A Compendium of Ecological Information on Australia's Northern Tropical Rivers

REPORT 4

Distribution and ecological preferences of riparian vegetation in northern Australia

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EXECUTIVE SUMMARY

- A relatively small number of plant species are confined strictly to the riparian zone of the seasonally dry tropical rivers of northern Australia. This low level of species diversity, but high level of individual species coverage, is a feature of the river systems. This assessment identified 263 plant species as occurring in the riparian zone in the TRIAP study area; but of these only 23 were obligate riparian species.

- Analysis of the 12 obligate riparian species that co-occurred in the three TRIAP focus catchments indicated that the species vary considerably amongst themselves as to their adaptation to environmental conditions, and some are indeed most common in, or restricted to, certain rainfall regimes, lithologies, soils and geomorphological formations.

- Rainfall has some constraint on distribution of riparian species, but overall the rainfall regime with respect to species distribution is not reliable in predicting distribution.

- In a broad sense the lithologies of the three focus catchments are not significantly different from each other. Sedimentary formations were by far the most common lithologies on which riparian species occurred, and it can be concluded that lithology is among the major constraints on distribution of riparian species as a functional group.

- Although the resolution of species distribution and soil types is relatively coarse based on the methods adopted here, it can be concluded that preference for soil types is strong in some species but of limited importance in others, but overall is not a major constraint on distribution of riparian species.

- Of the geomorphological formations used in this assessment, riparian species overall occur most commonly on alluvial formations, and it can be concluded that geomorphology is a primary constraint for distribution of riparian species as a functional group.

- A total of 19 riparian vegetation associations were recognised in the TRIAP catchments. A model to determine the distribution of vegetation was developed using elevation as the primary constraint. The model was tested in the Flinders River catchment at 28 sites. Results indicated that the model's reliability was very poor at two (7%) of sites, poor at 11 (40%) sites, good at 13 (46%) sites and very good at 2 (7%) sites. Overall, the model for predicting species composition within a vegetation association at the reach level was reliable at 53% of sites.

GLOSSARY

***facultative riparian species*:** plants that occur in the riparian zone, but are more common in other habitats.

freshwater aquatic species: plants that occur in freshwater systems, in either moving or free-standing water, and spend most of their life cycle in water, but does include species that can withstand periodic drying.

mangrove species: species that occur in saltwater or brackish water environments, fringing rivers, estuarine areas and coastal areas.

obligate riparian species: plants that occur exclusively in the riparian zones associated with creeks, rivers, lakes or lagoons.

1 INTRODUCTION

Inventories and assessments of the riparian vegetation of the rivers and watercourses in northern Australia are contained in a number of unrelated or limited focus reports, papers, articles, and other literature. Broad-scale vegetation assessment and mapping has been undertaken across this area (Beadle 1981; Coles 1986; DPI 1993; ANCA 1996; Sattler & Williams 1999; EPA 2001), but with varying degrees of resolution and detail with relationship to distribution, species composition and ecological preferences of riparian vegetation.

The study of the vegetation of the riparian zone, treated as a distinct functional/floristic group of species, has not been attempted for most of northern Australia. The ecology of some species is relatively well known, but very little research has been applied to the majority of species that occur in the riparian zone. Therefore, we are largely ignorant of the effects of environmental pressures, both natural and anthropogenic, on most riparian species in northern Australia. This lack of research in northern Australia contrasts with that which has been undertaken in parts of southeastern Australia, such as the Murray/Darling system, where research on the function and ecology of much of the riparian vegetation has been relatively more intense.

This report aims to collate, evaluate and analyse the available distribution data for riparian plant species in the broad context of Australia's northern tropical rivers, and with subsequent focus on the three TRIAP focus catchments, Fitzroy R. (WA), Daly R. (NT) and Flinders R. (Qld), to determine ecological attributes and preferences of the species with relation to rainfall, lithology, soils, geomorphology, and to determine patterns of distribution.

2 METHODS

A preliminary search to identify riparian species that occur within the Tropical Rivers Project coverage was conducted using a very broad range of literature (Perry & Lazarides 1964; Story 1970; Beadle 1981; Clifford & Specht 1986; Cole 1986; DPI 1993; Thurgate 1994; Russell-Smith 1995; ANCA 1996; Sattler & Williams 1999; Bowman 2000; Cowie *et al*. 2000; Pettit & Froend 2001; Start & Handasyde 2002; Stephens & Dowling 2002; Davis & Dowe 2004; Dowe 2004). The list of species generated from these searches were subsequently categorised as follows, based on the available data:

- obligate riparian species: occurring in no other habitats except those within the riparian zone
- facultative riparian species: occurring in the riparian zone but also in non-riparian habitats
- aquatic species
- mangrove species

For the obligate riparian species, distribution data were sought and obtained from the following sources:

1. Australian Centre for Tropical Freshwater Research (ACTFR)
2. Australian National Botanic Garden Herbarium (CANB)
3. CSIRO Herbarium, Atherton (QRS)
4. National Herbarium of New South Wales (NSW)
5. National Herbarium of Victoria (MEL)
6. Northern Territory Herbarium (DNA)
7. Queensland Herbarium (BRI)
8. South Australian Herbarium (AD)
9. Tropical Biology Herbarium, James Cook University (JCT)
10. Western Australian Herbarium (PERTH)

The distribution data were converted to be compatible with the mapping programs being used in the broader TRIAP project. Data were converted to degrees and decimalised minutes. Some data were received without precise geographical location, and an estimate of location was made from the available information. The rationalisation of data was achieved manually in most cases. From the list of obligate riparian species, those that were common to the three TRIAP focus catchments

were identified and isolated for more detailed assessment. The location of each species was overlaid with data on rainfall (BOM 2003), lithology (AGSO 1998), soils (BRS 1991), and geomorphology (adapted from Erskine *et al.* 2005), and an assessment of the ecological preference for each species was developed.

Maps were generated based on species distribution with regards to rainfall, lithology, and geomorphology, using either the entire TRIAP area or limited to the three focus catchments. Additional data based on soils were also generated, but as the resolution of soil distribution was too coarse to utilise, no maps of species distribution and soil distribution were able to be produced. Analysis of data explained preferences and abundance of species on different lithology and geomorphology formations, and a summary of environmental preference data was provided for the 12 species that co-occur in the three focus catchments.

In addition to investigating the distribution and ecology of individual species, patterns of species associations [herein termed vegetation associations] were determined. Within each TRIAP catchment, the dominant functional species were ascertained. Where co-distribution of species occurred, within catchments, vegetation associations were able to be established. With the establishment of vegetation associations, a model to predict the overall distribution of vegetation associations was developed. This predictive model attempted to align the established vegetation associations with environmental attributes. As species distribution data were scant or absent from some catchments, vegetation associations were only developed to an adequate level in the three focus catchments, where species distribution data were available. The vegetation associations were plotted onto maps of the three TRIAP focus catchments.

As a means to test the reliability of the predicted distribution of the vegetation associations, sites in the Flinders River catchment were visited and the actual distribution of the species within the established vegetation associations was documented. For this activity, full details of methodology and results are presented separately below. A reliability rating was provided for sites in the Flinders River catchment, the assumption being that the level of predictability of the distribution of the vegetation associations attained there would be similar for the other two focus catchments.

3 RESULTS

A total of 264 species was recognised as occurring in the riparian zone in the TRIAP project area (Appendix 1). Cautiously, this figure may be a considerable under-estimate of the total number of species that may occur in the riparian zone, as many herbs and shrubs with isolated distribution and of ephemeral seasonal appearance may not be detected by traditional plant collecting methods. The actual number of species may well be more than double the number presented here. However, of the presently recognized total, 23 species were identified as obligate riparian species [i.e. occurring in no other habitats except the riparian zone]; 126 as facultative riparian species [occurring in the riparian zone but also in non-riparian habitats]; 84 as freshwater aquatic species; and 28 as mangrove species (Appendix 1).

For the 23 obligate riparian species, distribution data from about 5800 herbarium accessions were obtained from ten herbaria, and the data made compatible with the mapping programs being used for the TRIAP project.

Of the 23 obligate riparian species, 12 species were found to co-occur in the three focus catchments (Table 1). Data on the numbers of distribution records within the focus catchments, rainfall and lithology for the 12 co-occurring species are presented in Table 2.

The average annual rainfall for the 12 co-occurring species is presented in Fig. 1 and all co-occurring species plotted on rainfall maps in the three focus catchments are presented in Figs 2-4. Distribution of the 12 co-occurring species relevant to lithology is presented in Figs 5-16 and all co-occurring species, plotted on lithology of the three focus catchments, are presented in Figs 17-19.

The soils on which the co-occurring species occur are presented in Table 3 and geomorphology in Table 4. Distribution of the 12 co-occurring species relevant to geomorphology is presented in Figs 20-31, and all co-occurring species, plotted on geomorphology of the three focus catchments, are presented in Figs 32-34. Graphs presenting the allocation of the 12 co-occurring species to the five geomorphological formations are presented in Figs 35-46.

Table 1. Obligate riparian plant species that were mapped from herbarium accession data, with catchment occurrence indicated. Those species (n=12) that co-occur in the three focus catchments are highlighted in bold.

Species (Family)	Fitzroy R.	Daly R.	Flinders R.
1. *Aeschynomene indica* (Fab.)	■	■	■
2. *Asteromyrtus symphyocarpa* (Myrt.)		■	■
3. *Calycopeplus casuarinoides* (Euphorb.)		■	■
4. *Casuarina cunninghamiana* (Casuarin.)		■	■
5. *Cathormion umbellatum* (Mimos.)	■	■	■
6. *Chrysopogon oblongatus* (Poa.)		■	■
7. *Corymbia bella* (Myrt.)	■	■	■
8. *Cyperus difformis* (Cyper.)	■	■	■
9. *Eucalyptus camaldulensis* (Myrt.)	■	■	■
10. *Flueggea virosa* (Euphorb.)	■	■	■
11. *Goodenia strangfordii* (Gooden.)			■
12. *Livistona rigida* (Arecac.)			■
13. *Lophostemon grandiflorus* (Myrt.)	■	■	■
14. *Melaleuca argentea* (Myrt.)	■	■	■
15. *Melaleuca bracteate* (Myrt.)	■	■	■
16. *Melaleuca fluviatilis* (Myrt.)			■
17. *Melaleuca leucadendra* (Myrt.)	■	■	■
18. *Melaleuca stenostachya* (Myrt.)			■
19. *Melaleuca trichostachya* (Myrt.)			■
20. *Persicaria attenuata* (Polygon.)	■	■	■
21. *Sesbania cannabina* (Fab.)	■	■	■
22. *Sesbania erubescens* (Fab.)	■	■	
23. *Vitex acuminata* (Verb.)	■	■	

Table 2. Distribution records, rainfall data and lithology for the 12 species that co-occur in the three focus catchments.

Lithology abbreviations

af	amphibolites-facies metamorphics
d&g	dolerites and gabbros
fv	felsic volcanics
g	granites
mv	mafic volcanics
sr	sedimentary rocks

Species	**Distribution records**				**Rainfall in mm**				**Major lithology**			
	total	**Fitz**	**Daly**	**Flin**	**Average mm**	**Fitz mm**	**Daly mm**	**Flin mm**	**Range**	**Fitz**	**Daly**	**Flin**
Aeschynomene indica	19	10	2	7	601	585	1021	502	383-1151	sr-10	sr-2	sr-6; mv-1
Cathormion umbellatum	23	1	21	1	1069	460	1111	771	460-1436	sr-1	sr-19. mv-2	sr-1
Corymbia bella	43	9	23	11	837	642	1050	549	440-1352	sr-8, mv-1	sr-18, mv-1, g-1, fv-3	sr-7; g-4,
Cyperus difformis	28	13	2	13	641	618	1311	560	429-1423	sr-8; mv-2; d&g-3	sr-1; mv-1, g-1	sr-10; mv-1; af-1
Eucalyptus camaldulensis	149	42	60	47	761	608	1061	512	376-1436	sr-38; mv-1; d&g-1	sr-7; mv-9; fv-6	sr-9; mv2; af-6
Flueggea virosa	52	10	31	11	857	572	1056	479	442-1456	sr-10	sr-23; fv-5; mv-2; g-1	sr-4; g-4; af-2

Table 2 (continued).

Species	Distribution records				Rainfall in mm					Major lithology		
	total	**Fitz**	**Daly**	**Flin**	**Average mm**	**Fitz mm**	**Daly mm**	**Flin mm**	**Range**	**Fitz**	**Daly**	**Flin**
Lophostemon grandiflorus	76	10	53	13	934	536	1106	463	414-1442	sr-9;	sr-45; g-1; mv-5; fv-1	sr-1; g-9; mv-1; af-4;
Melaleuca argentea	82	23	49	10	854	587	1055	484	388-1240	sr-20; fv-1; mv2	sr-32; g-4; mv-2	sr-8; fv-2; g-2; mv-1; af-4; fm-1
Melaleuca bracteata	32	13	3	16	594	586	817	558	411-818	sr-11; mv-1	mv-3	sr-3; mv-7; g-4; af-3
Melaleuca leucadendra	35	5	24	6	1000	760	1084	696	495-1436	sr-4; mv-1	sr-18; mv-3; fv-3	sr-5
Persicaria attenuata	14	6	6	2	923	674	1313	496	443-1445	sr-4; mv-2	sr-4; mv-2	sr-1; g-1
Sesbania cannabina	47	22	13	12	699	619	998	462	383-1436	sr-9; mv-1	sr-11; mv-1; g-1	sr-20; mv-1; g-1; af-1

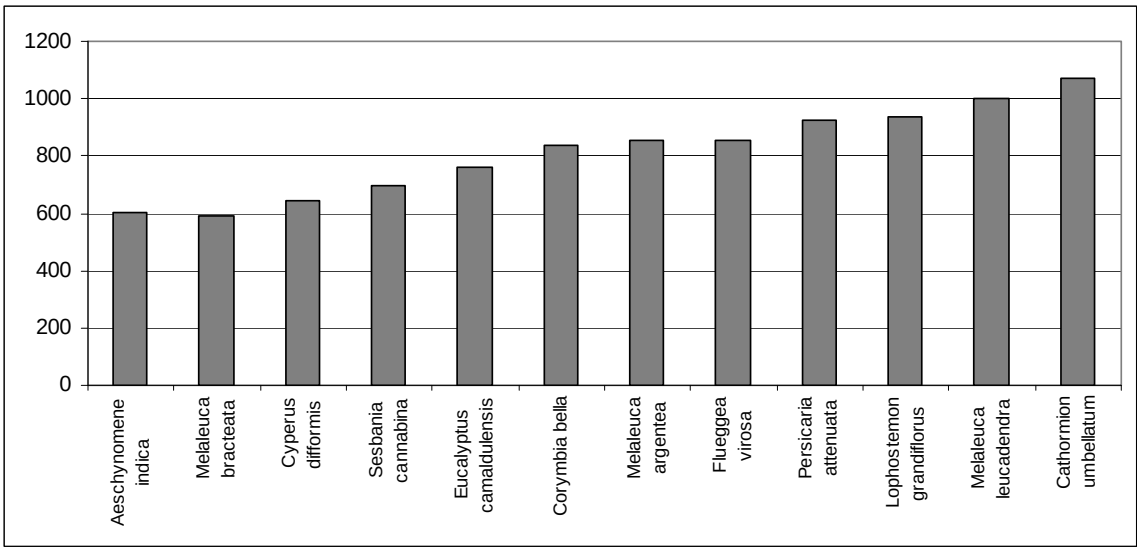


Figure 1. Average annual rainfall for the 12 species of riparian plants that co-occur in the TRIAP focus catchments.

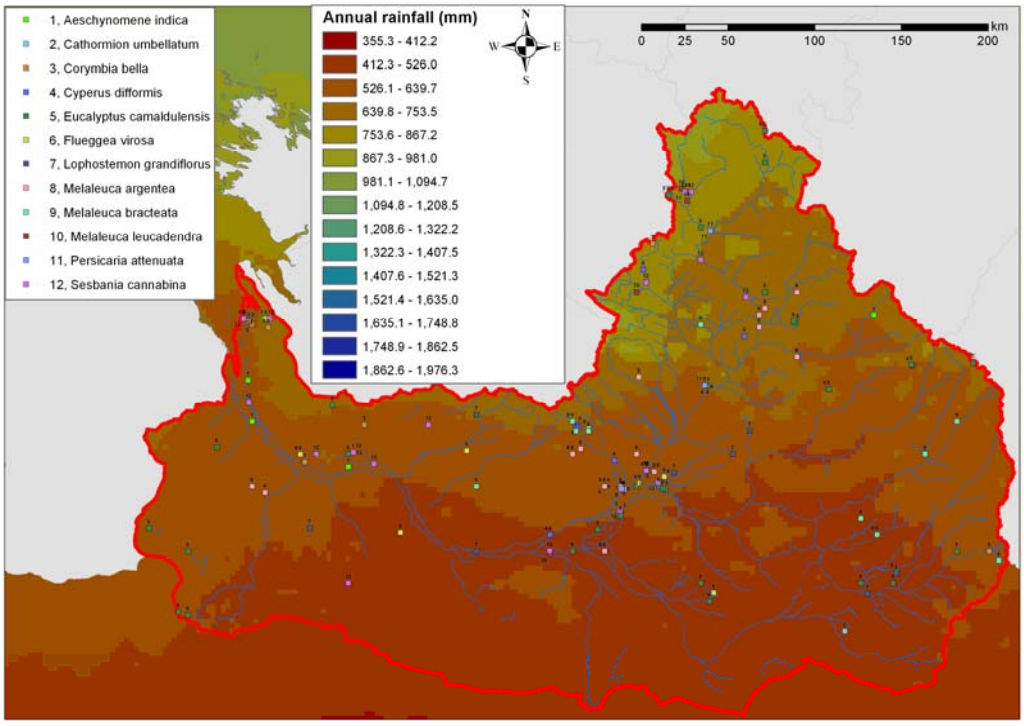


Figure 2. Distribution of 12 co-occurring species and rainfall in the Fitzroy River catchment.

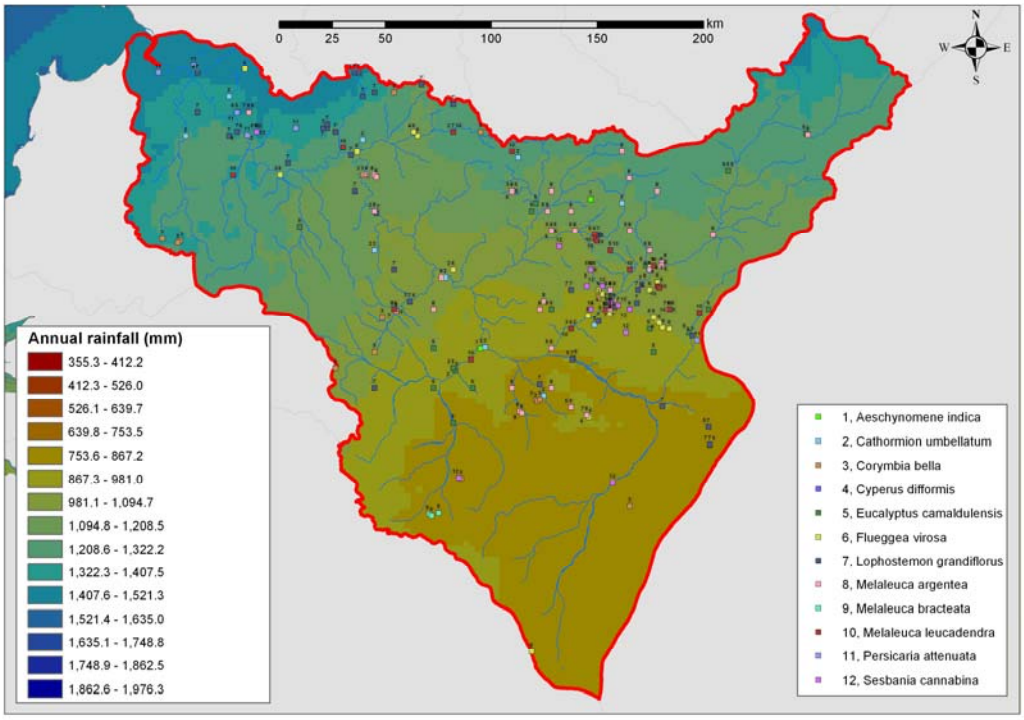


Figure 3. Distribution of 12 co-occurring species and rainfall in the Daly River catchment.

