Floristic communities of the lower Dawson River plains, mid-eastern Queensland

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Abstract: Floristic communities from the alluvial floodplains and near-alluvial plains of the lower Dawson River, mideastern Queensland, are described from near-intact sites. Three broad and ten detailed floristic groups were defined. Differences in community composition appeared related to soil type, localised disturbance and latitude. Weeds comprised a small proportion of the total flora, although they presently dominate some areas. Grasses were the main exotic species present, and appeared to have increased within the last forty years.

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Introduction

Floodplain ecosystems in sub-coastal Queensland have been comparatively little studied, despite a long history of gross modification through construction of impoundments. The plains of the lower Dawson River are no exception, although there have been useful investigations into the health and condition of the riparian zones of this system (Telfer 1995). Recent floristic studies of the lower Dawson River have been limited to the potential inundation area of the proposed Nathan Dam project (Dowling & Halford 1996).

The Nathan Dam, a new large-scale water storage on the lower Dawson River, will provide a significant water source for broad-scale, intensive irrigation purposes. Reliability of supply has been recognised as a major limitation for expansion of cultivation in the region (Speck et al. 1968, Gillespie et al. 1991). Intensification of regional land use heralds great changes in an already modified and disturbed floodplain system (Telfer 1995, Eberhard 1999), especially downstream of the impoundment. Elsewhere in Australia, altered flood regimes resulting from river regulation have had negative impacts on regeneration of riparian vegetation, such as *Eucalyptus camaldulensis* dominated systems (Stefano 2002). However, the effects of changes in Dawson River flow regimes on downstream ecosystems reliant upon flood inundation remain poorly understood (Eberhard 1999).

Kingsford (2000) outlined the lack of detailed baseline ecological information on floodplain ecosystems throughout Australia, and noted that assessment of the impact of structures such as dams on these ecosystems is therefore problematic. This study aims to outline the floristic associations on floodplains and clay-plains of the lower portion of the Dawson River system. Such information may provide a snapshot with which future floristic changes can be measured.

Study area

Location

The study area is located within the Brigalow Belt South bioregion (Thackway & Cresswell 1995). It extends from a southerly point immediately upstream of the Gyranda Weir, west of Cracow (25°11'S, 148°15'E) north to the junction with the Mackenzie River (23° 35'S, 149°44'E), some 180 km in length (Fig. 1). The major towns of Theodore, Baralaba and Moura occur within or closely adjacent to the area studied.

Landforms and soils

This study examined near-level alluvial floodplain systems of the lower Dawson River, as well as in-stream channels and depressions. It also included flat areas of undulating clay downs adjacent to the alluvial plain, although these are considered as two different broad geological categories (Sattler & Williams 1999).

Plains landforms are widespread in the Dawson River region (Speck et al. 1968). The fluvial plains of the lower Dawson River vary in width between 0.2 to 12 km, consisting of both stable and unstable trunk plains. Elevated depositional clay plains flank the alluvial systems, and extend a further 2–4 km from their outer edge. Speck et al. (1968) described the land systems of the alluvial and near-alluvial systems within the study area. Soils of these plain landforms are typically vertosols or dermosols, or less frequently chromosols or sodosols (McCarroll 1996, after Isbell 1996). These soils were derived from Upper Palaeozoic volcanic or sedimentary rocks and Mesozoic shales. Significant local differences in soil texture and chemistry were apparent (Speck et al. 1968, McCarroll 1996).

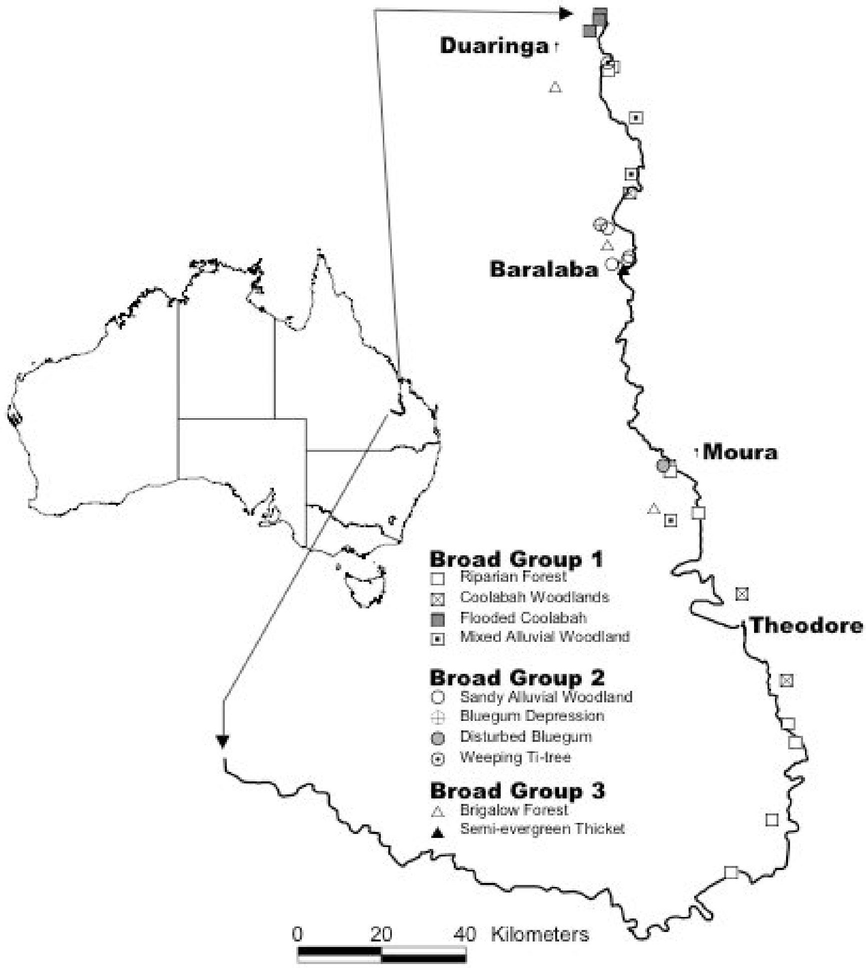

Fig. 1. Map showing the location of the study area and the distribution of sites and floristic groups along the lower Dawson River.

