Wetland biodiversity in coastal New South Wales: the Wallis Lake catchment as a case study

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Abstract: The floristic composition and environmental relations of wetland vegetation in the Wallis Lake catchment (32° 09'S; 152° 20'E), area 1292 km^2, on the lower North Coast of NSW are described. The catchment supports wetlands listed as Endangered Ecological Communities (NSW *Threatened Species Conservation Act 1995)* and plant species of high conservation value.

A methodology of air photo interpretation, site-based sampling (114 quadrats) and landscape differentiation was developed. A total of 393 vascular plant taxa were recorded (including 10% exotics). Wetland vegetation formations and subformations including mangrove forest, swamp sclerophyll forest, wet heathland, chenopod shrubland, tussock grassland, sedgeland and rushland are described using numerical classification. 31 plant species of national or regional conservation significance are identified. Four Endangered Ecological Communities are discussed – Coastal Saltmarsh, Swamp Oak Floodplain Forest, Swamp Sclerophyll Forest on Coastal Floodplains, and Freshwater Wetlands on Coastal Floodplains.

A key recommendation is the completion of reliable wetland vegetation and soil landscape mapping for all land tenures in the catchment – to assess wetland condition and conservation significance, and representation in formal conservation reserves, thereby directing future priorities for the protection of wetland biodiversity on both public and private lands. The methodology developed can be applied to the survey and conservation of wetland biodiversity in other parts of coastal NSW.

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Introduction

This case study describes the floristic composition and environmental relations of wetland vegetation in the Wallis Lake catchment (32° 09'S; 152° 20'E) within the Great Lakes Local Government Area (LGA). It provides a methodology for the conservation and management of wetland biodiversity within a coastal catchment, and identifies the requirements of additional investigations to achieve conservation and management outcomes. The methods so developed have application to wetland conservation throughout coastal NSW.

Wallis Lake and its catchment occur on the coastal lowlands of north-eastern NSW, within the North Coast botanical subdivision (Anderson 1961) and the NSW North Coast biogeographic region (Thackway and Cresswell 1995). Open waters of the Wallis Lake estuary occupy 91 km^2, and the catchment extends over 1292 km^2. Forster and Tuncurry are major urban centres in the catchment, and smaller villages include Failford, Nabiac, Coomba Park and Pacific Palms (Figure 1).

The study is Stage 1 of a wetland strategy for Wallis Lake catchment, in preparation by Great Lakes Council (GLC). It stems from the recognition that wetlands provide ecosystem services and functions that are vital to the quality and integrity of natural systems, and in turn to the health and productivity of biodiversity, amenity and the local economy. A number of wetlands throughout the catchment are designated under State Environmental Planning Policy (SEPP) No. 14 Coastal Wetlands (Figure 2), and several wetland floristic assemblages are Endangered Ecological Communities under the NSW *Threatened Species Conservation* (TSC) *Act 1995*. Nonetheless, one of the drivers of this study is a recognition that wetlands are being cumulatively and incrementally degraded, modified, simplified or destroyed through inappropriate land uses, pressures and threats (e.g. clearing, grazing, altered fire regimes, altered hydrological regimes, weeds, feral animals, anthropogenic climate change).

Climate

The climate of coastal northern NSW is subtropical with summer-dominant rainfall, although with increasing latitude there is a gradual shift towards temperate conditions and

relatively uniform rainfall throughout the year (Colls and Whitaker 1990).

The Bureau of Meteorology provides climatic data for Taree (rainfall 100+ years; temperature 80+ years), which is 40 km north of the Wallis Lake catchment although similar in altitude (5 m a.s.l.). The average rainfall at Taree during the three wettest months (January to March) accounts for 35% of the mean annual total (1179 mm), whereas 17% falls during the three driest months (July to September). Despite the average trends, the variability index [VI = (9th decile – 1st decile)/5th decile] for monthly rainfall ranges from 1.9–4.5. Relative to other parts of Australia these VI values are considered to be very high (1.5–2.0) or extreme (>2.0), and episodes of drought and flood are therefore likely.

Taree has a mean annual maximum temperature of 24.2°C and a mean annual minimum of 12.0°C. Mean monthly maxima are highest from December to February (28.3–28.9°C), lowest from June to August (18.4–19.9°C), and mean monthly diurnal variation is 10.9–13.9°C. Mean monthly 9 am relative humidity varies from 67–80%, and for 3 pm the range is 51–63%. Lower humidity predominantly occurs from mid-winter to late spring, which is also the period of generally lower mean monthly rainfall. Conditions of water deficit for plant growth may arise at this time when evaporation is high relative to rainfall.

Landforms, geology and soils

Extensive bedrock landforms dominate the middle and upper reaches of Wallis Lake catchment, and these vary from gently undulating rises to very steep hills and locally precipitous mountains (Murphy 2005). Outcropping strata are predominantly sedimentary, ranging in age from Devonian to Permian; common lithologies include sandstone, siltstone, mudstone and greywacke (Roberts et al. 1991). Characteristic soils include Lithosols and Red, Brown and Yellow Podzolic Soils on crests and slopes, and Soloths where there is waterlogging on lower slopes and along drainage lines (Murphy 2005).

The Coolongolook, Wallamba and Wallingat Rivers drain the catchment into Wallis Lake, which is a tidal lagoon open to the sea between Tuncurry and Forster (Figure 1). The Tuncurry and Wallis Lake bedrock embayments dominate the lower reaches of the catchment (Roberts et al. 1991). The Tuncurry embayment has formed over the last three interglacial cycles and comprises several barrier systems of

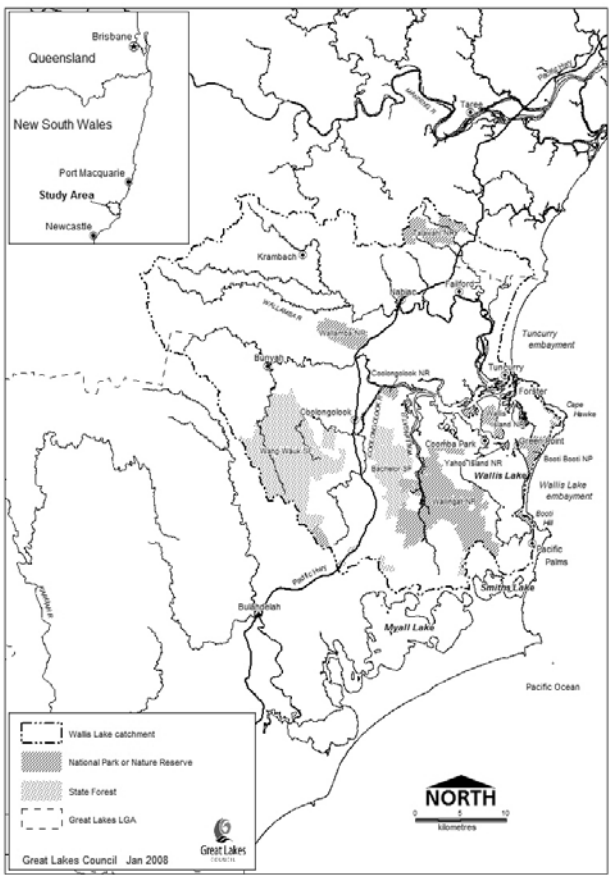


Fig. 1. Locality map of the Wallis Lake catchment.

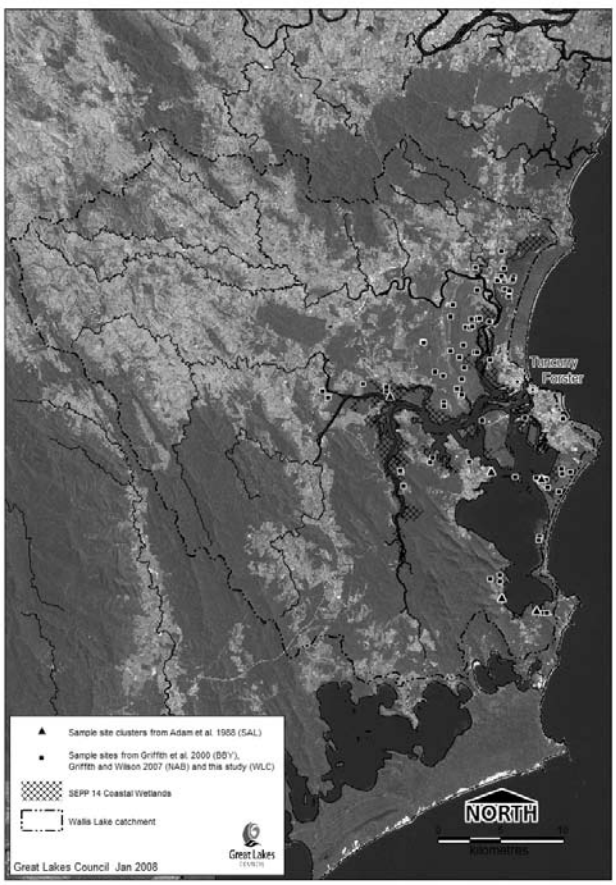


Fig. 2. Location of sample sites, and wetlands designated under SEPP No. 14. Base map highlights areas cleared of native vegitation.

marine-aeolian sand with associated estuarine and alluvial deposits (Melville 1984, Murphy 2005, Roy et al. 1997). The Pleistocene Nabiac barriers, west of the Wallamba River, range in age from approximately 80 000 to 260 000 years BP. These are distinguished from the Holocene Tuncurry barrier (8 000–1 000 years BP), east of the Wallamba River, which forms the present embayment shoreline. The Coolongolook – Wallingat River system has intersected the Nabiac barriers in the south, forming Wallis Island, and the Wallamba River intersects the barriers in the north. A dominant feature of the Wallis Lake embayment is the narrow sand barrier at the present coast between the bedrock hill complexes of Cape Hawke, a former offshore island during the late Pleistocene, and Booti Hill (Melville 1984, Murphy 2005, Roy 1982). The seaward sequence of this barrier consists of Holocene marine-aeolian deposits which overlie or interface with low-lying and partly eroded Pleistocene sands, some of which are indurated. In Wallis Lake, Pleistocene sands extend to a depth of 25 m below the present sea level. The western (lake) side of the barrier consists of Pleistocene and Holocene estuarine sediments. Alluvial landforms extend along the major streams, particularly the Wallamba River and its tributaries (Murphy 2005).

Soil landscape mapping is available for much of coastal northern NSW (e.g. Atkinson 1999, Eddie 2000), although for the Wallis Lake catchment this mapping is preliminary (Murphy 2005). Soil landscapes are map units with recognisable and specific topographies and soils; and the close relationship between topography and soils is attributed to similar causal factors. Wetland vegetation in the Wallis Lake catchment is associated with transferral, alluvial, aeolian/barrier, estuarine and swamp soil landscape process groups. These soil landscape groups are defined in published studies (e.g. Atkinson 1999), and the preliminary mapping of Murphy (2005) provides brief descriptions of landform elements and soils for each group in the Wallis Lake catchment.

Transferral soil landscapes are deep deposits of eroded soil and parent materials washed downslope from adjacent bedrock hillslopes. Landform elements include footslopes, drainage plains, drainage (open) depressions and fans. Soils are moderately deep to very deep (100 to >200 cm), imperfectly to poorly drained Soloths.

Alluvial soil landscapes are formed by deposition of sediment transported by streams. Landform elements include stream channels, levees, scrolls and plains. Soils are giant (>5 m) imperfectly to poorly drained Soloths on terraces, well drained deep (>150 cm) Alluvial Soils and Prairie Soils on active floodplains, deep (>200 cm) well drained Brown Podzolic Soils and occasional Yellow Earths on levees, and poorly drained Humic Gleys in swamps. In some instances soils are potentially acid sulphate or saline at depth.

Aeolian and barrier soil landscapes result from the accumulation of sand along the coast during periods of sea level fluctuation. Beach ridge plains, dunefields and associated sandy plains are characteristic landform patterns, and landform elements include ridges (dunes, beach ridges), open depressions (swales, drainage depressions) and flats. Soils include deep (>200 cm) well drained Podzols on dunes and beach ridges, and imperfectly drained Humus Podzols in swales and on flats where there is a permanently high watertable.

Estuarine soil landscapes develop where streams enter large bodies of tidal salt water. Landform elements include stream channels, tidal flats (intertidal to supratidal) and extratidal plains. Soils include deep (>300 cm) very poorly drained Solonchaks associated with tidal flats and streams, deep (>200 cm) poorly drained Acid Peat/Siliceous Sand or Acid Peat/Humic Gley intergrades on Holocene extratidal plains, and very poorly drained very deep (>200 cm) Humic Gleys on Pleistocene estuarine clay plains. Soils that are potentially acid sulphate or saline at depth are likely on extratidal plains (former estuaries).

Swamp soil landscapes are dominated by ground surfaces that are waterlogged or inundated at least seasonally, and the soil parent material typically includes a large proportion of decayed organic matter. Swamp landscapes may be former alluvial, barrier or estuarine environments, and closed depressions (generally swamps) are the dominant landscape element. Soils include deep (>200 cm) very poorly drained Acid Peats and Acid Peat/Siliceous Sand intergrades.

Landuse

The Worimi and Biripai Aboriginal tribes inhabited distinct, adjoining territories in the Wallis Lake district at the time of European settlement. Physical evidence of a rich Aboriginal culture includes middens, open campsites and stone artefact scatters, ceremonial grounds, and carved or otherwise scarred trees, all generally in close proximity to estuaries and swamps (Collins 2004, Gilbert 1954a,b).

Much of the Wallis Lake catchment was granted to the Australian Agricultural Company in the 1820s, although coastal areas were soon relinquished to the Crown in exchange for more suitable agricultural land further inland. Timber cutters logging Red Cedar (*Toona ciliata*) were operating in the district by the early 1830s (Gilbert 1954a).

The Wallis Lake catchment is now important for nature conservation, tourism, recreational and commercial fishing, and oyster farming (Great Lakes Council 2003). Conservation reserves include Booti Booti and Wallingat National Parks, and Coolongolook, Wallis Island and Yahoo Island Nature Reserves (Figure 1). The wetlands vary in condition from comparatively undisturbed (apart from fire) to severely modified or completely removed. Forms of wetland disturbance include agriculture, urban development, mineral sand mining on sand barriers, and drainage schemes in areas such as Darawakh, north of Tuncurry (Great Lakes Council 2007).

Previous vegetation surveys

Several earlier studies provide partial accounts of wetland vegetation within the Wallis Lake catchment, particularly saltmarsh (Coast and Wetlands Society 1985, West et al. 1985), seagrasses and mangroves (West et al. 1985), and sand barrier wetlands (Griffith et al. 2000, Griffith and Wilson 2007). Many unpublished reports, prepared for development proposals, describe wetland vegetation for specific parcels of land, although these vary in detail and methodology and are often difficult to access.

Methods

Data collection

Preliminary vegetation mapping is available for the entire Wallis Lake catchment within the Great Lakes LGA. This mapping was derived by conventional air photo interpretation (API) of 1:25 000 colour photography, although with limited field validation. The mapping is maintained in a GIS by Great Lakes Council, and distinguishes the following nine wetland groups:

(a) herbaceous wetland vegetation (e.g. sedgeland, rushland, chenopod shrubland, tussock grassland)
(b) heathland (with shrubland included)
(c) mangrove forest, woodland and shrubland
(d) swamp oak (*Casuarina glauca*) forest and woodland
(e) swamp mahogany (*Eucalyptus robusta*) forest and woodland
(f) paperbark forest and woodland dominated by *Melaleuca* species, although primarily *Melaleuca quinquenervia*
(g) paperbark – swamp oak forest and woodland
(h) swamp mahogany – swamp oak forest and woodland
(i) swamp mahogany – paperbark forest and woodland.

This catchment-wide vegetation layer formed the basis of sample site allocation, although stratification to a finer level of floristic and structural resolution was possible using alternative API mapping projects for the Frogalla and Darawakh wetlands north of Tuncurry (Griffith and Wilson 1996), and the Nabiac Pleistocene barriers south east of Nabiac (Griffith and Wilson 2007). API groups are the basic map unit of Griffith and Wilson (1996, 2007), and these are primarily distinguished by growth form and species composition in the dominant (generally tallest) stratum. When circumscribed in this manner, API groups are generally analogous to plant associations, *sensu* Beadle (1981): 'a community in which the dominant stratum exhibits uniform floristic composition, the community usually exhibiting uniform structure (also)'.

Sample sites were further stratified using GIS layers available at the time for: (a) altitude (<10, 10–20, >20 m); and (b) habitat (estuarine, alluvial, aeolian, swamp, bedrock – undifferentiated). As mapped in the GIS, bedrock included areas where transferral soil formation processes operate.

Sampling proceeded in randomly placed quadrats at 50 sites (WLC001–050) on freehold and Crown land, and quadrat size varied from 25 m^2 (in floristically and structurally simple vegetation) to 400 m^2. The majority of sites were remotely chosen and marked on aerial photographs before the fieldwork, although in a few instances vegetation types too small to be obvious on photographs were opportunistically sampled. The following data were collected for each quadrat:

(a) foliage cover (*sensu* Walker and Hopkins 1984) score for each vascular species: 1 (<1%); 2 (1–5%); 3 (6–25%); 4 (26–50%); 5 (51–75%); and 6 (76–100%)

(b) geology and soil landscape process group

(c) aspect (°)

(d) slope (°)

(e) altitude above sea level (m)

(f) topographic position (after Speight 1984) using categories for landform morphological type (e.g. closed depression, open depression, flat) and landform element (e.g. drainage depression, levee, plain, swale, swamp, tidal flat)

(g) geographic location (easting and northing)

(h) degree of exposure, determined as the azimuth (°) for each of the eight principal compass bearings (N, NE, etc.)

