Wallum and related vegetation on the NSW North Coast: description and phytosociological analysis

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Abstract: Wallum is the regionally distinct vegetation on coastal dunefields, beach ridge plains and sandy backbarrier flats in subtropical northern NSW and southern Queensland (22°S to 33°S). This study examined floristic patterns in the wallum and allied vegetation along 400 km of coastline in north-eastern NSW. Floristic and environmental data were compiled for 494 quadrats allocated on the basis of air photo pattern and latitude. A phytosociological classification displayed strong congruence with an initial classification based upon photo pattern, especially for single stratum vegetation, thereby suggesting that API (air photo interpretation) is a valuable technique for the recognition of floristic assemblages. The utility of API for depicting the spatial distribution of tallest stratum species in multi-stratum vegetation was also confirmed. Nonetheless, photo signatures of the tallest stratum are less satisfactory as surrogates for identifying noda for the full complement of species in multi-stratum vegetation. Ordination supported the numerical classification, and reinforced the value of API for capturing meaningful biological and environmental data. Plant – environment relationships were examined for a range of variables. The consistent trend to emerge was a comparatively strong correlation between floristic composition and topographic position, and in some instances also between floristic composition and geology. Mean species richness at the 25 m^2 scale was lower in wetter habitats, although differences were not consistently significant.

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Introduction

Use of the term wallum

The coastal lowlands of southern Queensland and northern NSW were extensively forested at the time of European settlement, and in this setting sand mass vegetation would have been visually distinct. Aboriginal people apparently recognised the differences, and in south-eastern Queensland they applied the name 'wallum' to heathlands and associated *Banksia aemula* shrublands of beach ridge plains and backbarrier flats, or more specifically to either of two *Banksia* species (*B. aemula* and *B. oblongifolia*) (Baxter 1968, Blake 1938, 1947, 1968, Whitehouse 1967, 1968). The term wallum has since been used more generally to include not only sand mass heathland and shrubland, but also various forest, woodland, sedgeland and grassland communities (Batianoff & Elsol 1989, Coaldrake 1961).

It seems that wallum may be applied in either a narrow sense or a much broader one. Orchard (1995), in the glossary supplements to *Flora of Australia*, defines wallum as 'coastal vegetation on sandy acidic soils, in south-eastern Queensland'. However, wallum is also a recognised botanical term for NSW where it is applied to a particular habitat or ecosystem — 'sandy coastal sites with impeded drainage, usually supporting heath, scrubby communities or swamps' (Harden 1993). For the purposes of the present study, wallum is simply defined as the vegetation, across the full range of structural formations, occurring on dunefields, beach ridge plains and sandy backbarrier flats in southern Queensland and northern NSW. These sand masses are concentrated between Newcastle (33°S) and the Shoalwater Bay region (22°S) near Rockhampton, with scattered occurrences further north and south (Thompson 1983). 'Sand plain' vegetation in south-western Australia is similarly known by an Aboriginal name, 'kwongan' (Beard 1976, Brown 1989, Brown & Hopkins 1983, Hnatiuk & Hopkins 1980, Orchard 1995). Although heathlands and shrublands are conspicuous in the kwongan, Hopkins and Hnatiuk (1981) point to the presence of other structural formations such as woodland. On this basis, they favour a broader usage of kwongan for reference to sand plain vegetation generally.

Scope and objectives of the study

This study is concerned with wallum structural formations other than forest and woodland. Also considered are sod grassland, tussock grassland, heathland and shrubland formations on bedrock soils of headlands and coastal hills, or heavier-textured soils of backbarrier flats. These were included because of their close proximity to wallum, and because they support many of the same species (Griffith & Williams 1997). Alluvial floodplain vegetation,which includes various sedgelands, rushlands and forblands, often adjoins wallum vegetation at its inland extremities, but this was excluded from the study. Floodplain vegetation, in particular wetland, shares some species in common with wallum although it is generally distinguishable in terms of either species dominance or overall floristic composition, and also on the basis of substrate (Goodrick 1970, Pressey 1987a,b, Pressey & Griffith 1987). Estuarine and beach strand vegetation was also excluded. Existing accounts of estuarine vegetation include Adam et al. (1988) and West et al. (1984), while Clarke (1989) and Griffith et al. (2000) describe vegetation associated with beaches.

The practice of distinguishing vegetation types by their physiognomy has a strong tradition in Australian plant ecology (Beadle 1981, Beadle & Costin 1952, Beard 1981, Carnahan 1981, Specht 1981, Specht et al. 1974, Walker & Hopkins 1984, Webb & Tracey 1981). Spatial patterns in the wallum and associated vegetation of eastern Australia can be delineated on the basis of air photo signature (Durrington 1977, Griffith 1983, Griffith et al. 2000, Myerscough & Carolin 1986). Air photo interpretation (API) is a widely used technique for portraying patterns of physiognomy and floristic composition of the dominant (tallest) vegetation layer or stratum. API groups generally display a degree of floristic homogeneity for the tallest stratum, but this may not be the case for understorey strata. Conversely, it may be possible to distinguish different structural formations on aerial photographs (e.g. shrubland and heathland), even though there is little obvious difference in floristic composition. API is also scale dependent, and it is sometimes possible to further subdivide map units with the aid of larger scale photography.

The potential limitations of vegetation classifications based upon API have ramifications for the identification of plant communities where a consideration of complete floristic composition is desirable, and in turn for the interpretation of spatial, biogeographical and plant – environment relationships (Adam et al. 1989, Bridgewater 1981, Dale et al. 1988, Hunter & Clarke 1998). Even so, vegetation mapping derived from API forms the basis of resource management in many coastal reserves of northern NSW, particularly in the design of fire management prescriptions to maximise species biodiversity (NSW National Parks & Wildlife Service 1997, 1998a,b). This application of API has proceeded in the absence of a regional phytosociological analysis of heathland and related formations (cf. NSW National Parks and Wildlife Service 1999, for forest and woodland).

In view of the known or perceived limitations of vegetation classifications based solely upon API, a methodology was designed to achieve the following objectives:

(a) explore phytosociological relationships in the wallum and related vegetation of northern NSW, using cover-abundance data for all vascular species;

(b) examine the phytosociological groups for plant – environment relationships;

(c) as a measure of the utility of API for depicting spatial and biogeographic relationships, and plant – environment relationships, assess the degree of congruence between the floristic groups derived in (a) and existing API groups.

The study area (Fig. 1) extended from Crowdy Bay National Park (NP) near Taree (31°53'S 152°39'E) northwards to Newrybar Swamp near Lennox Head (28°44'S 153°36'E). This coincided with available vegetation mapping at the time the study was initiated in 1996. More recently, vegetation maps were prepared for Booti Booti NP (Griffith et al. 2000) and Khappinghat NP (Griffith & Wilson 2000) to the south of Crowdy Bay NP. The study area occurs within the North Coast botanical subdivision (Anderson 1961).

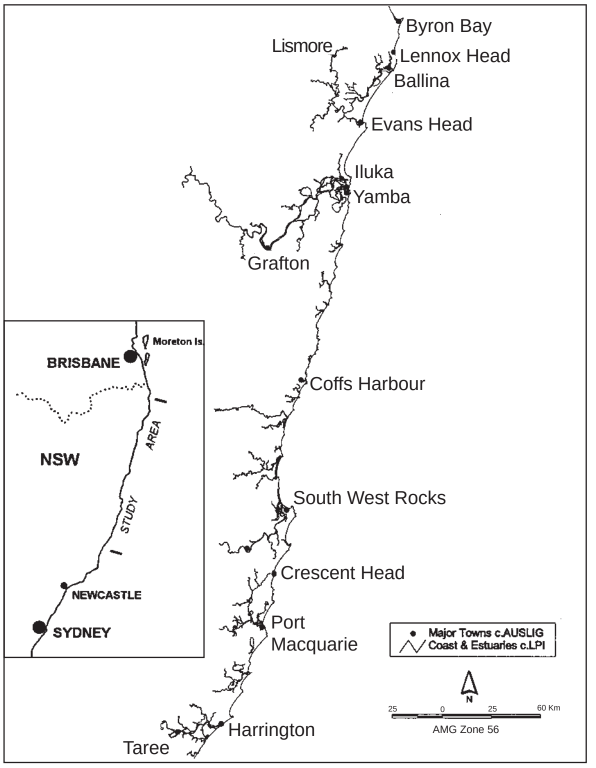


Fig. 1. The study area along the coast of north-eastern NSW

Climate

The climate of coastal northern NSW and southern Queensland is subtropical with summer-dominant rainfall (Colls & Whitaker 1990). The general pattern is one of hot, wet and humid summers followed by drier, cooler winters. Periods of heavy summer rainfall may be associated with the passage of tropical cyclones (Bureau of Meteorology 1972, NSW Water Conservation & Irrigation Commission 1970, Thompson & Moore 1984). More southerly parts of coastal NSW experience cooler conditions and a less pronounced dry season, and this climatic pattern is described as temperate with uniform rainfall (Colls & Whitaker 1990).

Climatic data for several coastal weather stations in northern NSW were sourced from the Bureau of Meteorology (pers. comm. 2000). These stations were selected on the basis of location, and the duration and completeness of their data – Byron Bay, Yamba, Coffs Harbour, South West Rocks, Port Macquarie, Harrington and Newcastle. Mean monthly rainfall and temperature data the upper (Byron Bay), mid- (South West Rocks) and lower (Newcastle) North Coast are summarised in Figure 2.

Mean annual rainfall ranges from 1144 mm at Newcastle to 1746 mm at Byron Bay, and the lowest totals occur on the lower North Coast (Harrington and Newcastle). The three consecutive months with the highest average rainfall generally occur between January and May inclusive.

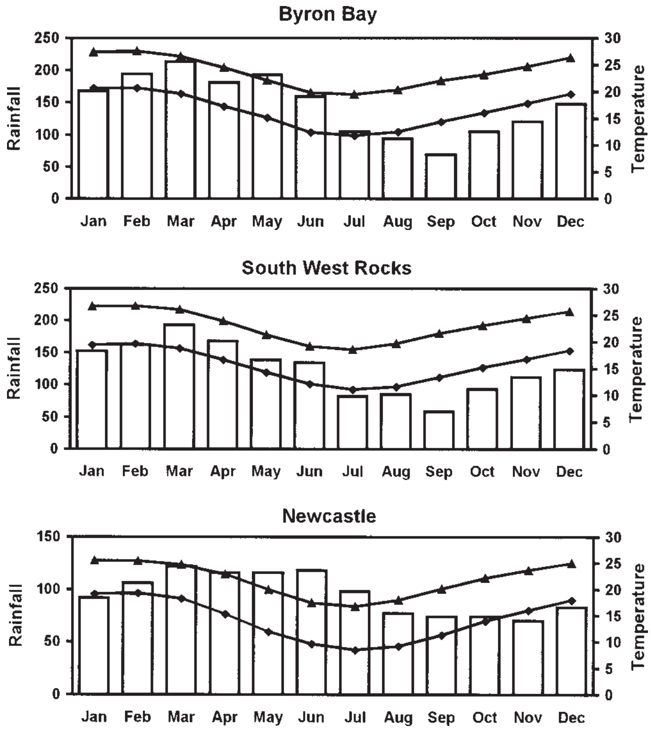


Fig. 2. Climatic data for the coast of northern NSW. Mean monthly trends for total rainfall (mm), and maximum and minimum temperature (°C).

However, on the lower North Coast the wettest three-month period occurs from March to June inclusive, and therefore the heaviest monthly falls may extend into early winter. Total mean rainfall for the three wettest months varies from 356 mm at Newcastle to 637 mm at Coffs Harbour. Total mean rainfall for the three driest months ranges from 215 mm at Yamba to 267 mm at Byron Bay. Although each weather station records a seasonal period of lower rainfall from mid-winter into spring, the difference between wet and dry seasons is less pronounced on the lower North Coast. Late winter–spring is generally a period of water stress in coastal southern Queensland where evaporation is high relative to monthly rainfall (Coaldrake 1961, Thompson & Moore 1984). An equivalent period of water deficit is also likely in coastal northern NSW, particularly in years of below-average rainfall (NSW Water Conservation & Irrigation Commission 1970). This is the so-called period of late winter–spring ‘drought’ (Coaldrake 1961).

Exceptionally high monthly rainfall totals in excess of 500 mm have been recorded for each weather station, with the highest at Port Macquarie (1388 mm in January) and Harrington (1045 mm in February). Unusually high monthly totals have also occurred in months that are, on average, relatively dry. Rainfall variability is also reflected in the incidence of extremely low monthly totals, and all weather stations other than Byron Bay have at some time recorded monthly totals of 20 mm or less during the seasonally wettest three-month period.

There is a general north – south gradient in temperature, from a mean annual maximum of 23.7°C at Byron Bay to 21.8°C at Newcastle. The latitudinal trend for mean annual minimum temperature is not so well defined, although there is nonetheless a tendency to lower values with increasing latitude. Byron Bay has recorded the highest mean annual minimum temperature (16.5°C), and the lowest is recorded for Port Macquarie (13.0°C). The three months with the highest mean daily maximum temperature occur in the period December to March inclusive (26.6–27.5°C at Byron Bay, down to 24.9–25.5°C at Newcastle). June, July and August register the lowest mean daily maxima (19.4–20.3°C at Byron Bay, down to 16.7–17.9°C at Newcastle).

Maximum daily temperatures in excess of 40°C are known for six of the seven weather stations, and the highest readings are reported for Harrington (43.3°C), Coffs Harbour (43.3°C) and Port Macquarie (42.3°C). Coffs Harbour, Harrington and Newcastle have recorded minimum daily temperatures of 0°C or less. Frosts are rare or uncommon along the immediate coastline in northern NSW and southern Queensland, although they can be expected at short distances inland during the coldest months (Coaldrake 1961, NSW Water Conservation & Irrigation Commission 1966, 1968, 1970).

Across all weather stations, mean annual 9 am relative humidity ranges from 68–78%. Similarly, mean annual 3 pm relative humidity ranges from 63–71%. There is a tendency for mean monthly relative humidity to be lower in the winter –spring period, which is also the time of generally lower rainfall.

Strong winds often associate with tropical cyclones and thunderstorm squalls, or occasionally with tornadoes, and these can be very destructive in northern NSW and southern Queensland (Bureau of Meteorology 1972, Coaldrake 1961, NSW Water Conservation & Irrigation Commission 1968, 1970, Thompson & Moore 1984). Coaldrake (1961) noted complete defoliation of eucalypt forest during cyclonic winds on the coastal lowlands of southern Queensland. The highest monthly maxima in northern NSW are registered for Newcastle (171 km/hr) and Coffs Harbour (124 km/hr). Hail can also result in severe localised damage to vegetation, and the Bureau of Meteorology (1972) estimates that any particular location along the far North Coast of NSW may experience hail at a frequency of about once in five years, particularly in October and November. Hail is frequently associated with thunderstorms (Coaldrake 1961), and under these conditions strong wind gusts are likely.

Landforms, geology and soils

Quaternary sediments of marine-aeolian and estuarine origin are extensive along the coast of northern NSW and southern Queensland (Coaldrake 1961, Roy & Hann 1983, Thompson & Moore 1984). These sediments are most evident as dunefields, beach ridge (strand) plains and backbarrier flats, and sand mass deposits in particular are noted to have a complex pre-depositional history (Tejan-Kella et al. 1991). Beach ridge plains display a characteristic pattern of ridge and swale topography, although in time slope processes operate to subdue this pattern (Thom et al. 1981). Compound dunes reach maximum elevations of around 260–280 m in southern Queensland (Coaldrake 1962, Thompson & Hubble 1980, Thompson & Moore 1984), and it is not uncommon for dunefields to contain perched swamps in swales well above sea level where a concave layer of indurated sand retards drainage (Coaldrake 1962, Heyligers et al. 1981, Reeve & Fergus 1982).

Apart from instances of aeolian reworking (Thom et al. 1981, Roy 1982), and despite apparent high wind intensities during the Last Glacial, geomorphic and pedological evidence suggests that extensive pre-glacial beach ridge plains and dunefields still evident today in northern NSW and southern Queensland have carried vegetation since deposition (Pickett et al. 1984, Thompson 1981, 1992, Walker et al. 1981). This indicates that precipitation levels remained effective for plant growth, and fossil evidence suggests that the continuous vegetative cover throughout the Last Glacial was very similar to contemporary wallum (Anon 1984, Ball 1924; Coaldrake 1962, Longmore 1997, Pickett et al. 1984, Walsh & Roy 1983, Whitehouse 1968).

Thompson and Hubble (1980) recognise three general forms of B horizon and hence soil type in sand masses, with differences linked to the degree of drainage and duration of weathering (see also Maze 1942). Iron Podzols display shallow or rudimentary profile development, and sesquioxide strongly dominates the B horizon in the absence of prominent organic enrichment. Humus-Iron Podzols of older, free-draining sites have B horizons in which both sesquioxide and organic compounds are prominent. Humus Podzols develop where influenced by intermittent or permanent watertables, and organic compounds are strongly dominant in the B horizon whereas iron accumulations other than thin pans are generally lacking. Under increasingly waterlogged conditions, Humus Podzols are replaced by Peaty Podzols (with a peat-rich A1), and then in turn by Acid Peats. With continued weathering of deep sand deposits over a long period of time, B horizons may migrate to depths of 4–10+ m below the ground surface. Although B horizons retard soil water drainage, they are nonetheless permeable to a varing extent (Reeve & Fergus 1982).

For use in agriculture and forestry, wallum soils are relatively infertile and deficient in various plant nutrients (Atkinson 1999, Coaldrake 1961, Thompson & Hubble 1980). Nonetheless, dunefields and beach ridge plains may support well-developed rainforest, or sclerophyll forest of *Eucalyptus*, *Corymbia* and allied genera in which the tallest stratum reaches heights of 35 m or more (Floyd 1990, Walker et al. 1981, Young & McDonald 1987). Despite the extremely siliceous composition of the soil parent material, proximity to the ocean ensures comparatively high inputs of seawater-derived nutrients such as the common metallic cations and sulphur (Charley & Richards 1991, Charley & Van Oyen 1991). Other nutrients such as phosphorus are a minor component of seawater, and therefore may be limiting.

The soils supporting heathland, shrubland and grassland on headlands, coastal hills, and flats associated with plains and backplains are often heavier-textured than soils associated with wallum on dunefields and beach ridge plains. Bedrock outcrops supporting coastal heathland and allied vegetation in north-eastern NSW have varied lithology, for example adamellite, rhyolite, sandstone or shale (Geological Survey of NSW 1970, 1971), and it appears that cyclic salt accessions are comparatively important to soil formation processes (e.g. Atkinson 1999). Soils on headlands and coastal hills include Lithosols, Yellow Earths, Yellow Podzolic Soils, Soloths and, after Parbery (1947), Black Headland Soils. Soils to be expected on flats include Acid Peats, Humic Gleys, Yellow Earths, and Yellow and Brown Podzolic Soils (Atkinson 1999, Griffith 1992a, Stone 1982). From an agricultural perspective, these soils are likely to display low fertility and nutrient deficiencies, low available waterholding capacity, and high aluminium toxicity potential (e.g. Atkinson 1999). The soils on elevated aspects are susceptible to waterlogging after high rainfall events, and those in low-lying areas are periodically saturated or inundated by a rising watertable.

South-eastern Queensland and north-eastern NSW are geologically similar. Shared soil parent materials are associated with strata of the Mesozoic Clarence–Moreton Basin (McElroy 1962, 1969), and older basement sequences such as the Palaeozoic Beenleigh Association (Korsch 1977). Tertiary basalts and associated rock types occur in both regions (eg. the Lamington Volcanics), along with extensive Quaternary sand mass, estuarine and floodplain deposits. Similarities in the coastal vegetation of both regions are noted in various studies (Beadle 1981, Griffith et al. 2000, McDonald & Elsol 1984, Myerscough & Carolin 1986).

Landuse and fire history

The coastal lowlands of north-eastern NSW are ancestral homelands to several groups of Aboriginals, for example the Bundjalung north of the Clarence River, the Kumbaingirri to the south, and the Biripi further south again. Material evidence of an extensive Aboriginal culture remains as camp sites, middens, rock shelters, fish traps, ceremonial grounds, tool manufacture sites, and marked or otherwise scarred trees. Many landforms are also important to Aboriginal mythology and customs, for example Lake Ainsworth at Lennox Head, Salty Lagoon in Broadwater NP, Goanna Headland at Evans Head, and North Brother, Middle Brother and South Brother Mountains between the Hastings and Manning Rivers. A large Kurrajong tree, *Brachychiton populneus*, still stands on an extensive midden along the bank of the Evans River in Bundjalung NP. It appears that Aboriginals from as far inland as Glen Innes travelled to the coast to trade. Kurrajong seed was one such item of trade, and this was used to prepare a beverage (Martin 1976). Despite the upheaval of their culture since European occupation, the Aboriginal groups of north-eastern NSW maintain a strong affinity with the lowlands.

The first European settlers in far north-eastern NSW were cedar getters, and they moved progressively northward in the early to mid 1800s. Graziers followed, at first relying upon native pasture. Cropping commenced on the Clarence River floodplain in 1864 with the establishment of sugar cane farms, and subsequently on the Richmond and Tweed River floodplains. Mining has occurred since the first half of the 1800s, particularly for gold, tin, antimony, silver, copper, manganese and mineral sands (NSW National Parks & Wildlife Service 1995). In 1948, A.P. Roux produced four tonnes of mixed concentrates at Jerusalem Creek near Evans Head, so beginning a period of rutile and zircon mining (Morley 1981). Mineral sand mining operations still continue over limited areas, and sand extraction for glass manufacture occurs in dunefields on the lower North Coast. These latter operations quarry thick deposits of bleached sand (the A2 horizon of podzols).

In 1968 the NSW Parliament held an inquiry into conflicts between mineral sand mining and nature conservation (the 'Sim Committee' enquiry), and as a result examples of wallum along the North Coast were set aside for conservation. Extensive areas of relatively undisturbed wallum and associated vegetation are now reserved in national parks and nature reserves in north-eastern NSW, in addition to many regenerating mine paths. Other reminders of European landuse in these reserves include broken and fallen fencelines, waterholes, ringbarked trees, stumps and disused log dumps, the ruins of stockyards and buildings, and the small clearings of beekeepers. Feral horses and pigs disturb soil and native vegetation in some areas, and illegal cattle grazing occurs from time to time. Invasive weeds include *Chrysanthemoides monilifera* subsp. *rotundata* (Bitou Bush) and *Baccharis halimifolia* (Groundsel Bush), particularly along foredunes and estuaries, although the older, strongly podzolised sand masses remain comparatively weed-free.

John Oxley provided a brief account of wallum on the North Coast. He and his men travelled south through what is now Crowdy Bay NP in October 1818: '… the low part of the country was an entire fresh water swamp, interspersed with thick barren brush ...' (in Birrell 1987).

Wallum is very flammable, and wet heathland can be regularly burnt at three-year intervals if conditions are conducive for ignition (S. Griffith unpub. data). It appears that most fires in the wallum of northern NSW over the last few decades have been unplanned and deliberately ignited (NSW National Parks & Wildlife Service 1997, 1998a,b). This scenario probably also reflects trends for a longer period of European settlement because prior to reservation for nature conservation wallum was utilised as unimproved pasture and also for harvesting of Christmas Bell, *Blandfordia grandiflora*. Both activities were promoted by regular burning.

Fire ecology studies on the upper South Coast, Central Coast and lower North Coast of NSW collectively suggest that fires of optimal intensity at intervals of around 10–15 years are likely to promote adequate regeneration of both resprouter and seeder species (Auld 1987, 1990, Benson 1985, Bradstock 1990, Bradstock & O'Connell 1988, Fox & Fox 1986, Nieuwenhuis 1987, Vaughton 1998). Nonetheless, some variation in the length of inter-fire intervals may facilitate the maximisation of species richness (Morrison et al. 1995). Current fire management prescriptions advocate a general avoidance of successive fires at intervals of less than 8 years, avoidance of successive fires at intervals greater than 15 years, and a maximum inter-fire interval of 30 years (NSW National Parks & Wildlife Service 1997, 1998a,b).

Methods

Vegetation mapping and classification using air photo interpretation

Detailed vegetation mapping is available for all major occurrences of wallum and related vegetation in NSW north from the Forster district (Griffith et al. 2000). Several national parks and nature reserves sample this vegetation in northern NSW, and from north to south these include Broadwater NP, Bundjalung NP, Yuraygir NP, Moonee Beach Nature Reserve (NR), Hat Head NP, Limeburners Creek NR, Lake Innes NR, Kattang NR, Crowdy Bay NP, Booti Booti NP, Myall Lakes NP and Tomaree NP. Significant areas of wallum also occur on freehold or crown land outside the reserve system, for example Newrybar Swamp at Lennox Head, and lands at Evans Head north and south of the Evans River.

Conventional API techniques were used to map vegetation in the study area. R. Wilson (formerly NSW National Parks and Wildlife Service) completed this task in collaboration with S.J. Griffith. The mapping program was initiated in the early 1980s to provide a basic understanding of the spatial distribution of coastal vegetation along the North Coast for the purposes of conservation planning and management. The methodology and limitations are discussed in Griffith et al. (2000).

The structural classification of Walker and Hopkins (1984) was used for mapping and vegetation description, and height and crown cover of the tallest stratum are expressed using classes (e.g. mid-high closed heathland, tall closed sedgeland). Subformation names were adopted from the classification proposed by Beadle and Costin (1952), although with some modifications and additions (e.g. wet or dry heathland, and swamp or dry sclerophyll shrubland).

As is generally the case for vegetation description based upon photo pattern, the API groups were named after dominant indicator species of the tallest (dominant) stratum. Most of the groups so described could be considered associations using the definition of Beadle (1981), 'a community in which the dominant stratum exhibits uniform floristic composition, the community usually exhibiting uniform structure (also)'. In applying Beadle's definition, it was assumed that a particular stand was structurally uniform if it spanned two or less height classes, and two or less crown cover classes. In this way, for example, *Banksia aemula* tall sparse to open shrubland (crown cover very sparse to sparse) could be considered a separate association from *B. aemula* tall shrubland and closed shrubland (crown cover mid-dense to dense). Five-digit numeric codes were used for mapping purposes to delineate API groups. The first four digits of each code identify the formation, subformation and dominant tallest stratum species. As an illustration, map codes 5200–5599 are reserved for formations in which the tallest stratum is dominated by shrubs i.e. shrubland. In the shrubland formation, map codes 5400–5499 are used for API groups in the dry sclerophyll shrubland subformation. Dry sclerophyll shrubland in which *Banksia aemula* is the characteristic dominant has the map code 5402. A fifth digit is used on vegetation maps to signify the crown cover range of the tallest stratum in each polygon: 1 = mid-dense to dense (e.g. 5402<u>1</u> for *B. aemula* shrubland and closed shrubland); and 2 = very sparse to sparse (e.g. 5402<u>2</u> for *B. aemula* sparse shrubland and open shrubland). Sun et al. (1997) compare this method of vegetation classification and mapping (as 'NSW National Parks and Wildlife Service Coastal Vegetation Mapping') with systems in use for other parts of NSW and Australia.

Sample stratification

The existing mapping was used for sample stratification. Sites were allocated on an area-proportional basis to each API group, and spread by initially subdividing the study area into four roughly equal bands of latitude (Table 1). Rare API groups were deliberately captured in the stratification process by assigning a minimum of one site per latitude band regardless of the area occupied. The total area of wallum and associated vegetation considered during the stratification process exceeded 27 000 ha.

Sites were remotely chosen using the vegetation mapping and additional API, and predetermined locations were marked on aerial photographs prior to entering the field. Once in the field, every endeavour was made to locate each site within 50 m of its predetermined location (i.e. within 2 mm at a scale of 1: 25 000); although where unavoidable due to disturbance or other unforeseen limitations, sites were relocated at a distance of no more than 100 m. In rare instances a site was relocated to a distance greater than 100 m. This was necessary where an error in the vegetation mapping became apparent during the fieldwork, or where the vegetation had changed. An example of the latter is the conversion of *Banksia ericifolia* subsp. *macrantha* swamp sclerophyll shrubland into wet heathland with the passage of fire. *Banksia ericifolia* subsp. *macrantha* is a bradysporous obligate seeder, and adult shrubs are readily killed by fire. Upon the death of the *B. ericifolia* subsp. *macrantha* overstorey, understorey species assume dominance as a structurally lower heathland formation.

Data collection

Each site generally consisted of a 30 × 20 m rectangular plot aligned across the slope, and this plot was in turn subdivided using a 10 × 10 m grid. A 15 × 10 m rectangular plot was used for structurally and floristically simple vegetation such as sedgeland. Two 10 × 10 m quadrats were randomly selected in each rectangular plot or, for the simpler vegetation, two 5 × 5 m quadrats. Species-area curves were used to determine these quadrat sizes. A complete list of vascular species was compiled for each quadrat, and each species was assigned to one of six foliage cover classes: 1 (<1%); 2 (1–5%); 3 (6–25%); 4 (26–50%); 5 (51–75%); and 6 (76–100%). Foliage cover is the percentage of a quadrat occupied by the vertical projection of foliage and branches (Walker & Hopkins 1984). To facilitate comparisons of species richness at a standard scale (in this case 25 m^2), a 5 × 5 m quadrat was nested within each 10 × 10 m quadrat and a separate list of vascular species compiled. Vegetation structure was recorded for every quadrat, in particular the height and total foliage cover of each stratum.

In addition to observations of structure and floristic composition, the following categorical and numerical environmental variables were determined for each quadrat:

(a) geology, as unconsolidated Quaternary sediments or one of three rock types (sedimentary–undifferentiated, igneous–adamellite, volcanic–rhyolite);

(b) aspect (°);

(c) slope (°);

(d) altitude above sea level (m);

(e) topographic position (after Speight 1984) using categories for landform morphological type (C = crest, D = closed depression, F = flat, L = lower slope, M = mid-slope, R = ridge, S = simple slope, U = upper slope, V = open depression) and landform element (BKP = backplain, BRI = beach ridge, DDE = drainage depression, DUN = dune, FOR = foredune, HCR = hillcrest, HSL = hillslope, LAK = lake, PLA = plain, SWL = swale, SWP = swamp);

(f) geographic location (easting and northing);

(g) degree of exposure, determined as the azimuth (°) for each of the eight principal compass bearings; and

(h) time elapsed since last burnt (0–5 years, 5–10 years, or >10 years), determined from fire history records held by the National Parks and Wildlife Service or otherwise estimated by field observation of incremental post-fire branching in species calibrated prior to sampling (*Banksia ericifolia* subsp. *macrantha* and *B. oblongifolia*).

Sampling of 494 randomly paired quadrats at 247 sites proceeded between March and October 1996, and at this time each site was permanently marked. Unfortunately, large areas of *Banksia ericifolia* subsp. *macrantha* shrubland (API group 55031) identified for sampling had reverted to heathland following the passage of fire. The target number of sites for this API group was not achieved, and only two were successfully allocated. A total of 441 plant taxa were observed during sampling. The nomenclature is generally consistent with current usage at the Royal Botanic Gardens (Sydney), and authorities are provided in Harden (1990–3, 2002) or Harden and Murray (2000).

Table 1. Areas of API groups of wallum and associated vegetation in latitude bands used to stratify sampling sites.

Band A: Newrybar Swamp (Lennox Head) to near Yamba. Band B: Yamba to Coffs Harbour. Band C: Coffs Harbour to Crescent Head. Band D: Crescent Head to Harrington. Each latitude band ranged over 40–50'. Plant communities were mapped using conventional API techniques at 1: 25 000 scale and a minimum polygon size of approximately 1 ha. Missing API codes apply to vegetation types (from broader inventory projects) not sampled in the present study.

			Latitude band (hectares)				
Formation, subformation	**API code**	**API group**	**A**	**B**	**C**	**D**	**Total**
Dry sclerophyll tree mallee	50021/2	*Eucalyptus pilularis*	703	9	0	25	737
	50031/2	*Eucalyptus signata*	13	0	0	7	20
	50041/2	*Eucalyptus planchoniana*	109	244	0	85	438
	50071	*Eucalyptus pilularis – E. planchoniana – Corymbia gummifera*	0	0	420	0	420
Swamp sclerophyll tree mallee	51021/2	*Eucalyptus robusta*	4	2	0	2	8
Dry sclerophyll shrubland	54021/2	*Banksia aemula*	2179	390	181	749	3499
	54031/2	*Banksia aemula – Allocasuarina littoralis*	39	0	0	45	84
	54051	*Banksia serrata – Allocasuarina littoralis – Leptospermum trinervium*	14	0	0	0	14
Swamp sclerophyll shrubland	55031	*Banksia ericifolia* subsp. *macrantha*	121	32	24	445	622
	55041	*Leptospermum juniperinum*	4	0	0	32	36
	55061/2	*Melaleuca quinquenervia*	202	21	46	1	270
	55081/2	*Melaleuca sieberi*	44	13	0	9	66
	55101	*Leptospermum speciosum*	1	0	0	0	1
	55111	*Leptospermum whitei – L. polygalifolium* subsp. *cismontanum*	5	0	0	0	5
Dry sclerophyll shrub mallee	56021	*Lophostemon confertus*	1	0	0	0	1
	56031/2	*Eucalyptus pilularis*	336	0	0	0	336
	56041	*Eucalyptus planchoniana*	32	0	0	0	32
Swamp sclerophyll shrub mallee	57022	*Eucalyptus robusta*	12	0	0	3	15
Dry heathland	58021	*Banksia aemula*	1168	653	115	785	2721
	58031	*Banksia aemula – Allocasuarina littoralis*	24	20	3	87	134
Graminoid clay heathland	59021	*Banksia oblongifolia – Allocasuarina littoralis – Aristida warburgii – Ptilothrix deusta*	40	1167	0	0	1207
	59031	*Banksia oblongifolia – Allocasuarina littoralis – Hakea teretifolia* subsp. *teretifolia – Aristida warburgii – Ptilothrix deusta*	0	0	0	105	105
	59041	*Banksia oblongifolia – Allocasuarina littoralis – Hakea teretifolia* subsp. *teretifolia – Aristida warburgii – Themeda australis*	0	0	21	0	21
Wet heathland	60021	*Banksia oblongifolia – Leptospermum liversidgei – Sporadanthus interruptus – Sprengelia sprengelioides – Xanthorrhoea fulva*	3350	1266	471	3582	8669
	60031	*Leptospermum juniperinum*	30	19	58	36	143
	60041	*Xanthorrhoea fulva*	309	121	0	1057	1487
	60071	*Banksia oblongifolia – Leptospermum polygalifolium* subsp. *cismontanum – Melaleuca nodosa*	29	44	0	39	112
Tussock grassland	62031	*Ischaemum australe – Ptilothrix deusta – Schoenus brevifolius – Themeda australis*	72	48	0	0	120
Sod grassland	63021	*Themeda australis*	9	28	9	14	60
Sedgeland	64031	*Leptocarpus tenax – Baloskion pallens – Schoenus brevifolius*	995	225	270	1928	3418
	64041	*Baumea rubiginosa*	74	364	44	398	880
	64051	*Lepironia articulata*	59	66	8	23	156
	64061	*Baumea articulata*	5	25	100	28	158
	64071	*Baloskion pallens – Baumea teretifolia – Melaleuca quinquenervia*	418	5	0	0	423
	64081	*Gahnia sieberiana – Gleichenia mendellii*	262	104	0	0	366
	64101	*Eleocharis sphacelata*	160	0	90	0	250
	64111	*Cladium procerum*	16	0	0	43	59
	64121	*Baumea arthrophylla*	0	0	24	78	102
	64141	*Baloskion pallens – Schoenus brevifolius*	39	0	0	0	39
	64181	*Gahnia sieberiana – Gleichenia dicarpa*	0	0	36	1	37
Rushland	65041	*Typha orientalis*	2	0	0	6	8
Fernland	67021	*Blechnum indicum*	4	0	0	6	10
							27289

Data analysis

Patterns in floristic composition were examined using ordination and numerical (cluster) analysis. These techniques facilitate a process of data reduction and exploration, often for the purpose of subsequent hypothesis generation (Kent & Coker 1992).