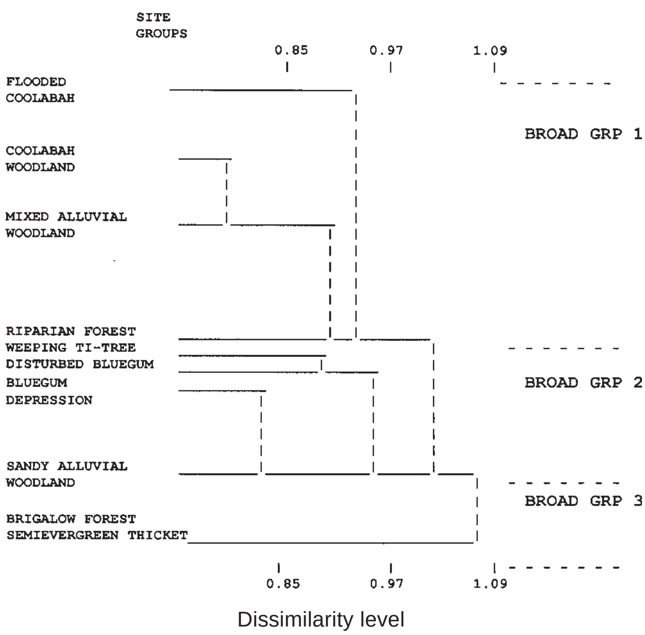

Fig. 2. Summary dendrogram of the PATN analysis of the Dawson River sites using the Kulczynski association measure, flexible UPGMA fusion strategy and a beta value of -0.1. Communities have been discerned at c. the 0.75–0.8 dissimilarity level, however an arbitrary uniform level was not chosen, as per Clarke et al. (1998).

Methods

Site data collection

A total of 30 detailed sites from the CORVEG database of the Queensland Herbarium were used in the analysis. All sites chosen sampled vegetation on alluvium and clay-plains and all of the major woodland vegetation types within the study area were sampled. A typical CORVEG quadrat was a 10 × 50 m plot (Neldner et al. 2004). The height and crown cover of trees and shrubs were recorded across the site, while foliage projected cover (FPC) was recorded for grasses and forbs in the ground layer. Sampling was undertaken from May 1997 to June 1999, during broadscale mapping projects within the region. CORVEG sites were located in areas subjectively considered undisturbed from recent heavy grazing or mechanical disturbance.

Identification and nomenclature

All vascular plants collected at detailed sites were identified using the resources of the Queensland Herbarium. Sampling spanned a number of years and conditions were poor for collection and identification of grasses and herbaceous taxa in some seasons. Thus some annual or ephemeral species have certainly been missed. Where good quality specimens were obtained, vouchers were lodged with the Queensland Herbarium (BRI). Botanical nomenclature followed Henderson (2002). An asterisk (*) denotes non-native species.

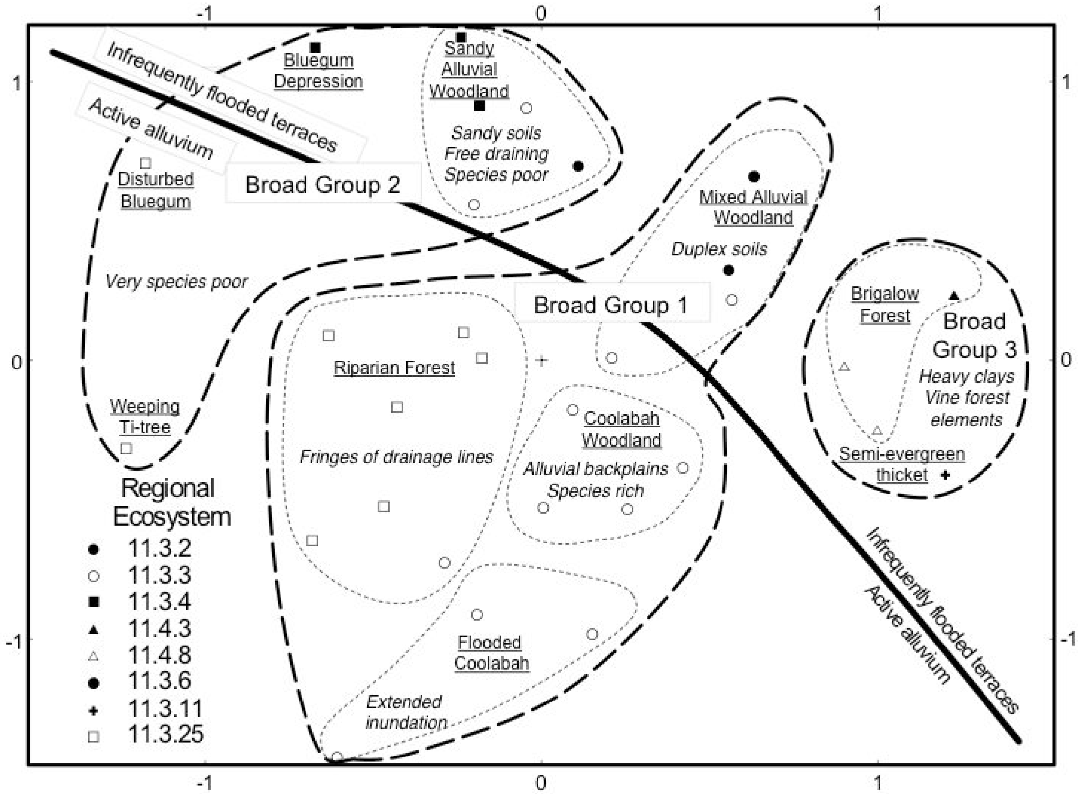

Fig. 3. Ordination diagram (MDS) illustrating floristic association between groups of sites (within fine dashed lines) within Broad Groups (heavy dashed lines) and notes on physical habitat characteristics. Site symbols indicate Regional Ecosystems, which are the basic biodiversity plannning units in Queensland (Sattler & Williams 1999).

Analyses

Floristic analysis of site data used the subroutines within PATN (Belbin 1993). A hierarchical classification with flexible UPGMA (Unweighted Pair-Group Mathematical Averaging) and the Kulczynski association was used to prepare a dendrogram outlining floristic groups. Additional analysis was completed using multi-dimensional scaling (MDS) within PRIMER (Anonymous 2000), using the Czechanowski Index of similarity. Both analyses were based on the presence/absence of all species recorded for a plot.

Results

Sampling intensity was relatively low, with 30 sites sampling about 24 000 ha of remnant vegetation (Pollock & Edginton 1999), or 1 site/800 ha. While sampling effort must be considered low relative to some recommendations (e.g. (Neldner et al. 1995), it was well above limits prescribed for the original mapping projects the sites were derived from (Neldner et al. 2004).

Floristics

A total of 312 vascular plants were recorded within the study area. This included site data from this study, and historical and recent collections recorded on the HERBRECS database (Appendix 1).

Poaceae dominated the flora (24 %), with Myrtaceae (6 %) and Cyperaceae (5 %) also prominent.

