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Some gaps in the reserve system of the southern Carnarvon Basin, Western Australia

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Abstract – Site-based data on patterns in terrestrial and wetland biodiversity were used to identify some major gaps in the comprehensiveness of the reserve system in a 75 000 km^2 region on the mid-west coast of Western Australia. Data comprised lists of plants, birds, reptiles, frogs, mammals, ground-dwelling spiders, scorpions and centipedes from 63 terrestrial sites, and waterbirds, wetland plants and aquatic invertebrates from 51 wetland sites. The sites were positioned in a stratified array across the geographical extent of the region, but their number and dispersal was limited by the cost of sampling such a variety of taxa. Although this geographical sparsity limited the geographical resolution of the reserve selection procedures, a distinct lack of cross-taxon congruence in the geographical patterns of taxa implied that data on a range of taxa should be used to design the region's reserve system. We specify the biological characteristics and pattern of occurrence of 12 terrestrial communities and eight wetland-types that need to be added to the reserve system.

INTRODUCTION

The Carnarvon Basin study area covers 75 000 km^2. It is centred on Shark Bay in Western Australia, and extends northwards from the Murchison River to the Minilya River, and eastwards to beyond Gascoyne Junction (Figure 1). In phytogeographic terms, the study area comprises the northern half of the Irwin District of the South-western Province, as well as the southern half of the Carnarvon District of the Eremaean Province (Beard, 1980). The area south of Shark Bay has a semi-arid climate influenced by temperate weather systems (mainly winter rainfall). From Shark Bay northward, the climate is influenced by both tropical and temperate systems; semi-arid at the coast, but arid with locally unreliable summer and winter rainfall further inland.

The region is a lowland characterised by gentle gradients on a basement of soft sediments. Under a variety of past climates, interacting alluvial and aeolian processes have produced a complex landscape mosaic (Figure 2) that has been further modified by extensive coastal transgressions associated with sea-level changes (Wyrwoll *et al.*, 2000). Alluvial plains dominate, although erosional uplands such as the Kennedy Range occur in its eastern parts. The plains are traversed from east to west by two large, ephemeral rivers lined with groves of river gum (*Eucalyptus victrix*): the Gascoyne and Wooramel. Low open woodlands of bowgada (*Acacia linophylla*) and snakewood (*A. xiphophylla*) over *Atriplex, Senna* and *Eremophila* shrubs and tussock grasses cover the plains, with *Acacia grasbyi* in areas where calcretes are exposed. Low red sand ridges scattered across the plains support shrubs over mainly hummock-grasses. In northern parts, the plains grade into red sand dune fields that support hummock-grass and mulga (*A. aneura*) communities reminiscent of Australia's 'red centre'. The area of dune field in the east, between the Gascoyne and Wooramel Rivers, supports low open woodlands of *Acacia coriacea* and *A. pruinocarpa* over bunch grasses (Figure 2). In the south the plains support woodlands of *Eucalyptus loxophleba* and *Callitris glaucophylla*, with mallee, *Banksia, Allocasuarina* and *Actinostrobus* scrubs and heaths on greyish and yellow sand dunes. A strip of limestone that follows the coast southwards from Shark Bay is partially mantled by pale yellow to grey sands supporting low proteaceous heaths with emergent thickets of *Banksia* and mallees such as *Eucalyptus illyarrie*. White coastal sand dunes support *Spinifex longifolius* communities. Low-lying saline areas, such as the fringes of Lake MacLeod and the coastal flats, support samphire and saltbush communities.

The five major reserves in the study area, and their previously proposed extensions, are shown in Figure 1. Even a superficial comparison of Figures 1 and 2 reveals major gaps in the reserve network with respect to 'land types' (Table 1): of 17 geomorphic units recognised in Figure 2, six were not represented in existing or previously proposed reserves. The existing reserve system covers less

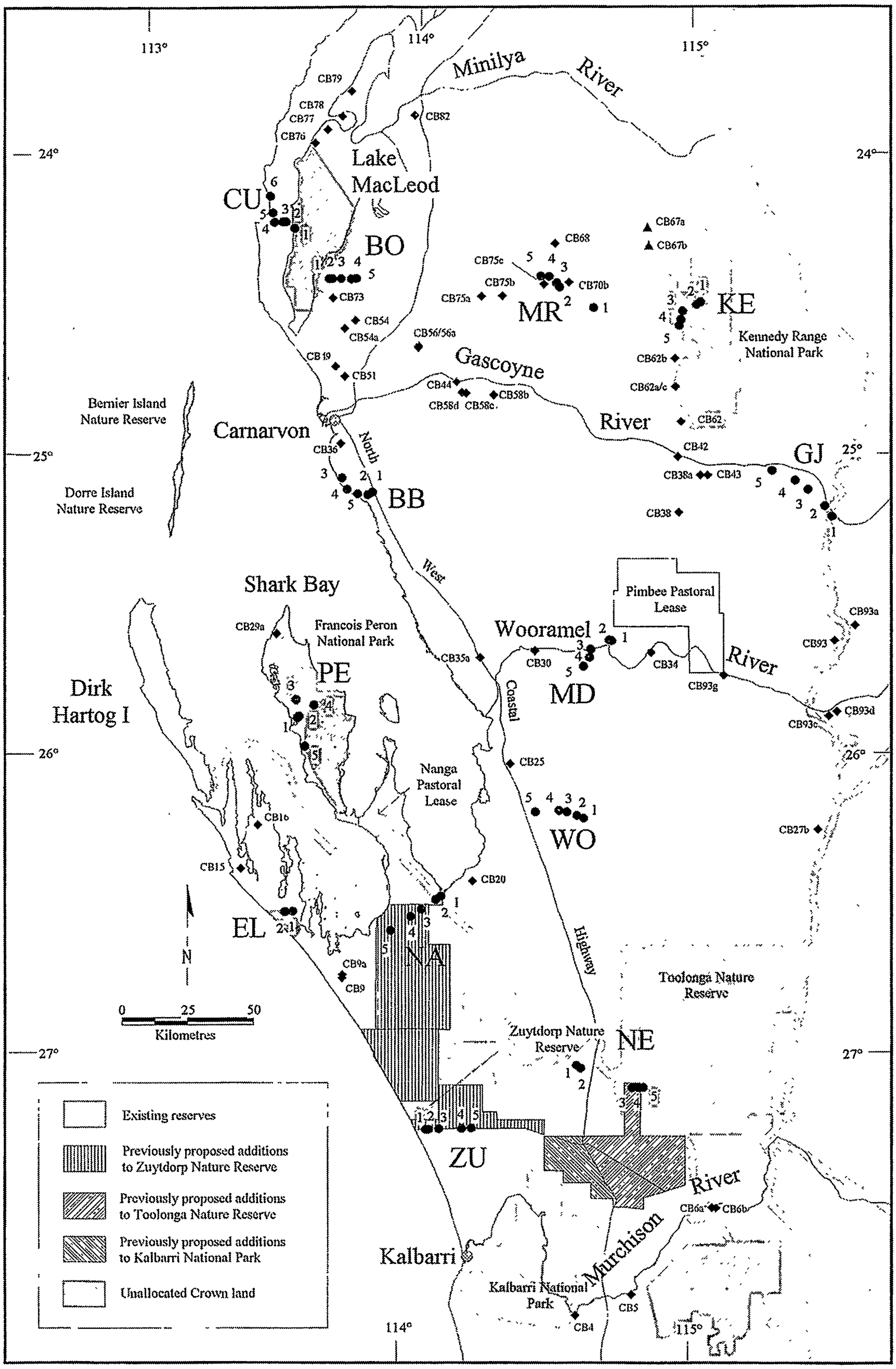


Figure 1 Existing and previously proposed reserves for nature conservation in the Carnarvon Basin study area, showing vacant Crown land, bioregion boundaries (grey lines), terrestrial survey campsites and their associated quadrats (black spots), and wetland sample sites (black diamonds). Campsite codes are as follows: BB (Bush Bay), BO (Boolathanna), CU (Cape Cuvier), EL (Edel Land), GJ (Gascoyne Junction), KE (Kennedy Range), MD (Meedo), MR (Mardathuna), NA (Nanga), NE (Nerren Nerren), PE (Peron), WO (Woodleigh) and ZU (Zuytdorp).

Table 1 Geomorphic units represented in the existing and previously proposed reserve system of the southern Carnarvon Basin. Patches too small to map at 1 : 250 000 scale are ignored.

Status (from Figure 1)	Geomorphic Unit (from Figure 2)																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Kalbarri NP			x		x		x					x			x		
Toolonga NR							x								x		
Zuytdorp NR															x	x	
Francois Peron NP									x	x					x	x	x
Bernier Island NR									x							x	x
Dorre Island NR									x							x	x
Kennedy Range NP		x			x										x		
Kalbarri extension												x			x		
Toolonga extension															x		
Zuytdorp extensions						x				x					x	x	

than 10% of the region (Thackway and Creswell, 1995) and is highly biased towards sand surfaces. Unreserved areas are subject to a variety of ongoing threatening processes, including grazing by stock and feral herbivores, predation by feral carnivores and colonisation by exotic plants (Thackway and Creswell, 1995). For these reasons, the Australian Government's National Reserve System Programme listed the Carnarvon Bioregion in the highest priority category for reserve acquisition in relation to the other bioregions of Australia.

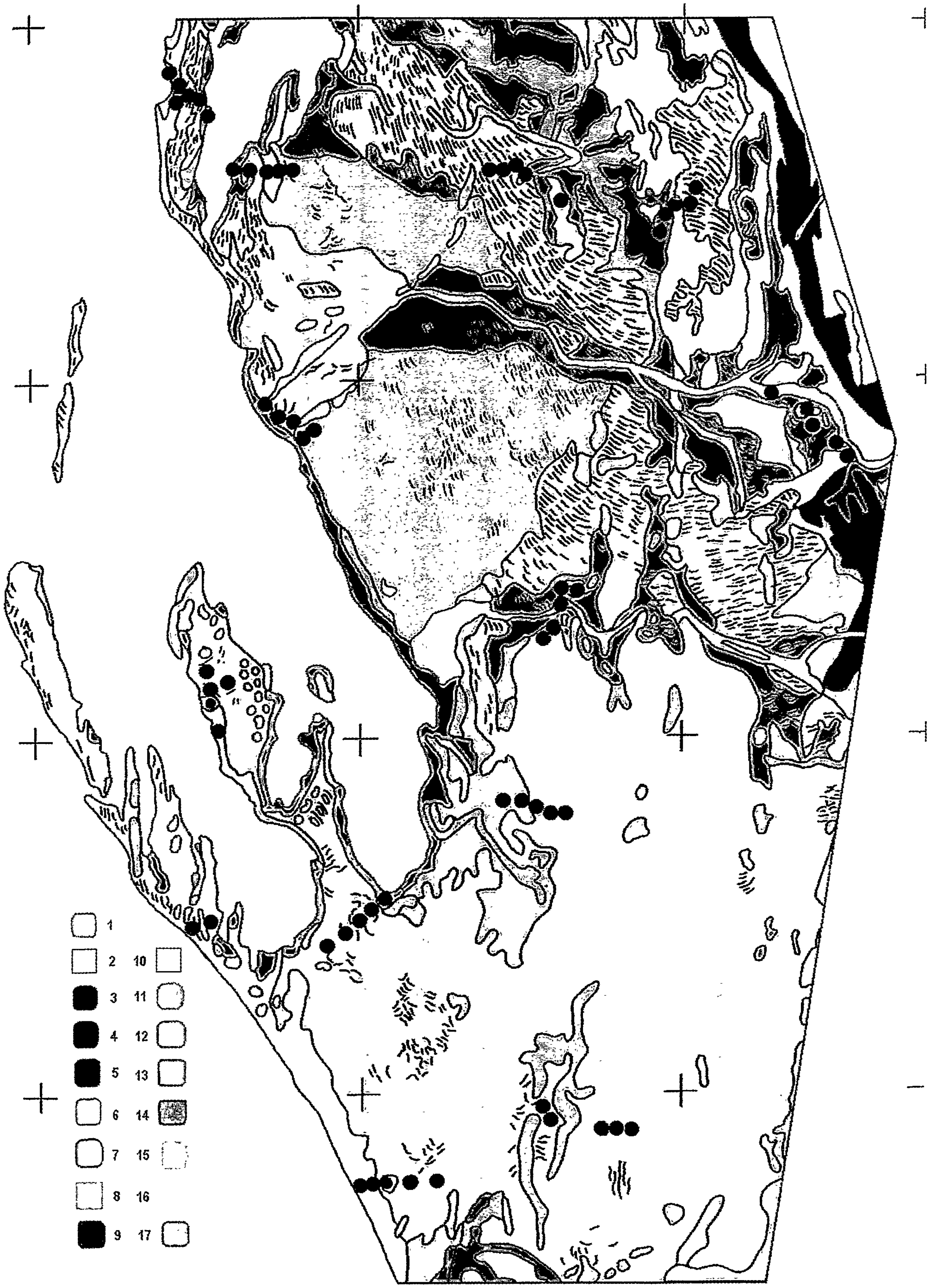
In this paper we use data collected during an ecological survey of the southern Carnarvon Basin (Burbidge *et al.*, 2000) to identify gaps in the existing reserve system. Examples of some communities may not become available for reservation, even by land purchase, so conservation strategies to maximise their persistence are recommended where necessary. Conservation strategies are particularly important for protecting wetland communities, condition and persistence of which are usually linked as much to events in their catchments as to events within the wetland (Humphries and Robinson, 1995; Green *et al.*, 1996; Brierley, 1998).

