north-east, but gullies are present, leading to greater variation in landform. The drainage basins are about 1.5 km long and 0.5 to 1.5 km wide, and the main stream directions appear to be joint-controlled. Most of these streams have a number of short steep side branches, many slightly incised and with headwaters on Hawkesbury Sandstone.

Coastal erosion of the Narrabeen Series often proceeds preferentially along joint-lines, producing large straight cliffs. Features associated with these include occasional super-littoral talus deposits, numerous broad wave-cut platforms and small coves where streams, often spring-fed, reach the coast. The presence of beaches backed by small cliffs, as at Maitland Bay, suggests that coastal erosion may have slowed, but west of Bombi Point is a cove that is evidently being actively enlarged.

The perched Pleistocene dunes tend to lie south-east of a line from Gerrin Point to MacMasters Beach, and appear to have covered a series of gullies on the Narrabeen Series strata (Figure 2). The marking of the south-eastern edge of this area by sea cliffs and the tendency of the dunes to slope towards the coast suggests that they are being eroded away on their coastal sides. In places springs emerge from under the dunes and flow into abrupt, deep gullies.

There are four soil types derived from the Narrabeen Series strata near the coast, all of which are heterogeneous, reflecting the variation in parent material. One is a talus deposit at the foot of the coastal cliffs ('super-littoral' deposits), with soils developing in situ, mainly through weathering of shales, pulverising of falling rocks and transporting of soils from above in the talus. The disruption of soils above cliff-lines and rock-ledges caused by coastal erosion leads to a soil that is very similar to the super-littoral talus. Another skeletal soil develops on the steep slopes above the headlands. The gullies often have small, waterlogged alluvial deposits.

Several different soils develop away from the coast, ranging from sandy and skeletal soils derived from sandstone to soils derived from shale that are deeper, higher in clay content and richer in nutrients. All of these soils are

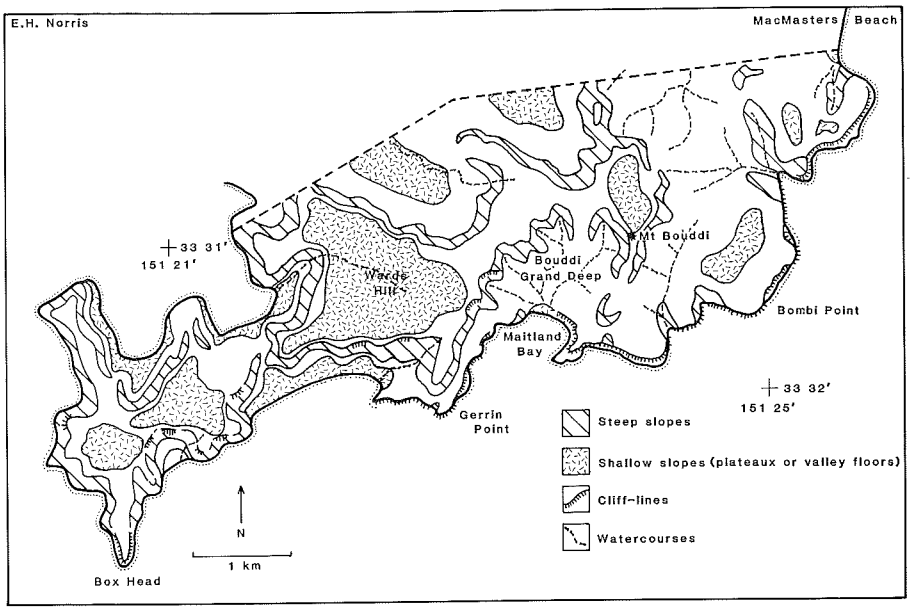


Figure 3. Major landforms on the Bouddi Peninsula. Based on aerial photograph interpretation.

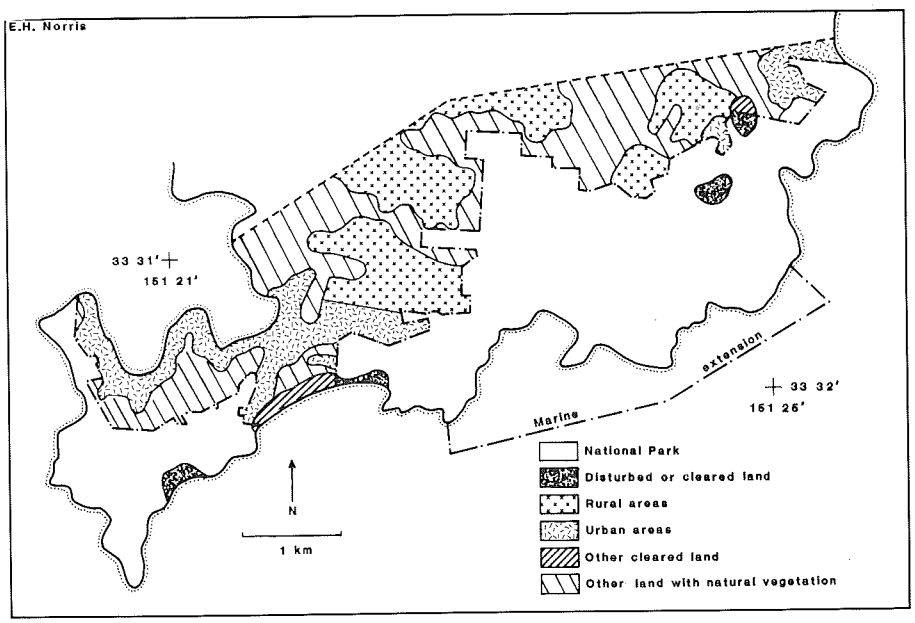


Figure 4. Major land uses on the Bouddi Peninsula.

associated with active erosion, and most include some material of colluvial origin.

There are three soil types derived from the Hawkesbury Sandstone. One is a 'laterite' in the sense used by Hunt, Mitchell & Paton (1977); the surface exposure of this ranges from a rich orange clay to a thick indurated ironstone. Another is a group of typical sandstone soils: gradational sandy soils, and duplex soils with clay subsoils derived from shale lenses interbedded in the sandstone. The third soil type is that associated with the edges of the Hawkesbury Sandstone plateaus: rocks from the plateau edges transported downslope as colluvium trap soil and humus. Although rocks of the Narrabeen Series underly this soil, they appear to contribute little to it.

A podsol, developed on the aeolian Pleistocene sands, has two main horizons: a leached A-horizon, which is very deep (in places apparently over 20 m) and an indurated B-horizon containing a pan cemented by iron and organic matter. Where the unconsolidated A-horizon has been removed, the B-horizon often persists.

The Recent alluvial soils are of two types. The beaches and hind-dunes are generally of undifferentiated sand. Podsolization is not evident, and there are no areas intermediate with the Pleistocene dunes. The alluvial deposits fringing Brisbane Water are infilled mud-basins (Chapman et al., 1982). The soils vary in depth, composition and salinity with distance from the estuary.

The history of Bouddi National Park and surrounding areas is described in Strom et al. (1979). The clearing of natural bushland on the Peninsula has mainly been for housing or small farms, with scattered clearing for other purposes. Housing generally occupies flat or scenic areas, such as Hardys Bay, Pretty Beach or Killcare. There are small orchards on the lateritic soils on Wards Hill and small hobby farms on the slopes and alluvial flats facing Brisbane Water. Except for some areas around Mount Bouddi and Box Head, almost all land has been either developed or included in Bouddi National Park. The distribution of major land-use classes is shown in Figure 4.

The vegetation of the Bouddi Peninsula has been relatively poorly studied compared with other areas close to Sydney. Work done here includes a series of studies on the ecology of the moors or heathlands (Siddiqi 1971; Siddiqi, Carolin & Anderson 1972; Siddiqi & Carolin 1976; and Siddiqi, Carolin & Myerscough 1976). Benson (1980) covered the Peninsula as part of a general vegetation mapping program working at a scale of 1:100 000. The wide-ranging ecological study of the vegetation of the Sydney basin by Pidgeon (1937, 1938, 1940 & 1941) has some relevence to this area, although her work was quite general. Strom et al. (1979) provided a general description of the Park. The topics of detailed vegetation description and discussion of management implications have not, to date, been addressed.

The plants in the area rely on a wide range of reproductive strategies to recover after fire. General discussion of these strategies can be found in Gill (1981), Groves (1981), Noble & Slatyer (1981) and Stanbury (1981). Siddiqi (1971), Siddiqi, Carolin & Myerscough (1976) and Strom et al. (1979) have briefly considered the effects of fire on the vegetation in the Park. Although the nature of this study precluded any detailed analysis of fire effects, any that were apparent were recorded and their importance for management of the area considered.

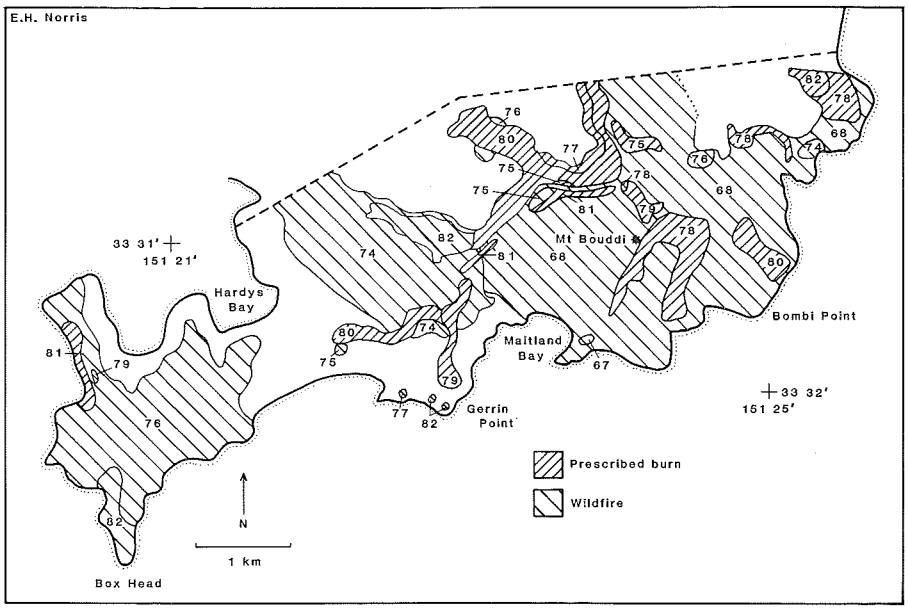


Figure 5. Fire history of the Bouddi Peninsula up to 1983, showing extent and year of fires. Based on office records of National Parks and Wildlife Service.