Rare species

The fan-palm *Livistona nitida* is listed as Rare under the Queensland *Nature Conservation Act (1992)* and is locally common along the Dawson River from north of Theodore, south to the southern boundary of the study area. *Livistona nitida* is endemic to the Dawson River and its upper tributaries (Rodd 1998) and forms a characteristic component of some riverine forests in the study area (Pollock & Edginton 1999).

Geographical limits

Taxa reaching their northern limits within the study area included: *Livistona nitida* (about 20 km north of Theodore); *Carex rhytidocarpa* (south-west of Theodore) and **Phyla canescens* (near Moura). Species reaching their southern limit included: *Corymbia dallachiana* (near Duaringa); *Melaleuca leucadendra* (Boolburra area); *Terminalia oblongata* (near Moura); *Abutilon asiaticum* var. *australiense* (near Mackenzie/Dawson River junction); *Lysiphyllum hookeri* (Dawson River near Nipan) and **Echinochloa polystachya* (near Moura).

Introduced species

Introduced taxa made up about 15 % of the known flora. The nine most common introduced plants observed in quadrats, in order of decreasing abundance (percent occurrence in brackets), were **Megathyrsus maximus* var. *pubiglumis* (37%), **Cenchrus ciliaris* (33%), **Senna barclayana* (23%), **Melinis repens* (20%), **Opuntia stricta* (20%), **Gomphrena celosioides* (13%), **Verbena* spp. (10%), **Acacia farnesiana* (10%) and **Bidens pilosa* (10%). Most of these species are typical of grassy woodlands across subcoastal Queensland. However, **Acacia farnesiana* is widespread on heavy clays and clay alluvia across Queensland (HERBRECS records), and was also frequently recorded in floodplain woodlands in inland NSW (Gosper et al. 2002).

Weeds of national significance (Thorp & Lynch 2000) present in the study area included **Parthenium hysterophorus* (present near Mimosa Creek/Dawson River junction); **Parkinsonia aculeata* (downstream of Don River/Dawson River junction) and **Cryptostegia grandiflora* (scattered downstream from the Knebworth area). Other significant weeds included **Hymenachne amplexicaulis* (present at Baralaba Weir), **Xanthium pungens* (widespread in *E. coolabah* and *E. camaldulensis* woodlands and forest), and **Bryophyllum delagoense* (present in small areas of semi-evergreen thicket on alluvia).

Environmental weeds, defined after Batianoff and Butler (2002), were conspicuous within most vegetation types. Introduced grasses were prominent, as observed earlier by Telfer (1995). The most widespread were **Megathyrsus maximus* var. *pubiglumis*, **Urochloa mosambicensis*, **Melinis repens* and **Cenchrus ciliaris*. The first two species were common in disturbed grassy woodlands on dark vertosols subject to flood inundation, such as *Eucalyptus coolabah* or *E. camaldulensis* grassy woodlands. The latter species were more common in better-drained, less frequently flooded situations, in areas dominated by *Corymbia tessellaris, Eucalyptus populnea* or *Eucalyptus tereticornis*. These responses to soil type illustrate the relative drought tolerance of these invasive exotic species (Williams & Baruch 2000).

Floristic associations

Classification of the thirty plots suggested three broad vegetation groups (Figs 1, 2 & 3). These were strongly correlated with soil type, landform element, and proximity to the main river channel.

Broad Group 1 encompassed predominantly grassy *Eucalyptus coolabah/Eucalyptus camaldulensis/Eucalyptus populnea* communities, with associated *Eucalyptus tereticornis/Lophostemon suaveolens* on or near levees. This broad group occurred frequently on dark vertosols. It was characterised as having a ground layer rich in grass or forb species. This group was always associated with alluvial plains.

Broad Group 2 was a set of sites occurring generally on deep sandy substrates associated with backplains or along sandy river channels. Predominant species were mainly *Eucalyptus tereticornis* and *Corymbia tessellaris*, with a ground layer of only a few species of grass or forb. Broad Group 2 was associated with light brown chromosols, often on broad stable levees.

An *Acacia harpophylla/Eucalyptus cambageana/*semi-evergreen thicket community formed Broad Group 3, occurring on very heavy vertosols or kandosols. This group was characterised by having a large number of tree and shrub species, with a comparatively species poor ground layer.

These three broad types were subdivided into ten floristic site groups, which were given descriptive names. The association of floristic groups with one another and with physical habitats is illustrated in Figure 3.

Broad Group 1 included four floodplain communities

Flooded Coolabah *Eucalyptus coolabah* (3 sites)

Species richness: 8–26 Mean species/site : 18.3
Mean weed species/site: 4.6 Mean total weed cover/site: 0.5 % FPC

This community included species such as *Eucalyptus coolabah*, *Basilicum polystachyon*, *Eustrephus latifolius*, *Abutilon asiaticum*, *Lysiphyllum carronii*, *Marsilea drummondii*, *Muehlenbeckia florulenta*, *Sporobolus mitchellii*, *Eriochloa pseudoacrotricha*, *Tetragonia tetragonioides*, *Alternanthera nodiflora* and **Parkinsonia aculeata*. Flooded Coolabah was characterised by landforms such as low-lying river channels and small billabongs that were subject to regular convergence flooding by the Dawson and Mackenzie Rivers. All sites were dominated by *Eucalyptus coolabah*, with a ground layer of species characteristic of prolonged inundation. Flooded Coolabah woodlands occurred consistently on heavy, dark grey to black vertosols that remained wet for long periods.

Coolabah *Eucalyptus coolabah* Woodland (4 sites)

Species richness: 26–44 Mean species/site: 37.2
Mean weed species/site: 6.5 Mean total weed cover: 6.0 % FPC

Coolabah Woodland always contained a tree layer of *Eucalyptus coolabah* with a sparse to mid-dense shrub layer of *Acacia salicina*. A diverse ground layer was evident, typically with *Achyranthes aspera*, *Cyperus gracilis*, *Bothriochloa bladhii*, *Cymbopogon refractus*, *Heteropogon contortus*, *Leptochloa decipiens*, **Malvastrum americanum*, **Sida spinosa*, and **Senna barclayana*. The epiphyte *Cymbidium canaliculatum* was almost always present within hollows of mature *E. coolabah*. Frequent weeds were **Megathyrsus maximus* var. *pubiglumis* and less commonly **Bidens pilosa* var. *pilosa*. Coolabah Woodland was characterised by a species-rich ground layer, and graded into grasslands of *Thellungia advena*, *Dichanthium sericeum* and *Panicum decompositum* where the *Eucalyptus coolabah* tree layer was greatly reduced. Black to grey vertosols were closely associated with this unit, and like Flooded Coolabah, were soils capable of retaining moisture for long periods (Burgess 2003). However, this floristic group displayed much greater species richness than Flooded Coolabah, and was probably inundated by floodwaters for briefer periods.