The southern Carnarvon Basin study comprised two concurrent field surveys: one sampled its terrestrial ecosystems and the other its wetlands. Data matrices derived from these programmes could not be combined for analysis because they had no sampling points in common and shared few environmental attributes. Birds, mammals, frogs, reptiles, scorpions, centipedes, spiders and plants were recorded at terrestrial quadrats, while aquatic invertebrates, waterbirds, and both aquatic and peripheral plants were sampled at wetland sites. Soil chemical and textural attributes, as well as geomorphic properties, were determined at terrestrial quadrats, while water flow characteristics, seasonal persistence and chemistry were recorded at wetland sites. Nevertheless, the two field surveys provided complementary perspectives on biological diversity because the two sets of sampling points were scattered across the same geographical area.

Previous papers in this series examined patterns in the biological diversity of the southern Carnarvon Basin from the perspectives of the different organisms sampled. The patterns are summarised by Halse *et al.* (2000) and Gibson *et al.* (2000a) for wetland communities, and by McKenzie *et al.* (2000a) for terrestrial communities. This paper should not be used without prior reference to all three of these publications. Data-sets on three additional terrestrial groups were analysed individually – mygalomorph spiders (Main *et al.*, 2000), millipedes (Harvey *et al.*, 2000b) and bats (McKenzie and Muir, 2000). Additional analyses of wetland data undertaken in this paper are comparable to those of McKenzie *et al.* (2000a), and aimed at showing patterns in the whole wetland community. Together, the terrestrial and aquatic community analyses provide a basis for identifying major gaps in the 'comprehensiveness' of the reserve system in the study area, but provide no data on either its 'adequacy' or its 'representativeness'. Definitions of these criteria are given by Woinarski and Norton (1993) and a practical interpretation is provided by JANIS (1996). In summary, a comprehensive system contains an example of every ecosystem identified within the region, an adequate system contains parcels of land and populations of species that are large enough to be self-sustaining through time, and a representative system encompasses the variation within each ecosystem and species' population.

METHODS

Different sampling methods were used for terrestrial and aquatic biota, with the most important difference being the way sampling 'points' were defined. Wetland sampling was done at sites, which consisted of a variably-sized area of water around a GPS-located point. For waterbirds, all inundated parts of the wetland constituted the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site unless the wetland was >50 ha (maximum size of a site); for wetland invertebrates, sampling was restricted to within 200 m of the GPS point and the maximum area available for sampling was about five ha. Plant species were recorded in a series of 1 m square quadrats in different vegetation zones in the water and on the bank near the GPS point. Thus, wetland sites were more loosely defined than terrestrial quadrats, which were permanently marked 200 m x 200 m squares, within which plants and animals were surveyed in a variety of ways. We use the term 'site' when referring to sampling points in wetlands, and quadrats when referring to terrestrial sampling points.

Environmental requirements of nearly all aquatic invertebrates in Australia are unknown (Williams, 1980). Thus, ecological niches of wetland species in the southern Carnarvon Basin cannot be characterised in the way that McKenzie *et al.* (2000a) characterised requirements of terrestrial species. This precluded using gradients in the composition of wetland species assemblages in reserve design, although this approach has been used successfully for terrestrial ecosystems elsewhere in Western Australia (McKenzie *et al.*, 1989; McKenzie and Belbin, 1991). Thus, we have applied the compositional gradient approach to reserve selection to the terrestrial data, but used site classification to identify gaps in the reserve system for aquatic biota.

Terrestrial Biodiversity

McKenzie *et al.* (2000a) classified the study area's terrestrial species into 13 assemblages of normally co-occurring species; several of these assemblages were represented at each quadrat, albeit to a greater or lesser extent. Herein, these assemblages are termed 'communities', and the broad-scale characterisation of their environmental niches provided by McKenzie *et al.* (2000a) was used as a basis for enhancing the reserve system's comprehensiveness. This was feasible in this instance because most of the scaled deviance in community richness could be explained in terms of climatic and other mapped environmental attributes (McKenzie *et al.*, 2000a). There were four steps in the process.

1. We used the interpolation module in the computer package SYSTAT (Wilkinson, 1990, p. 271) to contour the species richness of each community across the study area. Although the species richness gradients of the communities were related to combinations of climatic and substrate factors (the GLM equations are listed in Table 5 in McKenzie *et al.*, 2000a), substrates were expressed as local soil-mozaics within regional climatic patterns. Thus, we could suppress the localised influence of the soil attributes on the contour maps by basing the interpolations on the maximum community-richness value recorded from the quadrats in the vicinity of each campsite, excluding singletons (Table 2). This had the additional benefit of reducing the effect of any spatial autocorrelations induced by the contagious distribution of the quadrats across the study area – they were clustered around the campsites (Roxburgh and Chesson, 1998). The negative exponential smoothing option (NEXPO) was used because the point richness values were at least as high as our sampling programme indicated.
2. Climatic attributes were estimated for every 10 km square in the study area (using ANUCLIM), so that the richness contour maps could be corrected for any between-campsite

Figure 2 Simplified surface stratigraphy of the Carnarvon Basin study area, modified from Hocking *et al.* (1987) using the relevant 1:250 000 maps (Butcher *et al.*, 1984; Denman and van de Graaff, 1982; Denman *et al.*, 1985; Hocking *et al.*, 1982; Hocking *et al.*, 1985; van de Graaff *et al.*, 1983). • = Terrestrial quadrats. // indicate dune fields; **1, PB** Lower Permian siltstones and quartz wacke; **2, Pw** and **Pk** Permian siltstones, quartz wackes, quartz sandstones and shales; **3, St** Silurian sandstone as fluvial sequence; **4, CP** Carboniferous tillite, quartz wacke, siltstone and shale; **5, K** Cretaceous sandstone, siltstone, conglomerate and shale (includes Ks, Kw, Kg, Kt and Kb); **6, T** Tertiary calcarenite (includes Tl, Tp, Tg and Tt); **7, Czd** Cainozoic siliceous and ferruginous duricrust; **8, Czk** Cainozoic calcrete duricrust (often includes exposures of K); **9, Qm** Quaternary intertidal and supratidal flat deposits. Minor beach ridge, coastal dune and lake deposits; **10, Ql** Claypan and salt lake deposits of clay, silt, sand and gravel (includes coastal saline lakes: Qlb); **11, Qa** Alluvial dominated: alluvial, colluvial and diluvial deposits, including valley calcrete. Associated with major drainage lines. Along active river courses it includes Cainozoic colluvium; **12, Qc** Colluvium: Clay, silt, sand and gravel; sheet flood and soil creep deposits. Includes residual deposits; **13, Q** Deposits of mixed origin: Alluvial, colluvial and aeolian clay, silt, sand and gravel; commonly on older alluvial and diluvial deposits partially reworked by aeolian processes; **14, Qep** Playa and sand dune deposits: alluvial, diluvial and aeolian clay, silt, sand and gravel in mixed dune and playa terrain; commonly associated with major palaeodrainage; **15, Qe** Aeolian dominated: reddish-brown to yellowish brown sand plains and dunes, including residual and re-worked areas and inter-dune deposits, and some dune and playa terrain; **16, Qs** Aeolian dominated: coastal dune and beach ridge deposits of calcareous sand and calcarenite (Qbe); **17,** Quaternary calcarenite exposures (Qb, Qt, Qk and Qd).

Table 2 Maximum community richness value recorded from the terrestrial quadrats in the vicinity of each campsite. Campsite locations are provided in Figure 1.

Campsite	Community												
	1	2	3	4	5	6	7	8	9	10	11	12	13
BB	1	25	5	3	72	1	0	14	0	0	26	2	0
BO	1	48	4	4	92	1	2	4	0	1	18	1	0
CU	2	10	1	3	67	4	1	13	2	18	36	2	0
EL	0	10	0	0	32	2	2	5	9	1	36	4	0
GJ	5	27	25	2	61	0	3	0	0	0	5	0	0
KE	1	21	25	23	62	4	10	1	0	3	4	4	0
MD	17	41	7	5	71	0	11	1	0	0	9	1	0
MR	2	40	16	28	79	1	6	0	0	1	8	1	0
NA	0	17	1	3	82	28	14	6	1	0	27	7	0
NE	0	5	1	0	65	8	34	0	0	1	15	2	0
PE	0	6	1	3	70	3	7	11	0	0	61	1	0
WO	0	41	5	1	84	0	6	1	0	0	7	1	0
ZU	1	2	0	0	44	7	5	0	2	1	35	50	14

anomalies in the climatic and altitude factors identified as important in the relevant GLM equation (Table 5 in McKenzie *et al.*, 2000a).

3. Although species richness provided a reasonable surrogate of composition for most communities (as discussed in McKenzie *et al.*, 2000a, they approximated nested sub-sets), compositional discrepancies in the richness isolines of complex communities were identified at this stage by inspecting the relevant two-way table (Figure 12 in McKenzie *et al.*, 2000a) to allow for patterns of allopatry etc. Discrepancies are considered on a case-by-case basis in 'Results'.
4. Finally, the optimum geographical positions for reserves were determined by using substrate maps and existing reserve boundaries as masks on the isoline maps.

Wetland Biodiversity

Analyses involved 51 wetland sites for which aquatic invertebrate, waterbird and plant data were available (Figure 1). For nine wetland sites at which no waterbirds were recorded, the species label "no species recorded" was entered in the waterbird data-set as a pseudo-record. Singleton taxa were removed from the data-set for each biotic element, but sites with only one species were retained. The sites were classified into seven groups in terms of their aquatic invertebrate, waterbird and floristic attributes (Gibson *et al.*, 2000a; Halse *et al.*, 2000) but all three classifications had different partition structures.

To determine which data-set provided the best surrogate of biodiversity patterns, we combined the three wetland data-sets to generate a fourth data set, comprising 389 wetland species (34 bird taxa, 253 invertebrate taxa, and 102 plant taxa), and in which the species richness at individual wetland sites ranged from 11 to 74. Next, we generated a wetland-site similarity matrix from each data-set, then plotted the four matrices in the same ordination space using inter-matrix correlation coefficients as the input data (McKenzie *et al.*, 2000a). This provided a measure of cross-taxon congruence – of how closely spatial patterns in wetland species composition coincided across the three phylogenetic groups.

No geographical interpretation of compositional gradients in each of the wetland communities was attempted because wetland composition related to local topographic, edaphic and/or temporal factors, rather than to altitudinal and climatic gradients (Gibson *et al.*, 2000a; Halse *et al.*, 2000). Reserve recommendations are based on the wetland site classification groups.

RESULTS

Terrestrial Biodiversity

The environmental domain of each community of terrestrial species was characterised in McKenzie *et al.* (2000a). Compositional isolines for 12 of the 13 communities are mapped in Figure 3 and their climatic envelopes are mapped in Figure 4. Figures 1 and 2 show the study area's existing conservation reserves and substrate-types, respectively. They summarise the 1 : 250 000 scale maps of land tenure and surficial stratigraphy that, as masks for the isoline maps, were used to assess reserve system requirements. Most substrate-types occur in more than one of the geomorphological regions recognised in the study area (Figure 6 in Wyrwoll *et al.*, 2000), such as the 'Victoria Plateau' and the 'MacLeod Region', and could be further subdivided.

Community-1 occurs on riverine frontages in the arid zone of Western Australia, an environment that is well developed along the Wooramel and

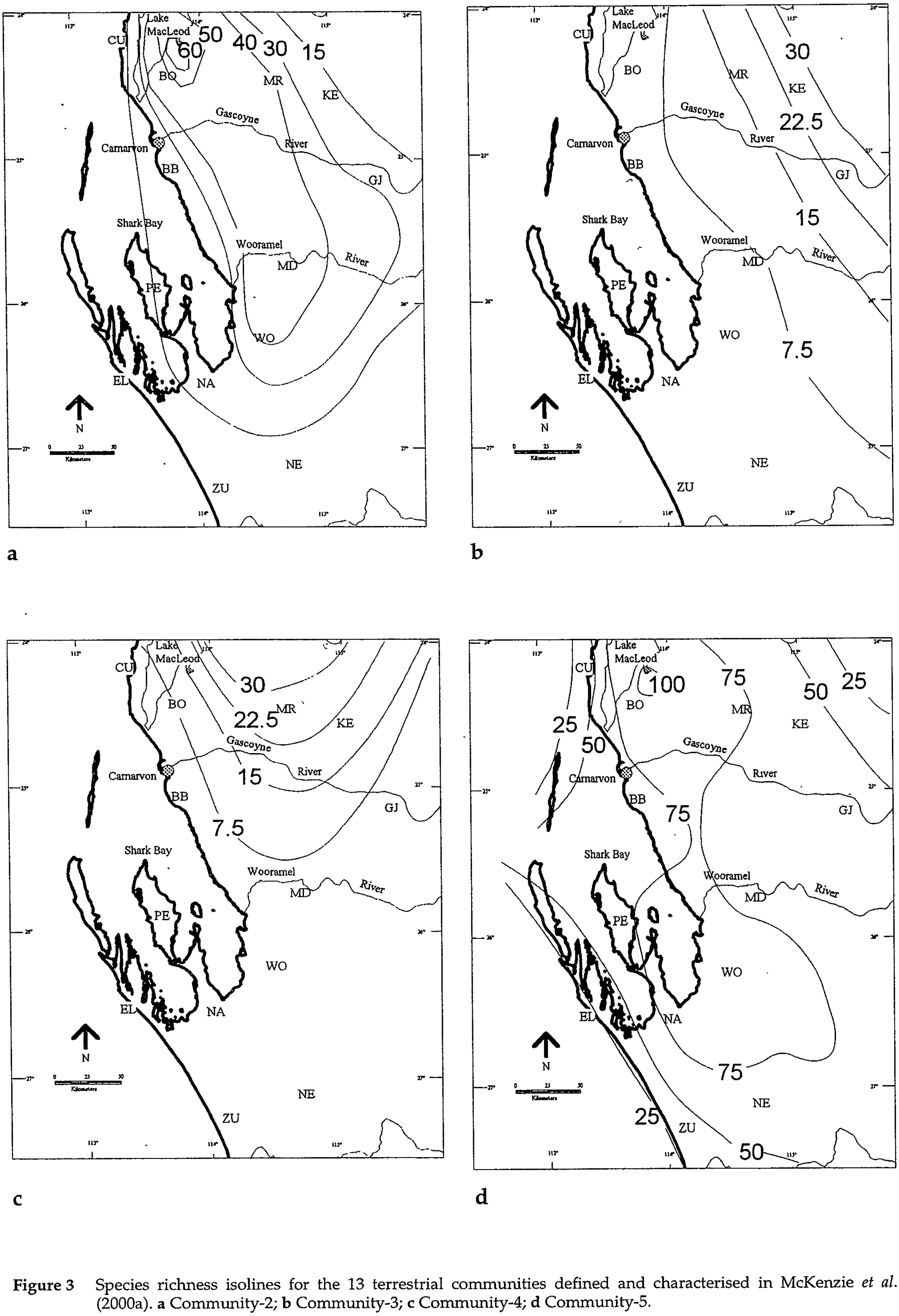


Figure 3 Species richness isolines for the 13 terrestrial communities defined and characterised in McKenzie *et al.* (2000a). **a** Community-2; **b** Community-3; **c** Community-4; **d** Community-5.