Numerical analysis of foliage cover scores (1 to 6) without further transformation was performed using PATN (Belbin 1993). The Bray-Curtis association coefficient was employed 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).

Measures of constancy and fidelity were derived to facilitate the characterisation of plant communities (floristic groups). Constancy is the number of quadrats in which a species occurs (Kent & Coker 1992), and five classes were employed: I = 1–20% of quadrats; II = 21–40%; III = 41–60%; IV = 61–80%; and V = 81–100%. Fidelity may be expressed using semi-quantitative categories (Kent & Coker 1992) where, for example, an *exclusive species* is completely or almost completely restricted to a single plant community and an *indifferent species* has no obvious affinity for any single community. Benson and Ashby (2000) employ a more quantitative approach for the recognition of species with comparatively high fidelity. This approach, based upon the algorithm of Westhoff and van der Maarel (1978), examines the full complement of plant communities for the purpose of identifying the maximum proportion of occurrence for a particular species. This maximum value is then divided by the sum of proportions of occurrence in all plant communities. The resulting *fidelity index* values for proportion of occurrence range from 0.0 to 1.0, and Benson and Ashby (2000) distinguish *indicator* (high-fidelity) species as those with a fidelity index equal to or greater than 0.8, with the added proviso of occurrence in at least 50% of samples (quadrats) for the respective plant community. The approach of Benson and Ashby (2000) was employed in the present study, with all calculations based upon a simultaneous consideration of the entire data set. However, it is important to appreciate that measures of fidelity are scale-dependent in terms of the geographic extent of the vegetation under consideration, and the level of detail to which the vegetation is being examined (Kent & Coker 1992). Software to compute fidelity index and constancy values was written by Dr G. Watson (Armidale, NSW).

Numerical analysis was performed on the entire data set and various subsets. Homogeneity analysis facilitated the delineation of an appropriate number of plant communities. Bedward et al. (1992) discussed the concept of homogeneity, which is a measure of the average within-group association between samples (quadrats). Measures of heterogeneity are first derived from the Bray-Curtis association values of a numerical analysis routine. Heterogeneity is calculated as the ratio of the average within-group association between quadrats to the average association for the entire data set. Homogeneity is then expressed as 1 minus heterogeneity. In this way, on an indexed scale of 0.0–1.0, a value of 0.0 represents complete heterogeneity whereas a value of 1.0 indicates complete homogeneity. A plot of homogeneity index (vertical axis) against number of plant communities or floristic groups (horizontal axis, where the maximum number of floristic groups = the total number of quadrats) allows visual recognition of the point (or zone) at which the resultant curve trends away from a predominantly vertical relationship (analogous to species-area curves for spatially homogenous vegetation), after which much smaller proportional gains in homogeneity are achieved by subdivision of the data set into additional floristic groups. The homogeneity analyses were performed using an unpublished software program (Dr G. Watson), and this incorporates the algorithm in Bedward et al. (1992). Despite the potential benefits of homogeneity analysis in terms of utility and relative objectivity, particularly for data sets where many species display indifferent fidelity, there are likely to be instances when it is appropriate to distinguish plant communities at different levels of similarity on a dendrogram (e.g. Webb et al. 1984). Such intuitive decisions are probably best exercised where they make 'ecological sense' (Kent & Coker 1992).

Spatial relationships between plant species and environmental variables were examined using Canonical Correspondence Analysis (CCA). This is a multivariate method of direct ordination in which correlation and regression procedures are integrated. It depicts both patterns in floristic composition and the principal relationships with environmental variables. To achieve this outcome CCA selects the linear combinations of environmental variables along which the distributions of the species are maximally separated. Species – environment response surfaces are assumed to be unimodal (in particular Gaussian or bell-shaped), although the method is considered to be reasonably robust when this assumption does not hold (Kent & Coker 1992, ter Braak 1986, 1987, ter Braak & Prentice 1988). Biplots present the ordination output, and these depict quadrats as points, numerical environmental variables as vectors, and categorical environmental variables as centroids. The ordinations were performed in an unconstrained manner (i.e. without *a priori* intuitive weighting of variables) using CANOCO (ter Braak 1988).

Patterns in species richness were examined using analysis of variance (ANOVA) and multiple comparison (Tukey-Kramer) tests. Data were log or square root transformed where appropriate. These analyses were performed using StatView (SAS Institute Inc., Cary USA 1998).

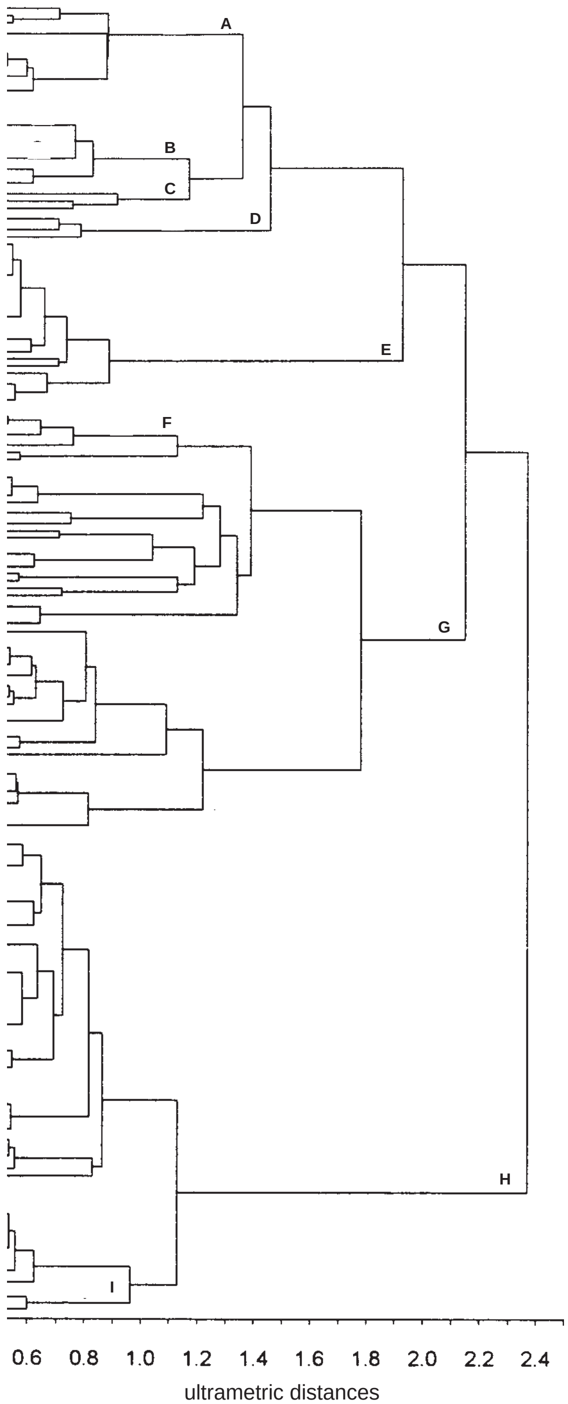


Fig. 3. Dendrogram for all samples of single stratum vegetation showing relationships of API groups

A: *Xanthorrhoea fulva* wet heathland (API group 60041) and *Ischaemum australe – Ptilothrix deusta – Schoenus brevifolius – Themeda australis* tussock grassland (62031). B: Graminoid clay heathland (59021, 59031, 59041). C: *Banksia oblongifolia – Leptospermum polygalifolium* subsp. *cismontanum – Melaleuca nodosa* wet heathland (60071). D: *Themeda australis* sod grassland (63021). E: *Banksia aemula* dry heathland (58021) and *Banksia aemula – Allocasuarina littoralis* dry heathland (58031). F: *Leptospermum juniperinum* wet heathland (60031). G: Sedgeland (64031, 64041, 64051, 64061, 64071, 64101, 64111, 64121, 64141), rushland 65041) and fernland (67021). H: *Banksia oblongifolia – Leptospermum liversidgei – Sporadanthus interruptus – Sprengelia sprengelioides – Xanthorrhoea fulva* wet heathland (60021). I: *Gahnia sieberiana – Gleichenia* sedgeland (64081, 64181).

Plant community circumscription and description

One of the distinguishing features of wallum is its often low stature and structural simplicity. Extensive areas are less than two metres high, and frequently lower than one metre. In these instances only a single vegetation stratum is discernible, and when shorter species are present (e.g. sedges and grasses in heathland) these are generally closely continuous in height with taller species such as heath shrubs (Durrington 1977, Griffith et al. 2000). Where only a single stratum is obvious, the air photo pattern is most likely a signature for the entire floristic composition. However, this may not be the case for taller, multi-layered vegetation where the tallest stratum (overstorey, canopy) obscures a lower stratum or strata. For the following examination of phytosociological relationships, a three-step process was therefore adopted:

1. Treatment of vegetation with a single stratum (fernland, heathland, rushland, sedgeland, sod grassland, tussock grassland);
2. Treatment of taller vegetation with two or more strata (shrubland, shrub mallee, tree mallee);
3. Simultaneous treatment of both single stratum and multi-stratum vegetation.

Floristic assemblages derived from numerical and homogeneity analyses in Steps 1 and 2 were elevated to plant community status, and these are generally named after the highest-ranked species in terms of constancy and mean foliage cover score (calculated for presence data only). The phytosociological classification so derived is reasonably comprehensive, but not definitive. The development of a formal hieriarchical classification into associations, alliances and so on would require analysis of samples for a wider geographic area (e.g. the inclusion of wallum in south-eastern Queensland).

A synoptic table (Appendix 2) provides the constancy class and mean cover score of every species in each plant community (although note that some constancy classes are not available where a community is represented by fewer than five quadrats). Each quadrat has a unique alpha-numeric code (e.g. HCR012.1 and HCR012.2 for Site No. 12 in Crowdy Bay NP, sampled at quadrats 12.1 and 12.2): 'H' distinguishes the data set (coastal 'heathlands') from others; AR = Arakoon State Recreation Area (SRA); BR = Broadwater NP; BU = Bundjalung NP; CR = Crowdy Bay NP; EV = Evans Head; HA = Hat Head NP; KA = Kattang NR; LA = Lake Innes NR; LI = Limeburners Creek NR; MO = Moonee Beach NR; NE = Newrybar Swamp; YU = Yuraygir NP.

Results and discussion

Vegetation with a single stratum

Single stratum vegetation was sampled in 364 randomly paired quadrats, and numerical analysis of this data for the entire complement of vascular species strongly supported the API group classification (Fig. 3). This outcome suggests that air photo signatures of structurally simple vegetation are useful for the recognition of floristic assemblages, although the utility of aerial photographs will depend upon limits of scale (i.e. degree of resolution). Numerical analysis also suggests that the data is strongly autocorrelated in terms of spatial distribution, with only a single pair of quadrats failing to re-unite at lower ultrametric distances.

This initial analysis provides preliminary insights into ecological relationships between floristic groups (Fig. 3). For example, *Leptospermum juniperinum* wet heathland (API group 60031) is floristically more similar to sedgeland, rushland and fernland vegetation than to another large group of wet heathland sites (API group 60021). *Leptospermum juniperinum* often occupies narrow drainage lines in association with sedgeland species. All sedgeland, rushland and fernland sites cluster in the analysis with the exception of sedgeland characterised by *Gahnia sieberiana* and either of two *Gleichenia* species (API groups 6408, 6418). This sedgeland clusters with wet heathland sites in API group 60021. The majority of sedgeland, rushland and fernland communities occur in closed depressions where standing water is present after periods of high rainfall if not more regularly. However, *Gahnia–Gleichenia* sedgeland more typically occupies the margins of open depressions where the soil receives groundwater seepage. In these situations *Gahnia–Gleichenia* sedgeland supports various heath shrubs in common with wet heathland (API group 60021), albeit at relatively minor foliage cover values. The analysis also suggests that vegetation on bedrock headlands and coastal hills (API groups for graminoid clay heathland and *Themeda australis* sod grassland) is more similar to *Xanthorrhoea fulva* wet heathland (API group 60041) and an associated tussock grassland (API group 62031) in clayey soils, than to most vegetation on strongly podzolised Quaternary sands (e.g. wet heathland API group 60021). Griffith et al. (2000) made a similar finding when comparing headland and sand mass vegetation.

Having established a general pattern of congruence between floristic groups derived from numerical analysis and those previously recognised by air photo pattern, it is appropriate to develop a phytosociological classification of plant communities using the site-derived data. This outcome could be achieved either for groups of samples within particular formations and subformations of single stratum vegetation, or without regard to structure. However, it is apparent from the clustering within API groups (Fig. 3) that strong links exist between floristic composition, structure and general habitat type. Homogeneity analysis indicated that at least 20 floristic groups could be recognised for the entire data set; and at this level of discrimination a clear separation of formations and subformations is maintained with the sole exception of *Xanthorrhoea fulva* wet heathland (API group 60041) and two sites for an associated tussock grassland (API group 62031). These API groups are topographically contiguous across somewhat gradational boundaries. Therefore, apart from the potential risk of failing to recognise the over-riding influence of floristic composition for two of 182 sites, it seemed reasonable to take a utilitarian approach in developing a phytosociological classification of single stratum vegetation by first assigning subsets of the data to particular groups of formations and subformations:

Subset: sedgeland, rushland and fernland;
Subset: sod grassland and tussock grassland;
Subset: heathlands – graminoid clay heathland;
Subset: heathlands – wet heathland;
Subset: heathlands – dry heathland.

Sedgeland, rushland and fernland

Wallum sedgeland in northern NSW is largely dominated by herbaceous species (Cyperaceae and Restionaceae), although in the least waterlogged sites certain heath shrubs may be subsidiary or occasionally co-dominant (e.g. *Callistemon pachyphyllus*, *Melaleuca quinquenervia*, *M. squamea*, *M. thymifolia*). Beadle (1981) uses the term 'sedge-heath' to describe communities in which both sedges and shrubs co-occur. A distinctive sedgeland in which ferns (*Gleichenia* spp.) co-dominate with *Gahnia sieberiana* is also recognised. *Typha orientalis* dominates limited areas of rushland in the wallum, and a fernland of *Blechnum indicum* has a widely scattered distribution. Sedgeland, rushland and fernland are common in interdunal swamps, lakes and other closed depressions. In a numerical analysis for this vegetation (Fig. 4), all sites except two (n=58) align with the respective API groups. This outcome suggests a high degree of congruence between the two systems of classification.

Zonation along a moisture gradient is often apparent in larger closed depressions with sloping or concave floors, where one API group replaces another as standing water depth increases away from the margins. The sedgelands of API groups 64031, 64071 and 64141 characterise relatively shallow levels of inundation; and a major floristic dichotomy (Fig. 4) is apparent between these and the sedgelands (and rushland) in depressions with generally deeper, more permanent standing water (e.g. API groups 65041 (*Typha orientalis* rushland), 64111 (*Cladium procerum* sedgeland) and 64101 (*Eleocharis sphacelata* sedgeland)). Numerical analysis also suggests that *Blechnum indicum* fernland (API group 67021) and *Gahnia sieberiana – Gleichenia* sedgeland (API groups 64081, 64181) have a relatively distinct floristic composition.

The sedgelands of shallower water bodies often support a larger number of species than sedgelands in deeper, more permanent water. The API groups of these shallow sedgelands have a notably variable floristic composition, and species mosaics are often discernible within individual closed depressions at scales measured in tens of metres. This is particularly so for the widespread API group 64031 (Griffith et al. 2000). *Leptocarpus tenax*, *Baloskion pallens* and *Schoenus brevifolius* are characteristic of this API group, although one (occasionally two) of these may be replaced locally by such species as *Baumea arthrophylla*, *B. teretifolia*, *Chorizandra sphaerocephala*, *Sporadanthus caudatus* or *Xyris operculata*. Certain heath shrubs (e.g. *Callistemon pachyphyllus*, *Melaleuca thymifolia*) can also make a significant contribution to total foliage cover. Although short-distance variation in floristic composition is often evident,

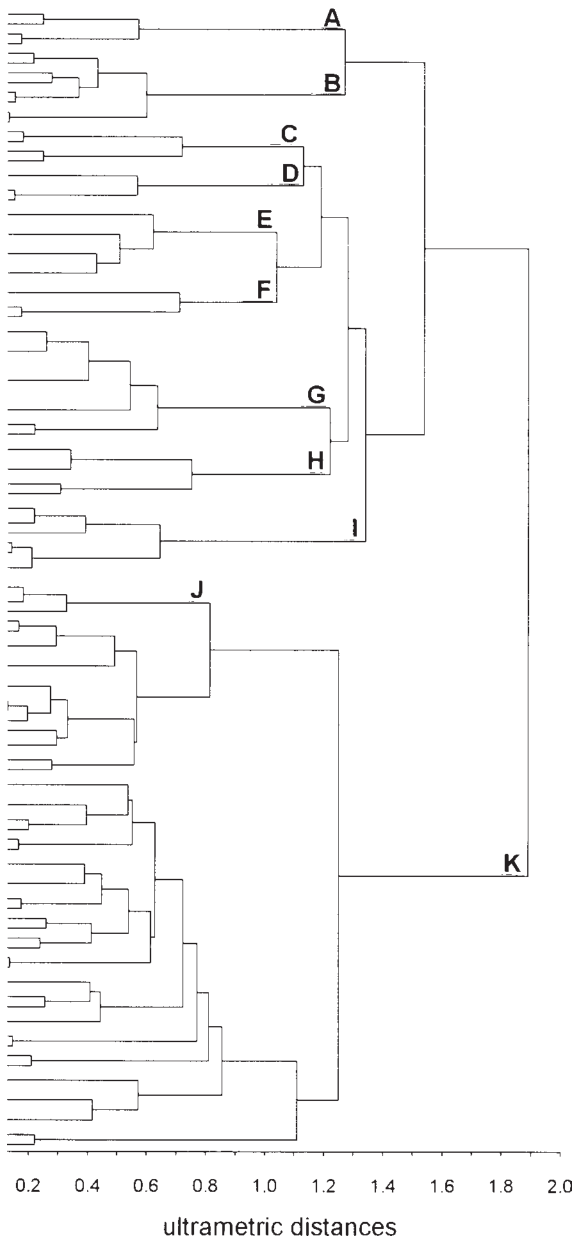


Fig. 4. Dendrogram for sedgeland, rushland and fernland samples, showing relationships of API groups.

Two of 58 sites did not align with the API groups to which they have been assigned a priori (HYU006.1/2, HYU008.1/2). These are discussed in Appendix 1.

A: *Blechnum indicum* fernland (API group 67021). B: *Gahnia sieberiana – Gleichenia mendellii* (64081) and *Gahnia sieberiana – Gleichenia dicarpa* (64181) sedgelands. C: *Typha orientalis* rushland (65041). D: *Cladium procerum* sedgeland (64111). E: *Baumea articulata* sedgeland (64061). F: *Eleocharis sphacelata* sedgeland (64101). G: *Baumea rubiginosa* sedgeland (64041). H: *Baumea arthrophylla* sedgeland (64121). I: *Lepironia articulata* sedgeland (64051). J: *Baloskion pallens – Baumea teretifolia – Melaleuca quinquenervia* sedgeland–heathland (64071). K: *Leptocarpus tenax – Baloskion pallens – Schoenus brevifolius* sedgeland (64031) and *Baloskion pallens – Schoenus brevifolius* sedgeland (64141).

shallow sedgelands of Newrybar Swamp on the far North Coast of NSW are notable for the complete absence of *L. tenax*. This apparent disjunction is curious, as *L. tenax* is found further north in south-eastern Queensland (Stanley & Ross 1989). A distinct API group (64141) was established to accommodate this regional anomaly, although it is most likely a geographic variant of the more widespread API group 64031. Numerical analysis confirmed the overall similarities in floristic composition for API groups 64031 and 64141 (Fig. 4).

Homogeneity analysis suggested that a maximum of around 17 floristic groups could be recognised for sedgeland, rushland and fernland, and below this level of group recognition all API groups other than 64031 and 64141 are readily discerned in Figure 4. Additional numerical analysis of API groups 64031 and 64141 in isolation confirmed their heterogenous composition, and subsequent homogeneity analysis indicated a three-group separation to be most appropriate. As an illustration of the considerable overlap in floristic composition between these shallow segelands, *Baloskion pallens* and *Baumea teretifolia* occurred in 89% of quadrats, *Schoenus brevifolius* occurred in 69%, and *Leptocarpus tenax* (which is absent in the north) occurred in 61%. It was also apparent for quadrat pairs (separated by distances of less than 15 metres) that a particular species may be abundant in one quadrat, although relatively uncommon in the second. This trend supports the utilitarian approach of mapping shallow sedgelands as floristically variable API groups.

Thirteen sedgeland, rushland and fernland plant communities are now recognised on the basis of phytosociological relationships (Appendices 1, 2), and very few indicator species occur in these wetlands:

Community 1: *Baumea rubiginosa* tall to very tall closed sedgeland (API group 64041);

Community 2: *Lepironia articulata* very tall closed sedgeland (API group 64051);

Community 3: *Baumea articulata* very tall sedgeland and closed sedgeland (API group 64061);

Community 4: *Eleocharis sphacelata* tall to very tall closed sedgeland (API group 64101);

Community 5: *Baumea arthrophylla* tall to very tall closed sedgeland (API group 64121);

Community 6: *Cladium procerum* very tall closed sedgeland (API group 64111);

Community 7: *Typha orientalis* very tall rushland and closed rushland (API group 65041);

Community 8: *Blechnum indicum* tall to very tall closed fernland (API group 67021);

Community 9: *Baloskion pallens – Melaleuca quinquenervia* mid-high to tall closed sedgeland–heathland (API group 64071);

Community 10: *Gahnia sieberiana – Gleichenia* tall to very tall closed sedgeland (API groups 64081, 64181);

Community 11: *Leptocarpus tenax – Baloskion pallens* tall to very tall closed sedgeland (part API group 64031);

Community 12: *Schoenus brevifolius – Baumea teretifolia* tall to very tall closed sedgeland (part API group 64031); and

Community13: *Baloskion pallens – Baumea teretifolia* tall to very tall closed sedgeland (API groups 64031 (part), 64141).

Ordination revealed considerable overlap between several sedgelands, most notably communities 1, 9, 11 and 12 (Fig. 5). This trend is consistent with similarities in floristic composition and habitat, particularly for shallower sedgelands. Most of the sedgeland and rushland communities cluster about the closed depression (D), lake (LAK) and swamp (SWP) centroids, and this trend is consistent with the sampled field situation. Samples for *Gahnia sieberiana–Gleichenia* sedgeland (10) behave differently, although again consistent with field observations, by clustering around the drainage depression (DDE), dune (DUN), swale (SWL) and open depression (V) centroids. In contrast to correlations with categorical variables for landform element and morphology, it is evident that vectors for the numerical variables are very short and therefore likely to be relatively unimportant in influencing community distribution.

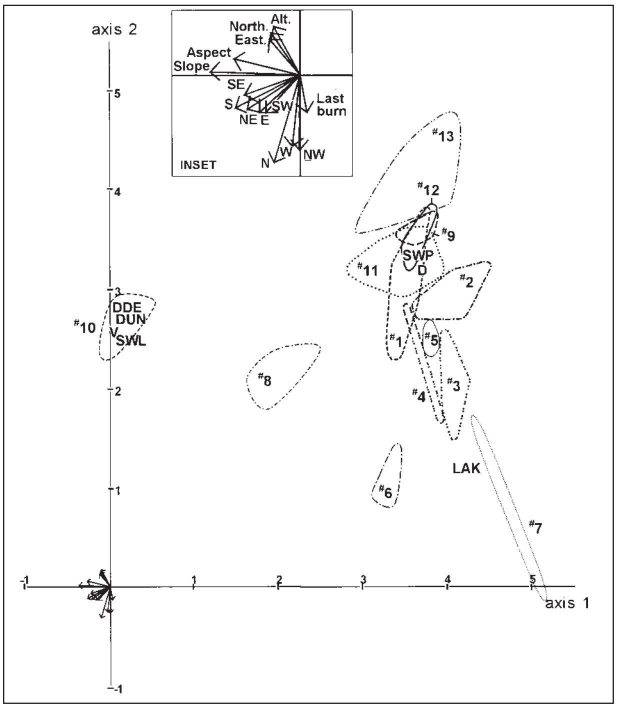


Fig. 5. Ordination for sedgeland, rushland and fernland. Plant communities (1–13) are numbered as they appear in the text. Eigenvalues: axis 1 = 0.7603; axis 2 = 0.4250. Vectors represent numerical variables. To improve interpretation, quadrats are shown as clusters (polygons) rather than points. The dune and ridge (R) centroids coincided (latter not shown). See the Methods for details of centroid and vector codes.

Sod grassland and tussock grassland

Two grassland formations associate with wallum in northern NSW, and these are distinguished on the basis of growth habit (after Walker & Hopkins 1984). Sod grassland has a closely interfacing leaf canopy in which individual grass plants are not obvious. In tussock grassland individual plants display a clumping or tufted habit and shoots are discrete. *Themeda australis* is common to both formations. Native grasslands appear to be relatively uncommon along the coast of northern NSW.

Numerical analysis demonstrated a clear dichotomy between sod grassland along the seaward extremities of coastal headlands, and tussock grassland of flats and drainage (open) depressions further inland from the sea (Griffith 2002). Homogeneity analysis supported this two-group separation, although it needs to be remembered that tussock grassland is floristically similar to a particular wet heathland (API group 60041), as previously discussed. A single plant community is recognised for each grassland formation (Appendices 1, 2), and both support indicator species (e.g. *Bracteantha bracteata* in 14, and *Rutidosis heterogama* in 15):

Community 14: *Themeda australis* low to tall closed sod grassland (API group 63021); and

Community 15: *Themeda australis – Ptilothrix deusta* mid-high to tall closed tussock grassland (API group 62031).

Ordination maintained the distinction established by numerical analysis (eigenvalues: axis 1 = 0.7885; axis 2 = 0.3909), and it was evident from vector length that the numerical environmental variables have comparatively little influence upon community distribution (Griffith 2002). Samples representing community 15 clustered about the centroids for backplain, drainage depression and Quaternary alluvium, whereas samples for community 14 enveloped the mid-slope, upper slope and sedimentary rock centroids. These outcomes were consistent with sampled field conditions.

Heathlands

Heathland is generally less than two metres high (Walker & Hopkins 1984), and coastal heathlands in northern NSW support a range of woody species, particularly from the families Proteaceae, Myrtaceae, Epacridaceae, Fabaceae and Rutaceae (Griffith & Williams 1997). Heath shrubs often, but not always, have ericoid leaves of nanophyll or smaller size. Heathland is a significant component of wallum, and two subformations are generally distinguished on sandy Quaternary sediments: wet heathland in open depressions where a shallow watertable is present following rain; and dry heathland on free-draining dunes and beach ridges (Beadle 1981, Griffith et al. 2000, Myerscough & Carolin 1986, Specht 1979, Williams 1982). A third subformation known as graminoid clay heathland occurs in clayey soils derived from bedrock of various lithologies (e.g. sandstone, adamellite, rhyolite). Grasses and sedges form a large component of the aboveground biomass in this subformation, hence the term ‘graminoid’ (Griffith et al. 2000). Other Australian studies distinguish between heathlands on sand masses and those on bedrock strata (Brown & Hopkins 1983, Froend 1988, Hnatiuk & Hopkins 1981, Hopkins & Hnatiuk 1981). All three subformations support a wide variety of herbaceous species, particularly from the families Cyperaceae, Poaceae and Restionaceae (Griffith & Williams 1997), and these are generally continuous in height with the heath shrubs. Numerical analysis preserved the three-group dichotomy into subformations (Griffith 2002; also Fig. 3), although this and subsequent homogeneity analysis indicated that further sub-division was warranted.

Graminoid clay heathland

Three API groups are recognised for graminoid clay heathland at the following localities: Evans Head to Red Rock on the upper North Coast (API group 59021); South West Rocks (Macleay River entrance) on the lower North Coast (API group 59041); and further south in Crowdy Bay NP (API group 59031). Graminoid clay heathland has a widely scattered, disjunct pattern of occurrence on headlands and coastal hills, and therefore tends to vary in floristic composition from one locality to the next as species reach their geographic limit of distribution (e.g. *Hakea teretifolia* subsp. *teretifolia* south from the Macleay River valley and *Hakea actites* north from the Coffs Harbour district). Graminoid clay heathland also appears to function as a refuge for species that are rare or otherwise restricted in the wallum and related vegetation of north-eastern NSW. Examples include: *Isopogon mnoraifolius* in Bundjalung NP and Yuraygir NP; *Cryptandra scortechinii* and *Bossiaea stephensonii* in Crowdy Bay NP; *Thesium australe*, *Xanthosia tridentata*, *Gahnia radula* and *Comesperma sphaerocarpum* in Old Bar Park (Greater Taree City Council 1996); and *Xanthosia tridentata* on Charlotte Head in Booti Booti NP (Griffith et al. 2000).

Numerical analysis preserved the identity of the three API groups, although with further separation of graminoid clay heathlands on the far North Coast (API group 59021) into three geographically disjunct subgroups (Fig. 6). One subgroup is located at Evans Head, approximately 50 km north of the next subgroup in the vicinity of Brooms Head (Yuraygir NP), and the third subgroup is found in the Wooli area (Yuraygir NP), about 19 km further south. Homogeneity analysis supported this five-group separation into the following communities (Appendices 1, 2):

Community 16: *Themeda australis – Banksia oblongifolia – Aristida warburgii* low to mid-high closed heathland (API group 59041);

Community 17: *Ptilothrix deusta – Aristida warburgii – Hakea teretifolia* subsp. *teretifolia* low to tall closed heathland (API group 59031);

Community 18: *Ptilothrix deusta – Banksia oblongifolia – Mirbelia rubiifolia* low to mid-high closed heathland (part API group 59021);

Community 19: *Ptilothrix deusta – Aristida warburgii – Banksia oblongifolia – Allocasuarina littoralis – Epacris pulchella* low to mid-high closed heathland (part API group 59021);

Community 20: *Banksia oblongifolia – Ptilothrix deusta – Aristida warburgii – Allocasuarina littoralis* low to mid-high closed heathland (part API group 59021).

Each community supports a minimum of two indicator species (e.g. *Bossiaea stephensonii*, *Cryptandra scortechinii*, *Euphrasia collina* subsp. *paludosa*, *Isopogon mnoraifolius*), and this trend contrasts with a relative paucity of indicators for wet and dry heathland communities (discussed below). Ordination preserved the five-group classification (eigenvalues: axis 1 = 0.3170; axis 2 = 0.2028), and also indicated that three communities on the upper North Coast at Evans Head (18) and in Yuraygir NP (19 and 20) are more

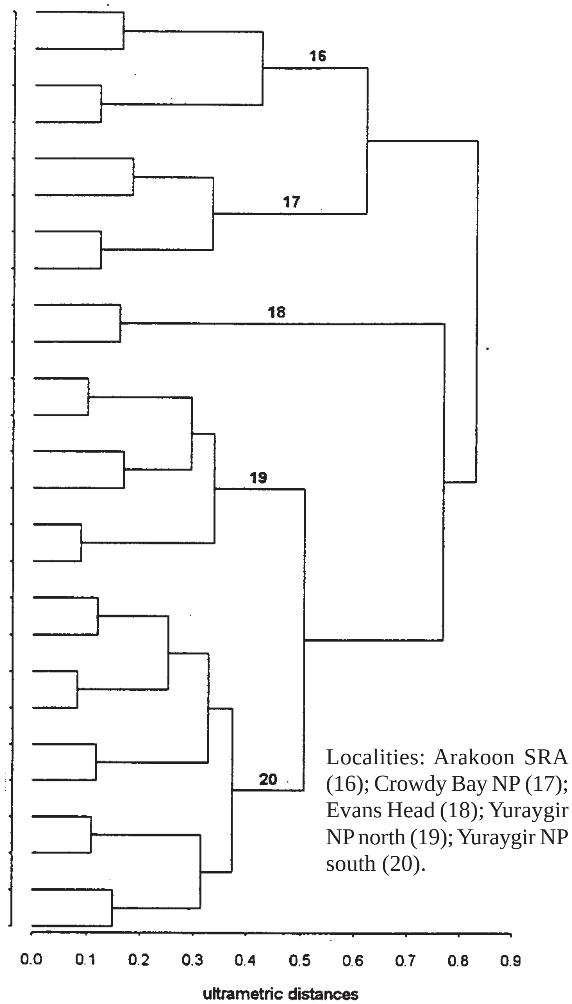


Fig. 6. Dendrogram for graminoid clay heathland samples. Communities (16–20) are labelled as they appear in the text.

closely aligned to each other than to communities further south in Arakoon SRA (16) and Crowdy Bay NP (17) (Griffith 2002). Communities 18, 19 and 20 clustered about the sedimentary rock, hillslope, lower slope and simple slope centroids. Community 17 clustered about the centroids for hillcrest and upper slope, and samples for community 16 were closest to the adamellite centroid. Vectors for the numerical environmental variables were short, and therefore these are likely to be relatively unimportant. In summary, the ordination trends for substrate and topographic position were consistent with sampled field conditions.

Wet heathland

The wet heathland subformation is widespread and extensive along the coast of northern NSW, and four API groups are recognised on the basis of floristic composition and general habitat conditions (Table 1). As presently circumscribed, API group 60021 has a somewhat variable floristic composition, although three or more of *Banksia oblongifolia*, *Leptospermum liversidgei*, *Sporadanthus interruptus*, *Sprengelia sprengelioides* and *Xanthorrhoea fulva* are usually conspicuous (e.g. Griffith et al. 2000). Some of this variation may be attributed to fire, particularly where frequent burning limits recruitment in obligate seeders (e.g. *Sprengelia sprengelioides*). API group 60071 (*Banksia oblongifolia – Leptospermum polygalifolium* subsp. *cismontanum – Melaleuca nodosa*) has a widely disjunct and rather restricted distribution, and therefore also displays some floristic variation. On the other hand, API groups 60031 (*Leptospermum juniperinum*) and 60041 (*Xanthorrhoea fulva*) display more consistent floristic composition, at least for the dominant heath shrubs.

Numerical analysis preserved the four API groups as primary subdivisions (Griffith 2002; see also Figure 3). Nonetheless, homogeneity analysis suggested a nine-group separation, further dividing API group 60021 into five subgroups and API group 60071 into two subgroups, although without division of API groups 60031 and 60041.

Eight wet heathland communities are now recognised, and this level of distinction accords with the numerical and homogeneity analyses except that one and not two communities are distinguished for API group 60071. This relatively uncommon API group was only sampled at three widely separated locations, and it was considered undesirable at this stage to further separate such a small data set into two poorly defined communities. The five communities distinguished for API group 60021 share many species, and so are likely to form mosaic distribution patterns in the field across diffuse boundaries. This overlap in floristic composition is apparent for the five species after which the API group is named – *Leptospermum liversidgei*, *Sporadanthus interruptus*, *Sprengelia sprengelioides* and *Xanthorrhoea fulva* occured in more than 90% of quadrats, whereas *Banksia oblongifolia* occurred in 60%. Such a trend would support the utilitarian approach of mapping a single, floristically variable API group, particularly where fire further complicates patterns of distribution and abundance for obligate seeders. The eight communities are identified as follows (Appendices 1, 2):

Community 21: *Leptospermum juniperinum* mid-high to tall heathland and closed heathland (API group 60031);

Community 22: *Xanthorrhoea fulva – Ptilothrix deusta* low to tall closed heathland (API group 60041);

Community 23: *Banksia oblongifolia – Leptospermum polygalifolium* subsp. *cismontanum – Melaleuca nodosa* low to tall heathland and closed heathland (API group 60071);

Community 24: *Sporadanthus interruptus – Xanthorrhoea fulva – Banksia ericifolia* subsp. *macrantha – Leptospermum liversidgei – Baeckea frutescens* mid-high to tall closed heathland (part API group 60021);

Community 25: *Sporadanthus interruptus – Xanthorrhoea fulva* low to tall closed heathland (part API group 60021);

Community 26: *Banksia oblongifolia – Xanthorrhoea fulva* low to tall closed heathland (part API group 60021);

Community 27: *Xanthorrhoea fulva – Schoenus paludosus – Banksia ericifolia* subsp. *macrantha* low to tall closed heathland (part API group 60021); and

Community 28: *Leptospermum liversidgei – Sporadanthus interruptus – Empodisma minus* low to tall closed heathland (part API group 60021).

