DOI: 10.18195/issn.0313-122x.61.2000.175-199
Records of the Western Australian Museum Supplement No. 61: 175–199 (2000).

The flora and vegetation of the seasonal and perennial wetlands of the southern Carnarvon Basin, Western Australia

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Abstract – A total flora of 265 taxa was recorded from 58 wetland areas in the southern Carnarvon Basin. The flora was dominated by arid species but also included 34 temperate taxa at the northern end of their range and 18 tropical taxa at the southern end of their range. Five species (*Dichopogon tyleri, Calandrinia* sp. Coolcalalaya (GJK and NG 698), *Myriocephalus gascoynensis* ms, *Lythrum* sp. Towrana (RJC 2183), *Psammagrostis wiseana)* are endemic to the study area. The *Calandrinia* sp. appears not to have been collected previously. A collection of *Rumex crystallinus* was the first recorded in Western Australia since 1885.

Classification of the wetlands was undertaken at two different scales; at both scales heterogeneity was high. The major division in the data sets was between the saline and non-saline wetlands. Percentage of single species occurrences was high in both datasets, ranging from 46–55%; this component of the flora adds significantly to plant biodiversity but is not a predictable component of vegetation communities. In the seven-group classification no floristic groups were restricted to particular habitat types but at the finer scale sampling there is a stronger correlation between floristic community type and habitat type. At this scale the major habitat types (e.g. river pools) encompassed a range of floristic groupings. The patterns in low species richness and very patchy species distribution found in this study are similar to those reported for wetlands in the higher rainfall areas of the south west but the underlying causal factors determining these patterns remain unclear.

INTRODUCTION

The flora and vegetation of the wetlands of the southern Carnarvon Basin (Anonymous, 1975) have been little studied (Figure 1). In the most recent and comprehensive review of nationally significant wetlands only two non-marine wetlands are listed from the study area (ANCA, 1996). These two large wetland systems highlight the diverse nature of wetlands in this area. Lake MacLeod covers some 150 000 ha formed on calcareous marine deposits and lies 30 km north west from Carnarvon. In part, it is fed by ocean water through 18 km of coastal limestone which upwells in sinkholes in the central western section of the wetland, but precipitation can also make a significant contribution to water supply in wetter years (Scott, 1962; ANCA, 1996). The mangrove community of Lake MacLeod is one of only two inland occurrences (ANCA, 1996). In contrast the McNeill claypan system is located on outwash alluvial deposits near the mouth of the Gascoyne River. The soils have been described by Bettenay *et al.* (1971) as saline-alkaline with high levels of exchangeable sodium and a high content of soluble salts. These flats are inundated with fresh water when the Gascoyne River floods. Both wetlands are important for migratory birds (ANCA, 1996).

Other major wetland habitats found in the study area include those associated with permanent and semi permanent river pools, and freshwater and saline springs, wetlands of seasonally inundated claypans, and the widespread saline samphire flats and birridas (gypsum pans) (Battye, 1915; Payne *et al.*, 1987). The flora and vegetation of Rocky Pool on the Gascoyne River (Kenneally, 1978) and the occurrence of *Psilotum nudum* in the lower Murchison River (Smith and Butler, 1961) are among the few accounts of wetland vegetation that have been published for this area.

Numerous classification systems for wetlands have been published both at the regional (Paijamans *et al.*, 1985; Lane and McComb, 1988; Jacobs and Brock, 1993; ANCA, 1996) and local scales (Semeniuk, 1987), using geomorphic and physical features, but none of these systems clearly differentiate the major geomorphic types recognised in the study area; as a consequence the terminology of Payne *et al.* (1987) is adopted here.

The aim of this paper is to describe the flora and vegetation of the major seasonal and permanent wetland types of the southern Carnarvon Basin and determine how floristic units correlate with major habitat types.

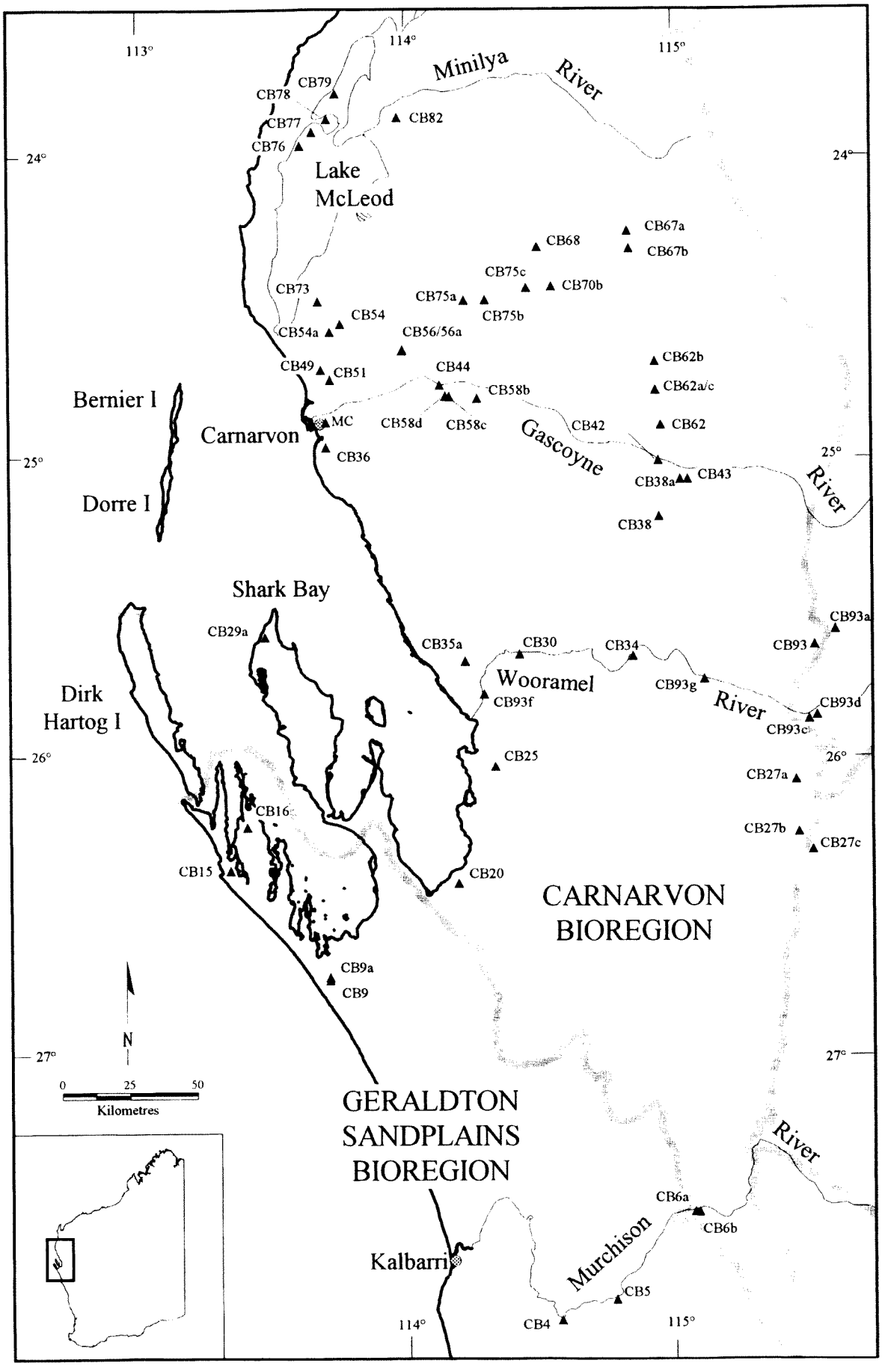


Figure 1 Location of wetland areas sampled and showing boundaries of major phytogeographic regions (Thackway and Cresswell, 1996).

METHODS

Fifty-eight wetland areas were sampled across the study area (Figure 1 and Appendix 1) in August and September 1995. No coastal saline wetlands or mangroves were included in the present survey. Several locations within some of the larger wetlands (e.g. Lake MacLeod) were sampled. The sites were the same as those used for the invertebrate sampling by Halse *et al.* (2000) with one exception, and the addition of a site on McNeill claypan. As clear vegetation zonation was apparent around many of the wetlands a series of 1 m x 1 m quadrats was used to sample each vegetation type, running along a transect at right angles to the shoreline. Lists were compiled of all taxa (species, subspecies and varieties) found in these quadrats. Taxa seen at each wetland but not recorded in quadrats were also noted. Sites were classified according to similarities in species composition using the Czekanowski coefficient and 'unweighted pair-group mean average' fusion method (UPGMA; Sneath and Sokal, 1973), while species were classified using the 'two step' method of Austin and Belbin (1982) and the UPGMA fusion method. This analysis of vegetation patterning was carried out at two scales — a larger scale using lists of species from each wetland area and the finer scale based on individual quadrats. Trees were excluded from the analysis of the quadrat data.

Water chemistry data were collected during the sampling of these sites for macro invertebrates in August 1994 and/or March 1995 [see Halse *et al.* (2000) for detailed methods]. These data were used as correlates for soil chemistry in analysis of between group differences. Statistical relationships between site groups were tested using Kruskal - Wallis non-parametric analysis of variance and Mann-Whitney U-tests (Siegel, 1956).

Species habitat preference and distribution information were compiled from collections held in the Western Australian Herbarium. Nomenclature follows Green (1985) and current usage at the Western Australian Herbarium. Selected voucher specimens have been lodged in that institution.

RESULTS

Flora

The flora of the wetlands was found to be dominated by arid zone species (Jessop, 1985). Two hundred and sixty three taxa were recorded from the fifty-eight wetland areas (Appendix 1). The best represented families were Asteraceae (32 native, 4 introduced species), Poaceae (25 native, 10 introduced species), Chenopodiaceae (24 natives), Cyperaceae (17 native, 1 introduced species) and Scrophulariaceae (10 natives). This composition clearly reflects the arid nature of the flora. At the generic level *Calandrinia* (8 taxa), *Eragrostis* (8 taxa), *Cyperus* (7 taxa), *Atriplex* (5 taxa) and *Goodenia* (5 taxa) were the most species rich.

Table 1 Wetland taxa endemic to the southern Carnarvon Basin.