Mixed Alluvial Woodland (4 sites)

Species richness: 29–40 Mean species/site: 32.5
Mean weed species/site: 3 Mean total weed cover/site: 5.5% FPC

This unit was often dominated by *Eucalyptus populnea* or *E. coolabah.* Occasionally *E. melanophloia* dominated. A species-rich ground layer of grasses and forbs was typical, commonly *Brunoniella triandra*, *Chloris divaricata*, *Enneapogon polyphyllus*, *Enteropogon acicularis*, *Galactia tenuifolia*, *Grewia latifolia*, **Opuntia stricta*, *Sporobolus caroli*, *Themeda triandra*, *Rhynchosia minima* var. *minima* and *Eremophila debilis*. Mixed Alluvial Woodland appeared much less subject to active riverine processes such as flooding, occurring on stable alluvial plains. Soils were coarse-textured with a sandy surface layer, and chromosols with occasional vertosols were predominant. These were likely to remain wet for shorter periods after heavy rainfall compared to Flooded Coolabah and Coolabah Woodland.

Riparian Forest (7 sites)

Species richness: 14–36 Mean species/site: 24.8
Mean weed species/site: 3.7 Mean total weed cover/site: 16.0 % FPC

Riparian Forest contained an upper stratum of *Eucalyptus camaldulensis* and *Eucalyptus coolabah* or occasionally *Eucalyptus tereticornis*, with a dense ground layer of *Eustrephus latifolius*, *Arundinella nepalensis*, *Lomandra longifolia*, **Megathyrsus maximus* var. *pubiglumis* and less frequently, **Sida spinosa*, **Senna barclayana*, *Ficus opposita*, *Chionachne cyathopoda*, *Chrysopogon filipes* and *Eulalia aurea*. Riparian Forest was associated with active levees and channel benches, subject to frequent inundation and high velocity flood wash. Predominant soils were grey vertosols underneath thin chromosols or kandosols. This group was discerned at a high (>0.80) dissimilarity level, as further subdivisions did not add significantly to the analysis. Despite locally heavy stock trampling and other pressures, this unit had a relatively low weed presence.

Broad Group 2 included three unusual sites along with mixed woodlands on sandy alluvium

Weeping Ti-tree *Melaleuca leucadendra* Forest (1 site)

Species richness: 23 Weed species: 4 Total weed cover: < 1 % FPC

Weeping Ti-tree Forest was dominated by *Melaleuca leucadendra* with emergent *Eucalyptus camaldulensis*. The ground and shrub layer were characterised by *Cynodon dactylon*, **Cryptostegia grandifolia*, *Glinus oppositifolius* and *Panicum laevinode*. This unit appeared subject to regular inundation, and occurred on deep sands within active river channels. Weeping Ti-tree Forest contained a number of species of open and disturbed areas, consistent with its location in areas subject to constant flooding. *Melaleuca leucadendra* appeared able to colonise broad spits of coarse river sands within the lowest reaches of the main Dawson River channel, an ecological role taken by *Melaleuca linariifolia* further south.

Disturbed Blue gum *Eucalyptus tereticornis* (1 site)

Species richness: 6 Weed species: 2 Total weed cover: 80 % FPC

Disturbed Blue gum contained a tree layer of *Eucalyptus tereticornis*. A dense ground layer of **Urochloa mosambicensis* dominated this site, to the exclusion of other ground layer species. Disturbed Blue gum appeared to undergo infrequent flooding, and occurred on grey loams or sands over vertosols. Prior to infestation by *U. mosambicensis,* the floristics of this community probably resembled the Blue Gum Depression site.

Blue gum *Eucalyptus tereticornis* Depression (1 site)

Species richness: 17 Weed species: 1 Total weed cover: 0.5 % FPC

This association formed a woodland of *Eucalyptus tereticornis*, with a ground layer of grasses such as *Bothriochloa ewartiana*, *Leptochloa decipiens* and *Sporobolus caroli*, and forbs typical of wet depressions, such as *Marsilea hirsuta*, *Alternanthera denticulata* and *Centipeda minima*. Surprisingly, there were few sedges present, apart from *Cyperus bifax*. Weeds were generally absent, apart from a minor presence of **Gomphrena celosioides*.

Sandy Alluvial Woodland (5 sites)

Species richness: 15–27 Species richness/site: 19.4
Mean weed species/site: 2.4 Mean total weed cover: 33.5 % FPC

This floristic group contained a tree layer of *Corymbia tessellaris* or *Eucalyptus coolabah* or *Eucalyptus populnea*, with *Eucalyptus tereticornis* consistently subdominant, and a ground layer of *Bothriochloa ewartiana*, *Plectranthus parviflorus*, **Melinis repens*, and **Cenchrus ciliaris*. The latter two species frequently dominated the ground layer. Less frequently *Oxalis perennans*, *Eucalyptus melanophloia*, *Wahlenbergia communis*, *Cyanthillium cinereum* and **Gomphrena celosioides* occurred. Sandy Alluvial Woodland was located on coarse or sandy textured soils, typically deep chromosols, dermosols and sodosols, and was probably seldom flooded except for run-on. These soils appeared to be free draining. Sandy Alluvial Woodland occurred on channel benches or narrow flats within upper tributaries.

Broad group 3 included open forests of Brigalow or Blackbutt or semievergreen thicket

Brigalow *Acacia harpophylla* Forest (3 sites)

Species richness: 20–26 species Mean species/site: 23
Mean weed species/site: 1.3 Mean total weed cover: < 1 % FPC

This group was located on the clay plains adjacent to the alluvial floodplain. It formed an open forest of *Acacia harpophylla* frequently with *Eucalyptus cambageana*, and was characterised by a dense, well-developed shrub layer of *Geijera parviflora*, *Carissa ovata and Capparis lasiantha*, with occasional vines such as *Cissus opaca*. A sparse ground layer of *Cyperus gracilis* and *Paspalidium caespitosum* was always present. Soils were dark brown sodosols. While probably seldom flooded, the soils of this floristic unit can remain wet for long periods, due to their location on very heavy clays, and by water ponding within gilgai microrelief (Burgess 2003).

Semi-evergreen thicket (1 site)

Species richness: 22 species Weed species: 3 Weed species cover: 40 % FPC

Semi-evergreen thicket occurred close to the Dawson River channel, on or near steep alluvial slopes. Typical species include a mixed tree layer of *Acacia fasciculifera*, *Geijera parviflora*, *Diospyros humilis*, *Diospyros geminata*, *Ehretia membranifolia*, *Denhamia oleaster*, and a sparse ground layer of *Enteropogon unispiceus*. Exotic species were prominent in the groundlayer, particularly **Megathyrsus maximus var. pubiglumis*, and **Bryophyllum delagoense*. Unlike the previous association this association is dominated by vine thicket species, and lacks emergent *Eucalyptus* or *Acacia* spp. Semievergreen thicket is probably only occasionally flooded, and appeared protected from drying winds and fire by the presence of steep alluvial banks in close proximity to moist riverbeds and channels.