Ordination (eigenvalues: axis 1 = 0.4710; axis 2 = 0.1610) once again indicated that the numerical variables are unlikely to play a major role in community variation (Griffith 2002). Communities 23 to 28 clustered around the swale and open depression centroids, whereas communities 21 and 22 clustered near the backplain, drainage depression and flat centroids. Ordination also reinforced the observation of considerable overlap in floristic composition and habitat for many examples of wet heathland. This was particularly so for communities 24, 25 and 28, as separated from the broader API group 60021. It was also apparent from the spread of samples that *Banksia oblongifolia – Leptospermum polygalifolium* subsp. *cismontanum – Melaleuca nodosa* wet heathland (23) may be internally heterogenous, and therefore worthy of further investigation.

Dry heathland

Dry heathland is a widespread and predominantly species-rich subformation on sand masses in northern NSW, and two API groups are distinguished. *Banksia aemula* (Wallum Banksia) is consistent and conspicuous in API group 54021 along with many other heath shrubs as associates. API group 54031 is distinguished by the presence of *B. aemula* in addition to a relatively high cover of *Allocasuarina littoralis*.

Casual field observations suggest that although dry heathland is floristically distinct from other heathland subformations, there is considerable floristic overlap from one dry heathland stand to the next. Numerical and homogeneity analyses appeared to support this generalisation (Griffith 2002), and three plant communities that nonetheless share many species in common are now recognised (Appendices 1, 2):

Community 29: *Banksia aemula – Leptospermum trinervium* low to tall closed heathland (part API groups 58021, 58031);

Community 30: *Banksia aemula – Allocasuarina littoralis* low to tall closed heathland (part API group 58031); and

Community 31: *Banksia aemula* low to tall closed heathland (part API groups 58021, 58031).

Samples for API group 58021 separated to dominate two of the three communities (29 and 31). Two of four sites in API group 58031 maintained their identity as the third community (30), whereas the remainder separated and merged into communities 29 and 31. Ordination maintained the identity of each community (eigenvalues: axis 1 = 0.2679; axis 2 = 0.1173), and a correlation with beach ridges and dunes was most apparent (Griffith 2002). Vectors for the numerical environmental variables were once again short and therefore relatively uninformative.

Vegetation with two or more strata

Sampling in mallee and shrubland provided data for 130 randomly paired quadrats. Walker and Hopkins (1984) distinguish between tree mallee and shrub mallee, and both formations are characterised by species of *Eucalyptus* and allied Myrtaceae. The tallest stratum of tree mallee is composed of multi-stemmed, lignotuberous individuals where each plant has fewer than five trunks, three or more of which exceed 100 mm in diameter at breast height. Shrub mallee is also composed of multi-stemmed, lignotuberous individuals, although each plant usually supports five or more trunks, with three or more of the largest not exceeding 100 mm in diameter at breast height. Both structural formations are present in the wallum, although stands may grade from tree mallee to shrub mallee over short distances. Fire influences the structure of mallee. This is evident where a severe crown fire kills all stems and the basal resprouts are smaller in diameter than the dead standing stems for many years. Less severe fires allow regeneration from epicormic buds without the death of mature stems. A small number of species characterise the tallest stratum of wallum mallee in northern NSW. *Eucalyptus pilularis*, *E. planchoniana* and *Corymbia gummifera* occupy extensive areas, whereas somewhat restricted species include *Eucalyptus robusta*, *E. signata* and *Lophostemon confertus* (Table 1).

Walker and Hopkins (1984) apply the shrub growth form to woody plants that are generally multi-stemmed at the base or within 20 cm of the ground surface. As opposed to heathland vegetation, the tallest stratum of wallum shrubland is generally much higher than two metres, hence the recognition of a lower stratum of shorter species. However, it needs to be appreciated that Walker and Hopkins (1984) set a minimum height of two metres for the tree growth form, and in wallum the distinction between shrubs and trees is not always clear-cut. As an example, some *Banksia* species may be multi-stemmed or heavily branched, although this branching can initiate higher than 20 cm above the ground surface. The development of a large woody lignotuber in *B. aemula* further complicates distinctions between mallee, shrub and tree growth forms. In the present study a consistent approach of distinguishing between the heath shrub (< 2 m) and shrub (>2 m) growth forms solely on the basis of height is adopted for species such as *B. aemula*. Some accounts of wallum in south-eastern Queensland using an alternative structural classification developed by R.L. Specht (Specht 1981, Specht et al. 1974) refer to taller stands dominated by *B. aemula* as low woodlands (e.g. Batianoff & Elsol 1989). Conspicuous shrub species in the wallum of northern NSW include *B. aemula* and *B. ericifolia* subsp. *macrantha*. *Leptospermum juniperinum*, *L. speciosum* and *Melaleuca sieberi* are examples of more restricted shrubs (Table 1).

Dry sclerophyll and swamp sclerophyll subformations are distinguished in tree mallee, shrub mallee and shrubland, and these can be linked to soil moisture and drainage conditions (Table 1). This distinction is analogous to that between dry heathland and wet heathland.

Comparative floristic relations of tallest stratum species

A simple test was devised to assess the efficacy of API for distinguishing tree mallee, shrub mallee and shrubland formations and subformations on the basis of floristic composition for the dominant growth form. Numerical analysis was performed as previously described; although after first excluding records for species restricted to lower strata, and adjusting foliage cover scores to preclude any unnecessary bias for tallest stratum species also represented in a lower stratum. Vines and hemiparasites associated with the tallest stratum were similarly excluded, for example *Cassytha* species and mistletoes. These generally achieved a foliage cover score of only 1 (<1% cover), or rarely 2 (1–5%).

Numerical analysis largely upheld the API classification, although without discrimination between tree mallee and shrub mallee (Fig. 7). *Banksia aemula – Allocasuarina littoralis* dry sclerophyll shrubland (54031/2) was the only API group not readily distinguished. This was sampled at two sites (HBR017.1/.2, HKA002.1/.2), and both clustered with samples for API group 54021/2, *B. aemula* dry sclerophyll shrubland (Group A, Fig. 7). As would be expected, the floristic composition of the tallest stratum was sufficient to discriminate between shrubland and mallee. Several other trends for the analysis are worthy of comment.

The *Banksia aemula* shrublands of API group 54021/2 separate into stands in which *B. aemula* is the sole dominant (Group N), and stands in which other species are minor or subsidiary associates of *B. aemula* in the tallest stratum (Group A). *Leptospermum trinervium* is the most common tallest stratum associate, and less common ones include *Allocasuarina littoralis*, *Leptospermum polygalifolium* subsp. *cismontanum*, *Xanthorrhoea glauca* subsp. *glauca* (south from Limeburners Creek NR), *Melaleuca nodosa*, *Monotoca elliptica* and *Callitris rhomboidea* (in Hat Head NP). Many of the associates are conspicuous in the lower stratum of *B. aemula* shrubland, and in the absence of fire for extended periods they appear to increase in height and so reach the tallest stratum (e.g. Griffith et al. 2000). It seems that *B. aemula – A. littoralis* dry sclerophyll shrubland (API group 54031/2) is also associated with long-unburnt wallum, where sufficient time has elapsed for *A. littoralis* to recruit and co-dominate. This API group has a scattered distribution on the North Coast of NSW (Table 1), and it extends into south-eastern Queensland (Batianoff & Elsol 1989). In practice, the application of API to further separate *B. aemula* shrublands on the basis of tallest stratum associates is problematic, for example where fire boundaries are not obvious on aerial photographs, or where burns vary in intensiy and spatial extent over small areas.

The dry sclerophyll mallee of well-drained, podzolised sands separates into API groups dominated by either *Eucalyptus pilularis* (Group C) or *E. planchoniana* (Group B). This separation also applies to the floristically variable tree mallee of API group 50071 (*E. pilularis*/*E. planchoniana*/*Corymbia gummifera*), which is found in Hat Head NP on the lower North Coast. For this API group shifts in dominance, often over distances measured in tens of metres, range from clear dominance of the tallest stratum by *E. pilularis* to varying combinations of *E. pilularis*, *E. planchoniana* and *Corymbia gummifera*, to clear dominance by *E. planchoniana*. Samples for API group 50071 dominated by *E. pilularis*

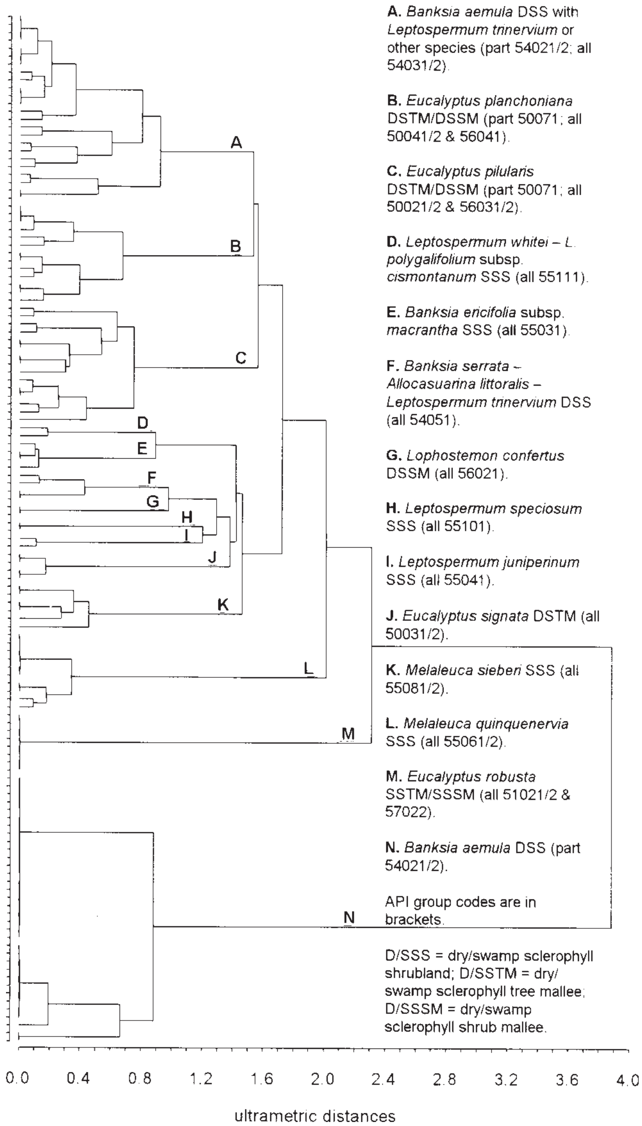


Fig. 7. Dendrogram for samples of the tallest stratum in tree mallee, shrub mallee and shrubland.

cluster with API groups 50021/2 (*E. pilularis* tree mallee) and 56031/2 (*E. pilularis* shrub mallee), whereas samples dominated by *E. planchoniana* cluster with API groups 50041/2 (*E. planchoniana* tree mallee) and 56041 (*E. planchoniana* shrub mallee).

Numerical analysis also separated mallee and shrubland API groups associated with relatively well-drained, podzolised sands (e.g. Groups A, B, C) from structurally equivalent API groups most commonly associated with either poorly drained podzolised sands (e.g. Groups H, I), or younger less podzolised sand masses (e.g. Groups F, G). This confirms the utility of API for distinguishing wallum subformations where floristic composition of the tallest stratum is also diagnostic for growth forms of lower strata (e.g. a prevalence of helophytes in waterlogged habitats).

Comparative floristic relations for all species

As previously demonstrated, a reasonable degree of discrimination can be expected for mallee and shrubland on the basis of air photo signature where a classification of floristic composition for the dominant growth form (tallest stratum) is desirable or adequate. Nonetheless, a thorough phytosociological treatment requires the simultaneous consideration of all species irrespective of vertical arrangement. For the purpose of community circumscription, shrubland samples were analysed as one subset, and shrub mallee and tree mallee samples together as a second subset. The mallee formations were combined because stands can be structurally gradational, especially in response to fire, and few samples are currently available for shrub mallee.

Shrublands

Numerical analysis revealed floristic overlap between several shrubland API groups, and this outcome suggests that species in lower strata strongly influence clustering patterns (Fig. 8). Nonetheless, the dry sclerophyll and swamp sclerophyll subformations remained distinct. All quadrat pairs re-united at lower ultrametric distances. Eight communities are now distinguished on the basis of trends for numerical and homogeneity analyses, and three of these support indicator species (Appendices 1, 2):

Community 32: *Banksia aemula – Phyllota phylicoides* tall to very tall (occasionally extremely tall), sparse to closed shrubland (90% of samples for API group 54021/2);

Community 33: *Banksia aemula – Allocasuarina littoralis* +/- *B. serrata* tall to extremely tall, sparse to closed shrubland (10% of samples for API group 54021/2, and all samples for 54031/2 and 54051;

Community 34: *Banksia ericifolia* subsp. *macrantha* +/- *Leptospermum whitei – L. polygalifolium* subsp. *cismontanum* tall to very tall shrubland and closed shrubland, or rarely open shrubland (part API group 55031, and all samples for 55111);

Community 35: *Melaleuca sieberi*/*Banksia ericifolia* subsp. *macrantha – M. thymifolia* tall to very tall, sparse to closed shrubland (part API group 55031, and all samples for 55081/2);

Community 36: *Melaleuca quinquenervia – Baumea teretifolia* tall to very tall, sparse to closed shrubland (part API group 55061/2);

Community 37: *Melaleuca quinquenervia – Baumea juncea* tall shrubland and closed shrubland (part API group 55061/2);

Community 38: *Leptospermum speciosum* tall to very tall closed shrubland (API group 55101);

Community 39: *Leptospermum juniperinum* tall to very tall shrubland and closed shrubland (API group 55041).

Seven communities remained relatively discrete in an ordination (eigenvalues: axis 1 = 0.7674; axis 2 = 0.5452). *Melaleuca quinquenervia – Baumea juncea* swamp sclerophyll shrubland (37) was an exception, and this outcome appeared to reflect the sampled habitat, which varied from drainage (open) depressions to swamps in closed

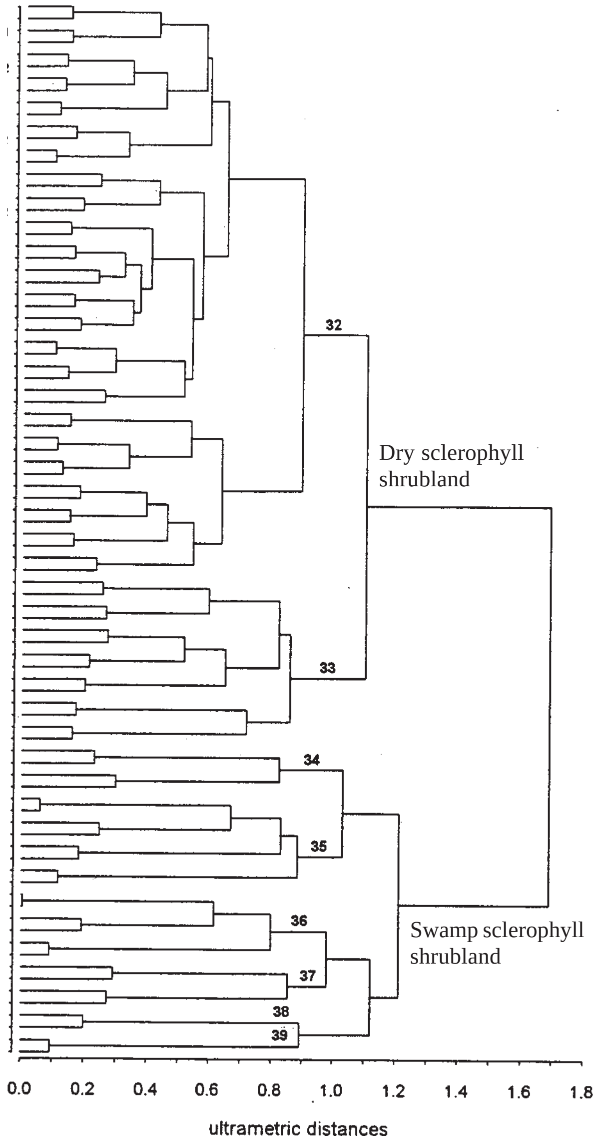


Fig. 8. Dendrogram for all shrubland quadrats. Community descriptions (32–39) and API group details are provided in the text.

depressions. Clustering patterns about centroids for the remaining communities were consistent with sampled field conditions, for example the association of 32 and 33 with beach ridges and dunes, 34 with swales, 35 predominantly with flats on plains or backplains and 39 with rhyolite. Vectors for the numerical variables were once again short (Griffith 2002), and these environmental factors probably have relatively little influence upon community distribution.

Mallee

Numerical analysis revealed floristic and structural overlap between the mallee API groups, although *Lophostemon confertus* dry sclerophyll mallee shrubland remained distinct. As for the shrublands, this outcome emphasises the significance of understorey species to floristic patterns in mallee. All quadrat pairs re-united at lower ultrametric distances. Three communities are now distinguished on the basis of trends for numerical and homogeneity analyses, and two of these support indicator species (Appendices 1, 2):

Community 40: *Lophostemon confertus* very tall closed mallee shrubland (API group 56021);

Community 41: *Eucalyptus robusta*/*E. signata* – *Baloskion tetraphyllum* subsp. *meiostachyum* very tall sparse to open mallee shrubland, and very tall to extremely tall, open mallee woodland to closed mallee forest (part API group 50031/2, and all samples for 51021/2 and 57022);

Community 42: *Eucalyptus pilularis*/*E. planchoniana*/*E. signata* – *Leptospermum trinervium* tall to very tall, sparse to closed mallee shrubland, and tall to extremely tall, open mallee woodland to closed mallee forest (part API group 50031/2, and all samples for 50021/2, 50041/2, 50071 and 56031/2).

The communities remained distinct in an ordination (eigenvalues: axis 1 = 0.7534; axis 2 = 0.2998), with most samples concentrated about centroids for topography in agreement with sampled field conditions. For example, *Lophostemon confertus* dry sclerophyll mallee shrubland (40) maintained its distinct association with foredunes (FOR centroid), whereas samples for community 42 in which *Eucalyptus pilularis* or *E. planchoniana* are often the dominant mallee coincided with the dune (DUN) and beach ridge (BRI) centroids representative of older dunefields and beach ridge plains respectively. Samples for *E. signata* tree mallee (API group 50031/2) separated in the numerical analysis and regrouped either with *E. robusta* swamp sclerophyll mallee (41) or *E. pilularis*/*E. planchoniana* dry sclerophyll mallee (42). This outcome suggests that *E. signata* mallee supports both dry and swamp facies in terms of understorey composition.

Comparative floristic relations of single stratum and multi-stratum vegetation

Floristic overlap between single stratum and multi-stratum vegetation would be consistent with the comparatively fine scale, mosaic patterning of different structural formations in wallum across seemingly slight environmental gradients (Batianoff & Elsol 1989, Griffith 1983, Griffith et al. 2000), the commonality of many species to two or more formations or subformations (Griffith & Williams 1997), and the potential for fire to alter structure. An exploratory ordination confirmed this overlap in structure, habitat and floristic composition (Fig. 9). The various formations and subformations of single stratum vegetation largely maintain their identity; and the primary axes of the biplot appear to reflect variations in drainage and substrate, most notably a perceived moisture gradient (linked to landform element and morphology) along axis 1 separating dry heathland, sod grassland and graminoid clay heathland (left of the origin) from tussock grassland, sedgeland, fernland, rushland, and the majority of the wet heathland quadrats (right of the origin). In contrast, samples for multi-stratum vegetation are widely dispersed and generally intermixed with those for single stratum vegetation. This ordination also displays a relatively strong correlation between vegetation and topography.

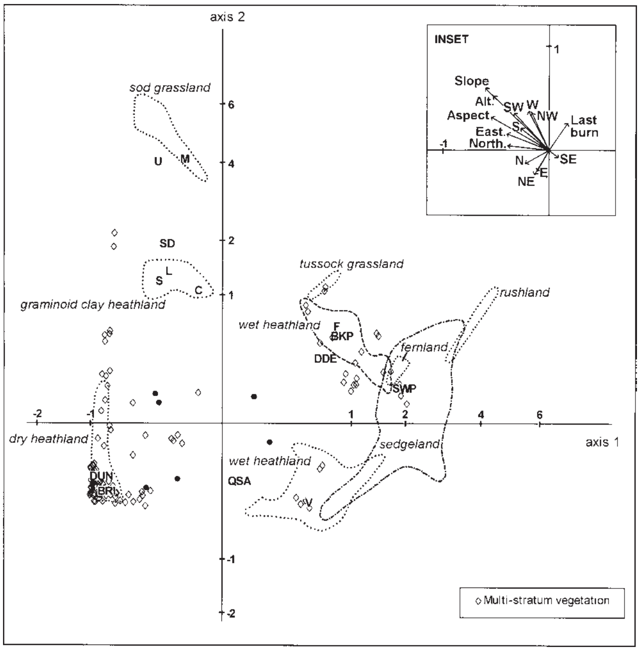
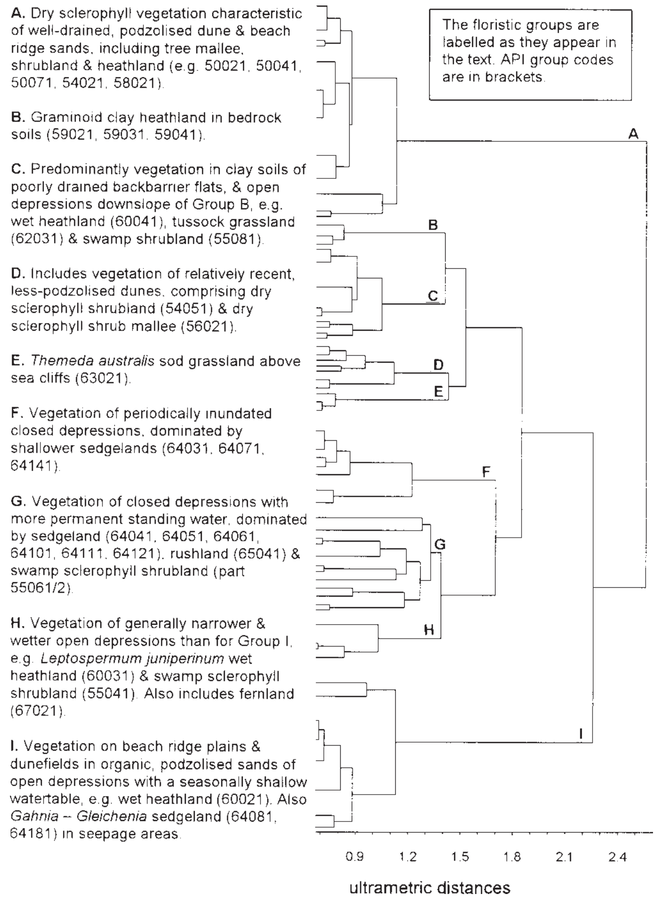


Fig. 9. Ordination for all samples of single stratum and multi-stratum vegetation.

Eigenvalues: axis 1 = 0.7157; axis 2 = 0.5170. Most (96%) wet heathland quadrats clustered either near the open depression (V) centroid, or the backplain (BKP), drainage depression (DDE) and flat (F) centroids. Polygons define quadrat distribution for single stratum vegetation (except outlying wet heathland quadrats of API group 60071, denoted '•'). To aid interpretation of the biplot, all values were square root transformed after the ordination. The dune and ridge (R) centroids coincided (latter not shown). See the Methods for details of other centroid and vector codes.



ultrametric distances

Fig. 10. Dendrogram for all samples of single stratum and multi-stratum vegetation

Floristic relations for single stratum and multi-stratum vegetation were examined simultaneously using numerical analysis, and for illustrative purposes this was constrained to nine groups (Groups A–I, Fig. 10). Homogeneity analysis supported this level of group recognition.

Several floristic groups exhibit considerable structural heterogeneity. For example, Group A is dominated by samples for dry sclerophyll tree mallee and shrub mallee supporting varying combinations of *Eucalyptus pilularis*, *E. planchoniana* and *Corymbia gummifera*, in addition to samples for *Banksia aemula* dry sclerophyll shrubland and dry heathland. Groups C, D, F, G, H and I also display varying amounts of structural heterogeneity, although this is not the case for Groups B and E. Group B is exclusive for samples of graminoid clay heathland on headlands and coastal hills, and therefore is both structurally and floristically robust. Likewise, Group E only comprises samples for *Themeda australis* sod grassland along sea cliffs. Although samples for multi-stratum vegetation are widely dispersed in the ordination (Fig. 9), they do not intermix with samples for graminoid clay heathland or *T. australis* sod grassland. Also note that graminoid clay heathland and *T. australis* sod grassland display a stronger (positive) correlation with slope and altitude than do, for example, wet heathland and sedgeland. Numerical analysis revealed that vegetation of relatively recent, less-podzolised dune sands (Group D, Fig. 10) is floristically more similar to *T. australis* sod grassland than to the vegetation of older, heavily podzolised dune and beach ridge deposits (e.g. Group A). Griffith et al. (2000) made a similar observation when comparing the vegetation of foredunes and older sand masses with *T. australis* sod grassland.

Patterns of species richness

Soil moisture relations are often used as the basis for separating wallum and similar vegetation into subformations (Beadle 1981, Griffith et al. 2000, Myerscough & Carolin 1986, Myerscough et al. 1995, Siddiqi et al. 1972, Specht 1979, Williams 1982), and the phytosociological analyses identified different floristic assemblages in wet and dry habitats. Vegetation patterns along known or perceived moisture gradients were further explored for trends in vascular species richness at the 25 m^2 scale.

Across all formations and subformations, mean species richness ranged from 4.0 in fernland to 34.5 in dry heathland (Fig. 11). Significant ($P < 0.05$) between-habitat differences in species richness were detected for sand mass vegetation

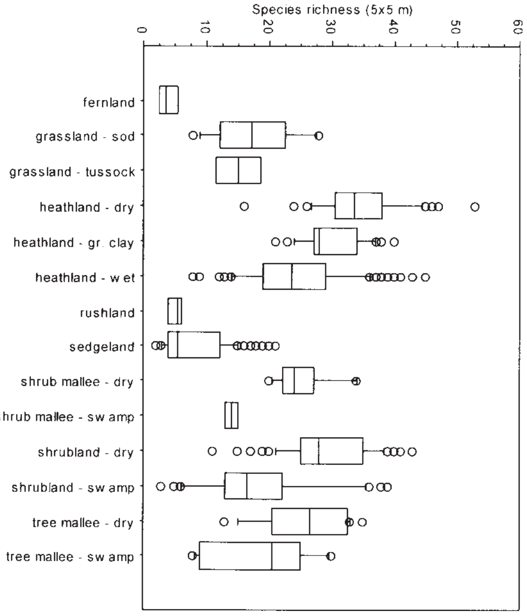


Fig. 11. Variation in species richness at the 25 m^2 scale. Median and quartiles shown as a box, 10th and 90th percentiles as whiskers, and outliers as open circles.

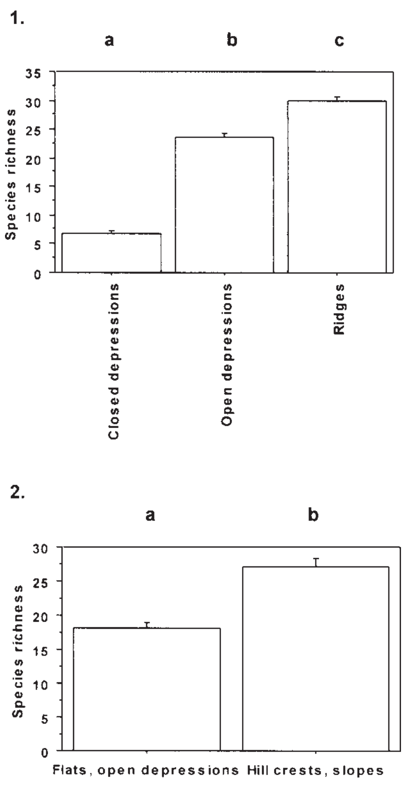


Fig. 12. Trends in mean (+/- SE) species richness (25 m^2)along moisture gradients for: (1) sand mass (wallum) soils; (2) clayey soils associated with hills, flats and drainage depressions. Significant differences (ANOVA: P<0.0001; Tukey/Kramer: P <0.05) are denoted with different letters.

when samples (n = 432) were assigned by characteristic position along a hypothetical ridge – open depression – closed depression toposequence. Significant between-habitat differences were also detected when the vegetation on bedrock hills and headlands was compared with vegetation occupying clayey soils on flats or along drainage (open) depressions (n = 62). The consistent trend was significantly lower species richness in wetter habitats (Fig. 12), and this finding supports observations for other parts of Australia in habitats with impeded drainage (Hnatiuk & Hopkins 1981, Keith 1993, Rice & Westoby 1983). However, it has been suggested that various issues may complicate the interpretation of species richness trends, for example: plant size and growth form; species longevity, life history and recruitment mode; disturbance history; the spatial distribution of resources; and variations in phenology linked to temporal partitioning of resources (Adam et al. 1989, Austin et al. 1996, Le Brocque 1998, Lunt 1990). It was not possible to control for all potentially confounding variables, although the likely influence of plant size and growth form was minimised by restricting comparisons to structurally similar vegetation. Mean species richness was consistently lower for the wetter member in each pair of structural analogues (Fig. 13), although the differences were not universally significant (P <0.05). A trend of significantly higher species richness in dry heathland than in wet heathland is noteworthy, as this differs from an earlier finding of no significant difference for wallum on the lower North Coast of NSW (Myerscough et al. 1995). Overall, the values for mean species richness are within the general range for equivalent formations in other parts of Australia (Keith & Myerscough 1993; Le Brocque 1998).

Overview of findings

Utility of air photo interpretation

A potential limitation of API is the inability to identify spatial relationships for all species. Nonetheless, a high level of congruence between API groups and numerically derived phytosociological units was achieved for single stratum vegetation, thereby demonstrating that photo signatures equate with noda for the full complement of vascular species. Air photo interpretation is also a suitable technique for depicting the spatial distribution of dominant species in the tallest stratum of multi-stratum vegetation, as demonstrated for mallee and shrubland. Growth form alone allows discrimination of photo patterns in multi-stratum vegetation, as with differences in crown architecture that separate mallee from shrubland. Differences in floristic composition of the tallest stratum registering as distinct photo signatures can in turn facilitate the recognition of subformations. However, photo signatures for floristic composition and growth form of the tallest stratum are less satisfactory as surrogates to identify noda for the full complement of species regardless of their vertical arrangement.

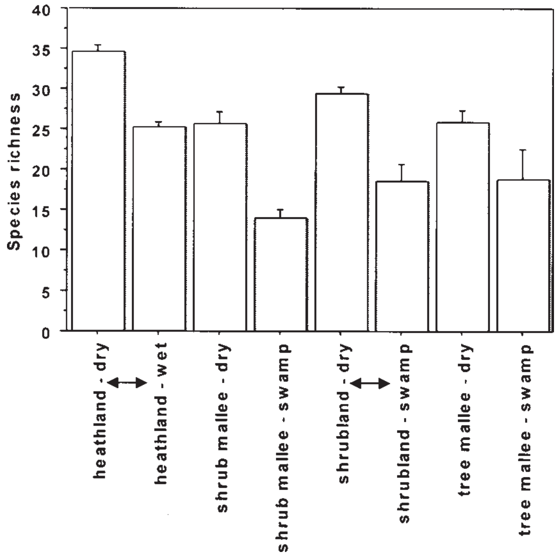


Fig. 13. Trends in mean (+/- SE) species richness of structural analogues for: (1) sand mass (wallum) vegetation; (2) vegetation of clayey soils associated with hills, flats and drainage depressions. For purposes of analysis, sod grassland and tussock grassland were considered sufficiently similar in terms of structure and growth-form size. Pairs for which differences were significant (Tukey/ Kramer: P <0.05) are identified with arrows.

It is likely that effective arguments could be constructed both for and against the segregation of data sets on the basis of vegetation structure prior to the circumscription of phytosociological units, and such decisions will influence the outcome of determinations for species descriptors such as fidelity. These issues do not arise to any extent in phytosociological treatments of vegetation with comparatively limited variation in structure and dominant growth form (Adam et al. 1988, Benson 1994, Webb et al. 1984). It is also apparent that decisions regarding the inclusivity of phytosociological treatments will impact upon the utility of vegetation classifications for nature conservation and land management. For example, it may be sufficient to implement fire management regimes in wallum at the level of formation and subformation without undue concern for floristic composition (NSW National Parks & Wildlife Service 1997, 1998a,b), and conventional API techniques can be applied to achieve the desired outcome. On the other hand, to model potential habitat for a rare species, detailed information about phytosociological and plant – environment relationships may prove more reliable. It would seem that there is value in classifying vegetation at various levels of structural and floristic detail, so that maximum end-use benefits are derived.

Plant – environment relationships

Although testing of additional environmental factors is required, categorical measures of topographic position appear to explain much of the floristic variation in the wallum and allied vegetation of northern NSW. Ironically, the likely overriding significance of topography in the wallum was first recognised almost half a century earlier (Coaldrake 1961), at a time when Australian ecologists were paying considerable attention to soil nutrient gradients as key determinants of vegetation pattern (Coaldrake & Haydock 1958).

Other Australian studies have demonstrated correlations between floristic composition and topography or micro-topography (Connor & Clifford 1972, Myerscough & Carolin 1986, Myerscough et al. 1995, Rayson 1957, Zammit 1981); and repetitive patterns of topography, soils and vegetation are apparent in north-eastern NSW and south-eastern Queensland (e.g. Atkinson 1999, Thompson & Moore 1984). The recognition of topography – vegetation relationships is also fundamental to the circumscription of soil landscapes in NSW (Eddie 2000; Matthei 1995; Milford 1999; Morand 1994, 1996; Murphy 1995). For coastal dunefields and beach ridge plains in eastern Australia generally, there are known or probable interactions between topographic position and rates of soil erosion and deposition, solum depth, the placement and morphology of B horizons, and in turn soil moisture characteristics with respect to seasonal and permanent watertables (e.g. Thompson 1992, Coaldrake 1961).

Species richness

Although mean vascular species richness in the wallum and associated vegetation of northern NSW is lower in wetter habitats at the 25 m^2 scale, differences were not always significant. This outcome suggests that soil moisture gradients alone may be insufficient to explain the species richness trends, and other variables such as fire should be explored. Whether or not the significantly lower species richness in some wet habitats is related to limiting environmental factors is unknown, and robust explanations of species richness in terms of resource availability would require detailed morphological and physiological studies of individual species with respect to resource utilisation.

Conservation

Some plant communities appear to be relatively uncommon in north-eastern NSW, and therefore require further assessment with respect to the adequacy of existing conservation reserves (e.g. 14 *Themeda australis* sod grassland, 38 *Leptospermum speciosum* swamp sclerophyll shrubland, and 40 *Lophostemon confertus* dry sclerophyll mallee shrubland; see Table 1, Appendix 1). For wallum dominated by species found in southern Queensland but only extending into the far north of NSW, for example *L. speciosum* shrubland, conservation strategies are best formulated in collaboration with Queensland environmental agencies.

The regularity with which paired quadrats reunited in numerical analyses suggests a high degree of spatial autocorrelation. This is particularly so for communities with a very disjunct distribution, for example *Themeda australis* sod grassland (14) and communities comprising graminoid clay heathland (16–20). In many instances this pattern of correlation probably demonstrates the influence of subordinate species rather than community dominants. Graminoid clay heathland is of particular interest, because the recognition of geographically discrete communities suggests that this subformation is likely to be in some way unique at each of its widely separated locations along the NSW North Coast. The component communities also support a relatively high number of high-fidelity species, and therefore function as refugia for rare or otherwise restricted species in the wallum. These observations support the listing of graminoid clay heathland at Byron Bay on the far North Coast (outside the study area) as an Endangered Ecological Community under the Threatened Species Conservation Act (1995). The conservation significance of other stands should also be considered, for example on the lower North Coast at Bonny Hills (Gardner Browne Planning Consultants 1989), Old Bar (Greater Taree City Council 1996), and Charlotte Head in Booti Booti NP (Griffith et al. 2000). For environmental agencies and consultants assessing the conservation status of coastal vegetation in northern NSW, it would be inappropriate to dismiss unreserved occurrences as superficially similar to reserved occurrences and therefore of diminished conservation value. Decisions as to the significance of stands currently lacking environmental protection should be based on thorough comparative assessments of floristic composition.