Dichopogon tyleri
Calandrinia sp. Coolcalalaya (GJK and NG 698)
Myriocephalus gascoynensis ms
Lythrum sp. Towrana (RJC 2183)
Psammagrostis wiseana

Thirty-one introduced species were recorded from the wetlands. The wetland vegetation was heavily disturbed around some of the springs and river pools with either the complete removal of understorey, or with taxa such as *Cenchrus ciliaris* and *Asphodelus fistulosus* becoming dominant. The vegetation of the saline wetlands and the wetlands of the ephemeral claypans was generally much less impacted.

A total of seven new populations of four taxa (*Bergia auriculata, Goodenia neogoodenia, Rumex crystallinus, Wurmbea murchisoniana*) listed on CALM's priority flora list (CALM, 1996) were located during the course of the survey. These taxa require further investigation before consideration of listing as threatened flora. *Rumex crystallinus* was collected on the McNeill claypan near Carnarvon; this was the first collection of this species in Western Australia since 1885 when it was recorded by Carey on the Lyndon River some 150 km to the north.

Five taxa endemic to the study area were recorded from the fifty-eight wetlands (Table 1). Of these, *Calandrinia* sp. Coolcalalaya (GJK and NG 698) and *Lythrum* sp. Towrana (RJC 2183) appear to be restricted to edges of ephemeral claypans. *Myriocephalus gascoynensis* ms may also be restricted to this habitat.

Seven of the taxa recorded in this study are totally restricted to water bodies while another six generally grow as emergents around permanent or semipermanent wetlands (Table 2). Two of the

Table 2 List of submerged and emergent aquatic taxa recorded from 58 wetlands in the southern Carnarvon Basin (* indicates introduced species).

Submerged or floating aquatic	Emergent aquatic
* *Callitriche stagnalis*	*Alternanthera nodiflora*
* *Crassula natans*	*Avicennia marina*
Elatine gratioloides	*Baumea articulata*
Najas marina	*Eleocharis acuta*
Potamogeton pectinatus	*Eleocharis geniculata*
Ruppia megacarpa	*Schoenoplectus subulatus*
Ruppia polycarpa	*Typha domingensis*
Ruppia tuberosa	

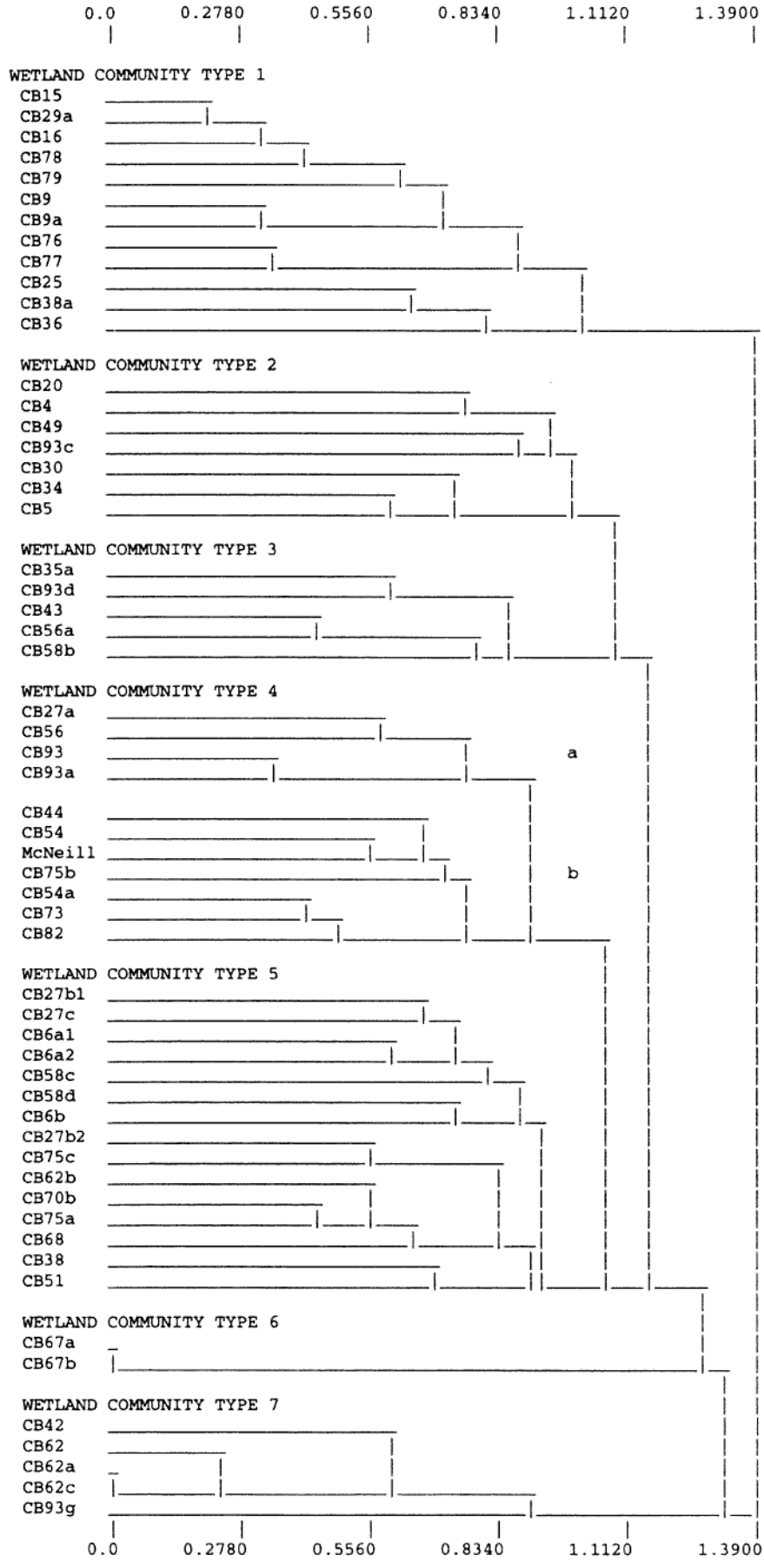


Figure 2 Dendrogram showing the UPGMA fusion of the wetland vegetation of 57 wetland areas in the southern Carnarvon Basin.

submerged aquatic taxa are widespread weed species across southern Australia (Aston, 1973). The habitat preference of other taxa generally restricted to wetland areas is listed (Appendix 1) where such information could be determined from herbarium labels. This information is lacking for some genera where the material is on loan.

The poor state of knowledge of the wetland flora of the southern Carnarvon Basin is highlighted by the first collections of one apparently undescribed *Calandrinia* sp. and major range extensions of 15 other taxa (Appendix 1).

Thirty-four taxa reach the northern limit of their range in the study area and another 18 primarily tropical taxa reach the southern ends of their range. The study area straddles Beard's (1990) major phytogeographic boundary between the temperate south west and the Eremaean zones (Figure 1).

Vegetation

Large scale patterning – the wetland classification

Amalgamation of some species was necessary as material could not always be positively identified to species level (e.g. *Centipeda* spp.). One of the claypans was completely bare of vegetation and was excluded from the analysis. Of the 259 taxa included in the final dataset some 142 taxa (55%) occurred only at one wetland area. The dataset was analysed with and without singletons (i.e. taxa that occurred at only one site). The results of both analyses were similar with clearer patterning seen in the analysis with the singletons excluded; these are the results presented below. Species richness varied from one to 25 taxa per wetland (with singletons excluded), with individual taxa occurring at between two and 22 wetlands. In this analysis

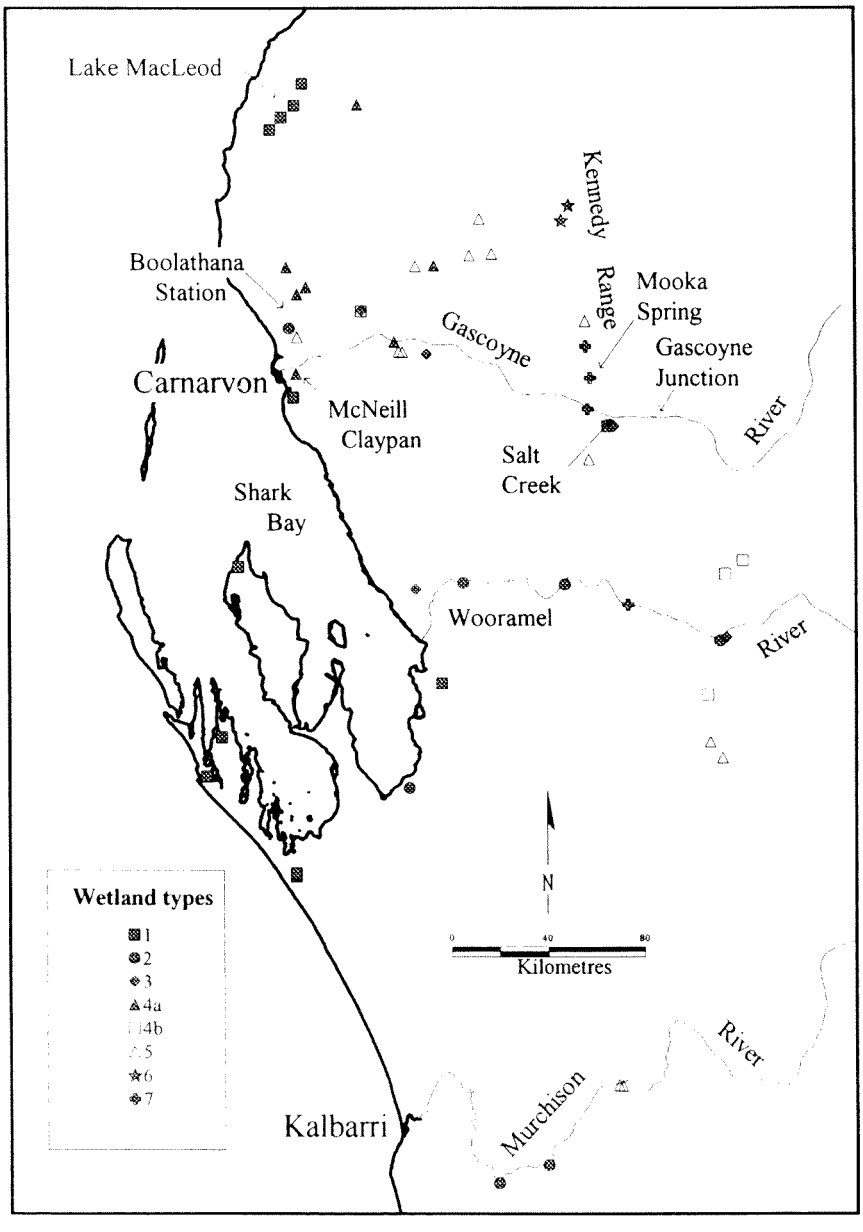


Figure 3 Distribution of the seven wetland community types across the southern Carnarvon Basin.