The fire history of the area is shown in Figure 5. Three large wildfires, in 1968, 1974 and 1976, have together burnt most of the Peninsula. Since these fires there have been many (almost 30) smaller fires, about half of which have been prescribed burns.

Studies in urban bushland in Sydney (Clements 1983 and Adamson & Buchanan 1974) and general reviews of exotic species in Australia (such as Michael 1981) are useful for interpreting local patterns. Data on weed invasion in the far northern suburbs of Sydney (McRae, Cooper & Benson 1981) suggest that weeds will generally cross from cleared or disturbed land into adjacent bushland at a rate that varies with land-use, land-form and the age of the disturbances. Further, movement of nutrient in run-off down watercourses will lead to weed spread down-stream and, more slowly, away from the watercourse.

The conservation of rare or restricted species is becoming a critical issue for the managers of public lands. With continuing land clearance and land degradation the need for conservation-oriented management is increasing. While the collection of a large quantity of data is needed for fully informed management, this was not practicable in this study. However, general data from ecological surveys such as this can complement those from taxonomic collections and form a useful initial knowledge-base.

The aims of the analysis of the vegetation of the Peninsula were to relate the various identifiable combinations of structure and floristic composition to variations in habitat and to identify any factors relevant to the management of the vegetation.

Methods

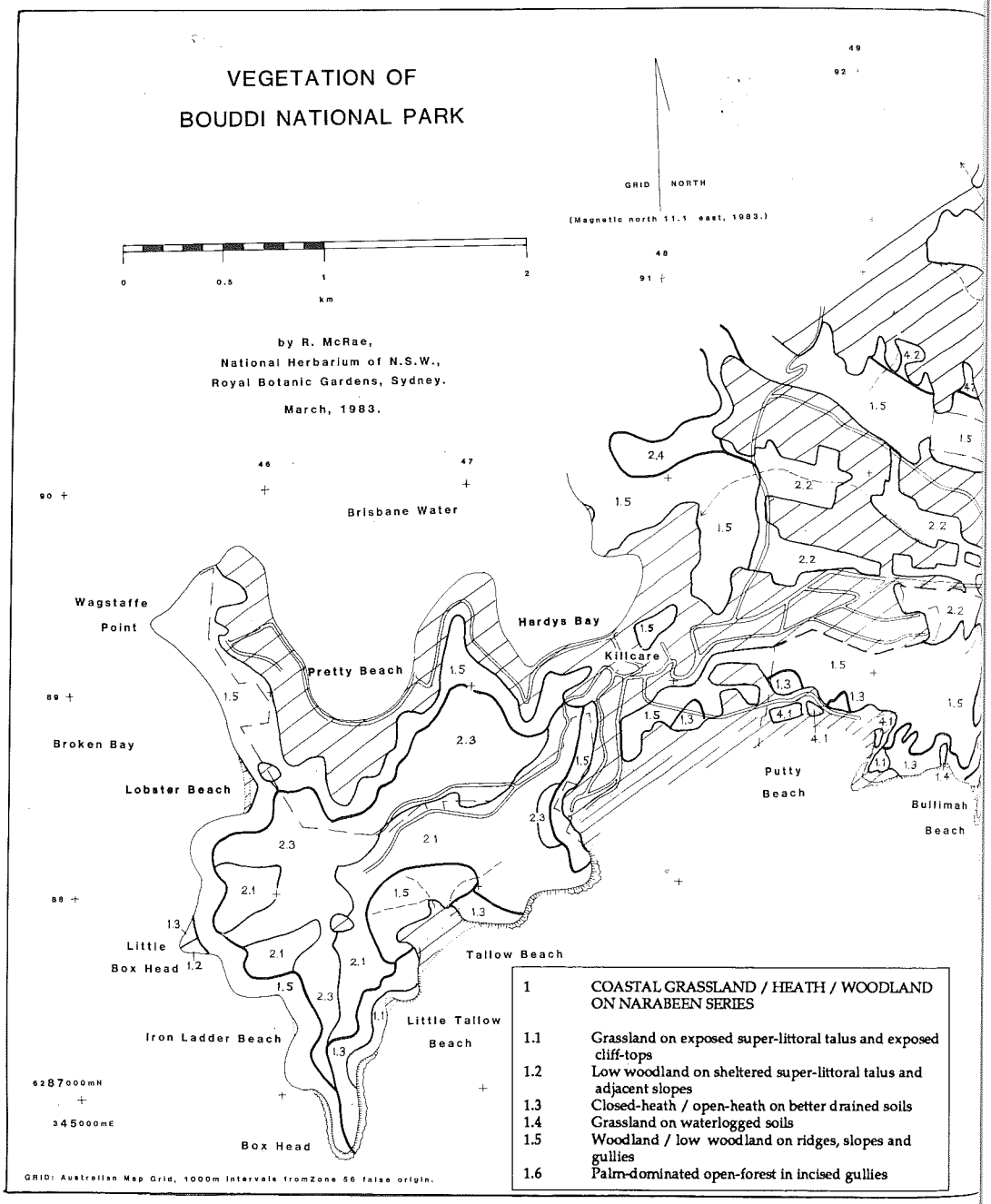
A series of sample sites was used to collect data on vegetation structure and floristics, and on the habitat. The data from these were sorted to identify vegetation patterns at two scales. Firstly, patterns in the vegetation that were identified and related to corresponding patterns in the habitat form map units that equate with vegetation communities. Secondly, the map units were grouped together on the basis of their geology. This grouping was chosen because geology correlates well with soil and geomorphology (and was readily mapped), and because it allows comparison with other work. Recent mapping around the Sydney area, usually at a smaller scale than the present work (e.g. Benson 1980), has treated geology as a major factor associated with local vegetation patterns.

The locations of the 26 sample sites are shown in Figure 2. They were each circular and 400 m^2. They were determined after preliminary field reconnaissance, to achieve a balance between the need for replication and adequate sampling of the full range of vegetation present. However, for some minor map units, field notes only were collected. At each site the following data were collected: (i) physiography (location, aspect, slope, elevation, geology, soil, drainage anomalies and a site sketch); (ii) the vegetation structure (height and projective foliage cover for each distinct stratum present); (iii) species present (height and cover); (iv) an index of abundance of each life-form present; (v) any evidence relating to the life history of significant species; and (vi) site disturbance. A species list for Bouddi National Park was prepared from these data and from other reliable sources (see Appendix). This list shows observed growth habits and the community groups in which the species occurred. The vegetation was mapped at a scale of 1:25 000. This scale was selected as the smallest commonly used that would permit display of detail to a resolution of 100 m. The mapping was based on interpretation of aerial photography (New South Wales Department of Lands 1975). Structural terminology is that of Specht (1970).

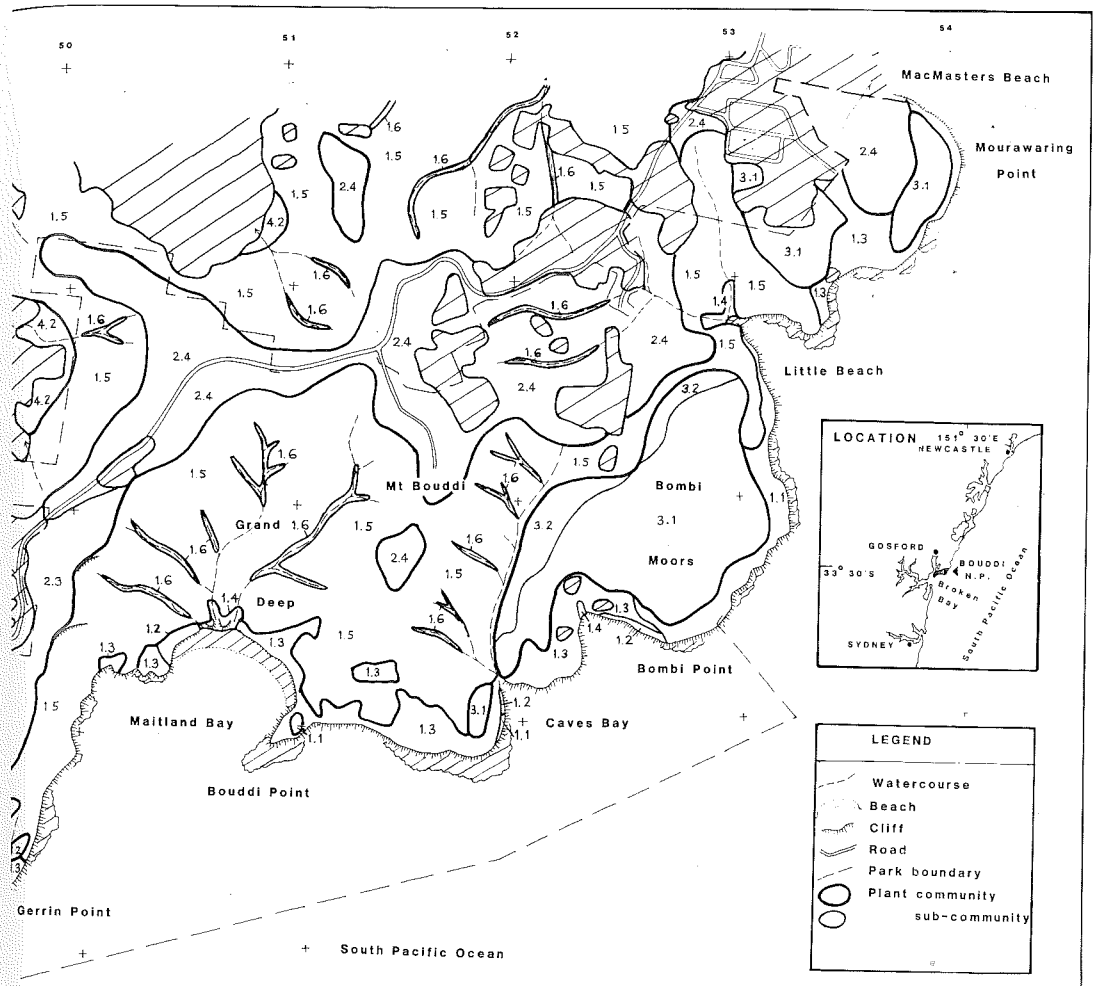
No quantitative methods were used for examining fire effects. General field reconnaissance was used for examination of broad-scale patterns, while detailed notes were taken at the quadrats if any fire effects were apparent. The fire history records held by the National Parks and Wildlife Service were consulted.