The sedgeland and rushland components of wallum occur in closed depressions, and they meet the inclusion criteria for protection under State Environmental Planning Policy (SEPP) No. 14 Coastal Wetlands (Adam et al. 1985). However, this policy specifically excludes wet heathland and the swamp facies of mallee and some shrublands found in open depressions. Dunefields and beach ridge plains have closely integrated catchment and drainage systems, often with watertables perched at many different elevations, and groundwater displays considerable lateral movement within sand masses. A comparatively strong relationship between vegetation and topography suggests that landscape processes are paramount to the long-term functioning of this ecosystem. Therefore, the objectives of SEPP 14 are likely to be better served if wallum wetlands are conserved as landform patterns rather than isolated landform elements, for example by protecting a beach ridge plain (landform pattern) rather than just a swamp (landform element) supporting sedgeland at the lowest part of the plain. In this respect the existing policy already takes a liberal approach with some designated wetlands (e.g. No. 484 in Limeburners Creek NR, Nos. 543 and 545 in Crowdy Bay NP, and No. 686 in Myall Lakes NP), where extensive beach ridge–swale–swamp and dune–swale–swamp toposequences supporting mosaics of forest, shrubland, heathland and sedgeland are protected. This approach would circumvent much of the ongoing debate about wetland definition and boundary delineation (e.g. Rogers & Saintilan 2002) as it relates to wallum.

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Appendix 1. Descriptions for 42 plant communities circumscribed using numerical and homogeneity analyses.

Species of highest constancy ('constant species') are listed in each community description as follows: plant name (constancy class), for example *Cladium procerum* (V). Species with the highest mean cover-abundance score ('cover-abundant species') are similarly listed: plant name (mean cover class score; constancy class), for example *Salvinia molesta* (4.00; III). Indicator species are identified: plant name (constancy class; mean cover class score), for example *Cladium procerum* (V; 5.00).

Each community description also provides details of: sites, where each represents one or both quadrats of a random pair (e.g. HBU007.1 and HBU007.2); API group (map unit) equivalence; structure, using the height and crown cover classes of Walker and Hopkins (1984); exotic species recorded in quadrats; species richness (total, and mean (+/- SE) in 25 m²); general habitat using data gathered at each quadrat; distribution in northern NSW (primarily localities on the vegetation mapping used for sample stratification); and equivalent or related vegetation types as recognised by others.

Community No. 1: *Baumea rubiginosa* sedgeland

Sites: HBU035.1/.2, HYU022.1/.2, HYU027.1/.2, HHA017.1/.2, HLA005.1/.2, HCR004.1/.2.

API group: 64041 (*Baumea rubiginosa* sedgeland).

Structure: tall to very tall closed sedgeland.

Floristic composition:
- Constant species: *Baumea rubiginosa* (V), *Triglochin procerum* s. lat. (V).
- Cover-abundant species: *Baumea rubiginosa* (3.83; V).
- Indicator species: none.
- Exotic species: *Salvinia molesta*.
- Species richness: total = 12; mean (+/- SE) in 25 m² = 3.75 (0.31).

Habitat:
- Topographic position: closed depressions (swamps).
- Altitude: <10, to 20 m ASL.
- Aspect: nil.
- Slope: 0°.
- Geology: Quaternary sediments.
- Comments: Often replaced by sedgeland communities No. 11, 12 or 13 upslope as average standing water depth decreases.

Map localities in northern NSW: Newrybar Swamp, Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR, Lake Innes NR, Crowdy Bay NP.

Equivalent vegetation types: *Baumea rubiginosa* has a widespread distribution in eastern NSW, and it is found in all other Australian states (Harden 1993). There are scattered records for *B. rubiginosa* sedgeland elsewhere on the North Coast of NSW (Pressey & Griffith 1987), and the community would be included under the *Baumea* sedgelands described for eastern and southern Australia by Briggs (1981). The community is likely to form part of a *B. rubiginosa* – *Baloskion pallens* (syn. *Restio pallens*) – *Gahnia* spp. vegetation unit reported for south-eastern Queensland (McDonald & Elsol 1984).

Community No. 2: *Lepironia articulata* sedgeland

Sites: HBU017.1/.2, HYU021.1/.2, HHA006.1/.2, HCR007.1/.2.

API group: 64051 (*Lepironia articulata* sedgeland).

Structure: very tall closed sedgeland.

Floristic composition:
- Constant species: *Lepironia articulata* (V).
- Cover-abundant species: *Lepironia articulata* (3.75; V).
- Indicator species: *Lepironia articulata* (V; 3.75).
- Exotic species: none.
- Species richness: total = 7; mean (+/- SE) in 25 m² = 3.00 (0.42).

Habitat:
- Topographic position: closed depressions (swamps, lakes).
- Altitude: <10, to 30 m ASL.
- Aspect: nil.
- Slope: 0°.
- Geology: Quaternary sediments (often sand).
- Comments: Occurs in perched swamps associated with interdunal depressions, and also along lake margins and on backbarriers. Often replaced by sedgeland communities No. 1, 11, 12 or 13 upslope as average standing water depth decreases.

Map localities in northern NSW: Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR, Lake Innes NR, Crowdy Bay NP.

Equivalent vegetation types: *Lepironia articulata* has a coastal distribution in NSW, extending northwards from the Central Coast (Harden 1993). Others report *Lepironia articulata* sedgeland for the North Coast of NSW (Bell 1997, Myerscough & Carolin 1986, Pressey 1987a,b), and also for south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Durrington 1977, Elsol & Dowling 1978). The community forms part of the 'coastal *Lepironia* swamp' wetland type of Goodrick (1970).

Community No. 3: *Baumea articulata* sedgeland

Sites: HBU006.1/.2, HYU028.1/.2, HHA018.1/.2, HLA007.1/.2.

API group: 64061 (*Baumea articulata* sedgeland).

Structure: very tall sedgeland and closed sedgeland.

Floristic composition:
- Constant species: *Baumea articulata* (V).
- Cover-abundant species: *Baumea articulata* (4.12; V).
- Indicator species: none.
- Exotic species: *Nymphaea caerulea* subsp. *zanzibarensis*.
- Species richness: total = 13; mean (+/- SE) in 25 m² = 4.38 (0.32).

Habitat:
- Topographic position: closed depressions (swamps).
- Altitude: <10 m ASL.
- Aspect: nil.
- Slope: 0°.
- Geology: Quaternary sediments.

Map localities in northern NSW: Bundjalung NP, Yuraygir NP, Hat Head NP, Lake Innes NR, Frogalla Swamp.

Equivalent vegetation types: *Baumea articulata* has a widespread distribution in coastal NSW, and it is found in most Australian states (Harden 1993). Others report *Baumea articulata* sedgeland for the North Coast of NSW, although it is apparently of limited extent (Bell 1997, Pressey 1987a,b, Pressey & Griffith 1987). The community would be included under the *Baumea* sedgelands broadly defined by Briggs (1981) for eastern, southern and south-western Australia. The community is likely to form part of a *B. articulata* – *Cladium procerum* – *Lepironia articulata* vegetation unit reported for south-eastern Queensland (McDonald & Elsol 1984).

Community No. 4: *Eleocharis sphacelata* sedgeland

Sites: HBU034.1/.2, HHA019.1/.2.

API group: 64101 (*Eleocharis sphacelata* sedgeland).

Structure: tall to very tall closed sedgeland.

Floristic composition:
- Constant species: *Eleocharis sphacelata* (V).
- Cover-abundant species: *Eleocharis sphacelata* (3.75; V).
- Indicator species: none.
- Exotic species: *Nymphaea caerulea* subsp. *zanzibarensis*.
- Species richness: total = 9; mean (+/- SE) in 25 m^2 = 4.50 (0.29).

Habitat:
- Topographic position: closed depressions (swamps).
- Altitude: <10 m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sediments.
- Comments: Often replaced by *Baumea rubiginosa* sedgeland (community No. 1) or *Lepironia articulata* sedgeland (community No. 2) as average standing water depth decreases.

Map localities in northern NSW: Bundjalung NP, Hat Head NP.

Equivalent vegetation types: *Eleocharis sphacelata* has a widespread distribution in NSW, and also throughout the remainder of Australia (Briggs 1981, Harden 1993). Others report sedgeland dominated by *Eleocharis sphacelata* for the North Coast of NSW (Pressey 1981, 1987a,b), and also for the Central Coast, South Coast and inland NSW (Benson 1989). The community would form part of the *Eleocharis* sedgelands broadly defined for Australia by Briggs (1981).

Community No. 5: *Baumea arthrophylla* sedgeland

Sites: HHA021.1/.2, HLA006.1/.2.

API group: 64121 (*Baumea arthrophylla* sedgeland).

Structure: tall to very tall closed sedgeland.

Floristic composition:
- Constant species: *Baumea arthrophylla* (V), *Triglochin procerum* s. lat. (IV).
- Cover-abundant species: *Baumea arthrophylla* (3.50; V).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 4; mean (+/- SE) in 25 m^2 = 2.50 (0.29).

Habitat:
- Topographic position: closed depressions (swamps).
- Altitude: <10 m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sediments.

Map localities in northern NSW: Hat Head NP, Lake Innes NR.

Equivalent vegetation types: Although *Baumea arthrophylla* is found throughout Australia, it is confined to the Central Coast and North Coast in NSW where it is considered to have a sporadic distribution (Harden 1993). Equivalent vegetation types are not known.

Community No. 6: *Cladium procerum* sedgeland

Sites: HBU015.1/.2, HCR005.1/.2.

API group: 64111 (*Cladium procerum* sedgeland).

Structure: very tall closed sedgeland.

Floristic composition:
- Constant species: *Cladium procerum* (V).
- Cover-abundant species: *Cladium procerum* (5.00; V), *Salvinia molesta* (4.00; III).
- Indicator species: *Cladium procerum* (V; 5.00).
- Exotic species: *Salvinia molesta*.
- Species richness: total = 8; mean (+/- SE) in 25 m^2 = 4.75 (0.48).

Habitat:
- Topographic posititon: closed depressions (swamps, lakes).
- Altitude: <10 m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sediments.
- Comments: Typically found bordering deep open water on floating mats of organic matter, the outer edge of which may break up to form rafts.

Map localities in northern NSW: Bundjalung NP, Hat Head NP, Lake Innes NR, Crowdy Bay NP.

Equivalent vegetation types: *Cladium procerum* has a sporadic distribution in coastal NSW (Harden 1993). Others report sedgeland dominated by *Cladium procerum* for the North Coast of NSW (Murphy 1995, Myerscough & Carolin 1986, Pressey 1987a,b). *Cladium procerum* is also likely to dominate sedgelands in south-eastern Queensland (Blake 1968, Dowling & McDonald 1976, Durrington 1977, Elsol & Dowling 1978).

Community No. 7: *Typha orientalis* rushland

Sites: HNE006.1/.2, HLA008.1/.2.

API group: 65041 (*Typha orientalis* rushland).

Structure: very tall rushland and closed rushland.

Floristic composition:
- Constant species: *Typha orientalis* (V).
- Cover-abundant species: *Typha orientalis* (3.75; V).
- Indicator species: *Typha orientalis* (V; 3.75), *Nymphoides indica* (III; 2.00).
- Exotic species: *Nymphaea caerulea* subsp. *zanzibarensis*, *Salvinia molesta*.
- Species richness: total = 11; mean (+/- SE) in 25 m^2 = 5.00 (0.71).

Habitat:
- Topographic position: closed depressions (swamps, lakes).
- Altitude: <10 m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sediments.

Map localities in northern NSW: Newrybar Swamp, Evans Head, Lake Innes NR.

Equivalent vegetation types: *Typha orientalis* has a widespread distribution in NSW, and throughout Australia generally (Harden 1993). Rushlands dominated by this species are likely to occur on floodplains in northern NSW (Pressey 1987a). Briggs (1981) describes 'grassland' communities dominated by one or other of *Typha domingensis* and *T. orientalis*.

Community No. 8: *Blechnum indicum* fernland

Sites: HBU007.1/.2, HCR002.1/.2.

API group: 67021 (*Blechnum indicum* fernland).

Structure: tall to very tall closed fernland.

Floristic composition:
- Constant species: *Blechnum indicum* (V).
- Cover-abundant species: *Blechnum indicum* (5.00; V).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 10; mean (+/- SE) in 25 m^2 = 4.00 (1.08).

Habitat:
- Topographic position: closed depressions (swamps).
- Altitude: <10 m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sand.
- Comments: Found in interbarrier swamps close to the sea where relatively high inputs of cyclic salt could be expected.

Map localities in northern NSW: Newrybar Swamp, Bundjalung NP, Crowdy Bay NP.

Equivalent vegetation types: *Blechnum indicum* has a coastal distribution, extending north from Jervis Bay on the NSW South Coast. This distribution continues disjunctly along the Queensland coastline into northern Australia (Chambers et al. 1998, Harden 1990). The community appears to have a scattered distribution on the North Coast of NSW (Murray 1989, Osborn & Robertson 1939 (as *B. serrulatum*), Pressey 1987a,b, Pressey & Griffith 1987), and possibly also on the Central Coast (see Hamilton 1919, as *B. serrulatum*).

Community No. 9: *Baloskion pallens – Melaleuca quinquenervia* sedgeland-heathland

Sites: HBR001.1/.2, HBR004.1/.2, HYU008.1/.2.

API group: 64071 (*Baloskion pallens – Baumea teretifolia – Melaleuca quinquenervia* sedgeland-heathland).

Structure: mid-high to tall closed sedgeland-heathland (or sedge-heath sensu Beadle 1981). *Melaleuca quinquenervia* is present as a heath shrub, although its crown cover varies and so the community is structurally heterogenous. Sedges are generally continuous in height with *M. quinquenervia*.

Floristic composition:
- Constant species: *Melaleuca quinquenervia* (V), *Baloskion pallens* (IV), *Melaleuca squamea* (IV).
- Cover-abundant species: *Melaleuca quinquenervia* (4.00; V), *Baloskion pallens* (4.00; IV), *Baumea juncea* (4.00; II).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 20; mean (+/- SE) in 25 m^2 = 6.67 (1.20).
- Comments: *Baloskion pallens* and *Baumea teretifolia* (III) are generally more constant in this community than the analyses would suggest. Site HYU008.1/.2 is considered to be somewhat atypical – at this location *B. pallens* and *B. teretifolia* were both locally absent in a relatively small stand of the community, whereas *Baumea juncea* was abundant. *Melaleuca squamea*, a fire-sensitive species, varies in constancy and cover-abundance with differences in the fire regime.

Habitat:
- Topographic position: closed depressions (swamps).
- Altitude: <10 m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sand.
- Comments: Often associated with deflated, windswept beach ridge plains, although occasionally present in interdunal depressions. This community is often replaced by wet heathland upslope.

Map localities in northern NSW: Newrybar Swamp, Broadwater NP, Evans Head, Bundjalung NP, Yamba area, Yuraygir NP.

Equivalent vegetation types: Apparently best developed on the far North Coast of NSW, although identical or similar communities are reported for south-eastern Queensland (Batianoff & Elsol 1989 (see Photograph 45), Durrington 1977).

Community No. 10: *Gahnia sieberiana – Gleichenia* sedgeland

Sites: HBU026.1/.2, HBU031.1/.2, HYU026.1/.2, HHA004.1/.2.

API groups: 64081 (*Gahnia sieberiana – Gleichenia mendellii* sedgeland); 64181 (*Gahnia sieberiana – Gleichenia dicarpa* sedgeland).

Structure: tall to very tall closed sedgeland.

Floristic composition:

- Constant species: *Gahnia sieberiana* (V), *Empodisma minus* (V), *Sporadanthus interruptus* (V), *Leptospermum liversidgei* (V), *Adrastaea salicifolia* (V), *Epacris microphylla* var. *microphylla* (V), *Gleichenia mendellii* (IV).
- Cover-abundant species: *Gleichenia dicarpa* (5.50; II), *G. mendellii* (4.83; IV), *Gahnia sieberiana* (3.50; V), *Empodisma minus* (3.50; V), *Sporadanthus interruptus* (3.12; V).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 37; mean (+/- SE) in 25 m^2 = 15.63 (1.10).
- Comments: This community is floristically more similar to wet heathland (see community No. 28 below) than to other sedgelands. Two geographic variants of the community could be recognised based upon the distributions of *Gleichenia mendellii* and *G. dicarpa*. *Gleichenia mendellii* has a restricted distribution, extending from south-eastern Queensland to the Wooli area (east of Grafton) in northern NSW, whereas *G. dicarpa* is widespread in eastern Australia (Chinnock & Bell 1998). *Durringtonia paludosa* (Rubiaceae), a restricted species and monotypic genus, is found in the community.

Habitat:
- Topographic position: open depressions (swales, drainage depressions); ridges (dunes).
- Altitude: <10, to 15 m ASL.
- Aspect: nil, N, SSW. • Slope: 0–4°.
- Geology: Quaternary sand.
- Comments: Characteristically associated with dunefields, in deep Acid Peats kept moist by groundwater seepage.

Map localities in northern NSW: Broadwater NP, Evans Head, Bundjalung NP, Yuraygir NP, Hat Head NP, Crowdy Bay NP. At the latter two localities *Gleichenia dicarpa* replaces *G. mendellii*.

Equivalent vegetation types: *Gahnia sieberiana* and *Gleichenia dicarpa* are common in sedgelands described for the Central Coast of NSW (Buchanan 1980, Pidgeon 1938) as *Gahnia psittacorum*, presumably in error), and a *G. sieberiana – Gleichenia* sp. community occurs in south-eastern Queensland (W. McDonald, Queensland Herbarium pers. comm.). See also Blake (1968) regarding the apparent dominance by *G. sieberiana* in localised areas of wallum in south-eastern Queensland.

Plant community No. 11: *Leptocarpus tenax – Baloskion pallens* sedgeland in Crowdy Bay NP (HCR028.2).

Community No. 11: *Leptocarpus tenax – Baloskion pallens* sedgeland

Sites: HBU001.1/.2, HBU003.1/.2, HBU027.1/.2, HYU006.1/.2, HHA012.1/.2, HLI011.1/.2, HLI013.1/.2, HLI025.1/.2, HLA001.1/.2, HCR006.1/.2, HCR014.1/.2, HCR017.1/.2, HCR019.1/.2, HCR021.1/.2, HCR028.1/.2, HCR031.1/.2.

API group: 64031 in part (*Leptocarpus tenax – Baloskion pallens – Schoenus brevifolius* sedgeland).

Structure: tall to very tall closed sedgeland.

Floristic composition:
- Constant species: *Callistemon pachyphyllus* (V), *Baloskion pallens* (V), *Baumea teretifolia* (V), *Leptocarpus tenax* (V).

- Cover-abundant species: *Leptocarpus tenax* (2.65; V), *Baloskion pallens* (2.50; V), *Schoenus brevifolius* (2.37; III), *Callistemon pachyphyllus* (2.33; V), *Sporadanthus caudatus* (2.33; I), *Melaleuca thymifolia* (2.17; II), *Baumea teretifolia* (2.04; V).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 47; mean (+/- SE) in 25 m^2 = 11.94 (0.66).
- Comments: This community could be separated from the floristically variable API group 64031. Although named after the two constant species of highest mean cover-abundance (*Leptocarpus tenax* and *Baloskion pallens*), other species that may be locally abundant include *Baumea teretifolia*, *Callistemon pachyphyllus*, *Melaleuca thymifolia* and *Schoenus brevifolius*. *Baumea arthrophylla* was subsidiary to co-dominant at one site (HYU006.1/.2),displaying floristic affinities with community No. 5. The community supports *Durringtonia paludosa*, a restricted species and monotypic genus.

Habitat:
- Topographic position: closed depressions (swamps).
- Altitude: <10, to 20 m ASL
- Aspect: generally nil (N at 1 site). • Slope: generally 0° (to 1°).
- Geology: Quaternary sediments (typically sand).
- Comments: Found in shallower swamps than many other sedgeland communities, where the watertable periodically drops to ground level if not beneath the soil surface.

Map localities in northern NSW: Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR, Lake Innes NR, Crowdy Bay NP.

Equivalent vegetation types: This community shares species in common with an *Empodisma minus* (syn. *Calorophus minor*) – *Leptocarpus tenax* alliance described by Beadle (1981) for south-eastern Queensland and NSW. *Leptocarpus tenax*, *Baloskion pallens*, *Schoenus brevifolius* and *Baumea teretifolia* are characteristic of a sedgeland community delineated for Tomaree NP on the lower North Coast of NSW (Bell 1997), and a related sedgeland of *L. tenax*, *S. brevifolius* and other species is described for the Gosford – Lake Macquarie area on the Central Coast (Benson 1986). Similar or related sedgelands occur in south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Elsol & Dowling 1978).

Community No. 12: *Schoenus brevifolius – Baumea teretifolia* sedgeland

Sites: HBU009.1/.2, HLI020.1/.2, HLI026.1/.2.

API group: 64031 in part (*Leptocarpus tenax – Baloskion pallens – Schoenus brevifolius* sedgeland).

Structure: tall to very tall closed sedgeland.

Floristic composition:
- Constant species: *Schoenus brevifolius* (V), *Baumea teretifolia* (V), *Chorizandra sphaerocephala* (V), *Lepyrodia muelleri* (V).
- Cover-abundant species: *Schoenus brevifolius* (3.00; V), *Baumea teretifolia* (3.00; V), *Melaleuca thymifolia* (3.00; IV), *Chorizandra sphaerocephala* (2.67; V).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 20; mean (+/- SE) in 25 m^2 = 10.83 (1.66).
- Comments: This community could be separated from the floristically variable API group 64031. Although named after the two constant species of highest mean cover-abundance (*Schoenus brevifolius* and *Baumea teretifolia*), other species that may be locally abundant are *Callistemon pachyphyllus*, *Chorizandra sphaerocephala* and *Melaleuca thymifolia*.

Habitat:
- Topographic position: closed depressions (swamps).
- Altitude: <10 m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sediments.
- Comments: Found in shallower swamps than many other sedgeland communities, where the watertable periodically drops to ground level if not beneath the soil surface.

Map localities in northern NSW: Bundjalung NP, Limeburners Creek NR.

Equivalent vegetation types: This community shares species in common with an *Empodisma minus* (syn. *Calorophus minor*) – *Leptocarpus tenax* alliance described by Beadle (1981) for south-eastern Queensland and NSW. *Leptocarpus tenax*, *Baloskion pallens*, *Schoenus brevifolius* and *Baumea teretifolia* are characteristic of a sedgeland community delineated for Tomaree NP on the lower North Coast of NSW (Bell 1997), and similar or related sedgelands occur in south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Elsol & Dowling 1978).

Community No. 13: *Baloskion pallens – Baumea teretifolia* sedgeland

Sites: HNE001.1/.2, HNE003.1/.2, HBU021.1/.2, HBU030.1/.2, HBU047.1/.2, HYU023.1/.2, HHA007.1/.2, HLI008.1/.2.

API groups: 64031 in part (*Leptocarpus tenax – Baloskion pallens – Schoenus brevifolius* sedgeland); 64141 (*Baloskion pallens – Schoenus brevifolius* sedgeland).

Structure: tall to very tall closed sedgeland.

Floristic composition:
- Constant species: *Baloskion pallens* (V), *Baumea teretifolia* (V), *Schoenus brevifolius* (IV).
- Cover-abundant species: *Baloskion pallens* (3.06; V), *Sporadanthus caudatus* (2.78; III), *Baumea teretifolia* (2.44; V), *Schoenus brevifolius* (2.17; IV), *Callistemon pachyphyllus* (2.00; I), *Melaleuca squamea* (2.00; I).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 16; mean (+/- SE) in 25 m^2 = 4.63 (0.36).
- Comments: API groups 64031 and 64141 could be re-evaluated to accommodate this community as a distinct entity. Although named after the two constant species of highest mean cover-abundance (*Baloskion pallens* and *Baumea teretifolia*), other species that may be locally abundant are *Schoenus brevifolius* and *Sporadanthus caudatus*. *Melaleuca squamea* is an obligate seeder, and is therefore likely to vary in cover-abundance with differences in the fire regime.

Habitat:
- Topographic position: closed depressions (swamps).
- Altitude: <10, to 30 m ASL.
- Aspect: generally nil (S at 1 site). • Slope: generally 0° (to 1°).
- Geology: Quaternary sediments (typically sand).
- Comments: Found in shallower swamps than many other sedgeland communities, where the watertable periodically drops to ground level if not beneath the soil surface.

Map localities in northern NSW: Newrybar Swamp, Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR.

Equivalent vegetation types: This community shares species in common with an *Empodisma minus* (syn. *Calorophus minor*) – *Leptocarpus tenax* alliance described by Beadle (1981) for south-eastern Queensland and NSW. *Leptocarpus tenax*, *Baloskion pallens*, *Schoenus brevifolius* and *Baumea teretifolia* are characteristic of a sedgeland community delineated for Tomaree NP on the lower North Coast of NSW (Bell 1997), and similar or related sedgelands occur in south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Elsol & Dowling 1978).

Community No. 14: *Themeda australis* sod grassland

Sites: HEV003.1/.2, HMO002.1/.2, HHA009.1/.2, HLI010.1/.2.

API group: 63021 (*Themeda australis* sod grassland).

Structure: low to tall closed sod grassland.

Floristic composition:
- Constant species: *Themeda australis* (V), *Pimelea linifolia* (V), *Polymeria calycina* (IV), *Hydrocotyle peduncularis* (IV), *Centella asiatica* (IV), *Carex breviculmis* (IV), *Poranthera microphylla* (IV), *Bracteantha bracteata* (IV).
- Cover-abundant species: *Themeda australis* (5.75; V), *Pultenaea maritima* ms. (3.50; II).
- Indicator species: *Polymeria calycina* (IV; 2.33), *Bracteantha bracteata* (IV; 2.00), *Hydrocotyle peduncularis* (IV; 1.67), *Poranthera microphylla* (IV; 1.33), *Centella asiatica* (IV; 1.00), *Carex breviculmis* (IV; 1.00).
- Exotic species: *Baccharis halimifolia*, *Chrysanthemoides monilifera* subsp. *rotundata*, *Hypochaeris radicata*, *Pennisetum clandestinum*.
- Species richness: total = 56; mean (+/- SE) in 25 m^2 = 17.38 (2.46).
- Comments: The rare species *Thesium australe* is found in this community, and also a restricted prostrate *Pultenaea* (*P. maritima* ms., Harden 2002).

Habitat:
- Topographic position: hillslopes.
- Altitude: 20–50 m ASL.
- Aspect: NE, E, S, SW. • Slope: 10–25°.
- Geology: sedimentary lithologies.
- Comments: Occupies very exposed seaward slopes of headlands, in Black Headland Soils formed under high levels of cyclic salt accession. Replaced by a range of other headland vegetation types on less exposed aspects. Also found on other substrates such as adamellite (not sampled).

Map localities in northern NSW: Evans Head, Bundjalung NP, Yuraygir NP, Moonee Beach NR, Hat Head NP, Limeburners Creek NR, Kattang NR, Crowdy Bay NP, Booti Booti NP.

Equivalent vegetation types: *Themeda australis* sod grassland is widespread on the North Coast of NSW (Griffith 1992b, Quint 1982). It also extends further south along the NSW coast (Adam et al. 1989, Beadle 1981, Benson 1986, Benson & Howell 1990, McRae 1990), and into coastal southern Queensland (see Batianoff & Elsol (1989), Sattler & Williams (1999) as *T. triandra*). Beadle (1981) describes an equivalent *T. australis* littoral grassland.

Community No. 15: *Themeda australis – Ptilothrix deusta* tussock grassland

Sites: HBU008.1/.2, HYU002.1/.2.

API group: 62031 (*Ischaemum australe – Ptilothrix deusta – Schoenus brevifolius – Themeda australis* tussock grassland).

Structure: mid-high to tall closed tussock grassland.

Floristic composition:
- Constant species: *Themeda australis* (V), *Ptilothrix deusta* (V), *Schoenus brevifolius* (V), *Gonocarpus tetragynus* (IV).
- Cover-abundant species: *Themeda australis* (4.00; V), *Ischaemum australe* (4.00; III), *Ptilothrix deusta* (3.50; V), *Entolasia stricta* (3.00; III).
- Indicator species: *Rutidosis heterogama* (III; 1.00).
- Exotic species: none.
- Species richness: total = 31; mean (+/- SE) in 25 m^2 = 15.00 (2.04).
- Comments: The API group name could be amended to recognise *Themeda australis* and *Ptilothrix deusta* as constant (both 100% occurrence), cover-abundant species. Nonetheless, *Ischaemum australe* is also abundant in some stands, and *Schoenus brevifolius* is constant (100% occurrence). The rare species *Rutidosis heterogama* is found in this community.

Habitat:
- Topographic position: flats (backplains) and drainage (open) depressions.
- Altitude: <10, to 25 m ASL.
- Aspect: nil, or SSE. • Slope: 0–1°.
- Geology: Quaternary sediments (heavy-textured).
- Comments: Found in poorly drained, heavy clay soils derived from muddy estuarine deposits or alluvium. This community often adjoins graminoid clay heathland, or *Xanthorrhoea fulva – Ptilothrix deusta* wet heathland (community No. 22 below).

Map localities in northern NSW: Bundjalung NP, Yuraygir NP.

Equivalent vegetation types: The distribution of this community elsewhere in NSW is uncertain, although grasslands in which *Ischaemum australe* features are known for south-eastern Queensland (Batianoff & Elsol 1989). The community possibly forms part of the 'wet grasslands' described by Briggs (1981) for Australia generally.

Community No. 16: *Themeda australis – Banksia oblongifolia – Aristida warburgii* graminoid clay heathland

Sites: HAR001.1/.2, HAR002.1/.2.

API group: 59041 (*Banksia oblongifolia – Allocasuarina littoralis – Hakea teretifolia* subsp. *teretifolia – Aristida warburgii – Themeda australis* graminoid clay heathland).

Structure: (occasionally dwarf to) low to mid-high closed heathland.

Floristic composition:
- Constant species: *Banksia oblongifolia* (V), *Themeda australis* (V), *Patersonia sericea* (V), *Gompholobium pinnatum* (V), *Panicum simile* (V), *Lepidosperma laterale* (V), *Aristida warburgii* (V), *Patersonia glabrata* (V), *Lomandra multiflora* subsp. *multiflora* (V), *Gonocarpus tetragynus* (V), *Pimelea linifolia* (V), *Lepidosperma neesii* (V), *Phyllota phylicoides* (V), *Entolasia stricta* (V), *Mirbelia rubiifolia* (V), *Austrostipa pubescens* (V), *Boronia pinnata* (V), *Hibbertia empetrifolia* subsp. *empetrifolia* (V), *Lomandra longifolia* (V), *Bossiaea ensata* (V).
- Cover-abundant species: *Themeda australis* (4.00; V), *Banksia oblongifolia* (3.50; V), *Allocasuarina littoralis* (3.00; IV), *Aristida warburgii* (3.00; V), *Hibbertia empetrifolia* subsp. *empetrifolia* (2.50; V), *Platysace ericoides* (2.50; III).
- Indicator species: *Hibbertia empetrifolia* subsp. *empetrifolia* (V; 2.50), *Lomatia silaifolia* (IV; 1.00), *Acacia leiocalyx* (III; 1.00), *Jacksonia scoparia* (III; 1.00).
- Exotic species: none.
- Species richness: total = 52; mean (+/- SE) in 25 m^2 = 29.75 (2.32).
- Comments: *Ptilothrix deusta*, a characteristic species of other graminoid clay heathlands on the North Coast of NSW, is apparently absent from this community in Arakoon SRA. *Hakea teretifolia* subsp. *teretifolia* reaches its northern distribution limit in the vicinity of Arakoon SRA (Harden 2002). The cover-abundance of *H. teretifolia* subsp. *teretifolia* (generally an obligate seeder) and *Allocasuarina littoralis* is likely to vary with differences in the fire regime. The API group name could be amended to recognise *Themeda australis, Banksia oblongifolia* and *Aristida warburgii* as the more constant (all 100% occurrence), cover-abundant species.

Habitat:
- Topographic position: hillslopes.
- Altitude: 40–70 m ASL.
- Aspect: NNE, WNW. • Slope: 8–22°.
- Geology: adamellite.
- Comments: Found in periodically waterlogged, solodic sandy clay loam to sandy clay soils on relatively exposed coastal hills.

Map localities in northern NSW: Arakoon SRA.

Equivalent vegetation types: This community forms part of an *Allocasuarina littoralis – Banksia oblongifolia* (syn. *Casuarina littoralis – B. aspleniifolia*) 'headland heath' alliance delineated by Beadle (1981) for south-eastern Queensland and northern NSW. Related communities occur elsewhere on the lower North Coast (Benson 1981, Griffith et al. 2000), and also on the Central Coast (McRae 1990). Similar heathland vegetation is found on trachyte and rhyolite in south-eastern Queensland (Batianoff & Elsol 1989), for example on Mount Coolum (S. Griffith pers. observ. 1999).

Community No. 17: *Ptilothrix deusta – Aristida warburgii – Hakea teretifolia* subsp. *teretifolia* graminoid clay heathland

Sites: HCR001.1/.2, HCR003.1/.2.

API group: 59031 (*Banksia oblongifolia – Allocasuarina littoralis – Hakea teretifolia* subsp. *teretifolia – Aristida warburgii – Ptilothrix deusta* graminoid clay heathland).

Structure: low to tall closed heathland.

Floristic composition:

- Constant species: *Banksia oblongifolia* (V), *Themeda australis* (V), *Patersonia sericea* (V), *Gompholobium pinnatum* (V), *Panicum simile* (V), *Allocasuarina littoralis* (V), *Lepidosperma laterale* (V), *Aristida warburgii* (V), *Cassytha glabella* forma *glabella* (V), *Lomandra multiflora* subsp. *multiflora* (V), *Melichrus procumbens* (V), *Gonocarpus tetragynus* (V), *Pimelea linifolia* (V), *Lepidosperma neesii* (V), *Ptilothrix deusta* (V), *Hakea laevipes* subsp. *laevipes* (V), *Entolasia stricta* (V), *Mirbelia rubiifolia* (V), *Tricoryne elatior* (V), *Schoenus brevifolius* (V), *Austrostipa pubescens* (V), *Boronia pinnata* (V), *Isopogon anemonifolius* (V), *Hakea teretifolia* subsp. *teretifolia* (V), *Hibbertia riparia* (V), *Goodenia stelligera* (V), *Sowerbaea juncea* (V).
- Cover-abundant species: *Ptilothrix deusta* (4.50; V), *Aristida warburgii* (4.00; V), *Hakea teretifolia* subsp. *teretifolia* (3.00; V), *Isopogon anemonifolius* (2.50; V).
- Indicator species: *Cryptandra scortechinii* (III; 1.50), *Euphrasia collina* subsp. *paludosa* (III; 1.50), *Bossiaea stephensonii* (III; 1.00), *Brunoniella pumilio* (III; 1.00), *Caesia parviflora* (III; 1.00).
- Exotic species: none.
- Species richness: total = 66; mean (+/- SE) in 25 m^2 = 37.00 (1.29).
- Comments: *Hakea teretifolia* subsp. *teretifolia* reaches its northern distribution limit in the Macleay River valley on the mid North Coast of NSW (Harden 2002). The cover-abundance of *H. teretifolia* subsp. *teretifolia* (generally an obligate seeder) is likely to vary with differences in the fire regime, and at exceptionally high cover values this species may displace other heath shrubs such as *Banksia oblongifolia* and *Allocasuarina littoralis*. The API group name could be amended to recognise *Ptilothrix deusta*, *Aristida warburgii* and *Hakea teretifolia* subsp. *teretifolia* as the more constant (all 100% occurrence), cover-abundant species.