Table 3 Two way table showing species distribution across the seven wetland community types identified by the UPGMA fusion.

	WETLAND COMMUNITY TYPES							SPECIES
	1	2	3	4a	4b	5	6 7	GROUPS
WETLAND AREAS	CCCCCCCCCCCC BBBBBBBBBBBB 121779977233 59689 a67586 a a	CCCCCCC BBBBBBB 2449335 0 9304 c	CCCCC BBBBB 39455 53368 ad ab	CCCC BBBB 2599 7633 a a	CCMCCCC BBcBBBB 45N7578 44e5432 iba	CCCCCCCCCCCCCCC BBBBBBBBBBBBBBB 226655627677635 77aa88b75205881 bc12cd bcbba 1 2	CC CCCCC BB BBBBB 66 46669 77 22223 ab acg	
Actinobole uliginosum				*		* *		A
Isoetopsis graminifolia				*		**		
Peplidium sp. C (Burbidge and Kain 8152)				*		** * * *		
Calotis hispidula			*	*	*	***		
Calandrinia granulifera						* *		
Gnephosis eriocephala						**		
Gypsophila australis						*	*	B
Crassula natans				*		*		
Pentaschistis airoides				*		* *		
Melaleuca uncinata				*		* *		
Atriplex holocarpa			**			*		
Myriocephalus gascoynensis MS						* *		
Eragrostis leptocarpa						* * *		
Trichanthodium skirrophorum			*			* *		
Calotis multicaulis		*	*		*	** **		
Cyperus rigidellus					*	* ** * **		
Calandrinia ptychosperma						** *		
Bergia auriculata						***		C
Bergia perennis subsp. *obtusifolia*						* *** ** *		
Calandrinia pumila						*** * **		
Goodenia neogoodenia						** *		
Eragrostis pergracilis	*					*		
Peplidium aithocheilum						**		
Glossostigma drummondii						* ** **		
Marsilea angustifolia						* *** *		
Isoetes sp.		*				* * *		
Calandrinia sp.Coolcalalaya (GJK and NG 698)	*					*		
Pogonolepis muelleriana	*					**		
Crassula colorata	* *					** *		D
Eragrostis dielsii	* **		**			* * ***** *		
Triglochin calcitrapum	* *	*		*		*** *		
Asphodelus fistulosus			*****					
Myriocephalus guerinae			**			*		
Atriplex lindleyi	*		*					

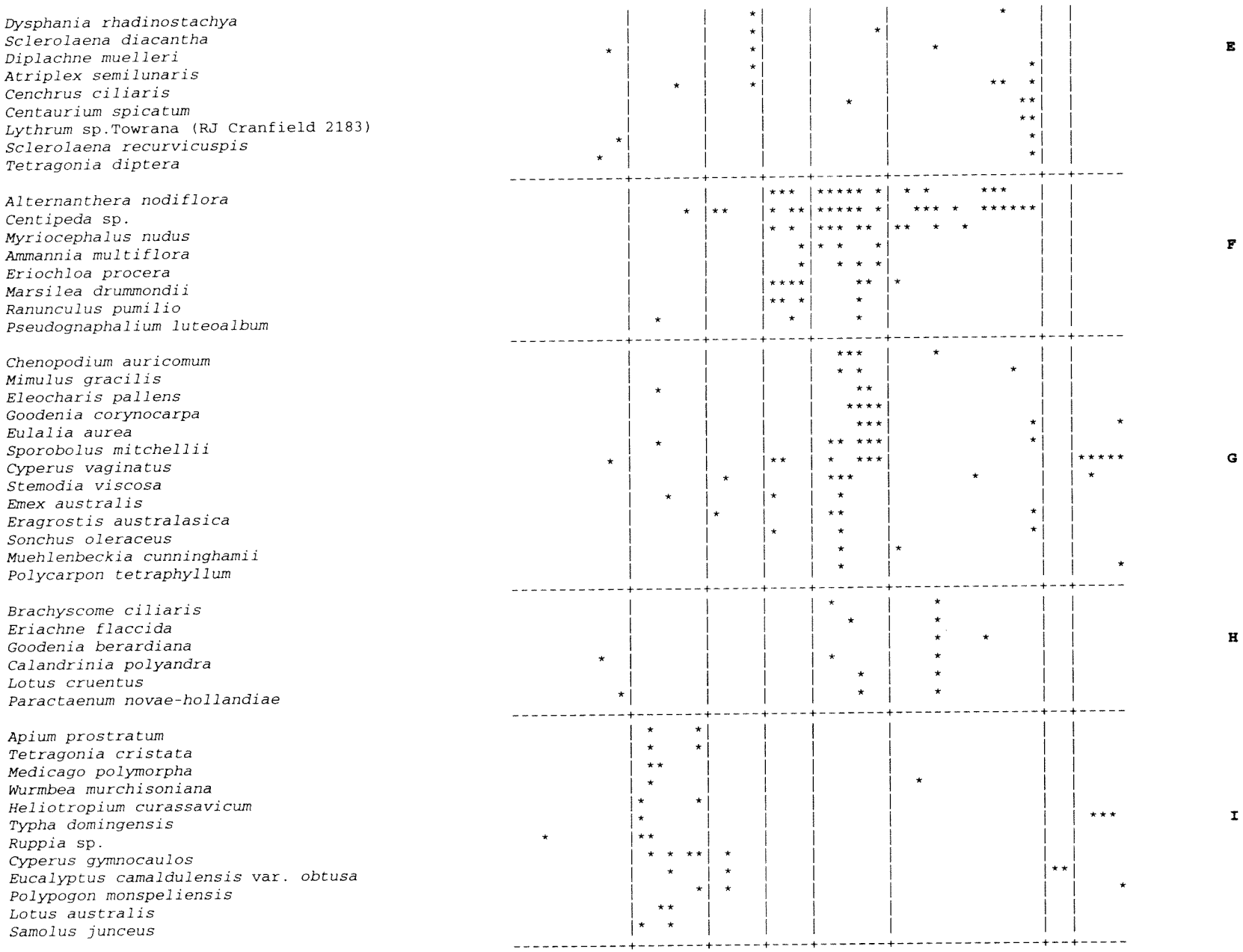

Dysphania rhadinostachya
Sclerolaena diacantha
Diplachne muelleri
Atriplex semilunaris
Cenchrus ciliaris
Centaurium spicatum
Lythrum sp.Towrana (RJ Cranfield 2183)
Sclerolaena recurvicuspis
Tetragonia diptera
E
Alternanthera nodiflora
Centipeda sp.
Myriocephalus nudus
Ammannia multiflora
Eriochloa procera
Marsilea drummondii
Ranunculus pumilio
Pseudognaphalium luteoalbum
F
Chenopodium auricomum
Mimulus gracilis
Eleocharis pallens
Goodenia corynocarpa
Eulalia aurea
Sporobolus mitchellii
Cyperus vaginatus
Stemodia viscosa
Emex australis
Eragrostis australasica
Sonchus oleraceus
Muehlenbeckia cunninghamii
Polycarpon tetraphyllum
G
Brachyscome ciliaris
Eriachne flaccida
Goodenia berardiana
Calandrinia polyandra
Lotus cruentus
Paractaenum novae-hollandiae
H
Apium prostratum
Tetragonia cristata
Medicago polymorpha
Wurmbea murchisoniana
Heliotropium curassavicum
Typha domingensis
Ruppia sp.
Cyperus gymnocaulos
Eucalyptus camaldulensis var. obtusa
Polypogon monspeliensis
Lotus australis
Samolus junceus
I

Table 3 (cont.)

WETLAND AREAS	WETLAND COMMUNITY TYPES 1	2	3	4a	4b	5	6	7	SPECIES GROUPS
	CCCCCCCCCCCC	CCCCCCC	CCCCC	CCCC	CCMCCCC	CCCCCCCCCCCCCCC	CC	CCCCC	
	BBBBBBBBBBBB	BBBBBBB	BBBBB	BBBB	BBcBBBB	BBBBBBBBBBBBBBB	BB	BBBBB	
	121779977233	2449335	39455	2599	45N7578	226655627677635	66	46669	
	59689 a67586	0 9304	53368	7633	44e5432	77aa88b75205881	77	22223	
	a a	c	ad ab	a a	iba	bc12cd bcbba	ab	acg	
						1 2			
Avicennia marina	* **								
Halodule uninervis	**								
Halosarcia pterygosperma subsp. *denticulata*	* * ***								
Ruppia tuberosa	*** *								
Frankenia pauciflora	* * **								
Muellerolimon salicorniaceum	** * ***								
Sarcocornia quinqueflora	*******								
Halosarcia halocnemoides	** *** ***								J
Halosarcia indica	**** *** **	**							
Cotula cotuloides	*	*							
Triglochin centrocarpum	*	*							
Lawrencia viridigrisea	**								
Neosciadium glochidiatum	**								
Samolus repens	**								
Triglochin mucronatum	**	*			*				
Rostraria pumila	* *				*				
Senecio glossanthus	* * *				*				
Anagallis arvensis			*	***				*	
Schoenoplectus lateriflorus				* **	*			*	
Eucalyptus victrix		***		**	*				
Daucus glochidiatus		*		***					
Glossostigma diandrum				* **					
Setaria dielsii				* *					
Isolepis congrua				* **		* *			
Centrolepis eremica		*		*				*	K
Hypericum japonicum		*		*					
Brachyscome iberidifolia				*		*			
Cyperus aff. *cunninghamii* (GJK and NG 592)				**					
Lipocarpha microcephala				**					
Oldenlandia galioides				**					
Schoenus elegans				**					
Drosera indica				**		*			
Eragrostis basedowii				**		*			
Elatine gratioloides				**		*			
Wahlenbergia tumidifructa				**	*				

site groups are discussed at the seven group level (referred to as 'wetland community types' or 'community types') which best reflected the scale of patterning seen in the field.