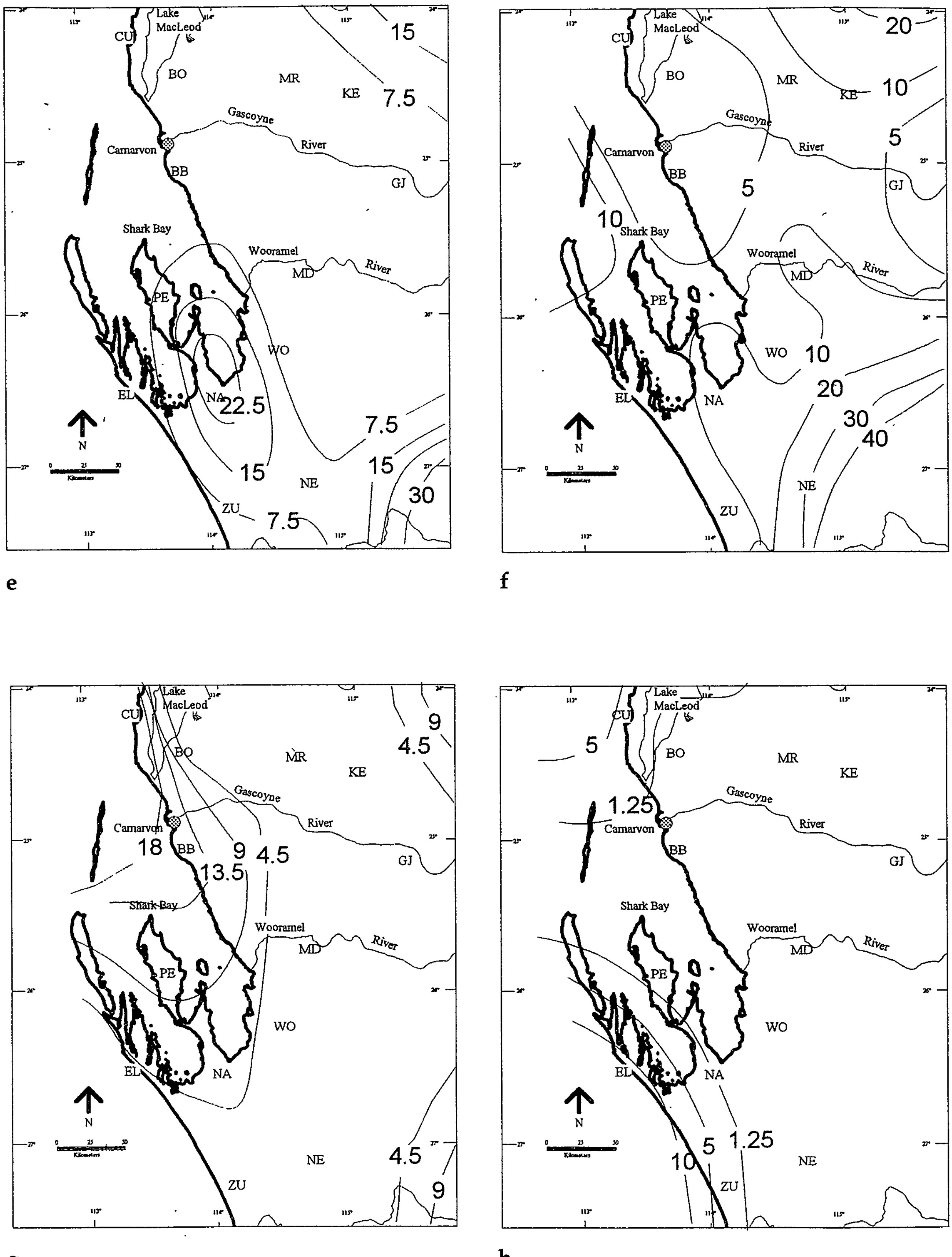


Figure 3 (cont.) e Community-6; f Community-7; g Community-8; h Community-9;.

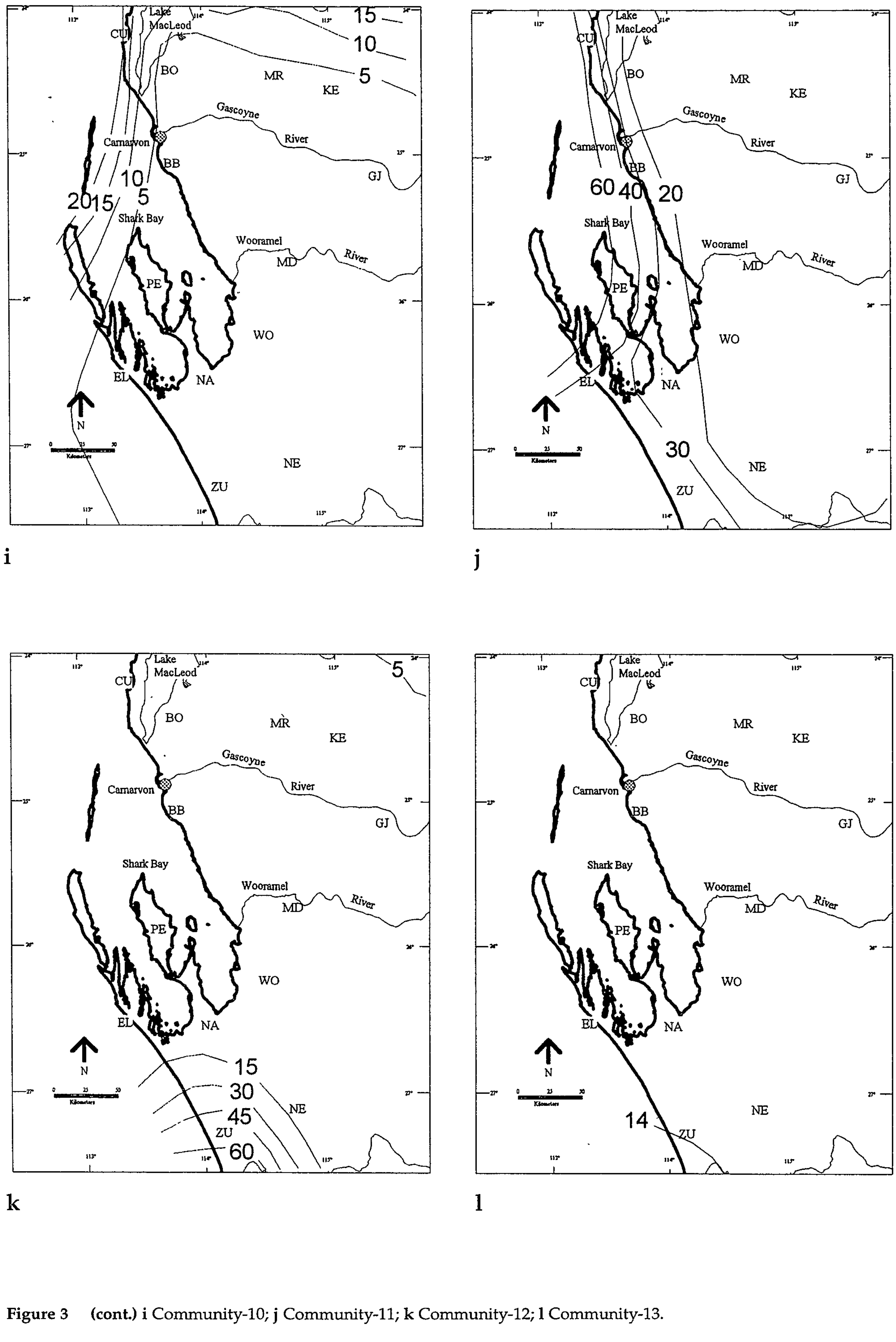


Figure 3 (cont.) i Community-10; j Community-11; k Community-12; l Community-13.

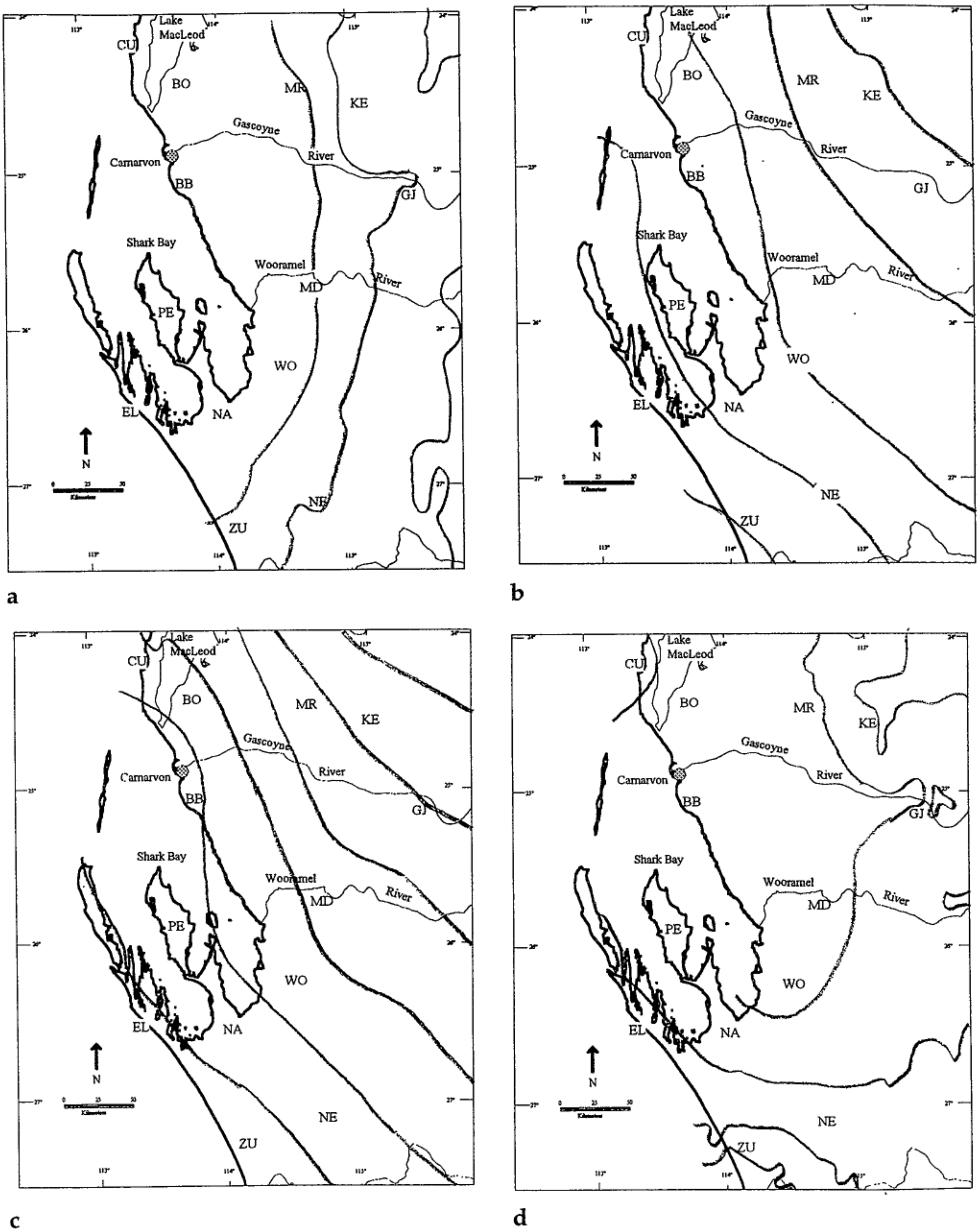
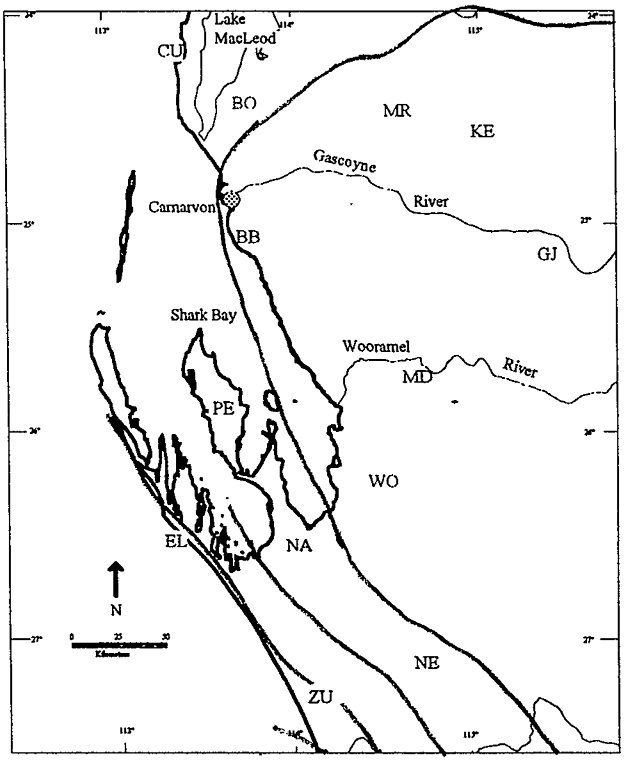


Figure 4 Climatic envelopes of terrestrial communities. They were derived from the climatic components of the GLM equations in Table 5 of McKenzie *et al.* (2000a). Climatic gradients were not important in relation to community-1, -8 and -13. **a**, Climatic surface for Community-2: Ln(richness) = - 0.02(Altitude) + 0.004(Altitude^2) - 0.02(Wettest Quarter Precipitation) + 0.24(Temperature Diurnal Range); **b**, Climatic surface for Community-3: Ln(richness) = 1.4(Warmest Quarter Temperature) - 8e^{-5}(Average Annual Precipitation^2); **c.** Climatic surface for Community-4: Ln(richness) = 0.06(Warmest Quarter Precipitation) + 0.61(Warmest Quarter Temperature); **d.** Climatic surface for Community-5: Ln(richness) = - 0.006(Wettest Quarter Precipitation) - 0.002(Altitude).