Habitat:

- Topographic position: hillslopes and hillcrests.
- Altitude: 10–50 m ASL.
- Aspect: NW. • Slope: 1–13°.
- Geology: sedimentary lithologies (rhyolite elsewhere).
- Comments: Found in periodically waterlogged, solodic clay loam to heavy clay soils on relatively exposed coastal and sub-coastal hills.

Map localities in northern NSW: Crowdy Bay NP.

Equivalent vegetation types: The community forms part of an *Allocasuarina littoralis – Banksia oblongifolia* (syn. *Casuarina littoralis – B. aspleniifolia*) 'headland heath' alliance delineated by Beadle (1981) for south-eastern Queensland and northern NSW. Related communities occur elsewhere on the lower North Coast (Benson 1981, Griffith et al. 2000), and also on the Central Coast (McRae 1990). Similar heathland vegetation is found on trachyte and rhyolite in south-eastern Queensland (Batianoff & Elsol 1989), for example on Mount Coolum (S. Griffith pers. observ. 1999).

Community No. 18: *Ptilothrix deusta – Banksia oblongifolia – Mirbelia rubiifolia* graminoid clay heathland

Sites: HEV001.1/.2.

API group: 59021, in part (*Banksia oblongifolia – Allocasuarina littoralis – Aristida warburgii – Ptilothrix deusta* graminoid clay heathland).

Structure: low to mid-high closed heathland.

Floristic composition:

- Constant species: *Banksia oblongifolia* (V), *Themeda australis* (V), *Patersonia sericea* (V), *Gompholobium pinnatum* (V), *Panicum simile* (V), *Allocasuarina littoralis* (V), *Lepidosperma laterale* (V), *Cassytha glabella* forma *glabella* (V), *Patersonia glabrata* (V), *Melichrus procumbens* (V), *Epacris pulchella* (V), *Ptilothrix deusta* (V), *Entolasia stricta* (V), *Mirbelia rubiifolia* (V), *Tricoryne elatior* (V), *Bossiaea ensata* (V), *Notelaea ovata* (V), *Hibbertia vestita* (V), *Phyllanthus hirtellus* (V), *Melaleuca nodosa* (V), *Leptospermum trinervium* (V), *Boronia safrolifera* (V), *Austromyrtus dulcis* (V), *Bossiaea rhombifolia* subsp. *rhombifolia* (V), *Xanthosia pilosa* (V), *Hibbertia diffusa* (V), *Ochrosperma citriodorum* (V), *Homoranthus virgatus* (V).
- Cover-abundant species: *Ptilothrix deusta* (5.00; V), *Banksia oblongifolia* (4.00; V), *Mirbelia rubiifolia* (4.00; V), *Epacris pulchella* (3.00; V), *Hibbertia vestita* (3.00; V), *Melaleuca nodosa* (3.00; V), *Boronia safrolifera* (3.00; V), *Bossiaea rhombifolia* subsp. *rhombifolia* (3.00; V).
- Indicator species: *Bossiaea rhombifolia* subsp. *rhombifolia* (V; 3.00), *Callitris columellaris* (III; 1.00).
- Exotic species: none.
- Species richness: total = 42; mean (+/- SE) in 25 m^2 = 31.50 (0.50).
- Comments: This community could be segregated from the broader API group 59021.

Habitat:

- Topographic position: hillslope.
- Altitude: 37 m ASL.
- Aspect: NE. • Slope: 7°.
- Geology: sedimentary lithology.
- Comments: Found in periodically waterlogged, solodic light sandy clay loam to sandy clay loam soil on a relatively exposed coastal hill.

Map localities in northern NSW: Evans Head.

Equivalent vegetation types: The community forms part of an *Allocasuarina littoralis – Banksia oblongifolia* (syn. *Casuarina littoralis – B. aspleniifolia*) 'headland heath' alliance delineated by Beadle (1981) for south-eastern Queensland and northern NSW. Related communities occur on the lower North Coast (Benson 1981, Griffith et al. 2000), and also on the Central Coast (McRae 1990, see also Adam et al. (1989) who report a *B. oblongifolia – Mirbelia rubiifolia* closed heathland). Similar heathland vegetation is found on trachyte and rhyolite in south-eastern Queensland (Batianoff & Elsol 1989), for example on Mount Coolum (S. Griffith pers. observ. 1999).

Community No. 19: *Ptilothrix deusta – Aristida warburgii – Banksia oblongifolia – Allocasuarina littoralis – Epacris pulchella* graminoid clay heathland

Sites: HYU001.1/.2, HYU004.1/.2, HYU005.1/.2.

API group: 59021, in part (*Banksia oblongifolia – Allocasuarina littoralis – Aristida warburgii – Ptilothrix deusta* graminoid clay heathland).

Structure: low to mid-high (occasionally dwarf or tall) closed heathland.

Floristic composition:

- Constant species: *Banksia oblongifolia* (V), *Themeda australis* (V), *Patersonia sericea* (V), *Gompholobium pinnatum* (V), *Panicum simile* (V), *Allocasuarina littoralis* (V), *Lepidosperma laterale* (V), *Aristida warburgii* (V), *Cassytha glabella* forma *glabella* (V), *Dampiera stricta* (V), *Pimelea linifolia* (V), *Goodenia bellidifolia* (V), *Epacris pulchella* (V), *Ptilothrix deusta* (V), *Hakea laevipes* subsp. *laevipes* (V), *Platysace ericoides* (V), *Hibbertia vestita* (V), *Phyllanthus hirtellus* (V), *Kunzea capitata* (V), *Dillwynia retorta* (V).
- Cover-abundant species: *Ptilothrix deusta* (4.67; V), *Aristida warburgii* (4.00; V), *Banksia oblongifolia* (3.50; V), *Allocasuarina littoralis* (3.17; V), *Epacris pulchella* (3.00; V).
- Indicator species: *Lambertia formosa* (IV; 2.00), *Lomandra obliqua* (IV; 2.00).
- Exotic species: none.
- Species richness: total = 52; mean (+/- SE) in 25 m^2 = 25.83 (1.14).
- Comments: This community could be segregated from the broader API group 59021.

Habitat:

- Topographic position: hillslopes.
- Altitude: 20–40 m ASL.
- Aspect: SE, S. • Slope: 2–3°.
- Geology: sedimentary lithologies.
- Comments: Found in periodically waterlogged, solodic sandy clay loam to heavy clay soils on relatively exposed coastal and sub-coastal hills.

Map localities in northern NSW: Yuraygir NP (and adjoining lands).

Equivalent vegetation types: The community forms part of an *Allocasuarina littoralis – Banksia oblongifolia* (syn. *Casuarina littoralis – B. aspleniifolia*) 'headland heath' alliance delineated by Beadle (1981) for south-eastern Queensland and northern NSW. Related communities occur on the lower North Coast (Benson 1981, Griffith et al. 2000), and also on the Central Coast (McRae 1990). Similar heathland vegetation is found on trachyte and rhyolite in south-eastern Queensland (Batianoff & Elsol 1989), for example on Mount Coolum (S. Griffith pers. observ. 1999).

Plant community No. 20: *Banksia oblongifolia – Ptilothrix deusta – Aristida warburgii – Allocasuarina littoralis* graminoid clay heathland in Yuraygir NP (HYU020.1). Lake Minnie Water in the background.

Community No. 20: *Banksia oblongifolia – Ptilothrix deusta – Aristida warburgii –Allocasuarina littoralis* graminoid clay heathland.

Sites: HYU016.1/.2, HYU017.1/.2, HYU018.1/.2, HYU019.1/.2, HYU020.1/.2.

API group: 59021, in part (*Banksia oblongifolia – Allocasuarina littoralis – Aristida warburgii – Ptilothrix deusta* graminoid clay heathland).

Structure: low to mid-high (occasionally dwarf or tall) closed heathland.

Floristic composition:

- Constant species: *Banksia oblongifolia* (V), *Themeda australis* (V), *Patersonia sericea* (V), *Gompholobium pinnatum* (V), *Panicum simile* (V), *Allocasuarina littoralis* (V), *Aristida warburgii* (V), *Lomandra multiflora* subsp. *multiflora* (V), *Dampiera stricta* (V), *Pimelea linifolia* (V), *Phyllota phylicoides* (V), *Goodenia bellidifolia* (V), *Ptilothrix deusta* (V), *Hibbertia vestita* (V), *Kunzea capitata* (V), *Eremochloa bimaculata* (V), *Lissanthe* sp. B (V).
- Cover-abundant species: *Banksia oblongifolia* (3.90; V), *Ptilothrix deusta* (3.60; V), *Aristida warburgii* (3.40; V), *Allocasuarina littoralis* (3.10; V).
- Indicator species: *Lissanthe* sp. B (V; 1.50), *Fimbristylis cinnamometorum* (III; 1.30), *Isopogon mnoraifolius* (IV; 1.00).
- Exotic species: none.
- Species richness: total = 62; mean (+/- SE) in 25 m^2 = 29.50 (1.54).
- Comments: This community could be segregated from the broader API group 59021, although without modification of the existing community name.

Habitat:

- Topographic position: hillslopes.
- Altitude: <10, to 20 m ASL.
- Aspect: S, SE, WSW. • Slope: 1–3°.
- Geology: sedimentary lithologies.
- Comments: Found in periodically waterlogged, solodic light sandy clay loam to heavy clay soils on relatively exposed sub-coastal hills.

Map localities in northern NSW: Yuraygir NP (and adjoining lands).

Equivalent vegetation types: The community forms part of an *Allocasuarina littoralis – Banksia oblongifolia* (syn. *Casuarina littoralis – B. aspleniifolia*) 'headland heath' alliance delineated by Beadle (1981) for south-eastern Queensland and northern NSW.

Related communities occur on the lower North Coast (Benson 1981, Griffith et al. 2000), and also on the Central Coast (McRae 1990). Similar heathland vegetation is found on trachyte and rhyolite in south-eastern Queensland (Batianoff & Elsol 1989), for example on Mount Coolum (S. Griffith pers. observ. 1999).

Community No. 21: *Leptospermum juniperinum* wet heathland

Sites: HBU025.1/.2, HYU029.1/.2, HHA008.1/.2, HCR023.1/.2.

API group: 60031 (*Leptospermum juniperinum* wet heathland).

Structure: mid-high to tall heathland and closed heathland.

Floristic composition:
- Constant species: *Leptospermum juniperinum* (V), *Baumea teretifolia* (V), *Entolasia stricta* (V), *Baumea rubiginosa* (V), *Blechnum indicum* (V).
- Cover-abundant species: *Leptospermum juniperinum* (5.00; V), *Sporadanthus caudatus* (3.00; IV).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 39; mean (+/- SE) in 25 m^2 = 12.38 (0.89).
- Comments: This community supports *Durringtonia paludosa*, a restricted species and monotypic genus.

Habitat:
- Topographic position: open depressions (swales, drainage depressions).
- Altitude: <10 m ASL.
- Aspect: nil.
- Slope: 0°.
- Geology: Quaternary sand.
- Comments: Found in wetter situations than other wet heathland communities where groundwater remains at or just above the soil surface for extended periods.

Map localities in northern NSW: Newrybar Swamp, Evans Head, Bundjalung NP, Yuraygir NP, Moonee Beach NR, Hat Head NP, Lake Innes NR, Crowdy Bay NP.

Equivalent vegetation types: *Leptospermum juniperinum* is widespread on the coast and adjoining tablelands of NSW, and continues into Queensland (Harden 2002, Queensland Herbarium 1994). Nonetheless, the community appears to have a scattered distribution along the North Coast. For Brisbane Waters NP on the Central Coast, Benson and Fallding (1981) report *L. juniperinum* as a dominant in poorly drained situations. *Leptospermum juniperinum* is a common species of wet heathland in coastal south-western Victoria (Head 1988).

Community No. 22: *Xanthorrhoea fulva – Ptilothrix deusta* wet heathland

Sites: HBU010.1/.2, HBU011.1/.2, HYU003.1/.2, HLI001.1/.2, HLI002.1/.2, HLI003.1/.2, HLI004.1/.2, HLI009.1/.2, HLI027.1/.2, HLI033.1/.2, HLI034.1/.2.

API group: 60041 (*Xanthorrhoea fulva* wet heathland).

Structure: low to tall closed heathland.

Floristic composition:
- Constant species: *Xanthorrhoea fulva* (V), *Entolasia stricta* (V), *Schoenus brevifolius* (V), *Melaleuca thymifolia* (V), *Ptilothrix deusta* (V).
- Cover-abundant species: *Ptilothrix deusta* (4.14; V), *Xanthorrhoea fulva* (4.09; V), *Pultenaea myrtoides* (2.60; II).
- Indicator species: none.
- Exotic species: *Verbena bonariensis*.
- Species richness: total = 97; mean (+/- SE) in 25 m^2 = 19.27 (0.89).
- Comments: The API group name could be amended to recognise *Ptilothrix deusta* as a constant (100% occurrence), cover-abundant species. This community supports the rare species *Gonocarpus salsoloides* and *Rutidosis heterogama*.

Habitat:
- Topographic position: flats (backplains), or less commonly drainage (open) depressions.
- Altitude: generally <10 (to 20) m ASL.
- Aspect: nil.
- Slope: 0°.
- Geology: Quaternary sediments.
- Comments: Typically found in sandy loam to heavy clay soils associated with muddy estuarine deposits or alluvium. The soils are periodically waterlogged by a rising watertable.

Map localities in northern NSW: Evans Head, Bundjalung NP, Yuraygir NP, Limeburners Creek NR, Lake Innes NR, Crowdy Bay NP.

Equivalent vegetation types: *Xanthorrhoea fulva* has a coastal distribution which extends north from Wyong on the Central Coast of NSW, and continues into Queensland (Harden 1993). Wet heathland dominated by *X. fulva* is reasonably widespread on the North Coast of NSW, and it also occurs in south-eastern Queensland (W. McDonald, Queensland Herbarium pers. comm.; see also Photograph 42 in Batianoff & Elsol 1989). For south-eastern Queensland and southwards, Beadle (1981) recognises a *Xanthorrhoea resinosa* s. lat. (= *X. fulva*/*X. concava*) association. Similarly, for the Central Coast and South Coast in NSW, Benson (1989) recognises a *X. resinosa* s. lat. +/- *Schoenus brevifolius* community.

Plant community No. 22: *Xanthorrhoea fulva – Ptilothrix deusta* wet heathland in Limeburners Creek NR (HLI003.1).

Plant community No. 23: *Banksia oblongifolia – Leptospermum polygalifolium* subsp. *cismontanum – Melaleuca nodosa* wet heathland in Yuraygir NP (HYU034.1/.2). Note also tree mallee and forest dominated by *Eucalyptus pilularis* in the background.

Community No. 23: *Banksia oblongifolia – Leptospermum polygalifolium* subsp. *cismontanum – Melaleuca nodosa* wet heathland

Sites: HBR025.1/.2, HYU034.1/.2, HLI031.1/.2.

API group: 60071 (*Banksia oblongifolia – Leptospermum polygalifolium* subsp. *cismontanum – Melaleuca nodosa* wet heathland).

Structure: low to tall heathland and closed heathland.

Floristic composition:

- Constant species: *Melaleuca nodosa* (V), *Banksia oblongifolia* (V), *Leptospermum polygalifolium* subsp. *cismontanum* (V), *Pseudanthus orientalis* (V).
- Cover-abundant species: *Pteridium esculentum* (4.00; II), *Banksia oblongifolia* (3.50; V), *Melaleuca nodosa* (3.17; V), *Leptospermum polygalifolium* subsp. *cismontanum* (3.00; V).
- Indicator species: none.
- Exotic species: *Lantana camara*.
- Species richness: total = 108; mean (+/- SE) in 25 m^2 = 30.00 (4.14).

Habitat:

- Topographic position: open depressions (swales).
- Altitude: <10, to 30 m ASL.
- Aspect: nil, or E. • Slope: 0–1°.
- Geology: Quaternary sand.
- Comments: This community appears to be associated with sandy podzolised soils in which a relatively shallow, weakly indurated or incipient pan retards, but doesn't prevent, vertical drainage.

Map localities in northern NSW: Broadwater NP, Bundjalung NP, Yuraygir NP, Limeburners Creek NR, Khappinghat NP.

Equivalent vegetation types: This community appears to have a scattered distribution on the North Coast of NSW, and it apparently extends to the Central Coast (see Benson 1989). A related *Melaleuca nodosa – Leptospermum polygalifolium* (syn. *L. flavescens*) 'shrub thicket' or 'closed scrub' is described for south-eastern Queensland (Coaldrake 1961, Specht et al. 1974), and also a *L. polygalifolium – L. semibaccatum – Banksia oblongifolia* heathland (Specht et al. 1974). Coaldrake (1961) further identifies a correlation between the occurrence of *L. polygalifolium* and soils with a soft organic pan. The community is probably best placed in the *L. polygalifolium – L. trinervium* (syn. *L. attenuatum*) alliance of Beadle (1981).

Community No. 24: *Sporadanthus interruptus – Xanthorrhoea fulva – Banksia ericifolia* subsp. *macrantha – Leptospermum liversidgei – Baeckea frutescens* wet heathland

Sites: HBR003.1/.2, HBR005.1/.2, HBR006.1/.2, HBR008.1/.2, HBR009.1/.2, HBR012.1/.2, HBR013.1/.2, HEV006.1/.2, HYU007.1/.2.

API group: 60021 in part (*Banksia oblongifolia – Leptospermum liversidgei – Sporadanthus interruptus – Sprengelia sprengelioides – Xanthorrhoea fulva* wet heathland).

Structure: (rarely low to) mid-high to tall closed heathland.

Floristic composition:

- Constant species: *Banksia ericifolia* subsp. *macrantha* (V), *Selaginella uliginosa* (V), *Leptocarpus tenax* (V), *Xanthorrhoea fulva* (V), *Cassytha glabella* forma *glabella* (V), *Sporadanthus interruptus* (V), *Epacris obtusifolia* (V), *Leptospermum liversidgei* (V), *Baeckea frutescens* (V), *Sprengelia sprengelioides* (V), *Aotus ericoides* (V).
- Cover-abundant species: *Sporadanthus interruptus* (4.00; V), *Xanthorrhoea fulva* (3.94; V), *Banksia ericifolia* subsp. *macrantha* (3.47; V), *Leptospermum liversidgei* (3.11; V), *Baeckea frutescens* (3.11; V), *Eurychorda complanata* (3.00; I).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 66; mean (+/- SE) in 25 m^2 = 20.78 (0.82).
- Comments: This community could be segregated from the broader API group 60021. *Banksia ericifolia* subsp. *macrantha* is a fire-sensitive obligate seeder, and therefore likely to vary in distribution and cover-abundance with differences in the fire regime.

Habitat:

- Topographic position: open depressions (swales).
- Altitude: <10 m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sand.
- Comments: Grows in poorly drained podzolised sands where a watertable remains close to the ground surface for extended periods. Often replaced by dry heathland or dry sclerophyll shrubland upslope as soil drainage improves. Replaced by sedgeland downslope where standing water accumulates.

Map localities in northern NSW: Broadwater NP, Evans Head, Yuraygir NP.

Equivalent vegetation types: Four of the five species for which this community is named reach their southern distribution limit on the lower North Coast, whereas *Xanthorrhoea fulva* extends further south (Bean 1997, Greater Taree City Council 1996, Harden 1993, 2002, McNair 1992). As presently known, the community appears to be restricted to the upper North Coast of NSW, although related heathlands (without *Banksia ericifolia* subsp. *macrantha*) are likely to be present in south-eastern Queensland (Batianoff & Elsol 1989, Clifford & Specht 1979, Durrington 1977, Elsol & Dowling 1978). The community is probably best placed in the *Leptospermum liversidgei* alliance of Beadle (1981).

Plant community No. 25: *Sporadanthus interruptus – Xanthorrhoea fulva* wet heathland in Crowdy Bay NP (HCR010.1), with *Banksia oblongifolia* also frequent. Note dense shrubland dominated by *Banksia ericifolia* subsp. *macrantha* in the background.

Community No. 25: *Sporadanthus interruptus – Xanthorrhoea fulva* wet heathland

Sites: HNE002.1/.2, HBR010.1/.2, HBU028.1, HBU041.1/.2, HBU042.1/.2, HBU045.1/.2, HBU049.1/.2, HBU051.1/.2, HYU025.1/.2, HHA001.1/.2, HLI005.1/.2, HLI007.1/.2, HLI015.1/.2, HLI018.1/.2, HLI022.1/.2, HLI023.1/.2, HLI024.1/.2, HLI028.1/.2, HLI029.1/.2, HLI030.1/.2, HLA002.1/.2, HCR008.1/.2, HCR010.1/.2, HCR011.1/.2, HCR013.1/.2, HCR015.1/.2, HCR016.1/.2, HCR018.1/.2, HCR020.1/.2, HCR024.1/.2, HCR027.1/.2, HCR035.1/.2, HCR036.1/.2, HCR037.1/.2.

API group: 60021 in part (*Banksia oblongifolia – Leptospermum liversidgei – Sporadanthus interruptus – Sprengelia sprengelioides – Xanthorrhoea fulva* wet heathland).

Structure: low to tall closed heathland.

Floristic composition:

- Constant species: *Banksia ericifolia* subsp. *macrantha* (V), *Baeckea imbricata* (V), *Xanthorrhoea fulva* (V), *Cassytha glabella* forma *glabella* (V), *Sporadanthus interruptus* (V), *Pimelea linifolia* (V), *Epacris obtusifolia* (V), *Leptospermum liversidgei* (V), *Dillwynia floribunda* (V), *Pseudanthus orientalis* (V), *Boronia falcifolia* (V), *Sprengelia sprengelioides* (V).
- Cover-abundant species: *Baeckea frutescens* (3.36; III), *Sporadanthus interruptus* (3.15; V), *Xanthorrhoea fulva* (3.07; V), *Baeckea linifolia* (3.00; I), *Leptospermum liversidgei* (2.94; V), *Banksia oblongifolia* (2.79; IV).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 154; mean (+/- SE) in 25 m^2 = 28.52 (0.79).
- Comments: This community could be segregated from the broader API group 60021. Although named after *Sporadanthus interruptus* and *Xanthorrhoea fulva*, the two constant species (both 100% occurrence) of highest mean cover-abundance, *Leptospermum liversidgei* is also constant as a subsidiary species. Some stands of the community in Hat Head NP support *Baeckea linifolia* as a sub-sidiary to co-dominant heath shrub, and this species is not known from wallum elsewhere in the study area. The community also supports the rare species *Allocasuarina defungens* and *Gonocarpus salsoloides*.

Habitat:

- Topographic position: open depressions (swales).
- Altitude: <10, to 20 m ASL.
- Aspect: nil, E, ESE, S, W, WNW, NW. • Slope: 0–4°.
- Geology: Quaternary sand.
- Comments: Grows in poorly drained podzolised sands where a watertable remains close to the ground surface for extended periods. Often replaced by dry heathland or dry sclerophyll shrubland upslope as soil drainage improves. Replaced by sedgeland downslope where standing water accumulates.

Map localities in northern NSW: Newrybar Swamp, Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR, Lake Innes NR, Crowdy Bay NP.

Equivalent vegetation types: Two of the three species for which this community is named reach their southern distribution limit on the lower North Coast, whereas *Xanthorrhoea fulva* extends further south (Harden 1993, McNair 1992). The community appears to be widespread on the North Coast of NSW, and similar communities are likely to be present in south-eastern Queensland (Batianoff & Elsol 1989, Clifford & Specht 1979, Elsol & Dowling 1978). The community is probably best placed in the *Leptospermum liversidgei* alliance of Beadle (1981).

Community No. 26: *Banksia oblongifolia – Xanthorrhoea fulva* wet heathland

Sites: HBU002.1/.2, HBU004.1/.2, HBU038.1/.2, HYU039.1/.2, HMO001.1/.2.

API group: 60021 in part (*Banksia oblongifolia – Leptospermum liversidgei – Sporadanthus interruptus – Sprengelia sprengelioides – Xanthorrhoea fulva* wet heathland).

Structure: low to tall closed heathland.

Floristic composition:

- Constant species: *Burchardia umbellata* (V), *Blandfordia grandiflora* (V), *Leptocarpus tenax* (V), *Xanthorrhoea fulva* (V), *Cassytha glabella* forma *glabella* (V), *Pimelea linifolia* (V), *Leptospermum liversidgei* (V), *Banksia oblongifolia* (V), *Drosera auriculata* (V), *Pseudanthus orientalis* (V), *Sprengelia sprengelioides* (V), *Persoonia virgata* (V), *Hibbertia vestita* (V), *Entolasia stricta* (V).
- Cover-abundant species: *Banksia oblongifolia* (3.70; V), *Xanthorrhoea fulva* (3.40; V), *Aotus ericoides* (3.00; I), *Platysace* sp. A (3.00; IV), *Lepidosperma neesii* (3.00; I), *Leptospermum liversidgei* (2.70; V), *Empodisma minus* (2.67; II), *Hibbertia vestita* (2.56; V).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 94; mean (+/- SE) in 25 m^2 = 32.20 (1.41).
- Comments: This community could be segregated from the broader API group 60021. Although named after *Banksia oblongifolia* and *Xanthorrhoea fulva*, the two constant species (both 100% occurrence) of highest mean cover-abundance, *Leptospermum liversidgei* (100% occurrence) and *Hibberita vestita* (90% occurrence) are frequent as subsidiary species. The community supports the rare species *Prostanthera palustris*.

Habitat:

- Topographic position: open depressions (swales).
- Altitude: generally <10 (to 10) m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sand.
- Comments: Grows in poorly drained podzolised sands where a watertable remains close to the ground surface for extended periods.

Map localities in northern NSW: Bundjalung NP, Yuraygir NP, Moonee Beach NR.

Equivalent vegetation types: This community appears to have a scattered distribution along the NSW North Coast, although both species for which it is named extend further south (Harden 1993, 2002). Similar or related communities are likely to occur in south-eastern Queensland (Batianoff & Elsol 1989). The community has affinities with the *Banksia oblongifolia* (syn. *B. aspleniifolia*) alliance of Beadle (1981).

Community No. 27: *Xanthorrhoea fulva – Schoenus paludosus – Banksia ericifolia* subsp. *macrantha* wet heathland

Sites: HCR022.1/.2.

API group: 60021 in part (*Banksia oblongifolia – Leptospermum liversidgei – Sporadanthus interruptus – Sprengelia sprengelioides – Xanthorrhoea fulva* wet heathland).

Structure: low to tall closed heathland.

Floristic composition:

- Constant species: *Banksia ericifolia* subsp. *macrantha* (V), *Burchardia umbellata* (V), *Blandfordia grandiflora* (V), *Selaginella uliginosa* (V), *Leptocarpus tenax* (V), *Xanthorrhoea fulva* (V), *Cassytha glabella* forma *glabella* (V), *Sporadanthus interruptus* (V), *Pimelea linifolia* (V), *Epacris obtusifolia* (V), *Entolasia stricta* (V), *Schoenus brevifolius* (V), *Eurychorda complanata* (V), *Sowerbaea juncea* (V), *Chorizandra sphaerocephala* (V), *Persoonia lanceolata* (V), *Schoenus paludosus* (V), *Sprengelia incarnata* (V), *Kunzea capitata* (V), *Gymnoschoenus sphaerocephalus* (V), *Lepyrodia* sp. A (V).
- Cover-abundant species: *Xanthorrhoea fulva* (4.00; V), *Schoenus paludosus* (4.00; V), *Banksia ericifolia* subsp. *macrantha* (3.50; V), *Sporadanthus interruptus* (3.00; V).
- Indicator species: *Gymnoschoenus sphaerocephalus* (V; 2.00), *Plinthanthesis paradoxa* (III; 1.00).
- Exotic species: none.
- Species richness: total = 34; mean (+/- SE) in 25 m^2 = 21.50 (0.50).
- Comments: This community could be segregated from the broader API group 60021.

Habitat:

- Topographic position: open depression (swale).

- Altitude: <10 m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sand.
- Comments: Grows in poorly drained podzolised sand where a watertable remains close to the ground surface for extended periods.

Map localities in northern NSW: Crowdy Bay NP.

Equivalent vegetation types: The high cover-abundance of *Schoenus paludosus* in this community seems unusual for wet heathlands along the North Coast of NSW. The community is probably most closely aligned with the *Banksia ericifolia* (subsp. *ericifolia* and subsp. *macrantha*) alliance of Beadle (1981).

Plant community No. 28: *Leptospermum liversidgei – Sporadanthus interruptus – Empodisma minus* wet heathland in Bundjalung NP (HBU022.1).

Community No. 28: *Leptospermum liversidgei – Sporadanthus interruptus – Empodisma minus* wet heathland

Sites: HBU013.1/.2, HBU020.1/.2, HBU022.1/.2, HBU028.2, HBU032.1/.2, HBU046.1/.2, HYU012.1/.2, HYU013.1/.2, HYU031.1/.2, HYU032.1/.2, HYU040.1/.2, HHA013.1/.2, HHA014.1/.2, HHA015.1/.2, HLI017.1/.2.

API group: 60021 in part (*Banksia oblongifolia – Leptospermum liversidgei – Sporadanthus interruptus – Sprengelia sprengelioides – Xanthorrhoea fulva* wet heathland).

Structure: low to tall closed heathland.

Floristic composition:

- Constant species: *Xanthorrhoea fulva* (V), *Cassytha glabella* forma *glabella* (V), *Sporadanthus interruptus* (V), *Pimelea linifolia* (V), *Leptospermum liversidgei* (V), *Baumea muelleri* (V), *Boronia falcifolia* (V), *Sprengelia sprengelioides* (V), *Adrastaea salicifolia* (V), *Empodisma minus* (V), *Epacris microphylla* var. *microphylla* (V).
- Cover-abundant species: *Leptospermum liversidgei* (3.69; V), *Sporadanthus interruptus* (3.24; V), *Empodisma minus* (3.10; V), *Baeckea frutescens* (3.06; IV), *Gleichenia mendellii* (3.00; I), *Baeckea linifolia* (3.00; I), *Xanthorrhoea fulva* (2.64; V).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 81; mean (+/- SE) in 25 m^2 = 19.90 (0.98).
- Comments: This community could be segregated from the broader API group 60021. Some stands of the community in Hat Head NP support *Baeckea linifolia* as a subsidiary heath shrub, and this species is not known from wallum elsewhere in the study area. The community supports a strong component of sedges (most notably *Empodisma minus* and *Sporadanthus interruptus*, but also *Schoenus scabripes* and others), and therefore may resemble a sedge-heath (sensu Beadle 1981) in appearance.

Habitat:

- Topographic position: open depressions (swales).
- Altitude: <10, to 20 m ASL.
- Aspect: nil, N, NE, ENE, E, SE, ESE, SSE, S, SSW, SW.
- Slope: 0–6°.
- Geology: Quaternary sand.
- Comments: Characteristic of soils with a well-developed layer of peat, and often associated with gentle slopes that appear to receive groundwater seepage.

Map localities in northern NSW: Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR.

Equivalent vegetation types: This community has floristic affinities with *Gahnia sieberiana – Gleichenia* sedgeland (community No. 10 above). Two of the three species for which the community is named reach their southern distribution limit on the lower North Coast of NSW, whereas *Empodisma minus* extends further south (Harden 1993, McNair 1992). Similar or related communities are likely to occur in south-eastern Queensland (Batianoff & Elsol 1989, Clifford & Specht 1979, Durrington 1977). The community has affinities with the *Leptospermum liversidgei* alliance of Beadle (1981).

Plant community No. 29: *Banksia aemula – Leptospermum trinervium* dry heathland in Yuraygir NP (HYU024.2). Note also wet heathland (relatively smooth appearance) in the background.

Community No. 29: *Banksia aemula – Leptospermum trinervium* dry heathland

Sites: HNE005.1/.2, HBR011.1/.2, HBR014.1/.2, HEV002.1/.2, HBU005.1/.2, HBU012.1/.2, HBU014.1/.2, HBU029.1/.2, HBU053.1/.2, HYU011.1/.2, HYU014.1/.2, HYU024.1/.2, HYU030.1/.2, HHA010.1/.2, HHA011.1/.2, HLI014.1/.2.

API groups: 58021 in part (*Banksia aemula* dry heathland); 58031 in part (*Banksia aemula – Allocasuarina littoralis* dry heathland).

Structure: low to tall closed heathland.

Floristic composition:

- Constant species: *Banksia aemula* (V), *Leucopogon leptospermoides* (V), *Caustis recurvata* var. *recurvata* (V), *Monotoca scoparia* (V), *Dillwynia retorta* (V), *Acacia ulicifolia* (V), *Schoenus ericetorum* (V), *Brachyloma daphnoides* (V), *Leucopogon virgatus* (V), *Bossiaea ensata* (V), *Acacia suaveolens* (V), *Gompholobium virgatum* var. *virgatum* (V), *Persoonia virgata* (V), *Leptospermum trinervium* (V), *Coleocarya gracilis* (V).
- Cover-abundant species: *Banksia aemula* (3.53; V), *Leptospermum trinervium* (3.04; V), *Calytrix tetragona* (3.00; I), *Xanthorrhoea glauca* subsp. *glauca* (3.00; I), *Melaleuca nodosa* (2.90; IV), *Leptospermum semibaccatum* (2.57; II), *Xanthorrhoea johnsonii* (2.50; IV), *Monotoca scoparia* (2.41; V).

- Indicator species: none.
- Exotic species: none.
- Species richness: total = 110; mean (+/- SE) in 25 m^2 = 35.31 (1.42).
- Comments: This community could be segregated from API groups 58021 and 58031. It is typically distinguished from other dry heathland communities by relatively high constancy (88% occurrence) and mean cover-abundance for *Leptospermum trinervium*. Other locally abundant species include *Calytrix tetragona*, *Xanthorrhoea glauca* subsp. *glauca* and *Melaleuca nodosa*. The community supports the rare species *Olax angulata*.

Habitat:
- Topographic position: ridges (beach ridges and dunes).
- Altitude: <10, to 45 m ASL.
- Aspect: nil, N, ENE, E, ESE, SE, S, SSW, SW.
- Slope: 0–12°.
- Geology: Quaternary sand.
- Comments: Found in deep, well-drained podzolised sands, typically where somewhat exposed to prevailing onshore winds. The community grades into dry sclerophyll shrubland (often API group 54021/2) on less exposed aspects.

Map localities in northern NSW: Newrybar Swamp, Broadwater NP, Evans Head, Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR.

Equivalent vegetation types: *Banksia aemula* has a coastal distribution, and this extends north from the Central Coast of NSW into south-eastern Queensland. *Leptospermum trinervium* is more widespread (Harden 2002, Queensland Herbarium 1994). As presently circumscribed, the *B. aemula* – *L. trinervium* community appears to be widespread along the North Coast of NSW to the north of the Hastings River. However, throughout this range some congeneric species interchange across distribution boundaries, for example *Xanthorrhoea johnsonii* north from the Macleay River valley and *Xanthorrhoea glauca* subsp. *glauca* to the south. The community is likely to extend into south-eastern Queensland (Durrington 1977), and it forms part of a *Banksia aemula* (syn. *B. serratifolia*) alliance erected by Beadle (1981).

Community No. 30: *Banksia aemula – Allocasuarina littoralis* dry heathland

Sites: HBR018.1/.2, HYU038.1/.2.

API group: 58031 in part (*Banksia aemula – Allocasuarina littoralis* dry heathland).

Structure: low to tall closed heathland.