(i) time elapsed since last burnt (0–5 years, 5–10 years, or >10 years), determined from historical accounts or by observation of incremental post-fire branching, fire scars etc.

The WLC data are compatible with another dataset of 13 wetland quadrats for the Nabiac Pleistocene barriers (Griffith and Wilson 2007) and these data (NAB) were included in analyses. Also included were data for 13 wetland sites (BBY) in Booti Booti National Park and Yahoo Island Nature Reserve (Griffith et al. 2000). Saltmarsh data for disturbed (e.g. grazed by livestock) and undisturbed sites are available from a study by Adam et al. (1988), and 38 samples (SAL) for undisturbed vegetation were included in analyses. The BBY and SAL data sets were compiled using different foliage cover scales, and these scales were standardised to be compatible with the WLC and NAB data sets (Table 1). The location of all sites is shown in Figure 2.

Plant growth forms and vegetation structure are described according to Walker and Hopkins (1984). Species nomenclature is generally consistent with current usage at the Royal Botanic Gardens (Sydney); authorities follow Harden (1990–3, 2002) or Harden and Murray (2000). Terms for landform patterns and elements follow Speight (1984) and Murphy (2005).

Sampling focused upon transferral, alluvial, aeolian/barrier, estuarine and swamp soil landscapes. Localised wetlands may occur on other soil landscapes within the catchment,

although these were not observed. Possibilities are sedgeland or forbland associated with seepage in beach soil landscapes or from exposed headlands where the landforms are colluvial, and swamp sclerophyll forest on lower bedrock hillslopes of residual soil landscapes. Seagrass vegetation was not investigated (see West et al. 1985), nor the truly aquatic (submerged) freshwater vegetation of streams and other open waters.

Data analysis

Numerical classification of sample sites was performed using PATN (Blatant Fabrications Pty Ltd 2001), to group quadrats on the basis of floristic similarity. Foliage cover scores (1 to 6) for all vascular species were analysed without further transformation. The Bray-Curtis association coefficient was employed in the analysis, in combination with the flexible UPGMA (unweighted pair group arithmetic averaging) clustering algorithm and a slightly negative (-0.1) beta value. Kent and Coker (1992) suggest that an appropriate numerical method, and hence classification, is one 'which enables a clear ecological interpretation to be made'. The Bray-Curtis coefficient was found to satisfy this requirement, and such an outcome is consistent with a view that it provides a good estimate of ecological distance, primarily because greater emphasis is placed upon similarity between common and abundant species, than upon similarity between rare species and those with low cover-abundance (Belbin 1992, 1993, Faith et al. 1987). PATN was performed on the entire set of samples irrespective of vegetation structure, and also on three subsets with samples grouped on the basis of similar vegetation structure: (1) forest and woodland; (2) shrubland and mallee; and (3) vegetation with a single stratum (e.g. heathland, sedgeland).

Trends in species richness (number of species per unit area) were examined using single-factor analysis of variance (ANOVA) and multiple comparison (Tukey-Kramer) tests. Data were log transformed where appropriate to conform to model assumptions. These analyses were performed using StatView (SAS Institute Inc. 1999).

Results

The wetland vegetation of Wallis Lake catchment displays considerable structural and floristic variation. A total of 393 vascular plant taxa were recorded in quadrats, and approximately 10% of these are exotic (Appendix 1). Based on PATN analyses (Figures 3–5), sample sites have been grouped by formation (e.g. forest and woodland) and subformation (e.g. swamp sclerophyll forest and woodland) into the following vegetation units with accompanying details of composition and habitat. Equivalent API groups (map units) are provided from Griffith and Wilson (1996, 2007) or related mapping projects elsewhere in coastal northern NSW (e.g. Griffith et al. 2003).

Wetland vegetation descriptions

Mangrove forest and woodland (MF/W), grading into mangrove shrubland (MS)

Structure: low to mid-high, open woodland to open forest (grading into tall to very tall, sparse to closed shrubland).

Floristic composition: *Avicennia marina* subsp. *australasica* dominates the tallest stratum. *Aegiceras corniculatum* may be present as an understorey, particularly where the tallest stratum is diffuse. The immediate ground surface is generally unvegetated except for pneumatophores, although saltmarsh species such as *Sporobolus virginicus* or *Juncus kraussii* subsp. *australiensis* can occupy gaps in the tallest stratum, particularly where the ground surface is slightly elevated.

Table 1. Foliage cover standardised to a 6-point scale for different data sets.

Score	NAB (Griffith & Wilson 2007) and WLC (this study)	BBY (Griffith et al. 2000)	SAL (Adam et al. 1988)
1	<1%	<5%; uncommon	<4% & very rare; <4% & scattered
2	1–5%	<5%; common	<4% & frequent
3	6–25%	6–20%	4–10%; 10–25%
4	26–50%	21–50%	25–33%; 33–50%
5	51–75%	51–75%	50–75%
6	76–100%	76–100%	75–90%; 90–100%

Notes:

1. Walker and Hopkins (1984) define foliage cover as 'the percentage of the sample site occupied by the vertical projection of foliage and branches', and this definition was applied when collecting the BBY, NAB and WLC data. The 10-point Domin cover-abundance scale as used by Adam et al. (1988) defines cover in a comparable manner (see Kent and Coker 1992).

2. The cover classes used by Griffith and Wilson (2007) follow the Braun-Blanquet scale, and this scale was applied when collecting the WLC data. The NSW Department of Environment and Climate Change has adopted a modified Braun-Blanquet scale, as used in Griffith et al. (2000).

Habitat and community relations: Found on intertidal flats (Figure 3). Saltmarsh vegetation generally replaces mangroves at slightly higher elevations.

Sample sites: BBY006, WLC018.

API groups: *Avicennia marina* subsp. *australasica* MF/W; *Avicennia marina* subsp. *australasica* MS.

Swamp sclerophyll forest and woodland (SSF/W)

Structure: (occasionally low to) mid-high to very tall, open woodland to closed forest.

Floristic composition: Many stands of SSF or SSW have a tallest stratum that is clearly dominated by one of the species *Eucalyptus robusta* (e.g. WLC019, WLC027), *Melaleuca quinquenervia* (e.g. NAB018, WLC021) or *Casuarina glauca* (e.g. WLC005, WLC030); although stands dominated by two of these species are not uncommon, typically of *Melaleuca quinquenervia* and *Casuarina glauca* (e.g. WLC023, WLC033) or *Melaleuca quinquenervia* and *Eucalyptus robusta* (e.g. WLC043, WLC024). Other locally subsidiary or co-dominant tallest stratum species with *Casuarina glauca*, *Eucalyptus robusta* or *Melaleuca quinquenervia* include *Eucalyptus grandis* (e.g. WLC049), *Eucalyptus resinifera* (WLC040), *Eucalyptus tereticornis* (e.g. WLC015) and *Livistona australis* (e.g. WLC032). *Melaleuca linariifolia* (WLC009) or *Melaleuca nodosa* (WLC029) also form limited areas of low to tall SSF. Understorey composition (Figure 3) varies in response to site differences in soil type, extent of waterlogging and water chemistry, and management (e.g. fire and livestock grazing). The saltmarsh species *Baumea juncea*, *Juncus kraussii* subsp. *australiensis* or *Sporobolus virginicus* are common dominants where there is a tidal influence, while the presence of *Phragmites australis* indicates probable brackish conditions. Likely species on sand barriers and associated flats include *Baloskion tetraphyllum* subsp. *meiostachyum*, *Blechnum indicum*, *Empodisma minus*, *Gleichenia microphylla*, *Leptocarpus tenax*, *Pteridium esculentum* and *Schoenus brevifolius*, sometimes with *Melaleuca sieberi* forming a distinct second tree stratum (e.g. NAB019). On extratidal plains (former estuaries) and associated alluvial landforms (e.g. backplains, levee toes) the understorey is diverse, although characteristic species include *Entolasia marginata*, *Gahnia clarkei*, *Hypolepis muelleri*, *Imperata cylindrica* var. *major*, *Ischaemum australe*, *Livistona australis* and *Melaleuca linariifolia*. *Entolasia stricta*, *Imperata cylindrica* var. *major*, *Lepidosperma neesii*, *Lepidosperma quadrangulatum* and many other species occupy the understorey of *Melaleuca nodosa* SSF on broad transferral drainage plains, whereas an understorey of *Gahnia clarkei* and various rainforest species was observed along transferral drainage depressions.

Habitat and community relations: Occupies open depressions (e.g. swales, drainage depressions) and poorly drained flats or plains. Also borders closed depressions (swamps) where standing water accumulates (Figure 3). Widespread on Quaternary sediments of estuarine and aeolian/barrier soil landscapes. Also associated with alluvial landscapes (e.g. backplains), and transferral drainage depressions and drainage plains deposited below bedrock hillslopes. Wet or dry sclerophyll forest and woodland often replaces the swamp subformations as soil drainage improves, although boundaries between the different subformations may be diffuse in areas of minimal relief (e.g. intergradation of *Eucalyptus grandis* WSF and *Melaleuca quinquenervia* SSF).

Sample sites:

BBY006, BBY023, BBY043, BBY046, BBY048, NAB018, NAB019, NAB026, WLC005, WLC006, WLC009, WLC011, WLC012, WLC013, WLC014, WLC015, WLC016, WLC017, WLC018, WLC019, WLC020, WLC021, WLC023, WLC024, WLC027, WLC028, WLC029, WLC030, WLC031, WLC032, WLC033, WLC034, WLC036, WLC037, WLC038, WLC039, WLC040, WLC041, WLC042, WLC043, WLC044, WLC045, WLC047, WLC048, WLC049.

API groups: *Eucalyptus robusta* SSF/W, *Melaleuca quinquenervia* SSF/W, *Casuarina glauca* SSF/W, *Melaleuca quinquenervia – Casuarina glauca* SSF/W, *Eucalyptus robusta – Melaleuca quinquenervia* SSF/W, *Eucalyptus robusta – Melaleuca sieberi* SSF/W, *Melaleuca quinquenervia – Livistona australis* SSF, *Melaleuca linariifolia* SSF and *Melaleuca nodosa* SSF are already mapped for parts of the catchment (Griffith and Wilson 1996, 2007). Others that may be present include *Eucalyptus resinifera – Eucalyptus robusta – Angophora costata* SSF/W and *Melaleuca quinquenervia – Eucalyptus tereticornis* SSF/W.

Swamp sclerophyll mallee woodland (SSMW)

Structure: very tall to extremely tall, mallee woodland and open mallee woodland.

Floristic composition: *Eucalyptus robusta* dominates the tallest stratum. Understorey species include *Baloskion tetraphyllum* subsp. *meiostachyum*, *Dianella caerulea*, *Imperata cylindrica* var. *major* and *Leptospermum polygalifolium* subsp. *cismontanum*.

Habitat and community relations: Found in open depressions associated with beach ridges and dunes (Figure 4), where a shallow watertable periodically rises to the ground surface. Often replaced upslope by dry sclerophyll shrubland or dry heathland.

Sample sites: BBY044.

API group: *Eucalyptus robusta* SSMW.

Swamp sclerophyll shrubland (SSS)

Structure: tall to very tall, sparse to closed shrubland.

Floristic composition: The tallest stratum is dominated by *Banksia ericifolia* subsp. *macrantha* (NAB015, NAB022), *Melaleuca ericifolia* (WLC008, WLC022), *Melaleuca quinquenervia* (BBY045) or *Melaleuca sieberi* (NAB010, NAB011). Understorey composition varies with site differences in soil type, extent of waterlogging and water chemistry, and the fire regime. Likely understorey species in *Banksia ericifolia* subsp. *macrantha* SSS include *Banksia oblongifolia*, *Eurychorda complanata*, *Lepidosperma filiforme*, *Leptospermum liversidgei* and *Xanthorrhoea fulva*. The understorey of *Melaleuca sieberi* SSS includes *Banksia oblongifolia*, *Leptocarpus tenax*, *Leptospermum arachnoides*, *Melaleuca thymifolia* and *Ptilothrix deusta*. *Melaleuca ericifolia* SSS supports an understorey of *Baumea juncea*, *Hemarthria uncinata*, *Ischaemum australe*, *Leptocarpus tenax* and other species, whereas *Baumea articulata*, *Baumea juncea* and *Juncus kraussii* subsp. *australiensis* are some of the species recorded in *Melaleuca quinquenervia* SSS.

Habitat and community relations: Generally associated with poorly drained open depressions (e.g. swales) and flats where a shallow watertable periodically rises to the ground surface, although also extends into closed depressions (swamps) where standing water accumulates (Figure 4). Swamp sclerophyll shrubland may grade into wet heathland, with boundaries between the two formations influenced in part by fire. It often adjoins swamp sclerophyll forest and woodland or, where soils are comparatively well drained, dry sclerophyll forest and woodland.

Sample sites: BBY045, NAB010, NAB011, NAB015, NAB022, WLC008, WLC022.

API groups: *Banksia ericifolia* subsp. *macrantha* SSS; *Melaleuca ericifolia* SSS; *Melaleuca quinquenervia* SSS; *Melaleuca sieberi* SSS.

Wet heathland (WH)

Structure: mid-high to tall closed heathland.

Floristic composition: This subformation is floristically variable. In swales, few to several of the heath shrubs *Banksia ericifolia* subsp. *macrantha*, *Banksia oblongifolia*, *Boronia falcifolia*, *Dillwynia floribunda*, *Epacris microphylla* var. *microphylla*, *Leptospermum liversidgei*, *Sprengelia* spp. and *Xanthorrhoea fulva*, and the sedges

Empodisma minus, *Gahnia sieberiana*, *Schoenus scabripes* and *Sporadanthus interruptus* are subsidiary to co-dominant in locally variable combinations. On flats the heath shrubs *Banksia oblongifolia*, *Hakea teretifolia* subsp. *teretifolia*, *Leptospermum arachnoides* and *Xanthorrhoea fulva* are locally co-dominant or subsidiary in varying combinations, along with one or more sedges (*Lepidosperma neesii*, *Leptocarpus tenax*, *Ptilothrix deusta*). Some of the heterogeneity in floristic composition may be attributed to fire, where frequent burning limits recruitment of seeders (e.g. *Banksia ericifolia* subsp. *macrantha*, *Dillwynia floribunda*, *Hakea teretifolia* subsp. *teretifolia*, *Leptospermum arachnoides*, *Sprengelia* spp.).

Habitat and community relations: Characteristic of poorly drained sand barrier swales (open depressions) and associated flats with a shallow watertable (Figure 5). In the absence of fire for extended periods, *Banksia ericifolia* subsp. *macrantha* may overtop shorter species to dominate as swamp sclerophyll shrubland. Wet heathland is replaced by sedgeland where soil waterlogging is more severe.

Sample sites: BBY019, NAB003, NAB004, NAB005, NAB014, WLC050.

API groups: *Banksia oblongifolia – Leptospermum liversidgei – Sporadanthus interruptus – Sprengelia* spp. *– Xanthorrhoea fulva* WH; *Banksia oblongifolia – Hakea teretifolia* subsp. *teretifolia – Ptilothrix deusta – Xanthorrhoea fulva* WH.

Chenopod shrubland (CS) and tussock grassland (TG)

Structure: dwarf to low, open to closed chenopod shrubland; low to mid-high, open to closed tussock grassland.

Floristic composition: Chenopod shrublands are generally dominated by *Sarcocornia quinqueflora* subsp. *quinqueflora* (eg. SAL832, SAL833), sometimes with the forb *Triglochin striatum* also abundant (eg. SAL854, SAL859). Another chenopod shrub, *Suaeda australis*, is a less frequent dominant (SAL926). Tussock grassland is dominated by *Sporobolus virginicus* (eg. SAL853, SAL855), although in places this species is more-or-less co-dominant with *Sarcocornia quinqueflora* subsp. *quinqueflora* (e.g. SAL834, SAL851).

Habitat and community relations: This is the characteristic saltmarsh vegetation on tidal flats (Figure 5). It generally occurs immediately upslope of mangroves although seaward of *Juncus kraussii* subsp. *australiensis* rushland.

Sample sites: BBY004, SAL832, SAL833, SAL834, SAL837, SAL851, SAL853, SAL854, SAL855, SAL856, SAL858, SAL859, SAL860, SAL863, SAL864, SAL902, SAL903, SAL904, SAL906, SAL910, SAL926.

API group: *Sarcocornia quinqueflora* subsp. *quinqueflora – Sporobolus virginicus* CS/TG, mapped as a community complex due to limits of scale; none assigned for *Suaeda australis* CS.

Sedgeland (S)

Structure: mid-high to very tall closed sedgeland.