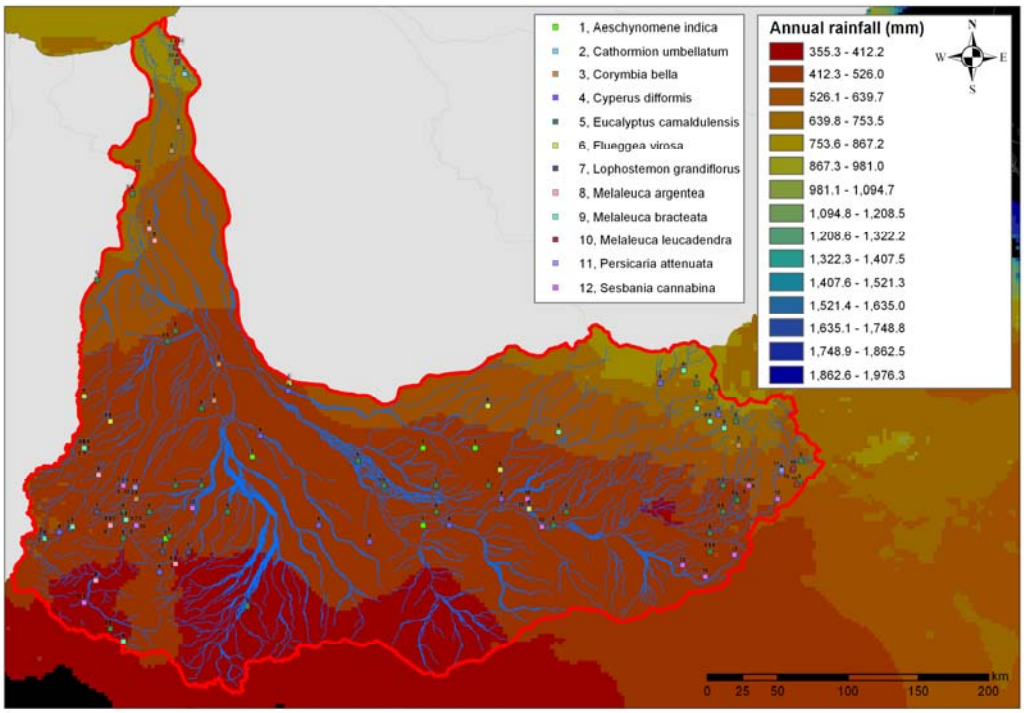


Figure 4. Distribution of 12 co-occurring species and rainfall in the Flinders River catchment.

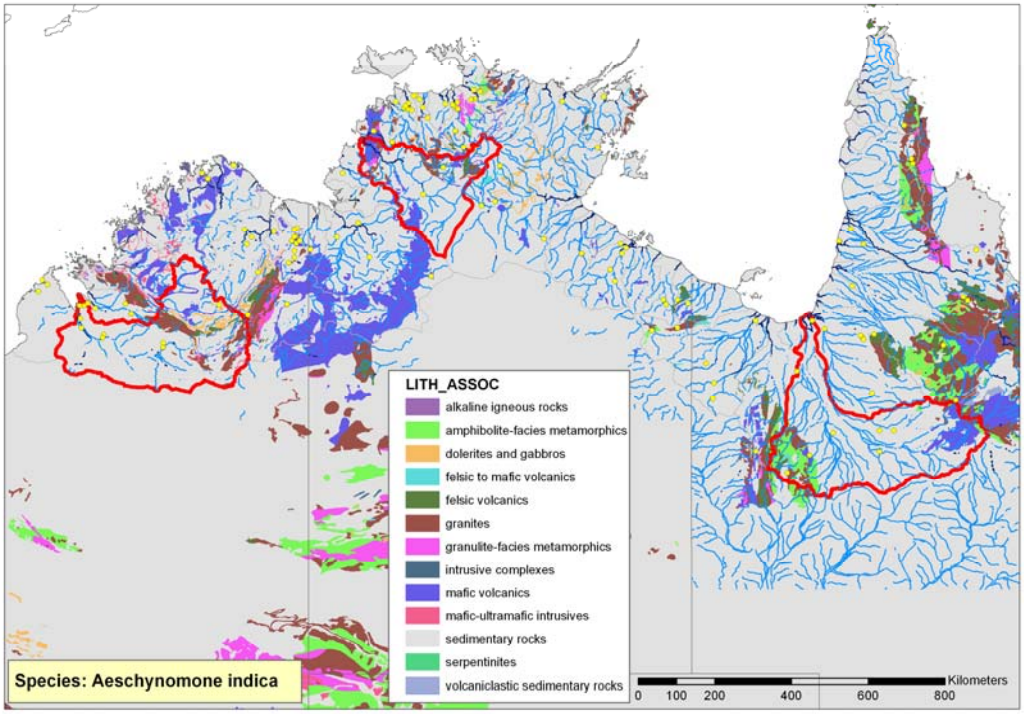


Figure 5. Distribution of *Aeschynomene indica* and lithology in the TRIAP study area.

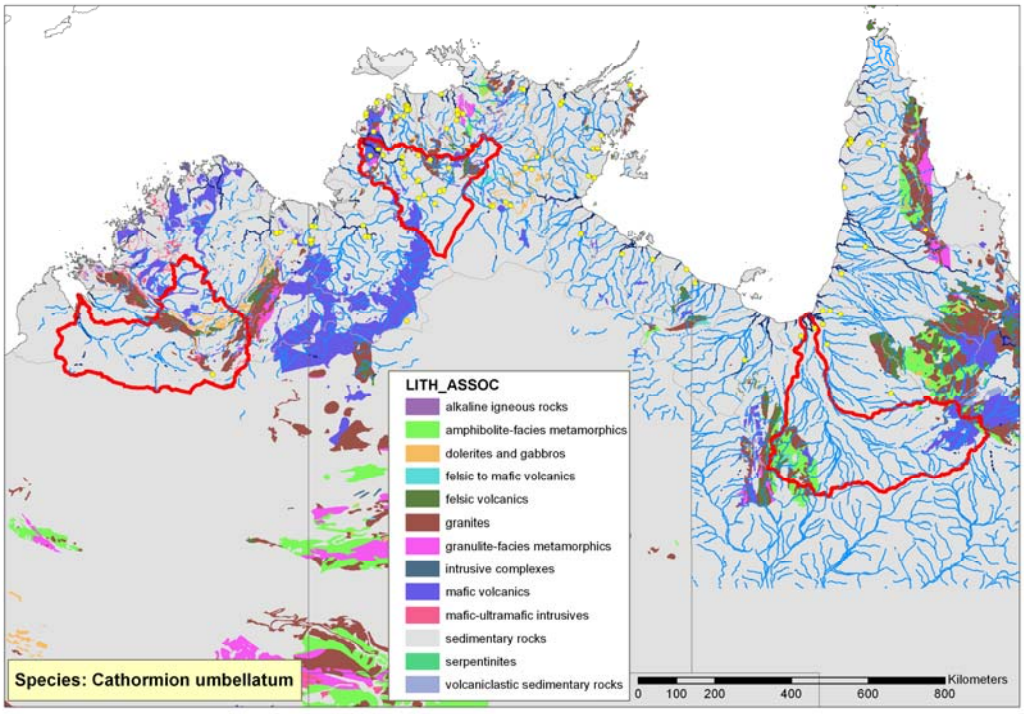


Figure 6. Distribution of *Cathormion umbellatum* and lithology in the TRIAP study area.

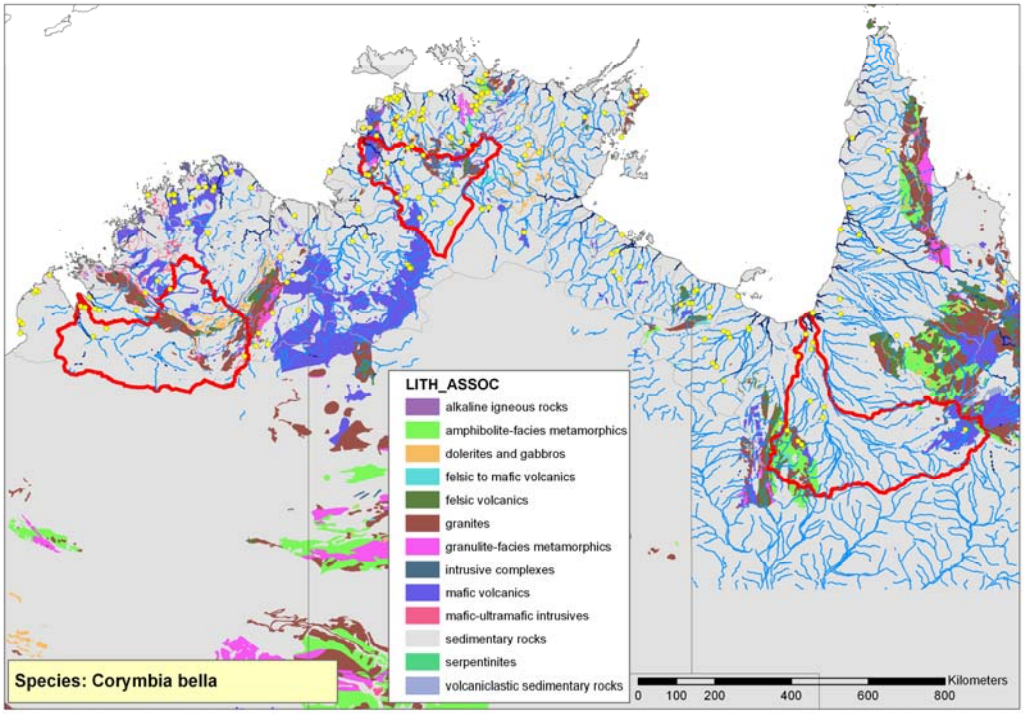


Figure 7. Distribution of *Corymbia bella* and lithology in the TRIAP study area.

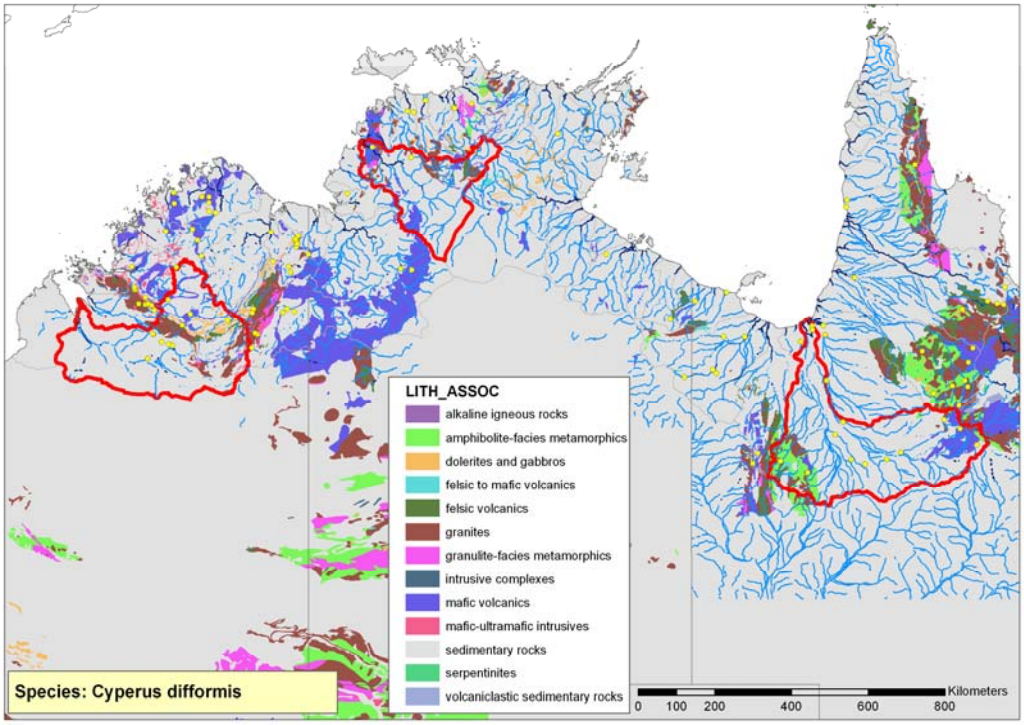


Figure 8. Distribution of *Cyperus difformis* and lithology in the TRIAP study area.

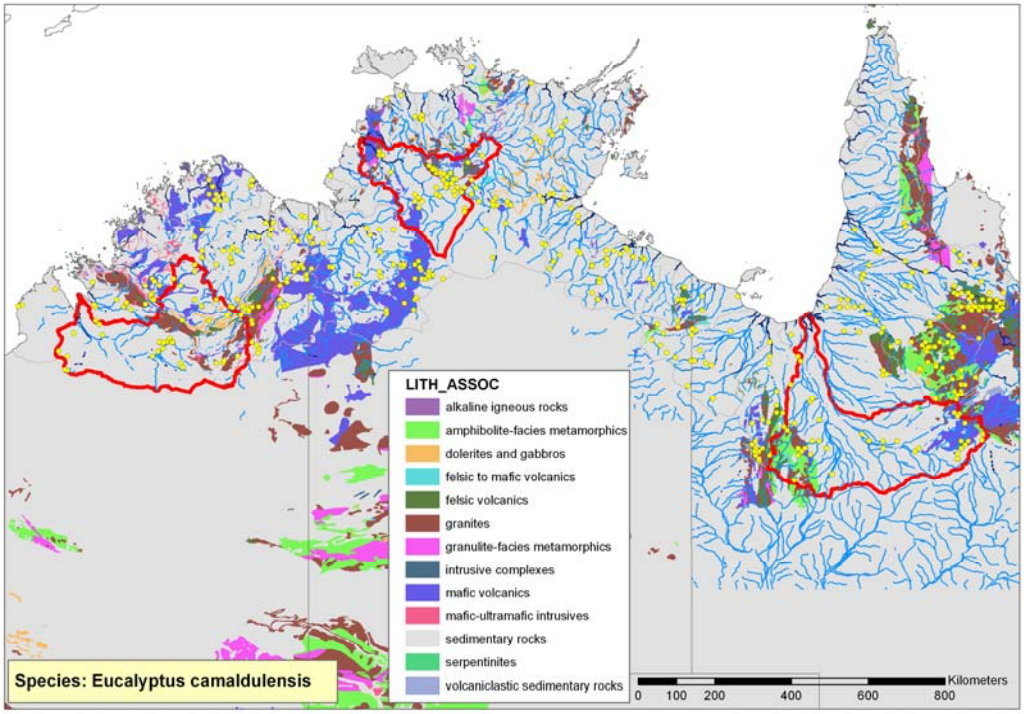


Figure 9. Distribution of *Eucalyptus camaldulensis* and lithology in the TRIAP study area.

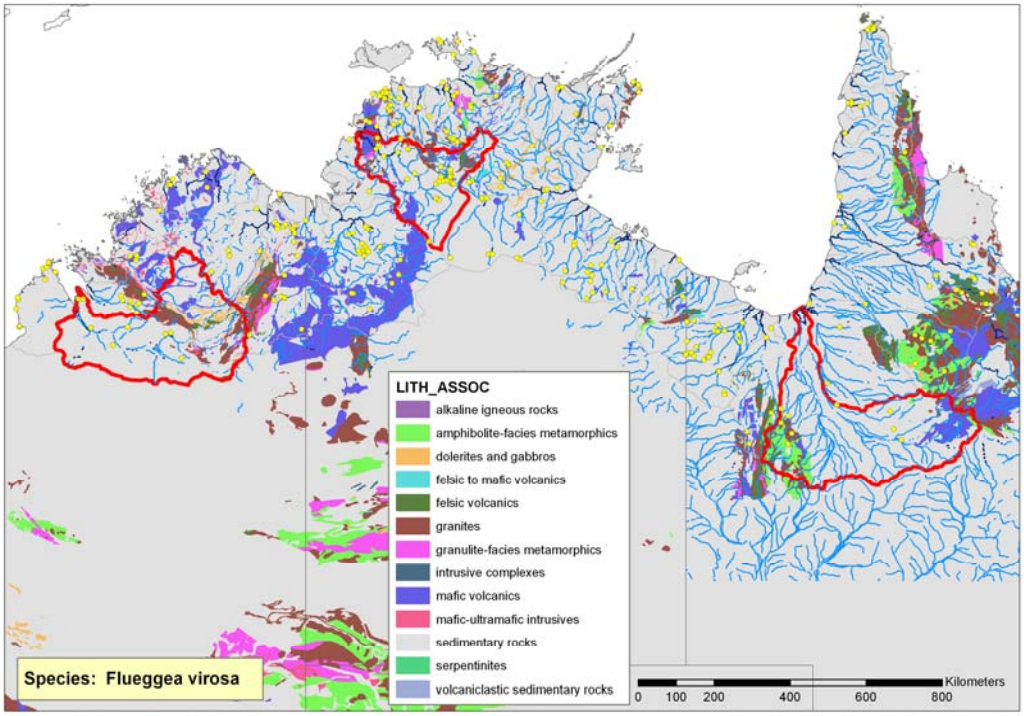


Figure 10. Distribution of *Flueggea virosa* and lithology in the TRIAP study area.

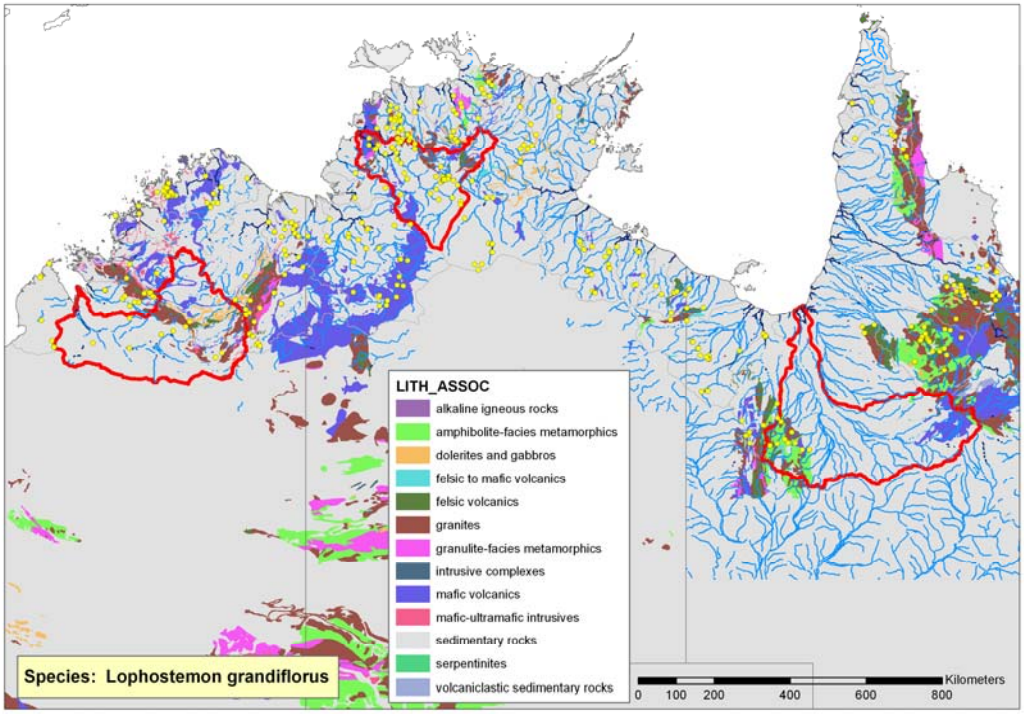


Figure 11. Distribution of *Lophostemon grandiflorus* and lithology in the TRIAP study area.