Floristic composition:

- Constant species: *Banksia aemula* (V), *Leucopogon leptospermoides* (V), *Caustis recurvata* var. *recurvata* (V), *Monotoca scoparia* (V), *Eriostemon australasius* (V), *Zieria laxiflora* (V), *Bossiaea ensata* (V), *Acacia suaveolens* (V), *Gompholobium virgatum* var. *virgatum* (V), *Allocasuarina littoralis* (V), *Tetratheca thymifolia* (V), *Pomax umbellata* (V), *Hibbertia vestita* (V).
- Cover-abundant species: *Banksia aemula* (3.50; V), *Allocasuarina littoralis* (3.50; V), *Hypolaena fastigiata* (3.00; III), *Platysace lanceolata* (3.00; III), *Leptospermum trinervium* (3.00; III), *Pteridium esculentum* (3.00; III), *Monotoca scoparia* (2.75; V).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 73; mean (+/- SE) in 25 m^2 = 33.25 (1.49).
- Comments: This community maintains the identity of API group 58031 for stands in which *Allocasuarina littoralis* clearly co-dominates with *Banksia aemula*. *Boronia rosmarinifolia*, an uncommon species of wallum on the North Coast of NSW, occurs in the community.

Habitat:
- Topographic position: ridges (dunes).
- Altitude: 20–35 m ASL.
- Aspect: E, SSW.
- Slope: 9°.
- Geology: Quaternary sand.
- Comments: Found in deep, well-drained podzolised sands, typically where somewhat exposed to prevailing onshore winds. Anecdotal evidence suggests that *Allocasuarina littoralis* develops high cover values under a regime of long inter-fire intervals, for example in parts of Broadwater NP.

Map localities in northern NSW: Broadwater NP, Yuraygir NP.

Equivalent vegetation types: The respective distributions of *Banksia aemula* and *Allocasuarina littoralis* overlap from the Central Coast of NSW northwards into south-eastern Queensland (Harden 1990,1991, Queensland Herbarium 1994). The community appears to have a very scattered distribution along the North Coast of NSW, although it is likely to be present in south-eastern Queensland (Batianoff & Elsol 1989). A related heathland in which another *Allocasuarina*, *A. simulans*, associates with *Banksia aemula* occurs in Booti Booti NP on the lower North Coast of NSW (Griffith et al. 2000). Further south on the Central Coast, McRae (1990) reports *A. distyla* as common in *B. aemula* heathland of Bouddi Peninsula. The community forms part of a *B. aemula* (syn. *B. serratifolia*) alliance erected by Beadle (1981).

Community No. 31: *Banksia aemula* dry heathland

Sites: HKA001.1/.2, HCR025.1/.2, HCR029.1/.2, HCR030.1/.2, HCR034.1/.2, HCR038.1/.2.

API groups: 58021 in part (*Banksia aemula* dry heathland); 58031 in part (*Banksia aemula – Allocasuarina littoralis* dry heathland).

Structure: low to tall closed heathland.

Floristic composition:

- Constant species: *Banksia aemula* (V), *Leucopogon leptospermoides* (V), *Caustis recurvata* var. *recurvata* (V), *Monotoca scoparia* (V), *Phyllota phylicoides* (V), *Hypolaena fastigiata* (V), *Hibbertia fasciculata* (V), *Ricinocarpus pinifolius* (V), *Pimelea linifolia* (V), *Schoenus ericetorum* (V), *Brachyloma daphnoides* (V), *Leucopogon virgatus* (V), *Pseudanthus orientalis* (V), *Leptospermum semibaccatum* (V), *Platysace lanceolata* (V), *Boronia pinnata* (V), *Lomandra glauca* (V).
- Cover-abundant species: *Banksia aemula* (3.42; V), *Philotheca salsolifolia* (3.00; I), *Boronia pinnata* (2.70; V), *Leptospermum semibaccatum* (2.60; V), *Monotoca scoparia* (2.58; V), *Phyllota phylicoides* (2.55; V), *Dillwynia retorta* (2.50; III), *Eriostemon australasius* (2.50; IV), *Coleocarya gracilis* (2.50; I), *Xanthorrhoea glauca* subsp. *glauca* (2.50; III).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 88; mean (+/- SE) in 25 m^2 = 32.75 (0.87).
- Comments: This community could be segregated from API groups 58021 and 58031. *Banksia aemula* is present at relatively high mean cover-abundance. Other locally conspicuous species include *Philotheca salsolifolia*, *Boronia pinnata*, *Leptospermum semibaccatum* and *Monotoca scoparia*. The community supports restricted or otherwise uncommon species in the wallum of north-eastern NSW, for example *Acacia quadrilateralis* and *Persoonia katerae*.

Habitat:
- Topographic position: ridges (beach ridges and dunes).
- Altitude: <10, to 60 m ASL.
- Aspect: nil, SE, WNW.
- Slope: 0–12°.
- Geology: Quaternary sand.

- Comments: Found in deep, well-drained podzolised sands, typically where somewhat exposed to prevailing onshore winds. The community may grade into wet heathland downslope as soil drainage deteriorates, and into dry sclerophyll shrubland on less exposed aspects.

Map localities in northern NSW: Kattang NR, Crowdy Bay NP.

Equivalent vegetation types: In contrast to *Banksia aemula – Leptospermum trinervium* dry heathland (community No. 29 above), this community represents those dry heathlands of the study area to the south of the Hastings River in which *L. trinervium* is conspicuous by its absence. Conversely, species such as *Boronia pinnata* feature in this community but not to any extent in *B. aemula – L. trinervium* dry heathland. *Hypolaena fastigiata* is constant, possibly linking this community to a *B. aemula – H. fastigiata* one described for the Central Coast of NSW by Adam et al. (1989). The community forms part of a *Banksia aemula* (syn. *B. serratifolia*) alliance erected by Beadle (1981).

Plant community No. 32: *Banksia aemula – Phyllota phylicoides* dry sclerophyll shrubland in Crowdy Bay NP (HCR033.2). *Banksia aemula* forms a tallest stratum to 4 m over lower heath shrubs and herbaceous species.

Community No. 32: *Banksia aemula – Phyllota phylicoides* dry sclerophyll shrubland

Sites: HNE004.1/.2, HBR021.1/.2, HBR023.1/.2, HBR024.1/.2, HBU019.1/.2, HBU033.1/.2, HBU037.1/.2, HBU039.1/.2, HBU040.1/.2, HBU043.1/.2, HBU044.1/.2, HBU048.1/.2, HBU050.1/.2, HBU052.1/.2, HBU054.1/.2, HYU036.1/.2, HYU037.1/.2, HHA002.1/.2, HLI006.1/.2, HLI019.1/.2, HLI021.1/.2, HLI032.1/.2, HCR032.1/.2, HCR033.1/.2.

API group: This community accounts for approximately 90% of samples for 54021/2 (*Banksia aemula* dry sclerophyll shrubland).

Structure: tall to very tall (occasionally extremely tall), sparse to closed shrubland.

Floristic composition:

- Constant species: *Banksia aemula* (V), *Leucopogon leptospermoides* (V), *Hibbertia fasciculata* (V), *Leptospermum polygalifolium* subsp. *cismontanum* (V), *Pseudanthus orientalis* (V), *Monotoca scoparia* (V), *Dillwynia retorta* (V), *Caustis recurvata* var. *recurvata* (V), *Schoenus ericetorum* (V), *Phyllota phylicoides* (V).
- Cover-abundant species: *Banksia aemula* (3.38; V), *Callitris rhomboidea* (3.00; I), *Xanthorrhoea glauca* subsp. *glauca* (2.80; II), *Leptospermum semibaccatum* (2.73; IV), *Leptospermum trinervium* (2.70; III), *Xanthorrhoea johnsonii* (2.64; IV), *Melaleuca nodosa* (2.54; III), *Boronia pinnata* (2.50; II), *Leucopogon leptospermoides* (2.47; V), *Phyllota phylicoides* (2.41; V).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 138; mean (+/- SE) in 25 m^2 = 30.10 (0.91).
- Comments: *Banksia aemula* is constant (100% occurrence) in the tallest stratum, and has the highest mean cover-abundance. Other relatively constant, cover-abundant species include the understorey heath shrubs *Phyllota phylicoides* (92% occurrence) and *Leucopogon leptospermoides* (98% occurrence). The community supports *Allocasuarina defungens* and *Leucopogon rodwayi*, which are rare in the wallum of northern NSW.

Habitat:

- Topographic position: ridges (dunes and beach ridges).
- Altitude: <10, to 30 m ASL.
- Aspect: nil, N, NE, E, SE, S, SW, WSW, NW.
- Slope: 0–5°.
- Geology: Quaternary sand.
- Comments: This community is characteristic of well-drained, podzolised sands. It grades structurally into dry heathland with increasing exposure to onshore winds.

Map localities in northern NSW: Newrybar Swamp, Broadwater NP, Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR, Crowdy Bay NP.

Equivalent vegetation types: *Banksia aemula* has a coastal distribution which extends north from the Central Coast of NSW into south-eastern Queensland, and *Phyllota phylicoides* is more widespread (Harden 2002, Queensland Herbarium 1994). The *B. aemula – P. phylicoides* community appears to be widespread along the North Coast of NSW, and throughout this range some congeneric species interchange across distribution boundaries, for example *Xanthorrhoea johnsonii* north from the Macleay River valley and *Xanthorrhoea glauca* subsp. *glauca* to the south. Similar or related communities are reported for the Central Coast (Benson & Howell 1990), and south-eastern Queensland (Batianoff & Elsol 1989, Dowling & McDonald 1976, Durrington 1977, Sattler & Williams 1999). The community would form part of a *B. aemula* (syn. *B. serratifolia*) alliance established by Beadle (1981).

Community No. 33: *Banksia aemula – Allocasuarina littoralis* +/- *B. serrata* dry sclerophyll shrubland

Sites: HBR015.1/.2, HBR016.1/.2, HBR017.1/.2, HEV007.1/.2, HYU010.1/.2, HMO003.1/.2, HKA002.1/.2.

API groups: This community accounts for approximately 10% of samples for 54021/2 (*Banksia aemula* dry sclerophyll shrubland), and all samples for 54031/2 (*B. aemula – Allocasuarina littoralis* dry sclerophyll shrubland) and 54051 (*B. serrata – A. littoralis – Leptospermum trinervium* dry sclerophyll shrubland).

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

Floristic composition:

- Constant species: *Banksia aemula* (V), *Leucopogon leptospermoides* (V), *Allocasuarina littoralis* (V), *Monotoca elliptica* (IV), *Pteridium esculentum* (IV), *Acacia suaveolens* (IV), *Panicum simile* (IV), *Themeda australis* (IV), *Leptospermum trinervium* (IV), *Dillwynia retorta* (IV), *Caustis recurvata* var. *recurvata* (IV), *Patersonia glabrata* (IV), *Pomax umbellata* (IV).
- Cover-abundant species: *Melaleuca nodosa* (4.00; I), *Hibbertia acuminata* (3.50; I), *Banksia serrata* (3.25; II), *Leptospermum polygalifolium* subsp. *cismontanum* (3.17; III), *Banksia aemula* (3.14; V), *Boronia safrolifera* (3.00; I), *Xanthorrhoea fulva* (3.00; I), *Leptospermum trinervium* (2.91; IV), *Pteridium esculentum* (2.73; IV), *Aotus lanigera* (2.50; I), *Austromyrtus dulcis* (2.50; III), *Austrostipa pubescens* (2.50; I), *Banksia integrifolia* subsp. *integrifolia* (2.50; I), *Acronychia imperforata* (2.33; II), *Allocasuarina littoralis* (2.25; V), *Leptospermum semibaccatum* (2.25; II).
- Indicator species: none.

- Exotic species: *Andropogon virginicus*.
- Species richness: total = 129; mean (+/- SE) in 25 m^2 = 26.64 (2.20).
- Comments: *Banksia aemula* and *Allocasuarina littoralis* are comparatively constant and cover-abundant, generally in the tallest stratum. *Banksia serrata* and *Leptospermum trinervium* are also abundant in the tallest stratum of some stands. Conspicuous understorey species include *Austromyrtus dulcis* and *Pteridium esculentum*. The community supports *Acronychia imperforata* and *Cupaniopsis anacardioides*, tree species that are typical of littoral rainforest (see Floyd 1990). These and other rainforest taxa may recruit into the community in the absence of fire for extended periods. Infrequent fire probably also favours *A. littoralis* (discussed previously). Two taxa, *Abildgaardia vaginata* and *Persoonia katerae*, have restricted distributions in the wallum of northern NSW.

Habitat:

- Topographic position: ridges (dunes).
- Altitude: <10, to 40 m ASL.
- Aspect: nil, NE, S, SW, WSW, WNW. • Slope: 0–12°.
- Geology: Quaternary sand.
- Comments: Often found in well-drained sands close to the sea where the soils are likely to be younger and therefore less podzolised (cf. community No. 32).

Map localities in northern NSW: Broadwater NP, Evans Head, Yuraygir NP, Moonee Beach NR, Kattang NR.

Equivalent vegetation types: This community appears to be sporadic along the North Coast of NSW. A related *Banksia serrata – Allocasuarina littoralis* (syn. *Casuarina littoralis*) low open forest is reported for Newcastle Bight on the lower North Coast (National Parks Association of NSW 1976), and for coastal NSW south from Forster (lower North Coast) Adam et al. (1989) describe a *B. serrata – Allocasuarina distyla* community. Related woodlands and low forests are described for south-eastern Queensland in which *B. serrata* and *A. littoralis* feature with other species, sometimes with *L. trinervium* (syn. *L. stellatum*) common in a lower stratum (Durrington 1977). Batianoff and Elsol (1989) also describe a *B. aemula – A. littoralis* community for south-eastern Queensland.

Community No. 34: *Banksia ericifolia* subsp. *macrantha* +/- *Leptospermum whitei – L. polygalifolium* subsp. *cismontanum* swamp sclerophyll shrubland

Sites: HNE008.1/.2, HCR009.1/.2.

API groups: 55031 in part (*Banksia ericifolia* subsp. *macrantha* swamp sclerophyll shrubland), and all samples for 55111 (*Leptospermum whitei – L. polygalifolium* subsp. *cismontanum* swamp sclerophyll shrubland).

Structure: tall to very tall shrubland and closed shrubland (rarely open shrubland).

Floristic composition:

- Constant species: *Pimelea linifolia* (V), *Sporadanthus interruptus* (V), *Xanthorrhoea fulva* (V), *Banksia ericifolia* subsp. *macrantha* (V), *Dillwynia floribunda* (V), *Burchardia umbellata* (V), *Blandfordia grandiflora* (V), *Gahnia sieberiana* (V).
- Cover-abundant species: *Leptospermum whitei* (4.50; III), *Banksia ericifolia* subsp. *macrantha* (4.00; V), *Leptospermum polygalifolium* subsp. *cismontanum* (3.50; III), *Baeckea frutescens* (3.00; III), *Banksia oblongifolia* (3.00; III), *Empodisma minus* (3.00; III), *Platysace* sp. A (3.00; III).
- Indicator species: *Acacia maidenii* (III; 1.00).
- Exotic species: *Crassocephalum crepidioides*, *Erechtites valerianifolia*.
- Species richness: total = 63; mean (+/- SE) in 25 m^2 = 25.25 (3.59).
- Comments: *Banksia ericifolia* subsp. *macrantha* is constant (100% occurrence) with relatively high mean cover-abundance. The tallest stratum of some stands is clearly dominated by *B. ericifolia* subsp. *macrantha*. In other stands *Leptospermum whitei* and *L. polygalifolium* subsp. *cismontanum* dominate the tallest stratum with *B. ericifolia* subsp. *macrantha* also co-dominant or subsidiary. *Banksia ericifolia* subsp. *macrantha* is fire-sensitive, and therefore likely to vary in cover-abundance with differences in the fire regime.

Habitat:

- Topographic position: open depressions (swales).
- Altitude: <10 m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sand.
- Comments: Found in poorly drained podzolised sands with a shallow watertable.

Map localities in northern NSW: Newrybar Swamp, Crowdy Bay NP.

Equivalent vegetation types: *Banksia ericifolia* subsp. *macrantha* is restricted to the North Coast in NSW, where it has a disjunct distribution north from the Forster area (Harden 2002). Stands of this community dominated by *B. ericifolia* subsp. *macrantha* form part of a *B. ericifolia* (subsp. *ericifolia* and subsp. *macrantha*) alliance for NSW (Beadle 1981). *Banksia ericifolia* subsp. *ericifolia* forms shrublands on the Central Coast of NSW (Benson & Fallding 1981). Stands of the community dominated by *Leptospermum whitei* and *L. polygalifolium* subsp. *cismontanum* possibly form part of a *L. polygalifolium – L. trinervium* (syn. *L. flavescens – L. attenuatum*) alliance (Beadle 1981).

Community No. 35: *Melaleuca sieberi*/*Banksia ericifolia* subsp. *macrantha – M. thymifolia* swamp sclerophyll shrubland

Sites: HBU036.1/.2, HYU015.1/.2, HLI012.1/.2, HCR039.1/.2.

API groups: 55031 in part (*Banksia ericifolia* subsp. *macrantha* swamp sclerophyll shrubland), and all samples for 55081/2 (*Melaleuca sieberi* swamp sclerophyll shrubland).

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

Floristic composition:

- Constant species: *Entolasia stricta* (V), *Schoenus brevifolius* (V), *Ischaemum australe* (V), *Melaleuca thymifolia* (V), *Callistemon pachyphyllus* (V).
- Cover-abundant species: *Banksia ericifolia* subsp. *macrantha* (4.00; II), *Melaleuca sieberi* (3.67; IV), *Ptilothrix deusta* (3.50; III), *Aristida warburgii* (3.00; II), *Goodenia paniculata* (3.00; II), *Hibbertia vestita* (3.00; II), *Themeda australis* (3.00; II), *Hakea actites* (2.50; III), *Melaleuca thymifolia* (2.38; V).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 81; mean (+/- SE) in 25 m^2 = 24.38 (3.76).
- Comments: This community comprises shrublands in which the tallest stratum is dominated by either *Melaleuca sieberi* or *Banksia ericifolia* subsp. *macrantha*. Constant, but not necessarily cover-abundant, understorey species include *Entolasia stricta*, *Schoenus brevifolius*, *Callistemon pachyphyllus* and *Melaleuca thymifolia* (all with 100% occurrence). *Banksia ericifolia* subsp. *macrantha* is fire-sensitive, and therefore likely to vary in cover-abundance with differences in the fire regime. *Almaleea paludosa* occurs in the community, and is apparently rare in the wallum and associated vegetation of northern NSW.

Habitat:

- Topographic position: flats (plains and backplains), open depressions (swales).
- Altitude: <10, to 40 m ASL.

- Aspect: nil, ESE. • Slope: 0–1°.
- Geology: Quaternary sediments.
- Comments: Often associated with heavier-textured soils (at least in the profile surface) than community No. 34, and periodically water-logged or inundated.

Map localities in northern NSW: Bundjalung NP, Yuraygir NP, Limeburners Creek NR, Crowdy Bay NP.

Equivalent vegetation types: *Banksia ericifolia* subsp. *macrantha* is restricted to the North Coast in NSW, where it has a disjunct distribution north from the Forster area (Harden 2002). Stands of this community dominated by *B. ericifolia* subsp. *macrantha* form part of a *B. ericifolia* (subsp. *ericifolia* and subsp. *macrantha*) alliance for NSW (Beadle 1981). *Banksia ericifolia* subsp. *ericifolia* forms shrublands on the Central Coast of NSW (Benson & Fallding 1981). *Melaleuca sieberi* reaches its southern distribution limit in the Gosford area on the Central Coast of NSW (Harden 2002), and Benson (1986) reports the species as a dominant of some swamp forests and 'scrubs' in this region. A *M. sieberi* scrub is also reported for south-eastern Queensland (Dowling & McDonald 1976).

Community No. 36: *Melaleuca quinquenervia – Baumea teretifolia* swamp sclerophyll shrubland

Sites: HNE009.1/.2, HBR002.1/.2, HHA020.1/.2.

API group: 55061/2 in part (*Melaleuca quinquenervia* swamp sclerophyll shrubland).

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

Floristic composition:

- Constant species: *Melaleuca quinquenervia* (V), *Baumea teretifolia* (V), *Blechnum indicum* (IV), *Baumea rubiginosa* (IV), *Baloskion pallens* (IV), *Leptospermum juniperinum* (IV).
- Cover-abundant species: *Blechnum indicum* (4.00; IV), *Baumea articulata* (3.00; II), *Gahnia sieberiana* (3.00; II), *Melaleuca quinquenervia* (3.00; V), *Baumea teretifolia* (2.83; V), *Baloskion pallens* (2.75; IV).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 25; mean (+/- SE) in 25 m^2 = 8.17 (1.92).
- Comments: *Baumea teretifolia* is conspicuous (100% occurrence) in the understorey of this *Melaleuca quinquenervia* shrubland. It supports *Durringtonia paludosa*, a restricted species and monotypic genus.
- Topographic position: closed depressions (swamps).
- Altitude: <10 m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sand.
- Comments: Found in swamps where standing water is present for extended periods.

Map localities in northern NSW: Newrybar Swamp, Broadwater NP, Hat Head NP.

Equivalent vegetation types: *Melaleuca quinquenervia* has a coastal distribution which extends from the Central Coast of NSW into northern Queensland, and *Baumea teretifolia* is more widespread (Harden 1993, 2002, Queensland Herbarium 1994). Minor occurrences of *M. quinquenervia* shrubland are reported for south-eastern Queensland (McDonald & Elsol 1984), and also related heathlands in which *M. quinquenervia* is dominant or co-dominant (Batianoff & Elsol 1989, Dowling & McDonald 1976, Durrington 1977).

Community No. 37: *Melaleuca quinquenervia – Baumea juncea* swamp sclerophyll shrubland

Sites: HYU009.1/.2, HKA003.1/.2.

API group: 55061/2 in part (*Melaleuca quinquenervia* swamp sclerophyll shrubland).

Structure: tall shrubland and closed shrubland.

Floristic composition:

- Constant species: *Parsonsia straminea* (V), *Melaleuca quinquenervia* (V), *Baumea juncea* (V), *Dianella caerulea* (IV), *Blechnum indicum* (IV).
- Cover-abundant species: *Melaleuca quinquenervia* (4.50; V), *Baumea rubiginosa* (3.00; III), *Baumea arthrophylla* (2.50; III), *Baumea juncea* (2.50; V), *Histiopteris incisa* (2.50; III).
- Indicator species: *Hypolepis muelleri* (III; 2.00), *Utricularia uliginosa* (III; 2.00), *Entolasia marginata* (III; 1.00), *Oplismenus imbecillis* (III; 1.00).
- Exotic species: *Chrysanthemoides monilifera* subsp. *rotundata*, *Lantana camara*.
- Species richness: total = 46; mean (+/- SE) in 25 m^2 = 18.00 (1.41).
- Comments: *Baumea juncea* is conspicuous in the understorey of this *Melaleuca quinquenervia* shrubland. Both species are constant (100% occurrence).

Habitat:

- Topographic position: open (drainage) depressions, closed depressions (swamps).
- Altitude: <10, to 25 m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sand (mantling bedrock at one location).
- Comments: Likely to be associated with more saline conditions than the previous community (No. 36), as indicated by the presence of *Baumea juncea*, a species also found in saltmarsh vegetation (Adam et al. 1988).

Map localities in northern NSW: Yuraygir NP, Kattang NR.

Equivalent vegetation types: *Melaleuca quinquenervia* has a coastal distribution which extends from the Central Coast of NSW into northern Queensland, and *Baumea juncea* is more widespread (Harden 1993, 2002, Queensland Herbarium 1994). Minor occurrences of *M. quinquenervia* shrubland are reported for south-eastern Queensland (McDonald & Elsol 1984), and also related heathlands in which *M. quinquenervia* is dominant or co-dominant (Batianoff & Elsol 1989, Dowling & McDonald 1976, Durrington 1977).

Community No. 38: *Leptospermum speciosum* swamp sclerophyll shrubland

Sites: HBR020.1/.2.

API group: 55101 (*Leptospermum speciosum* swamp sclerophyll shrubland).

Structure: tall to very tall closed shrubland.

Floristic composition:

- Constant species: *Leucopogon lanceolatus* var. *gracilis* (V), *Pteridium esculentum* (V), *Elaeocarpus reticulatus* (V), *Entolasia stricta* (V), *Leptospermum speciosum* (V), *Baloskion tetraphyllum* subsp. *meiostachyum* (V), *Blechnum indicum* (V), *Gahnia clarkei* (V), *Kennedia rubicunda* (V), *Acacia elongata* (V).
- Cover-abundant species: *Leptospermum speciosum* (5.00; V), *Baloskion tetraphyllum* subsp. *meiostachyum* (4.00; V), *Blechnum indicum* (3.50; V), *Entolasia stricta* (3.00; V), *Pteridium esculentum* (3.00; V), *Gahnia clarkei* (2.50; V).
- Indicator species: *Leptospermum speciosum* (V; 5.00), *Ageratum houstonianum* (III; 1.00), *Conyza albida* (III; 1.00), *Melastoma affine* (III; 1.00), *Oxylobium robustum* (III; 1.00).
- Exotic species: *Ageratum houstonianum*, *Conyza albida*.
- Species richness: total = 19; mean (+/- SE) in 25 m^2 = 15.00 (2.00).
- Comments: *Leptospermum speciosum* dominates the tallest stratum. Conspicuous understorey species include *Baloskion tetraphyllum* subsp. *meiostachyum* and *Blechnum indicum*.

Habitat:

- Topographic position: open (drainage) depression.
- Altitude: <10 m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sand.
- Comments: Found in poorly drained podzolised sands with a shallow watertable.

Map localities in northern NSW: Broadwater NP.

Equivalent vegetation types: *Leptospermum speciosum* has a coastal distribution, and extends from the Clarence River district (far NSW North Coast) into south-eastern Queensland (Harden 2002, Queensland Herbarium 1994). A related *L. speciosum* closed heathland is known for Queensland (Elsol & Sattler 1979, in Batianoff & Elsol 1989).

Community No. 39: *Leptospermum juniperinum* swamp sclerophyll shrubland

Sites: HCR012.1/.2.

API group: 55041 (*Leptospermum juniperinum* swamp sclerophyll shrubland).

Structure: tall to very tall shrubland and closed shrubland.

Floristic composition:

- Constant species: *Entolasia stricta* (V), *Imperata cylindrica* var. *major* (V), *Baloskion tetraphyllum* subsp. *meiostachyum* (V), *Blechnum indicum* (V), *Baumea teretifolia* (V), *Hemarthria uncinata* (V), *Chorizandra sphaerocephala* (V), *Gonocarpus tetragynus* (V), *Sphaerolobium vimineum* (V), *Leptospermum juniperinum* (V), *Gleichenia dicarpa* (V), *Empodisma minus* (V).
- Cover-abundant species: *Leptospermum juniperinum* (4.50; V), *Baloskion tetraphyllum* subsp. *meiostachyum* (4.00; V), *Chorizandra sphaerocephala* (3.00; V), *Gleichenia dicarpa* (3.00; V).
- Indicator species: none.
- Exotic species: none.
- Species richness: total = 14; mean (+/- SE) in 25 m^2 = 13.00 (0.00).
- Comments: *Leptospermum juniperinum* dominates the tallest stratum, and *Baloskion tetraphyllum* subsp. *meiostachyum* is conspicuous in the understorey. Both species are constant (100% occurrence).

Habitat:

- Topographic position: open (drainage) depression.
- Altitude: 35 m ASL.
- Aspect: NNW. • Slope: 3°.
- Geology: rhyolite.
- Comments: As sampled, this community was restricted to a narrow drainage line on a coastal hill.

Map localities in northern NSW: Crowdy Bay NP, and possibly Newrybar Swamp (the latter location requires sampling).

Equivalent vegetation types: *Leptospermum juniperinum* is widespread on the coast and adjoining tablelands of NSW, and continues into Queensland (Harden 2002, Queensland Herbarium 1994). Nonetheless, the community appears to have a scattered distribution along the North Coast. For Brisbane Waters NP on the Central Coast, Benson and Fallding (1981) report *L. juniperinum* as a dominant in poorly drained situations. *Leptospermum juniperinum* is a common species of wet heathland in coastal south-western Victoria (Head 1988).

Community No. 40: *Lophostemon confertus* dry sclerophyll mallee shrubland

Sites: HBR026.1/.2.

API group: 56021 (*Lophostemon confertus* dry sclerophyll mallee shrubland).

Structure: very tall closed mallee shrubland.

Floristic composition:

- Constant species: *Lophostemon confertus* (V), *Imperata cylindrica* var. *major* (V), *Acronychia imperforata* (V), *Cupaniopsis anacardioides* (V), *Cyperus stradbrokensis* (V), *Paspalidium distans* (V), *Geitonoplesium cymosum* (V), *Banksia integrifolia* subsp. *integrifolia* (V), *Acacia disparrima* subsp. *disparrima* (V), *Lomandra laxa* (V), *Chrysanthemoides monilifera* subsp. *rotundata* (V), *Austromyrtus dulcis* (V), *Hibbertia scandens* (V), *Lomandra longifolia* (V), *Cassytha pubescens* (V), *Pteridium esculentum* (V), *Pomax umbellata* (V), *Pandorea pandorana* (V).
- Cover-abundant species: *Lophostemon confertus* (5.00; V), *Acronychia imperforata* (3.00; V), *Austromyrtus dulcis* (3.00; V), *Chrysanthemoides monilifera* subsp. *rotundata* (3.00; V), *Lomandra longifolia* (2.50; V).
- Indicator species: *Lophostemon confertus* (V; 5.00), *Acronychia imperforata* (V; 3.00), *Acacia disparrima* subsp. *disparrima* (V; 1.00), *Cupaniopsis anacardioides* (V; 1.00), *Cyperus stradbrokensis* (V; 1.00), *Lomandra laxa* (V; 1.50), *Cyperus enervis* (III; 1.00), *Pittosporum revolutum* (III; 1.00), *Rapanea variabilis* (III; 1.00).
- Exotic species: *Chrysanthemoides monilifera* subsp. *rotundata*.
- Species richness: total = 26; mean (+/- SE) in 25 m^2 = 22.00 (2.00).
- Comments: *Lophostemon confertus* dominates the tallest stratum, and conspicuous understorey species include *Austromyrtus dulcis*, *Chrysanthemoides monilifera* subsp. *rotundata* and *Lomandra longifolia*.

Habitat:

- Topographic position: ridge (foredune).
- Altitude: 10 m ASL.
- Aspect: nil. • Slope: 0°.
- Geology: Quaternary sand.
- Comments: Found in well-drained foredune sands where the soils are likely to be younger and therefore less podzolised than those of inland sand masses.

Map localities in northern NSW: Broadwater NP.

Equivalent vegetation types: The natural distribution of *Lophostemon confertus* extends north from the Hunter River district on the lower North Coast of NSW, and continues into Queensland (Harden 2002, Queensland Herbarium 1994). This community is apparently uncommon along the North Coast, although similar *L. confertus* mallee is likely to occur in south-eastern Queensland (Dowling & McDonald 1976, Durrington 1977, Elsol & Dowling 1978). A related *L. confertus* littoral rainforest occupies North Coast headlands in soils derived from bedrock, and this may be reduced to mallee (Floyd 1990).

Community No. 41: *Eucalyptus robusta*/*E. signata* – *Baloskion tetraphyllum* subsp. *meiostachyum* swamp sclerophyll mallee shrubland, mallee forest and mallee woodland

Sites: HNE007.1/.2, HBR007.1/.2, HMO004.1/.2, HLA003.1/.2, HLA004.1/.2.

API groups: 50031/2 in part (*Eucalyptus signata* dry sclerophyll mallee forest and woodland); and all samples for 51021/2 (*E. robusta* swamp sclerophyll mallee forest and woodland) and 57022 (*E. robusta* swamp sclerophyll mallee shrubland).

Structure: very tall sparse to open mallee shrubland; very tall to extremely tall, open mallee woodland to closed mallee forest.

Floristic composition:

- Constant species: *Leptospermum polygalifolium* subsp. *cismontanum* (V), *Leucopogon lanceolatus* var. *gracilis* (V), *Baloskion tetraphyllum* subsp. *meiostachyum* (IV), *Cassytha glabella* forma *glabella* (IV), *Elaeocarpus reticulatus* (IV), *Eucalyptus robusta* (IV), *Xanthorrhoea fulva* (IV).
- Cover-abundant species: *Eucalyptus robusta* (4.00; IV), *E. signata* (3.50; I), *Baloskion tetraphyllum* subsp. *meiostachyum* (3.25; IV), *Baeckea frutescens* (3.00; II), *Gleichenia mendellii* (3.00; I), *Melaleuca nodosa* (3.00, II), *Xanthorrhoea fulva* (2.71; IV), *Blechnum indicum* (2.60; III), *Leptospermum polygalifolium* subsp. *cismontanum* (2.60; V), *Acacia elongata* (2.50, I), *Gahnia clarkei* (2.50; I), *Pteridium esculentum* (2.50; III).
- Indicator species: none.
- Exotic species: *Chrysanthemoides monilifera* subsp. *rotundata*.
- Species richness: total = 78; mean (+/- SE) in 25 m^2 = 17.70 (2.21).
- Comments: *Eucalyptus robusta* commonly dominates the tallest stratum, or occasionally *E. signata*. Comparatively constant, cover-abundant understorey species are *Baloskion tetraphyllum* subsp. *meiostachyum* (80% occurrence), *Leptospermum polygalifolium* subsp. *cismontanum* (100% occurrence) and *Xanthorrhoea fulva* (70% occurrence). Samples of API group 50031/2 included in this community (cf. community No. 42) suggest that a swamp facies of *E. signata* mallee should be recognised on the basis of understorey composition.

Habitat:

- Topographic position: open (drainage) depressions in which *Eucalyptus robusta* dominates, or ridges (dunes) of minimal relief where *E. signata* dominates.
- Altitude: <10 m ASL.
- Aspect: nil.
- Slope: 0°.
- Geology: Quaternary sand.
- Comments: Characteristic of poorly drained, podzolised sands.

Map localities in northern NSW: Newrybar Swamp, Broadwater NP, Evans Head, Moonee Beach NR, Lake Innes NR, Crowdy Bay NP, Booti Booti NP.

Equivalent vegetation types: The distributions of *Eucalyptus robusta*, *E. signata* and *Baloskion tetraphyllum* subsp. *meiostachyum* overlap in coastal districts of NSW and Queensland to the north of the upper Central Coast (Harden 1993, 2002, Queensland Herbarium 1994). The community appears to have a scattered distribution along the North Coast, and for this region other studies also document mallee stands of *E. robusta* and *E. signata* (Murray 1989, Pressey & Griffith 1992). *Eucalyptus signata* mallee occurs in south-eastern Queensland (Durrington 1977).

Community No. 42: *Eucalyptus pilularis/E. planchoniana/E. signata – Leptospermum trinervium* dry sclerophyll mallee shrubland, mallee forest and mallee woodland.

Sites: HBR019.1/.2, HBR022.1/.2, HEV004.1/.2, HEV005.1/.2, HBU016.1/.2, HBU018.1/.2, HBU023.1/.2, HBU024.1/.2, HYU033.1/.2, HYU035.1/.2, HHA003.1/.2, HHA005.1/.2, HHA016.1/.2, HLI016.1/.2, HCR026.1/.2.

API groups: 50031/2 in part (*Eucalyptus signata* dry sclerophyll mallee forest and woodland); and all samples for 50021/2 (*E. pilularis* dry sclerophyll mallee forest and woodland), 50041/2 (*E. planchoniana* dry sclerophyll mallee forest and woodland), 50071 (*E. pilularis*/*E. planchoniana*/*Corymbia gummifera* dry sclerophyll mallee forest), 56031/2 (*E. pilularis* dry sclerophyll mallee shrubland) and 56041 (*E. planchoniana* dry sclerophyll mallee shrubland).

Structure: tall to very tall, sparse to closed mallee shrubland; tall to extremely tall, open mallee woodland to closed mallee forest.