Floristic composition: Many sedgelands can be distinguished by the presence of one species as the tallest dominant, and in the Wallis Lake catchment this is the case for the following: *Baumea articulata* (NAB002, WLC004); *Baumea juncea* (eg. BBY005, SAL840); *Bolboschoenus caldwellii* (SAL913); *Eleocharis equisetina* (WLC002); *Eleocharis sphacelata* (WLC010); *Lepironia articulata* (WLC025); and *Schoenoplectus subulatus* (SAL909). Another floristically diverse sedgeland is distinguished for shallow swamps associated with beach ridge barriers and dunefields. Locally variable combinations of the sedges *Baloskion pallens*, *Baumea arthrophylla*, *Baumea teretifolia*, *Chorizandra sphaerocephala*, *Lepidosperma limicola*, *Leptocarpus tenax* and *Schoenus brevifolius* are likely in these shallow swamps, along with certain heath shrubs (e.g. *Callistemon pachyphyllus*, *Melaleuca thymifolia*).

Habitat and community relations: *Baumea juncea* sedgeland occupies supratidal flats, and sedgelands of *Bolboschoenus caldwellii* or *Schoenoplectus subulatus* occur in the upper reaches of saltmarsh (Figure 5) where conditions are likely to be brackish (Adam et al. 1988). The remaining sedgelands are more typical of closed depressions containing freshwater, although for some species (e.g. *Baloskion pallens*, *Lepironia articulata*, *Schoenus brevifolius*) this water can be acidic. Sedgeland is often replaced by wet heathland, swamp sclerophyll shrubland or swamp sclerophyll forest and woodland as drainage improves.

Sample sites: BBY002, BBY005, NAB002, NAB007, WLC002, WLC004, WLC010, WLC025, WLC026, SAL840, SAL870, SAL909, SAL913, SAL925.

API groups: *Baumea articulata* S; *Baumea juncea* S; *Bolboschoenus caldwellii* S; *Eleocharis equisetina* S; *Eleocharis sphacelata* S; *Lepironia articulata* S; *Schoenoplectus subulatus* S; *Leptocarpus tenax – Baloskion pallens – Schoenus brevifolius* S.

Rushland (R)

Structure: tall to very tall, open to closed rushland.

Floristic composition: Rushlands are distinguished by the presence of one species as the tallest dominant, and in the Wallis Lake catchment this is the case for *Juncus kraussii* subsp. *australiensis* (eg. BBY003, SAL836), *Phragmites australis* (eg. BBY026, WLC007) and *Typha domingensis* (WLC035). Adam et al. (1988) further classify *Juncus kraussii* subsp. *australiensis* rushlands to recognise shorter species that are nonetheless abundant in some stands (e.g. *Samolus repens*, *Sporobolus virginicus*).

Habitat and community relations: Rushlands dominated by *Juncus kraussii* subsp. *australiensis* or *Phragmites australis* generally occupy upper tidal to supratidal flats (Figure 5), or depressions where conditions are likely to be brackish (Adam et al. 1988). *Typha domingensis* rushland was observed close to an estuary, although where the drainage had been modified following the construction of an embankment and road, resulting in ponding.

Sample sites: BBY003, WLC007, WLC035, WLC046, SAL838, SAL868, BBY026, SAL905, SAL836, SAL845, SAL848, SAL852, SAL846, SAL850, SAL865, SAL867, SAL907, SAL908.

API groups: *Juncus kraussii* subsp. *australiensis* R; *Phragmites australis* R; *Typha domingensis* R.

Sod grassland (SG)

Structure: tall to extremely tall sod grassland and closed sod grassland.

Floristic composition: *Paspalum distichum* dominates, although *Eleocharis equisetina* may be present as a scattered emergent.

Habitat and community relations: Fringes freshwater swamps supporting *Eleocharis equisetina* sedgeland (Figure 5).

Sample sites: WLC003.

API group: none assigned, although *Paspalum distichum* SG reported for the NSW North Coast in other studies (e.g. Pressey 1981, 1987a,b, Pressey and Griffith 1987).

Plant – environment relationships

Site data analyses using PATN provide insights into the floristic and environmental relationships of wetlands in the Wallis Lake catchment (Figures 3–6). PATN optimised the number of floristic groups for each analysis at a single fusion (similarity) level (e.g. groups 1–7 in Figure 3), although there is no reason why floristic groups cannot be distinguished at different levels of similarity (e.g. groups

1. **Deep freshwater swamp:** *Melaleuca quinquenervia* SSF with *Baumea articulata* in understorey.
2. **Sand barrier open depressions and associated flats:** *Eucalyptus robusta* SSF/W and *E. robusta – Melaleuca quinquenervia* SSF/W, with *Baloskion tetraphyllum* subsp. *meiostachyum*, *Empodisma minus*, *Gleichenia microphylla* etc. in understorey.

3a. **Extratidal plains (former estuaries) and associated alluvial landforms (e.g. backplains, levee toes):** SSF (occasionally SSW) dominated by *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* in varying combinations, with *Eucalyptus grandis*, *E. resinifera*, *E. tereticornis* or *Livistona australis* sometimes subsidiary to co-dominant; also localised *Melaleuca linariifolia* SSF; understorey of *Entolasia marginata*, *Gahnia clarkei*, *Hypolepis muelleri*, *Imperata cylindrica* var. *major*, *Ischaemum australe*, *Melaleuca linariifolia* and many others.

3b. **Extratidal plains (former estuaries) with inferred residual soil salinity:** SSF/W dominated by *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* in varying combinations, with *Baumea juncea*, *Gahnia clarkei*, *Imperata cylindrica* var. *major* etc. in understorey.

3c. **Transferral drainage depression (merging downslope with an extratidal plain):** *Casuarina glauca – Eucalyptus robusta – Livistona australis* SSF with *Gahnia clarkei* and rainforest species in understorey.

4. **Transferral drainage plain:** *Melaleuca nodosa* SSF with *Entolasia stricta*, *Lepidosperma neesii*, *L. quadrangulatum* etc. in understorey.
5. **Brackish to upper tidal flats of contemporary estuary:** *Casuarina glauca* SSF and *C. glauca – Melaleuca quinquenervia* SSF/W with *Baumea juncea*, *uncus kraussii* subsp. *australiensis*, *Phragmites australis*, *Sporobolus virginicus* etc. in understorey.
6. **Prior stream channels associated with supratidal flats:** *Casuarina glauca* SSF/W with *Alocasia brisbanensis*, *Hypolepis muelleri*, *Melaleuca styphelioides*, *Myoporum acuminatum* etc. in understorey.
7. **Intertidal flats:** *Avicennia marina* subsp. *australasica* MF/W.

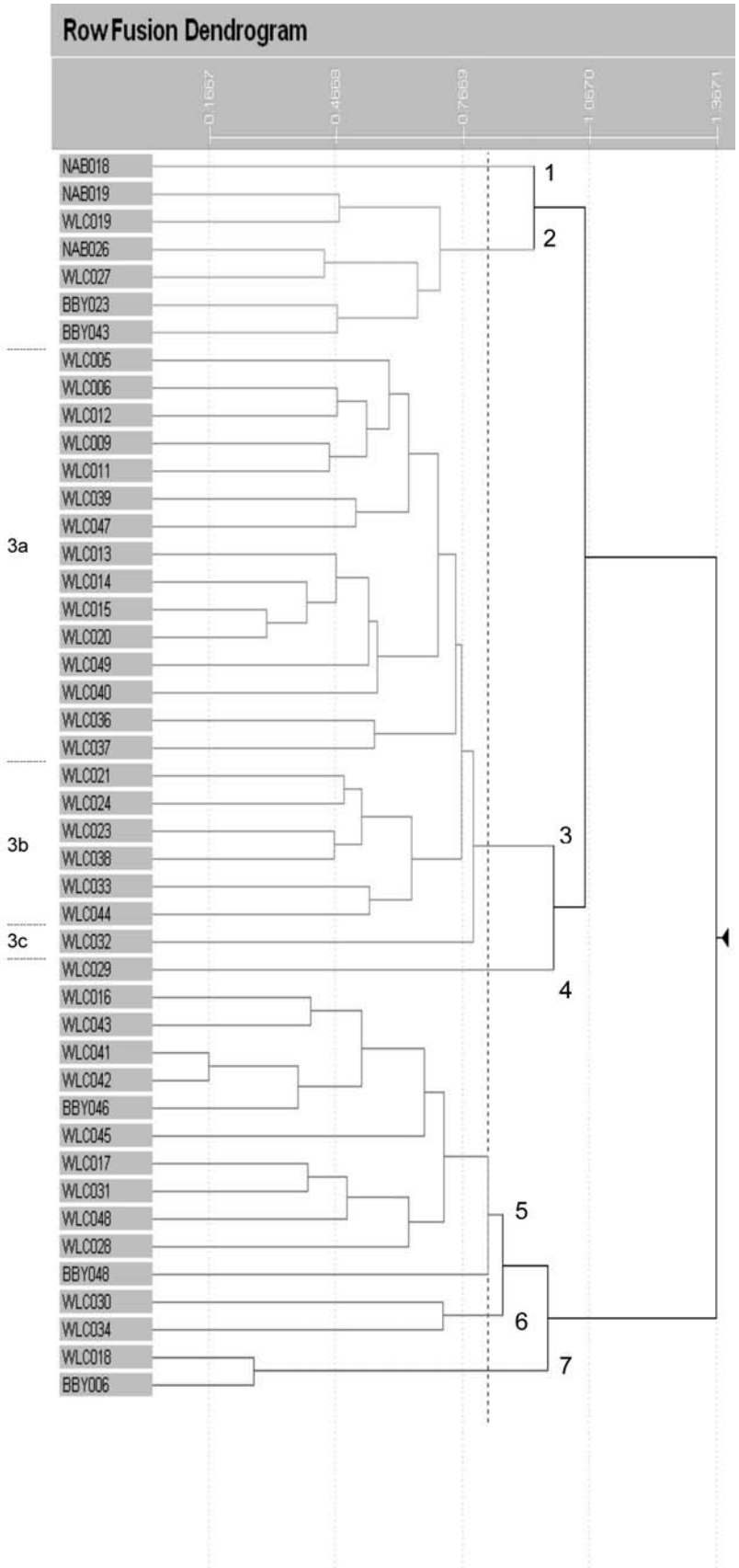


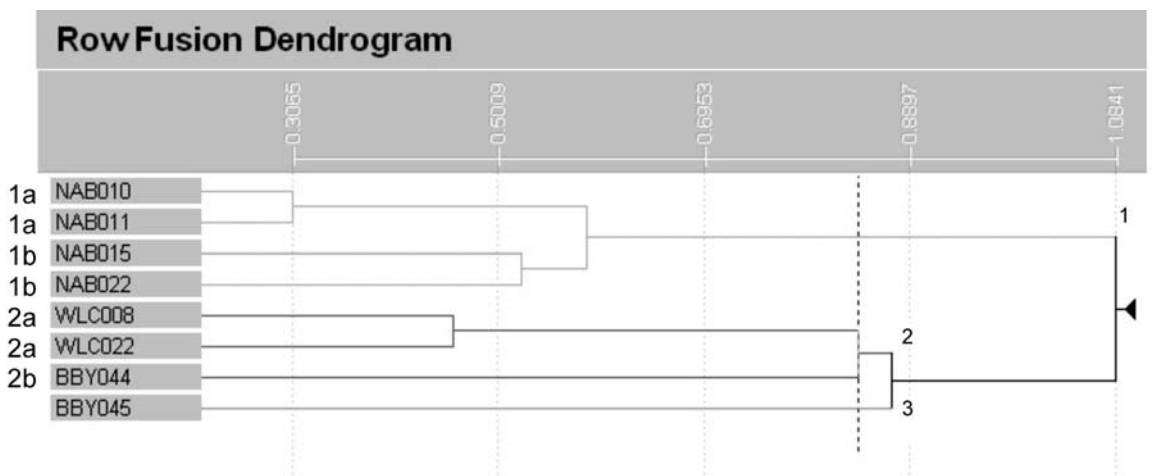
Fig. 3. Floristic classification of sites in swamp sclerophyll forest and woodland (SSF/W), and mangrove forest and woodland (MF/W).

3a–c in Figure 3) where such groups make 'ecological sense' (Kent and Coker 1992). Analyses were performed for 112 quadrats (Appendix 1). Two additional quadrats (WLC001 and WLC035) inadvertently placed in habitats with severe localised disturbance were omitted to avoid confounding the interpretation of relationships to soil landscape processes.

Wetland forests and woodlands have a tallest stratum that is primarily dominated by *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* in varying combinations (Figure 3). Nonetheless, floristic composition in the understorey is variable, and this variation aligns with differences in soil landscape and hydrology. For example, the swamp sclerophyll forests and woodlands on sand barriers (group 2) and extratidal plains of former estuaries (group 3) are floristically distinct even though both habitats support *Eucalyptus robusta* and *Melaleuca quinquenervia* as dominant species in the tallest stratum. Floristic differences are also apparent between stands of *Casuarina glauca* associated with former or contemporary estuaries (group 3 cf. group 5). Similar relationships between floristic composition, hydrology and landscape are apparent for shrubland and mallee woodland (Figure 4), and also for wetland vegetation with a single stratum (Figure 5). Examples for single-stratum vegetation are the floristic differences between vegetation associated with sand barriers (groups 5 and 6) and tidal flats (groups 7 and 8), and also the differences within sand barrier landscapes according to the extent of waterlogging (group 5 cf. group 6).

Relationships between floristic composition, soil landscape and hydrology remain apparent in an analysis of all sample sites irrespective of vegetation structure (Figure 6). This analysis also highlights overlap between vegetation structure and floristic composition, for example between wet heathland and swamp sclerophyll shrubland on sand barriers (group 9) where the latter supports an understorey of wet heathland species. Floristic overlap is also apparent between swamp sclerophyll forest, woodland and shrubland on extratidal plains (group 8c). Nonetheless, in some habitats vegetation formations comprising a single stratum remain floristically distinct from forests, woodlands and other multi-stratum vegetation (e.g. groups 2, 3 and 11 in Figure 6). *Melaleuca nodosa* swamp sclerophyll forest on a transferral drainage plain remained floristically distinct in the analysis of forest and woodland sites only (group 4 in Figure 3), and also in the analysis of all sites irrespective of structure (group 7 in Figure 6). Another site in swamp sclerophyll forest along a transferral drainage depression also remained comparatively distinct in relation to floristic composition of the understorey (group 3c in Figure 3; group 8b in Figure 6).

It is apparent that tree species such as *Melaleuca quinquenervia* tolerate a range of environmental conditions (Figure 3). This also seems to be the case for herbaceous species such as *Phragmites australis* and *Baumea juncea*. *Phragmites australis* forms a rushland in habitats that are likely to vary in salinity (groups 3 and 4 in Figure 5). *Baumea juncea* forms a sedgeland on supratidal flats (group 4 in Figure 5), although it is also locally conspicuous in the understorey of swamp sclerophyll forest or woodland in a range of habitats (e.g. groups 2, 3b and 5 in Figure 3; Appendix 1). Adam et al. (1988) noted an apparently wide range of ecological tolerance in both species.



1a. Sand barrier flats: *Melaleuca sieberi* SSS.
1b. Sand barrier swales: *Banksia ericifolia* subsp. *macrantha* SSS.
2a. Extratidal plains (former estuaries) with inferred residual soil salinity: *Melaleuca ericifolia* SSS.
2b. Sand barrier drainage depression: *Eucalyptus robusta* SSMW.
3. Brackish swamp: *Melaleuca quinquenervia* SSS.

Fig. 4. Floristic classification of sites in swamp sclerophyll shrubland (SSS) and swamp sclerophyll mallee woodland (SSMW).

1. **Deep freshwater swamps:** *Baumea articulata* S and *Eleocharis sphacelata* S.
2. **Shallow freshwater swamps:** *Eleocharis equisetina* S and *Paspalum distichum* SG.
3. **Brackish depressions and flats near estuary:** *Phragmites australis* R, *Bolboschoenus caldwellii* S and *Schoenoplectus subulatus* S.
4. **Supratidal flats:** *Phragmites australis* R, *Baumea juncea* S and *Suaeda australis* CS.
5. **Sand barrier swales and associated flats:** WH of *Banksia oblongifolia*, *Hakea teretifolia* subsp. *teretifolia*, *Leptospermum liversidgei*, *Xanthorrhoea fulva* etc.
6. **Sand barrier acid swamps:** *Baloskion pallens – Leptocarpus tenax – Schoenus brevifolius* etc. S and *Lepironia articulata* S.
7. **Upper tidal flats:** *Juncus kraussii* subsp. *australiensis* R and *Sporobolus virginicus* TG.
8. **Lower tidal flats:** *Sarcocornia quinqueflora* subsp. *quinqueflora* CS and *S. quinqueflora* subsp. *quinqueflora – Sporobolus virginicus* CS/TG.

Note: two sites (BBY004 and SAL910) placed in group 7 by PATN are somewhat intermediate in floristic composition with sites in group 8. Their placement in group 7 may be a reflection of comparatively low foliage cover scores due to the presence on unvegetated ground within the quadrats.