The wetland areas sampled showed a high level of heterogeneity in species composition (Figure 2). The primary division in the classification separates the vegetation of the saline flats (wetland community type 1) from all other sites. This can also be seen in the sorted two-way table (Table 3) where species group J is largely restricted to this community type. Most taxa in this group are highly faithful to it and species such as *Halosarcia halocnemoides, H. indica* and *Sarcocornia quinqueflora* have a high level of constancy. All other species groups are completely or almost completely lacking from this wetland community type except for low frequencies of species in species groups D and E. Species richness in this community type ranges from three to 16 taxa/wetland (average 6.8). This community type is largely restricted to the near coastal samphires and birridas between Shark Bay and Lake MacLeod (Figure 3). One outlying site was found at Salt Gully near Gascoyne Junction. The inland mangrove stands from Lake MacLeod are members of this group. While coastal samphires and mangroves were not sampled in this study they appear very similar to this community type.

Wetland community type 2 is generally associated with deeper river pools; one wetland formed from an uncapped artesian bore also belongs with this group. This community type is characterised by the occurrence of species group I. While a number of species are restricted to this community type, constancy values rarely exceed 50%. Species in species groups A, B, E and H are completely lacking, while species frequency in other species groups is low to very low. Average species richness was low (6 taxa/wetland). This community type was associated with the deepest pools which would not dry out in any but the driest years; it occurred from the Murchison River to north of Carnarvon and east along the Wooramel River (Figure 3).

Community type 3 are typically species-poor claypans (mean species richness 5.6 taxa/wetland). The only species constant and faithful to this group is the weed *Asphodelus fistulosus*. One species poor riverine site also belongs to this group. The occurrence of *A. fistulosus* indicates moderate levels of grazing. Whether the low species richness of these sites is also related to disturbance or local soil or moisture conditions is not clear. Several chenopod species were also recorded from this wetland community type.

Community types 4 and 5 encompass riverine wetlands and ephemeral claypans and swamps characterised by the occurrence of *Alternanthera nodiflora, Centipeda* spp. and to a lesser extent *Myriocephalus nudus*. Community type 4 differs from type 5 by the reasonably high frequency of other taxa in species group F while largely lacking taxa in species groups A, B, C, D and E which further characterise community type 5, although constancy of species in these groups is generally only moderate to low. Community type 4 was found both in riverine vegetation and ephemeral wetlands of the claypans and swamps while community type 5 was largely restricted to claypans and swamps (Table 4).

Two distinct subtypes are discernible in wetland community type 4. Subtype 4a was the most species-rich of the wetland groups sampled (mean species richness of 17.0/wetland), while community subtype 4b was much less rich (mean species richness of 10.6 taxa/wetland). Both subtypes are characterised by the occurrence of taxa in species group F, while the occurrences of species in species groups G and K define the subgroupings.

Three of the four sites in community subtype 4a are riverine and this subgroup is characterised by a moderate to high fidelity and constancy of taxa in species group K. The river pools tended to have a variety of microhabitats generally with a dense band of sedges (*Schoenoplectus lateriflorus* and/or *Cyperus vaginatus*) along the water's edge. This community subtype was found on upstream areas of the Wooramel River and its tributaries and around a large semi-permanent water body on Boolathana Station (north of Carnarvon) (Figure 3).

Community subtype 4b is restricted to claypans, ephemeral swamps and two river pools in the north west of the study area (Figure 3). Wetlands in this

Table 4 Comparison of the occurrences of the seven wetland community types with a broad habitat classification.

Wetland community type	Birrida (gypsum pan)	Samphire	River pool	Spring	Ephemeral swamp	Claypan
1	7	4	1	–	–	–
2	–	–	6	1	–	–
3	–	–	1	–	–	4
4	–	–	6	–	1	4
5	–	–	1	–	8	6
6	–	–	1	1	–	–
7	–	–	4	1	–	–

group were characterised by taxa in species group G while almost totally lacking taxa in species group K, which are typical of community subtype 4a. Subtype 4b wetlands tended to have a significant shrub component and the claypans and swamps were quite extensive.

The majority of the ephemeral swamps and claypans form wetland community type 5, and while *Centipeda* spp. and *Alternanthera nodiflora* were also common in this community type, the herbs of species groups A, B, C and D clearly differentiate it from the previous type. The sites in this type were quite heterogenous, with few constant taxa, but none the less species rich (mean 10.7 taxa/wetland). The most constant taxon was *Eragrostis dielsii*, occurring in 75% of sites in this group and totally lacking from the related community type 4. Species group C is most typical of this community type and is composed of annual taxa that either germinate in very shallow waters or rapidly germinate as the clay soils dry. This community type was very widespread across the study area (Figure 3). One riverine site was classified into this group. That site had rich alluvial soil on which suites of annuals were growing. Typically the riverbanks in the study area are either sandy or rocky.

A series of permanent springs are found along the western foothills of the Kennedy Range. These have until recently long been used as watering points for cattle. Some of the springs are fenced off and water piped from them but two have been used as cattle yards. There are no understorey species left at these two sites. The overstorey tree is *Eucalyptus camaldulensis* subsp. *obtusa*. These two sites form wetland community type 6 based on the sole occurrence of this species. One site was located at the spring itself while the second was along the watercourse below the spring.

The final community type (type 7) is comprised of tall dense species-poor sedgelands that occur at the less modified springs and the streams draining the west side of the Kennedy Range and as far south as a dammed section of the Wooramel River. These stands are typical of permanent or near permanent water bodies. *Cyperus vaginalis* is constant in this group but is also common in wetland community subtype 4b. *Typha domingensis* is also a common component of this community type. Mean species richness is 3.2 taxa/wetland.

While no soil sampling or analysis was undertaken during the present study, Halse *et al.* (2000) collected water chemistry data from all but one of these wetlands in their study of invertebrate patterning. This water chemistry data could be expected to be related to aspects of the soil chemistry. Measures of electrical conductivity and turbidity highlight patterns as discussed above (Figure 4).

When the claypans fill, the water becomes red brown in colour due to suspended clay particles. Only wetland community types 3, 4, and 5 occur in claypans, with the percentage of claypan sites

Turbidity (NTU) Kruskal-Wallis: 20.236, df: 6, Probability = 0.0025

```
  0.5000E-01        0.1550E+05        0.3100E+05        0.4650E+05      0.6200E+05
GRP +-----------------+-----------------+-----------------+-----------------+

  1 *M==3------U
  2 **
  3 L-----------------1=================M=======D======U   3
  4 LD======M=================3------------------------------U
  5 *=======M===================3-----------------------------------------U
  6 *
  7 *
```

Electrical conductivity (mSm^{-1}) Kruskal-Wallis: 37.524, df: 6, Probability < 0.0000

```
   29.00            0.5102E+05        0.1020E+06        0.1530E+06      0.2040E+06
GRP +-----------------+-----------------+-----------------+-----------------+

  1 L-------1============D=======M==================3-------------------U
  2 *M3U
  3 *
  4 *3U
  5 *U
  6  **=*
  7 *==*=3U
```

Figure 4 Turbidity (NTU) and electrical conductivity (mSm^{-1}) for the seven community types. L = lower limit, 1 = Mean – 1 standard deviation, M = mean, D = Median, 3 = Mean + 1 standard deviation, U = upper limit, * = more than one symbol at print position.