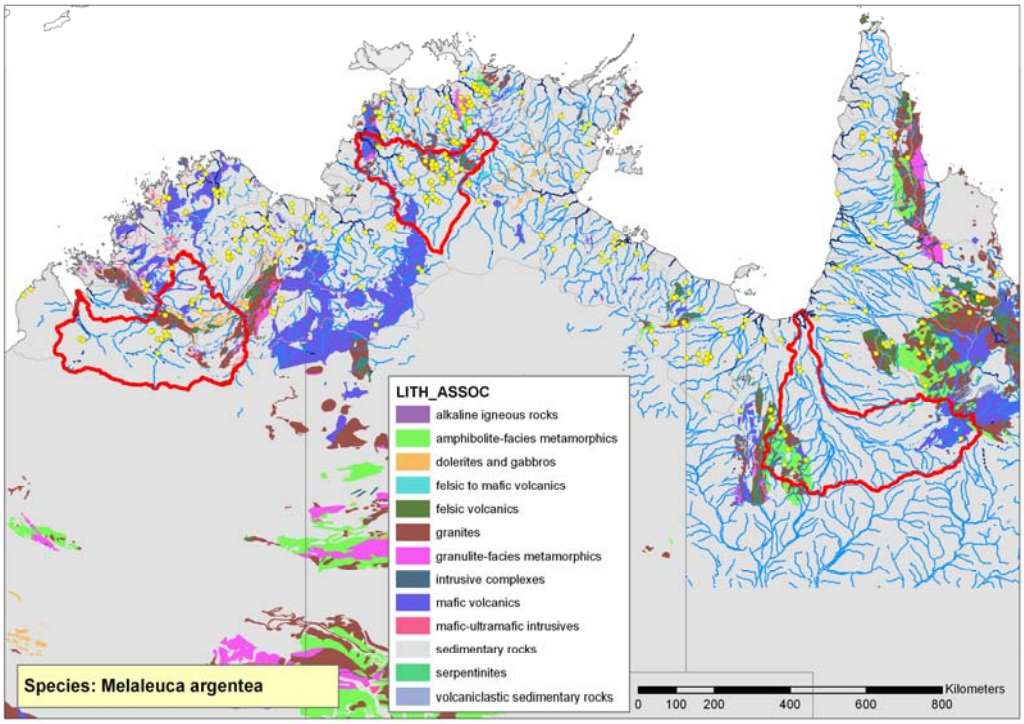


Figure 12. Distribution of *Melaleuca argentea* and lithology in the TRIAP study area.

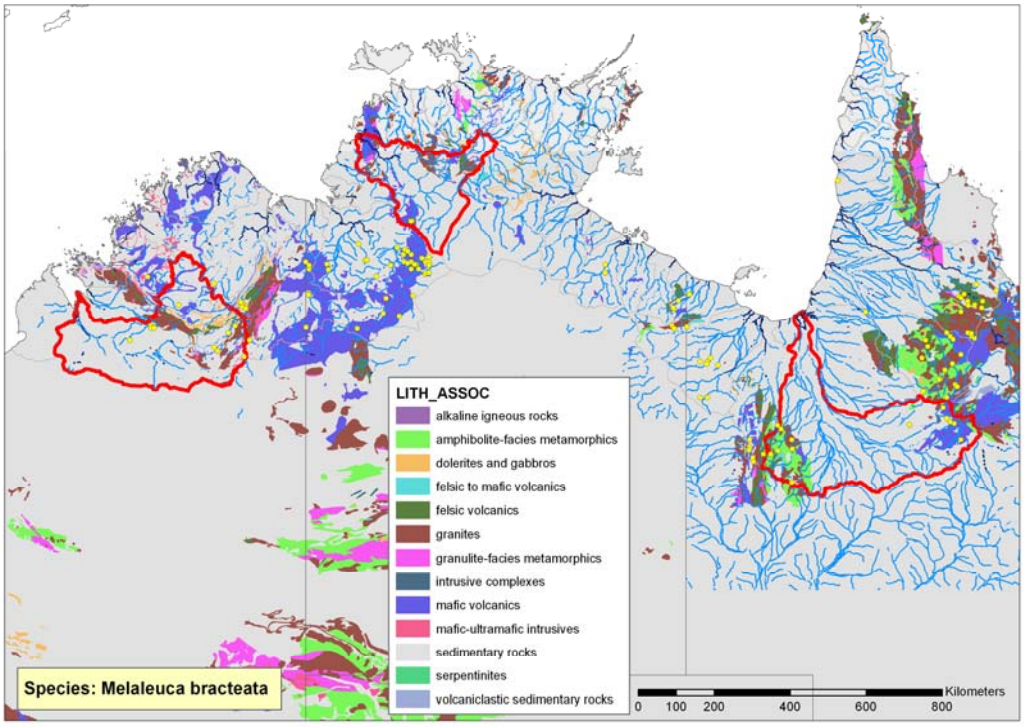


Figure 13. Distribution of *Melaleuca bracteata* and lithology in the TRIAP study area.

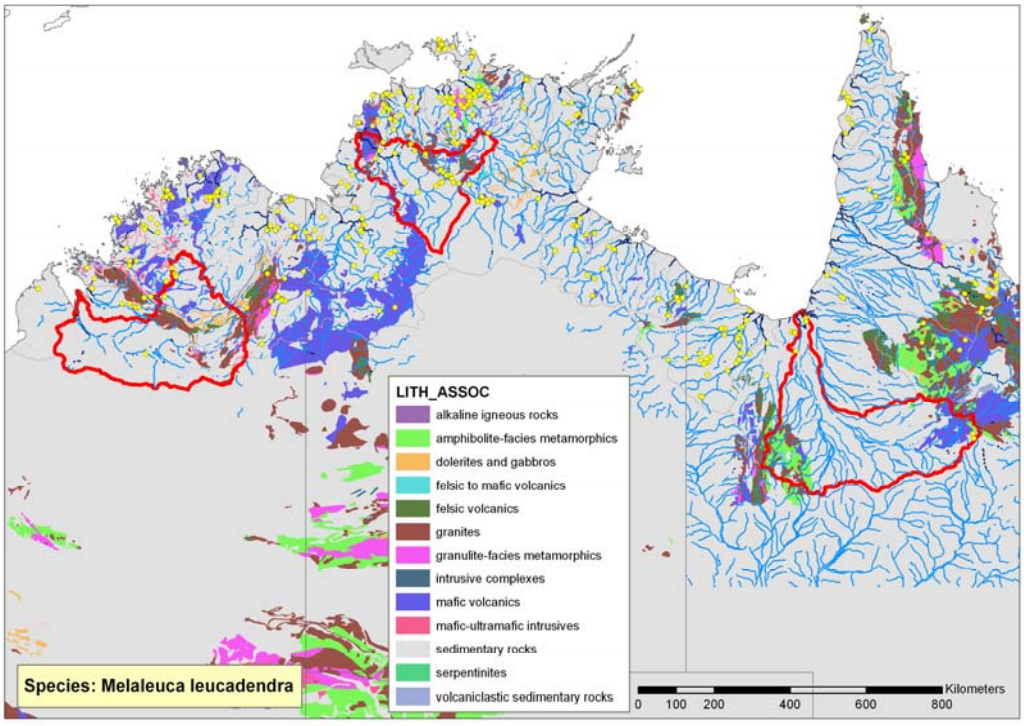


Figure 14. Distribution of *Melaleuca leucadendra* and lithology in the TRIAP study area.

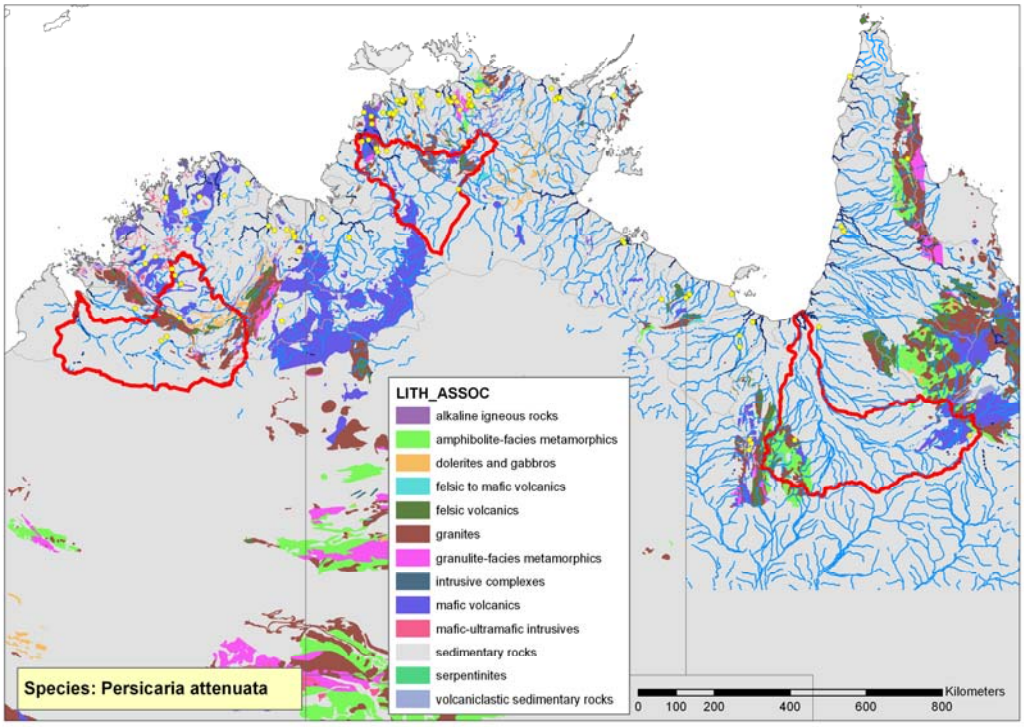


Figure 15. Distribution of *Persicaria attenuata* and lithology in the TRIAP study area.

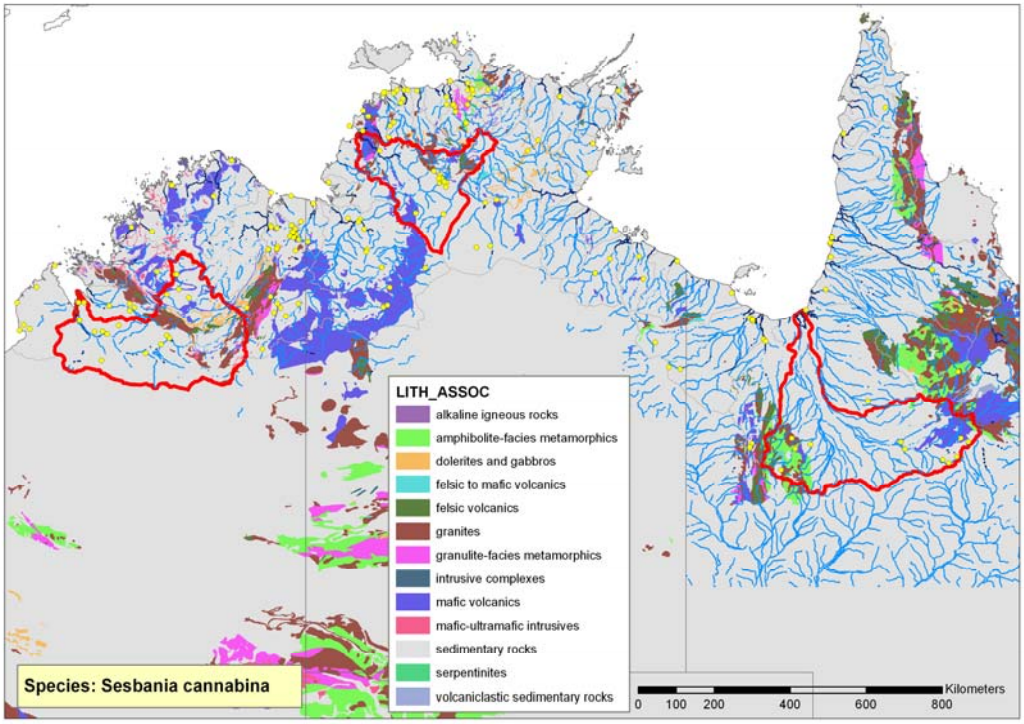


Figure 16. Distribution of *Sesbania cannabina* and lithology in the TRIAP study area.

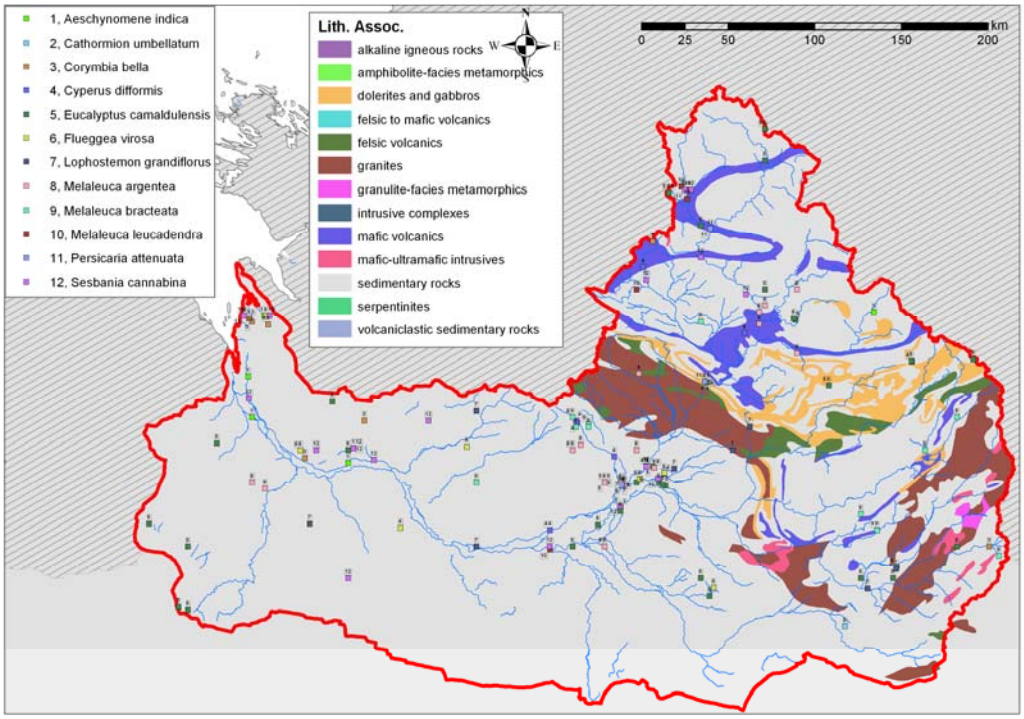


Figure 17. Distribution of 12 co-occurring species and lithology in the Fitzroy River catchment.

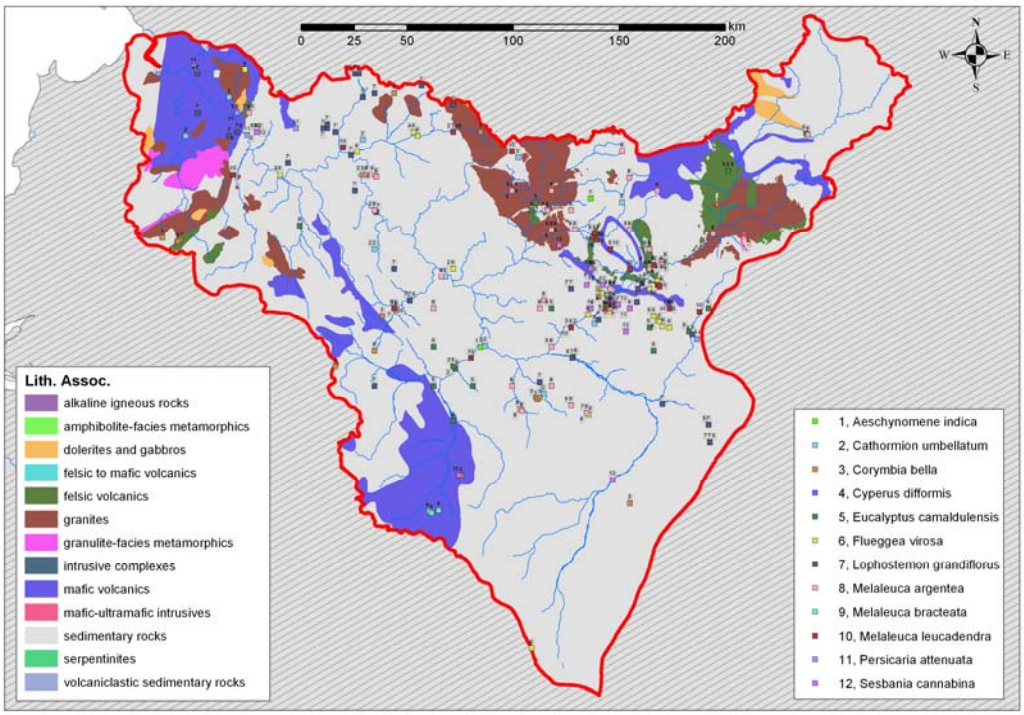


Figure 18. Distribution of 12 co-occurring species and lithology in the Daly River catchment.