Local evidence was collected by general field reconnaissance and by a detailed study of spread across the urban/bushland interface. Here the total cover of all weeds and the distribution of each weed species downslope, along a transect, taken from the urban edge were recorded. The length of the transect, running from the edge of urban development until the weed problem was seen to have ended, was divided into two-metre segments. A rough elevation profile was also prepared to aid in interpretation. Projected foliage cover, and species presence/absence were recorded for each segment. The field reconnaissance included collection of notes on the disturbance history of sites at which weeds were found and comments on their frequency of occurence.

Data from the National Herbarium of New South Wales provided initial information on the distributions of rare species on the Peninsula. Further information was collected on their distribution, abundance, life histories and fire responses during detailed field reconnaissance. No quantitative procedures were used.



Map 1. Vegetation areas of Bouddi Peninsula.



2	OPEN-HEATH / WOODLAND ON HAWKESBURY SANDSTONE
2.1	Low shrubland / open-heath on coastal plateaus
2.2	Woodland / open-heath on laterised soils
2.3	Woodland / open-heath on plateau soils
2.4	Woodland / on colluvial soil

3	OPEN-HEATH / LOW OPEN-WOODLAND ON PLEISTOCENE ALLUVIUM
3.1	Open-heath on coastal podsoils (A-horizon)
3.2	Low open-woodland on coastal podsoils (B-horizon)
4	TALL SHRUBLAND / WOODLAND ON PLEISTOCENE ALLUVIUM
4.1	Tall shrubland on coastal sand deposits
4.2	Woodland on estuarine alluvium

Results

Vegetation

Fifteen map units were recognized. Although classified by vegetation, these were associated with geology, geomorphology, soil and the coastal influences on the Peninsula's climate. The map units may be equated to plant communities. They have been grouped on the basis of geology. The species list is given in the Appendix and the distribution of the map units is shown in Map 1.

Group 1: Coastal grassland/heath/woodland on Narrabeen Series

This group includes all of the vegetation growing on the slopes and ridges formed on the Narrabeen Series rocks. The sites here form a series from very exposed 'super-littoral' situations to sheltered gullies away from strong coastal influences. Coastal sites, exposed to strong winds and salt spray, support mainly grasslands and closed-heath, and also occasional low open-woodland. Sheltered sites support mainly woodland and occasional open-forest.

1.1 Grassland on exposed super-littoral talus and exposed cliff-tops

This occurs above areas of strong wave action, where landslides leave a talus deposit immediately above the littoral zone, and along cliff-tops where undercutting leads to reworking of the soil. The grassland is dominated by *Themeda australis*, which forms a stratum up to 0.2 m high and of over 70% cover. In places a stratum of up to 1.0 m height is formed by shrubs such as *Westringia fruticosa*, *Banksia integrifolia* and *Baeckea imbricata*, graminoids such as *T. australis*, *Lomandra longifolia* and *Isolepis nodosa*, the ferns *Gleichenia dicarpa* and **Cyrtomium falcatum*[1] and the herbs *Apium prostratum* and *Carpobrotus glaucescens*.

1.2 Low woodland on sheltered super-littoral talus and adjacent slopes

A low woodland grows on areas of super-littoral talus and adjacent undercut slopes away from strong coastal exposure. The canopy is formed by a tall shrub layer, mostly 5–8 m high and with 30% cover, with *Banksia integrifolia* and, often, *Allocasuarina distyla* (Figure 6). The understorey in most sites has been altered by weed invasion, with species such as **Chrysanthemoides monilifera* and **Lantana camara* crowding out *Lomandra longifolia*, *Smilax glyciphylla*, *Kennedia rubicunda*, *Themeda australis* and *Acacia longifolia* var. *sophorae*. The last species is native here, but planted elsewhere on the Peninsula.

1.3 Closed-heath/open-heath on better-drained soils

This vegetation grows on coastal headlands under conditions of severe exposure to coastal winds (Figure 7). The steep slopes cutting across the various strata of the Narrabeen Series lead to considerable variation in bedrock and thus soil, but typically the soil is relatively well-drained and clayey and supports a closed-heath. Within this unit fire is an important cause of structural and floristic variation. When unburnt for 8–9 years the community is dominated by *Allocasuarina distyla*, usually forming a stratum about 1.5 m high and 95% cover. Other species include *Hakea teretifolia*, *Banksia ericifolia* and *Lasiopetalum ferrugineum*. The ground cover stratum is poorly developed or absent. After fire the *Allocasuarina* is killed off and relies on seed for regeneration. However, for a number of years its seedlings cannot attain dominance

[1] * indicates introduced species.

over those of other species or with species relying on lignotubers for regrowth. During this phase the local species richness is increased (based on species counts at the sample sites), and abundant species include *H. teretifolia*, *B. ericifolia*, *Isopogon anemonifolius*, *I. anethifolius*, *Petrophile pulchella*, *Woollsia pungens*, *Cyathochaeta diandra* and *Themeda australis*.

On sandy soils an open-heath or closed-heath develops. Common species in the tall shrub layer, which ranges from 0.5 m to 2.5 m tall and has a 60% cover, include *Hakea teretifolia*, *Banksia ericifolia* and *Allocasuarina distyla*. The understorey (0.2–1.0 m in height and 70% cover) contains shrubs such as *B. oblongifolia*, *Woollsia pungens* and *Leptospermum flavescens*, and graminoids such as *Themeda australis*, *Hypolaena fastigiata*, *Cyathochaeta diandra* and *Lepidosperma viscidum*. Where the soil becomes waterlogged to any degree a simpler structure, with one stratum (0.3–1.5 m; 100%), develops. The main species are then *Banksia oblongifolia*, *Mirbelia rubiifolia* and *Gahnia melanocarpa*.

The slopes immediately north of Tallow Beach support an open-heath on very steep, well drained but skeletal soil. The fire history is uncertain. The soil's shallowness and lack of structure, due to minor undercutting from wave action and a lack of talus from rock strata upslope, could be the critical habitat factor here. The main species in the single stratum (0.3–0.8 m; 50%) are shrubs such as *Allocasuarina distyla*, *Dillwynia floribunda*, *Banksia oblongifolia*, *B. ericifolia* and *Hakea teretifolia*, and graminoids such as *Lepidosperma squamatum*, *Lomandra longifolia* and *Patersonia glabrata*.

1.4 Grassland on waterlogged soils

The mouths of many of the short, deep coastal gullies have small flats with waterlogged sediments on which a grassland of variable species composition occurs. These areas have been invaded by exotic grasses. Although the structure comprises one stratum, it is variable and heterogeneous, with height ranging from 0.5 to 1.5 m and cover up to 100%. Species present include dominant graminoids such as *Phragmites australis*, *Isolepis nodosus*, *Imperata cylindrica*, **Stenotaphrum secundatum*, *Digitaria didactyla* and *Hemarthria uncinata*, herbs such as *Commelina cyanea*, **Hydrocotyle bonariensis* and *Dichondra repens*, and low growing exotic shrubs such as **Chrysanthemoides monilifera* and **Acacia longifolia* var. *sophorae*. Similar conditions occur on seepage areas below coastal cliffs, where *Gleichenia rupestris* is also abundant. These latter areas are too small or narrow to map separately.

1.5 Woodland/low woodland on ridges, slopes and gullies

The slopes running from the main ridges and plateaux towards the coast generally support a eucalypt woodland. The slopes here are steep, often up to 30°, the aspect varies, but tends towards south-east and there is always some minor exposure to coastal winds and to salt-spray. Where the wind exposure is extreme the structure changes to a low woodland, in which the canopy merges with the shrub layer, but without significant floristic changes. The main tree species, *Eucalyptus umbra*, *E. paniculata*, *Angophora costata* and *Syncarpia glomulifera*, form a layer that varies from a height of 25 m and a cover of 25% to a height of 3 m and 10% cover with increasing exposure. The shrub layer has a variable composition, with common species including *Macrozamia communis*, *Dodonaea triquetra* and *Pultenaea flexilis*. The tall ground cover layer (1.5 m; 30%) is dominated by *Lomandra longifolia*, *Imperata cylindrica*, *Gahnia melanocarpa* and *Pteridium esculentum*. Much variability in the strata

Figure 6. Low woodland, dominated by *Banksia integrifolia* (unit 1.2), on talus above the littoral zone. The talus is derived from the low cliff and from the soils above.

Figure 7. View of coastal heath on Box Head from north of Tallow Beach. The closed-heath on the lower slopes, dominated by *Allocasuarina distyla*, is unit 1.3 and the low shrubland/ open-heath on the ridge-top and upper slopes is unit 2.1.

may be related to aspect and soil, the latter arising from the variable nature of the parent rocks.