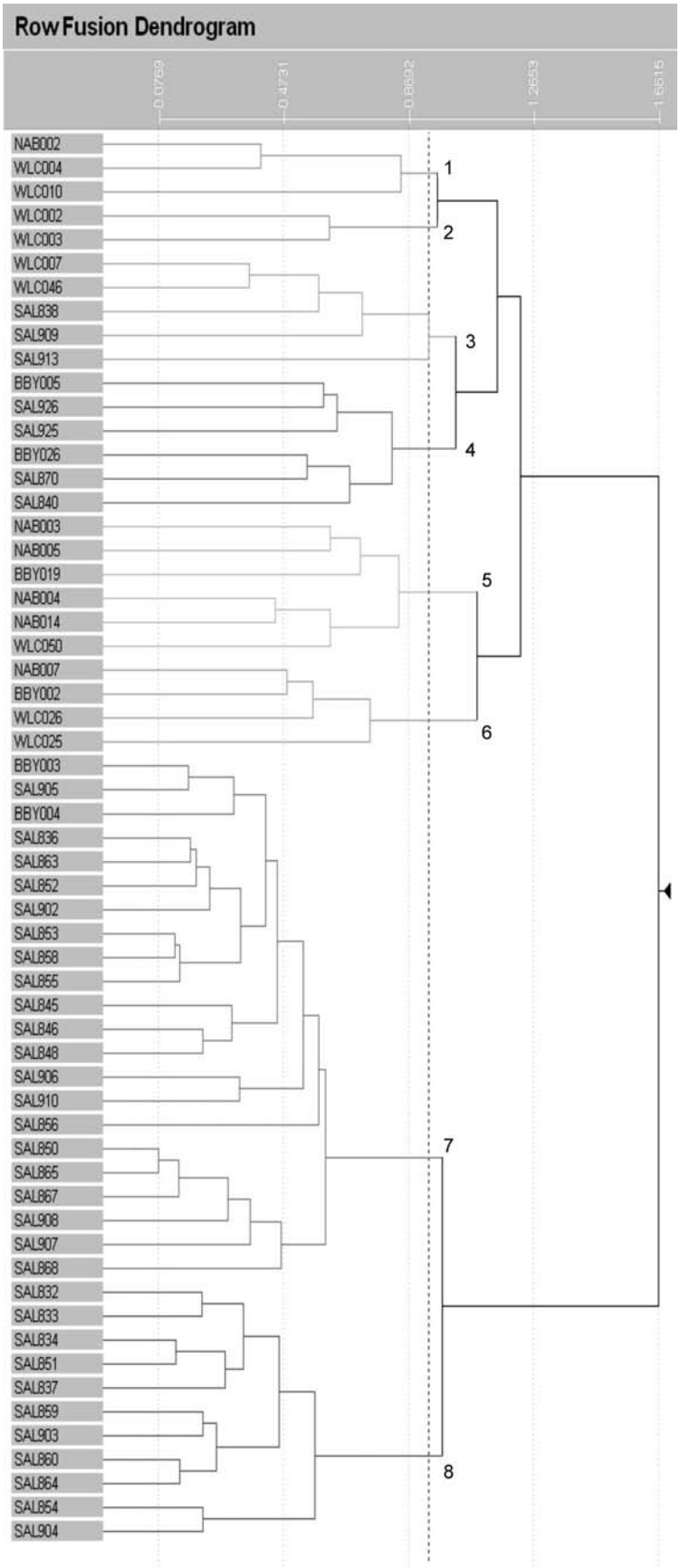


Fig. 5. Floristic classification of sites in vegetation with a single stratum.

CS: chenopod shrubland; R: rushland; S: sedgeland; SG: sod grassland; TG: tussock grassland; WH: wet heathland.

1. **Freshwater to brackish swamps:** *Melaleuca quinquenervia* SSF and *M. quinquenervia* SSS with *Baumea articulata* etc. in understorey; *Baumea articulata* S.
2. **Freshwater swamps:** *Eleocharis equisetina* S; *E. sphacelata* S; *Paspalum distichum* SG.
3. **Sand barrier acid swamps:** *Baloskion pallens – Leptocarpus tenax – Schoenus brevifolius* etc. S; *Lepironia articulata* S.
4. **Brackish depressions and flats near estuary:** *Melaleuca quinquenervia – Casuarina glauca* SSF/W with *Phragmites australis* in understorey; *Phragmites australis* R; *Bolboschoenus caldwellii* S; *Schoenoplectus subulatus* S.
5. **Supratidal flats and associated prior stream channels:** *Casuarina glauca* SSF/W, generally with *Phragmites australis* and/or *Baumea juncea* in understorey; *Phragmites australis* R; *Baumea juncea* S; *Suaeda australis* CS.
6. **Sand barrier open depressions and associated flats:** *Eucalyptus robusta* SSF/W, *E. robusta – Melaleuca quinquenervia* SSF/W and *E. robusta* SSMW with *Baloskion tetraphyllum* subsp. *meiostachyum*, *Empodisma minus*, *Gleichenia microphylla* etc. in understorey.
7. **Transferral drainage plain:** *Melaleuca nodosa* SSF with *Entolasia stricta*, *Lepidosperma neesii*, *L. quadrangulatum* etc. in understorey.

8a. **Extratidal plains (former estuaries) and associated alluvial landforms (e.g. backplains, levee toes):** SSF (occasionally SSW) dominated by *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* in varying combinations, with *Eucalyptus grandis*, *E. resinifera*, *E. tereticornis* or *Livistona australis* sometimes subsidiary to co-dominant; also localised *Melaleuca linariifolia* SSF; understorey of *Entolasia marginata*, *Gahnia clarkei*, *Hypolepis muelleri*, *Imperata cylindrica* var. *major*, *Ischaemum australe*, *Melaleuca linariifolia* and many others.

8b. **Transferral drainage depression (merging downslope with an extratidal plain):** *Casuarina glauca – Eucalyptus robusta – Livistona australis* SSF with *Gahnia clarkei* and rainforest species in understorey.

8c. **Extratidal plains (former estuaries) with inferred residual soil salinity:** SSF/W dominated by *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* in varying combinations, with *Baumea juncea*, *Gahnia clarkei*, *Imperata cylindrica* var. *major* etc. in understorey; *Melaleuca ericifolia* SSS with similar understorey.

9. **Sand barrier swales and associated flats:** WH of *Banksia oblongifolia*, *Hakea teretifolia* subsp. *teretifolia*, *Leptospermum liversidgei*, *Xanthorrhoea fulva* etc; *Banksia ericifolia* subsp. *macrantha* SSS and *Melaleuca sieberi* SSS with WH species in understorey.

10a. **Upper tidal flats:** *Casuarina glauca* SSF/W with *Juncus kraussii* subsp. *australiensis*, *Sporobolus virginicus* in understorey; *Juncus kraussii* subsp. *australiensis* R; *Sporobolus virginicus* TG.

10b. **Intertidal flats:** *Avicennia marina* subsp. *australasica* MF/W, sometimes with *Juncus kraussii* subsp. *australiensis*, *Sporobolus virginicus* in understorey.

11. **Lower tidal flats:** *Sarcocornia quinqueflora* subsp. *quinqueflora* CS; *S. quinqueflora* subsp. *quinqueflora – Sporobolus virginicus* CS/TG.

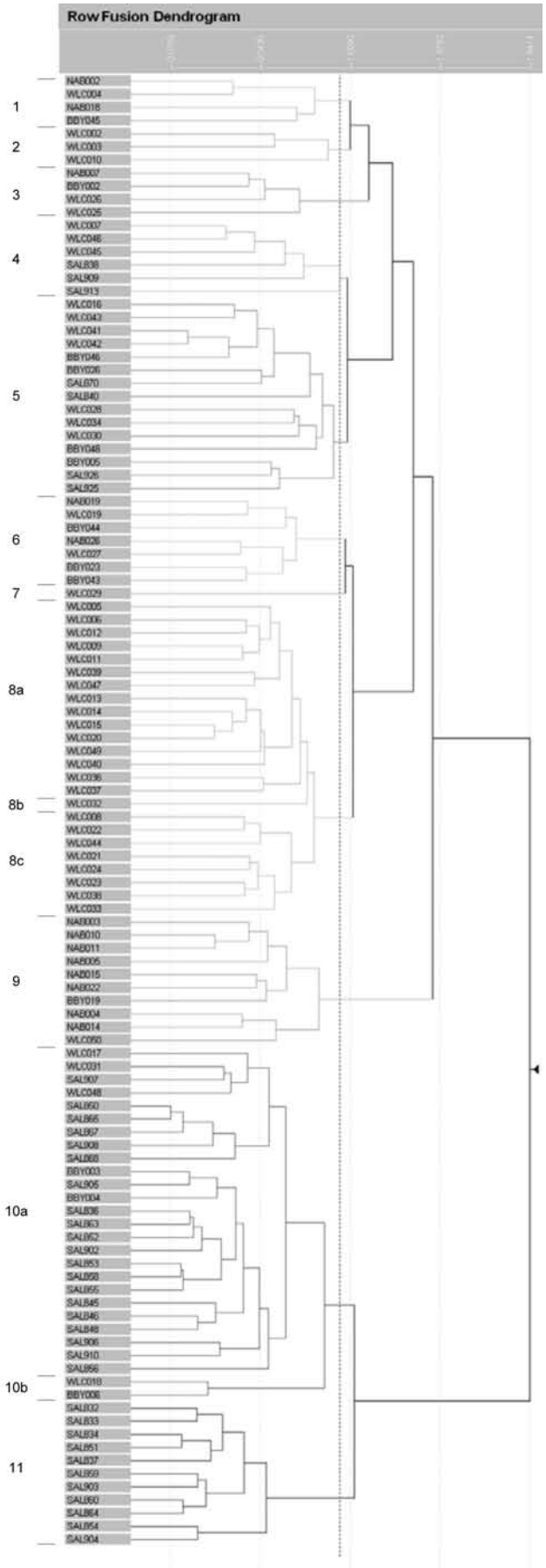


Fig. 6. Floristic classification of all wetland sites in Wallis Lake catchment.

CS: chenopod shrubland; MF/W: mangrove forest/woodland; R: rushland; S: sedgeland; SG: sod grassland; SSF/W: swamp sclerophyll forest/woodland; SSMW: swamp sclerophyll mallee woodland; SSS: swamp sclerophyll shrubland; TG: tussock grassland; WH: wet heathland.

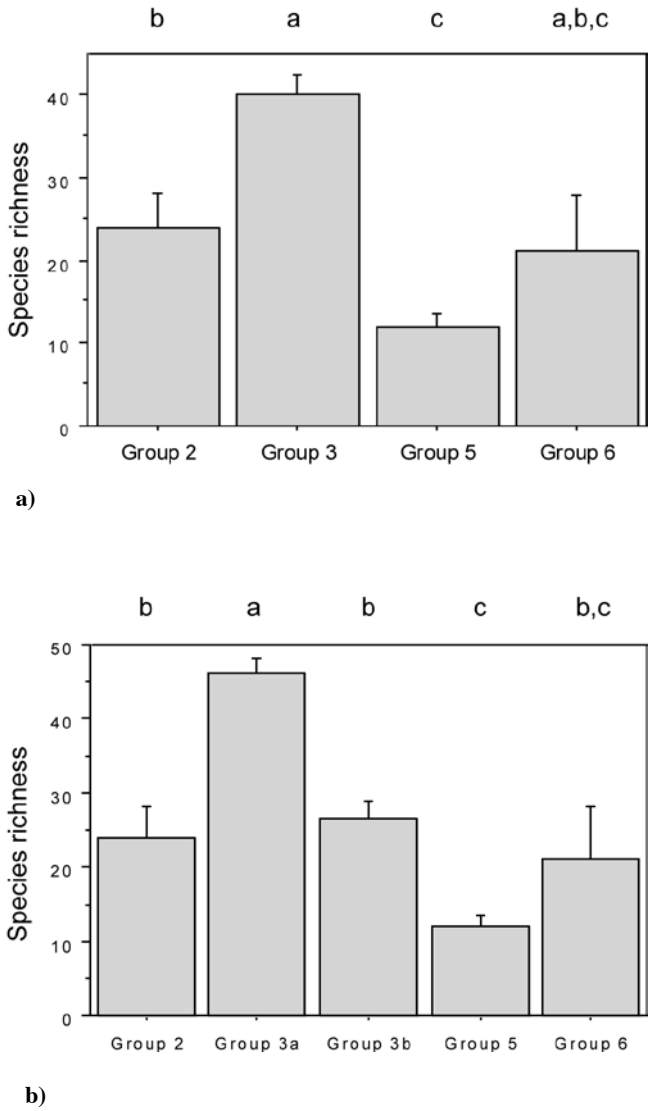


Fig. 7. Mean (+/- s.e.) species richness of native vascular plants in 400 m^2 quadrats for swamp sclerophyll forest and woodland.

Group 2: Sand barrier open depressions and associated flats.
Group 3: Extratidal plains (former estuaries), and associated alluvial landforms (e.g. backplains, levee toes) and transferral drainage depressions.
Group 3a: Extratidal plains (former estuaries) and associated alluvial landforms (e.g. backplains, levee toes).
Group 3b: Extratidal plains (former estuaries) with inferred residual soil salinity.
Group 5: Brackish to upper tidal flats of contemporary estuary.
Group 6: Prior stream channels associated with supratidal flats.

Significant differences (ANOVA: P <0.0001; Tukey-Kramer: P <0.05) are denoted with different letters.

Species richness in swamp sclerophyll forest and woodland

Species richness data for quadrats of uniform size (400 m^2) allowed a comparison of samples in swamp sclerophyll forest and woodland (quadrat size was either variable or unknown for samples in other vegetation formations). The mean species richness of native vascular plants (Figure 7a) was found to be significantly higher for swamp sclerophyll forest and woodland samples comprising floristic group 3 in Figure 3. These forests and woodlands occur on extratidal plains (former estuaries) and associated alluvial landforms (e.g. backplains, levee toes), and also along transferral drainage depressions. This trend of significantly higher mean species richness was even stronger for group 3a in Figure 3 when samples for extratidal plains with likely residual soil salinity (group 3b) were isolated (Figure 7b). In comparison, swamp sclerophyll forest and woodland associated with brackish to tidal flats of the contemporary estuary displayed the lowest mean species richness (group 5 in Figure 7a,b). This floristic group has a tallest stratum characteristically dominated by *Casuarina glauca*, with *Baumea juncea*, *Juncus kraussii* subsp. *australiensis* and *Phragmites australis* some of the likely understorey species.

The high species richness for native plants in swamp sclerophyll forests and woodlands on extratidal plains and associated alluvial and transferral landforms is a reflection of diversity in the understorey, particularly for the ground stratum which supports a variety of grasses, sedges, ferns and forbs. Unfortunately, extratidal plains and associated landforms also support a larger number of weeds. For example, the mean number of exotics per quadrat was 5.0 for floristic group 3a (Figure 3) although only 1.6 for group 5 on flats of the contemporary estuary, and weeds were absent from quadrats for group 2 on sand barriers.

Species of national or regional conservation significance

The present survey did not specifically target wetland plants of high conservation value, and records were largely incidental during the collection of site data. Species of known or potential conservation significance are outlined below. Three species (*Asperula asthenes*, *Lindernia alsinoides*, *Maundia triglochinoides*) are formally listed under the NSW *TSC Act*, and two (*Asperula asthenes*, *Gonocarpus salsoloides*) are *Rare or Threatened Australian Plants* (ROTAP) (Briggs and Leigh 1996). The remaining species are likely to be at least regionally significant.

Blechnum camfieldii (Blechnaceae)

Endemic to south-eastern Queensland and coastal NSW; reported to be locally extinct in places due to habitat destruction and therefore rare and possibly endangered (Chambers and Farrant 1998).

Recorded in *Eucalyptus robusta* (+/- *Melaleuca quinquenervia*) swamp sclerophyll forest and woodland (WLC024, WLC027).

Bolboschoenus caldwellii (Cyperaceae)

Occasional in swamps (Harden 1993); PlantNET has few records north of Wallis Lake on the NSW North Coast.

Dominates sedgeland (SAL913), and present in *Phragmites australis* rushland (SAL838).

Carex lobolepis (Cyperaceae)

PlantNET has no other records for coastal lowlands in NSW.

Recorded in *Casuarina glauca* swamp sclerophyll forest (WLC047).

Isolepis producta (Cyperaceae)

PlantNET has no other records for the NSW North Coast.

Recorded for Frogalla Swamp (452000 6449250) in 1996 during vegetation mapping by S. Griffith and R. Wilson.

Lepidosperma limicola (Cyperaceae)

Apparently absent from much of coastal NSW to the north of Wallis Lake; PlantNET has few records for the North Coast generally.

Recorded in wet heathland (NAB004, NAB014) and *Melaleuca sieberi* swamp sclerophyll shrubland (NAB010).

Schoenoplectus subulatus (Cyperaceae)

The distribution is scattered (Harden 1993); PlantNet has few records for the NSW North Coast.

Dominates sedgeland (SAL909). Also in *Baumea juncea* sedgeland (SAL925) and *Melaleuca quinquenervia* swamp sclerophyll shrubland (BBY045).

Schoenus scabripes (Cyperaceae)

Apart from a disjunct occurrence on the NSW South Coast (PlantNET), extends north from the Forster district.

Recorded in wet heathland (NAB004).

Maundia triglochinoides (Juncaginaceae)

Listed as Vulnerable under the NSW *TSC Act*.

Recorded in *Melaleuca quinquenervia* swamp sclerophyll forest (NAB018).

Deyeuxia quadriseta (Poaceae)

PlantNET has few records for the NSW North Coast.

Recorded in *Melaleuca quinquenervia* swamp sclerophyll forest (WLC038).

Poa poiformis var. *poiformis* (Poaceae)

Records for Yahoo Island NR in Wallis Lake and Kattang NR near Laurieton represent apparent outliers from the main distribution, which extends southwards from Port Stephens (Griffith et al. 2000, PlantNET).