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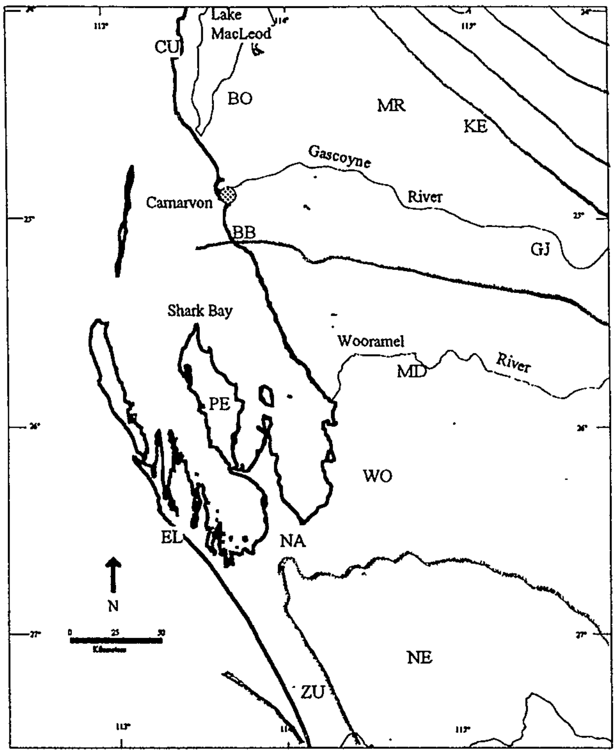

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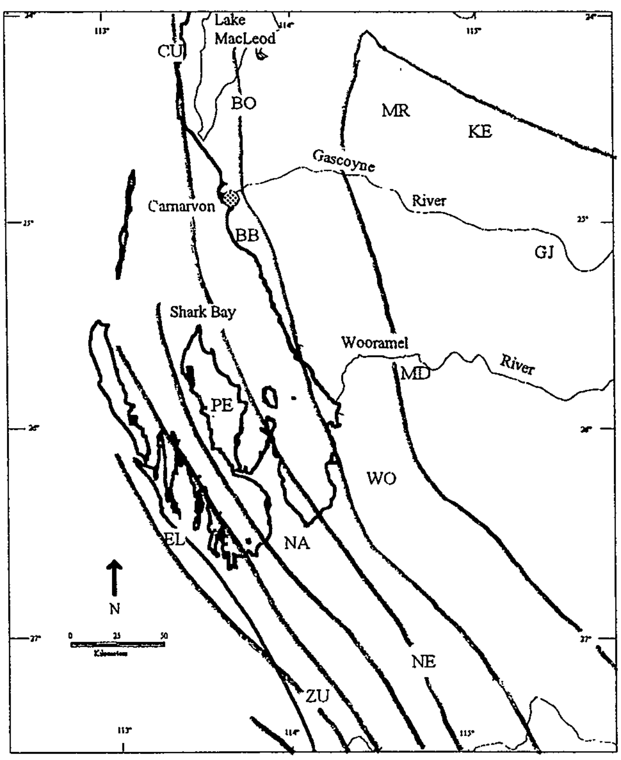

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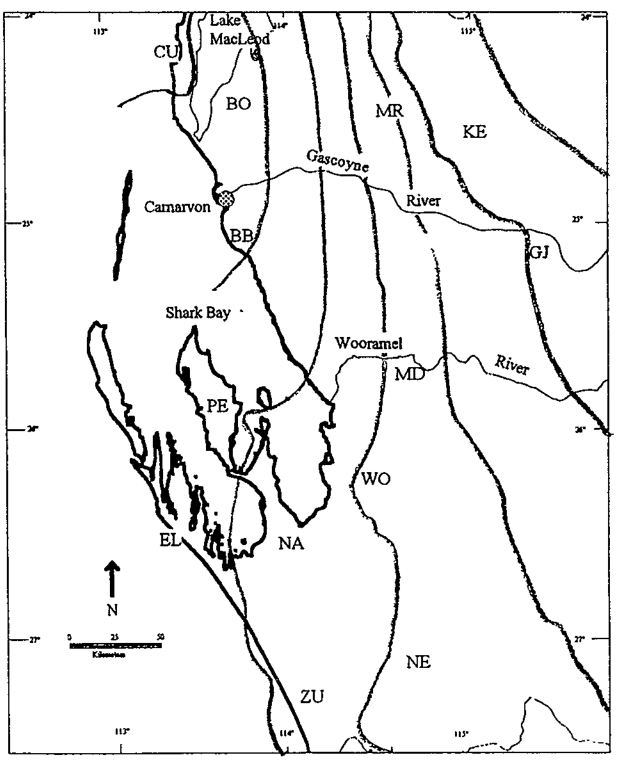

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Figure 4 **(cont.) e.** Climatic surface for Community-6: Ln(richness) = 0.117(Precipitation Seasonality) - 0.277(Average Annual Precipitation); **f.** Climatic surface for Community-7: Ln(richness) = 0.61(Coldest Quarter Precipitation) - 9.4e^{-4}(Coldest Quarter Precipitation^2) - 0.36(Wettest Quarter Precipitation) + 2.30(Average Annual Temperature); **g.** Climatic for Community-9: Ln(richness) = 0.071(Wettest Period Precipitation); **h.** Climatic surface for Community-10: Ln(richness) = -4.27(Latitude) + 0.27(Wettest Period Precipitation) + 0.71(Temperature Annual Range);

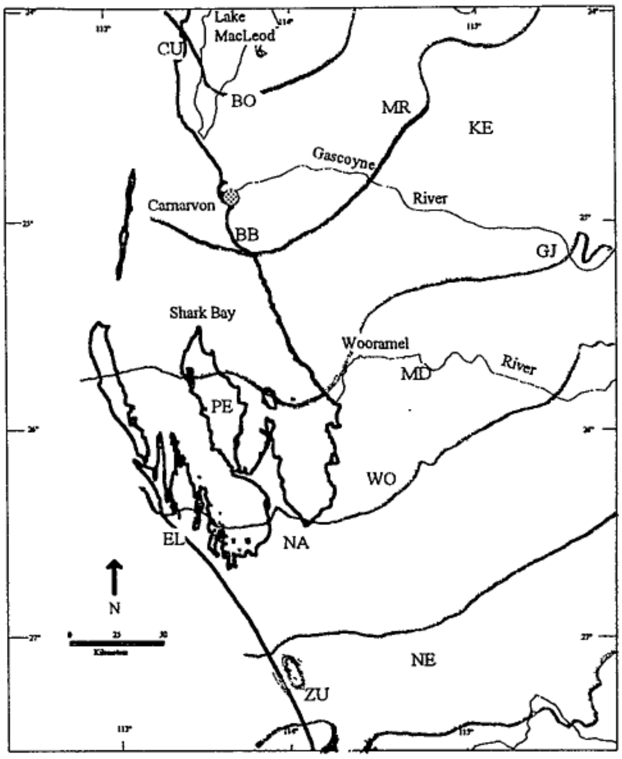

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Figure 4 **(cont.) i.** Climatic surface for Community-12: Ln(richness) = 0.027(Average Annual Precipitation) - 0.78(Coldest Quarter Temperature)

Gascoyne Rivers in our study area (Figure 2), but not represented in the existing reserve system (Figure 1). No isoline map was produced for community-1 because its optimum environmental domain was only sampled at one location (MD3), although sub-sets of its component species were recorded on floodplain-quadrats adjacent to these rivers (e.g. GJ5) (see Figure 12 in McKenzie *et al.*, 2000a). An example of river frontage will need to be reserved.

Community-2 occurs on fine-textured soils and associated sandy lunettes, including riverine alluvia, in the arid zone. Its climatic envelope, a function of altitude, wettest quarter precipitation and temperature diurnal range, showed only gradational changes at locations between the sampled points (Figure 4a), so we would not expect significant anomalies in Figure 3a from this source. However, inspection of the relevant two-way table (Assemblage-2 in Figure 12 of McKenzie *et al.*, 2000a) revealed compositional differences between the species-rich examples of this community in northern and southern areas, and locally in response to salinity. To represent this variation, the reserve system should include areas of fine-textured soil plains and associated lunettes at both the north and south end of the area enclosed by the '40-species' isoline (Figures 3a and 2).

Community-3 occurs on the heavy soils in the arid zone – floodplains, footslopes of ranges and clayey inter-dune plains. Its climatic envelope, a function of warmest quarter temperature and annual average precipitation, showed only gradational changes between the sampled points (Figure 4b), so we would not expect significant anomalies in the compositional isoline map (Figure 3b) from this source. However, inspection of the relevant two-way table (Assemblage-3 in Figure 12 of McKenzie *et al.*, 2000a) revealed compositional differences between the species-rich examples of this community on the footslopes of the Kennedy Range, compared with those found on floodplains adjacent to the Gascoyne River (Figure 2). Areas of these floodplains need to be reserved.

Community-4 is associated with the deep red desert sand dunes and sandplains of Australia's arid zone, including isolated dune fields close to the coast. The interpolated richness isolines are presented in Figure 3c. In this case, the relevant climatic factors (warmest quarter precipitation – Pwar, and warmest quarter temperature – Twar) accounted for most of the scaled deviance, reducing it from 481 in the null model, to 192 (Pwar) and thence to 155 (Pwar + Twar) in the GLM model (see Table 5 in McKenzie *et al.*, 2000a). The relevant climatic envelope (Figure 4c) indicates that suitable climatic conditions for community-4 also occur in the unsampled eastern part of the study area between MD and GJ, which includes an extensive area of the red dune-fields favoured by these species (Figure 2). In addition, inspection of the relevant two-way table (Assemblage-4 in Figure 12 of McKenzie *et al.*, 2000a) revealed distinct compositional differences between the species-rich examples of this community on top of the Kennedy Range and those near the MR campsite (Figure 2). The KE variant of this community is already conserved in the Kennedy Range National Park (Figure 1), but examples of this red dune-field community need to be reserved in the other two areas, one north-east of MD at the northern end of the Victoria Plateau (the Pimbee Pastoral Lease has now been purchased for this purpose), and the other in the Mardathuna Region (see Figure 6 in Wyrwoll *et al.*, 2000).

Community-5 comprises cosmopolitan species, although it was not as rich in the south-western parts of the study area and on saline substrates. Its climatic envelope, a function of wettest quarter precipitation and altitude, revealed no significant anomalies at locations between the quadrats (Figure 4d). In addition, inspection of the relevant two-way table (Assemblage-5 in Figure 12 of McKenzie *et al.*, 2000a) did not reveal strong compositional variants, so a reserve positioned anywhere within the 75-species contour line of Figure 3d that includes areas of non-saline surfaces in good condition (Figure 2) should represent species-rich examples of this community.

Community-6 occurs on sandy, semi-arid surfaces south of Shark Bay. Unlike community-4, substrate rather than climatic factors accounted for most of the scaled deviance in the GLM model, reducing it from 373 in the null model, to 189 (exchangeable potassium – exK) and thence to 170 (exK + phosphorus) (see Table 5 in McKenzie *et al.*, 2000a). Its climatic envelope, a function of precipitation seasonality and annual average precipitation, showed only gradational changes between the sampled points (Figure 4e), so we would not expect significant anomalies in Figure 3e from this source. In the absence of sample points, the increasing species richness isolines in the south-eastern corner of Figure 3e are treated as artifactual. In addition, inspection of the relevant two-way table (Assemblage-6 in Figure 12 of McKenzie *et al.*, 2000a) did not reveal strong compositional variants, so a single reserve positioned in the undulating sand surface of the Victoria Plateau (Figure 6 in Wyrwoll *et al.*, 2000) at the southern end of the Nanga Pastoral Lease (within the 22 species-isoline of Figure 3e) and extending southward towards the Zuytdorp Nature Reserve (Figures 1 and 2) would protect the compositional complexity of this community.