Discussion

Ecological factors underlying floristic patterns

The study area contains some of the most extensive, near-coastal examples of *Eucalyptus coolabah* and *Eucalyptus camaldulensis*-dominated communities in eastern Australia, occurring some 80 km west of the coastline near Rockhampton. These are unusual, mesic examples of plains communities more commonly associated with the rivers of central and southwestern Queensland e.g. Boyland (1984), Neldner (1984). This is reinforced by the presence of genera more typical of coastal eastern Queensland, such as *Livistona*, *Ficus*, *Imperata*, *Chionachne* and *Arundinella*, as well as rainforest taxa such as *Trophis scandens* and *Melia azedarach*.

Flooding is likely to be fundamental to ecological processes in most of the communities identified in this study. The establishment of *Eucalyptus camaldulensis* is dependent on availability of soil moisture, and is thought to occur through infrequent major flood events, leading to even-aged stands (Stefano 2002). Seedling recruitment of *Eucalyptus coolabah* is also thought to be reliant on heavy rainfall events, as confirmed elsewhere in southern Australia (Roberts 1993). Locally, stands of both species, as well as *Eucalyptus tereticornis*, are known to have arisen from recent historical flood events (Eberhard 1999), particularly from the 1950s and 1970s.

Flood frequencies together with soil drainage properties appear to be important determinants of floristic variation across the study area. For example, *Eucalyptus coolabah* dominated communities were associated with heavy clays subject to one in 10 to 20 year flood intervals (Eberhard 1999, Burgess 2003), while *Acacia harpophylla* or semi-evergreen thickets were associated with similar soils mostly free from flood influence, but able to remain moist for extended periods (Fig. 3). Riparian forests were intimately associated with primary river channels and one in two to five year flood intervals (Eberhard 1999, Burgess 2003). *Eucalyptus tereticornis*/*Corymbia tessellaris*-dominated communities were associated with well-drained sandy loams derived from quartz sandstones, often within narrow tributaries subject to very infrequent flood events.

The grassy woodlands in the study area supported the greatest richness of vascular plant species. Indeed, the most species rich site sampled from this study approached a *Dichanthium sericeum* grassland in structure and floristic composition. This site was classified within Coolabah Woodland, which exhibited the highest mean species richness/site of all the communities sampled in this study.

Conversely, *Eucalyptus coolabah* woodland sites with 'swampy' ground layers, indicated by presence of *Muehlenbeckia florulenta*, *Marsilea drummondii*, *Alternanthera* spp., *Eriochloa* spp. or *Eleocharis* spp. (Flooded Coolabah), were associated with lower species richness/site within the study area. Such species appear to be further examples of water-enrichment specialists or tolerators (McIntyre & Martin 2002). Both floristic groups occurred on similar soil types, and varied only in their likelihood and period of inundation. Thus *Eucalyptus coolabah* communities exhibited high levels of variation in native species richness, and environments prone to prolonged wet periods were associated with fewer species.

Flooded Coolabah can be considered a type of wooded wetland, which graded into treeless sedgeland or grassland associations dominated by *Cyperus* spp., *Eleocharis* spp., *Marsilea* spp. or *Paspalum distichum*. These ephemeral floodplain wetlands were not systematically sampled, but have clear floristic affinity, were widespread across the study area, and occurred on similar land elements and soil types as Coolabah Woodland.

Blue gum Depression can be considered the analogous floristic association within lighter textured soils, with a groundlayer that also includes water-enrichment specialists (McIntyre & Martin 2002).

Mixed Alluvial Woodland was characterised by a set of groundlayer species considered disturbance intolerant, or intolerant of artificial nutrient enrichment in the soil (McIntyre & Martin 2002). These species included *Brunoniella australis*, *Themeda triandra*, *Galactia tenuifolia* and *Eremophila debilis*. This confirms the choice of these sites as relatively undisturbed by severe grazing. Coolabah Woodland in contrast, had a dominance or presence of groundlayer species considered more typical of moderate levels of disturbance or grazing pressure, such as *Cyperus gracilis*, **Malvastrum americanum*, *Heteropogon contortus* and *Bothriochloa bladhii* var. *bladhii* (Grice & McIntyre 1995, McIntyre & Martin 2002).

This study recorded a general decrease in species richness in the ground layer of grassy woodlands from heavy clays to sandy alluvia, on non-riparian alluvial plains. The reasons for this are unclear, and appear not to be directly linked to grazing, given that at least two of the species (**Melinis repens* & *Themeda triandra*) observed distinctively within Sandy Alluvial Woodland are considered grazing intolerant (Grice & McIntyre 1995, Fensham & Holman 1998). It is possible that some exotic perennials more readily establish on sandier substrates or conversely, that fewer exotics tolerate the seasonally wet and heavy soils of *Eucalyptus coolabah* woodlands, as Cavaye (1991) observed for the exotic pasture species **Cenchrus ciliaris*.

Sites within the study area appear less species rich than similar grassy woodlands in southern and central Qld sampled by McIntyre and Martin (2001). This may be due to seasonally suboptimal sampling periods, or may reflect reduced species richness in a region with greater rainfall variability. Richness of species per floristic community is comparable to that recorded by Gosper et al. (2002) for the Darling Riverine Plains of NSW, and was sampled using quadrats of similar size.

Riparian Forest within the lower Dawson study area was characterised by a ground layer of very tall, woody-culmed native grasses such as *Arundinella nepalensis* or *Chionachne cyathopoda*, and less commonly *Leptochloa digitata* or *Eulalia aurea*. These grasses formed dense swards and dominated the ground layer, apparently excluding or suppressing some of the forbs and twiners more commonly observed in Coolabah Woodland.

Presence of exotic species

The studies and synthesis of Tothill and Gillies (1992) and Grice and McIntyre (1995) support our contention that sites sampled within this study contained perennial grasses typical of pastures subject to low grazing pressure (although see alternate viewpoint of use of increaser/decreaser as grazing indicator species by Vesk & Westoby 2001). The sites sampled indicate the condition of the least disturbed vegetation in the study area, and contrast strongly with the findings of Telfer (1995), whose study was not constrained by sampling within 'intact' sites. Despite this, our study showed a significant presence of exotic grasses in the two broad vegetation types of *E. camaldulensis* and *E. coolabah* forests and woodlands within the study area. Comparing this with the landscape descriptions of Speck et al. (1968), in which exotic plants are inconspicuous, suggests considerable changes in the abundance of exotic plants in the study area since the 1960s.