Recorded in *Casuarina glauca* swamp sclerophyll forest or woodland on Yahoo Island (Griffith et al. 2000).

Hydrocotyle pterocarpa (Apiaceae)

Apparently uncommon in NSW, and on the North Coast known only from the Wallis Lake catchment (PlantNET).

Recorded in *Eucalyptus robusta* swamp sclerophyll woodland (WLC027).

Lilaeopsis polyantha (Apiaceae)

PlantNET has few records for the NSW North Coast.

Recorded in *Melaleuca quinquenervia* swamp sclerophyll forest (WLC021).

Cynanchum carnosum (Apocynaceae)

Reaches southern limit of distribution in the vicinity of Wallis Lake (PlantNET).

Recorded in *Casuarina glauca* swamp sclerophyll forest (WLC031) and *Casuarina glauca – Melaleuca quinquenervia* swamp sclerophyll woodland (BBY048).

Adenostemma lavenia var. *lavenia* (Asteraceae)

Collections at the Royal Botanic Gardens, Sydney (pers. com. 2007) mostly date from more than 50 years ago (1848–1964); may now be rare across its range in coastal northern NSW.

Recorded in swamp sclerophyll forest dominated by *Melaleuca linariifolia* (WLC009), or by varying combinations of *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* (WLC006, WLC011, WLC039).

Almaleea paludosa (Fabaceae – Faboideae)

Apparently uncommon on the NSW North Coast (Griffith et al. 2003, PlantNET).

Recorded in *Melaleuca sieberi* swamp sclerophyll shrubland (NAB010).

Pultenaea blakelyi (Fabaceae – Faboideae)

Apparently reaches the northern limit of its coastal distribution in the vicinity of Wallis Lake (PlantNET).

Recorded in swamp sclerophyll forest or woodland dominated by varying combinations of *Casuarina glauca*, *Eucalyptus resinifera*, *Eucalyptus robusta*, *Livistona australis* and *Melaleuca quinquenervia* (WLC024, WLC032, WLC040, BBY043).

Gonocarpus salsoloides (Haloragaceae)

Listed as Rare (3RCa) on ROTAP.

Recorded in *Banksia ericifolia* subsp. *macrantha* swamp sclerophyll shrubland (NAB022) and *Melaleuca sieberi* swamp sclerophyll shrubland (NAB010, NAB011).

Lycopus australis (Lamiaceae)

Possibly infrequent on the NSW North Coast (PlantNET).

Recorded in swamp sclerophyll forest or woodland dominated by varying combinations of *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* (WLC012, WLC039).

Isotoma armstrongii (Lobeliaceae)

Confined to the North Coast in NSW where possibly infrequent (PlantNET).

Recorded in *Casuarina glauca* swamp sclerophyll forest (WLC037), and in a clearing near WLC020.

Villarsia reniformis (Menyanthaceae)

PlantNET has few records for the NSW North Coast.

Recorded in *Baumea articulata* sedgeland (WLC001).

Callistemon citrinus (Myrtaceae)

Apparently rare on the coastal lowlands of NSW north of Wallis Lake (Griffith and Wilson 2007, PlantNET).

Recorded in wet heathland (NAB003, NAB004, NAB005, NAB014, BBY019), *Banksia ericifolia* subsp. *macrantha* swamp sclerophyll shrubland (NAB022) and *Eucalyptus robusta* swamp sclerophyll forest or woodland (WLC019).

Leptospermum arachnoides (Myrtaceae)

Apparently rare on the coastal lowlands of NSW north of the Forster district (Griffith et al. 2003, PlantNET).

Recorded in wet heathland (NAB005), *Banksia ericifolia* subsp. *macrantha* swamp sclerophyll shrubland (NAB015) and *Melaleuca sieberi* swamp sclerophyll shrubland (NAB010, NAB011).

Melaleuca ericifolia (Myrtaceae)

Apart from a possible outlier in the vicinity of Coffs Harbour, extends south from the Coopernook area near Taree (PlantNET).

Dominates the tallest stratum in swamp sclerophyll shrubland (WLC008, WLC022), which may grade structurally into wet heathland. Also recorded in swamp sclerophyll forest or woodland dominated by *Melaleuca linariifolia* (WLC009), *Casuarina glauca* (WLC016, WLC034, WLC044), or varying combinations of *Casuarina glauca*, *Livistona australis* and *Melaleuca quinquenervia* (WLC013, WLC033).

Persicaria dichotoma (Polygonaceae)

Confined to coastal lowlands on the mid and upper North Coast in NSW, where considered rare (PlantNET).

Recorded in *Casuarina glauca* swamp sclerophyll forest (WLC005).

Banksia ericifolia subsp. *macrantha* (Proteaceae)

Confined to the NSW North Coast, reaching its southern limit of distribution around Wallis Lake (PlantNET).

Recorded in swamp sclerophyll shrubland, often as the tallest stratum dominant (NAB010, NAB011, NAB015, NAB022). Also found in wet heathland (NAB003, NAB004, NAB005, WLC050, BBY019) and *Eucalyptus robusta* swamp sclerophyll forest or woodland (WLC019).

Symphionema paludosum (Proteaceae)

Relatively uncommon on the NSW North Coast where distribution restricted and disjunct (Griffith and Wilson 2007, PlantNET).

Recorded in wet heathland on the Nabiac Pleistocene barriers (Griffith and Wilson 2007).

Cryptandra ericoides (Rhamnaceae)

PlantNET has no other records for the NSW North Coast; generally occurs south from Sydney.

Recorded for wet heathland (Griffith et al. 2000), in Booti Booti NP close to the northern boundary (456650 6433025).

Durringtonia paludosa (Rubiaceae)

Characteristic of deep peat in coastal barrier wetlands where uncommon; endemic to northern NSW and southern Queensland (PlantNET).

Recorded in swamp sclerophyll forest or woodland dominated by *Eucalyptus robusta* and/or *Melaleuca quinquenervia* (WLC019, BBY023, BBY043).

Asperula asthenes (Rubiaceae)

Listed as Vulnerable under the NSW *TSC Act* and ROTAP (3VC-).

Although not observed during this study, records in the Atlas of NSW Wildlife database or otherwise held by Great Lakes Council indicate that this species occurs in the Darawakh, Pipers Bay and North Tuncurry areas (M. Bell, GLC pers. com. 2008). The habitat is swamp sclerophyll forest and woodland dominated by *Eucalyptus robusta* and/or *Melaleuca quinquenervia*, sometimes with associated *Casuarina glauca* or *Livistona australis*. It also occurs in wet sclerophyll forest.

Opercularia varia (Rubiaceae)

Apparently rare on the NSW North Coast, with a coastal distribution generally south of Newcastle (PlantNET).

Recorded in *Eucalyptus robusta* swamp sclerophyll mallee woodland (BBY044).

Lindernia alsinoides (Scrophulariaceae)

Listed as Endangered under the NSW *TSC Act*.

Recorded during 1997/98 by S. Griffith on cleared land (former swamp sclerophyll forest) adjoining the northern boundary of Booti Booti NP, although not relocated during the present study. Also recorded more recently in disturbed wetlands and clearings in the vicinity of south Forster and north Tuncurry (M. Bell, GLC pers. com. 2008).

Discussion

The coastal wetlands of NSW have significant environmental and social values (Adam et al. 1985), although in some habitats wetland vegetation has been substantially cleared or severely modified (Keith and Scott 2005, Pressey and Griffith 1992). Apart from saltmarsh and mangroves (e.g. Adam et al. 1988, West et al. 1984, 1985), and wetlands of beach ridge plains, dunefields and associated landforms (e.g. Griffith et al. 2003, Griffith and Wilson 2007), the floristic composition and spatial distribution of many coastal wetlands is not well known for northern NSW (Griffith 2005), and it seems likely that a substantial proportion of wetland plant communities are poorly represented in existing conservation reserves.

The present study has identified floristic differences between wetlands in different habitats and, to a lesser extent, floristic differences between wetlands comprising different structural formations. Between-habitat differences in floristic composition for multi-stratum vegetation generally relate to understorey strata. Biodiversity conservation of wetland vegetation within the Wallis Lake catchment therefore requires the protection of representative samples across the full range of vegetation formations and habitats.

Existing conservation reserves within the Wallis Lake catchment contain wetlands associated with aeolian/barrier, estuarine and swamp soil landscapes, e.g. Booti Booti National Park and Yahoo Island Nature Reserve (Griffith et al. 2000). Nonetheless, limitations of resolution and reliability for existing catchment-wide vegetation mapping preclude its use to assess the adequacy of current reserves for the protection of wetland biodiversity. Another potential limitation of the mapping is the inability of conventional API to discriminate spatial patterns for understorey strata in multi-stratum vegetation, such as swamp sclerophyll forest, which supports the same tallest stratum species across a range of habitats. However, when used in conjunction with soil landscape mapping, API-derived vegetation mapping of acceptable resolution and reliability is likely to adequately portray environmental variation and plant biodiversity, irrespective of vegetation structure.

Wetland vegetation in the Wallis Lake catchment has known conservation significance. Coastal Saltmarsh, for example, is an Endangered Ecological Community (EEC) under the NSW *TSC Act*. This vegetation is widespread around Wallis Lake where associated with brackish to tidal flats and

depressions (groups 3, 4, 7 and 8 in Figure 5). Included in Coastal Saltmarsh are rushlands dominated by *Phragmites australis* or *Juncus kraussii* subsp. *australiensis*, sedgelands dominated by *Baumea juncea*, *Bolboschoenus caldwellii* or *Schoenoplectus subulatus*, chenopod shrublands dominated by *Sarcocornia quinqueflora* subsp. *quinqueflora* or *Suaeda australis*, and *Sporobolus virginicus* tussock grassland.

Wetlands in the catchment also support components of other Endangered Ecological Communities – Swamp Oak Floodplain Forest, Swamp Sclerophyll Forest on Coastal Floodplains, and Freshwater Wetlands on Coastal Floodplains. As delineated by Keith and Scott (2005), these vegetation types are not well known in relation to species dominance, particularly in the understorey for forests, and their habitats are only loosely circumscribed in reference to soil landscapes. As a consequence, the differences in floristic composition and habitat are not clear between say, Swamp Sclerophyll Forest on Coastal Floodplains, and the least saline examples of Swamp Oak Floodplain Forest. Differences in fire response may also confound distinctions between swamp sclerophyll forests, e.g. where a severe fire kills the crowns of mature *Casuarina glauca* in mixed stands with *Melaleuca quinquenervia*, whereas the latter species resprouts from epicormic buds. Despite these issues, the following floristic groups identified for the Wallis Lake catchment most likely align with the EEC's.

Swamp Oak Floodplain Forest

This EEC comprises swamp sclerophyll forest or woodland dominated by *Casuarina glauca*, particularly representing groups 5 and 6 (Figure 3) on brackish to upper tidal flats or in associated prior stream channels. Also included in the EEC would be stands in group 3b on extratidal plains (former estuaries) where *Casuarina glauca* clearly dominates. Understorey composition varies with habitat and water quality (brackish to saline), although common species include *Baumea juncea*, *Juncus kraussii* subsp. *australiensis*, *Phragmites australis* and *Sporobolus virginicus*. More restricted understorey species, as in prior stream channels, include *Alocasia brisbanensis*, *Hypolepis muelleri*, *Melaleuca ericifolia*, *Melaleuca styphelioides* and *Myoporum acuminatum*.

Swamp Sclerophyll Forest on Coastal Floodplains

Typical of this EEC are the swamp sclerophyll forests of groups 3a and 3c (Figure 3), on extratidal plains and associated alluvial and transferral landforms where freshwater conditions prevail. *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* dominate the tallest stratum in varying combinations, with *Eucalyptus grandis*, *Eucalyptus resinifera*, *Eucalyptus tereticornis* or *Livistona australis* sometimes subsidiary to co-dominant. Also included are localised stands of *Melaleuca linariifolia*. The understorey is typically diverse, although common species include *Entolasia marginata*, *Gahnia clarkei*, *Hypolepis muelleri*, *Imperata cylindrica* var. *major*, *Ischaemum australe* and *Melaleuca linariifolia*. Some stands also support various rainforest shrubs or small trees beneath the tallest stratum (e.g. *Glochidion ferdinandi*).

Freshwater Wetlands on Coastal Floodplains

This EEC is represented in the catchment by the herbaceous vegetation of shallow to deep freshwater swamps (closed depressions). Included are sedgelands dominated by *Baumea articulata*, *Eleocharis equisetina* or *Eleocharis sphacelata*, and also *Paspalum distichum* sod grassland (groups 1 and 2 in Figure 5).

The present study demonstrates a high degree of congruence between floristic composition and habitat (i.e. soil landscape), thereby providing a mechanism to facilitate the delineation of EEC's throughout the Wallis Lake catchment. This is particularly the case for floodplain forests and woodlands, which are most reliably distinguished by floristic composition of the understorey rather than the tallest stratum.

Recommendations

A key recommendation arising from this study is the completion of reliable mapping for wetland vegetation and soil landscapes across all land tenures throughout the Wallis Lake catchment, including an assessment of disturbance impacts. Mapping of acceptable resolution and reliability will facilitate planning, conservation and management, specifically for:

(a) the evaluation of wetland condition (e.g. Bolton 2001a, b) and significance, e.g. types and extent of disturbance, landuse constraints, threats to function and integrity, and intrinsic conservation values; and

(b) an assessment of the extent and representation of wetland vegetation in formal conservation reserves (e.g. national parks), thereby directing future priorities for the protection of wetland biodiversity on both public and private lands.

The environmental services provided by wetlands are widely recognised (e.g. NSW Government 1996). The Great Lakes community relies upon a high quality natural environment for key economic drivers (e.g. tourism, oyster production, commercial fishing), and the environmental service provisions of functioning wetlands are therefore important. Spatial information about wetland type, habitat, extent, tenure, condition and intrinsic conservation values will facilitate the development of a strategy and action plan to enact proper and reasonable wetland conservation, management and restoration throughout the Wallis Lake catchment.

Kingsford et al. (2003) noted that "*it is difficult to manage any natural resource without knowing its distribution and*

wetlands are no exception. Without a spatial context, effective conservation measures are difficult to implement because they should be contingent on the identification of threats and their operating scale... It follows that without this information, priorities for wetland protection or rehabilitation cannot be derived nor regional rates of wetland loss determined nor conservation priorities (set) for particular types of wetlands." It is considered appropriate to develop a wetland strategy for the Wallis Lake catchment within this context.

Wetland classification and delineation is challenged by considerable hydrological, ecological and geomorphological variability (Kingsford et al. 2003). Nonetheless, this study, using conventional API, site-based sampling and landscape differentiation provides a framework for the conservation of wetland biodiversity within the Wallis Lake catchment. Such an approach is likely to facilitate wetland conservation in the Smiths Lake, Myall Lake and Karuah River catchments within the Great Lakes LGA, and more widely throughout coastal NSW.

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Appendix 1. Frequency and mean foliage cover of vascular species in wetland floristic groups.

Floristic groups are numbered and described as they appear in Figures 3–5. Frequency of occurrence (first value in brackets) is the percentage of quadrats in which a species occurred. Mean foliage cover (second value in brackets) is the average of scores for quadrats in which a species occurred. Foliage cover scores: 1 (<1%); 2 (1–5%); 3 (6–25%); 4 (26–50%); 5 (51–75%); and 6 (76–100%). Exotic taxa are prefixed with an asterisk. Abbreviations: SSF/W: swamp sclerophyll forest/woodland; MF/W: mangrove forest/woodland; SSS: swamp sclerophyll shrubland; SSMW: swamp sclerophyll mallee woodland; S: sedgeland; SG: sod grassland; R: rushland; CS: chenopod shrubland; WH: wet heathland; TG: tussock grassland.