Community-7 is associated with semi-arid woodlands of the temperate zone. The interpolated richness isolines are presented in Figure 3f. Combined, the climatic factors were at least as important as substrate; soil phosphorus reduced the scaled deviance of the GLM model from 505 to 378, the climatic factors then reduced it to 125 (see Table 5 in McKenzie *et al.*, 2000a). There was one anomaly in the continuous surface model of the relevant climatic factors that was liable to influence the community's species composition, but it was near Kalbarri, 40 km south of the study area (Figure 4f). In addition, inspection of the relevant two-way table (Assemblage-7 in Figure 12 of McKenzie *et al.*, 2000a) did not reveal strong compositional variants in the south-eastern part of the Victoria Plateau (Figure 6 in Wyrwoll *et al.*, 2000), so a single reserve would protect the compositional complexity of this community in the study area. The Toolonga Nature Reserve (Figure 1) straddles the 35- and 40-species isolines of Figure 3f.

Community-8 comprises widespread species that associate with saline clayey soils; the climatic factors in the GLM model were artefacts because of the skewed occurrence of suitable environments in the substrates in the study area. Inspection of the relevant two-way table (Assemblage-8 in Figure 12 of McKenzie *et al.*, 2000a) revealed compositional differences between the species-rich examples of this community found near CU and PE (the MacLeod and Peron Geomorphological Regions), and those found on the Carnarvon Coastal Plain near BB (Figure 3g)(see also Figure 6 in Wyrwoll *et al.*, 2000). The first variant of this community is already reserved on Francois Peron National Park, but an additional reserve is required for the second variant that was found in the areas around BB (Figures 1 and 2).

Community-9 was associated with near-coastal sand surfaces in temperate, semi-arid parts of the study area. Interpolated richness isolines are presented in Figure 3h. Its climatic envelope, a function of wettest period precipitation, showed only gradational changes between the sampled points (Figure 4g), so we would not expect significant anomalies in the richness isoline map from this source. In addition, inspection of the relevant two-way table (Assemblage-9 in Figure 12 of McKenzie *et al.*, 2000a) did not reveal compositional variants in this strongly localised community, so a single reserve on the sand dunes in Edel Land (Figures 1 and 2) would protect its compositional complexity.

Community-10 is associated with sub-tropical, near-coastal red sand surfaces from Carnarvon to Exmouth, although the two hummock grasses (*Triodia basedowei* and *T. pungens*) have wider distributions across arid Australia. Interpolated richness isolines are presented in Figure 3i. Its climatic envelope, a function of latitude, wettest period precipitation and temperature annual range, was important, reducing the scaled deviance in the GLM model from 278 to 58 (Table 5 in McKenzie *et al.*, 2000a). But since this envelope showed only gradational changes between the sampled points (Figure 4h), we would not expect significant anomalies in the richness isoline map from this source. In addition, inspection of the relevant two-way table (Assemblage-10 in Figure 12 of McKenzie *et al.*, 2000a) did not reveal compositional variants in this strongly localised community. A single reserve in the red sand dune fields along the coast north of Cape Cuvier (Figures 1 and 2) in the MacLeod Geomorphological Region (Figure 6 in Wyrwoll *et al.*, 2000) is required to protect this community.

Community-11 comprises widespread temperate zone species of the arid, semi-arid and often the mesic; in the study area, they converge with the coast. Interpolated richness isolines are presented in Figure 3j. The relevant climatic envelope, a function of longitude and annual average temperature, was more important than substrate, reducing the scaled deviance in the GLM model from 828 to 216 (Table 5 in McKenzie *et al.*, 2000a). But since average annual temperature and, of course, longitude showed only gradational changes between the sampled points, we would not expect significant anomalies in the community richness isolines from this source. However, inspection of the relevant two-way table (Assemblage-11 in Figure 12 of McKenzie *et al.*, 2000a) revealed compositional differences between the species-rich examples of this community. Variants were associated with (1) temperate near-coastal areas from PE southwards; (2) semi-arid sandy and limestone surfaces found along the mid-latitude coast of the study area to BB and extending into semi-arid areas of the adjacent Avon and Coolgardie Bioregions; (3) the temperate zone generally, with a component of species that approach their northern limits at Shark Bay but follow the coast even further northward to CU (Figures 1 and 2). A species-rich example of the first variant of this community is already reserved on Francois Peron National Park and others occur in the area near NA proposed above for Community-6. An additional reserve, which should include an area of white beach dunes with *Spinifex longifolius* (Figure 1) as well as red dunes and swales, is required for the other variants in the vicinity of CU.

Community-12 occurs as heaths and scrubs in mesic to semi-arid areas of the temperate zone and is associated with sandy surfaces, sometimes mantling limestone. It is at its northern limit in coastal areas south of Shark Bay. Interpolated richness isolines are presented in Figure 3k. Its climatic envelope, a function of the interaction between annual average precipitation and coldest quarter temperature, was important, reducing the scaled deviance in the GLM model from 824 to 115 (Table 5 in McKenzie *et al.*, 2000a). This envelope showed anomalies to the south and north-west of the sampled points at ZU (Figure 4i), and we would expect a significant increase in the community richness south of ZU from this source, although there were only gradational changes in the climatic envelope between the sampled points elsewhere. Inspection of the relevant two-way table (Assemblage-12 in Figure 12 of McKenzie *et al.*, 2000a) revealed considerable local variation along the 20 km east-west transect sampled by the ZU quadrats. While a single sub-coastal reserve should be sufficient, it will need to be large – within the 45-species isoline of Figure 3k and extending eastwards across the sand ridge and sand plain surface of the southern Victoria Plateau (Figure 6 in Wyrwoll *et al.*, 2000) as far as the North West Coastal Highway (Figures 1 and 2). The Zuytdorp Nature Reserve, its proposed extensions, and the proposed extensions to Kalbarri National Park, encompass this area.

Community-13 comprises mesic to semi-arid specialists of sand and limestone surfaces that need to be close to the coast to even penetrate the south-western corner of the study area(Figure 3l). Inspection of the relevant two-way table (Assemblage-13 in Figure 12 of McKenzie *et al.*, 2000a) shows that it was sampled at only two adjacent quadrats, which is insufficient to assess its compositional variation. According to Figures 1 and 2, the community occurs in the Zuytdorp Nature Reserve.

Wetland Biodiversity

Wetland plants, wetland invertebrates and waterbirds showed clear differences in their patterns of occurrence (Figure 5). The 'combined wetland taxa' data-set was nearest neighbour to all three of its biotic components, and provided a useful summary of patterns in wetland biodiversity across the Basin.

The wetland sites sampled are shown in Figure 1. Eight groups of wetlands were recognised from the classification dendrogram derived from the 'combined wetland taxa' data-set (Figure 6). Brief descriptions of these groups are given below. Groups I to III were saline wetlands and corresponded to the primary division in the dendrogram. The second split separated wetlands of rivers, streams and seeps (groups IV to VII) from seasonal claypans (group VIII).

Saline Wetlands

Group I. Birridas are coastal saline pans, most common around Shark Bay, that often contain a raised, samphire-covered central area formed by precipitation of gypsum, which is surrounded by a 'moat'. Some (e.g. CB29a) are already protected in Francois Peron National Park but additional examples should be conserved. CB15 on Edel Land was closest to the group centroid.

Group II. The more inland saline pans are also of (older) marine origin. Although species-poor, the example sampled (CB25) appeared biologically

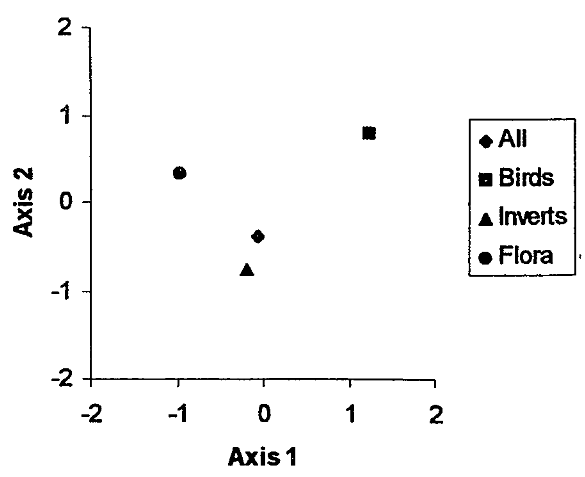

Figure 5 Coefficients of correlation between the association matrices derived from waterbird, wetland invertebrate, wetland plant, and 'combined wetland' data-sets, plotted in two-dimensional ordination space. Stress = 0.16.

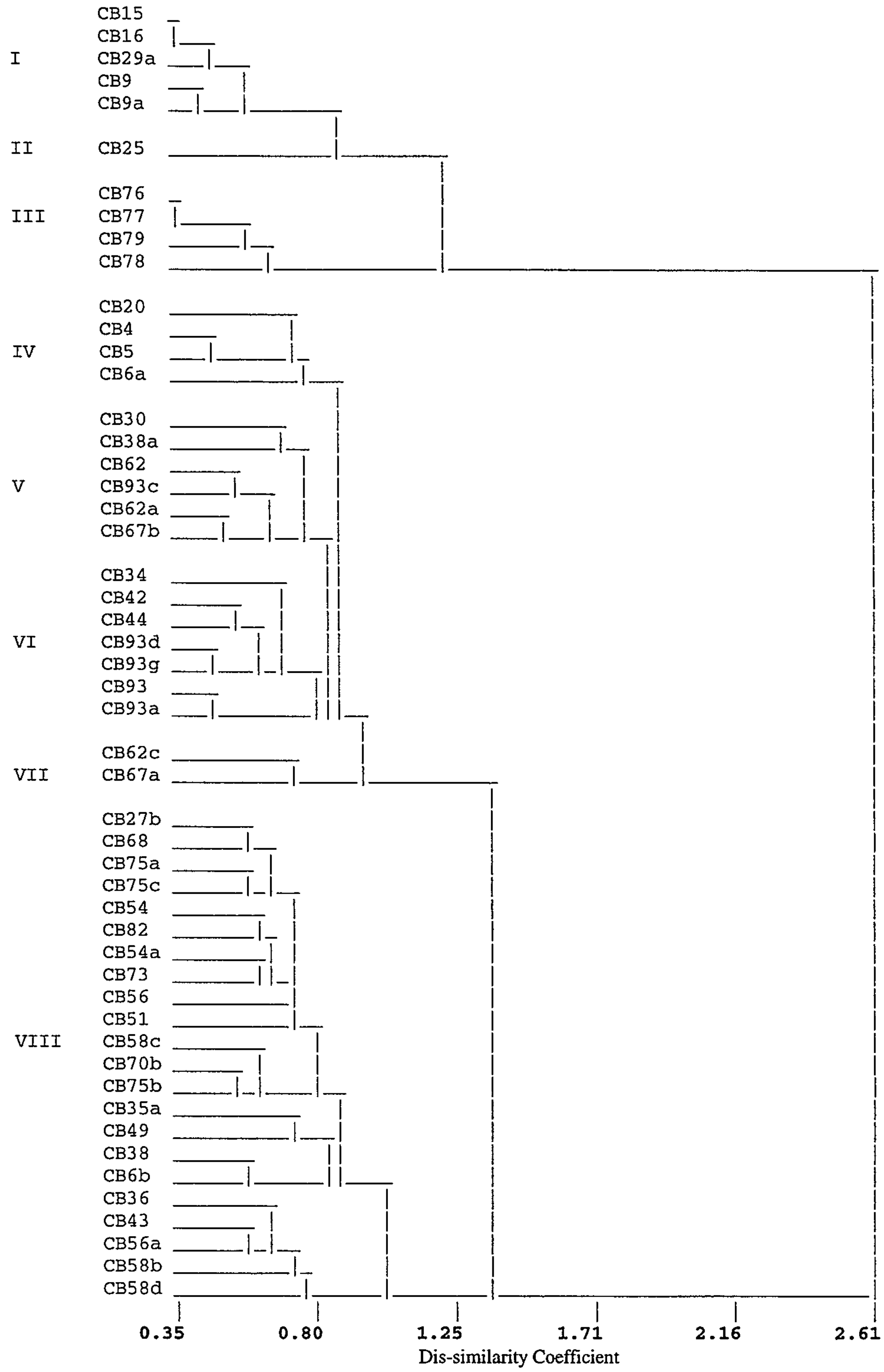

Figure 6 Classification of wetland sites in the southern Carnarvon Basin according to similarities in all wetland taxa (plant, waterbird and aquatic invertebrate). Singleton occurrences were removed. Eight groups of sites were identified, although Group VIII would have been divided into four sub-groups if the dendrogram had been cut at a single level.

distinct from other saline sites, particularly in terms of invertebrates (mean richness 12.0 versus 19.8 and 26.3 for Groups I and III, respectively). Although there are few such pans in the Basin, other than in the complex east of Shark Bay, an example should be conserved.

Group III. Lake MacLeod is biologically distinct from other birridas and wetlands in the southern Carnarvon Basin, being mangrove-dominated. It is a very important waterbird site. Based on waterbird numbers, it meets criteria for listing as a Wetland of International Importance. It also has a moderately rich invertebrate fauna of predominantly marine elements. There is a salt-harvesting operation in the southern part of the lake but sections north of this should be conserved. In terms of the adequacy criterion in reserve design (Woinarski and Norton, 1993), the hydrological continuity of Lake MacLeod system means that preservation of small sections of the lake in isolation will be ineffective but the areas of permanent inundation on the western shore in the central and northern parts of the lake are particularly important. Coastal mangrove communities also occur in the southern Carnarvon Basin; these were not sampled and their conservation needs are not addressed in this paper.

Riverine Wetlands

Group IV. Two types of site in this group warrant protection:

1. Main channel sites on the lower Murchison River. One of the sites sampled (CB4) occurs in Reserve number 13126, an unvested camping reserve immediately adjacent to Kalbarri National Park. The wetland-type also occurs further downstream in Kalbarri National Park, which probably represents adequate conservation.
2. Eucalypt swamps on the Murchison River floodplain represent a distinct and biologically rich type of wetland, examples of which need to be conserved. CB6a was sampled but similar wetlands occur nearby.