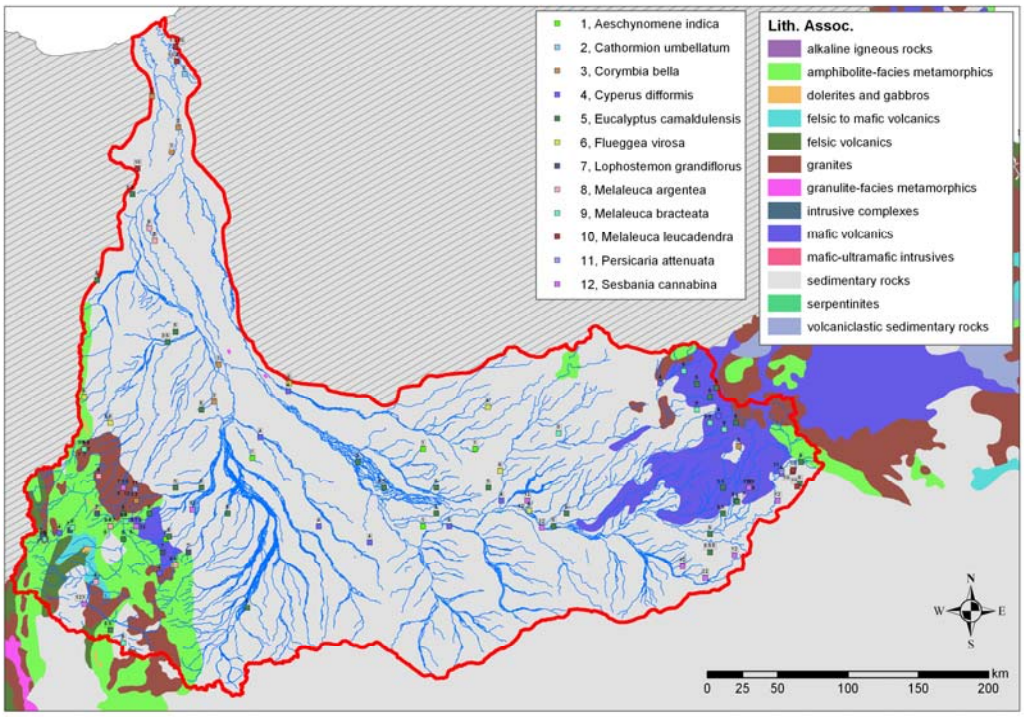
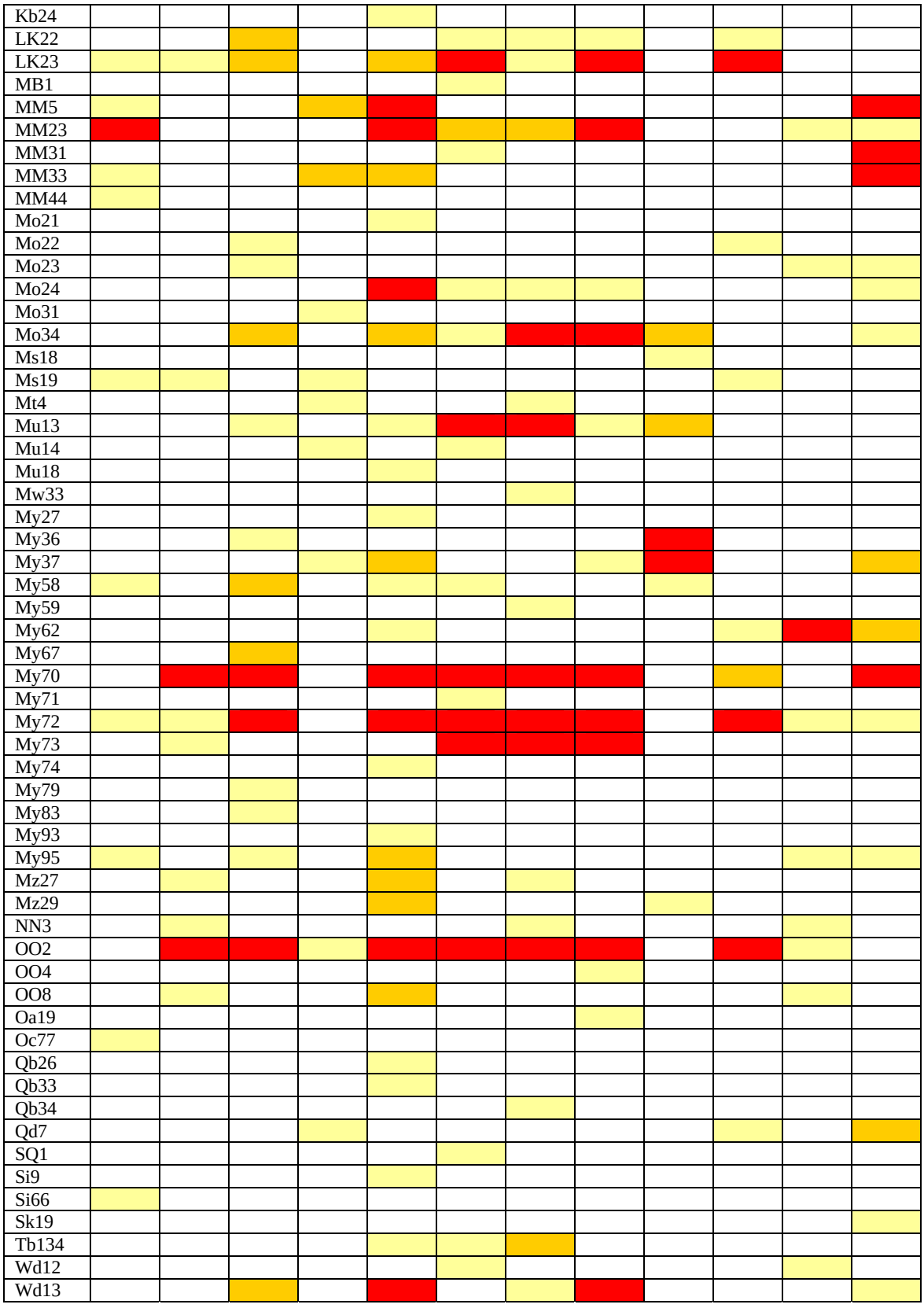


Figure 19. Distribution of 12 co-occurring species and lithology in the Flinders River catchment.

Table 3. Soils on which the 12 co-occurring riparian species occur: Soil types as designated by BRS (1991), and definitions presented in Appendix 2.

	most frequent occurrence
	moderate occurrence
	least frequent occurrence

Soil/spp.	A.indi	C.umb	C.bell	C.diff	E.cam	F.viro	L.gran	M.arg	M.bra	M.leu	P.atten	S.cann
AB21												
AB24												
AB26												
AB33												
AC20												
AZ2												
B28												
BA2												
BA6												
BA7												
BB12												
BB13												
Bz7												
BZ20												
CB9												
CC47												
CC48												
CC49												
CC50												
CC52												
CC56												
CC66												
CC70												
CC71												
CC73												
CC83												
F9												
Fa22												
Fa24												
Fa38												
Fa39												
Fz17												
Fz43												
Gj1												
II5												
JJ18												
JJ19												
JJ22												
JJ23												
JJ24												
JJ26												
JJ27												
JJ28												
JJ49												
JV1												
JV2												
JV3												
JZ3												
Jw1												
Kb23												


Kb24
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LK23
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MM23
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MM33
MM44
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Mu13
Mu14
Mu18
Mw33
My27
My36
My37
My58
My59
My62
My67
My70
My71
My72
My73
My74
My79
My83
My93
My95
Mz27
Mz29
NN3
OO2
OO4
OO8
Oa19
Oc77
Qb26
Qb33
Qb34
Qd7
SQ1
Si9
Si66
Sk19
Tb134
Wd12
Wd13

Table 4. Geomorphological formations on which the 12 co-occurring riparian plant species occur in the focus catchments, represented by percentage of records.

Species/geomorphology	Alluvial	Bedrock channel	Bedrock confined	Estuarine	Lake/swamp
Aeschynomene indica	79.2	8.3	8.3	0	4.2
Cathormion umbellatum	39.3	7.1	7.1	7.1	39.3
Corymbia bella	65	12.5	5	0	17.5
Cyperus difformis	52.6	21.1	23.7	0	2.6
Eucalyptus camaldulensis	52.8	19	17.6	0	10.6
Flueggea virosa	55	5	25	0	15
Lophostemon grandiflorus	66.7	8.3	8.3	0	16.7
Melaleuca argentea	47	20	24	0	9
Melaleuca bracteata	33.3	54.2	12.5	0	0
Melaleuca leucadendra	31.6	28.9	18.4	0	21.1
Persicaria attenuata	35	25	20	0	20
Sesbania cannabina	61.9	7.1	28.6	0	2.4

- **Alluvial** (mean 51.6%): Aeschynomene indica (79.2% of records); Lophostemon grandiflorus (66.7%); Corymbia bella (65%); Flueggea virosa (55%); Eucalyptus camaldulensis (52.8%); Cyperus difformis (52.6%).
- **Bedrock channel** (mean 18.4%): Melaleuca bracteata (54.2% of records); Melaleuca leucadendra (28.9%); Persicaria attenuata (25%); Cyperus difformis (21.1%); Melaleuca argentea (20%); Eucalyptus camaldulensis (19%).
- **Bedrock confined** (mean 16.5%): Sesbania cannabina (28.6% of records); Flueggea virosa (25%); Melaleuca argentea (24%); Cyperus difformis (23.7%); Persicaria attenuata (20%); Melaleuca leucadendra (18.4%); Eucalyptus camaldulensis (17.6%).
- **Estuarine** (mean 0.6%): Cathormion umbellatum (7.1% of records).
- **Lake/swamp** (mean 13.2%): Cathormion umbellatum (39.3% of records); Melaleuca leucadendra (21.1%); Persicaria attenuate (20%); Corymbia bella (17.5%); Lophostemon grandiflorus (16.7%); Flueggea virosa (15%).

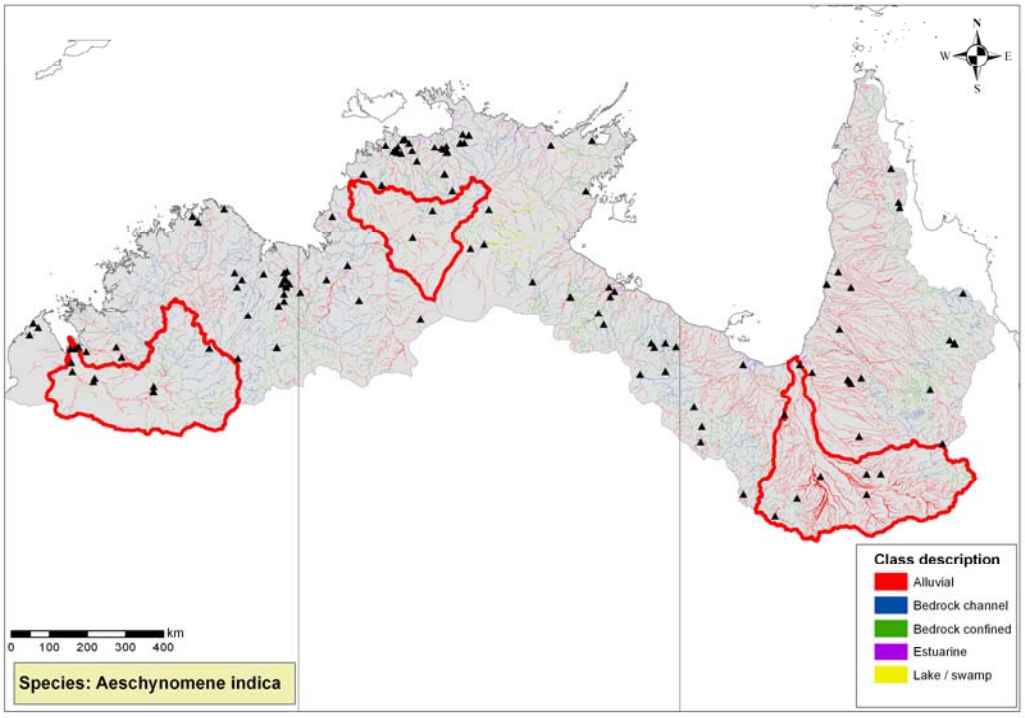

Figure 20. Distribution of *Aeschynomene indica* and geomorphology in the TRIAP study area.

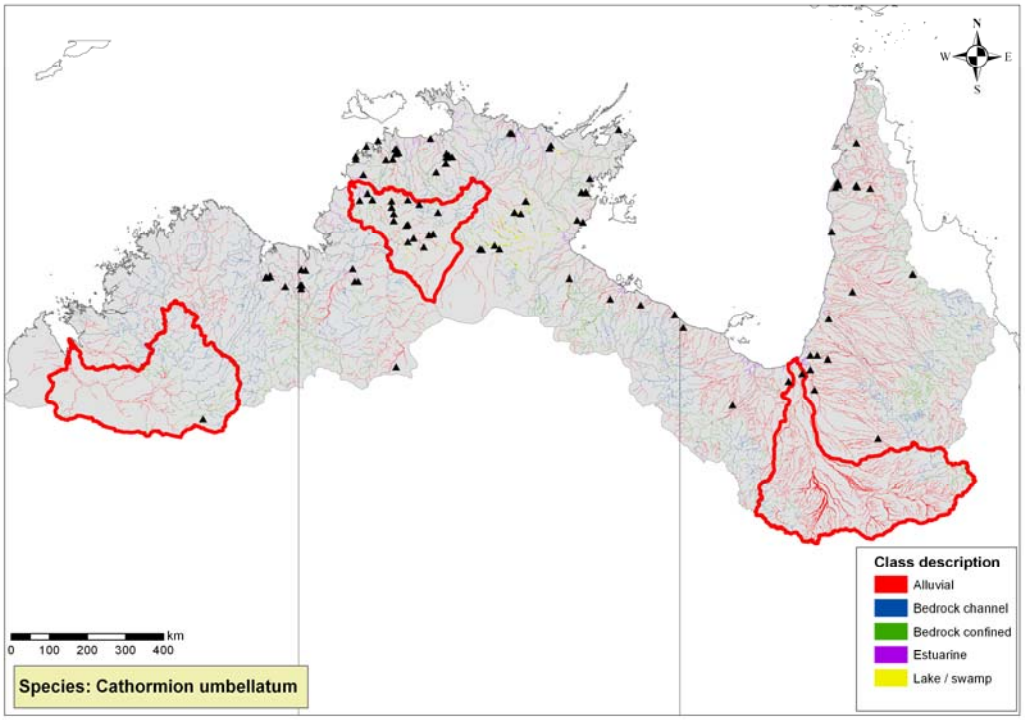

Figure 21. Distribution of *Cathormion umbellatum* and geomorphology in the TRIAP study area.

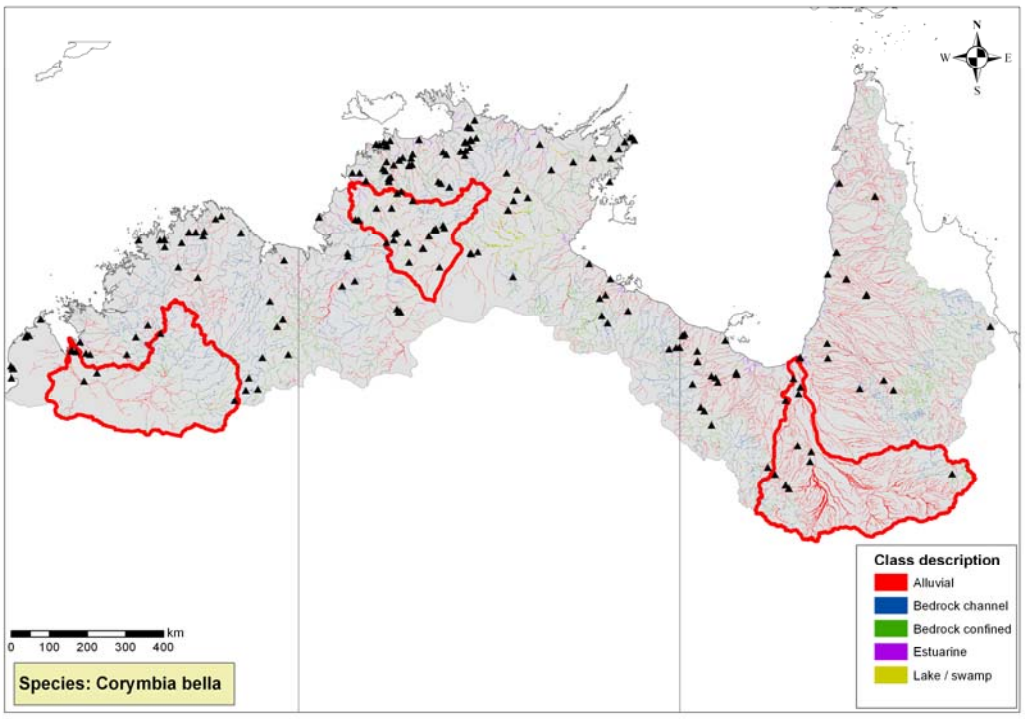

Figure 22. Distribution of *Corymbia bella* and geomorphology in the TRIAP study area.

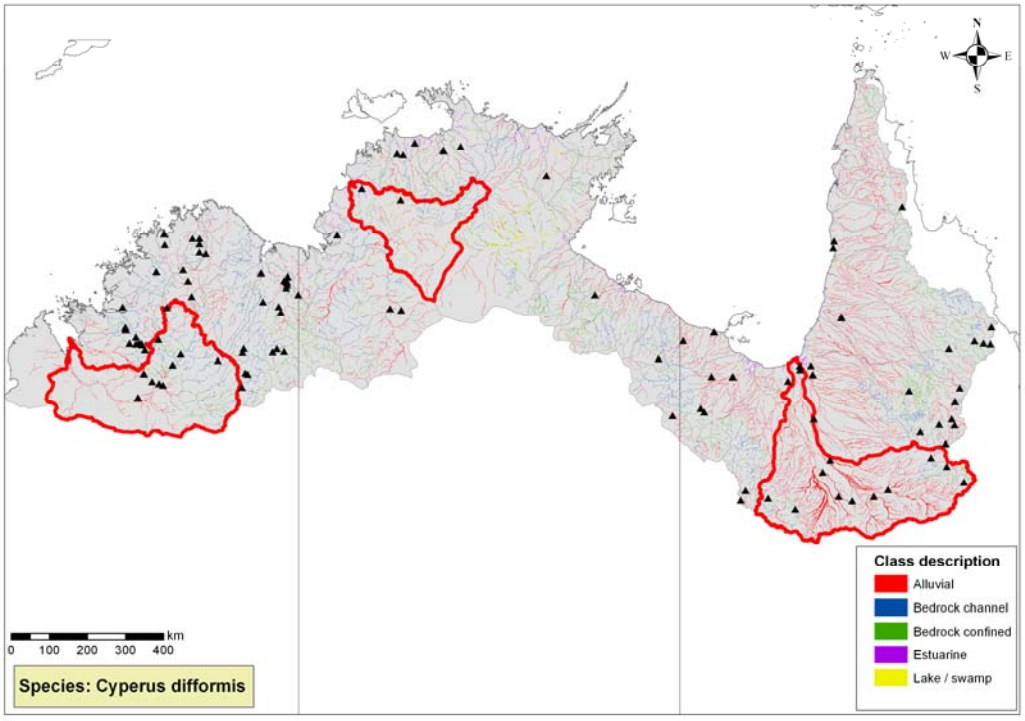

Figure 23. Distribution of *Cyperus difformis* and geomorphology in the TRIAP study area.

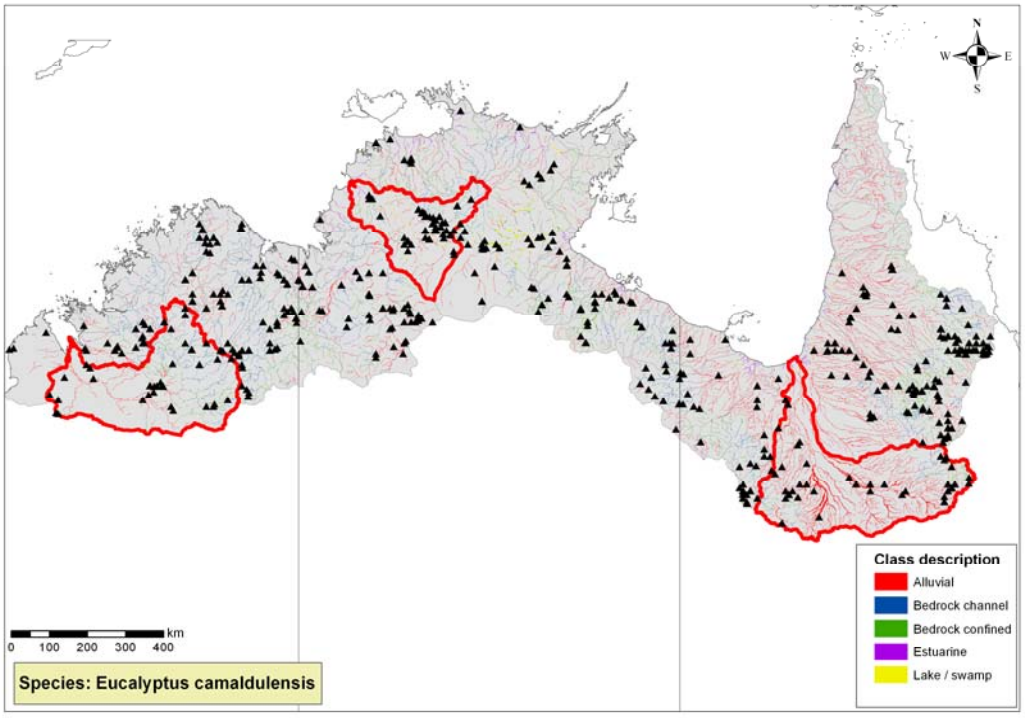

Figure 24. Distribution of *Eucalyptus camaldulensis* and geomorphology in the TRIAP study area.