The slopes leading down directly to Broken Bay or Brisbane Water, being away from strong coastal influences, support a woodland with different dominant species and a more consistent structure. The tree layer is usually around 20 m high, with 20% cover, and composed of *Eucalyptus maculata*, *Angophora costata*, *Allocasuarina torulosa*, *E. umbra* and *E. gummifera*. The shrub layer (1.2 m; 10%) has a variable florisitic composition. Common species are *Oxylobium ilicifolium*, *Acacia implexa*, *Pultenaea ferruginea*, *P. flexilis*, *Macrozamia communis*, *Hakea sericea* and *Persoonia linearis*, with the local abundance of these varying in a manner that suggests fire history as the cause. The ground cover (0.4 m; 25%) can be fire-affected, with species such as *Lomandra longifolia*, *Entolasia stricta* and *Panicum simile* being displaced by *Imperata cylindrica* after fire.

On the steep slopes north of Mount Bouddi and west of MacMasters Beach is a woodland with a florisitic composition that reflects its drier location, away from the influence of the coast or the bays. Only a small area of this, below the Northwest Ridge, is in the National Park. The tree layer is dominated by *Eucalyptus punctata* and *Allocasuarina torulosa*. As this community occurs mostly between the Park and developed areas the understorey has usually been affected by frequent low-intensity fires. *Imperata cylindrica* is abundant, along with *Pteridium esculentum*, *Culcita dubia* and *Macrozamia communis*.

1.6 Palm-dominated open-forest in incised gullies

On the slopes below Mount Bouddi the gullies are incised, providing a sheltered habitat in which there is an open-forest dominated by palms with an understorey allied to rainforest (Figure 8). The tree layer, growing to 30 m and reaching 60% cover, is composed mainly of *Archontophoenix cunninghamiana* with scattered *Eucalyptus deanei* and *Allocasuarina torulosa*. The small tree layer (10 m; 10%) includes *Livistona australis*, *Duboisia myoporoides*, *Glochidion ferdinandi* and *Acmena smithii*. The understorey is quite open (2 m; 20%), with scattered shrubs, tall graminoids and ground ferns. Shrub species include *Ficus coronata*, *Pittosporum undulatum*, *Notelaea venosa*, *Wilkiea huegeliana*, *Schizomeria ovata*, *Eupomatia laurina* and *Citriobatus pauciflorus*. Ground cover species include *Cissus antarctica*, *Rubus moorei*, *Morinda jasminoides*, *Gymnostachys anceps*, *Dioscorea transversa* and ferns such as *Lastreopsis decomposita*, *Doodia aspera* and *Blechnum cartilagineum*. *Todea barbara* and *Blechnum camfieldii* occur on the banks of the watercourses. **Lantana camara* is abundant in the surrounding eucalypt woodlands, and with time could increase from its currently isolated pockets.

Group 2: Open-heath/woodland on Hawkesbury Sandstone

The Hawkesbury Sandstone plateaus and ridge-tops support characteristic open-heaths and woodlands. These are a small, coastal sub-set of the Hawkesbury Series' sandstone vegetation. There are two main trends within this group: soils with a clay B-horizon and somewhat impeded drainage support such structural types as open-heath, closed-heath, low shrubland and tall shrubland; and other soils support woodland (most commonly), open-woodland and open-forest.

2.1 Low shrubland/open-heath on coastal plateaus

On the Box Head plateau in areas of strong coastal influence, an open-heath or low-shrubland occurs (Figure 7). The main species in the open shrub layer, which varies from 0.3 m to 0.8 m in height and which has typically 15% cover but may reach 30%, are *Allocasuarina distyla, Banksia oblongifolia, B. ericifolia, Dillwynia retorta, Persoonia lanceolata, Hakea teretifolia, Petrophile pulchella, Platysace linearifolia* and *Epacris pulchella.* The ground cover stratum (0.2 m; 20%) includes species such as *Xanthorrhoea media, Patersonia sericea, Cyathochaeta diandra, Lepidosperma viscidum* and *Ptilanthelium deustum.*

2.2 Woodland/open-heath on laterized soils

The 'laterized' soils on Wards Hill support a woodland whose extent has been severely affected by clearing for orchards or by degradation by too frequent burning. It is only poorly represented in the National Park. The tree stratum reaches 12 m and has around 15% cover. Common trees include *Syncarpia glomulifera, Eucalyptus piperita, E. gummifera* and *E. agglomerata.* Common species in the shrub layer (1.2 m; 40%) are *Persoonia levis, Cassinia* sp., *Xylomelum pyriforme, Lambertia formosa* and *Acacia ulicifolia,* while those common in the ground cover (0.5 m; 60%) include *Themeda australis, Xanthorrhoea media* and *Pteridium esculentum.*

Where streams cross the 'laterite' they are flanked by poorly drained areas in which an open-heath develops. There are scattered small trees up to 3 m tall and less than 10% cover, comprising mainly *Angophora costata, Eucalyptus piperita, E. umbra* and *E. pellita.* Under these is a diffuse stratum of shrubs and ground cover species (1 m; 60%). The main shrubs are *Lambertia formosa, Pultenaea elliptica, Banksia oblongifolia, Mirbelia rubiifolia, Acacia ulicifolia* and *Petrophile pulchella,* and the main ground cover species is *Lepidosperma laterale,* but with *Schoenus brevifolius, Xyris operculata* and *Ptilanthelium deustum* important above rock outcrops and other locally wetter areas.

2.3 Woodland/open-heath on plateau soils

On the plateaus where there is not a markedly clayey sub-soil there is a woodland of variable structure. The tree stratum, ranging in height from 8 m to 24 m with around 15% cover, contains species such as *Eucalyptus gummifera, E. piperita, E. pellita, E. paniculata, Angophora costata* and *Allocasuarina torulosa.* Sometimes there is a small tree stratum under this (4 m to 8 m; 20%) of *Banksia serrata, A. torulosa* and *Leptospermum flavescens.* The understorey contains a diverse shrub layer (0.5 m to 2.0 m; 20%) including *Pultenaea flexilis, Acacia ulicifolia, Platysace lanceolata, Dillwynia floribunda, Macrozamia communis* and *Pteridium esculentum* and a ground cover (0.6 m; 10%) dominated by *Themeda australis, Xanthorrhoea media* and *Entolasia stricta.*

On areas where there is a slight impedence of drainage (due to the presence of a clay sub-soil combined with a general concavity of the plateau surface) an open-heath is present, with scattered stands of low woodland. These areas are mainly on the broad 'shoulders' of the plateaus. The tree species *Eucalyptus gummifera, Angophora costata, E. piperita, E. pellita, E.agglomerata, Syncarpia glomulifera* and *E. haemastoma* form a distinct stratum of 3.0 m height and 30% cover in the low woodland stands, or a diffuse tall shrub component in the open-heath. The shrubs, such as *Lambertia formosa, Banksia serrata, Leptospermum attenuatum, Pultenaea elliptica, B. oblongifolia, Acacia ulicifolia* and *Petrophile pulchella* form a distinct layer (1.2 m; 30%) or merge with the

ground cover layer (0.3 m; 30%) which contains species such as *Lepidosperma elatius, Schoenus brevifolius, Xyris operculata* and *Ptilanthelium deustum.*

2.4 Woodland on colluvial soil

Where the sandstones are thin and broken-up, allowing the accumulation of humus-rich colluvial soil (which sometimes occurs downslope, over parent rocks of the Narrabeen Series), a woodland dominated by *Eucalyptus pilularis* and *Angophora costata* is present (Figure 9). Other species in the tree stratum (ranging in height from 15 m to 22 m and with 25% cover) include *E. gummifera, E. umbra, E. paniculata* and *Allocasuarina torulosa.* At moister sites there is a tall shrub layer (5 m to 9 m; 15%) with *Acacia irrorata, Glochidion ferdinandi, Leptospermum flavescens, Acacia maidenii, Banksia integrifolia* and *Elaeocarpus reticulatus.* The understorey is composed of a very sparse shrub layer (1.2 m; 2%) and a ground cover layer (0.5 m; 50%) into which the shrub layer frequently merges. Common species are *Macrozamia communis, Pteridium esculentum, Lomandra longifolia, Xanthorrhoea arborea* and *Culcita dubia.*

Group 3: Open-heath/low open-woodland on Pleistocene Alluvium

The vegetation on the perched Pleistocene sand-dunes, the Bombi and Mourawaring Moors, is a distinctive feature of the Peninsula. The podsolized sands support an open-heath or low open-woodland. Structurally these communities are very simple, with a shrub stratum, usually up to 1.5 m high and with 20% cover, often merging with a ground cover stratum, with 80% cover and dominated by graminoids.

3.1 Open-heath on coastal podsols

Where the leached A-horizon is intact there is a distinctive open-heath (Figure 10). The dominant shrub is *Banksia aemula*, with common species including *Allocasuarina distyla, Lambertia formosa, Platysace linearifolia, Isopogon anemonifolius, Persoonia lanceolata* and *Leptospermum flavescens*, mixed with low-growing *Eucalyptus umbra* and *Angophora costata.* Common understorey species include *Hypolaena fastigiata, Bossiaea ensata, Woollsia pungens* and *Lepidosperma* spp.

Where there has not been a recent fire a tall shrubland structure (1 m to 3 m; 15% cover) may develop, with species such as *Allocasuarina distyla, Eucalyptus umbra, Platysace lanceolata, Leptospermum flavescens* and *Styphelia laeta.*

3.2 Low open-woodland on coastal podsols

On the edges of the dunes where the indurated sands are exposed or covered with a thin layer of colluvial leached sand, a low open-woodland develops. Such sites are normally sheltered from any strong coastal influence by their aspect (which ranges from the west to the north), but are on nutrient-poor soils with little nutrient input from salt spray. The tree layer is low, of 3 m to 8 m height and 10% to 50% cover, dominated by *Angophora costata, Eucalyptus umbra* and *Allocasuarina distyla.* The shrub layer (1.2 m; 70%) is dominated by *Banksia aemula, B. serrata, Syncarpia glomulifera, Xanthorrhoea arborea* and *Podocarpus spinulosus.*

3.3 Woodland on inland podsols

Where the main sand-dunes are not affected by coastal exposure there was

Figure 8. Open-forest, dominated by *Archontophoenix cunninghamiana*, in a sheltered gully 1 km west of Little Beach (unit 1.6).