The bore swamp CB20 is not considered in terms of the reserve system because it is artificial.

Group V. This group consisted of sections of streams. Although some of the streams do not flow permanently, they are probably all spring-fed and are vulnerable to grazing and trampling by livestock, if the streams are used as watering points. Reservation of small sections of stream, in isolation, will not protect this habitat-type and its biota because surrounding land-use and upstream activities can have a major effect on site-condition. Streams need to be included in large reserves and/or integrated catchment management will be required. CB62, at the south end of the Kennedy Range, is a good example of a stream site suitable for conservation.

Group VI. Large river/rock pools on Gascoyne and Wooramel Rivers are biologically distinctive, as well as often being attractive. They have similar species richness to their counterparts along the Murchison River (Group IV) (mean richness = 58.4 versus 52.8, respectively), but are much richer than either streams or seeps (Group V – 37.5, Group VII – 18.0). Representative river and rock pools need to be protected. Sites such as CB93d on the Wooramel River should be included in large reserves. Many river and rock pools are used for watering livestock and as tourist areas (e.g. CB44 – Rocky Pool on the Gascoyne River). In conjunction with catchment management, some of these pools could be fenced and water pumped from the pool into adjacent troughs.

Group VII. Seeps or small springs are uncommon in the southern Carnarvon Basin, but form a biologically distinct group that is particularly vulnerable to grazing, trampling, and other disturbance. Several representatives should be protected. CB62c, adjacent to the Kennedy Range National Park, is a good example of the sort of sites that need to be conserved.

Claypans

Group VIII. Vegetation, and to a lesser extent birds, did not distinguish claypan habitats in the same way as invertebrates. Because the influence of turbidity on the invertebrate community varies according to stage in the drying cycle as well as soil type, patterns associated with turbidity are largely artifactual and will vary between years. In the long-term, most claypans probably provide habitat for the same pool of invertebrate species, so claypans have been treated as a homogeneous group for the purposes of conservation. Nevertheless, there was more variation within the claypan community than existed between some other groups, and a large pool of patchily distributed species (see Figure 6 in Halse *et al.*, 2000). Because of this variation, four claypans are recommended as typical of sites suitable for reservation: CB54, CB75a, CB70b and CB75b. The diversity of claypan communities suggests that a large number will need to be protected to provide adequate conservation of their biota. These should cover the full geomorphic spread of the study area and, as far as possible, claypans should be included within larger terrestrial reserves.

Only the main channel sites in the lower Murchison River are adequately reserved, the other wetland groups identified during this survey require protection by reservation or other means.

DISCUSSION

Land-class mosaics, defined in terms of both biotic and abiotic elements of the landscape, have frequently been used as a surrogate for biodiversity pattern in land-use planning (Pressey and Nicholls, 1991; Brooker and Margules, 1995). Belsky (1995) demonstrated the strong relationship between landscape pattern and flora and fauna, and stressed the importance of soil moisture, geomorphology and edaphic properties as the primary 'creators' of pattern in African savannas at the landscape scale. Given that Carnarvon Basin species often co-occurred at a site in response to different environmental attributes (McKenzie *et al.*, 2000a), our compositional gradient approach to reserve selection is based on a more realistic model of patterns in the region's terrestrial biodiversity than a land-class strategy would have provided. In addition, the isoline maps from the compositional gradient procedure provided an explicit focus for reserve positioning, thereby enhancing both flexibility and efficiency (Margules and Austin, 1991; Howard *et al.*, 1998).

Furthermore, in view of the distinct lack of cross-taxon congruence (*sensu* Howard *et al.*, 1998) in our study area's terrestrial (McKenzie *et al.*, 2000a) and wetland (results herein) biota, a reserve system defined using only a few landscape attributes was unlikely to be efficient in representing the region's biodiversity. It is this lack of cross-taxon congruence that justifies our decision to sample an expanded biodiversity domain even though this decision also reduced the number of quadrats and sites that could be sampled.

Alternative reserve selection strategies, based on land-classes or single taxa, would have been too shallow in biodiversity terms. The option of modelling each species individually, and selecting a minimum set of sites from their distributions was not viable because we would have had to derive more than 700 statistical models, and 45% of the species were recorded at less than 3 quadrats. Given the clumped distribution of the quadrats, a high proportion of the species models would not have been robust.

Being based on just 63 terrestrial quadrats and 51 wetland sites, with a combined area of less than 0.025% of the study area, our data were geographically sparse. Twenty-one percent of terrestrial species occurred at only one quadrat despite being known from other locations in the study area or outside it. This high proportion of singletons indicates that many more quadrats would need to be sampled if models were to represent the species-complexity of the study area even for array of terrestrial organisms that we were able to sample.

The geographical sparsity of the data meant that we could only identify major gaps in the comprehensiveness of the reserve system. For instance, floristic survey of 100 additional quadrats on sandplains in the southern end of our study area showed that a variety of distinct localised communities were overlooked by our broad-scale study and, even then, more than 25% of their vascular flora was naturally rare (Gibson *et al.*, 2000b), a level of geographical variation that did not emerge from our Zuytdorp and Nerren Nerren data. The clumped distribution of the quadrats meant that some communities were only sampled in the vicinity of a single campsite. For instance, Community-13 was sampled only at the ZU quadrats. This would result in a model that under-rated the community's area of occurrence, yielding a conservative result. Both the sparsity and the quadrat-distribution issues are offset by the substantial areas of the reserves proposed herein, but the system will need to be refined as data-resolution improves.

Mygalomorph spiders, millipedes and bats were not included in the terrestrial data matrix used for reserve selection. The mygalomorphs and millipedes conformed with similar environmental gradients to the ground-dwelling araneomorph spiders – coldest/wettest quarter precipitation and soil carbon (Main *et al.*, 2000; Harvey *et al.*, 2000a, 2000b). In relation to the bats, McKenzie and Muir (2000) concluded that the study area straddles a biogeographical boundary, and that three reserves would satisfy comprehensiveness and representativeness criteria at the species level:

1 rugged escarpment country, and springs with River Gum stands, in and around the Kennedy Range.
2 woodlands near Nerren Nerren and
3 an area of the Gascoyne River frontage near Carnarvon.

The first of these would be encompassed by extending the Kennedy Ranges National Park (recommended above in relation to 'terrestrial community-3'). Toolonga Nature Reserve provides for the second, and the third expands our recommendation for 'terrestrial community-1'.

In pragmatic terms, the adequacy criterion in reserve system design relates mainly to extent and condition (JANIS, 1996). The 11 terrestrial reserves recommended herein address gaps in coverage at regional scales. Their biota will continue to face a range of internal and external problems such as invasive weeds, feral herbivores and introduced predators (e.g. buffel grass, rabbits, goats, foxes). Most will continue to be surrounded by production lands where soil erosion is pervasive and in which vegetation cover/composition has changed in response to grazing by livestock (Payne *et al.*, 1980). The number of mammalian extinctions that has occurred in the region during the last century provides some indication of the effect of these processes (McKenzie *et al.*, 2000b). Given this context, we recommend that the reserves have an average area of 100 000 ha, and a minimum area of at least 10 000 ha even where an existing reserve is contiguous.

Six issues emerge in relation to the selection of sites for reservation or alternative protection:

1. The study area's terrestrial quadrats and wetland sites had a high proportion of naturally rare species – 21% of terrestrial and 33% of wetland species were only recorded at one site. Most quadrat-based studies of vascular flora have found 25–55% singletons (Gibson *et al.*, 1994; Wardell-Johnson and Williams, 1996; Gibson *et al.*, 2000b). Similar levels of rarity have been previously reported from wetlands in the south-west of Western

Australia, in which surveys of aquatic invertebrates have recorded 24–35% of taxa from only one wetland (Davis *et al.*, 1993; Edward *et al.*, 1994; Bayley, 1997). This makes species conservation extremely difficult at a regional scale because, to ensure representativeness (*sensu* Woinarski and Norton, 1993), a high proportion of areas need to be conserved.

2. Wetland surveys conducted over a short period of time (less than 10 years) are unlikely to sample a wide range of environmental conditions and may fail to detect significant biological communities (Halse *et al.*, 1998a, b). Many wetlands in the Carnarvon Basin were dry, or in the final stages of drying, on all three sampling occasions. Drier 'crabhole' swamps, saline pans east of Shark Bay and some large swamps on Mardathuna Station are examples of physiognomically distinctive wetlands that were poorly sampled or not sampled at all (Halse *et al.*, 2000). Thus, wetland reserve selection was adversely affected by lack of rainfall in parts of the study area. The wetland survey also suffered from the sparsity of sites sampled because of limited resources, which adversely affected the information base for reserve recommendations.
3. Single examples of each wetland-type are also unlikely to provide long-term conservation because wetlands function as a network for certain species, where resources (food and water) are continually redistributed among the members. Wetland birds are the most obvious example and often access wetlands over a very large area, especially Palaearctic shorebirds. But many aquatic insects are also highly mobile and re-colonise seasonal wetlands from more permanent waterbodies. Depending on the pattern of variability of individual patches, the less mobile invertebrate and plant species also occasionally need to re-colonise sites from which they are extirpated by drought, fire, grazing, predation and other disturbances.
4. The large size of proposed terrestrial reserves will increase the likelihood they contain an array of subtly different plant and animal communities, some of which may have been overlooked in the sparse sampling program (see above). Wetlands are discrete units that usually show little internal variation, especially if they are small. Therefore, several examples of each wetland-type identified in this paper should be protected to ensure that all typical wetland communities in the region are conserved.
5. Off-reserve management issues are particularly significant in wetland conservation because wetlands are low in the landscape and are directly affected by changes elsewhere in their catchment (Brierley, 1998). In the Carnarvon Basin, this problem is exacerbated by the small size of most playas and the narrow, linear shape of watercourses. Heavy grazing pressure by stock has reduced vegetation cover and, in some cases, led to erosion in much of the region. Payne *et al.* (1980) found more than half the area of some land systems to be in poor condition, including the delta floodplain system along the lower reaches of the Gascoyne, Minilya and Wooramel Rivers. Earlier work classified 14% of the Gascoyne 'Basin' as badly eroded and 52% as degraded, with some erosion (Wyrwoll *et al.*, 2000). Reducing erosion is important to the conservation of wetlands in the Carnarvon Basin.
6. Conservation of aquatic communities will require protection of a comparatively large number of wetlands, as well as sympathetic catchment management. Reservation will not always be the most appropriate means of achieving wetland protection, especially when wetlands are small. In some cases it may be more appropriate to pay lease holders to provide alternative watering points so they can fence stock out and manage wetlands primarily for conservation than to acquire them as reserves. This could be achieved by formal covenanting arrangements or more informally.

Landscape Context

In this paper we have define 12 terrestrial communities and eight wetland-types that need to be added to the region's reserve system. The flexibility offered by our approach to gap-identification will allow the system to be developed in conjunction with other components of the region's socio-economic framework.

In several cases, the terrestrial and wetland reserves specified in 'Results' (above) belong to the same landscape catena, so wetland and terrestrial requirements can be encompassed in the same reserves when boundaries are defined on the ground. The Pimbee Pastoral Lease, purchased for conservation purposes by the Western Australian Government in 1999, is an example. It includes examples of terrestrial community-4, several large claypans belonging to wetland group-VIII, and 15 km of Wooramel River frontage (terrestrial community-1) including Calytharra Pool (wetland group-VI). Table 3 is a list of terrestrial communities and wetland-types that belong to the same landscape catena, and includes our reserve recommendations.

Four of the surface stratigraphic units mapped in Figure 2 were not sampled during our study. Unit

Table 3 Reserve requirements. An integration of terrestrial communities and wetland-types that belong to the same landscape catena (localities are shown on Figure 1, Geomorphic units are mapped in Figure 2).

Terrestrial Community	Specification	Wetland-type	Specification	Reservation
-1	Riverine frontage (unit 11)	VI	Large river/rock pools	(a) Pimbee Pastoral Lease (b) Similar areas along Gascoyne River
-2 and -5	Alluvial plains and sandy lunettes of central Basin (units 13 and 14)	VIII II	Claypans (non-saline – units 10 and 11) Inland Birridas (unit 10)	(a) East of Lake MacLeod. (b) East of Shark Bay, south of Wooramel River mouth
-3	Heavy soils of footslopes, floodplains and clayey inter-dune plains (unit 11)	VIII V VII	Claypans (non-saline) Stream sections (spring fed) Seeps/small springs	(a) Gascoyne floodplains/ playa terrain near GJ (b) South-west extension of Kennedy Range National Park
-4	Red sand dune fields of arid zone (unit 15)	VIII	Claypans (non-saline)	(a) Kennedy Range National Park (b) near MR (c) Pimbee Pastoral Lease
-6	Temperate semi-arid sands immediately south of Shark Bay (unit 15)	I	Coastal birridas (units 9 and 10)	Previously proposed reserve from NA to Zuytdorp Nature Reserve
-7	Temperate semi-arid woodlands of Victoria Plateau sandplains (units 12 and 15)	IVb	Murchison River floodplains (unit 11)	Toolonga Nature Reserve, and an extension southwards to the Murchison River
-8a and -11a	Temperate arid and semi-arid sands and samphires (units 15, 9 and 10)	I	Coastal birridas	Francois Peron National Park
-8b	Samphire flats (units 9 and 10)	I	Coastal birridas	Coastal area near BB
-9	Edel Land dune systems (unit 16)	I	Coastal birridas (unit 10)	North-western Edel Land
-10 and -11b	Red dunefields near CU and adjacent beach dunes (units 15, 16)	III	Saline pools and mangroves in Lake MacLeod (units 9 and 10)	Large areas in north-western part of Lake, and adjacent strip of dune-field, north of CU
-12	Temperate mesic to semi-arid heaths and scrubs on sandplains (units 15, 12 and 6)	–	–	Previously proposed additions to Zuytdorp Nature Reserve and Kalbarri National Park
-13	Temperate mesic specialists (unit 16)	–	–	Zuytdorp Nature Reserve
–	–	IVa	Pools along Murchison River	Kalbarri National Park

3, 7 and 17 occur in the Kalbarri National Park, Toolonga Nature Reserve and Francois Peron National Park, respectively, while unit-4 is outside the boundary of the Carnarvon Basin. More detailed studies of the biodiversity of these substrates should be undertaken.