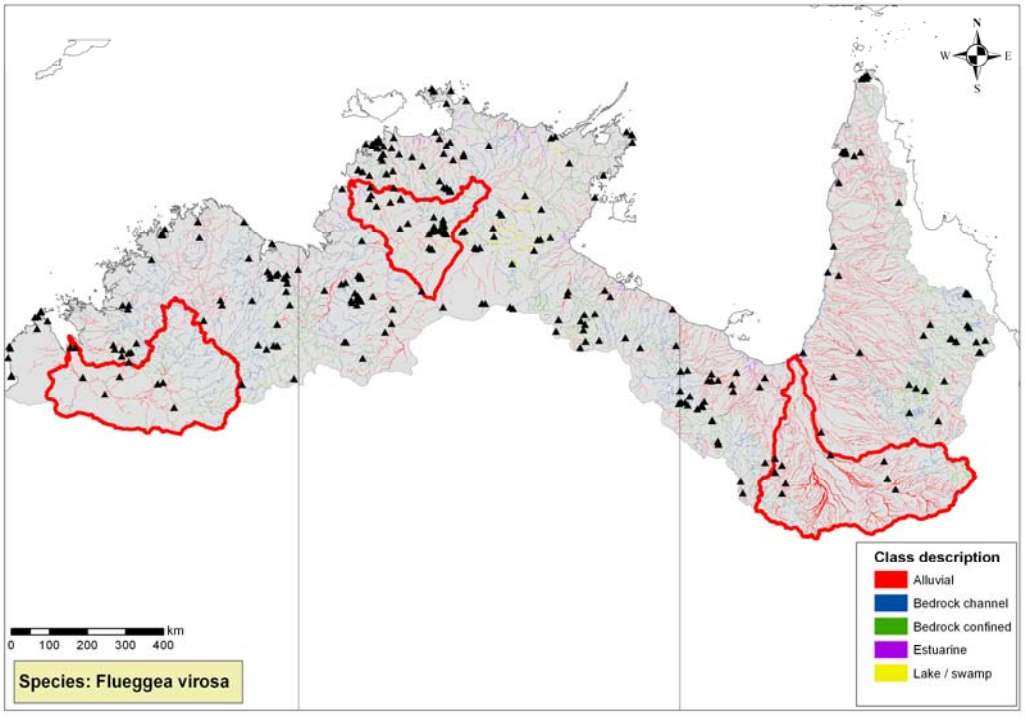

Figure 25. Distribution of *Flueggea virosa* and geomorphology in the TRIAP study area.

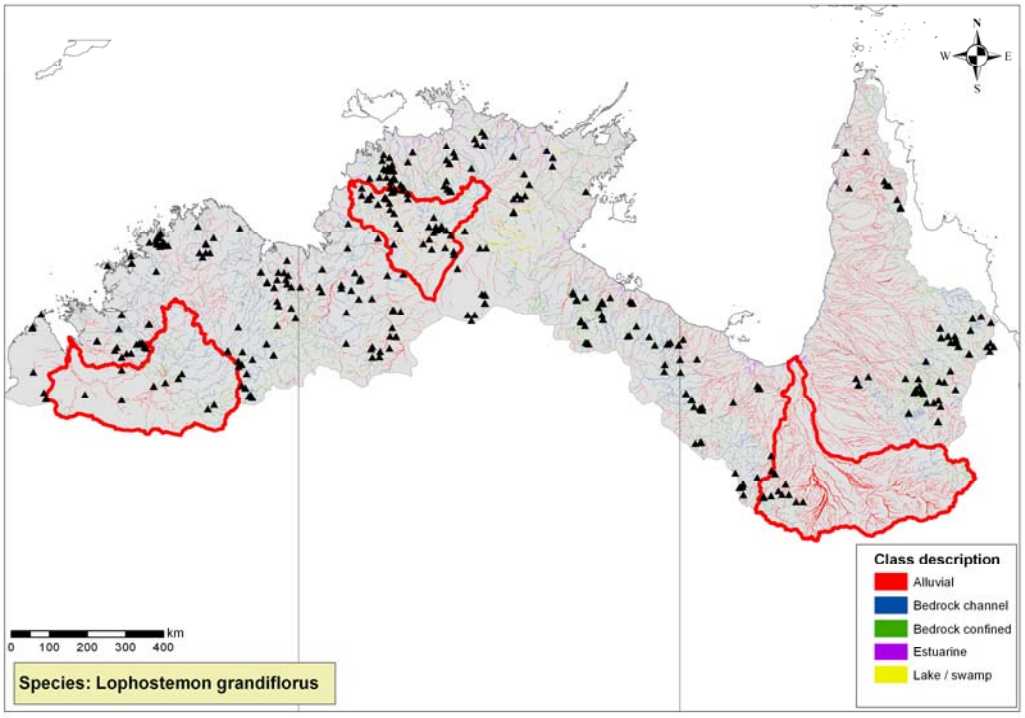

Figure 26. Distribution of *Lophostemon grandiflorus* and geomorphology in the TRIAP study area.

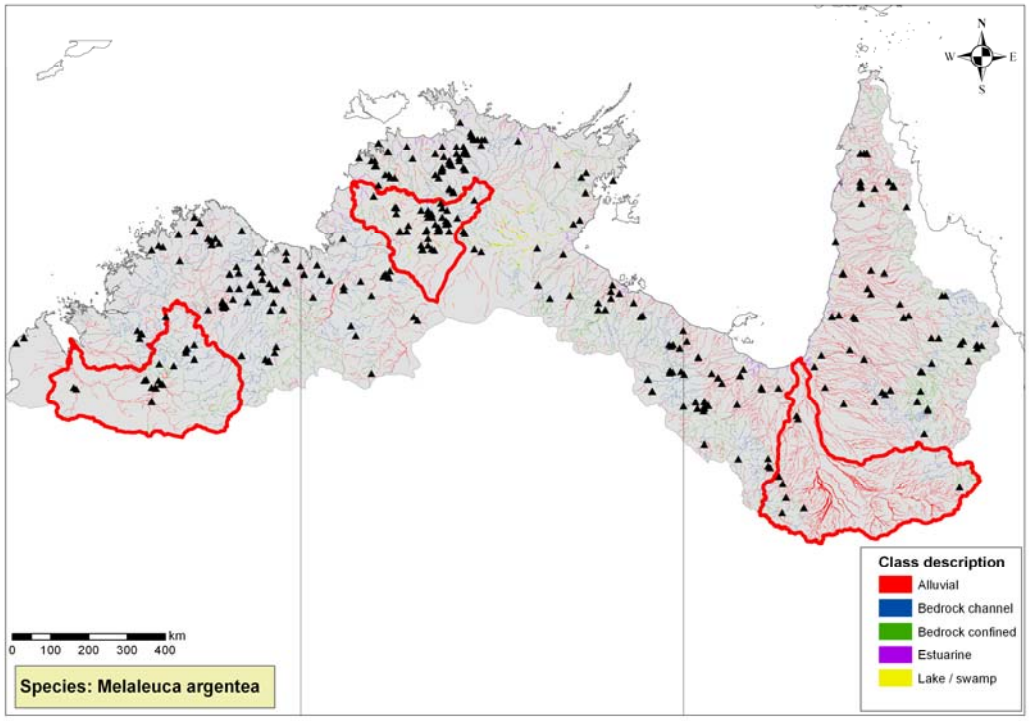

Figure 27. Distribution of *Melaleuca argentea* and geomorphology in the TRIAP study area.

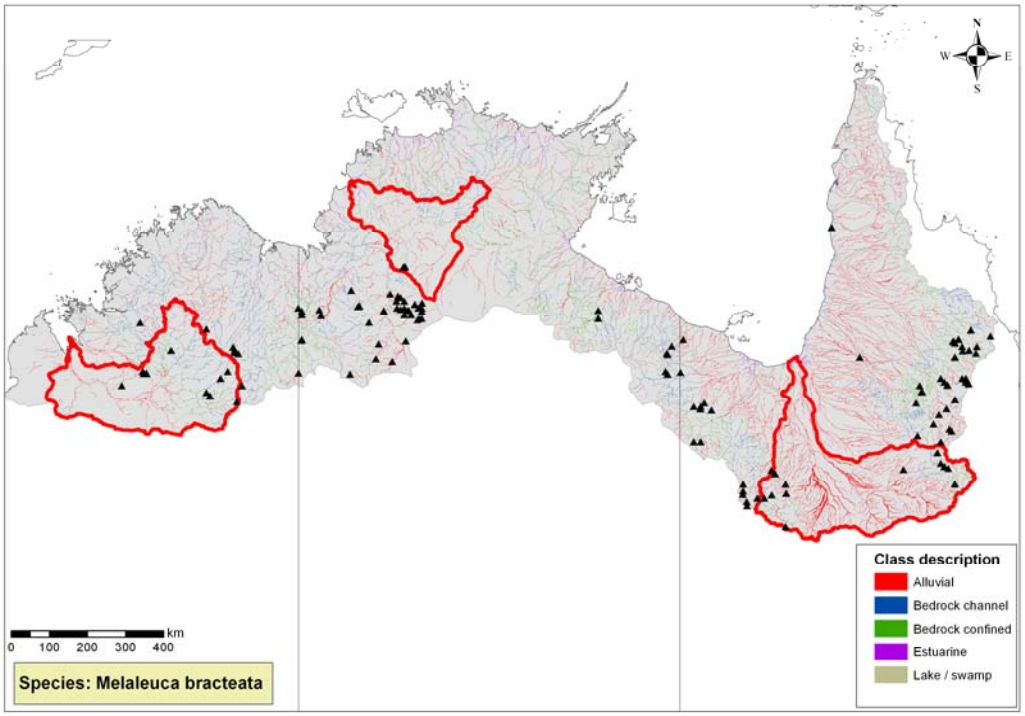

Figure 28. Distribution of *Melaleuca bracteata* and geomorphology in the TRIAP study area.

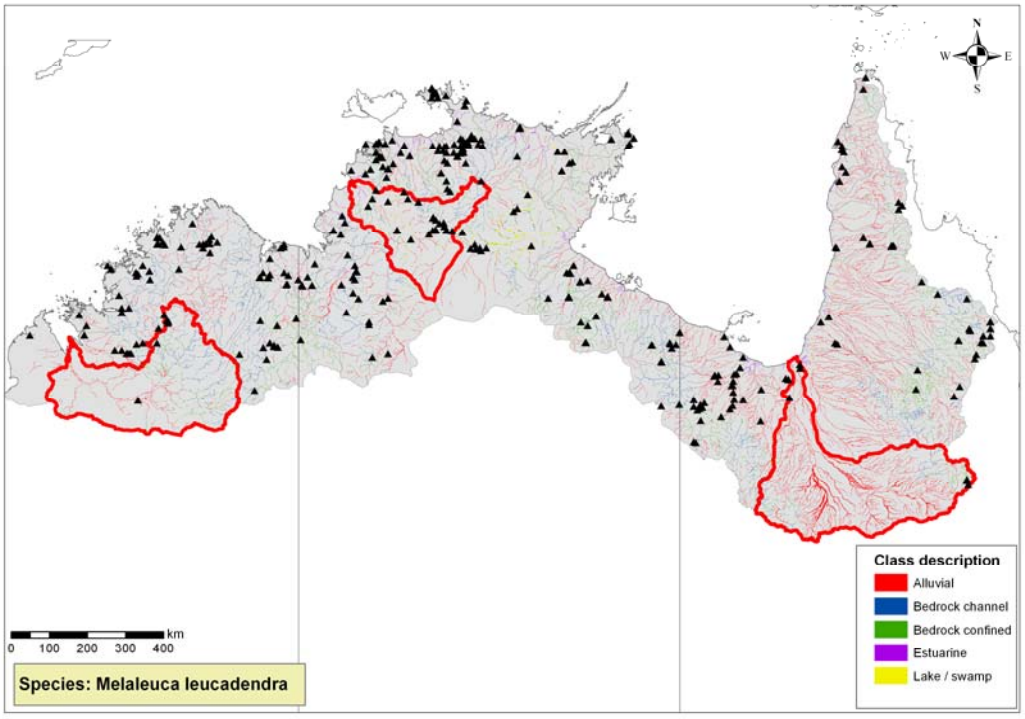

Figure 29. Distribution of *Melaleuca leucadendra* and geomorphology in the TRIAP study area.

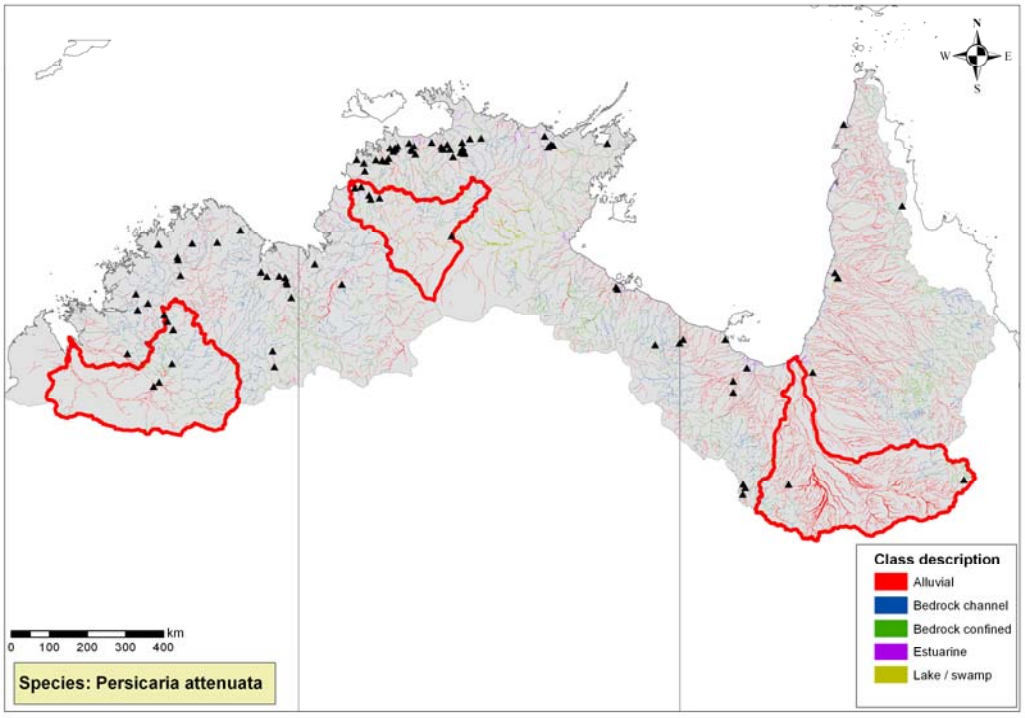

Figure 30. Distribution of *Persicaria attenuata* and geomorphology in the TRIAP study area.

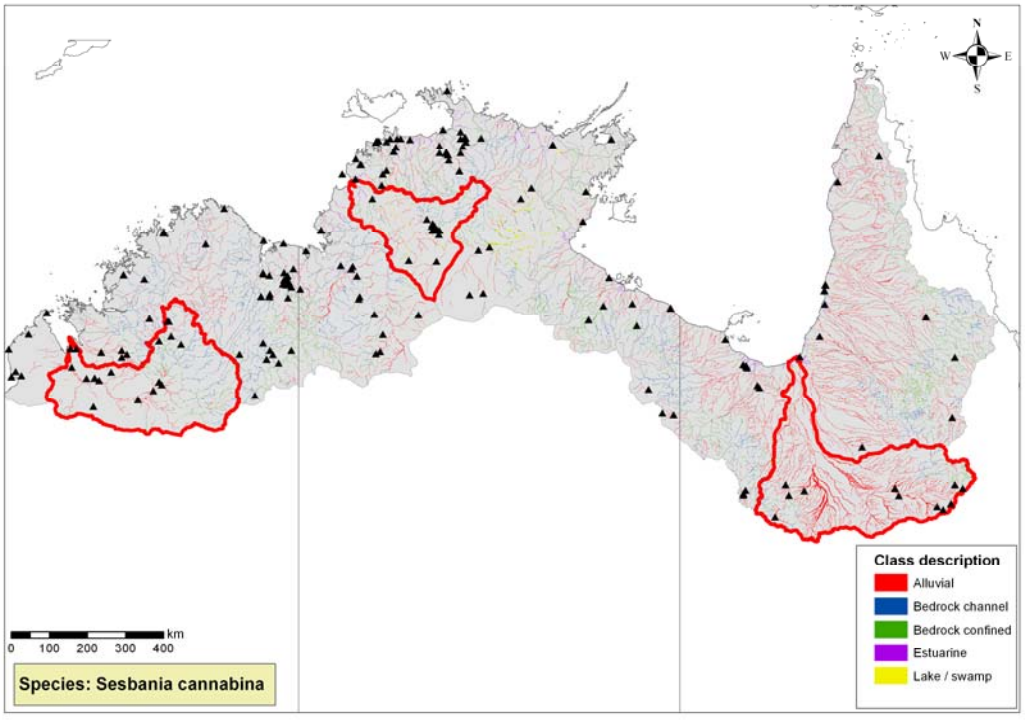

Figure 31. Distribution of *Sesbania cannabina* and geomorphology in the TRIAP study area.

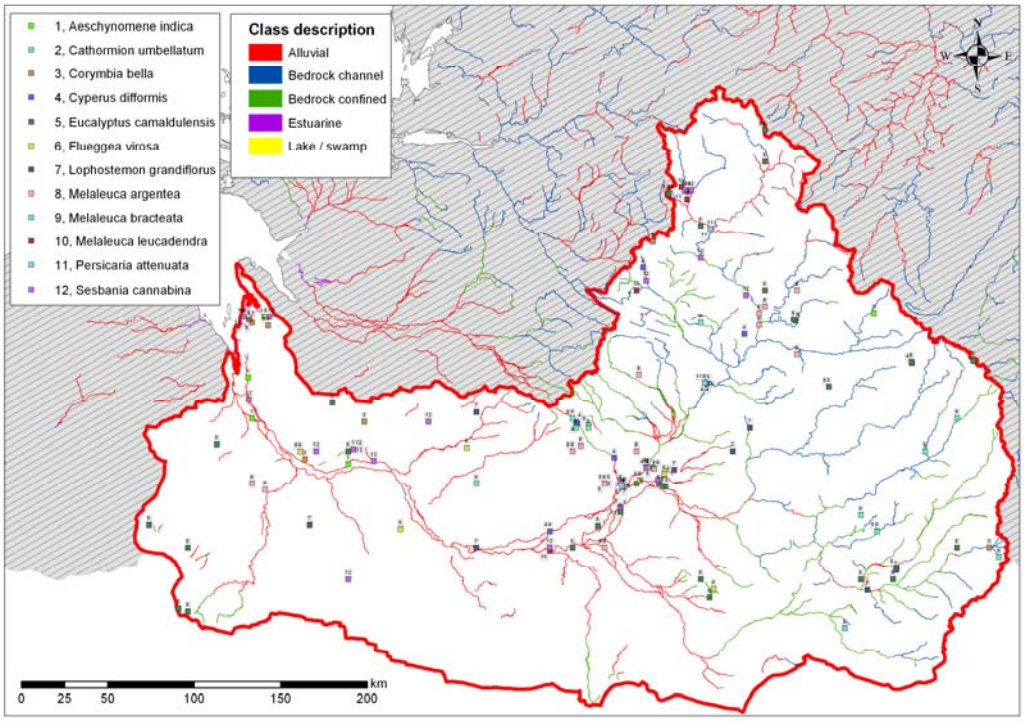

Figure 32. Distribution of the 12 co-occurring species and geomorphology in the Fitzroy River catchment.