Sites with a high FPC cover of the introduced grasses **Urochloa mosambicensis*, **Megathyrsus maximus* var. *pubiglumis*, **Cenchrus ciliaris* and **Melinis repens* tended to be the poorest in species within this study. These observations from the lower Dawson River support the findings of Fairfax and Fensham (2000) and Franks (2002), that exotic grasses may reduce native species richness within the ground layer of grassy woodlands in Queensland.

Unlike McIntyre and Martin (2001), strictly riparian vegetation was not the most weed-infested in this study, though at a broad scale much of the vegetation sampled was 'riparian'. Other than gross mechanical disturbance or deliberate introduction of exotic pastures, the most likely factors favouring weed invasion in remnant vegetation in the study area appear to be heavy stock use of remnant woodlands/ forest close to permanent water (itself influenced by impoundment construction).

Grazing is known to be the dominant land-use in the study area (Telfer 1995). Heavy localised stock use of riparian lands appears likely to influence establishment of some exotic species within intact riparian vegetation. Other studies of *Eucalyptus camaldulensis* ecosystems in south-eastern Australia have suggested that ecological condition declined as grazing intensity increased (e.g. Jansen & Robertson 2001). However it should be noted that grazing can suppress the growth of some weeds in riparian woodlands in subcoastal Qld (such as the climbing *Macfadyena unguis-cati*) and the interaction between grazing and weed invasion is complex.

Eberhard (1999) recorded a greater proportion of understorey weeds present within the study area at riverine sites upstream of weirs compared to downstream locations, suggesting that proximity to an abundant water source may influence establishment of exotic species.

**Megathyrsus maximus* var. *pubiglumis* was the third most frequent ground stratum species and the most prevalent exotic species in this study, occurring in eleven of the thirty sites sampled. It is therefore important to consider the ecology of this species. The dense shade cast by the tree layer of some riparian forests and woodlands in the study area appeared to suit the establishment of **Megathyrsus maximus* var. *pubiglumis*, a result observed elsewhere in sub-coastal Queensland (Wilson & Wild 1990). This may account for its significant presence in Coolabah Woodland and Riparian Forest recorded in this study. The apparent paradox of shading actually increasing the competitive ability of **Megathyrsus maximus* var. *pubiglumis* is thought to be related to an increase in available soil nitrogen in a shaded microclimate (Wilson & Wild 1990), perhaps further exacerbated by **M. maximus*'s ability to fix nitrogen (Skerman & Riveros 1990). We speculate that this process interacts with localised disturbances such as heavy stock use of frontage lands close to permanent water (not necessarily grazing *per se*) favouring establishment of **Megathyrsus maximus* var. *pubiglumis.*

In some instances, grazing pressure alone may be correlated with an increase in exotic grasses. In their review, Grice and McIntyre (1995) suggested that the presence of **Urochloa mosambicensis* was associated with high grazing pressure. In this study, **Urochloa mosambicensis* was distinctive to Disturbed Blue Gum, although this site did not appear to have undergone unusually heavy grazing pressure at time of sampling.

Relationships between floristic communities, vegetation types and regional ecosystems

Regional ecosystems (REs) are primarily distinguished by the composition of the ecologically dominant stratum, usually the tree layer (Sattler & Williams 1999), as well as their associated geological parent materials. It is important to know how classification based on dominant strata relates to classification based on total, or even ground stratum floristics. The relationships between the floristic groups developed in this study are also inherently interesting. The total floristic ordination conducted in this study (Fig. 3) tended to group together sites representing the same RE. However, classification suggested several groups that contained more than one RE, and sites dominated by *Eucalyptus coolabah* were placed into several floristic groups (mostly without any sites from other REs), suggesting several subunits within RE 11.3.3 in the study area.

The floristic analysis suggested *Eucalyptus populnea*-dominated communities have affinity with some forms of *Eucalyptus coolabah* or *Eucalyptus tereticornis* grassy woodlands. Other field observations also showed this tendency, usually as an infrequent intermixing of these dominant trees between and within stands, particularly within channel benches and active levees. Burgess (2003) observed similar intergradation of tree species in riparian vegetation within the Isaac and Mackenzie Rivers. Other forms of *Eucalyptus coolabah*-dominated woodlands clearly graded into *Eucalyptus camaldulensis*-dominated riverine forest on levees. In this region and in several other extensive areas of central and inland Qld, *Eucalyptus coolabah* was a frequent subdominant tree in this broad community (e.g. Neldner 1984).

While some of this community variability appears related to significant local soil differences (McCarrol 1996), it seems clear that the delineation of natural floristic groups must remain imprecise, if based on dominant trees alone. Fensham

(1998) studied and compared vegetation and floristic patterns in grassy woodlands of the Darling Downs, and concluded that the presence of a dominant tree species did not always match floristic groupings. Gosper et al. (2002) found dominant canopy vegetation was a poor predictor of floristic assemblage in their analysis of floodplain vegetation of the Darling River Plains.

Acacia harpophylla and *Eucalyptus cambageana* -dominated communities appeared related to the semi-evergreen vine thicket sampled in this study, due to the large number of shrub species common to both associations. Partridge et al. (1994) also noted the presence of many shrubs common to these broad vegetation types. Occurring as dense structural formations, these units contained few weeds, except when occurring as isolates in paddocks of exotic sown pastures.

Given that Poaceae dominated the flora of the study area, was the analysis biased toward the presence/absence of dominant or subdominant perennial grasses? Re-examination of the communities defined does not suggest this. Firstly, an additional ordination of sites with all woody species removed produced similar community groupings for grassy woodlands, and did not separate them in further meaningful groups. Secondly, there were few floristic groups where there was a consistent dominance or presence of a grass species (mainly Flooded Coolabah and Riparian Forest). Coolabah Woodland (the most floristically rich group), did not have a single consistent dominant or subdominant grass, whereas within Sandy Alluvial Woodland there was a weak trend of dominance of **Cenchrus ciliaris*, **Melinis repens* or *Themeda triandra*. Mixed Alluvial Woodland showed a weak subdominant trend of *Chloris divaricata*. Thus communities cannot be discerned from the presence of dominant grasses alone. In fact within the 30 sites recorded, there were 26 different frequent grass species, underlining their variability within plant assemblages in the study area. Other authors have noted the high variability within the ground layer of perennial pasture within a single paddock (e.g. McDonald & Hodgkinson 1996). It appears that the single large quadrats used in this study did not adequately sample the full range of floristic variability within the groundlayer, and that smaller, more numerous quadrats would be required for this.