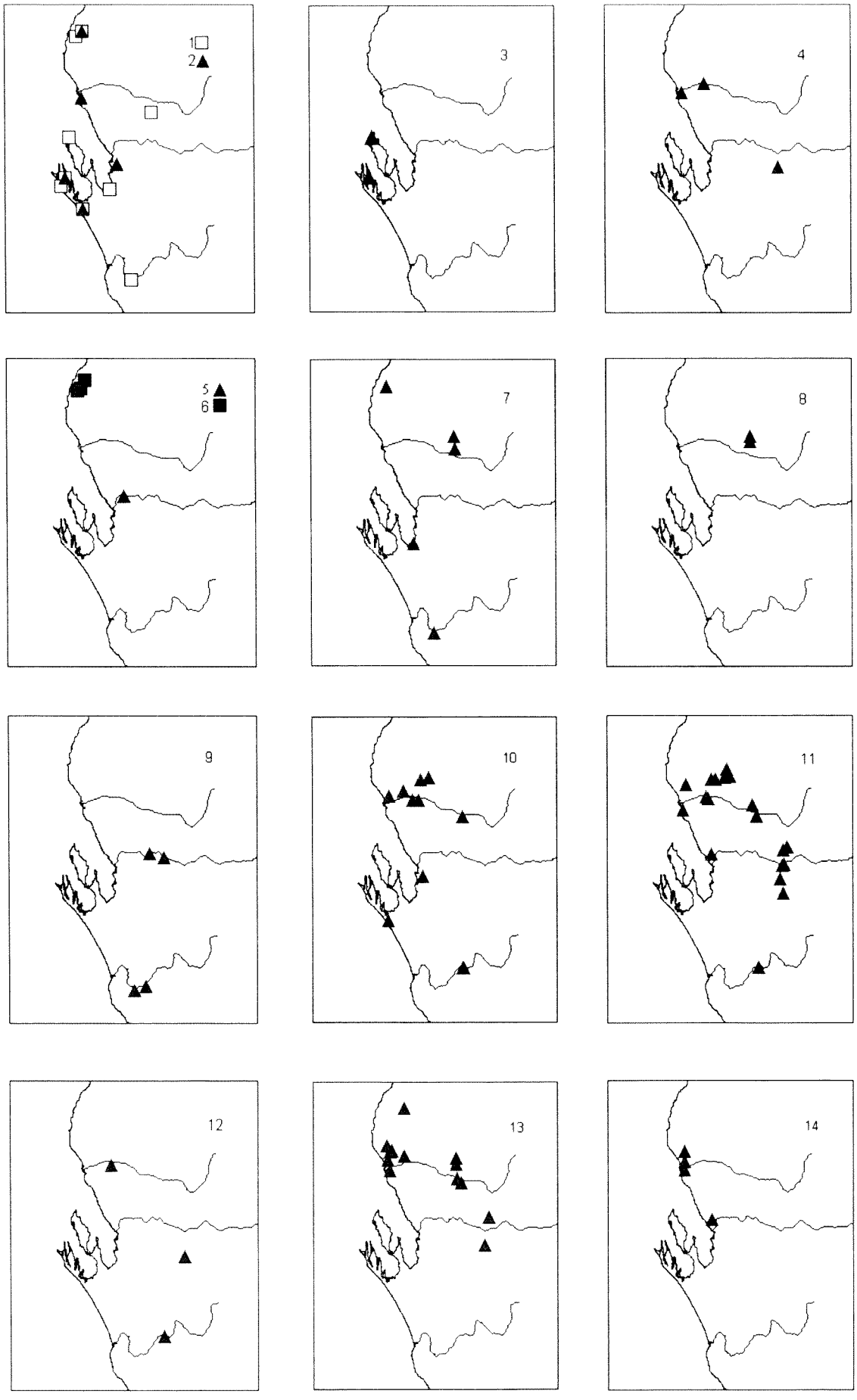
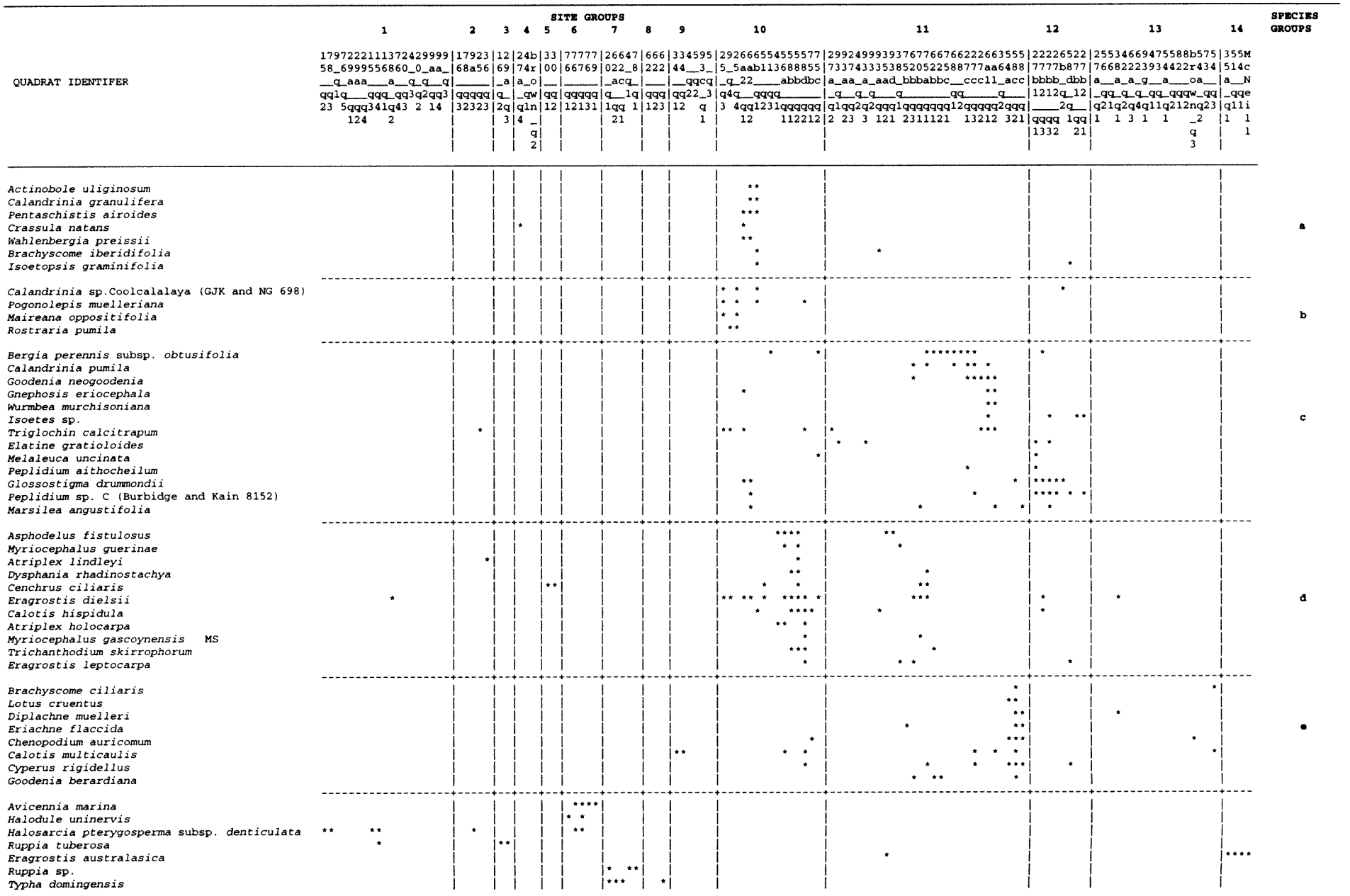
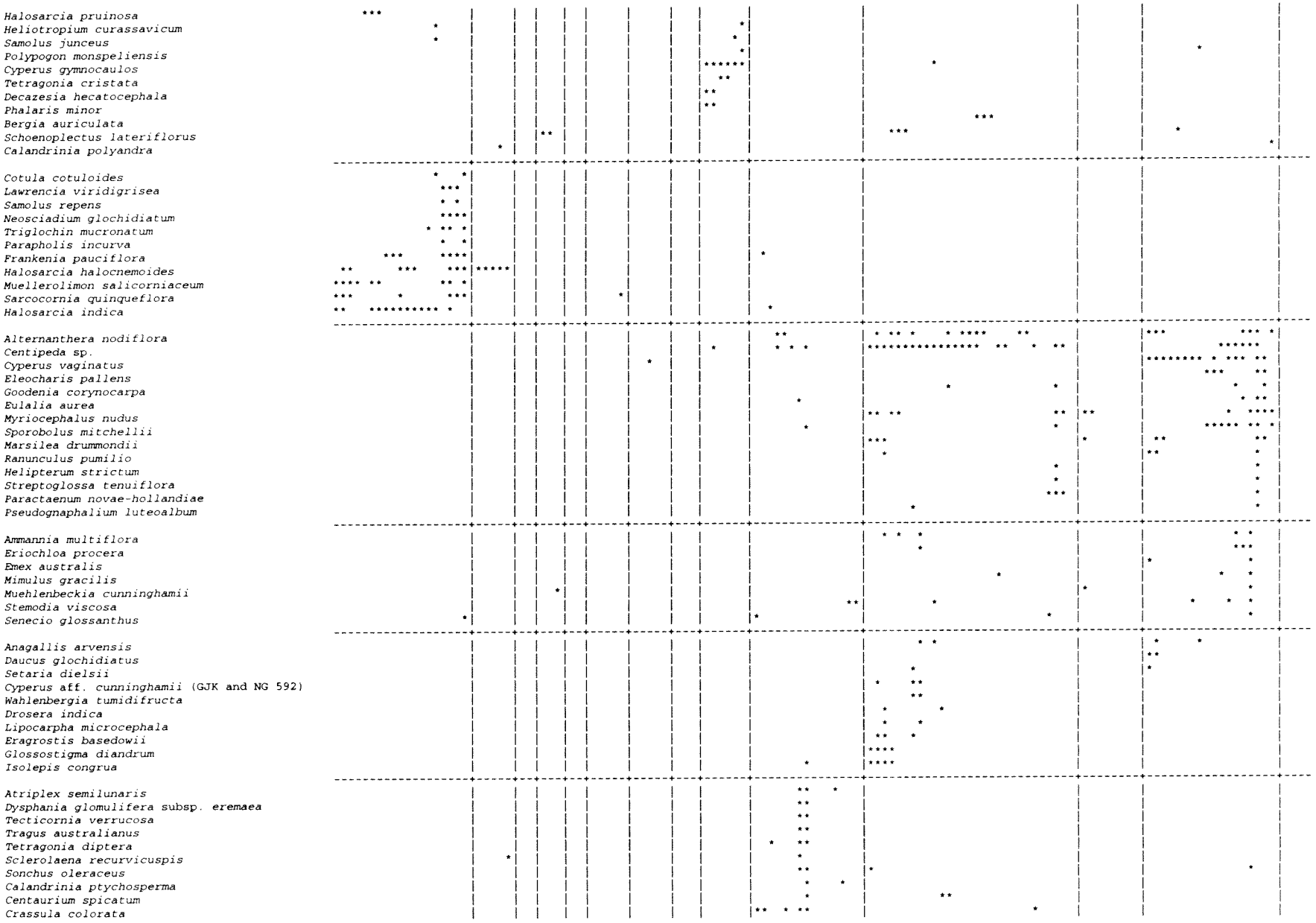


Figure 5 Distribution of the 14 site groups based on individual 1 m^2 across the southern Carnarvon Basin.

Table 5 Two-way table derived from the UPGMA classification of the 124 wetland quadrats from the southern Carnarvon Basin study area.