Figure 9. Woodland, dominated by *Eucalyptus pilularis*, on colluvial soil behind Little Beach (unit 2.4).

Figure 10. Open-heath on perched sand dune, dominated by *Banksia aemula*, on Bombi Moors (unit 3.1). The low trees are *Eucalyptus umbra* and the main ground cover species is *Hypolaena fastigiata.*

formerly a woodland dominated by *Eucalyptus pilularis* and *Angophora costata.* All of this has been cleared for urban development or for sand extraction, leaving only remnant trees. It appears to have had affinities with the vegetation in the gully south of MacMasters Beach (map unit 2.4).

Group 4: Tall shrubland/woodland on Recent Alluvium.

4.1 Tall shrubland on coastal sand deposits

The beaches on the Peninsula are from 100 m to 1.2 km long and from 20 m to 100 m wide, with the larger beaches backed by simple sand-dune systems. The vegetation on these has been cleared in the past for mineral sand extraction, while the few remaining untouched sections, at the eastern end of Putty Beach, suffer from heavy recreational use. Remnants of the original vegetation include a tall shrub stratum, ranging from 2 m to 8 m in height and with 40% cover, dominated by *Leptospermum laevigatum* and with other shrubs such as *Banksia integrifolia, L. attenuatum* and *Macrozamia communis.* The weeds **Lantana camara* and **Chrysanthemoides monilifera* subsp. *monilifera* show fluctuations in local abundance with implementation of various weed control measures. Immediately behind the beaches, in areas disturbed by storm waves, are typical coastal colonizing species such as *Spinifex sericeus*, **Cakile edentula*, *Tetragona tetragonioides* and **Hydrocotyle bonariensis.*

4.2 Woodland on estuarine alluvium

The inlets of Broken Bay and Brisbane Water are fringed by infilled mud-basins, which support a distinctive range of vegetation types. These range from

an estuarine complex on saline soils to a moist eucalypt woodland in the enclosed valleys. The latter occurs below Northwest Ridge. Typically the canopy is up to 25 m in height and has 60% foliage cover, and includes species such as *Eucalyptus amplifolia*, *E. deanei*, *E. pilularis*, *E. robusta*, *Angophora floribunda*, *Allocasuarina torulosa* and *Casuarina glauca*. The understorey has generally been modified or cleared for grazing, as has the canopy in many areas. Based on the remnants of the understorey, it may be assumed that tall shrubs were formerly common, especially *Melaleuca styphelioides*, and that there was a dense and diverse ground cover.

Weed Invasion

Reconnaissance indicated that the extent of weed invasion is generally minimal, but also that there were several specific problems that could be related to specific non-natural disturbances. Weed invasion into the periphery of bushland from disturbed ground was generally minor in extent and severity, but was occasionally locally severe around urban areas and along roadways. The detailed study of peripheral weed ingress was conducted at such a site east of Killcare Heights (Figure 1) downslope of a well tended lawn and subject to the deposition of garden clippings and fertiliser. The data are summarised in Figure 11.

The beaches that were mined for mineral sands have major infestations of **Chrysanthemoides monilifera* subsp. *monilifera*. While it is not clear whether or not the local populations arose from plantings as an aid to rehabilitation, they are well established now. Seedlings are often seen in adjacent bushland, apparently due to dispersal of seed by birds. **Lantana camara* was seen to be the most serious problem for the vegetation of the Peninsula. Many hectares of understorey are dominated by dense stands of this bush. The approximate present extent, based on field reconnaissance, is shown in Figure 12. Seed dispersal by birds is probably the primary means of invasion. A number of minor areas of disturbance were found close to the coast. Here species with wind-blown seeds, such as **Gomphocarpus fruticosus* and **Sonchus oleraceus* were occasionally present.

There were 46 exotic species found during the study, and these are listed in Table 2. These species were mainly from the families Poaceae, Asteraceae, Fabaceae and Verbenaceae. Species present only in largely disturbed lands (including lawns, gardens and agricultural lands) were not considered, but some might with time spread into undisturbed lands.

Of the species found, 17 were considered able to invade natural bushland (shown by 'I' after the species' names in Table 2). The other species occurred only on sites that have experienced some form of disturbance, either clearance, too frequent burning or nutrient enrichment. It was possible to assign the species to frequency classes as an index of their general impact on bushland (also shown in Table 2). Seven species had been planted or deposited with garden clippings (shown by '0'). Of the remaining 39 species, 28 are present in bushland only as scattered occurrences, mainly of low local frequency (shown by '1'). Seven species are found more widely, usually in specific habitats and with low or moderate local frequency (shown by '2'). Four species are present with high local frequency (shown by '3'): **C. monilifera*, **G. fruticosus*, **Hydrocotyle bonariensis* and **L. camara*.

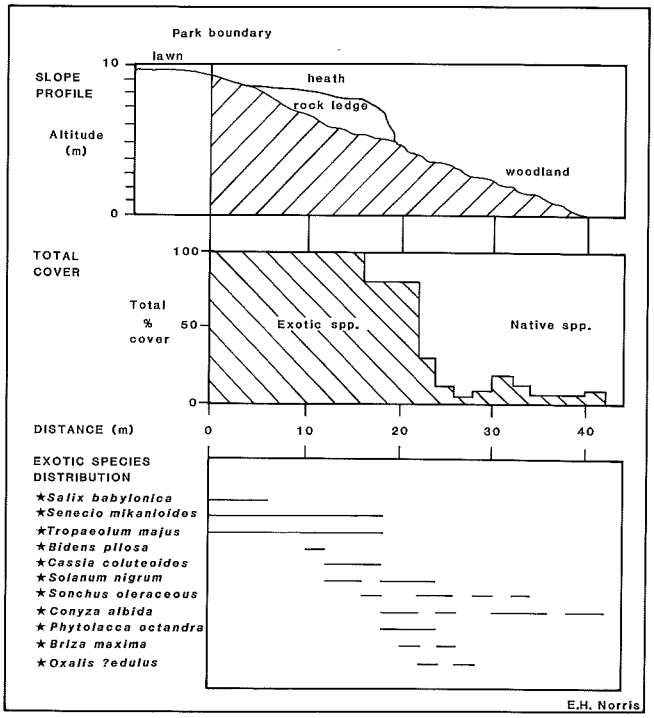


Figure 11. Weeds recorded along a transect at Killcare Heights fall into two groups that could progress further into bushland with time. The first group of three species occurs in areas with high nutrient in-wash, in which native species have been displaced. The second group, which apparently precedes the first, co-exists with native species.

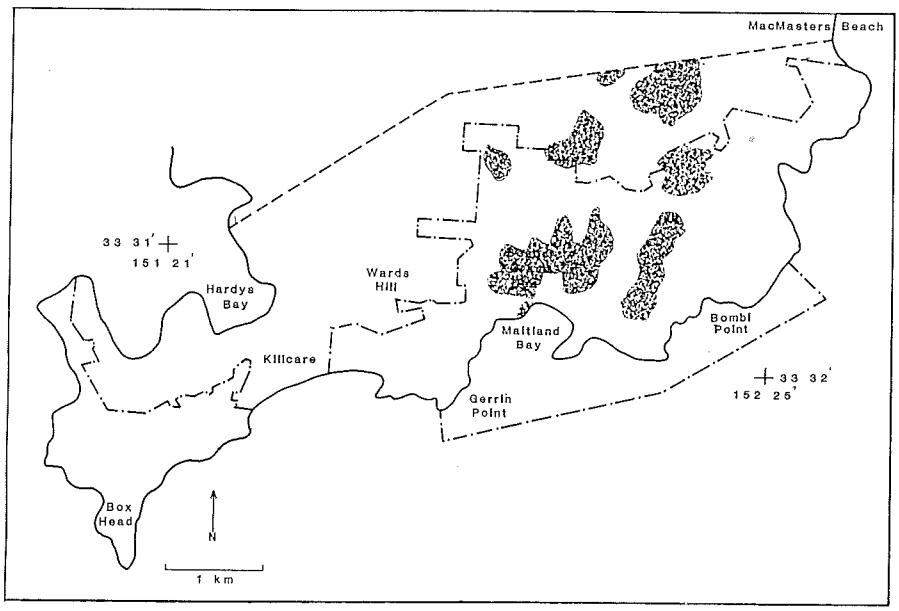


Figure 12. The approximate distribution of **Lantana camara* in the study area.

Table 2. Exotic species in Bouddi National Park.

Species capable of invading bushland are indicated by an (I). A frequency score of '0' (planted or from garden cuttings), '1' (scattered occurrences), '2' (low-moderate frequency, and '3' (high local frequency) is listed for every species.