Speck et al. (1968) recognised broad recurring understorey assemblages as ‘native pasture communities’ in the Fitzroy–Dawson River region. The two most frequent types appropriate for the lower Dawson were ‘eastern mid-height grass’ occurring in grassy woodland on alluvia, and ‘frontage grass’ associated with riverine woodlands and forests. There is broad concurrence between the listed species of Speck et al. (1968) and this study.

More recently, Tothill and Gillies (1992) outlined the broad pasture communities of northern Australia, including the Dawson River study area. The groundlayer of most of the grassy woodlands within this study closely matched elements of the widespread Southern black speargrass community, specifically LPU 30 (Tothill & Gillies 1992), particularly Coolabah Woodland and Mixed Alluvial Woodland. On very heavy alluvial clays, the groundlayer of Coolabah Woodland approached Southern flooded Alluvial plains (LPU 74), a grassland unit (Tothill & Gillies 1992). The groundlayer of the Riparian Forest floristic assemblage appeared similar to that described for the Fringing tallgrass pastures of the rivers of the Eastern Kimberly, LPU 5 (Tothill & Gillies 1992), although apparently undescribed for mid-eastern Queensland.

Conclusions

Flooding frequency, duration, and soil texture appear to be major determinants of floristics within the study area. Regional Ecosystems (Sattler & Williams 1999) formed reasonable associations within floristic composition but some contained several clear ‘within RE’ types.

The remnant natural vegetation of the study area remains in a mostly intact condition, with localised infestations of exotic weed grasses. These were correlated with reduced native species richness, and their establishment is possibly facilitated by disturbance associated with intensive stock use of areas close to permanent water. **Megathyrsus maximus* var. *pubiglumis* was associated with denser vegetation of clay soils, while **Cenchrus ciliaris* was more common in woodlands with sandy-textured soils.

Speck et al. (1968) did not record or otherwise note any local occurrence or dominance of land units by exotic plants. These were readily observed in this study, and have been recorded widely along the lower Dawson (Telfer 1995). It seems likely many environmental and agricultural weeds have established and spread since the 1960s.

Given the relationships between flood frequency and floristics, it would be prudent to monitor floodplain vegetation and floristics across future major river modifications within the lower Dawson system. The findings and sampling sites of this study provide a basis and context for this.

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Appendix 1. Vascular plant species recorded from the Lower Dawson River study area. Nomenclature according to Henderson (2002).

* denotes exotic species
R = rare in QLD (Under the schedules of the Nature Conservation Act 1992)

ACANTHACEAE

Brunoniella australis
Dipteracanthus australasicus subsp. *australasicus*
Pseuderanthemum variabile
Rostellularia adscendens

ADIANTACEAE

Cheilanthes sieberi

AIZOACEAE

Tetragonia tetragonioides
Zaleya galericulata subsp. *galericulata*

AMARANTHACEAE

Achyranthes aspera
Alternanthera denticulata
Alternanthera nana
Alternanthera nodiflora
Amaranthus interruptus
**Gomphrena celosioides*
Nyssanthes diffusa

APOCYNACEAE

Alstonia constricta
Carissa ovata
Parsonsia eucalyptophylla
Parsonsia straminea

ARACEAE

**Pistia stratiotes*

ARECACEAE

Livistona nitida **R**

ASCLEPIADACEAE

**Cryptostegia grandiflora*
Marsdenia viridiflora

ASTERACEAE

**Ageratum houstonianum*
**Baccharis halimifolia*
**Bidens pilosa*
Calotis cuneata
Cassinia laevis
Centipeda minima var. *minima*
Chrysocephalum apiculatum
Cyanthillium cinereum
**Emilia sonchifolia*
Ozothamnus apiculatum
**Parthenium hysterophorus*
Pterocaulon redolens
Senecio lautus subsp. *dissectifolius*
**Sonchus oleraceus*
Vittadinia dissecta
Vittadinia sulcata
**Xanthium pungens*

AZOLLACEAE

Azolla pinnata

BRASSICACEAE

Rorippa eustylis

BORAGINACEAE

Ehretia membranifolia
**Heliotropium indicum*

CACTACEAE

**Opuntia stricta* var. *stricta*
**Opuntia tomentosa*

CAESALPINIACEAE

Cassia tomentella
Lysiphyllum carronii
Lysiphyllum hookeri
**Parkinsonia aculeata*
Senna barclayana
Senna artemisioides subsp. *zygophylla*

CAMPANULACEAE

Wahlenbergia gracilis

CAPPARACEAE

Apophyllum anomalum
Capparis sp.
Capparis canescens
Capparis lasiantha

CASUARINACEAE

Casuarina cunninghamiana
Casuarina cristata

CELASTRACEAE

Denhamia oleaster
Elaeodendron australis var. *integrifolium*
Maytenus bilocularis
Maytenus cunninghamii

CERATOPHYLLACEAE

Ceratophyllum demersum

CHENOPODIACEAE

Atriplex muelleri
Einadia hastata
Einadia nutans var. *linifolia*
Enchylaena tomentosa
Maireana microphylla
Salsola kali
Sclerolaena anisacanthoides
Sclerolaena birchii
Sclerolaena muricata
Sclerolaena tetracuspis

COMBRETACEAE

Terminalia oblongata

COMMELINACEAE

Commelina ensifolia

CONVOLVULACEAE

Convolvulus arvensis
Evolvulus alsinoides

CRASSULACEAE

**Bryophyllum delagoense*

CUPRESSACEAE

Callitris glaucophylla

CYPERACEAE

Carex rhytidocarpa
Cyperus bifax
Cyperus bulbosus
Cyperus concinnus
Cyperus curvistylis
Cyperus difformis
Cyperus distans
Cyperus exaltatus
Cyperus fulvus
Cyperus gracilis
Cyperus javanicus
**Cyperus tuberosus*
Cyperus victoriensis
Eleocharis acuta
Eleocharis plana
Eleocharis sphacelata
Fimbristylis dichotoma
Scleria mackaviensis

DILLENIACEAE

Hibbertia vestita

EBENACEAE

Diospyros geminata
Diospyros humilis

EUPHORBIACEAE

Acalypha eremorum
Chamaesyce drummondii
Chamaesyce psammogeton
Excoecaria dallachyana
Petalostigma pubescens

FABACEAE

**Aeschynomene indica*
**Cajanus cajan*
Crotalaria juncea
Crotalaria mitchellii
**Crotalaria montana*
Galactia tenuiflora var. *lucida*
Glycine tabacina
Glycine tomentella
Indigofera pratensis
Rhynchosia minima
Sesbania cannabina
Vigna vexillata

HALORAGACEAE

Haloragis aspera

HYDROCHARITACEAE

Ottelia ovalifolia

JUNCACEAE

Juncus polyanthemus
Juncus usitatus

JUNCAGINACEAE

Triglochin dubium

LAMIACEAE

Basilicum polystachyon
Plectranthus parviflorus

LEMNACEAE

Lemna aequinoctialis
Lemna sp.