Floristic composition:

- Constant species: *Banksia aemula* (V), *Pimelea linifolia* (V), *Leptospermum trinervium* (V), *Acacia ulicifolia* (V), *A. suaveolens* (V), *Caustis recurvata* var. *recurvata* (V), *Leucopogon leptospermoides* (V), *Xanthorrhoea johnsonii* (V).
- Cover-abundant species: *Eucalyptus signata* (3.50; I), *E. planchoniana* (3.43; III), *E. pilularis* (3.19; III), *Aotus ericoides* (3.00; I), *Xanthorrhoea glauca* subsp. *glauca* (3.00; I), *X. johnsonii* (2.92; V), *Banksia aemula* (2.80; V), *Phyllota phylicoides* (2.76; IV), *Corymbia gummifera* (2.50; I), *Monotoca scoparia* (2.50; IV), *Leptospermum trinervium* (2.48; V), *Boronia pinnata* (2.44; II), *Leucopogon leptospermoides* (2.43; V).
- Indicator species: *Eucalyptus pilularis* (III; 3.19).
- Exotic species: none.
- Species richness: total = 112; mean (+/- SE) in 25 m^2 = 26.57 (1.11).
- Comments: Comprises mallee vegetation with a tallest stratum dominated by varying combinations of *Eucalyptus pilularis* and *E. planchoniana* (+/- *Corymbia gummifera*), or rarely *E. signata*. Comparatively constant, cover-abundant understorey species include *Banksia aemula*, *Leptospermum trinervium*, *Monotoca scoparia*, *Phyllota phylicoides* and *Xanthorrhoea johnsonii* (north from the Macleay River district).

Habitat:

- Topographic position: ridges (dunes, or rarely beach ridges).
- Altitude: <10, to 50 m ASL.
- Aspect: N, NNE, NE, ENE, E, ESE, SE, S, SSW, W, WNW, NNW.
- Slope: 2–15°.
- Geology: Quaternary sand.
- Comments: Characteristic of well-drained, podzolised sands.

Map localities in northern NSW: Broadwater NP, Evans Head, Bundjalung NP, Yuraygir NP, Hat Head NP, Limeburners Creek NR, Lake Innes NR, Crowdy Bay NP, Booti Booti NP.

Equivalent vegetation types: The distributions of *Eucalyptus pilularis*, *E. planchoniana*, *E. signata* and *Leptospermum trinervium* overlap along much of the NSW North Coast and in southern Queensland (Harden 1993, 2002, Queensland Herbarium 1994). *Eucalyptus planchoniana* is common in some 'mallee-heaths' of south-eastern Queensland (Clifford & Specht 1979, Dowling & McDonald 1976, Elsol & Dowling 1978, McDonald & Elsol 1984), and in places becomes a community dominant (W. McDonald, Queensland Herbarium pers. comm., Sattler & Williams 1999). *Eucalyptus signata* mallee is also known for south-eastern Queensland (Durrington 1977).

Appendix 2. Synoptic constancy table for plant communities

This table complements plant community descriptions provided as Appendix 1, and the numbering (1–42) is identical:

1: *Baumea rubiginosa* tall to very tall closed sedgeland
2: *Lepironia articulata* very tall closed sedgeland
3: *Baumea articulata* very tall sedgeland and closed sedgeland
4: *Eleocharis sphacelata* tall to very tall closed sedgeland
5: *Baumea arthrophylla* tall to very tall closed sedgeland
6: *Cladium procerum* very tall closed sedgeland
7: *Typha orientalis* very tall rushland and closed rushland
8: *Blechnum indicum* tall to very tall closed fernland
9: *Baloskion pallens* – *Melaleuca quinquenervia* mid-high to tall closed sedgeland–heathland
10: *Gahnia sieberiana* – *Gleichenia* tall to very tall closed sedgeland
11: *Leptocarpus tenax* – *Baloskion pallens* tall to very tall closed sedgeland
12: *Schoenus brevifolius* – *Baumea teretifolia* tall to very tall closed sedgeland
13: *Baloskion pallens* – *Baumea teretifolia* tall to very tall closed sedgeland
14: *Themeda australis* low to tall closed sod grassland
15: *Themeda australis* – *Ptilothrix deusta* mid-high to tall closed tussock grassland
16: *Themeda australis* – *Banksia oblongifolia* – *Aristida warburgii* (occasionally dwarf to) low to mid-high closed heathland
17: *Ptilothrix deusta* – *Aristida warburgii* – *Hakea teretifolia* subsp. *teretifolia* low to tall closed heathland
18: *Ptilothrix deusta* – *Banksia oblongifolia* – *Mirbelia rubiifolia* low to mid-high closed heathland
19: *Ptilothrix deusta* – *Aristida warburgii* – *Banksia oblongifolia* – *Allocasuarina littoralis* – *Epacris pulchella* low to mid-high (occasionally dwarf or tall) closed heathland
20: *Banksia oblongifolia* – *Ptilothrix deusta* – *Aristida warburgii* – *Allocasuarina littoralis* low to mid-high (occasionally dwarf or tall)closed heathland
21: *Leptospermum juniperinum* mid-high to tall heathland and closed heathland
22: *Xanthorrhoea fulva* – *Ptilothrix deusta* low to tall closed heathland
23: *Banksia oblongifolia* – *Leptospermum polygalifolium* subsp. *cismontanum* – *Melaleuca nodosa* low to tall heathland and closed heathland
24: *Sporadanthus interruptus* – *Xanthorrhoea fulva* – *Banksia ericifolia* subsp. *macrantha* – *Leptospermum liversidgei* – *Baeckea frutescens* (rarely low to) mid-high to tall closed heathland
25: *Sporadanthus interruptus* – *Xanthorrhoea fulva* low to tall closed heathland
26: *Banksia oblongifolia* – *Xanthorrhoea fulva* low to tall closed heathland
27: *Xanthorrhoea fulva* – *Schoenus paludosus* – *Banksia ericifolia* subsp. *macrantha* low to tall closed heathland
28: *Leptospermum liversidgei* – *Sporadanthus interruptus* – *Empodisma minus* low to tall closed heathland
29: *Banksia aemula* – *Leptospermum trinervium* low to tall closed heathland
30: *Banksia aemula* – *Allocasuarina littoralis* low to tall closed heathland
31: *Banksia aemula* low to tall closed heathland
32: *Banksia aemula* – *Phyllota phylicoides* tall to very tall (occasionally extremely tall), sparse to closed shrubland
33: *Banksia aemula* – *Allocasuarina littoralis* +/- *B. serrata* tall to extremely tall, sparse to closed shrubland
34: *Banksia ericifolia* subsp. *macrantha* +/- *Leptospermum whitei* – *L. polygalifolium* subsp. *cismontanum* tall to very tall shrubland and closed shrubland, or rarely open shrubland
35: *Melaleuca sieberi*/*Banksia ericifolia* subsp. *macrantha* – *M. thymifolia* tall to very tall, sparse to closed shrubland
36: *Melaleuca quinquenervia* – *Baumea teretifolia* tall to very tall, sparse to closed shrubland
37: *Melaleuca quinquenervia* – *Baumea juncea* tall shrubland and closed shrubland
38: *Leptospermum speciosum* tall to very tall closed shrubland
39: *Leptospermum juniperinum* tall to very tall shrubland and closed shrubland
40: *Lophostemon confertus* very tall closed mallee shrubland
41: *Eucalyptus robusta*/*E. signata* – *Baloskion tetraphyllum* subsp. *meiostachyum* very tall sparse to open mallee shrubland, and very tall to extremely tall, open mallee woodland to closed mallee forest
42: *Eucalyptus pilularis*/*E. planchoniana*/*E. signata* – *Leptospermum trinervium* tall to very tall, sparse to closed mallee shrubland, and tall to extremely tall, open mallee woodland to closed mallee forest.

Constancy classes: I = 1–20% of quadrats; II = 21–40%; III = 41–60%; IV = 61–80%; and V = 81–100%. Note: for communities represented by fewer than 5 quadrats, some constancy classes are not applicable (e.g. community 18 was sampled in 2 quadrats, and classes V and III are the only alternatives).

Species exhibiting high fidelity to a particular community (fidelity index >/= 0.8, and occurring in >/= 50% of quadrats) are denoted with an asterisk (*).

An average cover class score is provided for all species in each community. These are mean rankings for six foliage cover classes: 1 (<1% cover); 2 (1–5%); 3 (6–25%); 4 (26–50%); 5 (51–75%); and 6 (76–100%).

	Community (constancy; average cover)
Class LYCOPSIDA	
LYCOPODIACEAE	
Lycopodiella lateralis	25(I;1.50) 28(II;1.67)
SELAGINELLACEAE	
Selaginella uliginosa	11(III;1.62) 15(III;1.00) 21(II;1.00) 22(I;1.00) 23(II;1.00) 24(V;1.44) 25(IV;1.12) 26(III;1.40) 27(V;2.00) 28(III;1.25) 31(II;1.00) 32(I;1.17) 35(II;1.00) 36(I;1.00) 41(II;1.25)
Class FILICOPSIDA	
ASPLENIACEAE	
Asplenium sp.	25(I;1.00)
AZOLLACEAE	
Azolla filiculoides	7(II;1.00)
Azolla pinnata	3(I;1.00)
BLECHNACEAE	
Blechnum indicum	1(I;1.00) 6(III;1.50) 8(V;5.00) 10(III;2.00) 11(II;1.88) 13(I;1.00) 21(V;1.57) 36(IV;4.00) 37(IV;1.33) 38(V;3.50) 39(V;2.00) 41(III;2.60)

DENNSTAEDTIACEAE

Histiopteris incisa 34(II;2.00) 37(III;2.50)

Hypolepis muelleri 37*(III;2.00)

Pteridium esculentum 23(II;4.00) 25(I;1.00) 26(I;1.00) 28(I;1.50) 29(I;1.00) 30(III;3.00) 32(I;1.33) 33(IV;2.73) 34(II;2.00) 38(V;3.00) 40(V;1.50) 41(III;2.50) 42(IV;1.79)

GLEICHENIACEAE

Gleichenia dicarpa 10(II;5.50) 21(II;1.00) 34(III;1.50) 39(V;3.00)

Gleichenia mendellii 10(IV;4.83) 21(I;1.00) 28(I;3.00) 41(I;3.00)

LINDSAEACEAE

Lindsaea linearis 16(III;1.00) 17(IV;1.00) 18(III;1.00) 35(II;1.00)

Lindsaea sp. 20(I;1.00)

SALVINIACEAE

Salvinia molesta 1(I;2.50) 6(III;4.00) 7(II;1.00)

SCHIZAEACEAE

Schizaea bifida 16(II;1.00) 18(III;1.00) 22(I;1.00) 25(I;1.00) 28(II;1.00) 29(I;1.00) 32(I;1.00) 37(II;1.00) 42(I;1.00)

Schizaea dichotoma 29(III;1.08) 30(III;2.00) 32(I;1.00) 33(II;1.00) 42(I;1.00)

Class CONIFEROPSIDA

CUPRESSACEAE

Callitris columellaris 18*(III;1.00)

Callitris rhomboidea 29(I;1.00) 32(I;3.00) 42(I;1.00)

Class MAGNOLIOPSIDA – LILIIDAE

ANTHERICACEAE

Caesia parviflora 17*(III;1.00) 29(I;1.00)

Laxmannia gracilis 23(IV;1.50) 25(I;1.00) 26(I;1.00) 29(II;1.29) 30(III;1.00) 32(II;1.00) 33(I;1.00) 42(II;1.00)

Sowerbaea juncea 14(I;1.00) 17(V;1.00) 20(I;1.00) 22(I;1.00) 23(II;1.00) 25(II;1.15) 26(I;1.00) 27(V;1.50) 28(I;1.20) 31(I;1.00) 32(I;1.00) 42(I;1.00)

Thysanotus juncifolius 17(II;1.00) 31(I;1.00)

Tricoryne elatior 14(II;1.00) 16(IV;1.00) 17(V;1.00) 18(V;1.00) 22(I;1.00) 23(I;1.00) 25(I;1.00) 29(II;1.43) 30(IV;1.00) 32(I;1.00) 33(II;1.00) 42(I;1.00)

Tricoryne simplex 17(II;1.00)

BLANDFORDIACEAE

Blandfordia grandiflora 10(I;1.00) 22(II;1.00) 23(II;1.00) 24(II;1.00) 25(III;1.06) 26(V;1.78) 27(V;2.00) 28(III;1.87) 32(I;1.00) 34(V;1.00) 35(II;1.00)

COLCHICACEAE

Burchardia umbellata 15(III;1.00) 16(II;1.00) 17(II;1.00) 19(IV;1.00) 20(IV;1.00) 22(IV;1.00) 24(III;1.00) 25(III;1.00) 26(V;1.00) 27(V;1.00) 28(II;1.00) 31(II;1.00) 32(I;1.00) 34(V;1.00) 35(II;1.00)

Wurmbea biglandulosa 22(I;1.00)

CYPERACEAE

Abildgaardia vaginata 33(I;1.50)

Baumea acuta 25(I;1.00)

Baumea arthrophylla 1(II;1.50) 3(II;1.00) 4(II;1.00) 5(V;3.5) 11(III;1.85) 12(III;1.33) 36(I;1.00) 37(III;2.50)

Baumea articulata 1(I;1.00) 2(III;1.25) 3(V;4.12) 4(III;1.00) 6(III;1.00) 7(III;1.00) 36(II;3.00) 37(III;2.00)

Baumea juncea 9(II;4.00) 22(I;1.00) 37(V;2.50)

Baumea muelleri 21(I;1.00) 24(IV;1.17) 25(IV;1.23) 26(II;1.00) 28(V;1.54) 41(I;1.00)

Baumea rubiginosa 1(V;3.83) 2(III;2.25) 3(II;1.33) 4(III;2.00) 5(II;1.00) 6(III;1.50) 7(III;2.00) 8(II;1.00) 10(I;1.00) 11(I;1.67) 13(I;1.00) 21(V;2.00) 36(IV;2.25) 37(III;3.00) 41(I;2.00)

Baumea teretifolia 1(II;1.50) 2(II;1.67) 4(III;2.00) 9(III;2.33) 10(III;1.50) 11(V;2.04) 12(V;3.00) 13(V;2.44) 15(II;1.00) 21(V;2.00) 22(I;1.00) 24(I;1.00) 25(I;1.00) 26(III;1.33) 27(III;1.00) 28(I;1.00) 35(III;2.00) 36(V;2.83) 39(V;1.00)

Carex breviculmis 14*(IV;1.00)

Caustis blakei subsp. *blakei* 42(I;2.33)

Caustis recurvata var. *recurvata* 23(III;1.67) 24(I;1.50) 25(II;1.96) 26(I;1.00) 28(I;1.00) 29(V;1.69) 30(V;2.25) 31(V;2.42) 32(V;2.04) 33(IV;1.90) 41(I;2.00) 42(V;1.28)

Chorizandra cymbaria 11(I;1.00) 12(II;1.00) 21(I;1.00) 22(I;1.00) 35(II;1.00)

Chorizandra sphaerocephala 1(I;1.00) 10(II;1.50) 11(II;1.91) 12(V;2.67) 15(III;1.00) 21(IV;1.60) 22(III;1.44) 24(I;1.00) 25(I;1.12) 27(V;1.00) 28(I;2.00) 35(III;1.50) 39(V;3.00)

Cladium procerum 6*(V;5.00)

Cyperus enervis 40*(III;1.00)

Cyperus stradbrokensis 40*(V;1.00)

Eleocharis sphacelata 3(III;1.00) 4(V;3.75) 5(III;1.00)

Fimbristylis cinnamometorum 20*(III;1.30)

Fimbristylis dichotoma 14(I;1.00)

Gahnia clarkei 37(II;1.00) 38(V;2.50) 41(I;2.50)

Gahnia sieberiana 10(V;3.50) 11(I;1.50) 21(IV;2.00) 22(I;1.50) 24(I;1.00) 25(II;1.22) 26(I;2.00) 28(IV;1.28) 32(I;1.00) 34(V;1.25) 36(II;3.00) 41(III;2.00)

Gymnoschoenus sphaerocephalus 25(I;2.17) 27*(V;2.00)

Isolepis nodosa 37(II;1.00) 40(III;1.00)

Lepidosperma concavum 29(II;1.62) 31(I;2.00) 32(I;1.00) 33(I;1.50) 42(I;1.00)

Lepidosperma filiforme 23(II;2.00) 25(II;1.62) 26(I;1.50)

Lepidosperma laterale 16(V;1.50) 17(V;1.00) 18(V;2.00) 19(V;1.00) 20(IV;1.00) 35(I;1.00)

Lepidosperma longitudinale 22(I;1.00)

Lepidosperma neesii 16(V;2.25) 17(V;1.75) 20(II;1.30) 22(II;1.25) 23(II;1.00) 25(I;1.33) 26(I;3.00) 35(II;1.50)

Lepidosperma quadrangulatum 22(I;1.50) 28(I;1.00)

Lepironia articulata 2*(V;3.75) 13(I;1.00)

Ptilothrix deusta 15(V;3.50) 17(V;4.50) 18(V;5.00) 19(V;4.67) 20(V;3.60) 22(V;4.14) 23(II;1.00) 25(I;2.00) 26(I;1.00) 35(III;3.50)

Schoenus apogon 14(II;1.33)

Schoenus brevifolius 1(I;1.50) 8(II;2.00) 9(II;1.00) 11(III;2.37) 12(V;3.00) 13(IV;2.17) 15(V;1.50) 16(IV;1.00) 17(V;1.50) 18(III;1.00) 20(I;1.00) 21(II;1.00) 22(V;1.48) 23(II;1.00) 24(I;1.00) 25(III;1.24) 26(III;1.33) 27(V;2.00) 28(I;1.00) 32(I;1.00) 35(V;2.00) 37(III;2.00) 39(III;1.00) 41(I;2.00)

Schoenus ericetorum 17(II;1.00) 23(I;1.00) 29(V;1.59) 30(III;2.00) 31(V;1.90) 32(V;1.50) 33(III;1.71) 42(IV;1.00)

Schoenus lepidosperma subsp. *pachylepis* 24(I;1.00) 25(IV;1.71) 26(III;1.00) 28(II;1.22) 32(I;1.00) 34(II;1.00)

Schoenus paludosus 11(I;1.00) 22(I;1.50) 25(I;1.17) 26(I;1.00) 27(V;4.00) 35(I;2.00)

Schoenus scabripes 10(IV;1.40) 25(I;1.25) 28(IV;1.62)

Schoenus turbinatus 29(I;1.00) 31(I;1.00) 32(I;1.00) 42(I;2.00)

Tricostularia pauciflora 23(II;2.00)

ERIOCAULACEAE

Eriocaulon australe 1(I;2.00) 11(I;1.33) 21(I;1.00)

Eriocaulon scariosum 12(I;1.00) 35(II;1.00)

GEITONOPLESIACEAE

Geitonoplesium cymosum 33(II;1.00) 37(II;1.00) 40(V;1.00)

HAEMODORACEAE

Haemodorum austroqueenslandicum 20(I;1.00) 26(I;1.00)

Haemodorum corymbosum 17(II;1.00)

Haemodorum planifolium 23(I;1.00)

Haemodorum tenuifolium 10(I;1.00) 25(I;1.00) 26(II;1.00) 28(I;1.00) 34(II;1.00)

IRIDACEAE

Patersonia fragilis 25(I;1.00) 32(I;1.00)

Patersonia glabrata 16(V;1.50) 17(III;1.50) 18(V;1.00) 19(IV;1.50) 20(II;1.00) 29(III;1.12) 30(III;1.00) 31(II;1.00) 32(I;1.00) 33(IV;1.44) 42(I;1.00)

Patersonia sericea 15(II;1.00) 16(V;2.25) 17(V;2.00) 18(V;1.00) 19(V;2.33) 20(V;2.00) 22(II;1.00) 23(III;1.33) 25(I;1.00) 29(III;1.00) 30(II;1.00) 31(I;1.00) 32(II;1.00) 33(II;1.00) 35(II;1.50) 42(I;1.00)

Patersonia sp. aff. *fragilis* 17(II;1.00) 22(I;1.00) 23(II;1.00) 24(I;1.00) 25(III;1.05) 26(I;1.00) 28(I;1.00) 29(I;1.00) 31(III;1.00) 32(I;1.00) 33(I;1.00) 34(II;1.00)

JUNCAGINACEAE

Triglochin procerum s. lat. 1(V;1.00) 2(II;1.00) 3(III;1.00) 4(III;1.00) 5(IV;1.00) 6(III;1.00) 7(III;1.50) 8(II;1.00) 11(II;1.00) 13(I;1.00) 21(III;1.00) 36(II;1.00) 37(II;1.00)

LEMNACEAE

Lemna disperma 7(II;1.00)

LOMANDRACEAE

Lomandra elongata 23(I;1.00) 25(I;1.00) 26(II;1.00) 29(IV;1.30) 30(II;1.00) 32(III;1.08) 33(III;1.33) 42(III;1.00)

Lomandra filiformis 20(II;2.00) 33(I;1.00) 35(I;1.00)

Lomandra glauca 17(III;1.00) 23(II;1.00) 25(I;1.10) 29(I;1.00) 31(V;1.30) 32(I;1.00) 33(I;1.50) 42(I;1.00)

Lomandra laxa 40*(V;1.50)

Lomandra longifolia 14(II;1.00) 16(V;1.00) 25(I;1.33) 26(I;1.00) 33(III;2.12) 37(II;1.00) 40(V;2.50) 41(III;1.83) 42(I;1.50)

Lomandra multiflora subsp. *multiflora* 16(V;1.50) 17(V;1.00) 18(III;1.00) 19(II;1.00) 20(V;1.20) 22(I;1.00) 35(I;1.00)

Lomandra obliqua 19*(IV;2.00)

ORCHIDACEAE

Acianthus sp. 23(I;1.00) 25(I;1.00)

Caleana major 31(I;1.00) 42(I;1.00)

Calochilus grandiflorus 25(I;1.00)

Calochilus sp. 25(I;1.00)

Corybas sp. 20(I;1.00) 28(I;1.00)

Cryptostylis sp. 22(I;1.00) 25(I;1.00) 26(I;1.00) 27(III;1.00) 28(I;1.00) 34(II;1.00) 35(I;1.00) 37(II;1.00) 38(V;1.00) 41(I;1.00)

Eriochilus sp. 22(I;1.00)

Genoplesium rufum 29(I;1.00)

Genoplesium sp. 42(I;1.00)

Microtis sp. 20(I;1.00)

Pterostylis sp. 28(I;1.00) 29(I;1.00) 32(I;1.00) 33(II;1.33) 41(I;1.00) 42(I;1.00)

Thelymitra pauciflora 23(I;1.00)

Thelymitra purpurata 22(I;1.00) 25(I;1.00)

Thelymitra sp. 25(I;1.00)

unidentified sp. 22(I;1.00) 25(I;1.00) 28(I;1.00) 32(I;1.00) 33(I;1.00) 42(I;1.00)

PHILYDRACEAE

Philydrum lanuginosum 3(I;1.00) 11(I;1.00) 37(II;1.00)

PHORMIACEAE

Dianella caerulea 16(III;1.00) 29(I;1.17) 30(III;2.50) 32(I;1.00) 33(III;1.00) 37(IV;1.00) 40(III;1.00) 41(II;1.00) 42(I;1.20)

Dianella crinoides 14(II;1.00)

Dianella revoluta 15(II;1.00) 22(I;1.00) 25(I;1.00) 32(I;1.00)

POACEAE

Andropogon virginicus 33(II;1.00)

Aristida warburgii 16(V;3.00) 17(V;4.00) 18(III;1.00) 19(V;4.00) 20(V;3.40) 22(I;1.00) 23(I;1.00) 35(II;3.00)

Austrostipa pubescens 16(V;1.50) 17(V;2.00) 22(I;1.00) 23(II;1.50) 25(I;1.00) 31(II;2.00) 33(I;2.50)

Cymbopogon refractus 42(I;1.00)

Digitaria parviflora 33(I;1.00) 42(I;1.00)

Entolasia marginata 37*(III;1.00)

Entolasia stricta 8(II;1.00) 9(I;1.00) 10(IV;1.00) 11(II;1.56) 15(III;3.00) 16(V;1.75) 17(V;1.25) 18(V;2.00) 20(I;1.00) 21(V;1.43) 22(V;1.40) 23(III;1.33) 24(II;1.00) 25(II;1.05) 26(V;1.67) 27(V;1.00) 28(I;1.00) 29(I;1.00) 31(I;1.00) 32(I;1.14) 33(II;1.00) 34(III;1.00) 35(V;1.38) 36(I;1.00) 37(II;1.00) 38(V;3.00) 39(V;1.00) 41(III;1.80)

Eragrostis brownii 15(III;1.50) 16(III;1.00) 22(I;1.67) 29(I;1.00) 30(III;2.00) 33(I;1.00)

Eragrostis sororia 15(II;1.00) 22(I;1.00) 33(I;1.00)

Eremochloa bimaculata 19(I;1.00) 20(V;1.60) 22(III;1.27) 23(II;2.00) 25(I;1.00) 35(II;2.00)

Hemarthria uncinata 8(II;1.00) 11(II;1.25) 15(II;1.00) 21(III;1.50) 22(I;1.00) 35(III;1.00) 36(II;1.00) 39(V;2.00)

Imperata cylindrica var. *major* 21(II;1.00) 33(I;1.00) 37(II;2.00) 39(V;1.50) 40(V;2.00)

Ischaemum australe 9(I;1.00) 11(III;1.00) 12(IV;1.50) 14(II;2.50) 15(III;4.00) 21(III;1.25) 22(II;1.29) 26(I;1.50) 27(III;1.00) 35(V;1.29) 36(I;1.00) 37(III;1.00)

Leersia hexandra 21(I;1.00)

Oplismenus imbecillis 33(I;1.00) 37*(III;1.00)

Panicum simile 15(III;2.00) 16(V;2.00) 17(V;1.50) 18(V;1.00) 19(V;1.67) 20(V;1.40) 22(IV;1.33) 23(IV;2.00) 24(I;1.00) 25(II;1.52) 26(IV;1.29) 29(IV;1.00) 30(III;1.00) 31(I;1.00) 32(I;1.00) 33(IV;1.22) 35(III;1.50) 42(I;1.00)

Paspalidium distans 15(III;1.00) 16(III;1.00) 17(IV;1.00) 19(I;1.00) 22(I;1.00) 23(I;1.00) 33(III;1.00) 35(II;1.00) 40(V;1.50)

Paspalum orbiculare 3(I;1.00) 9(I;1.00) 11(I;1.00) 15(III;1.50) 22(I;1.00) 37(III;1.00)

Pennisetum clandestinum 14(I;1.00)

Phragmites australis 3(II;1.00) 9(I;1.00) 36(II;1.00)

Plinthanthesis paradoxa 25(I;1.00) 27*(III;1.00)

Pseudoraphis spinescens 3(II;3.00)

Themeda australis 14(V;5.75) 15(V;4.00) 16(V;4.00) 17(V;2.00) 18(V;1.00) 19(V;2.67) 20(V;2.50) 22(III;1.36) 23(II;1.50) 25(I;1.00) 26(I;1.50) 29(III;1.94) 30(III;2.00) 31(II;1.50) 32(I;1.00) 33(IV;1.20) 35(II;3.00) 40(III;1.00) 42(II;1.12)

Zoysia macrantha 14(I;1.00)

RESTIONACEAE

Baloskion pallens 1(II;1.67) 2(I;1.00) 9(IV;4.00) 11(V;2.50) 12(IV;1.50) 13(V;3.06) 21(I;1.00) 22(I;1.00) 23(IV;2.00) 24(III;1.33) 25(IV;1.20) 28(I;1.00) 32(I;1.22) 35(III;1.75) 36(IV;2.75) 41(I;2.00)

Baloskion tenuiculme 24(I;1.50) 25(I;1.43) 31(I;1.00) 32(I;1.00)

Baloskion tetraphyllum subsp. *meiostachyum* 8(III;1.00) 10(I;100) 21(IV;2.20) 25(I;1.00) 32(I;1.00) 36(I;2.00) 38(V;4.00) 39(V;4.00) 41(IV;3.25)

Coleocarya gracilis 29(V;2.19) 31(I;2.50) 32(III;2.00) 33(I;1.00) 42(III;1.78)

Empodisma minus 10(V;3.50) 21(III;1.75) 23(II;2.00) 25(II;2.50) 26(II;2.67) 28(V;3.10) 34(III;3.00) 39(V;1.00)

Eurychorda complanata 11(I;1.33) 22(I;1.00) 24(I;3.00) 25(II;1.30) 26(IV;1.86) 27(V;1.00) 28(I;1.50) 34(III;1.00) 35(IV;1.00)

Hypolaena fastigiata 23(IV;1.75) 24(I;1.00) 25(II;1.40) 29(III;1.82) 30(III;3.00) 31(V;2.36) 32(IV;2.30) 33(III;1.57) 41(I;1.00) 42(I;2.00)

Leptocarpus tenax 9(I;1.00) 11(V;2.65) 12(II;1.50) 22(IV;1.65) 23(IV;2.00) 24(V;1.73) 25(IV;1.18) 26(V;1.40) 27(V;2.00) 28(I;1.67) 32(I;1.33) 34(II;1.00) 35(IV;1.33) 36(II;2.00) 37(II;1.00)

Lepyrodia muelleri 11(II;1.75) 12(V;1.67) 35(III;1.50)

Lepyrodia scariosa 22(III;1.62) 23(IV;2.00) 25(I;1.30) 26(I;2.00) 35(II;1.00)

Lepyrodia sp. *A* 22(III;1.30) 27(V;1.00)

Sporadanthus caudatus 9(I;1.00) 11(I;2.33) 13(III;2.78) 21(IV;3.00) 22(I;1.00) 36(I;1.00)

Sporadanthus interruptus 10(V;3.12) 20(I;1.00) 21(II;2.00) 24(V;4.00) 25(V;3.15) 26(IV;2.50) 27(V;3.00) 28(V;3.24) 31(I;1.00) 32(II;1.50) 33(I;1.00) 34(V;2.00) 41(II;1.50)

SMILACACEAE

Smilax australis 33(I;1.00) 34(II;1.00)

Smilax glyciphylla 33(II;1.00) 37(II;1.00) 41(I;1.00)

TYPHACEAE

Typha orientalis 7*(V;3.75)

XANTHORRHOEACEAE

Xanthorrhoea fulva 9(II;1.00) 10(III;1.50) 11(I;1.50) 17(II;1.00) 19(I;1.00) 20(I;1.00) 22(V;4.09) 24(V;3.91) 25(V;3.07) 26(V;3.40) 27(V;4.00) 28(V;2.64) 31(II;1.50) 32(I;1.71) 33(I;3.00) 34(V;2.00) 35(IV;2.00) 41(IV;2.71)

Xanthorrhoea glauca subsp. *glauca* 25(I;1.67) 29(I;3.00) 31(III;2.50) 32(II;2.80) 42(I;3.00)

Xanthorrhoea johnsonii 23(III;1.00) 26(I;1.00) 29(IV;2.50) 30(III;1.00) 32(IV;2.64) 33(II;2.20) 42(V;2.92)

Xanthorrhoea latifolia subsp. *latifolia* 19(I;1.00) 20(III;1.30) 33(I;2.00)

XYRIDACEAE

Xyris gracilis subsp. *gracilis* 22(I;1.00) 23(III;1.67) 24(I;1.00) 25(I;1.00) 31(I;1.00) 32(I;1.00)

Xyris juncea 25(II;1.00) 28(III;1.00) 34(II;1.00) 35(II;1.00)

Xyris operculata 10(II;1.00) 11(III;1.73) 12(II;1.00) 22(II;1.00) 25(II;1.32) 26(I;1.00) 27(III;1.00) 28(IV;1.55) 34(II;1.00) 35(II;1.67) 41(I;2.00)

Class MAGNOLIOPSIDA – MAGNOLIIDAE

ACANTHACEAE

Brunoniella australis 15(III;1.50) 19(I;1.00) 22(I;1.00) 35(I;1.00)

Brunoniella pumilio 17*(III;1.00)

Pseuderanthemum variabile 37(II;1.00)

AIZOACEAE

Macarthuria neo-cambrica 29(I;1.00) 32(I;1.00) 33(I;1.00) 42(I;1.00)

APIACEAE

Actinotus helianthi 29(II;2.14) 30(III;1.00) 31(I;1.00) 33(I;1.00) 42(I;1.33)

Centella asiatica 14*(IV;1.00)

Hydrocotyle peduncularis 14*(IV;1.67)

Platysace ericoides 16(III;2.50) 19(V;1.50) 20(II;1.80) 23(I;1.00) 25(I;1.80) 26(I;1.50) 29(III;1.25) 30(III;2.00) 31(I;1.00) 32(III;1.57) 33(III;1.71) 41(II;1.00) 42(III;1.50)

Platysace lanceolata 23(II;1.50) 29(I;2.25) 30(III;3.00) 31(V;1.60) 32(I;1.50) 42(I;1.67)

Platysace sp. *A* 10(I;1.00) 23(II;1.00) 24(I;1.50) 25(I;1.17) 26(IV;3.00) 28(II;1.75) 34(III;3.00) 35(II;2.00)

Trachymene incisa subsp. *incisa* 17(II;1.00) 20(III;1.00) 25(I;1.00) 26(I;1.00) 29(I;1.00) 32(I;1.00) 42(I;1.00)

Xanthosia pilosa 18(V;1.00) 23(I;1.00) 25(I;1.00) 29(II;1.18) 30(II;1.00) 31(III;1.60) 32(I;1.00) 33(II;1.40) 34(II;1.00) 41(II;1.25) 42(IV;1.21)

APOCYNACEAE

Parsonsia straminea 21(I;1.00) 22(I;1.00) 23(II;1.50) 30(II;1.00) 33(III;1.14) 34(III;1.00) 37(V;2.00) 38(III;1.00)

ARALIACEAE

Astrotricha longifolia 29(I;1.00)

Polyscias sambucifolia 33(I;1.00)

ASCLEPIADACEAE

Marsdenia fraseri 29(I;1.00) 33(I;1.00) 41(I;1.00)

Marsdenia rostrata 33(I;1.00) 37(II;1.00)

Marsdenia suaveolens 31(I;1.00) 33(I;1.00)

ASTERACEAE

Ageratum houstonianum 38(III;1.00)

Baccharis halimifolia 14(I;1.00)

Brachycome multifida var. *multifida* 14(II;1.00)

Bracteantha bracteata 14*(IV;2.00)

Chrysanthemoides monilifera subsp. *rotundata* 14(II;1.00) 37(III;2.00) 40(V;3.00) 41(I;1.00)

Conyza albida 38(III;1.00)

Craspedia variabilis 14(II;1.00)

Crassocephalum crepidioides 34(II;1.00)

Erechtites valerianifolia 34(II;1.00)

Helichrysum elatum 33(I;1.00)

Hypochaeris radicata 14(II;2.00)

Ozothamnus diosmifolius 26(I;1.00)

Picris angustifolia subsp. *carolorum-hericorum* 14(I;1.00)

Rutidosis heterogama 15*(III;1.00) 22(I;1.00)

Senecio lautus subsp. *maritimus* 14(II;2.00)

BAUERACEAE

Bauera capitata 17(III;1.00) 23(II;1.50) 24(II;2.00) 25(IV;2.15) 26(I;1.00) 28(III;2.08) 32(I;1.00) 34(II;1.00)

BIGNONIACEAE

Pandorea pandorana 23(I;1.00) 30(II;1.00) 33(II;1.00) 37(III;1.50) 40(V;1.00) 42(I;1.50)

CAMPANULACEAE

Wahlenbergia littoricola 14(II;1.00)

CASUARINACEAE

Allocasuarina defungens 25(I;1.00) 32(I;2.00)

Allocasuarina defungens × *littoralis* 32(I;2.00)

Allocasuarina littoralis 16(IV;3.00) 17(V;1.50) 18(V;2.00) 19(V;3.17) 20(V;3.10) 23(I;1.00) 29(II;1.57) 30(V;3.50) 31(III;2.33) 33(V;2.25) 42(I;1.00)

Allocasuarina torulosa 16(II;1.00)

Casuarina glauca 37(II;1.00)

CLUSIACEAE

Hypericum gramineum 19(II;1.00) 20(I;1.00) 22(II;1.00)

CONVOLVULACEAE

Dichondra repens 14(II;1.00)

Polymeria calycina 14*(IV;2.33)