Halosarcia pruinosa
Heliotropium curassavicum
Samolus junceus
Polypogon monspeliensis
Cyperus gymnocaulos
Tetragonia cristata
Decazesia hecatocephala
Phalaris minor
Bergia auriculata
Schoenoplectus lateriflorus
Calandrinia polyandra
Cotula cotuloides
Lawrencia viridigrisea
Samolus repens
Neosciadium glochidiatum
Triglochin mucronatum
Parapholis incurva
Frankenia pauciflora
Halosarcia halocnemoides
Muellerolimon salicorniaceum
Sarcocornia quinqueflora
Halosarcia indica
Alternanthera nodiflora
Centipeda sp.
Cyperus vaginatus
Eleocharis pallens
Goodenia corynocarpa
Eulalia aurea
Myriocephalus nudus
Sporobolus mitchellii
Marsilea drummondii
Ranunculus pumilio
Helipterum strictum
Streptoglossa tenuiflora
Paractaenum novae-hollandiae
Pseudognaphalium luteoalbum
Ammannia multiflora
Eriochloa procera
Emex australis
Mimulus gracilis
Muehlenbeckia cunninghamii
Stemodia viscosa
Senecio glossanthus
Anagallis arvensis
Daucus glochidiatus
Setaria dielsii
Cyperus aff. cunninghamii (GJK and NG 592)
Wahlenbergia tumidifructa
Drosera indica
Lipocarpha microcephala
Eragrostis basedowii
Glossostigma diandrum
Isolepis congrua
Atriplex semilunaris
Dysphania glomulifera subsp. eremaea
Tecticornia verrucosa
Tragus australianus
Tetragonia diptera
Sclerolaena recurvicuspis
Sonchus oleraceus
Calandrinia ptychosperma
Centaurium spicatum
Crassula colorata
g
g
b
i
j
k

increasing from 31% in community type 4 to 80% in community type 3. Mean turbidity values increase in the same fashion. Only one wetland in the saline community type 1 has turbidity values approaching those of claypan groups. The high levels of electrical conductivity seen in community type 1 clearly separates it from all other wetland types. Essentially the same pattern was seen for other elements such Ca, Mg, Na, K, Cl, and SO_4. The only other community types with significant but much lower levels of electrical conductivity, Ca, Mg, Na, K, Cl, and SO_4 were the wetlands fed from springs along the western edge of the Kennedy Range (community types 6 and 7).

Fine scale patterning - the quadrat classification

In addition to the floristic analysis of the wetland areas a second analysis was undertaken of the 1 m x 1 m quadrats which sampled the finer scale vegetation pattern. In all, 124 quadrats were established in 55 of the 58 wetland areas. Three of the wetland areas had no shrub or herb layer. Two hundred and thirteen taxa were recorded from these quadrats. Of these 213 taxa, 99 (46%) only occurred in one quadrat; these taxa were excluded from the analysis as discussed above. With these exclusions species richness varied from one to 13 taxa/quadrat with individual taxa represented in between two and 31 quadrats.

Fourteen quadrat groupings (referred to as 'site groups') and 11 species groupings were recognised (Table 5). The data set showed high levels of heterogeneity with few quadrats in many of the site groups and generally low species richness (Table 6). The first division in the classification again separated the *Halosarcia* flats (site groups 1 and 2) from the rest of the data set. The two remaining saline groups, the quadrats containing *Ruppia tuberosa* (site group 3) and the mangrove quadrats (site group 6), totally lack taxa in species group g which are faithful to site groups 1 and 2.

Table 6 Mean species richness of the 14 site groups identified in the analysis of the 124 wetland quadrats.

Site group	Mean species richness	Number of quadrats
1	4.2	19
2	2.2	5
3	1.0	2
4	1.7	3
5	1.5	2
6	1.8	5
7	1.4	5
8	2.0	3
9	3.8	6
10	9.9	15
11	6.6	29
12	4.0	8
13	5.6	18
14	1.3	4

Other species-poor site groups include groups 4, 7, 8, and 9 which are mostly fringing freshwater sedgelands or *Typha* stands, and site group 14, the cane grass swamps (*Eragrostis australasica).* The characteristic taxa of each of these communities are different but all belong to species group f. The other species-poor site group (group 5) occurred on the Wooramel River flats which had been heavily grazed. The sole species recorded in these quadrats was the introduced Buffel Grass (*Cenchrus ciliaris*).

The three remaining site groups are herblands (groups 10, 11, and 12). *Eragrostis dielsii* is the typical species of site group 10. Species groups a, b, d and k are largely confined to this type. Site groups 11 and 12 differ from each other primarily in the proportions of species groups c and h (Table 5). Site group 13 is generally a sedgeland on riverbanks or drainage channels usually dominated by *Cyperus vaginatus.* Taxa in species group h are also well represented in this group.

This fourteen site group classification showed a

Table 7 Comparison of the number of quadrats of the fourteen site groups with a broad habitat classification.

Site group	Birrida (gypsum pan)	Samphire	Spring	River pool	Ephemeral swamp	Claypan
1	14	1	2	2	–	–
2	2	3	–	–	–	–
3	2	–	–	–	–	–
4	–	–	–	2	–	1
5	–	–	–	2	–	–
6	4	1	–	–	–	–
7	–	1	2	2	–	–
8	–	–	–	3	–	–
9	–	–	–	6	–	–
10	1	2	–	–	3	9
11	–	1	–	10	13	5
12	–	–	–	–	6	2
13	–	–	–	11	–	7
14	–	–	–	–	–	4

strong correlation with the broad habitat classification, again with the wetlands associated with major stream being the most diverse (Table 7). Turbidity and electrical conductivity of the wet season water body showed significance differences between site type means (Figure 4). The occurrence of claypans in site types 10 – 14 is highlighted by high mean turbidity values, and some of the saline water bodies had slightly elevated turbidity (Figure 6). The water bodies associated with site types 1, 2, 3 and 6 were moderately to highly saline. A lesser saline influence can also be seen in site types 7, 10 and 13.

The highly saline site groups (groups 1, 2, 3 and 6) were largely restricted to the coastal belt except for a quadrat at Salt Creek near Gascoyne Junction (Figure 5). The hyper saline *Ruppia tuberosa* quadrats of site group 3 were restricted to Shark Bay and the mangrove dominated quadrats (group 6) were restricted to Lake MacLeod. However, as was noted previously, the coastal mangrove communities were not sampled in this survey. Site groups 5, 8, 9, and 14 were found to be quite restricted, with group 8 being restricted to Mooka Springs area, group 9 to the Murchison and Wooramel Rivers and group 14 (cane grass swamps) to the area around Carnarvon (Figure 5). In contrast site groups 10 and 11 were widespread in the study area and group 13 was widespread in the northern half.

Many of the wetland areas had more than one site group present and this concentric zonation of the vegetation around the wetland was an obvious feature of the study area. At five of the 57 wetlands three different site groups were recorded, a further

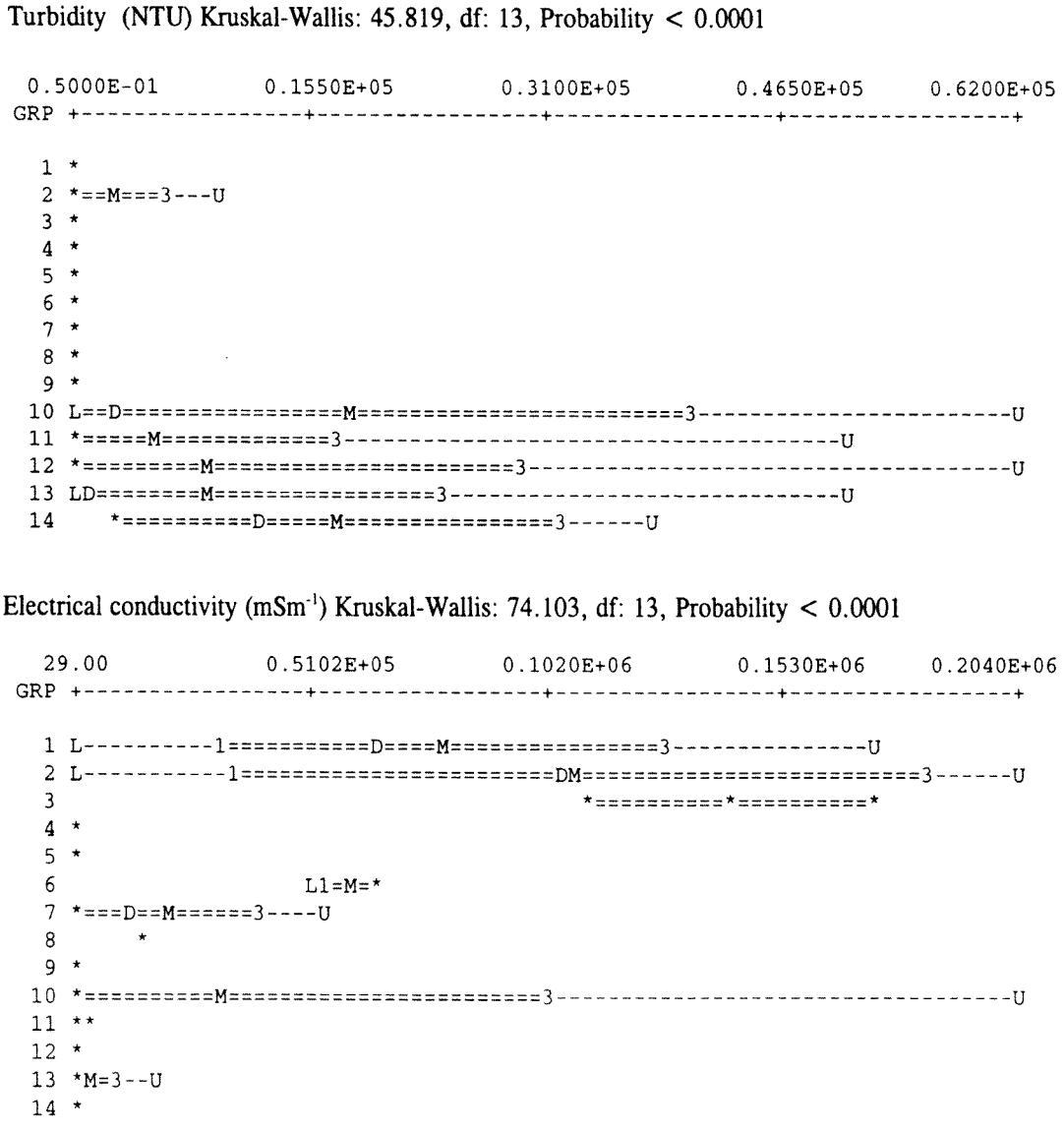


Figure 6 Turbidity (NTU) and electrical conductivity (mSm^{-1}) for the 14 site types. L = lower limit, 1 = Mean – 1 standard deviation, M = mean, D = Median, 3 = Mean + 1 standard deviation, U = upper limit, * = more than one symbol at print position.

19 had two distinct site groups and a single group was recorded from the remaining wetlands.