LORANTHACEAE

Amyema quandang

MALVACEAE

Abutilon asiaticum var. *australiense*
Abutilon fraseri
Abutilon oxycarpum
**Malvastrum americanum*
Sida cordifolia
**Sida rhombifolia*
**Sida spinosa*
Sida subspicata
Sida trichopoda

MARSILEACEAE

Marsilea drummondii
Marsilea mutica

MELIACEAE

Melia azedarach
Owenia acidula
Owenia venosa

MENYANTHACEAE

Nymphoides indica

MIMOSACEAE

Acacia excelsa
**Acacia farnesiana*
Acacia fasciculifera
Acacia harpophylla
Acacia oswaldii
Acacia rhodoxylon
Acacia salicina
Acacia stenophylla
Archidendropsis basaltica
**Mimosa pudica*
Neptunia gracilis

MORACEAE

Ficus opposita
Trophis scandens

MYOPORACEAE

Eremophila debilis
Eremophila maculata
Eremophila mitchellii
Myoporum montanum

MYRTACEAE

Angophora floribunda
Angophora leiocarpa
Callistemon viminalis
Corymbia clarksoniana
Corymbia dallachiana
Corymbia tessellaris
Eucalyptus camaldulensis
Eucalyptus cambageana
Eucalyptus coolabah
Eucalyptus crebra
Eucalyptus melanophloia
Eucalyptus moluccana
Eucalyptus populnea
Eucalyptus tereticornis
Eucalyptus thozetiana
Lophostemon suaveolens
Melaleuca bracteata
Melaleuca leucadendra
Melaleuca linariifolia var. *trichostachya*

NELUMBONACEAE

Nelumbo nucifera

NYCTAGINACEAE

Boerhavia dominii
Boerhavia sp. (Bargara L. Pedley 5382)

NYMPHAEACEAE

Nymphaea gigantea

OLEACEAE

Jasminum didymum subsp. *punctatum*

ONAGRACEAE

Ludwigia octovalvis
**Ludwigia peploides* var. *montevidensis*

ORCHIDACEAE

Cymbidium canaliculatum

OXALIDACEAE

Oxalis perennans

PAPAVERACEAE

**Argemone ochroleuca*

PASSIFLORACEAE

**Passiflora foetida* var. *foetida*
**Passiflora suberosa*

PHORMIACEAE

Dianella caerulea

PITTOSPORACEAE

Bursaria incana
Pittosporum spinescens

POACEAE

Aristida benthamii
Aristida calycina
Aristida gracilipes
Aristida holathera var. *holathera*
Aristida jerichoensis
Aristida lignosa
Aristida longicollis
Aristida personata
Aristida ramosa
Arundinella nepalensis
Bothriochloa bladhii subsp. *bladhii*
Bothriochloa decipiens
Bothriochloa erianthoides
Bothriochloa ewartiana
Brachiaria gilesii
Brachyachne tenella
**Cenchrus ciliaris*
Chionachne cyathopoda
Chloris divaricata
**Chloris gayana*
Chloris truncata
Chloris ventricosa
**Chloris virgata*
Chrysopogon fallax
Chrysopogon filipes
Cymbopogon queenslandicus
Cymbopogon refractus
Cynodon dactylon
**Dichanthium annulatum*
Dichanthium sericeum subsp. *humilius*
Dichanthium sericeum subsp. *sericeum*
Digitaria brownii
**Echinochloa colona*
**Echinochloa crus-galli*
**Echinochloa polystachya*
Enneapogon cylindricus
Enneapogon lindleyanus
Enneapogon polyphyllus
Enteropogon acicularis
Enteropogon ramosus
Eragrostis elongata
Eragrostis lacunaria
Eragrostis leptocarpa
Eragrostis parviflora
Eragrostis sororia
Eragrostis tenellula
Eriochloa sp.
Eriochloa crebra
Eriochloa procera
Eriochloa pseudoacrotricha
Eulalia aurea
Heteropogon contortus
**Hymenachne amplexicaule*
Imperata cylindrica
Iseilema vaginiflorum
Leptochloa decipiens
Leptochloa digitata
Leptochloa fusca
**Melinis repens*
**Megathyrsus maximus* var. *pubiglumis*
Panicum buncei
Panicum decompositum
Panicum effusum var. *effusum*
Panicum queenslandicum
Paspalidium caespitosum
Paspalidium criniforme
Paspalidium distans
Paspalidium gracile
Paspalidium jubiflorum
**Paspalum* sp.
Perotis rara
Setaria sp.
Sporobolus caroli
Sporobolus contiguus
Sporobolus creber
Sporobolus mitchellii
Sporobolus scabridus
Thellungia advena
Themeda triandra

POLYGONACEAE

Muehlenbeckia florulenta
Persicaria decipiens
Persicaria hydropiper
**Persicaria lapathifolia*
Persicaria orientalis

PONTEDERIACEAE

Monochoria cyanea

PORTULACACEAE

Portulaca oleracea
Portulaca pilosa

POTAMOGETONACEAE

Potamogeton tricarinatus

PROTEACEAE

Grevillea striata

RHAMNACEAE

Alphitonia excelsa
Ventilago viminalis

RUBIACEAE

Canthium odoratum
Canthium oleifolium
Spermacoce multicaulis

RUTACEAE

Citrus glauca
Geijera parviflora

SALVINIACEAE

**Salvinia molesta*

SANTALACEAE

Santalum lanceolatum

SAPINDACEAE

Alectryon diversifolius
Alectryon oleifolius
Atalaya hemiglauca
Atalaya salicifolia
**Cardiospermum halicacabum* var. *halicacabum*
Cupaniopsis anacardioides
Elattostachys xylocarpa

SAPOTACEAE

Pouteria cotinifolia

SCROPHULARIACEAE

Limnophila aromatica
**Scoparia dulcis*

SMILACACEAE

Eustrephus latifolius

SOLANACEAE

Solanum semiarmatum

STERCULIACEAE

Brachychiton australis
Brachychiton populneus
Brachychiton rupestris
Melhania oblongifolia
**Melochia pyramidata*

TILIACEAE

Grewia latifolia

TYPHACEAE

Typha orientalis

VERBENACEAE

**Phyla canescens*
**Verbena aristigera*
**Verbena bonariensis*
**Verbena litoralis*
**Verbena officinalis*

VITACEAE

Cissus opaca

XANTHORRHOEACEAE

Lomandra longifolia

ZYGOPHYLLACEAE

Tribulus micrococcus
Zygophyllum apiculatum