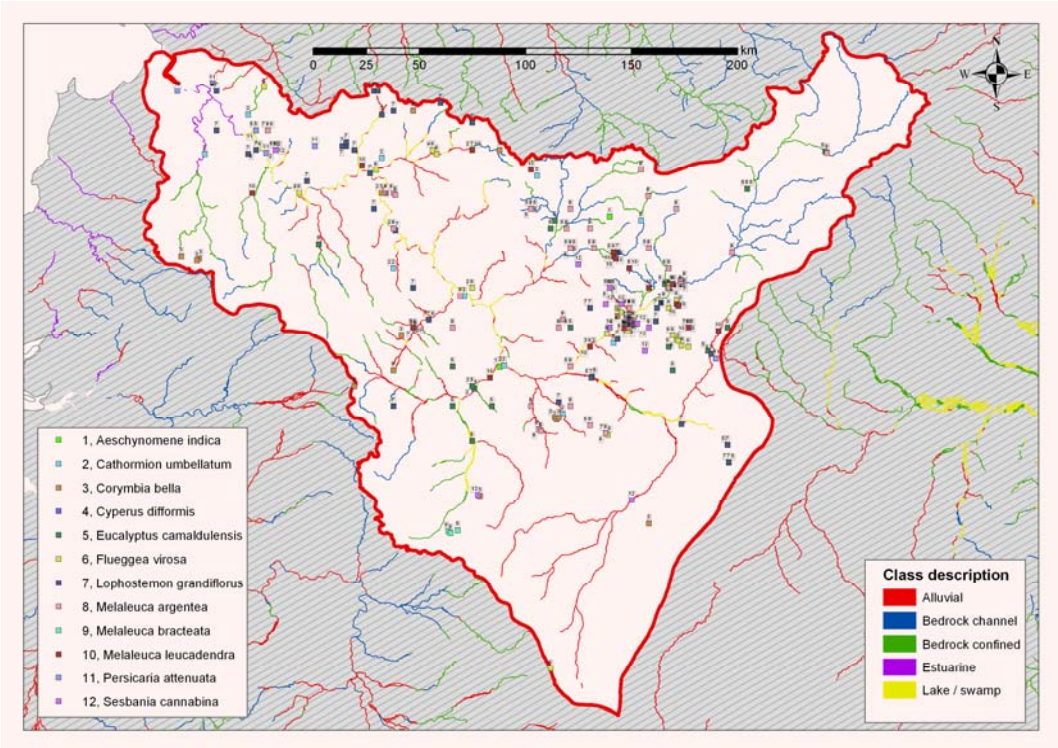

Figure 33. Distribution of the 12 co-occurring species and geomorphology in the Daly River catchment.

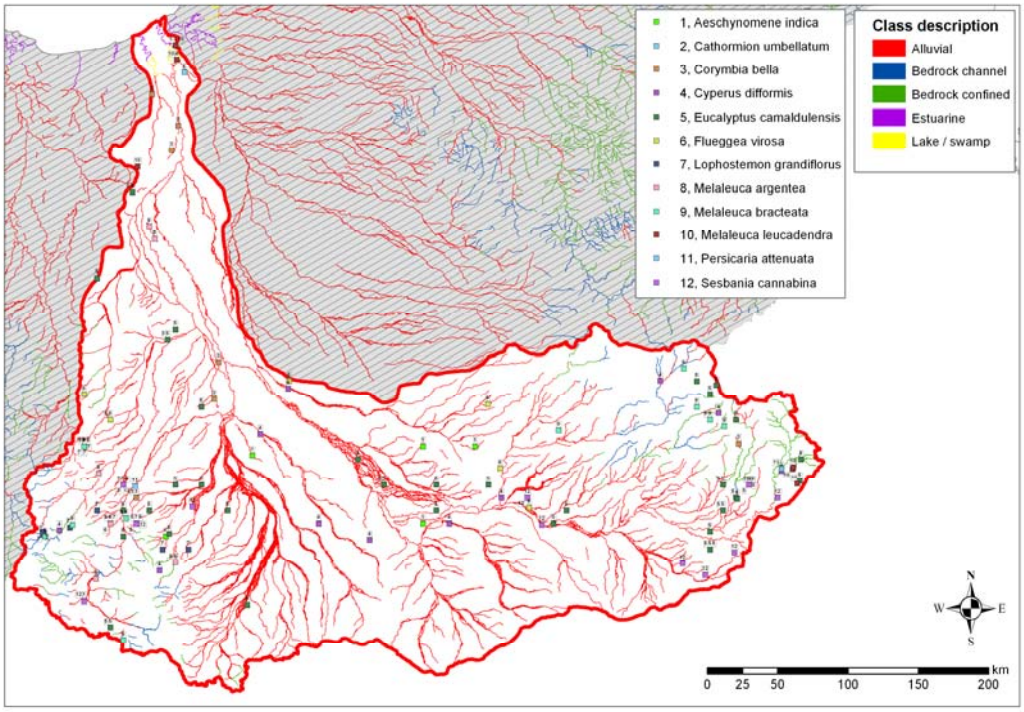

Figure 34. Distribution of the 12 co-occurring species and geomorphology in the Flinders River catchment.

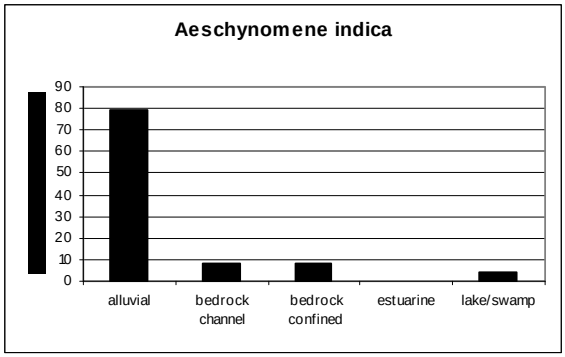

Figure 35: Percentage of population of *Aeschynomene indica* (based on herbarium records) occurring on geomorphological formations in the TRIAP focus catchments.

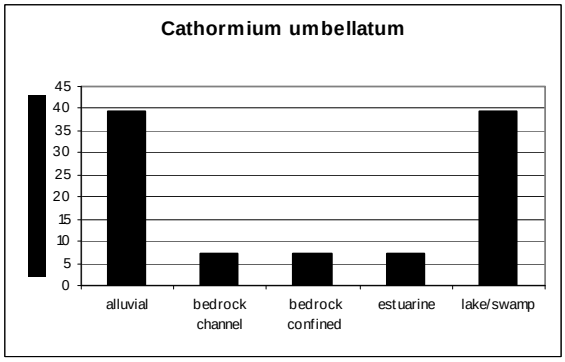

Figure 36: Percentage of population of *Cathormion umbellatum* (based on herbarium records) occurring on geomorphological formations in the TRIAP focus catchments.

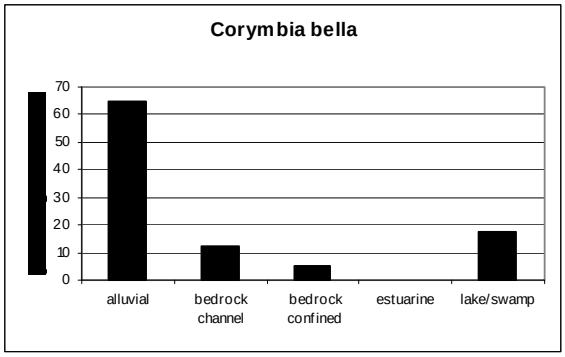

Figure 37: Percentage of population of *Corymbia bella* (based on herbarium records) occurring on geomorphological formations in the TRIAP focus catchments.

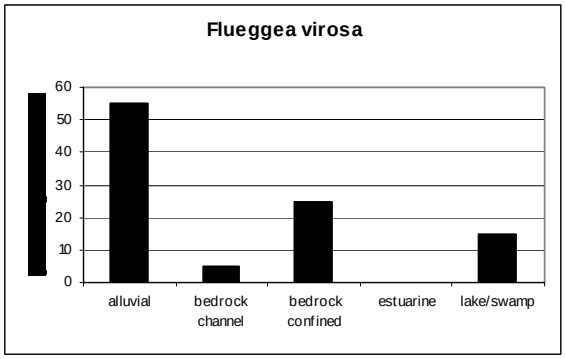

Figure 40: Percentage of population of *Flueggea virosa* (based on herbarium records) occurring on geomorphological formations in the TRIAP focus catchments.

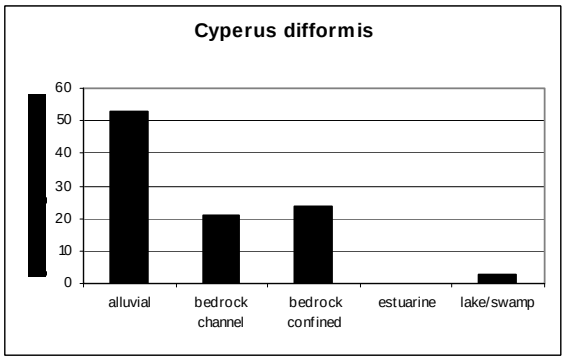

Figure 38: Percentage of population of *Cyperus difformis* (based on herbarium records) occurring on geomorphological formations in the TRIAP focus catchments.

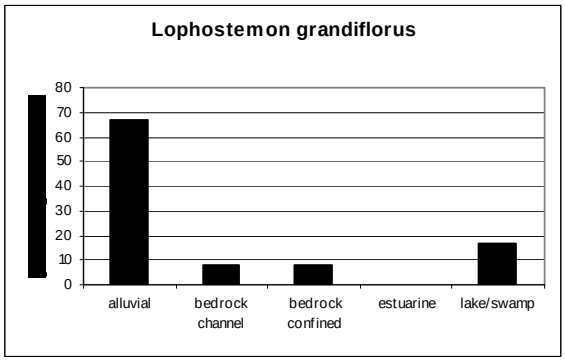

Figure 41: Percentage of population of *Lophostemon grandiflorus* (based on herbarium records) occurring on geomorphological formations in the TRIAP focus catchments.

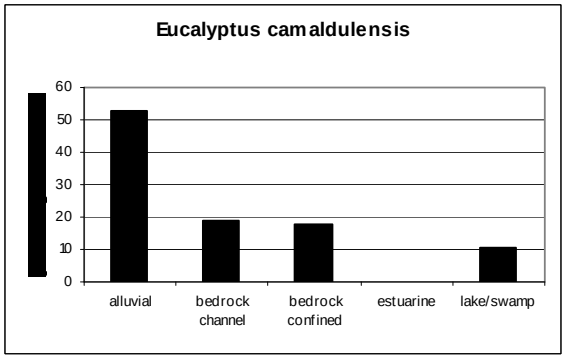

Figure 39: Percentage of population of *Eucalyptus camaldulensis* (based on herbarium records) occurring on geomorphological formations in the TRIAP focus catchments.

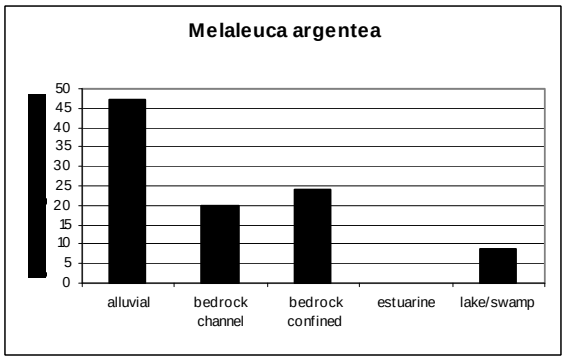

Figure 42: Percentage of population of *Melaleuca argentea* (based on herbarium records) occurring on geomorphological formations in the TRIAP focus catchments.

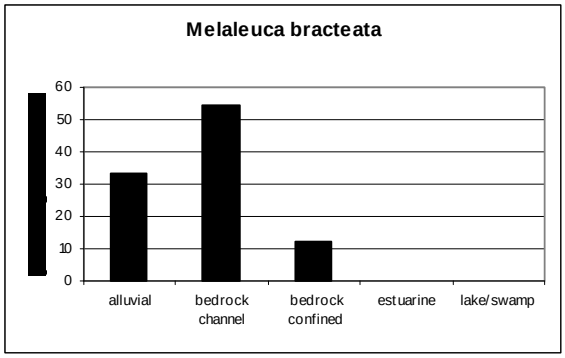

Figure 43: Percentage of population of *Melaleuca bracteata* (based on herbarium records) occurring on geomorphological formations in the TRIAP focus catchments.

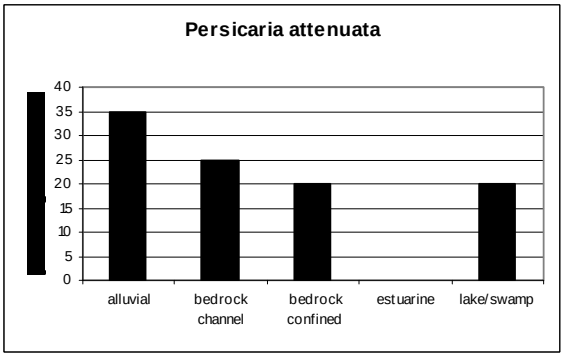

Figure 45: Percentage of population of *Persicaria attenuata* (based on herbarium records) occurring on geomorphological formations in the TRIAP focus catchments.

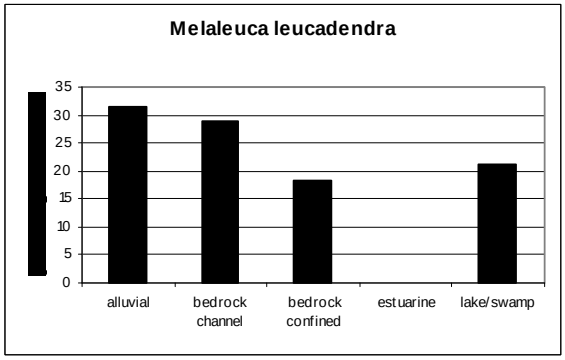

Figure 44: Percentage of population of *Melaleuca leucadendra* (based on herbarium records) occurring on geomorphological formations in the TRIAP focus catchments.

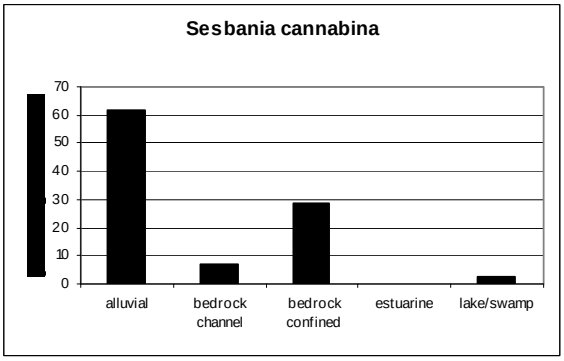

Figure 46: Percentage of population of *Sesbania cannabina* (based on herbarium records) occurring on geomorphological formations in the TRIAP focus catchments.

3.1 SUMMARIES OF RIPARIAN SPECIES THAT CO-OCCUR IN THE TRIAP FOCUS CATCHMENTS

3.1.1 *Aeschynomene indica* L. (Fabaceae)

Shrub to 1.5 m tall. Stems hairy, often viscid. Leaf compound, to 14.5 cm long; leaflets in 19-40 pairs, oblong, to 9 mm long, 2.6 mm wide, one main nerve, margin entire or sparsely serrulate. Inflorescence axillary or terminal, to 4 cm long. Corolla yellow, orange-red in centre, standard obovate. Pod to 45 mm long, pale brown, sparsely hairy; segments verrucose over seeds. Seeds dark brown to black, to 4 mm long, 3 mm wide.

Distribution and environmental preferences:

Widespread in most parts of tropical and arid Australia, except Victoria and Tasmania, otherwise pan-tropical and with closest relatives in South America. In the TRIAP region collections are remarkable evenly spread, but with some preference for areas away from the coast then inland throughout the catchments of most systems. The species tends to occur in drier areas, rainfall range 383-1151 mm per annum, with average rainfall at all recorded sites of 601 mm per annum. However, collections from the Daly Catchment (2 only) occur in high rainfall zones. Lithological preference is for sedimentary rocks in active floodplains and low lying coastal plains, and soils are predominantly grey-brown, saline and brown cracking clays. Geomorphological preference is predominantly for alluvial formations (79.2% of records), and secondarily for bedrock channel and bedrock confined (8.3% each), and lake/swamp (4.2%) formations.

3.1.2 *Cathormion umbellatum* (Vahl) Kosterm. var. *moniliforme* (DC.) Brummitt (Mimosaceae)

Shrub or tree to 10 m tall. Bark dark grey to black, forming plates. Leaf compound, to 9.3 cm long, leaflets in 1-3 pairs; leaflets obovate to elliptic, to 43 mm long, 27 mm wide, shiny above, dull to hairy below. Inflorescence axillary or rarely terminal, a many-flowered umbel, to 5 cm long. Calyx cylindrical, toothed, corolla deeply lobed to 5 mm long; stamens numerous to 12 mm long. Pods to 17 cm long, 2.5 cm wide, dark or rusty velvet. Seeds dark brown, oblong, to 12 mm long, 10 mm wide.

Distribution and environmental preferences: Widespread in coastal northern Australia, and also in Asia. In the TRIAP region collections are widespread, but with some preference for areas near the coast, particularly in the Gulf of Carpentaria and Top End areas. The species tends to occur in areas of relatively high rainfall, ranging 460-1436 mm per annum, with average rainfall at all recorded sites of 1069 mm per annum. There is a concentration of collections in the Daly River catchment [21 of the 23 focus catchment collections]. Lithological preference is for sedimentary rocks in flood plains and flat undulating plains, and soils are predominantly grey

clays and sandstone, limestone, shale and slate based. Geomorphological preference is equally predominant for alluvial and lake/swamp formations (39.3% of records), and secondarily for bedrock channel, bedrock confined and estuarine (7.1% each) formations.

3.1.3 *Corymbia bella* K.D.Hill & L.A.S.Johnson (Myrtaceae)

Tree to 30 m tall. Bark smooth, white, shedding in thin scales. Leaves (adult) disjunct, concolorous, linear to lanceolate, acuminate, 7-22 cm long, 6-25 mm wide; petiole 5-21 mm long; oil glands obscure. Inflorescences expanded, umbels 3-flowered; peduncle 2-4 mm long. Mature buds pyriform to clavate, 5-6 mm long, 4-5 mm diameter; calyptra ¼ to ⅓ as long as hypanthium, patelliform to shallowly hemispherical. Fruit ovoid, 8-11 mm long, 6-9 mm diameter.

Distribution and environmental preferences: Northern Australia. Endemic. In the TRIAP region collections are evenly spread with no apparent preference for either coastal or inlands locations. The species tends to occur in relatively wet areas, rainfall range 440-1352 mm per annum, with average rainfall at all recorded sites of 837 mm per annum. There were greater numbers of collections in the Daly and Flinders catchments than in the Fitzroy. Lithological preference is for sedimentary rocks, but also occurs on a variety of other types including mafic and felsic volcanics, and granites, in alluvial plains and gently sloping terrains, and soils are predominantly grey-brown cacking clays and sandstone, silkstone and limestone based. Geomorphological preference is predominantly for alluvial formations (65% of records), and secondarily for lake/swamp (17.5%), bedrock channel (12.5%) and bedrock confined (5%) formations.

3.1.4 *Cyperus difformis* L. (Cyperaceae)

Annual sedge to 50 cm tall. Roots reddish. Leaves drooping, 1-4 mm wide. Inflorescence with up to seven branches, each to 3.5 cm long. Bracts at the base of the inflorescence longer than the inflorescence. Flowers in roundish clusters, 7-17 mm diameter, spikelets dark coloured.