SSF–1: *Melaleuca quinquenervia* SSF in a deep freshwater swamp (1 quadrat)

SSF/W–2: *Eucalyptus robusta* SSF/W and *E. robusta – Melaleuca quinquenervia* SSF/W associated with sand barrier open depressions and flats (6 quadrats)

SSF/W–3a: SSF (occasionally SSW) on extratidal plains (former estuaries) and associated alluvial landforms, dominated by *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* in varying combinations, with *Eucalyptus grandis*, *E. resinifera*, *E. tereticornis* or *Livistona australis* sometimes subsidiary to co-dominant; also localised *Melaleuca linariifolia* SSF (15 quadrats)

SSF/W–3b: SSF/W on extratidal plains with inferred residual soil salinity, dominated by *Casuarina glauca*, *Eucalyptus robusta* and *Melaleuca quinquenervia* in varying combinations (6 quadrats)

SSF–3c: *Casuarina glauca – Eucalyptus robusta – Livistona australis* SSF along a transferral drainage depression (1 quadrat)

SSF–4: *Melaleuca nodosa* SSF on a transferral drainage plain (1 quadrat)

SSF/W–5: *Casuarina glauca* SSF and *C. glauca – Melaleuca quinquenervia* SSF/W on brackish to upper tidal flats of contemporary estuary (11 quadrats)

SSF/W–6: *Casuarina glauca* SSF/W along prior stream channels associated with supratidal flats (2 quadrats)

MF/W–7: *Avicennia marina* subsp. *australasica* MF/W on intertidal flats (2 quadrats)

SSS–1a: *Melaleuca sieberi* SSS on sand barrier flats (2 quadrats)

SSS–1b: *Banksia ericifolia* subsp. *macrantha* SSS in sand barrier swales (2 quadrats)

SSS–2a: *Melaleuca ericifolia* SSS on extratidal plains with inferred residual soil salinity (2 quadrats)

SSMW–2b: *Eucalyptus robusta* SSMW along a sand barrier drainage depression (1 quadrat)

SSS–3: *Melaleuca quinquenervia* SSS in a brackish swamp (1 quadrat)

S–1: *Baumea articulata* S and *Eleocharis sphacelata* S in deep freshwater swamps (3 quadrats)

S/SG–2: *Eleocharis equisetina* S and *Paspalum distichum* SG in shallow freshwater swamps (2 quadrats)

R/S–3: *Phragmites australis* R, *Bolboschoenus caldwellii* S and *Schoenoplectus subulatus* S associated with brackish depressions and flats near estuary (5 quadrats)

R/S/CS–4: *Phragmites australis* R, *Baumea juncea* S and *Suaeda australis* CS on supratidal flats (6 quadrats)

WH–5: WH of *Banksia oblongifolia*, *Hakea teretifolia* subsp. *teretifolia*, *Leptospermum liversidgei*, *Xanthorrhoea fulva* etc., associated with sand barrier swales and flats (6 quadrats)

S–6: *Baloskion pallens – Leptocarpus tenax – Schoenus brevifolius* etc. S and *Lepironia articulata* S in sand barrier acid swamps (4 quadrats)

R/TG–7: *Juncus kraussii* subsp. *australiensis* R and *Sporobolus virginicus* TG on upper tidal flats (22 quadrats)

CS/TG–8: *Sarcocornia quinqueflora* subsp. *quinqueflora* CS and S. *quinqueflora* subsp. *quinqueflora – Sporobolus virginicus* CS/TG on lower tidal flats (11 quadrats)

Class LYCOPSIDA

LYCOPODIACEAE					
Lycopodiella lateralis	SSS-1b (50%,2.00)	WH-5 (17%,3.00)			
SELAGINELLACEAE					
Selaginella uliginosa	SSF/W-2 (33%,1.50)	SSF/W-3a (20%,1.33)	SSF/W-3b (17%,1.00)	SSS-1a (100%,1.50)	SSS-1b (50%,1.00)
	SSS-2a (50%,2.00)	WH-5 (50%,1.67)			

Class FILICOPSIDA

ASPLENIACEAE					
Asplenium australasicum	SSF/W-6 (50%,1.00)				
ADIANTACEAE					
Adiantum aethiopicum	SSF/W-3a (7%,1.00)				
AZOLLACEAE					
Azolla pinnata	S/SG-2 (50%,1.00)				
BLECHNACEAE					
Blechnum camfieldii	SSF/W-2 (17%,1.00)	SSF/W-3b (17%,1.00)			
Blechnum indicum	SSF-1 (100%,1.00)	SSF/W-2 (100%,2.83)	SSF/W-3a (53%,1.75)	SSF/W-3b (50%,2.67)	SSF/W-5 (9%,2.00)
	SSS-2a (50%,1.00)	SSMW-2b (100%,1.00)	R/S-3 (40%,1.50)	S-6 (25%,1.00)	
CULCITACEAE					
Calochlaena dubia	SSF/W-3a (13%,1.00)	SSF-3c (100%,2.00)			
CYATHEACEAE					
Cyathea cooperi	SSF-3c (100%,1.00)				
DENNSTAEDTIACEAE					
Histiopteris incisa	SSF/W-3a (7%,3.00)	SSF/W-5 (9%,1.00)			
Hypolepis muelleri	SSF/W-2 (17%,1.00)	SSF/W-3a (53%,2.50)	SSF-3c (100%,2.00)	SSF/W-5 (9%,2.00)	SSF/W-6 (50%,5.00
Pteridium esculentum	SSF/W-2 (83%,2.40)	SSF/W-3a (73%,2.09)	SSF/W-3b (33%,1.50)	SSMW-2b (100%,2.00)	
GLEICHENIACEAE					
Gleichenia microphylla	SSF/W-2 (33%,4.50)	WH-5 (17%,1.00)			
LINDSAEACEAE					
Lindsaea linearis	WH-5 (17%,2.00)				
OPHIOGLOSSACEAE					
Botrychium australe	SSF/W-3a (20%,1.00)				
POLYPODIACEAE					
Platycerium bifurcatum	SSF/W-3a (27%,1.25)	SSF/W-3b (17%,1.00)	SSF/W-6 (100%,1.00)		
Pyrrosia confluens var. *dielsii*	SSF/W-3a (13%,1.00)	SSF/W-6 (50%,1.00)			
Pyrrosia rupestris	SSF/W-6 (50%,1.00)				
SCHIZAEACEAE					
Schizaea bifida	WH-5 (17%,1.00)				
SINOPTERIDACEAE					
Cheilanthes sieberi subsp. *sieberi*	SSF-4 (100%,1.00)				
Pellaea falcata	SSF/W-6 (50%,1.00)				
THELYPTERIDACEAE					
Christella dentata	SSF/W-3a (7%,1.00)				
Cyclosorus interruptus	SSF/W-3a (20%,2.00)	SSF/W-5 (9%,1.00)			

Class MAGNOLIOPSIDA – LILIIDAE

AMARYLLIDACEAE					
Crinum pedunculatum	SSF-3c (100%,2.00)	SSF/W-5 (9%,1.00)			
ANTHERICACEAE					
Arthropodium species B	SSF-4 (100%,1.00)				
Caesia parviflora var. *parviflora*	SSF/W-3a (7%,1.00)				
Sowerbaea juncea	WH-5 (17%,1.00)				
ARACEAE					
Alocasia brisbanensis	SSF/W-3a (7%,1.00)	SSF/W-6 (50%,3.00)			
ARECACEAE					
Livistona australis	SSF/W-2 (33%,1.50)	SSF/W-3a (80%,1.83)	SSF/W-3b (33%,1.00)	SSF-3c (100%,4.00)	SSF/W-5 (9%,1.00)
	SSF/W-6 (50%,1.00)				
BLANDFORDIACEAE					
Blandfordia grandiflora	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)	WH-5 (50%,1.00)		
COLCHICACEAE					
Burchardia umbellata	WH-5 (17%,1.00)				
COMMELINACEAE					
Commelina cyanea	SSF/W-3a (20%,1.00)	SSF/W-3b (17%,1.00)	SSF/W-5 (27%,1.00)	SSF/W-6 (50%,2.00)	
CYPERACEAE					
Baumea arthrophylla	S-6 (75%,2.00)				
Baumea articulata	SSF-1 (100%,4.00)	SSF/W-3a (47%,1.43)	SSF/W-3b (100%,1.83)	SSF/W-5 (18%,1.50)	SSS-2a (100%,1.00)
	SSS-3 (100%,2.00)	S-1 (67%,4.50)	R/S-3 (20%,1.00)	R/S/CS-4 (17%,1.00)	
Baumea juncea	SSF/W-2 (17%,3.00)	SSF/W-3a (40%,2.50)	SSF/W-3b (67%,3.75)	SSF/W-5 (73%,3.25)	SSF/W-6 (50%,1.00)
	SSS-2a (100%,3.00)	SSMW-2b (100%,2.00)	SSS-3 (100%,2.00)	R/S/CS-4 (100%,4.50)	R/TG-7 (9%,2.00)
Baumea muelleri	WH-5 (17%,1.00)				
Baumea rubiginosa	SSF-1 (100%,2.00)	SSF/W-2 (33%,2.50)	SSF/W-3a (40%,2.33)	SSF/W-3b (50%,2.67)	SSS-2a (50%,1.00)
	SSS-3 (100%,1.00)	R/S/CS-4 (17%,1.00)			
Baumea teretifolia	SSF-1 (100%,2.00)	SSF/W-2 (50%,2.00)	SSF/W-3a (20%,1.00)	SSF/W-3b (33%,2.00)	SSS-2a (50%,1.00
	WH-5 (33%,1.50)	S-6 (75%,2.67)			
Bolboschoenus caldwellii	R/S-3 (40%,4.00)				
Carex appressa	SSF/W-3a (13%,1.50)	SSF/W-6 (50%,1.00)			
Carex declinata	SSF/W-3a (7%,1.00)				
Carex lobolepis	SSF/W-3a (7%,1.00)				
Carex maculata	SSF/W-3a (27%,2.25)	SSF/W-3b (33%,2.50)	SSF/W-5 (18%,1.00)		
Chorizandra cymbaria	SSF/W-2 (17%,1.00)	SSF/W-3a (7%,2.00)	SSF/W-3b (33%,1.50)		
Chorizandra sphaerocephala	SSF/W-2 (33%,2.00)	SSS-1b (50%,1.00)	WH-5 (67%,1.75)		
Cyperus haspan subsp. *haspan*	SSF/W-3a (7%,1.00)				
Cyperus lucidus	SSF/W-3b (17%,1.00)				
Cyperus polystachyos	SSF/W-3a (20%,1.00)	SSF/W-5 (27%,1.00)	R/S/CS-4 (17%,3.00)		
**Cyperus rotundus*	R/S/CS-4 (17%,2.00)				
Eleocharis equisetina	SSF/W-5 (9%,3.00)	S/SG-2 (100%,3.00)	R/S-3 (20%,2.00)		
Eleocharis sphacelata	S-1 (100%,2.33)				
Ficinia nodosa	SSF/W-5 (9%,1.00)				
Fimbristylis dichotoma	SSF/W-3a (13%,1.00)	SSF/W-5 (9%,1.00)			
Fimbristylis ferruginea	SSF/W-5 (36%,1.25)	SSF/W-6 (50%,1.00)	SSS-3 (100%,2.00)	R/S/CS-4 (33%,2.00)	R/TG-7 (18%,1.75)
Gahnia clarkei	SSF/W-2 (100%,1.83)	SSF/W-3a (100%,2.80)	SSF/W-3b (100%,2.50)	SSF-3c (100%,5.00)	SSF/W-5 (45%,1.60)
	SSS-2a (100%,2.00)	SSMW-2b (100%,2.00)	R/S-3 (20%,1.00)		
Gahnia sieberiana	SSS-1b (50%,1.00)	WH-5 (50%,2.33)			
Isolepis cernua	R/TG-7 (5%,2.00)				

Isolepis inundata	SSF/W-2 (33%,1.00)	SSF/W-3a (27%,1.50)	SSF/W-3b (33%,1.50)	R/S/CS-4 (17%,3.00)	
Lepidosperma filiforme	SSS-1b (50%,3.00)				
Lepidosperma gunnii	SSS-1a (50%,1.00)				
Lepidosperma limicola	SSS-1a (50%,3.00)	WH-5 (33%,2.00)			
Lepidosperma longitudinale	SSF-1 (100%,2.00)				
Lepidosperma neesii	SSF-4 (100%,3.00)	WH-5 (17%,2.00)			
Lepidosperma quadrangulatum	SSF/W-2 (17%,3.00)	SSF-4 (100%,3.00)			
Lepironia articulata	S-6 (50%,3.00)				
Ptilothrix deusta	SSS-1a (100%,4.00)	SSS-1b (50%,2.00)	WH-5 (50%,2.67)		
Rhynchospora brownii	SSF/W-3a (7%,1.00)	SSF/W-3b (17%,1.00)			
Schoenoplectus subulatus	SSS-3 (100%,2.00)	R/S-3 (20%,5.00)	R/S/CS-4 (17%,2.00)		
Schoenus apogon	SSF/W-3a (20%,1.33)	SSF/W-3b (17%,1.00)			
Schoenus brevifolius	SSF/W-2 (33%,2.50)	SSF/W-3a (7%,2.00)	SSF/W-3b (17%,1.00)	SSS-1a (100%,2.00)	SSS-1b (100%,2.00)
	SSMW-2b (100%,2.00)	WH-5 (67%,1.75)	S-6 (25%,3.00)		
Schoenus melanostachys	SSF-3c (100%,1.00)				
Schoenus paludosus	SSS-1a (100%,1.00)	WH-5 (17%,1.00)			
Schoenus scabripes	WH-5 (17%,2.00)				
Schoenus sp.	R/TG-7 (5%,1.00)				
GEITONOPLESIACEAE					
Eustrephus latifolius	SSF/W-3a (7%,1.00)				
Geitonoplesium cymosum	SSF/W-3a (13%,1.00)	SSF-3c (100%,1.00)			
HAEMODORACEAE					
Haemodorum corymbosum	SSS-1a (100%,1.00)	WH-5 (17%,1.00)			
HYPOXIDACEAE					
Hypoxis pratensis var. *pratensis*	SSF/W-3a (7%,1.00)	SSF-4 (100%,1.00)			
IRIDACEAE					
Patersonia sericea	WH-5 (17%,1.00)				
Patersonia sp. aff. *fragilis*	SSS-1a (50%,1.00)	WH-5 (17%,1.00)			
JUNCACEAE					
**Juncus cognatus*					
Juncus continuus	SSF/W-3a (7%,1.00)				
Juncus kraussii subsp. *australiensis*	SSF/W-3b (33%,1.00)	SSF/W-5 (82%,2.56)	SSF/W-6 (50%,2.00)	MF/W-7 (100%,1.50)	SSS-3 (100%,4.00)
	R/S-3 (20%,3.00)	R/S/CS-4 (33%,3.00)	R/TG-7 (95%,3.86)	CS/TG-8 (27%,1.67)	
Juncus mollis	SSF/W-3a (13%,1.00)				
Juncus polyanthemus	SSF/W-3a (7%,1.00)	SSF/W-3b (33%,1.00)			
Juncus prismatocarpus					
Juncus usitatus	SSF/W-3a (7%,1.00)				
JUNCAGINACEAE					
Maundia triglochinoides	SSF-1 (100%,3.00)				
Triglochin procerum s. lat.	SSF-1 (100%,1.00)	SSF/W-2 (17%,1.00)	SSF/W-5 (18%,1.00)	S-1 (67%,1.50)	S/SG-2 (50%,1.00)
	R/S-3 (20%,1.00)	S-6 (50%,1.00)			
Triglochin striatum	SSF/W-5 (27%,1.33)	R/S-3 (20%,3.00)	R/TG-7 (18%,2.25)	CS/TG-8 (73%,2.63)	
LAXMANNIACEAE					
Cordyline stricta	SSF/W-3a (7%,1.00)				
LEMNACEAE					
Spirodela punctata					

LOMANDRACEAE					
Lomandra longifolia	SSF/W-2 (17%,2.00)	SSF/W-3a (47%,1.71)	SSF/W-3b (33%,1.00)	SSF-3c (100%,1.00)	SSMW-2b (100%,1.00)
	WH-5 (17%,1.00)				
Lomandra multiflora subsp. *multiflora*	SSF-4 (100%,1.00)				
ORCHIDACEAE					
Acianthus sp.	SSF-4 (100%,1.00)	SSMW-2b (100%,1.00)			
Caladenia picta	SSF-4 (100%,1.00)				
Cryptostylis sp.	SSF/W-3b (50%,1.00)				
Cryptostylis subulata	SSF/W-3a (7%,1.00)				
Cymbidium suave	SSF/W-3a (7%,1.00)				
Dockrillia teretifolia	SSF/W-3a (20%,1.00)	SSF/W-5 (9%,1.00)			
Plectorrhiza tridentata	SSF/W-3b (17%,1.00)				
Pterostylis sp.	SSF/W-3a (27%,1.00)				
PHILYDRACEAE					
Philydrum lanuginosum	SSF/W-3a (13%,1.00)	SSF/W-3b (50%,1.00)	S/SG-2 (50%,1.00)		
PHORMIACEAE					
Dianella caerulea	SSF/W-2 (50%,1.00)	SSF/W-3a (100%,1.20)	SSF/W-3b (50%,1.00)	SSF-4 (100%,1.00)	SSMW-2b (100%,3.00)
Dianella longifolia	SSF/W-3a (7%,1.00)	SSF/W-5 (9%,1.00)	SSF/W-6 (50%,1.00)		
Dianella revoluta	SSF-4 (100%,1.00)				
POACEAE					
Agrostis sp.	R/S/CS-4 (17%,1.00)	R/TG-7 (5%,1.00)			
**Andropogon virginicus*	SSF/W-3a (40%,1.00)	SSF-4 (100%,1.00)	SSMW-2b (100%,1.00)	S-6 (25%,1.00)	
Aristida vagans	SSF-4 (100%,2.00)				
**Axonopus fissifolius*	SSF/W-3a (53%,1.38)				
**Cortaderia selloana*	SSF/W-5 (9%,1.00)				
Cynodon dactylon	SSF/W-3a (7%,1.00)	SSF/W-3b (17%,1.00)	SSF/W-6 (50%,1.00)		
Deyeuxia quadriseta	SSF/W-3b (17%,1.00)				
Dichelachne micrantha	SSF/W-3a (7%,1.00)				
Echinopogon ovatus	SSF/W-3a (20%,1.00)				
**Ehrharta erecta*	SSF/W-5 (9%,1.00)				
Entolasia marginata	SSF/W-3a (100%,2.20)	SSF/W-3b (50%,1.33)	SSF-3c (100%,1.00)	SSF/W-5 (9%,1.00)	SSF/W-6 (50%,2.00)
	SSS-2a (50%,2.00)				
Entolasia stricta	SSF/W-2 (83%,1.40)	SSF/W-3a (13%,2.00)	SSF/W-3b (17%,1.00)	SSF-3c (100%,1.00)	SSF-4 (100%,3.00)
	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)	SSS-2a (50%,1.00)	WH-5 (67%,1.25)	
Eragrostis benthamii	SSF/W-3a (7%,1.00)				
Eragrostis brownii	SSF/W-3a (13%,2.00)	SSF/W-3b (17%,1.00)	SSF-4 (100%,1.00)		
Eriochloa procera	SSF/W-5 (9%,4.00)	R/S/CS-4 (17%,1.00)			
Hemarthria uncinata	SSF/W-2 (67%,1.50)	SSF/W-3a (87%,1.62)	SSF/W-3b (83%,2.00)	SSF/W-5 (9%,2.00)	SSS-2a (100%,3.00)
Imperata cylindrica var. *major*	SSF/W-2 (33%,1.00)	SSF/W-3a (93%,2.29)	SSF/W-3b (83%,2.40)	SSF-3c (100%,1.00)	SSF-4 (100%,3.00)
	SSS-2a (100%,2.00)	SSMW-2b (100%,3.00)			
Isachne globosa	SSF/W-2 (17%,2.00)	SSF/W-3a (27%,1.25)	SSF/W-3b (33%,1.50)	SSF/W-6 (50%,1.00)	S-1 (33%,1.00)
	S/SG-2 (50%,1.00)				
Ischaemum australe	SSF/W-2 (50%,2.00)	SSF/W-3a (47%,2.71)	SSF/W-3b (83%,2.00)	SSS-2a (50%,3.00)	WH-5 (17%,1.00)
Leersia hexandra	SSF-1 (100%,2.00)	SSF/W-2 (17%,1.00)			
Microlaena stipoides var. *stipoides*	SSF/W-3a (67%,1.20)	SSF/W-6 (50%,3.00)			
Oplismenus aemulus	SSF/W-3a (67%,1.40)	SSF/W-6 (50%,3.00)			
Oplismenus imbecillis	SSF/W-3a (47%,1.86)	SSF-3c (100%,1.00)			
Ottochloa gracillima	SSF/W-3a (7%,5.00)				
Panicum bisulcatum	SSF/W-3a (7%,1.00)				