	Invasiveness	Frequency
PTERIDOPHYTES		
ASPIDIACEAE		
**Cyrtomium falcatum*		1
ANGIOSPERMS		
MONOCOTYLEDONS		
COMMELINACEAE		
**Tradescantia albiflora*	I	1
IRIDACEAE		
**Crocosmia* X *crocosmiiflora*		2
LILIACEAE		
**Protasparagus aethiopicus*	I	1
POACEAE		
**Andropogon virginicus*	I	2
**Briza maxima*		1
**B. minor*		1
**Chloris gayana*		1
**Cortaderia selloana*		2
**Cynodon dactylon*	I	1
**Lagurus ovata*		1
**Paspalum dilatatum*		1
**P. urvillei*	0	
**Stenotaphrum secundatum*		1
DICOTYLEDONS		
APIACEAE		
**Hydrocotyle bonariensis*	I	3
ASCLEPIADACEAE		
**Gomphocarpus fruticosus*	I	3
ASTERACEAE		
**Ageratina adenophora*	I	1
**Bidens pilosa*		1
**Chrysanthemoides monilifera*	I	3
**Chrysanthemum maximum*		0
**Conyza albida*	I	2
**Coreopsis lanceolata*		1
**Hypochoeris radicata*		1
**Senecio mikanioides*		1
**Sonchus oleraceus*	I	1
BRASSICACEAE		
**Cakile edentula*		1
CACTACEAE		
**Opuntia stricta*		0
CONVOLVULACEAE		
**Ipomoea indica*		1
CRASSULACEAE		
**Kalanchoe tubiflora*		1
FABACEAE — CAESALPINIOIDEAE		
**Cassia coluteoides*		1
FABOIDEAE		
**Erythrina* X *sykesii*	1	
**Trifolium* sp.		0
MIMOSOIDEAE		
Acacia longifolia var. *sophorae*		2
LAURACEAE		
**Cinnamomum camphora*	I	1
MALVACEAE		
**Sida rhombifolia*	I	2
OLEACEAE		
**Ligustrum lucidum*	I	1
**L. sinense*	I	2
OXALIDACEAE		
**Oxalis ?edulis*		1
PASSIFLORACEAE		
**Passiflora edulis*		1
PHYTOLACCACEAE		
**Phytolacca octandra*	I	1
SALICACEAE		
**Salix babylonica*		0
SOLANACEAE		
**Solanum nigrum*	I	1
THUNBERGIACEAE		
**Thunbergia alata*		1
TROPAEOLACEAE		
**Tropaeolum majus*		0
VERBENACEAE		
**Lantana camara*	I	3
**Verbena bonariensis*		0

Rare or restricted species

Records for the Peninsula include one rare species and one vulnerable species (as defined by Leigh et al., 1981), but no restricted or endangered species. However, in the future, other species may be recorded or current species may change in status, due to changes in fire regime, pressure from exotic species or further land clearance.

Blechnum ambiguum[2] (Blechnaceae) is a ground fern found around the edges of the Hawkesbury Sandstone. It is considered to be vulnerable and at a long-term risk (classed as '3V' by Leigh et al.). It was listed for the Park in the National Parks and Wildlife Service plant list (1978), and was not found during the current survey.

Rulingia hermaniifolia (Sterculiaceae) is a shrub found on coastal headlands from Kurnell to Broken Bay and also inland from Jervis Bay along the Shoalhaven River. It is considered to be rare and to be adequately conserved, because, although it occurs in small populations, it is protected within national parks. It was recorded within Bouddi National Park by Siddiqi (1971), by D. Lambert (pers. comm.) and was found in the present survey at two locations: two plants and about 15 seedlings were found on a small ledge on top of a cliff at Caves Bay, and a group of small plants were found in heath, burnt three years previously, on the eastern edge of the Bombi Moors. Field observations suggest this low spreading shrub may be fire sensitive. It flowers in October and old seed pods have been seen on (presumably) three-year-old plants.

Discussion

Vegetation

Bouddi National Park is the only conservation reserve in the study area. Its efficacy in conserving the vegetation of the Peninsula can be estimated from the areas, in both absolute and relative terms, that the plant communities and groups occupy in the Park (given in Table 3). It is useful to consider these values on local, district, region and State scales.

On the local scale, some communities on the Peninsula are not well represented in the Park. Unit 2.2 (woodland/ open-heath on 'laterized' soils) is poorly represented, and the area that is in the Park shows little of its overall diversity. Both map units in group 4 (Tall shrubland/ woodland on recent alluvium) are represented by very small areas that have been largely disturbed.

On the district scale, the range of vegetation in Bouddi National Park has marked differences with that of nearby conservation reserves, as shown in Table 4 (Benson & Fallding 1981 and Benson 1980 and general reconnaissance). Only group 2 is well represented in these reserves.

The pattern on the regional scale is like that on the local scale: vegetation types

[2] A revision of Leigh et al., which was published after this work was completed, omits *B. ambiguum* but includes *R. hermaniifolia* with the same status. [Briggs, J.D. & Leigh, J.H. (1988), *Rare or threatened Australian Plants*. Special Publication 14, Australian National Parks and Wildlife Service, Canberra.]

represented by map units 2.2, 4.1 and 4.2 have generally been cleared or disturbed throughout their extent in the Central Coast. Unit 1.6 (palm-dominated open-forest) is on the edge of a gap in the distribution of the diverse warm-temperate rainforests of the coastal ranges, with which it is allied (on the basis of general species composition, not dominant species). Warm-temperate rainforest occurs to the west in the most sheltered or enriched sites in the Blue Mountains, but with a generally depauperate species composition, and rarely including *Archontophoenix cunninghamiana*. Further, the species composition changes with latitude (Baur 1957), with most of the dominant species occurring no further south than Batemans Bay. Reserves in the region with this rainforest include Barrington Tops National Park and some Flora Reserves in the State Forests of the Watagan Ranges (to the north); Wollemi National Park, and Blue Mountains National Park (to the west) and Royal National Park (to the south) (Figure 1).

On the State-wide scale, Bouddi National Park is an important part of the State's system of conservation reserves in that it is one of only five in the coastal portion of the Central Coast and is also part of an important series of reserves in the valley of the Hawkesbury River, covering almost the full range of habitats present from the coast to the Great Divide.

Table 3. Areas of plant communities and groups of map units in Bouddi National Park.

Map units	Area (ha)	% Area of unit	% Area of Park
1	456		54
1.1	24	5	3
1.2	4	1	~0
1.3	65	14	8
1.4	6	1	~0
1.5	332	73	39
1.6	25	5	3
2	261		31
2.1	68	26	8
2.2	5	2	1
2.3	46	18	6
2.4	142	54	17
3	110		14
3.1	100	91	13
3.2	10	9	1
4	3		~0
4.1	3	100	~0
4.2	~0	~0	~0

Notes: * "~0" signifies that the value is less than 0.5.

* The total area covered by the vegetation is 830 ha. There are also 41 ha in the Park that are cleared, disturbed or naturally without vegetation (e.g. rock ledges). A further 290 ha of the Park are in a marine extension.

Fire

The frequency of fires may strongly influence the effectiveness of any plant reproduction strategy. Seed-based strategies require an interval between fires long enough to allow sufficient seed set. Too-frequent fires can deplete the

Table 4. Conservation status of the four map unit groups in Bouddi National Park compared with three adjacent reserves.

Map Unit Group	Bouddi National Park	Brisbane Water Park	Ku-ring-gai Natnl.Chase Park	Muogamarra Natnl.Nature Group
1	+	~	~	—
2	+	+	+	+
3	+	—	—	—
4	~	—	—	—

Key: + well conserved, ~ minor representation, — not conserved.

nutrient reserves in lignotubers, limit the number of epicormic buds available, deplete seed reserves or leave a plant with insufficient nutrients to resprout. This often leads to selection of plants not so affected which have been uncommon under other fire regimes. The time of year in which a fire occurs may affect the rates of germination of seeds, and so may determine the dominant species in the initial stages of recovery. Two significant fire effects were observed.

Firstly, where repeated burns aimed at fuel reduction occur around the urban edges *Imperata cylindrica* and *Pteridium esculentum* have become locally dominant. While this may not be a desirable event in the National Park it is an acceptable consequence of the steps necessary to protect life and property from fire elsewhere on the Peninsula. Secondly, it appears that fire interacting with an extreme environmental factor can affect the distribution and structure of the vegetation, specifically at the boundary of the areas exposed to coastal winds and saltspray. The mapped boundaries between units 1.3 (closed or open-heath) and 1.5 (woodland/low woodland) probably reflect past fire patterns. In such cases there appears to be a balance between two opposing processes. Firstly fires push the woodland edge away from the coast by allowing die-back due to salt spray where previously sheltering foliage is burnt. Secondly the woodland species can re-establish themselves where the coastal heath (1.3) that replaces them provides shelter from exposure to salt spray. This process must be considered during the planning of fuel reduction burns, to avoid unwanted changes in areas of high recreational or aesthetic amenity.

Weed Invasion

The level of weed ingress from the edges of cleared or disturbed land is presently limited due mainly to the relatively recent spread of urban development, with newer developments tending to be placed on the periphery of older developments. Also the prescribed burns around the edge of developed areas, aimed at reducing wildfire hazard, have not often stressed the native vegetation to a level that would facilitate weed spread.

With time the urban areas will become more established, with lawns and gardens maturing and diversifying and providing more sources of weed species. Existing areas of weed ingress will, in the absence of active management, consolidate. Further, there will be increased pressure on managers of bushland to provide more frequent fuel reduction burns, which will further stress native vegetation.

The areas of disturbed beach sand currently supporting stands of

**Chrysanthemoides monilifera* are subjected, at erratic intervals, to rehabilitation measures ranging from hand extraction in the National Park to bulldozing elsewhere. As a result the state of these problems in the future is unpredictable. The spread of seeds into surrounding woodlands results in scattered and sometimes dense seedling establishment. While such occurences are reported occasionally throughout the coastal parts of the Sydney Basin, there is little indication that mature plants are likely to result.

The stands of **Lantana camara* in relatively undisturbed bushland will be extremely difficult to control. The combination of limited access and the need to avoid disturbing the native species rule out most control measures. There is some potential for biological control (as discussed by Hadlington 1968). The outlook for the future is thus that active management will be required to restrict weed invasion.

Rare or restricted species

The conservation of the rare or restricted species in an area such as the Peninsula is possible as long as the species' requirements are taken into account when planning management operations such as prescription burning and as long as their distributions are made known to those who plan operations that lead to disturbance or clearing of bushland. This should be possible in and around Bouddi National Park.

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Appendix

Floristic list for Bouddi Peninsula

There were 359 species from 94 families recorded during this survey. An additional 69 species were recorded from the area by other sources (Siddiqi 1971; National Parks and Wildlife Service 1978; Jelinek 1979). The floristic list is arranged heirarchically: alphabetically for species, genera and families and systematically for higher groups. All names used are as in Jacobs & Pickard (1981) except for those where the National Herbarium of New South Wales has since adopted another name.