Distribution and environmental preferences: Widespread throughout Australia [except Tasmania], also in the Old World tropics. In the TRIAP region collections are scattered but with a bicentricity based on west/east focii, with some preference for areas away from the coast then inland throughout the catchments of most systems. The species tends to occur in relatively wetter areas, rainfall range 429-1423 mm per annum, with average rainfall at all recorded sites of 641 mm per annum. The species is much less common in the Top End and Daly River catchment than other locations. Lithological preference is for sedimentary rocks in active floodplains and gently sloping plains, and soils are predominantly basaltic or grey and grey-brown clays. Geomorphological preference is predominantly for alluvial formations (52.6% of records), and

secondarily for bedrock confined (23.7%), bedrock channel (21.1%) and lake/swamp (2.6%) formations.

3.1.5 *Eucalyptus camaldulensis* Dehnh. (Myrtaceae)

Tree to 20 m tall. Bark smooth, white to pale grey, shedding in sheets. Leaves (adult) alternate, smooth, narrow, lanceolate, 10-25 cm long, 1-3.5 cm wide, green on both side, acuminate, finely veined. Inflorescences in leaf axils. Flowers small, cream, in clusters of 5-10; calyptra prominently pointed. Fruit cup-shaped, 0.5-0.6 cm long, 0.5-0.7 cm wide, woody, with prominent protruding triangular valves.

Distribution and environmental preferences: Throughout mainland Australia. Endemic. In the TRIAP region collections are evenly spread, but with some preference for areas away from the coast and predominantly inland throughout the catchments of most systems. The species tends to occur in both the driest and wettest areas within the TRIAP, rainfall range 376-1436 mm per annum, with average rainfall at all recorded sites of 761 mm per annum. Lithological preference is for sedimentary rocks but also on granites, mafic and felsic volcanics, amphibolites and dolerites in undulating and flat plains, and soils are predominantly granitic, sandstone, siltstone and limestone based, and clays. Geomorphological preference is predominantly for alluvial formations (52.8% of records), and secondarily for bedrock channel (19%), bedrock confined (17.6%) and lake/swamp (10.6%) formations.

3.1.6 *Flueggea virosa* (Willd.) Voigt (Euphorbiaceae) (*Phyllanthus virosus* Willd.)

Dioecious spreading shrub to 2 m tall. Bark smooth, light brown to grey. Leaves simple, alternate, ovate, smooth, 3.5-8.5 cm long by 2.5-5.5 cm wide, light green above, lighter green below, venation prominent, apex acuminate. Flowers in small clusters in leaf axils, about 1-2 mm long, cream. Fruit a globose fleshy berry, 5-8 mm diameter, white at maturity, with 3-4 seeds.

Distribution and environmental preferences: Northern Australia and New Guinea. In the TRIAP region collections are evenly spread, but with no apparent preference for coastal or inland locations. The species tends to occur in some of the wettest areas in the TRIAP, rainfall range 442-1456 mm per annum, with average rainfall at all recorded sites of 857 mm per annum. Lithological preference is for sedimentary rocks as well as granites, felsic and mafic volcanics and amphibolites in flat, gently sloping and undulating plains, and hilly ranges, and soils are predominantly sandstone, siltstone, greywacke and limestone based, and loamy red earths. Geomorphological preference is predominantly for alluvial formations (55% of records), and

secondarily for bedrock confined (25%), lake/swamp (15%) and bedrock channel (5%) formations.

3.1.7 *Lophostemon grandiflorus spp. riparius* (Benth.) Peter G.Wilson & J.T.Waterh. (Myrtaceae) (*Tristania suaveolens var. grandiflora* Benth.)

Tree to 18 m tall. Bark rough, hard, dark grey to black, fibrous, finely fissured. Leaves simple, alternate, smooth or finely hairy, ovate to oblong, tapered to the base, 8-15.5 cm long, 3.5-5 cm wide, grey green above, paler whitish green below, midrib yellowish, apex rounded. Flowers in leaf axis, in small clusters on short pedicels, small, greenish cream with feathery stamens, about 1 cm across. Fruit a cup-shaped capsule, 5-8 mm long, 5-10 mm wide, toothed around the rim, brown at maturity; seeds numerous, fine.

Distribution and environmental preferences: Northern Australia. Endemic. In the TRIAP region collections are evenly spread, but with some preference for areas away from the coast then predominantly inland throughout the catchments of most systems. The species tends to occur in wetter locations, rainfall range 414-1442 mm per annum, with average rainfall at all recorded sites of 1106 mm per annum. The species is a dominant element in the Daly River catchment. Lithological preference is for sedimentary rocks and also granites, mafic and felsic volcanics and amphibolites on floodplains and gently sloping to undulating plains, and soils are predominantly sandstone, siltstone and limestone based, and grey clays. Geomorphological preference is predominantly for alluvial formations (66.7% of records), and secondarily for lake/swamp (16.7%) and bedrock channel and bedrock confined (8.3% each) formations.

3.1.8 *Melaleuca argentea* W.Fitz. (Myrtaceae)

Spreading tree to 20 m tall. Branchlets slender and pendulous. Bark papery, creamy white to grey, soft, layered. Leaves simple, alternate, 5-14 cm long, 1-2 cm wide, narrow elliptic, tapering to both ends, silvery silky when young, aging silvery grey green, 3-5 main longitudinal veins, apex pointed; petiole about 1 cm long. Inflorescences in leaf axils or terminal, cylindrical spikes 5-12 cm long, single or in groups of up to 4. Flowers in clusters along the inflorescence axis, pedicels very short, cream to greenish cream, 12-15 mm long, stamens numerous. Fruit cup-shaped woody capsule, pedicel lacking, 2-4 mm long, 2-4 mm wide, clustered along the inflorescence axis, grey brown when mature; seeds very fine, numerous.

Distribution and environmental preferences: Northern Australia. Endemic. In the TRIAP region collections are more common in Western Australia and Northern Territory than in Queensland, and most predominant in the larger river basins. There is a preference for areas away from the coast, but otherwise is relatively evenly spread throughout most catchments. The

species tends to occur in dry to only moderately wet locations, rainfall range 388-1240 mm per annum, with average rainfall at all recorded sites of 484 mm per annum. The species is one of the dominant elements in the Daly River catchment. Lithological preference is for sedimentary rocks and also felsic and mafic volcanics, granites, and amphibolites in hilly areas and flat to undulating plains, and soils are predominantly greywacke, sandstone, siltstone and limestone based. Geomorphological preference is predominantly for alluvial formations (47% of records), and secondarily for bedrock confined (24%), bedrock channel (20%) and lake/swamp (9%) formations.

3.1.9 *Melaleuca bracteata* F.Muell. (Myrtaceae)

Shrub or tree to 15 m tall. Bark hard, dark, and fissured. Young branches hairy. Leaves scattered, narrow ovate to ovate, 5-28 mm long, often twisted, acute to acuminate; petiole absent. Inflorescences open or dense spikes, terminal or near terminal or in leaf axils. Flowers solitary or in triads; calyx hemispherical, cup-shaped or globose, 1-2 mm long, 1-2 mm wide, pubescent; petals white, nearly circular, 1.5-2 mm long, deciduous; stamens 16-25, white, glabrous; style 7-8 mm long, glabrous; stigma small. Fruit cup-shaped, 2-2.5 mm long, 2.5-3 mm wide; orifice 2-2.5 mm wide.

Distribution and environmental preferences: Widespread throughout central and eastern mainland Australia, except Victoria, and not in the Top End or far northern Cape York Peninsula. Endemic. In the TRIAP region collections display a bicentricity in Western Australia and Queensland, are relatively disjunctly distributed, and with strong preference to the upper reaches of river systems away from the coast. The species tends to occur in the driest areas within the catchments, rainfall range 411-818 mm per annum, with average rainfall at all recorded sites of 558 mm per annum. Lithological preference is for sedimentary rocks, mafic volcanics, granites and amphibolites in gently undulating plains and some mountainous areas, and soils are granite and basalt based grey-brown clays, stony sandy soils, sandy red earths and loamy red earths. Geomorphological preference is predominantly for bedrock channel formations (54.2% of records), and secondarily for alluvial (33.3%) and bedrock confined (12.5%) formations.

3.1.10 *Melaleuca leucadendra* (L.) L. (Myrtaceae)

Spreading tree to 30 m tall. Branchlets slender and pendulous. Bark papery, creamy white to grey, soft, layered. Leaves simple, alternate, smooth, 7-18.5 cm long, 1-2.5 cm wide, narrow ovate, widest at or below the middle, tapered to a pointed apex, 5-6 main longitudinal veins; petiole 1-2 cm long. Inflorescences in leaf axils or terminal, cylindrical spikes 7-16 cm long, single or in groups of up to 3. Flowers in clusters along the inflorescence axis, pedicels very short, white or

cream to greenish cream, 10-15 mm long, stamens numerous. Fruit cup-shaped woody capsule, pedicel lacking, 3-4 mm long, 3-5 mm wide, clustered along the inflorescence axis, brown when mature; seeds very fine, numerous.

Distribution and environmental preferences: Northern Australia, New Guinea and the Moluccas. In the TRIAP region collections are unevenly spread with focii of distribution in the Gregory River, Alligator Rivers, Daly River and Ord River catchments, but otherwise scattered and with preference for subcoastal and inland locations. The species tends to occur in the wetter areas, rainfall range 495-1436 mm per annum, with average rainfall at all recorded sites of 696mm per annum. Lithological preference is for sedimentary rocks, and mafic and felsic volcanics in gently sloping to undulating terrain, hilly ranges, and floodplains with billabongs, and soils are greywacke, siltstone, sandstone, and limestone based, and grey clays. Geomorphological preference is predominantly for alluvial formations (31.6% of records), and secondarily for bedrock channel (28.9%), lake/swamp (21.1%) and bedrock confined (18.4%) formations.

3.1.11 *Persicaria attenuata* (R.Br.) Sojak (Polygonaceae) [*Polygonum attenuatum* R.Br.]

Erect or trailing perennial herb or shrub to 1.5 m tall, with trailing branches to 3 m long, stems jointed. Leaves simple, narrowly ovate, acuminate, 5-20 cm long, 1.5-4.5 cm wide, both surfaces densely pubescent; petiole lacking or to no more than 3 cm long. Inflorescence of 2-4 pseudo-spikes, each 3-13 cm long. Flowers 3-5 mm long, white or greenish. Nut lenticelular, 2.5-3 mm long, dark reddish brown, shiny.

Distribution and environmental preferences: Throughout most of Australia (except Victoria and Tasmania), New Guinea and Timor. In the TRIAP region collections are focussed in the Northern Territory and Western Australia, with preference for coastal lowland locations in the former, and for inland upland locations in the latter. The species tends to occur in wetter areas, rainfall range 443-1445 mm per annum, with average rainfall at all recorded sites of 496 mm per annum. Lithological preference is for sedimentary rocks, mafic volcanics and granites in gently undulating plains, and soils are predominantly sandstone based. Geomorphological preference is predominantly for alluvial formations (35% of records), and secondarily for bedrock channel (25%), and bedrock confined and lake/swamp (20% each) formations.

3.1.12 *Sesbania cannabina* (Retz.) Pers. (Fabaceae)

Annual shrub to 2.5 m tall. Stem erect, with branches to 35 cm long. Leaves compound; leaflets in 5-36 pairs, discolorous, narrowly oblong, 7-29 mm long, 2-5.5 mm wide; apices acute.

Inflorescences axillary racemes, 1.6 – 8 cm long, with 2-9 flowers; pedicels 3.5-8 mm long; calyx 3-6 mm long; corolla with yellow standard streaked or spotted purple, 9-12 mm long, orbicular. Pod sessile, to 24 cm long, 2-4 mm wide; seeds 23-40, brown or olivaceous, flattened oblong, 3-3.2 mm long, 1.6-2 mm wide.

Distribution and environmental preferences: Throughout most of Australia (except Victoria and Tasmania), and the Old World tropics. In the TRIAP region collections are focussed in Western Australia and Northern Territory, with preference for inland upland locations in the former, and for coastal lowland locations in the latter. In Queensland distribution tends to be either coastal or in the upper reaches of river systems. The species tends to occur in wetter areas, rainfall range 443-1445 mm per annum, with average rainfall at all recorded sites of 1313 mm per annum. Lithological preference is for sedimentary rocks, mafic volcanics, granites and amphibolites in active floodplains, low lying coastal plains, flat to undulating plains, and soils are sandstone, siltstone and limestone based grey-brown and saline clays. Geomorphological preference is predominantly for alluvial formations (61.9% of records), and secondarily for bedrock confined (28.6%), bedrock channel (7.1%) and lake/swamp (2.4%) formations.

3.2 VEGETATION ASSOCIATIONS

3.2.1 Vegetation associations in all catchments

Nineteen vegetation associations were recognized in the 51 TRIAP catchments, based on the methodology described above. This methodology applied narrow parameters to the vegetation associations, so that many are differentiated on the presence/absence of only a single species, namely the five most common trees recorded in the riparian zone- *Eucalyptus camaldulensis*, *Callistemon viminalis*, *Corymbia bella*, *Casuarina cunninghamiana* and *Lophostemon grandiflorus*. Conversely, there are some species, at least designated as part of the functional group '*Melaleuca* large-leaf species' (*Mmelaleuca leucadendra*, *M. argentea*, *M. fluviatilis*) that occur in all 19 vegetation associations. The vegetation associations and the number of catchments in which they occur are presented in Fig. 47.

3.2.2 Vegetation associations in the focus catchments

Vegetation in the three focus catchments was studied in more detail than the non-focus catchments. The distribution data of the dominant functional tree species were aligned with environmental data. There were no significant relationships detected between distribution of the vegetation associations and factors such as rainfall, geomorphology or lithology. However, the

most meaningful relationship was between distribution and elevation, i.e., certain species very often fell within certain elevational ranges. From these data, a model to predict vegetation associations on the catchment scale was developed, and presented in Table 5.

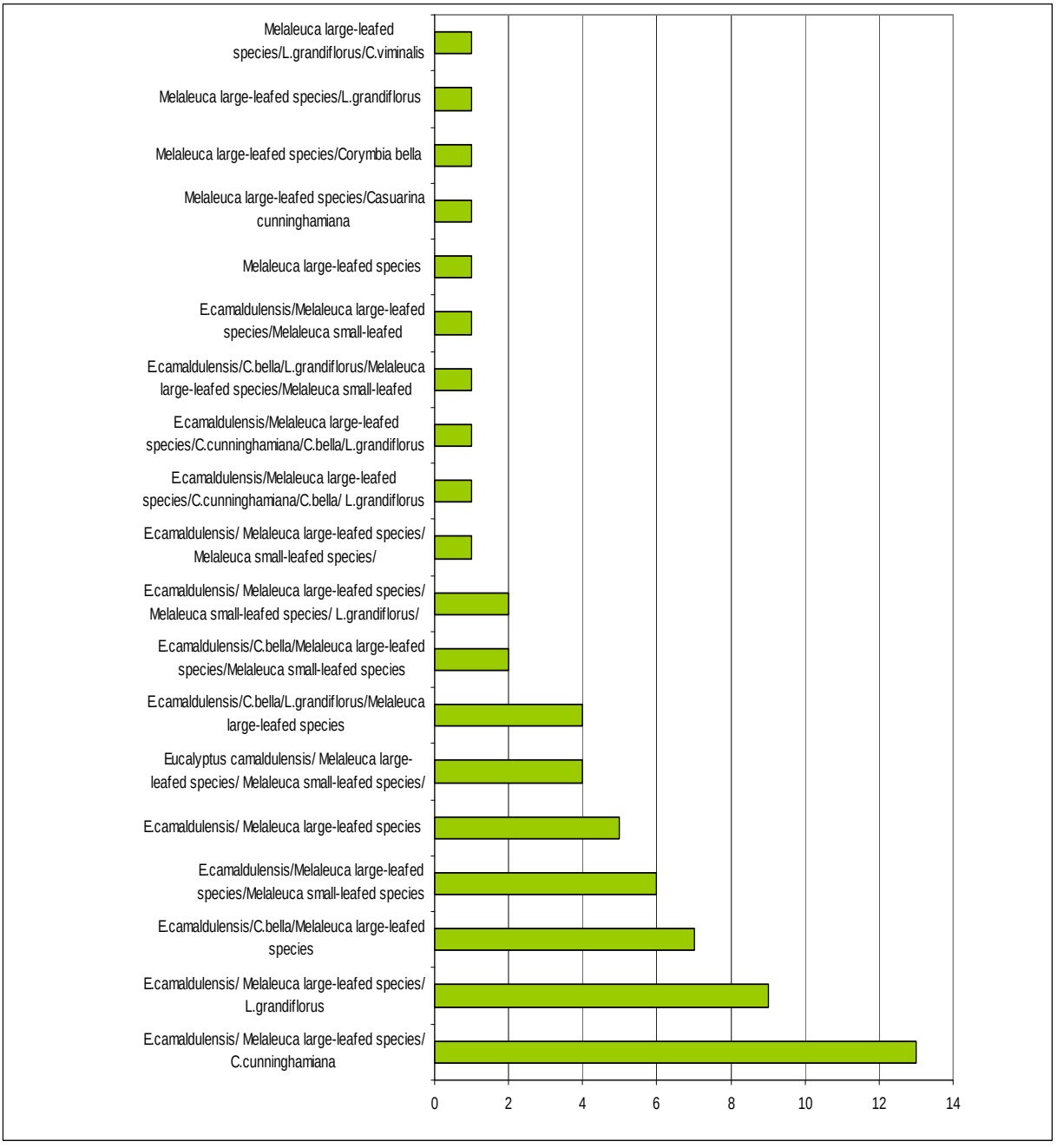

Figure 47. Vegetation associations and the number of catchments in which they occur.

Table 5. Vegetation associations predicted for the three TRIAP focus catchments, based on distribution records and elevation. The distribution of the vegetation associations is plotted on maps in Figures 48-50.