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Appendix A

Brief description of the 63 terrestrial quadrats sampled for all attributes in the biogeographic survey of the southern Carnarvon Basin. Each entry consists of site label, altitude, latitude, longitude, approximate location in words and a description of vegetation; broader context is provided in Burbidge, McKenzie and Harvey (this volume). Latitudes and longitudes were determined by GPS using the Australian Geodetic Datum 1966; precision at the time was about ± 100 m. Soils and geomorphology are described in Wyrwoll, Stoneman, Elliott and Sandercock (this volume).

BB BUSH BAY

BB1 9 m, 25°7'33.6"S, 113°49'22.4"E
1.25 km W of North West Coastal Highway.
Atriplex vesicaria low shrubland on flats with *Acacia* spp. and *Hakea preissii* scrub on rises on south side of road.

BB2 19 m, 25°8'4.6"S, 113°48'20.2"E
3.25 km W of North West Coastal Highway.
Acacia sclerosperma and *Alectryon oleifoliium* scrub over *Eremophila maitlandii* low shrubland on south side of road.

BB3 4 m, 25°4'40.1"S, 113°42'36.0"E
6.1 km W of North West Coastal Highway, then 11.3 km N of intersection with coastal track.
Samphire (*Halosarcia halocnemoides*) flat on W side of road.

BB4 13 m, 25°6'57.6"S, 113°43'45.1"E
6.1 km W of North West Coastal Highway, then 7.0 km N of intersection with coastal track (go 0.9 km further N and follow fence S along E of fence); dune with trig. point.
Low shrubland of *Acacia sclerosperma* and *A. tetragonophylla* over *Scholtzia* sp., *Rhagodia preissii* and *Pityrodia loxocarpa* low shrubs.

BB5 2 m, 25°7'53.8"S, 113°46'5.2"E
6.1 km W of North West Coastal Highway, then 2.4 km N of intersection with coastal track.
Mixed low shrubland (*Acacia ligulata, Exocarpus aphyllus, Rhagodia,* etc) on E side of road.

BO BOOLATHANA

BO1 2 m, 24°24'48.6"S, 113°39'47.2"E
c. 18 km N of Boolathana HS and 2.0 km W of track from Boolan Pool.
Shrubland of *Atriplex* and *Cratystylis* on S side of track.
Cratystylis subspinescens and *Atriplex vesicaria* low shrubs over *Chenopodium gaudichaudianum.*

BO2 2 m, 24°24'49.0"S, 113°40'29.6"E
c. 18 km N of Boolathana HS and 1.0 km W of track from Boolan Pool.
Samphire (*Sclerostegia disarticulata*) low shrubland on S side of track.

BO3 2 m, 24°24'48.6"S, 113°42'23.8"E
c. 18 km N of Boolathana HS and 2.4 km E of track from Boolan Pool.
Low shrubland of *Acacia sclerosperma, A. tetragonophylla* over *Chorizema racemosum, Brachycome latisquamea* and *Eremophila subfloccosa* on S side of track.

BO4 4 m, 24°24'50.0"S, 113°44'43.1"E
c. 18 km N of Boolathana HS and 6.3 km E of track from Boolan Pool.
Shrubland of *Acacia linophylla* and *A. sclerosperma* over *Eremophila* spp., *Stylobasium spathulatum* and *Ptilotus polystachus* on S side of track.

BO5 10 m, 24°24'49.3"S, 113°45'48.6"E
c. 18 km N of Boolathana HS and 8.3 km E of track from Boolan Pool.
Acacia linophylla shrubland on dune crest, N and S of track.

CU CUVIER

CU1 2 m, 24°14'41.3"S, 113°32'7.1"E
12.2 km E of Quobba - Gnaraloo road and 2.4 km S along edge of Lake MacLeod (E of Cape Cuvier).
Samphire (*Halosarcia halocnemoides*) low shrubland on lake margin.

CU2 7 m, 24°13'22.4"S, 113°30'11.5"E
6.9 km E of Quobba - Gnaraloo road, east of Cape Cuvier.
Stunted mallee (*Eucalyptus fruticosa*) and shrubs of *Acacia tetragonophylla, Scaevola spinescens,* etc over *Triodia pungens* on S side of track.

CU3 40 m, 24°13'23.2"S, 113°29'29.0"E
5.8 km E of Quobba - Gnaraloo road, east of Cape Cuvier.
Acacia coriaceae and *Calothamnus borealis* shrubland over *Triodia pungens* on S side of track.

CU4 35 m, 24°13'26.8"S, 113°27'41.4"E
2.7 km E of Quobba - Gnaraloo road, east of Cape Cuvier.
Very open shrubland of *Acacia chartacea, A. coriacea* and *Heterodendron oleifolium* over *Thryptomene baeckeacea* and *Dampiera incana* and *Triodia pungens* on S side of track.

CU5 50 m, 24°11'35.2"S, 113°27'19.1"E
4.4 km N of Cape Cuvier turnoff.
Acacia spathulifolia, Olearia dampieri and *Heterodendron oleifolium* shrubland over *Melaleuca cardiophylla* and *Calothamnus* sp. low shrubs and *Triodia pungens* on W side of track.

CU6 60 m, 24°8'19.3"S, 113°26'45.6"E
10.4 km N of Cape Cuvier turnoff.
Scattered *Acacia coriaceae* spp. *coriaceae* emergent over *Spinifex longifolius* on dune.

EDEL LAND

EL1 60 m, 26°31'39.4"S, 113°31'36.1"E
S boundary of Carrarang, 0.3 km W of Useless Loop road.
Low shrubland of *Melaleuca cardiophylla, Beyeria cinerea* and *Thryptomene baeckeacea* over *Triodia plurinervata* on S side of fence.

EL2 90 m, 26°31'44.4"S, 113°29'56.8"E
S boundary of Carrarang, 3.4 km W of Useless Loop road.
Low shrubland dominated by *Melaleuca cardiophylla, Frankenia pauciflora* and *Beyeria cygnorum* on S side of fence.

GJ GASCOYNE JUNCTION

GJ1 197 m, 25°12'35.6"S, 115°30'51.5"E
0.6 km W of Pells Creek (38.7 km E of Gascoyne Junction) on N side of road.
Senna artemisioides ssp. *helmsii* shrubland with emergent mulga shrubs.

GJ2 170 m, 25°10'31.4"S, 115°29'18.6"E
5.4 km W of Pells Creek (33.9 km E of Gascoyne Junction) on N side of road.
Acacia aneura low woodland over shrubs of *Senna artemisioides* ssp. *helmsii* and *Corchorus walcottii.*

GJ3 170 m, 25°7'10.2"S, 115°25'35.8"E
14.5 km W of Pells Creek (24.8 km E of Gascoyne Junction) on S side of road.
Low woodland of *Acacia aneura* and *A. linophylla* over sparse shrubs of *Solanum lasiophyllum* and *Ptilotus polystachyus.*

GJ4 160 m, 25°5'17.9"S, 115°22'48.0"E
20.4 km W of Pells Creek (18.9 km E of Gascoyne Junction) on N side of road.
Shrubland of *Hakea preissii* and *Acacia victoriae,* with smaller shrubs of *Senna artemisioides* ssp. *helmsii* and *Ptilotus.*

GJ5 147 m, 25°3'18.4"S, 115°17'38.4"E
30.4 km W of Pells Creek (8.9 km E of Gascoyne Junction) on S side of road.
Scattered *Eucalyptus victrix* emergent in *Acacia tetragonophylla* and *Hakea preissii* shrubland with low shrubs of *Senna artemisioides* ssp. *helmsii.*

KE KENNEDY RANGE

KE1 350 m, 24°29'35.9"S, 115°1'51.2"E
41.0 km from Binthalya HS on track over Kennedy Range; on S side of track.
Open shrubland of *Acacia ligulata, Banksia ashbyi, Senna glutinosa, Calytrix* and *Verticordia* over *Triodia basedowii.*

KE2 320 m, 24°30'4.3"S, 115°1'3.4"E
38.9 km from Binthalya HS on track over Kennedy Range; on S side of track.
Scattered *Eucalyptus lenziana* (mallee) with scattered *Brachychiton gregorii* and *Chorizema racemosum* over *Triodia basedowii.*

KE3 235 m, 24°31'23.2"S, 114°57'55.4"E
31.2 km from Binthalya HS on track over Kennedy Range; on E and W side of track.
Scattered *Eucalyptus striatcalyx* (mallee) emergent over shrubs of *Acacia aneura, A. ramulosa* and *Senna artemisioides.*

KE4 230 m, 24°33'4.7"S, 114°57'31.7"E
27.8 km from Binthalya HS on track over Kennedy Range; on W side of track.
Shrubland of *Acacia aneura, A. tetragonophylla, Hakea preissii* and *Stylobasium sphathulatum.*

KE5 220 m, 24°34'13.1"S, 114°57'11.9"E
25.9 km from Binthalya HS on track over Kennedy Range; on E side of track.
Low mulga *Acacia aneura* woodland.

MD MEEDO

MD1 89 m, 25°37'30.7"S, 114°42'15.5"E
10.9 km NE of Meedo Homestead.
Open shrubland of *Acacia sclerosperma* over *Mirbelia ramulosa* and *Eremophila* on N side of road.

MD2 77 m, 25°37'22.8"S, 114°41'39.5"E
9.7 km NE of Meedo Homestead.
Shrubland of *Hakea preissii, Eremophila crenulata* and *Scaevola spinescens* on S side of road.

MD3 60 m, 25°39'14.4"S, 114°37'33.2"E
1.25 km NE of Meedo Homestead on banks of Wooramel River.
Low woodland of *Eucalyptus victrix* over *Acacia citrinoviridis* and *A. sclerosperma* downstream from road.

MD4 70 m, 25°40'50.2"S, 114°37'18.5"E
1.9 km W of Meedo Homestead on road to North West Coastal Highway.
Acacia linophylla shrubland with scattered *Rhagodia latifolia* on E side of road.

MD5 74 m, 25°42'39.6"S, 114°35'59.6"E
6.0 km W of Meedo Homestead on road to North West Coastal Highway.
Shrubland of *Acacia linophylla* and *A. victoriae* over *Eremophila clarkei* on E side of road.

MR MARDATHUNA

MR1 125 m, 24°30'41.0"S, 114°38'12.5"E
9.8 km E of Mardathuna HS on road to Binthalya; N side of road.
Low woodland of *Acacia xinophyla* and *A. sclerosperma* over *Eremophila subfloccosa.*

MR2 98 m, 24°26'35.9"S, 114°30'43.6"E
5.6 km E of Mardathuna HS on road to Binthalya; N side of road.
Mulga *Acacia aneura* over *A. anastema* shrubs over *Plectrachne rigidissima.*

MR3 105 m, 24°25'43.7"S, 114°29'59.6"E
7.7 km W of Mardathuna HS on road to NW Coastal Highway; N side of road.
Grevillea stenobotrya and other shrubs (including *Olearia, Calytrix* and *Verticordia*) over *Plectrachne rigidissima.*

MR4 91 m, 24°24'25.6"S, 114°28'23.9"E
11.8 km W of Mardathuna HS on road to NW Coastal Highway; S side of road.
Acacia anastema low woodland over *Plectrachne rigidissima.*

MR5 88 m, 24°24'20.5"S, 114°26'40.2"E
14.7 km W of Mardathuna HS on road to NW Coastal Highway; N and S side of road.
Low woodland of mulga *Acacia aneura* and *A. anastema* over *Eremophila subfloccsa* and *Plectrachne rigidissima.*

NA NANGA

NA1 1 m, 26°28'40.1"S, 114°4'33.6"E
0.45 km E of Overlander-Denham Road, immediately east of junction with Useless Loop road.
Shrubland of samphire (*Halosarcia indica*) N and S of track through birrida.

NA2 60 m, 26°29'23.3"S, 114°3'20.9"E
2.5 km W of Overlander-Denham Road towards Tamala.
Low woodland of *Acacia roycei, Brachychiton gregorii* and *Eucalyptus mannensis* (mallee) over sparse *Lamarchea hakeifolia* on N side of road.

NA3 45 m, 26°31'21.4"S, 114°0'8.6"E
8.8 km W of Overlander-Denham Road towards Tamala.
Low woodland of *Banksia sceptrum* and *B. ashbyi* with

Eucalyptus spp. mallees over shrubs (including *Acacia* spp., *Verticordia* and *Thryptomene*) and *Plectrachne* on N side of road.

NA4 50 m, 26°32'46.7"S, 113°57'48.6"E
13.6 km W of Overlander-Denham Road towards Tamala.
Mallee (*Eucalyptus* spp.) over shrubs (including *Calothamnus, Melaleuca, Malleostemon* and *Lamarchea*) over *Plectrachne* on N side of road.

NA5 20 m, 26°35'33.7"S, 113°53'22.6"E
22.7 km W of Overlander-Denham Road towards Tamala.
Shrubland of *Calothamnus, Melaleuca, Lamarchea* and *Acacia* over *Plectrachne* on N side of road.

NE NERREN NERREN

NE1 175 m, 27°2'49.6"S, 114°34'23.2"E
7 km W of North West Coastal Highway and 1.14 km N of intersection.
Eucalyptus eudesmoides mallees emergent in shrubland of *Acacia* spp., *Labichea* and *Ptilotus* over *Ecdeiocolea monostachya*, E and W of track.