Panicum simile	SSF/W-2 (17%,1.00)	SSF/W-3a (13%,1.00)	SSF-4 (100%,2.00)	SSS-1a (50%,1.00)	SSS-1b (50%,1.00)
	WH-5 (17%,1.00)				
Paspalidium distans	SSF/W-2 (17%,1.00)	SSF/W-3a (53%,1.25)	SSF/W-3b (33%,1.00)	SSF-4 (100%,1.00)	SSF/W-6 (50%,2.00)
	SSMW-2b (100%,1.00)				
**Paspalum dilatatum*	SSF/W-3a (13%,1.50)				
Paspalum distichum	S/SG-2 (50%,5.00)				
Paspalum orbiculare	SSF/W-3a (53%,1.13)	SSF/W-3b (50%,1.00)			
**Paspalum urvillei*	SSF/W-3a (20%,1.00)				
**Paspalum wettsteinii*	SSF/W-3a (7%,1.00)				
Phragmites australis	SSF/W-2 (33%,1.00)	SSF/W-3a (20%,1.00)	SSF/W-3b (67%,1.50)	SSF/W-5 (64%,2.43)	SSF/W-6 (50%,2.00)
	R/S-3 (80%,4.50)	R/S/CS-4 (50%,2.67)	R/TG-7 (9%,3.00)		
Poa labillardieri	SSF/W-3a (13%,2.00)				
**Polypogon monspeliensis*	R/TG-7 (5%,2.00)				
Pseudoraphis paradoxa	SSF-1 (100%,1.00)				
Sacciolepis indica	SSF/W-3a (20%,1.00)	SSF/W-3b (17%,1.00)			
**Setaria gracilis*	SSF/W-5 (9%,1.00)				
Sporobolus diander	SSF/W-3a (7%,1.00)				
Sporobolus laxus	SSF/W-3a (7%,1.00)	SSF-4 (100%,1.00)			
Sporobolus virginicus	SSF/W-5 (73%,2.38)	SSF/W-6 (50%,3.00)	MF/W-7 (100%,3.00)	R/S/CS-4 (50%,2.67)	R/TG-7 (95%,5.38)
	CS/TG-8 (64%,3.43)				
Themeda australis	SSF/W-3a (27%,2.75)				
Zoysia macrantha	SSF/W-5 (9%,2.00)				
POTAMOGETONACEAE					
**Ruppia maritima*	R/S/CS-4 (17%,2.00)	CS/TG-8 (9%,1.00)			
RESTIONACEAE					
Baloskion pallens	SSS-1b (100%,1.00)	SSMW-2b (100%,1.00)	WH-5 (33%,2.00)	S-6 (75%,3.67)	
Baloskion tetraphyllum subsp. *meiostachyum*	SSF/W-2 (100%,3.50)	SSF/W-3b (17%,3.00)	SSMW-2b (100%,4.00)		
Empodisma minus	SSF/W-2 (33%,3.00)	SSF/W-3a (7%,4.00)	WH-5 (50%,4.00)		
Eurychorda complanata	SSS-1a (50%,1.00)	SSS-1b (100%,2.00)	WH-5 (33%,1.50)		
Hypolaena fastigiata	WH-5 (17%,2.00)				
Leptocarpus tenax	SSF/W-2 (33%,2.50)	SSS-1a (100%,3.00)	SSS-1b (100%,1.50)	SSS-2a (50%,3.00)	SSMW-2b (100%,1.00)
	WH-5 (67%,2.25)	S-6 (25%,2.00)			
Lepyrodia scariosa	SSS-1a (50%,2.00)	SSS-1b (50%,1.00)	WH-5 (33%,1.50)		
Lepyrodia sp. A (‘*imitans*’)	SSF/W-2 (33%,1.50)	SSS-1a (50%,2.00)	WH-5 (17%,1.00)		
Sporadanthus caudatus	SSS-1b (50%,1.00)				
Sporadanthus interruptus	SSS-1b (100%,1.50)	SSMW-2b (100%,1.00)	WH-5 (67%,2.25)		
SMILACACEAE					
Smilax glyciphylla	SSF/W-3a (7%,1.00)				
TYPHACEAE					
Typha domingensis	SSF/W-3a (7%,1.00)				
XANTHORRHOEACEAE					
Xanthorrhoea fulva	SSF/W-2 (67%,1.25)	SSS-1a (50%,1.00)	SSS-1b (100%,2.50)	WH-5 (67%,2.75)	
XYRIDACEAE					
Xyris gracilis subsp. *gracilis*	SSS-1a (50%,1.00)	WH-5 (17%,1.00)			
Xyris juncea	SSS-1a (50%,1.00)				
Xyris operculata	SSS-1a (100%,2.00)	SSS-1b (100%,2.00)	WH-5 (67%,2.00)		

Class MAGNOLIOPSIDA – MAGNOLIIDAE

ACANTHACEAE					
Pseuderanthemum variabile	SSF/W-3a (20%,1.00)				
AIZOACEAE					
Sesuvium portulacastrum	R/S/CS-4 (17%,3.00)				
Tetragonia tetragonioides	SSF/W-5 (9%,1.00)				
AMARANTHACEAE					
Alternanthera denticulata	SSF/W-5 (18%,1.00)				
APIACEAE					
Apium prostratum subsp. *prostratum*	SSF/W-5 (18%,1.00)	R/S/CS-4 (17%,2.00)	R/TG-7 (18%,2.75)	CS/TG-8 (27%,1.33)	
Centella asiatica	SSF/W-2 (17%,1.00)	SSF/W-3a (87%,1.15)	SSF/W-5 (9%,1.00)		
Hydrocotyle acutiloba	SSF/W-3a (33%,1.40)				
**Hydrocotyle bonariensis*					
Hydrocotyle peduncularis	SSF/W-2 (17%,1.00)	SSF/W-3a (87%,1.00)	SSF/W-3b (17%,1.00)	SSF-4 (100%,1.00)	
Hydrocotyle pterocarpa	SSF/W-2 (17%,1.00)				
Lilaeopsis polyantha	SSF/W-3b (17%,1.00)				
Platysace ericoides	SSS-1a (50%,1.00)	WH-5 (17%,1.00)			
Platysace lanceolata	SSMW-2b (100%,1.00)	WH-5 (17%,1.00)			
Xanthosia pilosa	WH-5 (17%,1.00)				
APOCYNACEAE					
**Araujia sericifera*	SSF/W-3a (7%,1.00)				
Cynanchum carnosum	SSF/W-5 (18%,1.50)				
**Gomphocarpus fruticosus*	SSF/W-3a (40%,1.00)	SSF/W-5 (9%,1.00)			
Marsdenia rostrata	SSF/W-3a (20%,1.33)	SSF-3c (100%,1.00)			
Marsdenia suaveolens	SSF/W-3a (7%,1.00)				
Parsonsia straminea	SSF/W-3a (80%,1.58)	SSF/W-3b (83%,1.20)	SSF/W-5 (18%,1.50)	SSS-2a (50%,1.00)	
ARALIACEAE					
Polyscias sambucifolia	SSF/W-3a (27%,1.00)				
ASTERACEAE					
Adenostemma lavenia var. *lavenia*	SSF/W-3a (27%,1.00)				
**Ageratina adenophora*	SSF/W-3a (47%,1.00)	SSF/W-6 (50%,1.00)			
**Aster subulatus*	SSF/W-3a (20%,1.00)	SSF/W-3b (17%,1.00)	SSF/W-5 (27%,1.33)	R/S-3 (20%,1.00)	R/S/CS-4 (50%,1.00)
	R/TG-7 (14%,2.00)	CS/TG-8 (9%,3.00)			
**Baccharis halimifolia*	R/S/CS-4 (17%,1.00)				
Centipeda minima	SSF/W-3a (7%,1.00)				
**Chrysanthemoides monilifera*					
subsp. *rotundata*	SSF/W-5 (18%,1.50)				
**Cirsium vulgare*	SSF/W-3a (27%,1.00)				
**Conyza albida*	SSF/W-3a (33%,1.00)	SSF/W-5 (9%,2.00)			
Eclipta platyglossa	SSF/W-3a (53%,1.13)	SSF/W-3b (50%,1.00)	SSF/W-5 (18%,1.00)		
Enydra fluctuans	SSF/W-3a (13%,2.00)	SSF/W-3b (17%,1.00)	SSF/W-5 (18%,1.00)	R/S/CS-4 (17%,3.00)	
Epaltes australis	SSF/W-3a (13%,1.00)				
**Erechtites valerianifolia*	SSF/W-3a (7%,1.00)				
Euchiton gymnocephalus	SSF/W-3a (13%,1.00)	SSF-4 (100%,1.00)			
**Hypochaeris radicata*	SSF/W-3a (27%,1.00)	SSF/W-5 (9%,1.00)			
Lagenifera gracilis	SSF/W-3a (27%,1.00)	SSF-4 (100%,1.00)	SSS-2a (50%,1.00)		
**Leontodon taraxacoides*					
subsp. *taraxacoides*	SSF/W-3a (20%,1.00)	SSF/W-3b (17%,1.00)			

Leptinella longipes	SSF/W-3a (7%,1.00)	SSF/W-3b (33%,2.00)	SSF/W-5 (18%,1.00)		
Pseudognaphalium luteoalbum	SSF/W-3a (7%,1.00)	SSF/W-5 (9%,1.00)			
Senecio hispidulus	SSF/W-3a (20%,1.00)	SSF/W-5 (9%,1.00)	SSF/W-6 (50%,1.00)		
**Senecio madagascariensis*	SSF/W-3a (27%,1.00)	SSF-4 (100%,1.00)	SSF/W-5 (36%,1.00)	SSF/W-6 (50%,1.00)	R/TG-7 (5%,2.00)
Senecio minimus	SSF/W-3a (7%,1.00)				
**Sonchus asper* subsp. *glaucescens*	SSF/W-5 (9%,1.00)				
**Sonchus oleraceus*	SSF/W-3a (7%,1.00)				
Sonchus sp.	R/TG-7 (9%,2.00)				
Vernonia cinerea var. *cinerea*	SSF/W-3a (67%,1.10)	SSF-4 (100%,1.00)	R/S/CS-4 (17%,1.00)		
**Xanthium occidentale*	SSF/W-3a (7%,1.00)	SSF/W-5 (9%,1.00)			
AVICENNIACEAE					
Avicennia marina subsp. *australasica*	MF/W-7 (100%,5.00)				
BAUERACEAE					
Bauera capitata	SSS-1a (50%,1.00)	WH-5 (17%,1.00)			
BIGNONIACEAE					
Pandorea pandorana	SSF/W-3a (13%,1.00)				
CAMPANULACEAE					
Wahlenbergia gracilis	SSF-4 (100%,1.00)				
CASUARINACEAE					
Allocasuarina littoralis	SSF/W-3a (13%,2.00)				
Casuarina glauca	SSF/W-3a (93%,2.93)	SSF/W-3b (83%,3.20)	SSF-3c (100%,3.00)	SSF/W-5 (100%,4.45)	SSF/W-6 (100%,4.50)
	MF/W-7 (50%,2.00)	SSS-2a (100%,1.50)	SSS-3 (100%,1.00)	S/SG-2 (50%,1.00)	R/S-3 (60%,1.67)
	R/S/CS-4 (17%,2.00)	R/TG-7 (18%,1.50)			
CHENOPODIACEAE					
**Atriplex prostrata*	R/S/CS-4 (17%,3.00)				
Einadia hastata	SSF/W-5 (18%,1.00)				
Sarcocornia quinqueflora subsp. *quinqueflora*	SSF/W-5 (9%,1.00)	MF/W-7 (50%,1.00)	R/S/CS-4 (17%,1.00)	R/TG-7 (73%,2.75)	CS/TG-8(100%, 5.55)
Suaeda australis	SSF/W-5 (9%,2.00)	R/S-3 (20%,1.00)	R/S/CS-4 (33%,3.00)		
CLUSIACEAE					
Hypericum gramineum	SSF/W-3a (13%,1.00)	SSF-4 (100%,1.00)			
Hypericum japonicum	WH-5 (17%,1.00)				
CONVOLVULACEAE					
Dichondra repens	SSF/W-3a (60%,1.00)	SSF-4 (100%,1.00)	SSF/W-6 (50%,1.00)		
**Ipomoea cairica*	SSF/W-5 (9%,1.00)	R/S/CS-4 (17%,3.00)			
Polymeria calycina	SSF/W-3a (60%,1.00)	SSF-4 (100%,1.00)			
DILLENIACEAE					
Adrastaea salicifolia	WH-5 (17%,2.00)				
Hibbertia dentata	SSF/W-2 (33%,1.50)				
Hibbertia fasciculata	WH-5 (17%,1.00)				
Hibbertia scandens	SSF/W-3a (20%,1.00)				
DROSERACEAE					
Drosera binata	SSF/W-2 (17%,1.00)	WH-5 (17%,1.00)			
Drosera spatulata	SSS-1a (100%,1.50)	SSS-1b (50%,1.00)	WH-5 (33%,1.00)		
EBENACEAE					
Diospyros pentamera	SSF-3c (100%,1.00)				
ELAEOCARPACEAE					
Elaeocarpus obovatus	SSF/W-3a (7%,1.00)	SSF-3c (100%,1.00)			