DISCUSSION

The present survey has improved on the poor state of knowledge of the flora and vegetation of the seasonal and permanent wetlands of the southern Carnarvon Basin. During the course of this work one apparently new species was collected, seven new populations of priority flora were located and major range extensions were recorded for a further 15 taxa (Appendix 1). The flora of the wetlands is largely arid (Jessop, 1985) but with both a significant temperate component (34 taxa reaching their northern range limit) and a significant tropical component (18 taxa reaching their southern limit).

The composition and affinities of the wetlands reported here do not accord with the recently published review of biogeography of freshwater plants, which concentrated almost entirely on wet temperate and tropical regions (Jacobs and Wilson, 1996). Our study area overlaps the northern edge of their south west Western Australian region but the affinities of the freshwater plants (defined in Jacobs and Wilson's study as plants that grow in or near water) in our study are largely with the arid zone (Jessop, 1985) and not with New Zealand. Jacobs and Wilson's (1996) work does indicate the lack of knowledge of the seasonal and permanent wetlands in the arid temperate zone (south of the Tropic) is not restricted to southern Carnarvon Basin but is true across Australia. With an increase in knowledge of the wetland systems of arid areas of both the temperate and tropical zones the very strong division between the tropical and temperate regions reported by them can be expected to break down.

Detailed quadrat-based floristic surveys of the Swan Coastal Plain, the coastal communities of the Warren bioregion (Thackway and Cresswell, 1995), and the Tingle forests of the high rainfall zone have all shown that there is a high proportion of naturally rare species in south west Western Australian ecosystems (Gibson *et al.*, 1994; Gibson and Lyons, unpublished data; Wardell-Johnson and Williams, 1996). In all three studies approximately 25% of total floras (1485 taxa in 509 quadrats; 901 taxa in 301 quadrats; and 857 taxa in 441 quadrats respectively) were only recorded at one site. Data from the present survey shows the same pattern with taxa being recorded at only one site comprising 55% of species at the individual wetland scale (58 wetland areas) and 46% at the 1 m^2 quadrat scale (124 quadrats). The regional vegetation survey of the southern Carnarvon Basin study area and a detailed study of the sandplain vegetation in the south of the study area show essentially similar trends (Keighery *et al.*, 2000; Gibson *et al.*, 2000). This rare component of the floras adds significantly to the biodiversity but is not a predictable component of vegetation communities. The conservation status of this component of the flora will continue to be difficult to assess.

The highly variable nature of wetlands in south-west Western Australia has been reported both at the landscape scale (Churchward *et al.*, 1988) and plant and animal community scales (Gibson *et al.*, 1994; Wardell-Johnson and Williams, 1996; Wardell-Johnson and Horwitz, 1996). In the survey of the plant communities of the Swan Coastal Plain the seasonal wetlands were found to comprise 16 of the 30 groups defined (Gibson *et al.*, 1994), while in a study in high rainfall forest areas near Walpole wetlands comprised 22 of the 44 community types defined (Wardell-Johnson and Williams, 1996). The reasons for these high levels of heterogeneity are not clear but appear to result at least in part from differences in substrate and differences in period and depth of inundation. High levels of heterogeneity can be seen from the present study at both scales examined.

It could be argued that part of the reason for heterogeneity at the larger scale could be related to the obvious zonation of the vegetation around many of the wetlands. Vegetation zonation is commonly observed in wetlands across Western Australia (Hopper *et al.*, 1996; Halse *et al.*, 1993). However when sampled at a finer scale the wetland classification still showed a high level of heterogeneity, indicating factors other than zonation are involved.

While some of the community types in the seven group classification generally occur in a particular wetland habitat (e.g. birridas/samphires or claypans/ephemeral swamps), none were restricted to these habitats (Table 4). At the finer scale sampling there is a much stronger correlation between site groups and wetland habitat (Table 7). Even at this scale, however, some site groups are recorded from several wetland habitats. The most diverse wetland habitat was the riverine wetlands reflecting the heterogeneous nature of these areas with variation in substrate composition, texture, slope, degree of disturbance and salinity to which the floristic groups respond.

Examination of the distribution maps of the floristic groupings indicate only moderate biogeographic patterning (Figures 3 and 6). In the seven group wetland classification, the saline community type is generally restricted to the coastal belt but with an outlier near Gascoyne Junction and type 7 is restricted to wetlands at the base of the Kennedy Range south to Wooramel River. The other community types (with the exception of type 3 which are highly disturbed) are widespread across the region, although community type 4 only occurs

in the north of the study area (Figure 3).

At the finer scale of analysis of the 14 site groups, much stronger biogeographic patterning is seen. Eight site groups (groups 1, 2, 3, 5, 6, 8, 9 and 14 – Figure 5) have a restricted distribution, while site groups 10, 11 and 13 are widespread. This increased patterning results from the finer subdivisions possible in the larger dataset.

While most wetlands visited were not obviously impacted by grazing, the use of two springs in the Kennedy Range as cattle yards had resulted in the total removal of the understorey (wetland community type 6). Grazing impacts could also be seen in the claypans and riverine areas of wetland community type 3. These sites were generally dominated by *Asphodelus fistulosus*, a weed indicative of over grazing (Parsons and Cuthbertson, 1992), and were typically quite species poor.

The seasonal and permanent wetlands of the southern Carnarvon Basin have a diverse and poorly known flora. The present study has shown that patterns in species distribution and species richness are similar to those reported for wetlands in higher rainfall area of the southwest, however as in the southwest, the causal factors operating are still poorly understood.

ACKNOWLEDGEMENTS

Funding was provided by the Commonwealth through the National Reserves System Co-operative Program of the Australian Nature Conservation Agency (now Environment Australia), and by the Western Australian Department of Conservation and Land Management.

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Manuscript received 3 April 1998; accepted 29 January 1999.

Appendix 1

List of taxa found in the 57 wetlands in the southern Carnarvon Basin study area, showing aquatic taxa (taxa restricted or almost restricted to aquatic habitats), habitat, the endemic taxa, range ends and geographic limits of the 265 taxa recorded. (Aquatic taxa – EAq emergent aquatic; Aq submerged or floating aquatic. Habitat – EW ephemeral wetlands; HW heavy soil wetlands; R riverine; R/F riverine or fringing; S saline. Range ends – N northern; S southern. * indicates an introduced species).

Aquatics	Taxon	Habitat	Endemics	Range ends	Geographic limits
	Family: Aizoaceae				
	Gunniopsis septifraga				
	Tetragonia cristata				
	Tetragonia diptera				
	Family: Amaranthaceae				
EAq	*Alternanthera nodiflora*				
	Hemichroa diandra	EW			
	Ptilotus gaudichaudii				
	Ptilotus macrocephalus				
	Ptilotus murrayi				
	Family: Anthericaceae				
	Dichopogon tyleri		endemic		Shark Bay to Lake McLeod
	Family: Apiaceae				
	Apium annuum				
	Apium prostratum				
	Daucus glochidiatus				
	Neosciadium glochidiatum			N	Dirk Hartog Island
	Trachymene glaucifolia				
	Family: Asphodelaceae				
*	*Asphodelus fistulosus*				
	Family: Asteraceae				
	Actinobole uliginosum				
	Angianthus tomentosus				
*	*Bidens bipinnata*				
	Brachyscome ciliaris				
	Brachyscome iberidifolia				
	Calotis hispidula				
	Calotis multicaulis				
	Centipeda cunninghamii	HW		N	Rocky Pool, Gascoyne River
	Centipeda minima	HW		S	Carnarvon
	Centipeda thespidioides	HW		S	Gascoyne River
	Chthonocephalus pseudevax			N	40 km N Gascoyne Junction
	Cotula cotuloides	HW		N	Dirk Hartog Island
	Decazesia hecatocephala			S	93 km N Carnarvon
	Gnephosis arachnoidea				
	Gnephosis brevifolia				
	Gnephosis eriocephala			N	56 km N Carnarvon
	Isoetopsis graminifolia				
	Minuria integerrima				
	Myriocephalus gascoynensis ms		endemic		Carnarvon area
	Myriocephalus guerinae			N	Gascoyne River
	Myriocephalus nudus	HW			
	Myriocephalus pygmaea				
	Pluchea rubelliflora	HW		S	Rocky Pool, Gascoyne River
	Podolepis lessonii				
	Pogonolepis muelleriana				
	Pogonolepis stricta			N	Three Rivers Station, Gascoyne R.
*	*Pseudognaphalium luteoalbum*				
	Rhodanthe chlorocephala subsp. *splendia*				
	Rhodanthe margarethae				

Aquatics	Taxon	Habitat	Endemics	Range ends	Geographic limits
	Rhodanthe stricta				
	Senecio glossanthus				
	* *Sonchus oleraceus*				
	Streptoglossa tenuiflora	HW		S	Boolathana
	Trichanthodium skirrophorum				
	* *Urospermum picroides*				
	Family: Avicenniaceae				
EAq	*Avicennia marina*				
	Family: Boraginaceae				
	Heliotropium curassavicum	EW			
	Plagiobothrys plurisepalus			N	Coolcalalaya
	Family: Brassicaceae				
	* *Brassica tournefortii*				
	* *Coronopus didymus*				
	Lepidium oxytrichum				
	Lepidium pseudoruderale				
	Lepidium rotundum				
	Menkea australis				
	Menkea villosula	EW			
	* *Sisymbrium erysimoides*				
	Stenopetalum pedicellare				
	Stenopetalum sphaerocarpum				
	Family: Caesalpiniaceae				
	Senna sp. Austin (A. Strid. 20210)				
	Family: Callitrichaceae				
Aq	* *Callitriche stagnalis*				
	Family: Campanulaceae				
	Wahlenbergia preissii			N	Coolcalalaya
	Wahlenbergia tumidifructa				
	Family: Caryophyllaceae				
	Gypsophila australis				
	* *Polycarpon tetraphyllum*				
	* *Spergularia rubra*				
	Family: Casuarinaceae				
	Casuarina obesa	R/F			
	Family: Centrolepidaceae				
	Centrolepis eremica				
	Centrolepis humillima			N	Wooramel River
	Family: Chenopodiaceae				
	Atriplex holocarpa			N	Lake MacLeod
	Atriplex lindleyi subsp. *inflata*			N	Flats near Gascoyne River
	Atriplex paludosa subsp. *moquiniana*				
	Atriplex semilunaris	S			
	Atriplex vesicaria				
	Chenopodium auricomum	EW			
	Chenopodium cristatum				
	Dysphania glomulifera subsp. *eremaea*	EW			
	Dysphania platycarpa	EW			
	Dysphania rhadinostachya	S			
	Halosarcia halocnemoides	S			
	Halosarcia indica	S			
	Halosarcia pruinosa	S			
	Halosarcia pterygosperma subsp. *denticulata*	S			