Flinders River	
Elevation in m	***Vegetation classification***
0-99	Eucalyptus camaldulensis/Corymbia bella/Melaleuca large-leafed species
100-199	Eucalyptus camaldulensis/Corymbia bella/Lophostemon grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species
200-299	Eucalyptus camaldulensis/Lophostemon grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species
300-399	Eucalyptus camaldulensis/Casuarina cunninghamiana/Lophostemon grandiflorus/Melaleuca large-leafed species/Melaleuca small-leaved species
400-900	Eucalyptus camaldulensis/Melaleuca large-leafed species/Melaleuca small-leafed species

Fitzroy River	
Elevation in m	***Vegetation classification***
0-99	Eucalyptus camaldulensis/Corymbia bella/Lophostemon grandiflorus/Melaleuca large-leafed species
100-299	Eucalyptus camaldulensis/Lophostemon grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species
300-399	Eucalyptus camaldulensis/Melaleuca large-leafed species/Melaleuca small-leafed species
400-499	Eucalyptus camaldulensis/Corymbia bella/Melaleuca large-leafed species/Melaleuca small-leafed species
500-900	Eucalyptus camaldulensis/Melaleuca large-leafed species

Daly River	
Elevation in m	***Vegetation classification***
0-99	Eucalyptus camaldulensis/Melaleuca large-leafed species/Casuarina cunninghamiana/Corymbia bella/ Lophostemon grandiflorus
100-199	Eucalyptus camaldulensis/Melaleuca large-leafed species/Melaleuca small-leafed species/Casuarina cunninghamiana/Corymbia bella/Lophostemon grandiflorus
200-454	Eucalyptus camaldulensis/Melaleuca large-leafed species/Casuarina cunninghamiana/Corymbia bella/Lophostemon grandiflorus

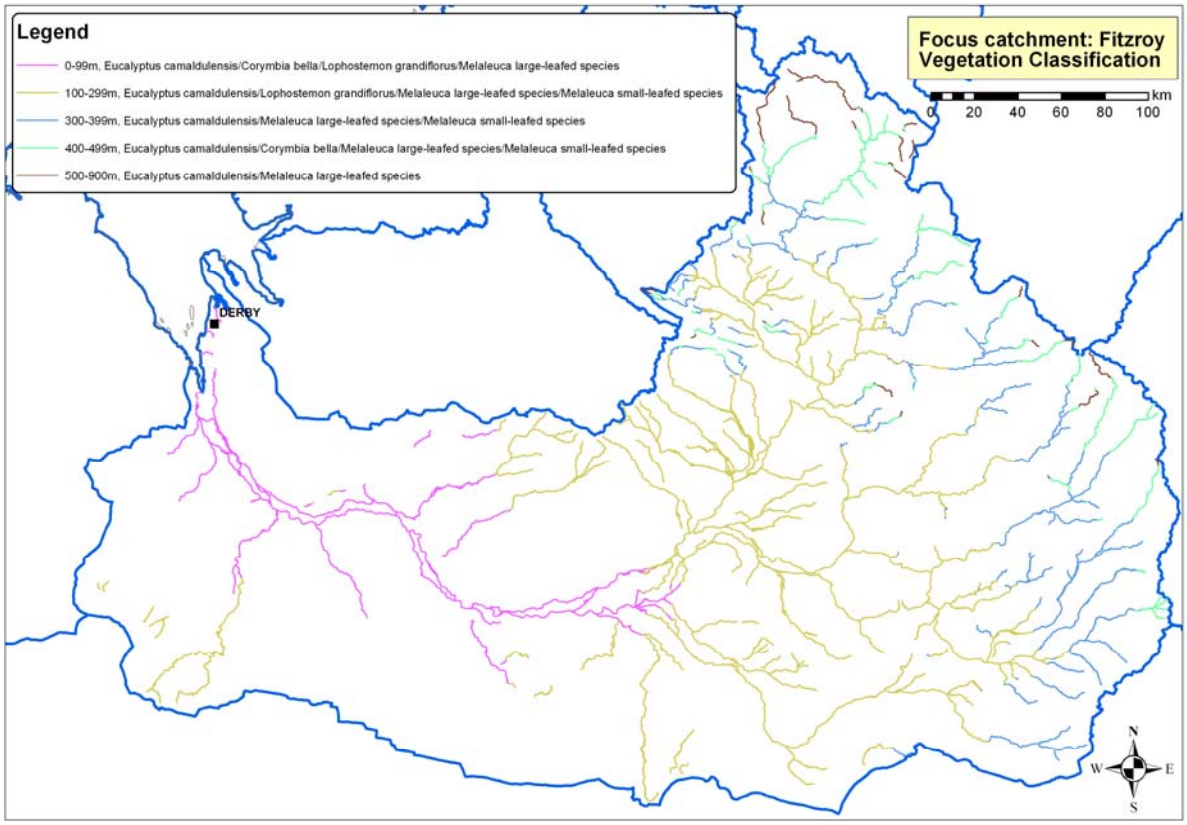

Figure 48. Fitzroy River catchment with predicted vegetation associations indicated.

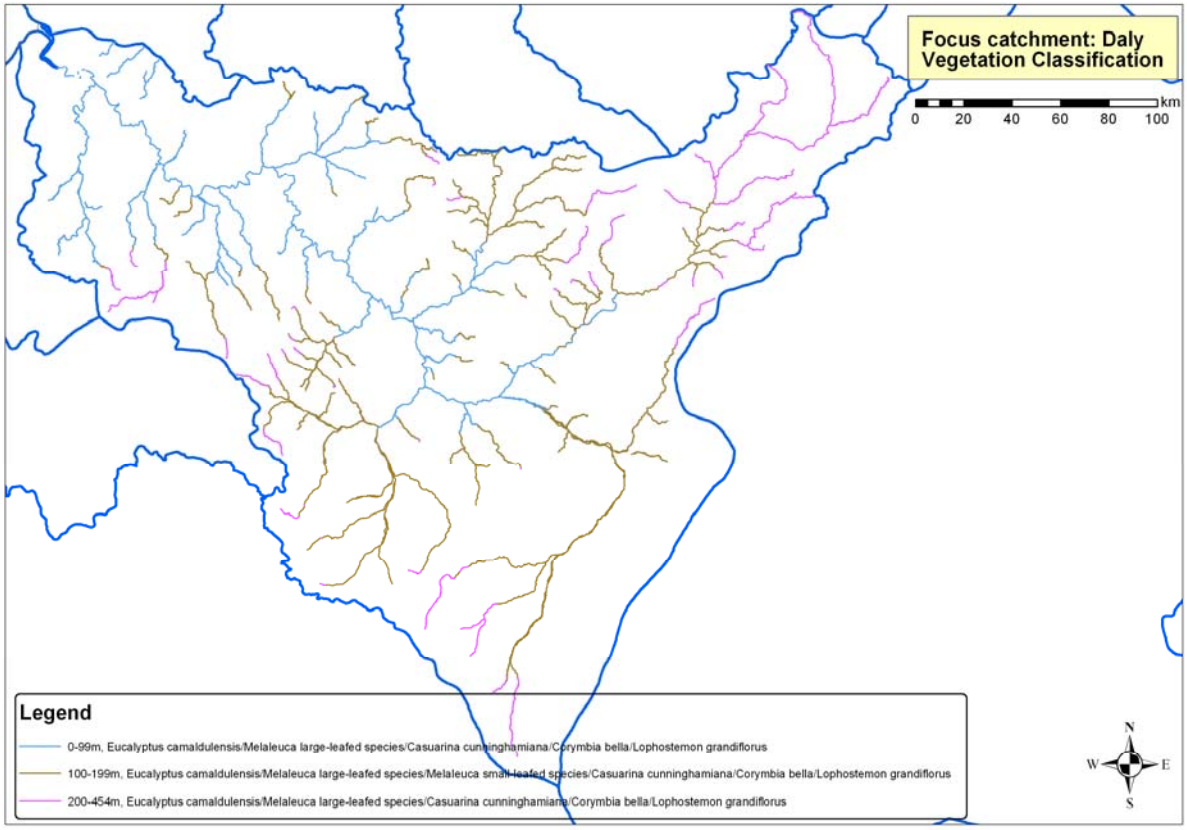

Figure 49. Daly River catchment with predicted vegetation associations indicated.

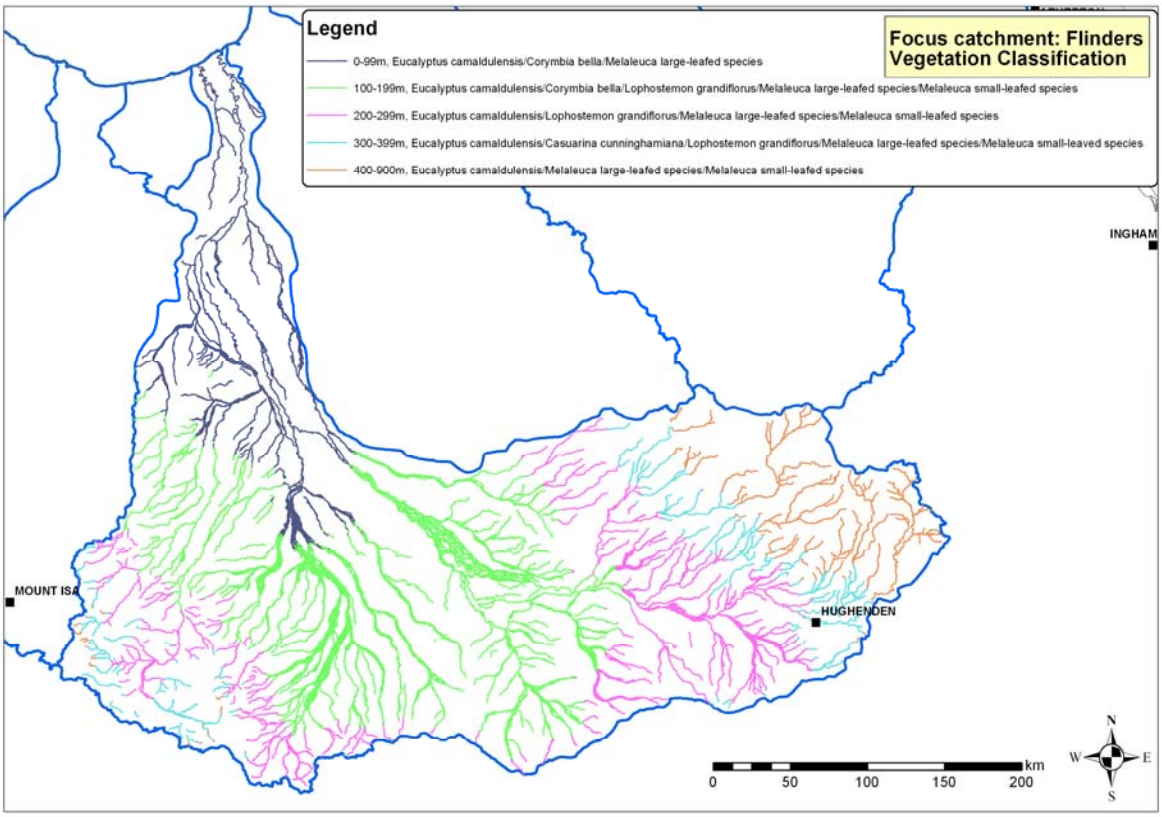

Figure 50. Flinders River catchment with predicted vegetation associations indicated.

3.2.3 Testing the predicted vegetation associations in the Flinders River catchment

Methodology: The composition of the riparian vegetation was studied at 28 sites in the Flinders River catchment (Table 6). The data obtained allowed comparisons between the predicted vegetation association and the actual vegetation association at each site. The 28 sites, with the predicted vegetation association and the actual dominant tree species recorded at the site, are listed in Table 7.

Results: Of the 28 sites, there were two (7%) that did not contained any of the species within the predicted vegetation associations. Eleven sites (40%) had a poor relationship, 13 sites (46%) had a good relationship and two sites (75%) had an very good relationship.

Discussion: From these results, it can be concluded that the method of predicting vegetation associations is reliable in only 54% of sites within the Flinders River catchment. Whether this same rate would apply to other catchments is not known.

Table 6. Sites in the Flinders River Catchment where riparian vegetation was documented.

Site	GPS position
Betts Ck down	S20. 40' 39.1", E144. 05' 04.2"
Betts Ck up	S20. 40' 45.4", E144. 07' 30.5"
Canterbury Ck	S20. 42' 15.1", E144. 11' 44.4"
Cloncurry R	S20. 40' 58.7", E140. 29' 40.4"
Corella R	S20. 26' 24.0", E140. 19' 00.5"
Desolation Ck	S20. 32' 18.1", E143. 58' 17.8"
Double Barrel Ck	S20. 37' 49.3", E143. 04' 00.3"
Dugald R	S20. 12' 08.8", E140. 14' 14.0"
Dutton R	S20. 12' 42.3", E144. 19" 03.9"
Dutton R homestead	S20. 27' 29.1", E143. 46' 50.8"
Flinders R	S20. 44' 38.4", E143. 40' 58.9"
Flinders R Hughenden	S20. 45' 25.9", E144. 28' 54.7"
Flinders R Maxwellton	S20. 38' 34.0", E142. 37' 35.8"
Flinders R Nelia	S20. 32' 29.1", E142. 15' 18.0"
Flinders R Richmond	S20. 42' 03.0", E143. 08' 07.8"
Fullerton R	S20. 37' 42.3", E141. 09' 55.4"
Gallah Ck	S20. 47' 01.5", E144. 12' 52.1"
Gorge Ck	S20. 22' 36.4", E144. 24' 51.9"
Julia Ck	S20. 23' 54.2", E141. 38' 47.2"
Pine Tree Ck	S20. 01' 52.5", E144. 18' 08.2"
Poison Ck	S19. 56' 18.2", E144. 15' 59.9"
Porcupine Ck	S20. 36' 45.1", E144. 24' 11.7'
Porcupine Gorge Pyramid	S20. 20' 49.6", E144. 27' 36.2"
Sawpit Ck	S20. 39' 00.6", E143. 41' 12.7"
Soda Ck	S20. 28' 52.3", E143. 55. 48.4"
Spring Valley Ck	S20. 35' 31.1", E143. 57' 55.2"
Stawell R	S20. 25' 38.4", E142. 55' 13.1"
Williams R	20. 38' 16.6", E140. 57' 33.3"

Table 7. Sites in the Flinders River catchment, with the predicted vegetation association, the actual vegetation present and a summary of reliability based on number of species in common.

Site	Predicted vegetation	Actual vegetation	# sp in common	Total # spp
Betts Ck down	E.camaldulensis/L.grandiflorus/ Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis/Melaleuca small-leafed species	2	4
Betts Ck up	E.camaldulensis/C.cunninghamiana/ L.grandiflorus/Melaleuca large-leafed species/ Melaleuca small-leaved species	E.camaldulensis/Melaleuca small-leafed species	2	5
Canterbury Ck	E.camaldulensis/C.cunninghamiana/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leaved	C.bella	0	5
Cloncurry R	E.camaldulensis/C.bella/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	Melaleuca large-leafed species	1	5
Corella R	E.camaldulensis/C.bella/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis/Melaleuca large-leafed species	2	5
Desolation Ck	E.camaldulensis/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis	1	5
Double Barrel Ck	E.camaldulensis/C.bella/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	C.bella	1	5
Dugald R	E.camaldulensis/C.bella/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis/Melaleuca small-leafed species	2	5
Dutton R	E.camaldulensis/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis	1	5
Dutton R homestead	E.camaldulensis/C.cunninghamiana/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leaved species	E.camaldulensis	1	5
Flinders R	E.camaldulensis/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis/Melaleuca large-leafed species/Melaleuca small-leafed species	2	5
Flinders R Hughenden	E.camaldulensis/C.cunninghamiana/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leaved species	E.camaldulensis	2	5
Flinders R Maxwellton	E.camaldulensis/C.bella/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis/Melaleuca large-leafed species	2	5
Flinders R Nelia	E.camaldulensis/C.bella/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis/C.bella	3	5
Flinders R Richmond	E.camaldulensis/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis/Melaleuca large-leafed species	2	5
Fullerton R	E.camaldulensis/C.bella/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis/C.bella	2	5
Gallah Ck	E.camaldulensis/C.cunninghamiana/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leaved species	E.camaldulensis/Melaleuca small-leafed species	2	5

Gorge Ck	E.camaldulensis/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis/Melaleuca small-leafed species	2	3
Julia Ck	E.camaldulensis/C.bella/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	C.bella	1	5
Pine Tree Ck	E.camaldulensis/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis	1	3
Poison Ck	E.camaldulensis/Melaleuca large-leafed species/Melaleuca small-leafed species		0	3
Porcupine Ck	E.camaldulensis/C.cunninghamiana/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leaved species	E.camaldulensis	1	5
Porcupine Gorge Pyramid	E.camaldulensis/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis/C.cunninghamiana	1	3
Sawpit Ck	E.camaldulensis/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis	1	4
Soda Ck	E.camaldulensis/C.cunninghamiana/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leaved species	E.camaldulensis	1	5
Spring Valley Ck	E.camaldulensis/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	Melaleuca small-leafed species	1	5
Stawell R	E.camaldulensis/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis/Melaleuca large-leafed species	2	4
Williams R	E.camaldulensis/C.bella/L.grandiflorus/Melaleuca large-leafed species/Melaleuca small-leafed species	E.camaldulensis	1	5

4 DISCUSSION

Perhaps the most unusual result of this assessment, based on available data, is the relatively small number of plant species that occur strictly within the riparian zone [here termed obligate riparian species] in the seasonally dry tropical rivers of northern Australia. This assessment contrasts with the greater diversity of riparian vegetation in areas such as the wet regions of northeastern Queensland and Tasmania for example, and also for river systems in seasonally dry climates in South America. If appears that a low level of species diversity, but a high level of individual species coverage, is a feature of the river systems in seasonally dry tropical Australia. Of the 263 species recognized as occurring in the riparian zone in this study, only 23 were obligate riparian species. Of these 23 species, 12 were recorded from all three focus catchments, thus indicating that these at least are widespread species, whilst the remaining 11 have a more restricted distribution.

Analysis of the 12 co-occurring species indicated that they indeed vary considerably amongst themselves as to their adaptation to either a broad or narrow range of environmental conditions, and some are indeed most common in, or restricted to, certain rainfall regimes, geomorphological formations and lithologies. For example some species [*Cathormion umbellatum*, *Melaleuca leucadendra*, *Lophostemon grandiflorus* and *Persicaria attenuata*] are most common in high rainfall areas greater that 900 mm per annum within the catchments, whilst other species [*Aeschynomene indica*, *Melaleuca bracteata* and *Cyperus difformis*] are most common in drier parts with rainfall less than 700 mm per annum. Rainfall has some constraint on distribution of riparian species, but overall the parameters of a rainfall regime with respect to species distribution is not reliable in predicting distribution.

In a broad sense, the lithologies of the three focus catchments are not significantly different from each other, although there are some unique associations within each catchment. The distribution of the 12 co-occurring species, in most cases, follows the same or similar lithological associations in each focus catchment, where the lithological association occurs in each catchment. However, where those species that are most commonly distributed on sedimentary rocks occur, there may be rarer lithologies, such as dolerites and gabbros in the Fitzroy catchment and granites in the Daly and Flinders catchments, where the same species may also occur. Sedimentary formations were by far the most common lithologies on which riparian species occurred, which is not unusual considering that these are the primary formations associated with rivers and watercourses. It can be concluded that lithology is among the major constraints on distribution of riparian species.

Although the resolution of species distribution and soil types is relatively coarse based on the methods adopted here, some general assessment came be presented. Species varied greatly as to their preference for soil types and adaptability to many soil types. For example, widespread species such as *Eucalyptus camaldulensis* occurred on 56 soil types and was predominant on 11

of those types; *Lophostemon grandiflorus* occurred on 32 soils types and predominant on 8 of those types; and *Sebania cannabina* occurred on 27 soil types and was predominant on six of those types: these are examples of species that occurred on a broad range of soil types and were more or less not largely confined to single or few soil types and therefore categorized as adaptable species. On the other hand, there are some species that, although occurring on many soil types, are strongly associated with a single or few of those types. For example, *Corymbia bella* occurred on 25 soil types, but was predominant on only four of those types; *Cyperus difformis* occurred on 20 soil types but was predominant on only a single type; and *Persicaria attenuata* occurred on 12 soil types but was predominant on only a single type; these are examples of species that have a low level of adaptability to soil types, and a strong preference for a single soil type. It can be concluded that preference for soil types is strong in some species but of limited constraint in others, but overall is not a major constraint on distribution of riparian species.

Of the five geomorphological formations used in this assessment, riparian species overall occur most commonly on alluvial formations. However, some species expressed a strong preference for other formations. For example, *Melaleuca bracteata* was most common on bedrock channel formations; *Sesbania cannabina* and *Flueggea virosa* occurred most commonly on bedrock confined sites; and *Cathormoin umbellatum* with an equal preference for alluvial and lake/swamp formations. Overall, most of the 12 co-occurring species showed a strong preference for a single geomorphological formation, and it can be concluded that geomorphology is a primary constraint for distribution of riparian species.

The preliminary nature of this study did not allow for an examination of the distribution of rare or restricted riparian species, but rather provided an assessment of widespread species and in particular those species co-occurring in the three focus catchments. Upon this basis, the similarities of the three focus catchments, not their differences, are highlighted. The research presented here represents base-data upon which further assessment of the riparian vegetation can be undertaken.

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