ERICACEAE					
Epacris microphylla var. *microphylla*	SSS-1b (50%,1.00)	WH-5 (33%,1.50)			
Epacris obtusifolia	SSS-1a (100%,1.00)	SSS-1b (100%,2.00)	WH-5 (83%,1.40)		
Epacris pulchella	SSF/W-2 (17%,1.00)	SSS-1a (50%,1.00)			
Leucopogon juniperinus	SSF/W-3a (7%,1.00)	SSF-4 (100%,1.00)			
Leucopogon lanceolatus var. *gracilis*	SSF/W-2 (50%,1.00)	SSF/W-3a (20%,1.00)			
Sprengelia incarnata	SSS-1a (50%,1.00)	WH-5 (50%,2.33)			
Sprengelia sprengelioides	SSS-1b (100%,1.00)	WH-5 (33%,1.00)			
Trochocarpa laurina	SSF/W-3a (7%,1.00)				
EUPHORBIACEAE					
Homalanthus populifolius	SSF/W-5 (9%,1.00)				
Pseudanthus orientalis	SSS-1a (50%,1.00)	SSS-1b (50%,1.00)	WH-5 (17%,1.00)		
FABACEAE - CAESALPINIOIDEAE					
**Senna pendula* var. *glabrata*	SSF/W-3a (7%,1.00)	SSF-3c (100%,1.00)	SSF/W-6 (50%,1.00)		
FABACEAE - FABOIDEAE					
Almaleea paludosa	SSS-1a (50%,1.00)				
Chorizema parviflorum	SSS-1a (50%,1.00)				
Desmodium brachypodum	SSF/W-2 (17%,1.00)				
Desmodium gunnii	SSF/W-3a (13%,1.00)				
Dillwynia floribunda	SSS-1a (100%,2.00)	SSS-1b (100%,1.50)	WH-5 (50%,1.67)		
Glycine clandestina	SSF/W-3a (33%,1.00)	SSF-4 (100%,1.00)			
Glycine microphylla	SSF/W-3a (13%,1.00)	SSF-4 (100%,1.00)	SSF/W-6 (50%,1.00)		
Gompholobium pinnatum	SSS-1a (100%,1.00)	WH-5 (17%,1.00)			
Kennedia rubicunda	SSF/W-2 (17%,1.00)	SSF/W-3a (60%,1.11)	SSS-2a (50%,1.00)	SSMW-2b (100%,2.00)	
Mirbelia rubiifolia	WH-5 (17%,1.00)				
Pultenaea blakelyi	SSF/W-2 (17%,2.00)	SSF/W-3a (7%,1.00)	SSF/W-3b (17%,1.00)	SSF-3c (100%,1.00)	
Pultenaea retusa	SSF/W-2 (17%,1.00)	SSF/W-3a (27%,1.00)			
Sphaerolobium minus	SSS-1a (100%,1.00)	WH-5 (17%,1.00)			
Sphaerolobium vimineum	WH-5 (17%,1.00)				
FABACEAE - MIMOSOIDEAE					
Acacia elongata	SSF/W-2 (67%,1.00)	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)	WH-5 (33%,1.00)	
Acacia irrorata	SSF/W-3a (13%,1.00)				
Acacia longifolia subsp. *longifolia*	SSF/W-2 (50%,1.00)	SSF/W-3a (27%,1.00)	SSF/W-3b (17%,1.00)	SSF/W-5 (18%,1.50)	SSS-2a (50%,2.00)
Acacia longifolia subsp. *sophorae*	WH-5 (17%,1.00)				
Acacia maidenii	SSF/W-3a (47%,1.14)	SSF/W-6 (50%,1.00)			
GENTIANACEAE					
Centaurium sp.	R/TG-7 (14%,2.00)	CS/TG-8 (9%,1.00)			
Centaurium spicatum	SSF/W-5 (9%,1.00)				
GERANIACEAE					
Geranium homeanum	SSF/W-3a (13%,1.00)				
GOODENIACEAE					
Dampiera stricta	SSS-1a (50%,1.00)	SSMW-2b (100%,1.00)	WH-5 (17%,1.00)		
Goodenia heterophylla subsp. *eglandulosa*	SSF/W-3a (7%,1.00)				
Goodenia ovata	SSF/W-3b (33%,1.00)	SSF/W-6 (50%,2.00)			
Goodenia paniculata	SSF/W-2 (17%,1.00)	SSF/W-3a (33%,1.20)	SSF/W-3b (17%,1.00)		
Goodenia sp.	R/S/CS-4 (17%,1.00)				
Goodenia stelligera	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)	WH-5 (33%,1.00)		

HALORAGACEAE					
Gonocarpus chinensis subsp. *verrucosus*	SSF/W-3a (20%,1.00)				
Gonocarpus micranthus	SSF/W-2 (17%,1.00)	SSF/W-3a (20%,1.00)	SSS-1a (50%,1.00)	WH-5 (17%,1.00)	
Gonocarpus salsoloides	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)			
Gonocarpus tetragynus	SSF/W-2 (50%,1.33)	SSF/W-3a (53%,1.13)	SSF/W-3b (17%,1.00)	SSF-4 (100%,1.00)	
Gonocarpus teucrioides	SSMW-2b (100%,2.00)				
LAMIACEAE					
Lycopus australis	SSF/W-3a (13%,1.00)				
LAURACEAE					
Cassytha glabella forma *glabella*	SSF/W-3a (7%,1.00)	SSF/W-5 (9%,1.00)	SSS-1a (100%,1.00)	SSS-1b (100%,1.00)	WH-5 (67%,1.25)
Cassytha pubescens	SSS-1b (50%,1.00)				
**Cinnamomum camphora*	SSF/W-3a (20%,1.00)				
Endiandra sieberi	SSF/W-3a (7%,1.00)	SSF/W-3b (17%,1.00)			
LENTIBULARIACEAE					
Utricularia australis	SSF-1 (100%,3.00)				
Utricularia gibba	SSF-1 (100%,1.00)	S-1 (33%,3.00)			
Utricularia lateriflora	SSS-1b (50%,1.00)				
LOBELIACEAE					
Isotoma armstrongii	SSF/W-3a (7%,1.00)				
Lobelia alata	SSF/W-3a (67%,1.00)	SSF/W-3b (100%,1.00)	SSF/W-5 (9%,2.00)	R/S-3 (20%,2.00)	R/TG-7 (5%,4.00)
Pratia purpurascens	SSF/W-3a (53%,1.13)	SSF-4 (100%,1.00)			
LOGANIACEAE					
Mitrasacme polymorpha	SSS-1a (50%,1.00)	WH-5 (17%,1.00)			
LORANTHACEAE					
Amyema cambagei	SSF/W-3a (7%,1.00)	SSF/W-3b (33%,1.00)	SSF/W-5 (9%,1.00)		
MALVACEAE					
**Sida rhombifolia*	SSF/W-6 (50%,1.00)				
MENISPERMACEAE					
Stephania japonica var. *discolor*	SSF/W-3a (20%,1.33)	SSF/W-6 (50%,1.00)			
MENYANTHACEAE					
Villarsia exaltata	SSF-1 (100%,1.00)	SSF/W-2 (50%,1.00)	WH-5 (17%,2.00)	S-6 (75%,2.00)	
Villarsia reniformis					
MORACEAE					
Ficus coronata	SSF/W-3a (7%,1.00)				
MYRTACEAE					
Angophora costata	SSF/W-3a (7%,1.00)				
Baeckea imbricata	SSS-1a (100%,1.50)	SSS-1b (100%,1.50)			
Callistemon citrinus	SSF/W-2 (17%,1.00)	SSS-1b (50%,3.00)	WH-5 (83%,1.40)		
Callistemon pachyphyllus	SSF/W-2 (17%,1.00) S-6 (50%,1.50)	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)	SSMW-2b (100%,2.00)	WH-5 (83%,1.60)
Callistemon salignus	SSF/W-3a (53%,1.50)	SSF/W-3b (50%,1.33)	SSF-3c (100%,2.00)		
Corymbia maculata	SSF-4 (100%,1.00)				
Darwinia leptantha	SSS-1b (50%,2.00)	WH-5 (17%,2.00)			
Eucalyptus grandis	SSF/W-3a (27%,2.50)				
Eucalyptus microcorys	SSF/W-3a (7%,1.00)				
Eucalyptus propinqua	SSF/W-3a (7%,2.00)				
Eucalyptus resinifera	SSF/W-3a (7%,3.00)				
Eucalyptus robusta	SSF/W-2 (100%,3.17) SSS-2a (50%,2.00)	SSF/W-3a (67%,2.20) SSMW-2b (100%,4.00)	SSF/W-3b (83%,2.20)	SSF-3c (100%,3.00)	SSS-1b (100%,1.00)

Eucalyptus robusta X *tereticornis*	SSF/W-3b (17%,1.00)				
Eucalyptus siderophloia	SSF/W-3a (7%,1.00)				
Eucalyptus tereticornis	SSF/W-3a (20%,2.33)	SSF/W-3b (17%,1.00)	SSF-3c (100%,2.00)		
Leptospermum arachnoides	SSS-1a (100%,2.00)	SSS-1b (50%,2.00)	WH-5 (17%,1.00)		
Leptospermum juniperinum	SSF/W-2 (17%,1.00)	SSS-1a (50%,1.00)	SSS-1b (50%,1.00)	WH-5 (33%,1.50)	
Leptospermum liversidgei	SSF/W-2 (17%,2.00)	SSS-1a (50%,1.00)	SSS-1b (100%,2.00)	WH-5 (67%,3.75)	
Leptospermum polygalifolium subsp. *cismontanum*	SSF/W-2 (33%,1.50)	SSF/W-3a (13%,2.00)	SSS-1b (100%,2.50)	SSMW-2b (100%,3.00)	WH-5 (33%,1.00)
Leptospermum trinervium	SSF/W-2 (17%,1.00)				
Melaleuca ericifolia	SSF/W-3a (13%,1.50)	SSF/W-3b (33%,2.50)	SSF/W-5 (9%,1.00)	SSF/W-6 (50%,1.00)	SSS-2a (100%,5.00)
Melaleuca linariifolia	SSF/W-2 (67%,1.75) SSS-2a (100%,1.00)	SSF/W-3a (87%,2.31)	SSF/W-3b (83%,2.60)	SSF-3c (100%,3.00)	SSF-4 (100%,3.00)
Melaleuca nodosa	SSF/W-3a (7%,4.00) SSMW-2b (100%,2.00)	SSF/W-3b (17%,2.00)	SSF-4 (100%,5.00)	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)
Melaleuca quinquenervia	SSF-1 (100%,4.00) SSMW-2b (100%,1.00)	SSF/W-2 (50%,3.00) SSS-3 (100%,3.00)	SSF/W-3a (87%,3.15) R/S-3 (20%,1.00)	SSF/W-3b (100%,3.83) WH-5 (17%,1.00)	SSF/W-5 (45%,2.60) S-6 (25%,1.00)
Melaleuca sieberi	SSF/W-2 (33%,3.00) WH-5 (17%,1.00)	SSF-4 (100%,1.00)	SSS-1a (100%,3.00)	SSS-1b (100%,1.50)	SSMW-2b (100%,1.00)
Melaleuca styphelioides	SSF/W-3a (53%,1.50)	SSF/W-3b (33%,2.50)	SSF-3c (100%,2.00)	SSF-4 (100%,2.00)	SSF/W-6 (100%,3.00)
Melaleuca thymifolia	SSF/W-2 (17%,3.00)	SSS-1a (100%,3.00)	SSS-1b (50%,1.00)	SSMW-2b (100%,1.00)	WH-5 (33%,3.00)
Syzygium smithii	SSF/W-3a (7%,2.00)				
OLACACEAE					
Olax stricta	SSMW-2b (100%,1.00)				
OLEACEAE					
Notelaea longifolia forma *intermedia*	SSF/W-3a (13%,1.50)				
ONAGRACEAE					
Ludwigia peploides subsp. *montevidensis*	S-1 (33%,1.00)	S/SG-2 (100%,1.00)			
OXALIDACEAE					
Oxalis exilis	SSF/W-3a (20%,1.00)	SSF-4 (100%,1.00)			
PHYLLANTHACEAE					
Breynia oblongifolia	SSF/W-3a (53%,1.00)	SSF-3c (100%,1.00)	SSF/W-6 (50%,1.00)		
Glochidion ferdinandi var. *ferdinandi*	SSF/W-3a (60%,1.56)	SSF/W-3b (33%,1.00)	SSF-3c (100%,2.00)		
Glochidion ferdinandi var. *pubens*	SSF/W-3a (47%,1.43)	SSF/W-3b (17%,2.00)	SSF-3c (100%,2.00)		
PITTOSPORACEAE					
Billardiera scandens	SSF/W-3a (13%,1.00)	SSF-4 (100%,1.00)			
Pittosporum revolutum	SSF-3c (100%,1.00)				
Pittosporum undulatum	SSF-3c (100%,2.00)				
PLANTAGINACEAE					
**Plantago lanceolata*	SSF/W-3a (7%,1.00)				
POLYGALACEAE					
Comesperma defoliatum	SSF/W-2 (17%,1.00)	WH-5 (17%,1.00)			
POLYGONACEAE					
Persicaria decipiens	SSF-3c (100%,1.00)	S-1 (33%,1.00)	S/SG-2 (50%,1.00)	R/S/CS-4 (17%,2.00)	
Persicaria dichotoma	SSF/W-3a (7%,1.00)				
Persicaria praetermissa	SSF/W-3a (7%,1.00)	S/SG-2 (100%,1.00)			
Persicaria strigosa	SSF/W-3a (7%,1.00)				

PRIMULACEAE					
Myrsine variabilis	SSF/W-3a (7%,1.00)				
Samolus repens	SSF/W-5 (36%,1.75)	SSF/W-6 (50%,3.00)	R/S/CS-4 (17%,1.00)	R/TG-7 (73%,2.44)	CS/TG-8 (64%,2.29)
PROTEACEAE					
Banksia aemula	SSMW-2b (100%,1.00)	WH-5 (17%,1.00)			
Banksia ericifolia subsp. *macrantha*	SSF/W-2 (17%,2.00)	SSS-1a (100%,1.50)	SSS-1b (100%,3.50)	WH-5 (83%,1.00)	
Banksia integrifolia subsp. *integrifolia*	SSF/W-3a (7%,1.00)				
Banksia oblongifolia	SSF/W-2 (17%,1.00)	SSS-1a (100%,3.50)	SSS-1b (100%,2.00)	SSMW-2b (100%,1.00)	WH-5 (50%,3.00)
Banksia robur	SSF/W-2 (33%,2.00)	WH-5 (17%,3.00)			
Banksia spinulosa var. *collina*	WH-5 (17%,1.00)				
Conospermum taxifolium	SSS-1a (50%,1.00)	WH-5 (17%,1.00)			
Hakea teretifolia subsp. *teretifolia*	SSF/W-2 (17%,1.00)	SSS-1a (100%,1.50)	SSS-1b (50%,1.00)	WH-5 (50%,2.67)	
Persoonia lanceolata	SSS-1b (100%,1.50)				
Persoonia levis	SSF/W-3a (7%,1.00)				
Persoonia linearis	SSF/W-3a (13%,1.00)				
Petrophile pulchella	SSS-1a (50%,1.00)	SSS-1b (50%,2.00)			
RANUNCULACEAE					
Ranunculus inundatus	SSF/W-3a (40%,1.00)	SSF/W-3b (17%,1.00)	R/S/CS-4 (17%,4.00)		
Ranunculus lappaceus	SSF/W-3a (13%,1.50)				
RHAMNACEAE					
Alphitonia excelsa	SSF/W-3a (13%,1.00)				
ROSACEAE					
Rubus moluccanus	SSF/W-3a (53%,1.00)				
RUBIACEAE					
Durringtonia paludosa	SSF/W-2 (50%,1.33)				
Galium binifolium	SSF/W-3a (13%,1.00)				
Galium propinquum	SSF/W-3a (7%,1.00)				
Morinda jasminoides	SSF/W-3a (13%,1.00)	SSF-3c (100%,1.00)			
Opercularia aspera	SSMW-2b (100%,2.00)				
Opercularia diphylla	SSF/W-3a (20%,1.00)	SSF-4 (100%,1.00)			
Opercularia varia	SSMW-2b (100%,2.00)				
Pomax umbellata	SSF/W-2 (17%,2.00)				
RUTACEAE					
Acronychia oblongifolia	SSF/W-3a (7%,1.00)	SSF-3c (100%,1.00)			
Boronia falcifolia	SSS-1a (50%,1.00)	SSS-1b (100%,1.50)	WH-5 (17%,2.00)		
Boronia parviflora	SSS-1a (100%,1.00)	SSS-1b (50%,1.00)	WH-5 (33%,1.00)		
SANTALACEAE					
Exocarpos cupressiformis	SSF/W-5 (9%,1.00)				
Notothixos subaureus	SSF/W-3a (7%,1.00)	SSF/W-5 (9%,1.00)			
SAPINDACEAE					
Cupaniopsis anacardioides	SSF/W-3a (7%,1.00)	SSF/W-5 (18%,1.50)			
Guioa semiglauca	SSF/W-3a (7%,1.00)				
SCROPHULARIACEAE					
Bacopa monnieri	SSF/W-3a (13%,1.00)	SSF/W-5 (9%,1.00)	SSS-3 (100%,1.00)		
Mimulus repens	R/S-3 (20%,2.00)				
Myoporum acuminatum	SSF/W-5 (18%,1.00)	SSF/W-6 (50%,4.00)			
Veronica plebeia	SSF/W-3a (13%,1.00)				

SOLANACEAE					
Duboisia myoporoides	SSF/W-3a (20%,1.66)				
Solanum americanum	SSF/W-3a (7%,1.00)	SSF/W-6 (50%,1.00)			
**Solanum mauritianum*	SSF/W-3a (20%,1.00)				
Solanum prinophyllum	SSF/W-3a (20%,1.00)	SSF/W-5 (9%,1.00)	SSF/W-6 (50%,1.00)		
STACKHOUSIACEAE					
Stackhousia nuda	SSS-1a (100%,1.00)				
STYLIDIACEAE					
Stylidium graminifolium	WH-5 (17%,1.00)				
THYMELAEACEAE					
Pimelea linifolia	SSF/W-2 (17%,1.00)	SSF/W-3a (13%,1.00)	SSS-1a (50%,1.00)	SSS-1b (50%,1.00)	WH-5 (33%,1.00)
Wikstroemia indica	SSF/W-3a (7%,1.00)				
VERBENACEAE					
**Lantana camara*	SSF/W-3a (47%,1.57)	SSF-3c (100%,1.00)	SSF/W-6 (100%,1.00)		
**Verbena bonariensis*	SSF/W-3a (7%,1.00)				
VIOLACEAE					
Hybanthus stellarioides	SSF-4 (100%,1.00)				
Viola banksii	SSF/W-3a (100%,1.87) R/S/CS-4 (17%,2.00)	SSF/W-3b (50%,1.00)	SSF/W-5 (18%,1.00)	SSF/W-6 (100%,3.00)	SSS-2a (50%,1.00)
VITACEAE					
Cayratia clematidea	SSF/W-6 (50%,1.00)				
Cissus antarctica	SSF/W-2 (17%,1.00)				