In the list the taxa are given first, with species italicised and higher groups in upper case. Exotic species are prefixed with an asterix (*). After this, for those species recorded during this survey, is a code for the main growth habit observed. The numbers after these are the map unit groups in which the species was observed, or if prefixed with a question mark (?), the groups in which it is reported to occur. Where a hash symbol (#) is given, the species was not found in natural vegetation in the study area.

The map unit groups are:

1 Coastal grassland/heath/woodland on Narrabeen Series.
2 Open-heath/woodland on Hawkesbury Sandstone.
3 Open-heath/low open-woodland on Pleistocene alluvium.
4 Tall shrubland/woodland on Recent alluvium.

The life-form abbreviations are:

T: tree, ST: small tree, TS: tall shrub, S: shrub, SS: small shrub, CY: cycad, TG: tall graminoid, G: graminoid, SE: seedling only, GF: ground fern, RF: rock fern, RO: rock orchid, EP: epiphyte, V: vine, TH: tall herb, H: herb.

PTERIDOPHYTES
ADIANTACEAE
Adiantum aethiopicum (GF) 1 2
A. *hispidulum* (GF) 1
Cheilanthes sieberi (GF) 2
ASPIDIACEAE
**Cyrtomium falcatum* (RF) 1
Lastreopsis decomposita (GF) 1
Polystichum australiense (GF) 1
ASPLENIACEAE
Asplenium flabellifolium (GF) 1
BLECHNACEAE
Blechnum camfieldii (GF) 1
B. cartilagineum (GF) 1 2
Doodia aspera (GF) 1 2
CYATHEACEAE
Calochlaena dubia (GF) 1 2
DAVALLIACEAE
Davallia pyxidata (RF) 2
DENNSTAEDTIACEAE
Pteridium esculentum (GF) 1 2 3
GLEICHENIACEAE
Gleichenia dicarpa (GF) 2
G. *rupestris* (GF) 1
LINDSAEACEAE
Lindsaea linearis (GF) 1 2
OSMUNDACEAE
Todea barbara (GF) 1
POLYPODIACEAE
Platycerium bifurcatum (RF) 2
SELAGINELLACEAE
Selaginella uliginosa (SS) 2
THELYPTERIDACEAE
Christella dentata (GF) 1

GYMNOSPERMS
PODOCARPACEAE
Podocarpus spinulosus (S) 2 3
ZAMIACEAE
Macrozamia communis (CY) 1 2 3

ANGIOSPERMS
MONOCOTYLEDONS
ARACEAE
Gymnostachys anceps (TG) 1 2
ARECACEAE
Archontophoenix cunninghamiana (T) 1
Livistona australis (T) 1
COMMELINACEAE
Commelina cyanea (H) 1
**Tradescantia albiflora* (H) #
CYPERACEAE
Carex appressa (G) 1
Caustis flexuosa (G) 2
C. *pentandra* (G) 2
Cyathochaeta diandra (G) 1 2
Eleocharis sp. (G) 2
Gahnia clarkei (TG) 2
G. *melanocarpa* (TG) 1
Isolepis nodosus (G) 1
Lepidosperma elatius (TG) 2
L. laterale (G) 1 2
L. squamatum (G) 1
L. viscidum (G) 1 2
Ptilanthelium deustum (G) 2
Schoenus brevifolius (G) 2 3

S. ericetorum (G) 3
S. melanostachys (G) 1 2
DIOSCOREACEAE
Dioscorea transversa (V) 1 2
HAEMODORACEAE
Haemodorum planifolium (G) 2 3
IRIDACEAE
**Crocosmia* X *crocosmiiflora* (G) #
Libertia paniculata ?1
Patersonia glabrata (G) 1 2 3
P. sericea ?2
JUNCACEAE
Juncus antarcticus (G) 1
**J. cognatus* (G) 2
J. continuus ?1
J. kraussii (G) 1
J. planifolius (G) 1
JUNCAGINACEAE
Triglochin striata (G) 1
LILIACEAE
Blandfordia sp. (G) 1
Caesia sp. (G) 1
Dianella caerulea (G) 1 2
**Protasparagus aethiopicus* cv. 'sprengeri' (V) #
Schelhammera undulata (H) 2
Sowerbaea juncea ?3
Stypandra glauca (G) 1
Thelionema umbellatum ?3
Thysanotus juncifolius (G) 2
ORCHIDACEAE
Calaena major ?3
Cryptostylis erecta (G) 2
Cymbidium suave (EP) 2
Dendrobium linguiforme (RO) 2
D. speciosum (RO) 2
Dipodium punctatum (G) 2
Diurus aurea ?3
Liparis reflexa (RO) 2
PHILESIACEAE
Eustrephus latifolius (V) 1 2
Geitonoplesium cymosum (V) 1
POACEAE
**Ammophila arenaria* (G) ?4
**Andropogon virginicus* (G) #
Anisopogon avenaceus (G) 1 2 3
Aristida sp. (G) 1
**Briza maxima* (G) #
**B. minor* (G) #
Chionochloa pallida (G) 1
**Chloris gayana* (G) #
**Cortaderia selloana* (TG) 2
**Cynodon dactylon* (G) #
Danthonia pilosa (G) 2
Deyeuxia quadriseta (G) 1
Digitaria didactyla (G) 1
D. parviflora (G) 1
Echinopogon caespitosus (G) 1
Entolasia marginata (G) 2
E. stricta (G) 1 2
Eragrostis brownii (G) 1
Festuca littoralis (G) 1
Hemarthria uncinata (G) 1
Imperata cylindrica (G) 1 2
**Lagurus ovatus* (G) #
Oplismenus imbecillis (G) 1 2
Panicum simile (G) 2
Paspalidium radiatum (G) 1
**Paspalum dilatatum* (G) #
**P. urvillei* ?3
Phragmites australis (TG) 1
Poa affinis (G) 1
P. poiformis (G) 1
Spinifex sericeus (G) 4
**Stenotaphrum secundatum* (G) 1
Stipa rudis (G) 1
Themeda australis (G) 1 2
RESTIONACEAE
Hypolaena fastigiata (G) 1 2 3 4
Lepyrodia scariosa ssp.*meiostachyus* (G) 2
Restio tetraphyllus (G) 2
SMILACACEAE
Smilax australis (V) 1 2
S. glyciphylla (V) 1 2 4
Ripogonum fawcettianum (V) 1
XANTHORRHOEACEAE
Lomandra glauca (G) 1 3
L. confertifolia ssp.*rubiginosa* ?2
L. filiformis ?2
L. longifolia (G) 1 2 3 4
L. micrantha ?1
L. multiflora (G) 1 2
L. obliqua (G) 1 2
Xanthorrhoea arborea (TG) 2 3
X. macronema (TG) 1
X. media (TG) 1 2
XYRIDACEAE
Xyris gracilis (G) 2
X. operculata ?3

DICOTYLEDONS
ACANTHACEAE
Pseuderanthemum variabile (H) 2
AIZOACEAE
Carpobrotus glaucescens (H) 1
Tetragonia tetragonioides (H) 4
APIACEAE
Actinotus helianthi (H) 1 2 3 4
A. minor (H) 1
Apium prostratum (H) 1
Centella asiatica (H) 1
**Hydrocotyle bonariensis* (H) 1
Platysace lanceolata (S) 3
P. linearifolia (S) 2 3
Xanthosia pilosa (H) 1 2 3
X. tridentata (H) 1 2

APOCYNACEAE
Parsonsia straminea (V) 1 2
ARALIACEAE
Astrotricha latifolia (S) 1
Polyscias sambucifolia (TH) 1
ASCLEPIADACEAE
**Gomphocarpus fruticosus* (TH) 1
Marsdenia suaveolens ?1 ?3
ASTERACEAE
**Ageratina adenophora* (TH) 1
**Bidens pilosa* (H) #
Cassinia aureonitens (S) 1
C. longifolia ?2
C. uncata (S) 1 2
**Chrysanthemoides monilifera* (S) 1
**Conyza albida* (H) 1
**Coreopsis lanceolata* (H) #
Epaltes australis (H) 1
Helichrysum bracteatum ?2
H. diosmifolium (S) 2
**Hypochaeris radicata* (H) #
Olearia tomentosa ?1
Senecio bipinnatisectus ?1
S. hispidulus (H) 4
S. lautus ?1
S. linearifolius ?1
**S. mikanioides* (V) #
S. vagus (H) 1
**Sonchus oleraceus* (H) 1
Vernonia cinerea (H) 2
BAUERACEAE
Bauera rubioides ?2
BIGNONIACEAE
Pandorea pandorana (V) 1 2
BRASSICACEAE
**Cakile edentula* (H) 4
CACTACEAE
**Opuntia stricta* ?1
CAMPANULACEAE
Wahlenbergia gracilis ?1
CASUARINACEAE
Allocasuarina distyla (S) 1 2 3 4
A. littoralis (S) 1 2
A. torulosa (S) 1 2
CELASTRACEAE
Maytenus silvestris (S) 1 2 3
CHLOANTHACEAE
Chloanthes stoechadis (S) 1 2
CONVOLVULACEAE
Dichondra repens (H) 1
**Ipomoea indica* (V) #
Polymeria calycina (H) 1
CRASSULACEAE
Crassula sieberiana (H) 1
**Kalanchoe tubiflora* (H) 1
CUNONIACEAE
Ceratopetalum apetalum (T) 1
Schizomeria ovata (T) 1
DILLENIACEAE
Hibbertia aspera (SS) 2
H. bracteata ?1
H. cistiflora ?1
H. dentata (V) 1
H. empetrifolia (SS) 2
H. fasciculata ?1
H. monogyna (SS) 1 2 3 4
H. obtusifolia ?1
H. riparia ?1
H. scandens (V) 1
DROSERACEAE
Drosera auriculata ?2
D. binata ?2 ?3
D. spathulata ?2
EBENACEAE
Diospyros australis (TS) 1 2
ELAEOCARPACEAE
Elaeocarpus reticulatus (TS) 1 2
EPACRIDACEAE
Acrotriche divaricata (S) 2
Astroloma humifusum (S) 3
A. pinifolium (SS) 3
Brachyloma daphnoides (SS) 3
Epacris longiflora (S) 1
E. microphylla (S) 2
E. pulchella (S) 1 2 3
Leucopogon appressus ?1
L. deformis ?1
L. ericoides ?1
L. esquamatus (S) 1 2 3
L. juniperinus ?1
L. lanceolatus (S) 1
L. parvifolium ?1
Monotoca elliptica (S) 2
M. scoparia (S) 1 2 3
Sprengelia incarnata (S) 2
Styphelia laeta (S) 2 3
S. tubiflora (S) 1 3
Trochocarpa laurina (S) 1
Woollsia pungens (SS) 1 2 3
EUPHORBIACEAE
Amperea xiphoclada ?1
Breynia oblongifolia (S) 1 2
Glochidion ferdinandi (TS) 1 2
Micrantheum ericoides (SS) 1 2 3
Omalanthus populifolius (S) 1
Phyllanthus hirtellus (SS) 1 2
Poranthera corymbosa ?3
P. ericifolia ?3
Pseudanthus orientalis ?3
Ricinocarpos pinifolius (S) 1 2 3
EUPOMATIACEAE
Eupomatia laurina (TS) 1
FABACEAE
CAESALPINIOIDEAE
**Cassia coluteoides* (S) 2