Aquatics	Taxon	Habitat	Endemics	Range ends	Geographic limits
	Maireana aphylla				
	Maireana oppositifolia			N	Yaringa
	Maireana stipitata			S	Tamala
	Osteocarpum acropterum var. *acropterum*			N	Boolathana
	Salsola kali				
	Sarcocornia quinqueflora	R/F			
	Sarcocornia sp.				
	Sclerolaena diacantha				
	Sclerolaena recurvicuspis				
	Tecticornia verrucosa	HW			
	Threlkeldia diffusa				
	Family: Clusiaceae				
	Hypericum gramineum				
	Hypericum japonicum				
	Family: Colchicaceae				
	Wurmbea murchisoniana	EW		N	Coolcalalaya
	Family: Crassulaceae				
	Crassula colorata				
	Crassula exserta				
Aq	* *Crassula natans*				
	Crassula pedicellosa				
	Family: Cymodoceaceae				
	Halodule uninervis	EW			
	Family: Cyperaceae				
EAq	*Baumea articulata*	R			
	Cyperus aff. *cunninghamii*				
	Cyperus bifax	R/F;		S	Talisker
	Cyperus gymnocaulos	R			
	* *Cyperus hamulosus*				
	Cyperus rigidellus	EW			
	Cyperus squarrosus	EW		S	50 km S Carnarvon
	Cyperus vaginatus	R			
EAq	*Eleocharis acuta*			N	Carnarvon
EAq	*Eleocharis geniculata*			S	Mooka Creek, range extension
	Eleocharis pallens	EW			
	Isolepis congrua			N	Kennedy Range, Boolathana
	Isolepis cyperoides			N	Coolcalalaya, range extension
	Lipocarpha microcephala				
	Schoenoplectus lateriflorus	EW		S	Cardilya Ck, Carey Downs, range extension
EAq	*Schoenoplectus subulatus*			S	Murchison River
	Schoenus elegans				
	Schoenus humilis			N	Wooramel River
	Family: Droseraceae				
	Drosera indica	EW			
	Family: Elatinaceae				
	Bergia auriculata	EW			
	Bergia perennis subsp. *obtusifolia*	EW			Range extension
Aq	*Elatine gratioloides*	EW			Range extension
	Family: Frankeniaceae				
	Frankenia cinerea				
	Frankenia laxiflora			N	Talisker
	Frankenia pauciflora				
	Family: Gentianaceae				
	Centaurium spicatum				

Aquatics	Taxon	Habitat	Endemics	Range ends	Geographic limits
	* Family: Geraniaceae				
	Erodium cicutarium				
	Family: Goodeniaceae				
	Goodenia berardiana				
	Goodenia corynocarpa				
	Goodenia maideniana				
	Goodenia neogoodenia				Range extension
	Goodenia pinnatifida				
	Velleia hispida				
	Family: Haloragaceae				
	Haloragis trigonocarpa				
	Myriophyllum decussatum			N	Doorawarrah
	Family: Hypoxidaceae				
	Hypoxis occidentalis			N	Kalbarri
	Family: Isoetaceae				
	Isoetes muelleri				
	Isoetes sp.				
	Family: Juncaceae				
	Juncus aridicola			N	Cardilya Creek, Carey Downs
	* *Juncus bufonius*				
	Juncus kraussii				
	Family: Juncaginaceae				
	Triglochin calcitrapum			N	Kennedy Range
	Triglochin centrocarpum				
	Triglochin minutissimum			N	Boolathana
	Triglochin mucronatum			N	Dirk Hartog Island
	Family: Lythraceae				
	Ammannia baccifera			S	Wooramel River, range extension
	Ammannia multiflora			S	Cardilya Creek, Carey Downs, range extension
	Lythrum sp.Towrana (RJC 2183)	EW	endemic[A]		Carnarvon - Gascoyne Junction area
	Rotala diandra			S	Cardilya Creek, Carey Downs, range extension
	Family: Malvaceae				
	Abutilon sp.				
	Lawrencia glomerata				
	Lawrencia viridigrisea				
	* *Malva parviflora*				
	Family: Marsileaceae				
	Marsilea angustifolia	EW			
	Marsilea drummondii	EW			
	Marsilea sp.				
	Family: Mimosaceae				
	Acacia aneura				
	Family: Myoporaceae				
	Eremophila oldfieldii subsp. *oldfieldii*				
	Myoporum acuminatum				
	Family: Myrtaceae				
	Eucalyptus camaldulensis var. *obtusa*	R/F			

Aquatics	Taxon	Habitat	Endemics	Range ends	Geographic limits
	Eucalyptus coolabah	R/F			
	Eucalyptus victrix	R/F			
	Melaleuca glomerata	R/F			
	Melaleuca leucadendra	R/F			
	Melaleuca linophylla	R/F			
	Melaleuca uncinata				
	Verticordia forrestii				
	Family: Najadaceae				
Aq	*Najas marina*				
	Family: Nyctaginaceae				
	Boerhavia coccinea				
	Family: Ophioglossaceae				
	Ophioglossum lusitanicum				
	Family: Orchidaceae				
	Prasophyllum gracile			N	Tamala
	Family: Papilionaceae				
	Lotus australis				
	Lotus cruentus				
*	*Medicago polymorpha*				
*	*Medicago truncatula*				
	Muelleranthus trifoliolatus				
	Rhynchosia minima			S	Cardilya Creek, Carey Downs
	Swainsona pterostylis				
	Swainsona sp.				
	Trigonella suavissima				
	Family: Plantaginaceae				
	Plantago drummondii				
	Family: Plumbaginaceae				
	Muellerolimon salicorniaceum	S			
	Family: Poaceae				
	Agrostis sp.				
*	*Aira caryophyllea*				
	Aristida holathera				
	Austrostipa trichophylla				
*	*Avena barbata*				
	Bromus arenarius				
*	*Cenchrus ciliaris*				
	Diplachne muelleri				
*	*Ehrharta longiflora*				
	Eragrostis australasica	EW			
	Eragrostis basedowii				
	Eragrostis cumingii				
	Eragrostis dielsii				
	Eragrostis leptocarpa				
	Eragrostis pergracilis				
	Eragrostis tenellula				
	Eragrostis xerophila				
	Eriachne aristidea				
	Eriachne flaccida				
	Eriachne ovata				
	Eriachne pulchella				
	Eriochloa procera			S	Cardilya Creek, Carey Downs
	Eulalia aurea				
*	*Hordeum leporinum*				
	Iseilema eremaeum			N	Minilya

Aquatics	Taxon	Habitat	Endemics	Range ends	Geographic limits
	Paractaenum novae-hollandiae				
	* *Parapholis incurva*			N	Tamala, range extension
	* *Pentaschistis airoides*				
	* *Phalaris minor*				
	* *Polypogon monspeliensis*				
	Psammagrostis wiseana		endemic		Lake MacLeod area
	* *Rostraria pumila*				
	Setaria dielsii				
	Sporobolus mitchellii				
	Tragus australianus				
	Family: Polygonaceae				
	* *Emex australis*				
	Muehlenbeckia cunninghamii	EW			
	Rumex crystallinus	EW			Lyndon R. and McNeill Claypan, Gascoyne R. in WA
	* *Rumex vesicarius*				
	Family: Portulacaceae				
	Calandrinia corrigioloides				
	Calandrinia eremaea				
	Calandrinia granulifera				
	Calandrinia polyandra				
	Calandrinia ptychosperma				
	Calandrinia pumila				
	Calandrinia sp. Coolcalalaya (GJK and NG 698)	EW	endemic		Coolcalalaya area
	Calandrinia stagnensis				
	Portulaca oleracea				
	Family: Potamogetonaceae				
Aq	*Potamogeton pectinatus*				
Aq	*Ruppia megacarpa*				
Aq	*Ruppia polycarpa*				
Aq	*Ruppia tuberosa*			N	Shark Bay
	Family: Primulaceae				
	* *Anagallis arvensis*				
	Samolus junceus				
	Samolus repens				
	Family: Ranunculaceae				
	Ranunculus pumilio			N	Boolathana, range extension
	Ranunculus sessiliflorus			N	Eurardy
	Family: Rubiaceae				
	Oldenlandia galioides	EW		S	Cardilya Creek, Carney Downs, range extension
	Synaptantha tillaeacea				
	Family: Sapindaceae				
	Dodonaea petiolaris				
	Family: Scrophulariaceae				
	Elacholoma hornii				Range extension
	Glossostigma diandrum	EW		N	Kennedy Range
	Glossostigma drummondii	EW		N	Doorawarrah
	Mimulus gracilis	EW		S	McNeill claypan, Gascoyne River, range extension
	Peplidium aithocheilum	EW			
	Peplidium muelleri	EW			
	Peplidium sp. C (N.T. Burbidge and A. Kain 8152)	EW			

Aquatics	Taxon	Habitat	Endemics	Range ends	Geographic limits
	Stemodia florulenta	EW			
	Stemodia grossa				
	Stemodia viscosa				
	Family: Solanaceae				
	Nicotiana occidentalis				
	Solanum lasiophyllum				
	Family: Thymelaeaceae				
	Pimelea trichostachya				Range extension
	Family: Tiliaceae				
	Corchorus walcottii				
	Family: Typhaceae				
EAq	*Typha domingensis*				
	Family: Urticaceae				
	Parietaria debilis				
	Family: Zygophyllaceae				
	Zygophyllum ammophilum				

[A] A recent (August 2000) taxonomic review of the genus *Lythrum* in WA (Lepschi, 2000, *Nutysia* **13**: 273–282) has included this taxon in *Lythrum wilsonii* which is widespread across the arid and semi-arid regions of New South Wales, the Northern Territory, Queensland and South Australia.