DILLENIACEAE

Adrastaea salicifolia 10(V;1.43) 21(I;1.00) 24(II;1.25) 25(II;1.33) 26(I;1.50) 28(V;2.46)

Hibbertia acuminata 29(III;1.56) 32(I;1.25) 33(I;3.50) 42(II;1.50)

Hibbertia aspera 14(II;2.00) 33(I;1.00)

Hibbertia diffusa 18(V;1.00) 29(I;2.00) 32(I;1.00) 42(I;1.00)

Hibbertia empetrifolia subsp. *empetrifolia* 16*(V;2.50)

Hibbertia fasciculata 23(II;2.00) 25(III;1.00) 29(III;1.00) 30(III;1.00) 31(V;1.27) 32(V;1.14) 33(I;1.00) 34(II;1.00) 41(I;1.00) 42(III;1.15)

Hibbertia linearis 29(II;1.11) 30(IV;2.00) 31(II;1.50) 32(II;1.57) 33(I;1.00) 42(II;1.50)

Hibbertia riparia 17(V;1.50) 25(I;1.60) 31(II;1.00) 32(I;1.00)

Hibbertia rufa 23(I;1.00) 25(I;1.00) 29(IV;1.00) 30(II;1.00) 31(IV;1.11) 32(IV;1.06) 33(I;1.50) 42(II;1.00)

Hibbertia scandens 23(I;1.00) 33(III;1.00) 34(II;1.00) 40(V;1.50) 41(I;1.00)

Hibbertia vestita 14(II;2.00) 18(V;3.00) 19(V;2.67) 20(V;2.50) 22(II;1.71) 23(II;1.50) 24(I;1.00) 25(I;1.00) 26(V;2.56) 29(I;1.40) 30(V;1.50) 33(I;1.50) 35(II;3.00) 42(I;2.00)

DROSERACEAE

Drosera auriculata 15(II;1.00) 20(IV;1.00) 22(I;1.00) 23(II;1.00) 24(IV;1.00) 25(III;1.00) 26(V;1.00) 28(III;1.00) 29(I;1.00) 32(II;1.00) 34(IV;1.00) 41(II;1.00)

Drosera binata 8(III;1.00) 10(IV;1.00) 11(I;1.00) 21(I;1.00) 25(I;1.00) 28(III;1.08)

Drosera pygmaea 22(II;1.00) 25(I;1.00) 28(I;1.00)

Drosera spatulata 22(I;1.00) 23(I;1.00) 24(I;1.00) 25(II;1.05) 28(I;1.00) 35(II;1.00)

ELAEOCARPACEAE

Elaeocarpus reticulatus 23(I;1.00) 30(II;1.00) 33(II;1.40) 34(III;2.00) 38(V;1.00) 41(IV;2.14)

EPACRIDACEAE

Astroloma pinifolium 29(I;1.00) 30(IV;1.33) 32(I;1.00) 33(II;1.00) 42(I;1.00)

Brachyloma daphnoides 16(III;2.00) 29(V;1.46) 30(III;1.50) 31(V;2.42) 32(III;1.46) 33(II;1.00) 42(II;1.33)

Brachyloma scortechinii 25(I;1.00) 29(I;1.00) 32(I;1.00) 33(I;1.00)

Epacris microphylla var. *microphylla* 10(V;1.29) 11(I;1.25) 21(II;1.67) 22(II;1.60) 23(II;2.00) 24(I;1.00) 25(I;1.67) 28(V;1.62) 31(II;1.00) 32(I;1.50)

Epacris obtusifolia 10(I;1.00) 11(I;1.00) 22(I;1.67) 24(V;2.61) 25(V;1.84) 26(IV;1.50) 27(V;2.50) 28(IV;1.35) 34(III;1.00) 35(II;2.00) 36(I;1.00) 41(I;1.00)

Epacris pulchella 17(IV;2.33) 18(V;3.00) 19(V;3.00) 20(II;1.50) 24(I;2.00) 25(II;1.19) 26(II;1.00) 29(II;1.82) 31(I;1.00) 32(III;1.20) 33(I;2.00) 35(I;1.00) 41(II;1.50) 42(I;1.60)

Leucopogon deformis 23(I;1.00) 28(I;1.00) 29(IV;1.14) 30(II;1.00) 32(III;1.57) 33(I;1.00) 42(II;1.20)

Leucopogon ericoides 23(II;1.50) 25(I;1.00) 26(I;1.00) 29(III;1.37) 30(II;1.00) 31(II;1.67) 32(II;1.13) 33(III;1.17) 41(I;1.00) 42(IV;1.63)

Leucopogon esquamatus 17(II;1.00)

Leucopogon lanceolatus var. *gracilis* 23(II;2.00) 25(I;1.00) 29(I;1.00) 30(II;1.00) 32(I;1.00) 33(III;1.62) 34(IV;1.00) 38(V;1.50) 41(V;2.11) 42(II;1.50)

Leucopogon lanceolatus var. *lanceolatus* 19(I;1.00)

Leucopogon leptospermoides 23(II;1.00) 24(III;1.67) 25(II;1.33) 26(II;1.00) 28(I;1.00) 29(V;2.12) 30(V;2.50) 31(V;1.80) 32(V;2.47) 33(V;1.85) 34(III;1.00) 41(III;1.50) 42(V;2.43)

Leucopogon margarodes 33(II;1.50) 34(II;1.00) 41(III;1.20) 42(I;1.00)

Leucopogon rodwayi 25(I;1.00) 26(I;1.00) 32(I;1.00)

Leucopogon virgatus 29(V;1.61) 30(IV;1.33) 31(V;1.67) 32(IV;1.40) 33(I;2.00) 42(III;1.86)

Lissanthe sp. *A* 18(III;1.00) 23(II;1.00) 24(II;1.29) 25(I;1.50) 26(III;1.00) 28(I;1.00) 32(I;1.33) 34(III;1.50)

Lissanthe sp. *B* 20*(V;1.50)

Melichrus procumbens 16(II;1.00) 17(V;1.00) 18(V;1.00) 19(II;1.00) 20(II;1.00)

Monotoca elliptica 25(I;1.14) 29(I;1.33) 30(II;1.00) 32(I;1.20) 33(IV;1.64) 34(II;1.00) 36(I;1.00) 41(II;1.25) 42(II;1.36)

Monotoca scoparia 16(III;2.00) 17(IV;1.33) 19(IV;1.50) 20(II;1.30) 24(I;1.00) 25(I;1.08) 29(V;2.41) 30(V;2.75) 31(V;2.58) 32(V;2.31) 33(II;1.40) 42(IV;2.50)

Sprengelia incarnata 10(II;1.00) 22(I;1.33) 25(I;1.75) 27(V;1.00) 35(I;1.00)

Sprengelia sprengelioides 10(III;1.00) 11(I;1.00) 24(V;2.50) 25(V;1.76) 26(V;2.00) 28(V;2.21) 35(II;1.00)

Styphelia viridis subsp. *breviflora* 18(III;1.00) 19(I;1.00) 23(III;1.00) 26(I;1.00) 29(III;1.56) 30(IV;1.00) 32(II;1.27) 33(I;1.00) 42(II;1.00)

Woollsia pungens 29(III;1.62) 30(III;2.00) 32(I;2.33) 33(II;1.50) 42(I;1.40)

EUPHORBIACEAE

Amperea xiphoclada 29(II;1.12) 30(III;1.00) 31(IV;1.11) 32(II;1.21) 33(II;1.00) 41(II;1.00) 42(II;1.10)

Phyllanthus hirtellus 18(V;1.00) 19(V;1.00) 20(IV;1.00) 29(I;1.00) 30(IV;1.33) 33(II;1.00) 42(I;1.00)

Poranthera microphylla 14*(IV;1.33) 42(I;1.00)

Pseudanthus orientalis 17(IV;1.00) 23(V;1.67) 24(III;1.10) 25(V;1.35) 26(V;1.11) 28(I;1.00) 29(IV;1.14) 31(V;1.73) 32(V;1.27) 33(II;1.25) 34(II;1.00) 35(II;1.00) 42(II;1.08)

Ricinocarpus pinifolius 17(II;1.00) 24(I;1.00) 25(II;1.26) 26(I;1.00) 29(IV;2.04) 30(III;1.00) 31(V;1.75) 32(IV;1.44) 33(II;1.00) 42(IV;1.62)

FABACEAE – FABOIDEAE

Almaleea paludosa 22(I;1.00) 35(II;1.00)

Aotus ericoides 10(II;1.00) 24(V;2.44) 25(II;1.56) 26(I;3.00) 28(III;1.92) 32(I;1.20) 34(III;1.50) 35(II;1.00) 41(II;2.00) 42(I;3.00)

Aotus lanigera 11(I;1.00) 23(I;2.00) 24(I;1.00) 25(I;1.00) 28(I;1.00) 29(I;1.60) 32(II;1.80) 33(I;2.50) 41(I;1.00) 42(I;2.00)

Bossiaea ensata 16(V;1.50) 18(V;2.50) 29(V;1.47) 30(V;1.50) 31(III;1.67) 32(II;1.00) 33(II;1.00) 42(III;1.00)

Bossiaea heterophylla 23(II;2.00) 25(I;1.00) 29(IV;1.75) 31(IV;1.88) 32(II;1.50) 33(I;1.00) 42(IV;1.70)

Bossiaea rhombifolia subsp. *rhombifolia* 18*(V;3.00)

Bossiaea stephensonii 17*(III;1.00)

Chorizema parviflorum 14(II;1.00)

Daviesia umbellulata 19(I;1.00) 20(II;1.50)

Dillwynia floribunda 17(IV;1.00) 23(II;2.00) 24(II;1.83) 25(V;1.89) 26(IV;2.50) 28(IV;2.06) 32(II;1.10) 34(V;1.00) 35(II;1.50)

Dillwynia glaberrima 25(I;1.00) 29(I;2.00) 30(III;1.00) 31(III;1.67) 32(II;1.69)

Dillwynia retorta 19(V;1.50) 23(II;1.00) 25(I;1.00) 29(V;1.88) 30(III;1.00) 31(III;2.50) 32(V;1.79) 33(IV;1.22) 42(IV;1.87)

Glycine microphylla 14(I;1.00) 33(I;1.00)

Glycine tomentella 14(II;1.00)

Gompholobium glabratum 23(I;1.00) 32(I;1.00)

Gompholobium pinnatum 16(V;1.50) 17(V;1.00) 18(V;1.00) 19(V;1.40) 20(V;1.00) 22(I;1.25) 23(II;1.00) 25(I;1.00) 26(III;1.00) 35(III;1.00)

Gompholobium virgatum var. *virgatum* 29(V;1.16) 30(V;1.25) 31(I;1.00) 32(IV;1.68) 33(II;1.40) 42(IV;1.33)

Hardenbergia violacea 14(I;1.00) 30(II;1.00) 42(I;1.50)

Hovea heterophylla 14(II;1.00) 19(II;1.00)

Jacksonia scoparia 14(I;2.00) 16*(III;1.00)

Jacksonia stackhousii 29(III;1.24) 32(I;1.14)

Kennedia rubicunda 37(II;1.00) 38(V;2.00) 41(II;1.00)

Mirbelia rubiifolia 16(V;2.00) 17(V;1.75) 18(V;4.00) 20(II;1.00) 25(I;1.00) 26(III;1.83) 35(II;1.00)

Oxylobium robustum 38*(III;1.00)

Phyllota phylicoides 14(II;2.50) 16(V;1.50) 17(III;1.00) 20(V;1.50) 23(IV;1.75) 29(IV;2.29) 30(II;1.00) 31(V;2.55) 32(V;2.41) 42(IV;2.76)

Pultenaea maritima ms. 14(II;3.50)

Pultenaea myrtoides 19(IV;2.75) 20(II;1.50) 22(II;2.60) 26(I;2.00) 28(I;1.00) 35(II;1.00)

Pultenaea retusa 14(II;1.50)

Sphaerolobium minus 17(II;1.00) 23(II;1.00)

Sphaerolobium vimineum 22(I;1.00) 35(II;1.00) 39(V;1.00)

Swainsona galegifolia 14(II;1.00)

Viminaria juncea 11(I;1.00) 21(I;1.00) 22(I;1.50)

Zornia dyctiocarpa var. *dyctiocarpa* 14(I;1.00)

FABACEAE – MIMOSOIDEAE

Acacia baueri subsp. *baueri* 25(I;1.00) 28(I;1.00) 29(II;1.00) 31(II;1.00) 32(II;1.00) 42(I;1.00)

Acacia brownii 19(II;1.00) 20(III;1.20)

Acacia disparrima subsp. *disparrima* 40*(V;1.00)

Acacia elongata 21(I;2.00) 34(III;1.00) 35(I;1.00) 38(V;1.00) 41(I;2.50)

Acacia leiocalyx 14(I;1.00) 16*(III;1.00)

Acacia longifolia subsp. *longifolia* 27(III;1.00) 37(II;1.00) 41(II;1.00) 42(I;1.00)

Acacia longifolia subsp. *sophorae* 15(II;1.00) 19(I;1.00) 31(I;1.00) 33(I;1.00) 34(II;1.00) 42(I;1.00)

Acacia maidenii 34*(III;1.00)

Acacia myrtifolia 14(II;1.00) 16(III;1.00)

Acacia quadrilateralis 31(I;1.00)

Acacia suaveolens 16(IV;1.00) 17(III;1.00) 23(II;1.00) 25(I;1.00) 28(I;1.00) 29(V;1.56) 30(V;1.00) 31(I;1.00) 32(II;1.08) 33(IV;1.00) 35(I;1.00) 41(I;1.00) 42(V;1.37)

Acacia ulicifolia 29(V;1.48) 30(III;2.00) 31(IV;1.12) 32(III;1.48) 33(I;1.00) 41(I;1.00) 42(V;1.73)

GOODENIACEAE

Dampiera stricta 10(I;1.00) 15(II;2.00) 16(III;2.00) 17(IV;1.33) 19(V;1.83) 20(V;1.80) 22(II;1.60) 23(III;1.00) 24(I;1.00) 25(II;1.17) 26(III;1.33) 28(I;1.00) 29(II;1.20) 30(III;1.00) 31(IV;1.00) 32(II;1.08) 33(III;1.12) 35(II;1.00) 37(II;1.00) 41(III;1.00) 42(I;1.00)

Goodenia bellidifolia 15(III;1.50) 17(III;1.00) 19(V;1.17) 20(V;1.80) 26(I;1.50) 35(II;1.00)

Goodenia hederacea subsp. *hederacea* 14(II;1.50) 22(I;1.00)

Goodenia heterophylla 19(II;1.00) 22(I;1.00)

Goodenia paniculata 12(II;2.00) 22(I;1.75) 35(II;3.00)

Goodenia rotundifolia 14(I;3.00)

Goodenia stelligera 10(II;1.00) 11(I;1.00) 12(II;1.00) 17(V;1.25) 22(II;1.29) 24(I;1.00) 25(II;1.00) 26(II;1.00) 28(II;1.00) 35(I;1.00)

Velleia spathulata 15(III;1.50) 20(II;1.00) 22(II;1.12)

HALORAGACEAE

Gonocarpus micranthus 8(II;1.00) 11(I;1.00) 22(III;1.09) 23(II;1.00) 24(II;1.00) 25(III;1.24) 26(III;1.20) 27(III;1.00) 34(II;1.00) 35(II;1.50) 38(III;2.00) 41(II;1.00)

Gonocarpus salsoloides 22(I;1.00) 25(I;1.00)

Gonocarpus tetragynus 15(IV;2.33) 16(V;2.00) 17(V;1.50) 19(IV;2.00) 20(III;1.00) 21(II;1.00) 22(II;1.40) 35(II;1.00) 39(V;1.00)

LAMIACEAE

Prostanthera palustris 26(I;1.50)

LAURACEAE

Cassytha filiformis 14(I;1.00) 18(III;1.00) 23(I;1.00) 24(I;1.67) 25(I;1.25) 29(II;1.36) 31(I;1.00) 32(I;1.17) 33(II;1.67) 34(III;1.00) 35(I;1.00) 39(III;2.00) 41(I;1.00) 42(I;1.00)

Cassytha glabella forma *glabella* 2(II;2.00) 9(II;1.50) 10(II;1.00) 11(I;1.00) 13(I;1.50) 14(II;1.00) 15(III;1.00) 16(III;1.50) 17(V;1.00) 18(V;1.50) 19(V;1.33) 20(III;1.00) 21(II;1.00) 22(II;1.25) 23(III;1.00) 24(V;1.47) 25(V;1.05) 26(V;1.00) 27(V;1.00) 28(V;1.19) 29(III;1.21) 30(III;1.00) 31(III;1.00) 32(III;1.12) 33(II;1.25) 35(III;1.00) 37(III;1.50) 41(IV;1.43)

Cassytha pubescens 24(I;1.00) 25(I;1.00) 29(II;1.36) 30(IV;1.33) 31(II;1.33) 32(I;1.57) 33(II;1.25) 37(II;1.00) 40(V;1.00) 41(I;1.50) 42(I;1.50)

Endiandra sieberi 41(I;1.00)

LENTIBULARIACEAE

Utricularia australis 3(II;2.00) 4(II;1.00) 6(III;1.00) 7(III;1.50)

Utricularia biloba 13(I;1.00)

Utricularia dichotoma 11(II;1.00) 12(II;2.00)

Utricularia gibba 3(II;1.00) 4(III;1.00)

Utricularia lateriflora 24(I;1.00) 25(I;1.00) 28(I;1.00)

Utricularia uliginosa 35(I;1.00) 37*(III;2.00)

LOBELIACEAE

Lobelia alata 11(I;1.00) 14(II;1.00)

LOGANIACEAE

Logania pusilla 14(II;1.00) 17(III;1.00) 19(I;1.00)

Mitrasacme alsinoides 22(I;1.00) 28(I;1.00)

Mitrasacme paludosa 26(II;1.25)

Mitrasacme polymorpha 17(III;1.00) 25(II;1.00) 26(II;1.00) 28(I;1.00) 29(I;1.00) 30(II;1.00) 32(I;1.00) 34(II;1.00)

LORANTHACEAE

Amyema congener subsp. *congener* 33(I;1.50)

Dendrophthoe vitellina 9(I;1.00) 20(I;1.00) 23(I;1.00) 33(I;1.00) 36(II;1.00) 37(II;1.00) 42(I;1.00)

Muellerina celastroides 33(I;1.00) 42(I;1.50)

MELASTOMATACEAE

Melastoma affine 38*(III;1.00)

MENYANTHACEAE

Nymphoides indica 7*(III;2.00)

Villarsia exaltata 8(III;1.00) 9(II;1.00) 11(IV;1.64) 12(II;1.00) 13(I;1.00) 21(III;1.25) 28(I;1.00) 35(II;1.00) 36(II;2.00) 41(I;1.00)

MORACEAE

Ficus superba var. *henneana* 34(II;1.00)

MYRSINACEAE

Rapanea howittiana 33(I;1.00)

Rapanea variabilis 33(I;1.00) 40*(III;1.00)

MYRTACEAE

Angophora costata 25(I;1.00) 35(I;1.00)

Angophora woodsiana 42(I;2.00)

Austromyrtus dulcis 18(V;2.50) 23(II;2.50) 29(I;2.00) 30(III;1.00) 32(I;1.00) 33(III;2.50) 40(V;3.00) 41(I;1.00)

Baeckea diosmifolia 23(II;2.00) 25(I;1.33) 31(III;2.40) 32(II;2.00)

Baeckea frutescens 9(I;2.00) 10(II;1.50) 23(IV;1.75) 24(V;3.11) 25(III;3.36) 26(I;1.00) 28(IV;3.06) 32(II;1.46) 34(III;3.00) 41(II;3.00)

Baeckea imbricata 22(II;1.17) 23(III;1.00) 24(IV;2.27) 25(V;1.70) 26(III;1.17) 27(III;1.00) 28(II;1.56) 32(I;1.00) 35(II;1.00)

Baeckea linifolia 25(I;3.00) 28(I;3.00)

Callistemon pachyphyllus 9(II;2.00) 10(II;1.00) 11(V;2.33) 12(IV;2.00) 13(I;2.00) 15(III;1.00) 21(II;1.67) 22(IV;1.36) 24(IV;1.36) 25(II;1.07) 26(IV;1.62) 28(I;1.00) 34(III;1.00) 35(V;1.38) 36(II;2.00)

Calytrix tetragona 29(I;3.00) 31(III;1.60) 32(II;1.50) 42(I;1.00)

Corymbia gummifera 22(I;1.00) 42(I;2.50)

Corymbia intermedia 20(I;1.00)

Darwinia leptantha 23(I;1.00) 25(III;1.69) 27(III;1.00) 31(I;1.00) 32(I;1.00) 34(III;1.00)

Eucalyptus globoidea 32(I;2.00)

Eucalyptus pilularis 33(I;1.00) 42*(III;3.19)

Eucalyptus planchoniana 42(III;3.43)

Eucalyptus resinifera 25(I;1.00)

Eucalyptus robusta 21(I;1.00) 24(I;1.00) 25(I;1.00) 33(I;1.50) 35(II;1.00) 38(III;1.00) 41(IV;4.00)

Eucalyptus signata 35(II;1.50) 41(I;3.50) 42(I;3.50)

Eucalyptus tereticornis 22(I;1.00)

Euryomyrtus ramosissima subsp. *ramosissima* 23(I;2.00) 25(I;1.00) 29(I;2.00) 31(IV;2.00) 32(II;2.00) 42(I;2.00)

Homoranthus virgatus 18(V;1.00) 23(II;1.00) 25(I;1.00) 29(IV;1.33) 30(IV;1.00) 31(II;1.50) 32(III;1.64) 33(III;2.12) 41(I;2.00) 42(IV;1.40)

Kunzea capitata 19(V;1.33) 20(V;2.20) 23(II;1.00) 25(I;1.67) 27(V;1.00) 31(I;1.00) 32(I;1.50)

Leptospermum arachnoides 23(II;2.00)

Leptospermum juniperinum 10(III;1.00) 11(I;1.40) 21(V;5.00) 22(I;1.00) 24(I;1.67) 25(III;1.24) 26(I;1.00) 27(III;1.00) 28(I;1.00) 34(III;2.00) 35(II;1.33) 36(IV;1.00) 39(V;4.50) 41(I;1.00)

Leptospermum laevigatum 31(I;1.00)

Leptospermum liversidgei 10(V;1.88) 11(I;1.00) 13(I;1.00) 21(I;1.00) 24(V;3.11) 25(V;2.94) 26(V;2.70) 27(III;2.00) 28(V;3.69) 34(III;1.00) 36(I;1.00) 41(I;2.00)

Leptospermum polygalifolium subsp. *cismontanum* 17(III;2.00) 18(III;1.00) 19(II;1.50) 20(IV;1.40) 23(V;3.00) 24(IV;1.69) 25(I;1.57) 26(III;1.40) 28(I;1.00) 29(II;2.20) 30(III;2.50) 31(IV;1.62) 32(V;2.38) 33(III;3.17) 34(III;3.50) 35(II;2.00) 37(III;2.00) 41(V;2.60) 42(III;1.92)

Leptospermum semibaccatum 23(II;2.50) 25(I;1.67) 29(II;2.57) 30(III;2.50) 31(V;2.60) 32(IV;2.73) 33(II;2.25)

Leptospermum speciosum 32(I;1.00) 38*(V;5.00)

Leptospermum trinervium 18(V;2.00) 20(IV;1.60) 29(V;3.04) 30(III;3.00) 32(III;2.70) 33(IV;2.91) 41(I;1.50) 42(V;2.48)

Leptospermum whitei 23(I;1.00) 24(I;1.33) 25(II;1.93) 26(II;2.25) 32(II;1.94) 34(III;4.50) 41(I;1.00) 42(I;1.00)

Lophostemon confertus 40*(V;5.00)

Lophostemon suaveolens 22(I;1.00)

Melaleuca alternifolia 15(III;2.00) 35(II;1.00)

Melaleuca linariifolia 12(I;1.00)

Melaleuca nodosa 18(V;3.00) 19(IV;1.25) 20(III;2.30) 22(I;1.00) 23(V;3.17) 24(III;1.89) 25(II;1.56) 26(IV;2.38) 28(I;1.00) 29(IV;2.90) 31(I;1.50) 32(III;2.54) 33(I;4.00) 35(II;2.00) 37(III;1.00) 41(II;3.00) 42(I;2.00)

Melaleuca quinquenervia 1(I;1.00) 6(IV;1.00) 9(V;4.00) 11(II;1.00) 13(I;1.00) 22(I;1.00) 24(II;1.00) 25(I;1.00) 26(II;1.00) 28(I;1.00) 33(I;1.00) 34(III;1.50) 36(V;3.00) 37(V;4.50) 41(II;1.33)

Melaleuca sieberi 15(III;1.00) 22(II;1.67) 23(III;1.33) 25(I;1.00) 26(I;1.00) 35(IV;3.67)

Melaleuca squamea 9(IV;1.75) 11(I;1.50) 13(I;2.00) 24(IV;1.92)

Melaleuca thymifolia 9(II;1.50) 11(II;2.17) 12(IV;3.00) 15(III;1.50) 22(V;1.94) 23(I;1.00) 25(I;1.00) 26(II;2.00) 35(V;2.38)

Ochrosperma citriodorum 18(V;1.00) 23(II;2.00) 25(I;1.44) 26(I;1.00) 29(I;1.00) 32(II;1.40)

Ochrosperma lineare 23(II;1.50) 25(I;1.00) 29(IV;2.10) 30(III;1.50) 31(IV;2.00) 32(IV;1.86) 33(II;1.40) 41(I;1.00) 42(III;1.57)

Syzygium oleosum 41(I;1.00)

NYMPHAEACEAE

Nymphaea caerulea subsp. *zanzibarensis* 3(II;1.00) 4(III;2.00) 7(III;1.50)

OLACACEAE

Olax angulata 29(I;1.50)

Olax retusa 24(I;1.00) 25(II;1.00) 26(I;1.00) 28(III;1.19) 29(I;1.00) 32(I;1.00)

Olax stricta 23(I;1.00) 25(I;1.00) 29(I;1.00) 30(II;1.00) 31(I;1.00) 32(II;1.08) 42(I;1.00)

OLEACEAE

Notelaea longifolia 33(II;1.00) 41(I;1.00)

Notelaea ovata 16(IV;1.00) 18(V;1.50) 19(III;1.00) 20(III;1.20)

OXALIDACEAE

Oxalis exilis 14(II;1.00)

Oxalis rubens 14(II;1.00)

PITTOSPORACEAE

Billardiera scandens 16(II;1.00) 17(III;1.00) 23(II;1.00) 26(I;1.00) 30(II;1.00) 33(III;1.17) 34(III;1.00) 41(I;1.00)

Pittosporum revolutum 40*(III;1.00)

POLYGALACEAE

Comesperma defoliatum 10(II;1.00) 24(II;1.00) 25(I;1.00) 28(II;1.00) 31(I;1.00) 32(I;1.00)

Comesperma ericinum 16(III;2.00) 20(I;1.00) 22(II;1.00) 25(II;1.25) 27(III;1.00) 28(I;1.00) 31(III;1.14) 32(I;1.50) 35(II;1.00) 42(I;1.00)

POLYGONACEAE

Persicaria attenuata 7(II;1.00)

PROTEACEAE

Banksia aemula 10(II;1.00) 23(I;1.00) 25(II;1.07) 28(I;1.00) 29(V;3.53) 30(V;3.50) 31(V;3.42) 32(V;3.38) 33(V;3.14) 34(II;1.00) 40(III;2.00) 41(II;1.50) 42(V;2.80)

Banksia ericifolia subsp. *macrantha* 11(I;1.50) 12(III;1.00) 13(I;1.00) 17(IV;1.00) 21(II;1.00) 22(II;1.00) 23(IV;1.75) 24(V;3.47) 25(V;2.37) 26(I;1.00) 27(V;3.50) 28(III;1.38) 29(I;2.00) 31(I;1.00) 32(II;1.08) 34(V;4.00) 35(II;4.00) 41(II;1.00)

Banksia integrifolia subsp. *integrifolia* 14(II;1.00) 33(I;2.50) 37(III;1.50) 40(V;2.00)

Banksia oblongifolia 11(I;1.00) 16(V;3.50) 17(V;2.25) 18(V;4.00) 19(V;3.50) 20(V;3.90) 22(III;1.85) 23(V;3.50) 24(IV;2.00) 25(IV;2.79) 26(V;3.70) 28(II;1.25) 29(I;1.00) 32(III;1.63) 33(I;1.00) 34(III;3.00) 35(IV;2.00) 41(I;1.00)

Banksia robur 11(I;2.00)

Banksia serrata 33(II;3.25)

Conospermum taxifolium 17(II;1.00) 23(IV;2.00) 25(II;1.74) 29(IV;1.08) 30(III;2.00) 31(II;1.33) 32(II;1.29) 42(III;1.21)

Grevillea humilis 22(II;1.00) 26(I;1.00)

Hakea actites 9(I;1.00) 19(I;1.00) 22(I;2.00) 26(I;1.00) 35(III;2.50)

Hakea laevipes subsp. *laevipes* 17(V;2.00) 18(III;1.00) 19(V;1.50) 20(IV;1.30) 23(II;2.00)

Hakea teretifolia subsp. *teretifolia* 12(III;1.00) 16(II;2.00) 17(V;3.00) 22(III;1.17) 23(II;1.00) 25(I;2.00) 35(II;1.67)

Isopogon anemonifolius 16(III;1.50) 17(V;2.50) 23(II;1.00) 25(I;1.40) 29(I;1.33) 31(IV;1.56) 32(I;1.33) 33(I;1.00) 42(I;1.00)

Isopogon mnoraifolius 19(I;1.00) 20*(IV;1.00)

Lambertia formosa 19*(IV;2.00)

Lomatia silaifolia 16*(IV;1.00)

Persoonia adenantha 32(I;1.00) 33(I;1.00)

Persoonia conjuncta 17(II;1.00) 29(I;1.00) 34(II;1.00) 35(I;1.00)

Persoonia katerae 31(I;1.00) 33(I;1.00)

Persoonia lanceolata 23(II;1.00) 25(II;1.20) 27(V;1.00) 28(I;1.00) 29(I;1.00) 31(I;1.00) 32(I;1.00)

Persoonia levis 26(I;1.00) 42(I;1.00)

Persoonia stradbrokensis 16(III;1.00) 18(III;1.00) 20(I;1.00) 26(II;1.00) 28(I;1.00) 29(I;1.00) 30(II;1.00) 32(I;1.00) 33(I;1.00) 41(II;1.00) 42(I;1.00)

Persoonia tenuifolia 18(III;1.00) 19(II;1.00) 20(II;1.00)

Persoonia virgata 10(II;1.00) 23(II;1.00) 24(I;1.00) 25(II;1.00) 26(V;1.10) 28(II;1.09) 29(V;1.14) 30(II;1.00) 31(I;1.50) 32(IV;1.15) 33(II;1.00) 41(I;1.00) 42(IV;1.13)

Petrophile canescens 16(III;1.50) 20(I;1.00) 23(II;1.50) 25(I;1.00) 29(IV;1.10) 32(II;1.00) 42(II;1.00)

Petrophile pulchella 23(II;1.00) 25(I;1.40) 32(I;1.00) 42(I;1.00)

Symphionema paludosum 25(I;1.00)

RANUNCULACEAE

Ranunculus lappaceus 14(II;1.00)

RHAMNACEAE

Cryptandra propinqua 16(II;1.00)

Cryptandra scortechinii 17*(III;1.50)

RUBIACEAE

Cyclophyllum longipetalum 41(I;1.00)

Durringtonia paludosa 10(II;1.00) 11(I;1.00) 21(II;1.33) 36(II;1.00)

Pomax umbellata 23(I;1.00) 29(I;1.00) 30(V;1.00) 33(IV;1.55) 38(III;2.00) 40(V;1.00) 42(III;1.00)

RUTACEAE

Acronychia imperforata 33(II;2.33) 40*(V;3.00)

Boronia falcifolia 23(II;1.00) 24(IV;2.08) 25(V;2.15) 26(IV;1.86) 28(V;1.73) 32(I;1.00) 34(II;1.00)

Boronia parviflora 11(I;1.00) 22(II;1.00) 25(I;1.00) 26(I;1.00) 27(III;1.00) 35(II;1.00)

Boronia pinnata 16(V;1.50) 17(V;1.50) 25(I;2.00) 29(I;1.83) 31(V;2.70) 32(II;2.50) 33(I;2.00) 34(II;1.00) 41(II;1.67) 42(II;2.44)

Boronia polygalifolia 14(II;1.00) 17(III;1.00) 19(IV;1.00)

Boronia rosmarinifolia 30(II;2.00)

Boronia safrolifera 18(V;3.00) 29(II;2.00) 32(II;1.89) 33(I;3.00) 41(I;2.00) 42(I;1.33)

Eriostemon australasius 29(III;1.06) 30(V;1.75) 31(IV;2.50) 32(I;1.14) 33(I;1.00) 42(III;1.29)

Nematolepis squamea subsp. *squamea* 23(II;1.50) 33(III;1.17) 37(II;1.00)

Philotheca salsolifolia 29(II;1.60) 31(I;3.00) 33(I;2.00)

Zieria arborescens subsp. *arborescens* 33(I;1.00)

Zieria laxiflora 16(III;1.00) 23(II;1.00) 29(IV;1.36) 30(V;2.00) 31(IV;1.33) 32(III;1.38) 33(II;1.40) 42(III;1.00)

SANTALACEAE

Leptomeria acida 22(I;1.00) 24(II;1.17) 25(I;1.14) 26(I;1.00) 28(I;1.00) 29(III;1.59) 30(II;1.00) 32(II;1.11) 33(III;1.33) 35(I;1.00) 41(III;1.20) 42(II;1.00)

Thesium australe 14(I;1.00)

SAPINDACEAE

Cupaniopsis anacardioides 33(I;1.00) 40*(V;1.00)

Dodonaea triquetra 33(I;1.00)

Guioa semiglauca 41(I;1.00)

SCROPHULARIACEAE

Euphrasia collina subsp. *paludosa* 17*(III;1.50) 22(I;1.00)

STACKHOUSIACEAE

Stackhousia nuda 10(I;1.00) 17(II;1.00) 20(II;1.00) 21(II;1.00) 22(I;1.00) 25(I;1.00) 26(II;1.00) 29(I;1.00) 30(II;1.00) 32(I;1.00) 34(II;1.00) 42(I;1.00)

STYLIDIACEAE

Stylidium graminifolium 16(II;1.00) 17(III;1.00) 20(I;1.00) 22(II;1.00) 23(II;1.00) 25(II;1.00) 26(I;1.00) 29(I;1.00) 31(IV;1.00) 32(II;1.00) 35(II;1.00)

Stylidium ornatum 24(I;1.00) 25(IV;1.43) 26(II;1.50) 28(II;1.40) 31(I;1.00) 32(I;1.17) 34(III;1.00)

THYMELAEACEAE

Pimelea linifolia 10(I;1.00) 14(V;2.12) 15(II;1.00) 16(V;1.75) 17(V;2.00) 19(V;1.50) 20(V;1.60) 22(IV;1.33) 23(IV;1.00) 24(IV;1.18) 25(V;1.27) 26(V;2.20) 27(V;1.50) 28(V;1.40) 29(IV;1.18) 30(IV;1.67) 31(V;1.36) 32(IV;1.11) 33(III;1.00) 34(V;1.25) 40(III;1.00) 42(V;1.24)

Wikstroemia indica 37(II;1.00)

TREMANDRACEAE

Tetratheca thymifolia 16(III;1.00) 18(III;1.00) 29(II;1.00) 30(V;1.25) 31(III;1.50) 32(I;1.25) 33(II;1.00) 42(II;1.25)

VERBENACEAE

Lantana camara 23(I;1.00) 37(III;1.00)

Verbena bonariensis 22(I;1.00)

VIOLACEAE

Hybanthus stellarioides 14(I;1.00) 19(I;1.00)

Hybanthus vernonii subsp. *scaber* 19(I;1.00)

Viola betonicifolia 14(II;1.00)

Viola hederacea 14(III;1.50) 37(III;2.00)