FABOIDEAE
Aotus ericoides (S) 3
Bossiaea ensata (SS) 2 3
B. heterophylla (SS) 2 3
B. scolopendria ?3
Daviesia corymbosa ?1
D. ulicifolia (SS) 2
Desmodium brachypodum (V) 1 2
Dillwynia floribunda (S) 1 2
D. glaberrima (S) 1
D. retorta (S) 2
D. sericea (S) 2
**Erythrina* X *sykesii* (ST) #
Glycine tabacina (V) 1 2
Gompholobium grandiflorum ?1
G. latifolium (S) 1 2
G. virgatum ?2
Hardenbergia violacea (V) 1 2
Indigofera australis ?1
Jacksonia scoparia ?3
Kennedia rubicunda (V) 1 2
Mirbelia rubiifolia (SS) 1 2
Oxylobium ilicifolium (S) 1 2
Platylobium formosum (SS) 1 2
Pultenaea daphnoides (S) 2
P. elliptica (S) 1 2
P. ferruginea var. *deanei* (S) 1 2 3
P. flexilis (TS) 1 2
**Trifolium* sp. ?1
MIMOSOIDEAE
Acacia elata ?1
A. filicifolia ?1
A. implexa (TS) 1
A. irrorata (TS) 2
A. longifolia var.*sophorae* (TS) 1
A. maidenii (TS) 2
A. myrtifolia (S) 1 2
A. oxycedrus (S) 2
**A. saligna* (TS) 1
A. suaveolens (S) 1 2 3
A. ulicifolia (S) 1 2 3
FLACOURTIACEAE
Scolopia braunii (S) 1
GERANIACEAE
Pelargonium australe (H) 1
P. inodorum (H) 2
GOODENIACEAE
Dampiera stricta (H) 1 2
Goodenia bellidifolia (H) 1 2
G. heterophylla (H) 2
Scaevola ramosissima (H) 1 2
HALORAGACEAE
Gonocarpus teucrioides (SS) 1 2
LAMIACEAE
Plectranthus parviflorus (H) 2
Prostanthera linearis (S) 2
Westringia fruticosa (S) 1 4
LAURACEAE
Cassytha glabella (V) 1 2 3
**Cinnamomum camphora* (ST) 1
Cryptocarya sp. (S) 1
Endiandra sieberi (ST) 1
LENTIBULARIACEAE
Utricularia laterifolia ?2
LOBELIACEAE
Lobelia alata (H) 1
Pratia purpurascens (H) 1
LOGANIACEAE
Logania albiflora ?1
Mitrasacme polymorpha (H) 2
LORANTHACEAE
Amyema pendulum (EP) 2
Dendrophthoe vitellina (EP) 2
Muellerina eucalyptoides ?3
MALVACEAE
Howittia trilocularis (S) 1
**Sida rhombifolia* (H) 1
MELIACEAE
Synoum glandulosum ?1
MENISPERMACEAE
Sarcopetalum harveyanum (V) 1 2
Stephania japonica var. *discolor* (V) 1
MONIMIACEAE
Wilkiea huegeliana (S) 1
MORACEAE
Ficus coronata (S) 1
F. rubiginosa (ST) 1
Malaisia scandens (V) 1
MYOPORACEAE
Myoporum acuminatum ?1
M. insulare (H) 1
MYRSINACEAE
Aegiceras corniculatum (SE) 1
Rapanea howittiana (S) 1 2
R. variabilis (S) 1 2
MYRTACEAE
Acmena smithii (S) 1
Angophora costata (T) 1 2 3
A. floribunda (T) 1 2
A. hispida (TS) 2
Backhousia myrtifolia ?1
Baeckea brevifolia ?1
B. diosmifolia (S) 1
B. imbricata (S) 1 4
B. ramosissima (S) 2
Callistemon citrinus (TS) 1
C. linearis (TS) 1
Calytrix tetragona (S) 2
Eucalyptus botryoides (T) 1
E. capitellata (ST) 2
E. deanei (T) 1
E. gummifera (T) 1 2
E. haemastoma (ST) 2
E. maculata (T) 1
E. paniculata (T) 1 2

E. pellita (ST) 2
E. pilularis (T) 1 2
E. piperita subsp. *piperita* (T) 2
E. punctata subsp. *punctata* (T) 2
E. robusta (T) 4
E. umbra subsp. *umbra* (T) 1 2 3
Kunzea ambigua (S) 2
Leptospermum attenuatum (TS) 2
L. juniperimun (S) 1
L. laevigatum (TS) 1 4
L. polygalifolium (TS) 1 2 3
L. scoparium ?2
L. squarrosum (S) 1
Melaleuca biconvexa ?4
M. linariifolia ?4
M. styphelioides (TS) 4
M. thymifolia (TS) 1
Micromyrtus ciliata ?2
Rhodamnia rubescens (S) 1
Syncarpia glomulifera (ST) 1 2 3
Syzygium oleosum (S) 1
Tristaniopsis collina (TS) 1
T. laurina (TS) 1
OLEACEAE
**Ligustrum lucidum* (ST) #
**L. sinense* (TS) 1
Notelaea longifolia (TS) 1
N. venosa (S) 1
OXALIDACEAE
**Oxalis* ?*edulis* (H) #
**O.* ?*rubens* (H) 1
PASSIFLORACEAE
**Passiflora edulis* (V) 4
PHYTOLACCACEAE
**Phytolacca octandra* (H) #
PITTOSPORACEAE
Billardiera scandens (V) 1 2
Citriobatus pauciflorus (S) 1
Pittosporum revolutum (S) 1 2
P. undulatum (S) 1
PLANTAGINACEAE
Plantago hispida (H) 1
POLYGALACEAE
Comesperma ericinum (S) 2
PROTEACEAE
Banksia aemula (TS) 1 2 3
B. ericifolia (TS) 1 2 4
B. integrifolia (ST) 1 2
B. oblongifolia (S) 1 2 3
B. serrata (TS) 2 3
B. spinulosa var. *collina* (S) 1 2
Conospermum longifolium (S) 2
C. taxifolium (S) 3 4
Grevillea linearifolia (S) 1 2
Hakea dactyloides (S) 2
H. gibbosa (S) 1 2 4
H. sericea (S) 1 2 3
H. teretifolia (S) 1 2
Isopogon anemonifolius (S) 1 2 3 4
I. anethifolius (S) 1 2 3 4
Lambertia formosa (S) 1 2 3
Lomatia silaifolia (S) 2
Persoonia lanceolata (TS) 1 2 3 4
P. levis (TS) 1 2
P. linearis (TS) 1
P. sp. aff. *pinifolia* (S) 2
Petrophile pulchella (S) 1 2
P. sessilis ?3
Telopea speciosissima ?2
Xylomelum pyriforme (TS) 2 3
RANUNCULACEAE
Clematis aristata (V) 1 2
RHAMNACEAE
Pomaderris ?*ferruginea* (S) 1
P. lanigera (S) 1
ROSACEAE
Rubus hillii (V) 1
R. moorei (V) 1
R. rosifolius (V) 1
RUBIACEAE
**Coprosma repens* ?2
Morinda jasminoides (V) 1
Opercularia aspera (S) 1
Pomax umbellata (H) 1 2
Psychotria loniceroides (S) 1
RUTACEAE
Asterolasia correifolia (S) 1
Correa reflexa (S) 1 4
Crowea saligna (S) 2
Eriostemon australasius (S) 2 3
E. hispidulus (S) 2
Zieria pilosa (S) 1
Z. smithii (S) 1
SALICACEAE
**Salix babylonica* ?2
SANTALACEAE
Exocarpos cupressiformis (TS) 1
SAPINDACEAE
Dodonaea triquetra (S) 1 2 3
Guioa semiglauca ?1
SOLANACEAE
Duboisia myoporoides (S) 1
**Solanum nigrum* (S) #
STERCULIACEAE
Brachychiton populneus (T) 2
Lasiopetalum ferrugineum (S) 1 2 4
L. macrophyllum ?1
Rulingia hermanniifolia (SS) 1
THUNBERGIACEAE
**Thunbergia alata* (H) #
THYMELAEACEAE
Pimelea linifolia (S) 1 2 3 4
Wikstroemia indica (S) 1
TREMANDRACEAE
Tetratheca ericifolia ?3
T. thymifolia (SS) 2

TROPAEOLACEAE
**Tropaeolum majus* ?2
VERBENACEAE
Clerodendrum tomentosum (S) 1
**Lantana camara* (TS) 1 2
**Verbena bonariensis* ?1
VIOLACEAE
Hybanthus monopetalus (H) 1 2
Viola betonicifolia (H) 1
VITACEAE
Cayratia clematidea (V) 2
Cissus antarctica (V) 1
C. hypoglauca (V) 1 2

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