NE2 180 m, 27°3'23.8"S, 114°35'21.1"E
4.6 km W of North West Coastal Highway.
Banksia ashbyi and *B. sceptrum* emergent in shrubland including *Allocasuarina acutivalvis, Grevillea eriostachya* and *Verticordia* on S side of track.

NE3 180 m, 27°7'23.9"S, 114°46'40.8"E
2.0 km E of Nerren Nerren boundary fence, E of North West Coastal Highway.
Eucalyptus spp., *Callitris glaucophylla* and *Bursaria occidentalis* emergent in *Acacia* spp. shrubland over *Ecdeiocolea monostachya*, N and S of track.

NE4 190 m, 27°7'22.1"S, 114°47'57.5"E
4.0 km E of Nerren Nerren boundary fence, E of North West Coastal Highway, and 2.0 km E of NE3.
Eucalyptus eudesmoides and *E. oldfieldii* mallees emergent in shrubland including *Acacia* spp., *Solanum, Rhagodia* and *Bursaria*, N and S of track.

NE5 200 m, 27°7'21.4"S, 114°49'4.8"E
5.9 km E of Nerren Nerren boundary fence, E of North West Coastal Highway, and 1.9 km E of NE4.
Eucalyptus mannensis and *Callitris glaucophylla* emergent over *Acacia* spp. shrubland, N and S of track.

PE PERON

PE1 10 m, 25°52'53.8"S, 113°32'42.7"E
1.1 km N of Monkey Mia Road on road to Peron HS.
Samphire (*Halosarcia halocnemoides*) flat in birrida on W side of road.

PE2 20 m, 25°52'31.1"S, 113°33'1.4"E
4.1 km S of Peron Homestead, just north of birrida.
Acacia ligulata shrubland over *Triodia plurinervata* on W side of road.

PE3 40 m, 25°49'14.2"S, 113°32'21.5"E
2.7 km NW of Peron Homestead on track to Big Lagoon.
Acacia ligulata and *A. tetragonophylla* shrubland on SW side of road.

PE4 30 m, 25°50'20.0"S, 113°36'23.0"E
1.6 km NW of Monkey Mia Road.
Acacia spp. shrubland, on SW side of track.

PE5 30 m, 25°58'33.6"S, 113°34'16.0"E
7.2 km S of Denham-Monkey Mia Road along Overlander-Denham Road, and 0.15 km W along track.
Scattered shrubs of *Acacia rostulata* and *A. tetragonophylla* over *Triodia pleurinervata*, N and S of track.

WO WOODLEIGH

WO1 90 m, 26°13'2.6"S, 114°35'56.8"E
22.8 km E of North West Coastal Highway on Woodleigh - Byro road.
Acacia ramulosa shrubland on S side of road.

WO2 80 m, 26°12'31.0"S, 114°34'35.0"E
20.3 km E of North West Coastal Highway on Woodleigh - Byro road.
Shrubland of *Acacia sclerosperma* and *A. linophylla* over *Eremophila latrobei* and *E. leucophylla* on S side of road.

WO3 60 m, 26°11'46.3"S, 114°32'15.7"E
15.9 km E of North West Coastal Highway on Woodleigh - Byro road.
Acacia grasbyi, A. sclerosperma and *Acacia tetragonophylla* shrubland over *Eremophila leucophylla* on S side of road.

WO4 50 m, 26°11'29.8"S, 114°30'33.8"E
12.9 km E of North West Coastal Highway on Woodleigh - Byro road.
Acacia grasbyi and *A. sclerosperma* shrubland over *Senna* sp. and *Maireana carnosa* on N side of road.

WO5 45 m, 26°11'44.2"S, 114°25'24.2"E
4.15 km E of North West Coastal Highway on Woodleigh - Byro road.
Acacia grasbyi, A. xiphophylla and *A. tetragonophylla* shrubland over *Atriplex vesicaria* on N side of road.

ZU ZUYTDORP

ZU1 185 m, 27°15'42.1"S, 114°1'8.8"E
60.4 km W of North West Coastal Highway, on S side of fence.
Low heath dominated by *Calothamnus oldfieldii, Melaleuca acerosa* and *Grevillea preissii*, with some *Ecdeicolea monostachya*.

ZU2 170 m, 27°15'41.0"S, 114°1'47.6"E
59.3 km W of North West Coastal Highway, on S side of fence
Banksia sceptrum shrubland over *Melaleuca acerosa* and *Conospermum microflorum* with some *Ecdeicolea monostachya*.

ZU3 120 m, 27°15'34.2"S, 114°4'2.6"E
54.7 km W of North West Coastal Highway, on S side of fence.
Acacia rostellifera/Eucalyptus eudesmoides tall shrubland over *Pimelea microcephala, Olearia axillaris, Melaleuca acerosa* and *Rhagodia latifolia*.

ZU4 150 m, 27°15'28.1"S, 114°9'1.8"E
46.4 km W of North West Coastal Highway, on track parallel with barrier fence, on S side of track.
Actinostrobus/Acacia/Banksia prionotes in Myrtaceous heath (*Calothamnus, Melaleuca, Malleostemon*).

ZU5 155 m, 27°15'25.2"S, 114°11'16.1"E
42.6 km W of North West Coastal Highway, on track parallel with barrier fence, on S side of track.
Proteaceous/Myrtaceous heath with emergent *Actinostrobus arenarius*.

Appendix B

Brief description of the terrestrial sites sampled for vascular plants only in the floristic survey (Gibson, Burbidge, Keighery and Lyons, this volume) forming part of the biogeographic survey of the southern Carnarvon Basin. Each entry consists of site label, altitude, latitude, longitude and a description of vegetation. Latitudes and longitudes were determined by GPS using the Australian Geodetic Datum 1966; precision at the time was about ± 100 m. Vegetation at each site was described using Muir's (1977) system of vegetation classification.

01, 170 m, 26°40'37.9"S, 114°52'14.2"E
Emergent *Callitris glaucophylla* and *Bursaria occidentalis* over *Acacia ramulosa, Thryptomene* sp. Scrub over *Grevillea intricata* Low Scrub B over *Monachather paradoxa, Stipa* sp. and *Aristida* sp. Very Open Grass over *Schoenia cassiniana* Open Herbs.

02, 195 m, 26°42'23.0"S, 114°55'14.9"E
Emergent *Brachychiton gregorii, Bursaria occidenatlis* over *Acacia* sp. and *Thryptomene* sp. Scrub over *Acacia* spp., *Grevillea intricata* and *Solanum* sp. Low Scrub A over *Ptilotus* sp. and *Eremophila* sp. Low Scrub B over *Monachather paradoxa* Very Open Grass.

03, 207 m, 26°43'39.0"S, 115°0'46.1"E
Emergent *Callitris glaucophylla* over *Acacia* sp., *Hakea* sp. and *Thryptomene* sp. Scrub over *Acacia* sp. and *Solanum* sp. Low Scrub A over *Eremophila viscida, Acacia* sp. and *Ptilotus schwartzii* Low Scrub B over Very Open Grass over *Calandrinia* sp. Very Open Herbs.

04, 278 m, 27°6'51.1"S, 115°11'10.0"E
Emergent *Callitris glaucophylla* and *Eucalyptus* sp. over *Acacia* spp. Scrub over *Eremophila viscida, Eremophila* sp. and *Rhagodia* sp. Low Scrub B over *Monachather paradoxa* Very Open Grass over *Calandrinia* sp., *Lobelia* sp. and *Trachymene* sp. Very Open Herbs.

06, 260 m, 27°37'52.0"S, 115°15'31.0"E
Emergent *Eucalyptus* spp. and *Callitris glaucophylla* over *Acacia ramulosa* Scrub over *Acacia* sp. and *Grevillea* sp. Open Low Scrub B over *Pileanthus* sp. and *Olearia* sp. Open Dwarf Scrub C over Very Open Grass over *Calandrinia* sp. and *Ptilotus* sp. Very Open Herbs.

07, 260 m, 27°38'56.0"S, 115°19'22.1"E
Scarce emergent *Eucalyptus* spp. mallee over *Acacia* spp. Thicket over *Olearia* sp. Open Dwarf Scrub C over *Monachather paradoxa* Very Open Grass over *Ptilotus* sp. Very Open Herbs.

08, 262 m, 27°41'8.2"S, 115°15'33.8"E
Emergent *Eucalyptus* spp., *Callitris glaucophylla* over *Lamarchea hakeifolia* and *Acacia ramulosa* with rare *Bursaria occidentalis* Scrub over Mixed spp. including *Olearia* sp. Low Scrub B over Very Open Grass over Very Open Herbs.

09, 260 m, 27°48'38.9"S, 115°20'3.8"E
Emergent *Callitris glaucophylla* over *Allocasuarina acutivalvis, Exocarpos aphyllus* and *Acacia ramulosa* Scrub over *Eremophila* sp. and *Acacia ramulosa* Low Scrub A over *Monachather paradoxa* Very Open Grass over *Ptilotus* sp. and *Waitzia acuminata* Open Herbs.

10, 254 m, 27°47'20.0"S, 115°18'20.2"E
Rare emergent *Eucalyptus eudesmoides* tree mallee over *Allocasuarina acutivalvis* and *Calothamnus* sp. Open Scrub over *Acacia* sp. and *Calothamnus* sp. Heath B over *Grevillea* sp. Open Dwarf Scrub C over *Ecdeiocolea monostachya* Very Open Sedges.

11, 250 m, 27°45'9.0"S, 115°15'51.8"E
Very open *Eucalyptus* spp. tree mallee over *Acacia* sp., *Dodonaea* and *Exocarpos aphyllus* Open Scrub over *Acacia* sp. to 1.5 m Low Scrub A over *Acacia* sp., *Ptilotus obovatus* and Chenopods Low Scrub B over *Stipa* sp. Very Low Open Grass over *Ptilotus* sp. Open Herbs.

16, 241 m, 27°44'3.8"S, 115°15'32.0"E
Rare emergent *Callitris* to 4 m and *Eucalyptus eudesmoides* over *Acacia* spp. Open Scrub over Myrtaceous spp. Open Low Scrub B over Open Dwarf Scrub D over *Waitzia* sp. Very Open Herbs over *Ecdeiocolea monostachya* Open Low Sedges.

17, 260 m, 27°41'12.8"S, 115°4'54.8"E
Emergent *Eucalyptus jucunda, E. oldfieldii, Eucalyptus* sp. and *Bursaria occidentalis* over *Acacia* sp. Scrub over *Thryptomene* sp. Open Dwarf Scrub C over *Eriachne* sp. and *Amphipogon strictus* Very Open Grass over mixed Very Open Herbs.

18, 250 m, 27°41'17.9"S, 115°1'44.0"E
Rare emergent *Eucalyptus eudesmoides* and *E. oldfieldii* to 5 m over emergent *Actinostrobus arenarius* and *Acacia* sp. over *Thryptomene* sp. Open Dwarf Scrub C over *Ecdeiocolea monostachya* Open Low Sedges.

19, 258 m, 27°41'17.9"S, 115°0'38.9"E
Emergent *Eucalyptus oldfieldii* over *Hakea* sp. Open Scrub over *Acacia* sp. Low Scrub A over *Plectrachne drummondi* Open Low Grass.

20, 262 m, 27°41'17.2"S, 115°0'0.0"E
Scattered emergent *Callitris glaucophylla* over *Eucalyptus oldfieldii* Very Open Tall Mallee over *Eremophila* sp. Open Scrub over *Calytrix* Open Dwarf Scrub C over *Eriachne* sp. Very Open Grass.

21, 240 m, 27°41'35.2"S, 114°55'59.2"E
Allocasuarina acutivalvis and *Acacia acuminata* Thicket over *Baeckea* sp. and *Mirbelia* sp. Dwarf Scrub C.

22, 220 m, 27°43'3.0"S, 114°54'37.1"E
Scattered emergent *Eucalyptus* sp. and *Eucalyptus eudesmoides* over scattered emergents of *Acacia* sp. over *Acacia* sp. Low Heath C over *Kunzea* sp. Dense Heath B.

23, 234 m, 27°45'20.9"S, 114°52'32.2"E
Scattered emergent *Acacia acuminata* and *Melaleuca* sp. over *Acacia ramulosa* and *Allocasuarina acutivalvis* Scrub over *Grevillea* sp. Open Dwarf Scrub C over *Eriachne* sp. Very Open Grass over Asteraceae spp. Open Herbs.

24, 206 m, 27°43'41.9"S, 114°53'55.0"E
Acacia acuminata and *Melaleuca* sp. over *Acacia ramulosa* and *Allocasuarina acutivalvis* Scrub over Open Dwarf Scrub C over Asteraceae spp. Herbs.

25, 260 m, 27°54'47.9"S, 114°58'54.1"E
Actinostrobus arenarius Open Low Scrub A over *Conospermum stoechadis* and *Allocasuarina campestris* Open Dwarf Scrub C over *Actinostrobus arenarius* Open Dwarf Scrub D over Open Herbs over *Ecdeiocolea monostachya* Very Open Sedges.

26, 260 m, 27°55'10.9"S, 114°58'59.2"E
Occasional emergent *Eucalyptus jucunda* over

Actinostrobus arenarius Low Woodland B over Myrtaceous spp. Open Dwarf Scrub C over Myrtaceous spp. Open Dwarf Scrub D over *Ecdeiocolea monostachya* Open Sedges.

27, 270 m, 27°13'50.9"S, 115°11'6.0"E
Eucalyptus spp., *Callitris glaucophylla* and *Brachychiton gregorii* Open Low Woodland A over *Acacia* spp. Scrub over *Ptilotus* sp. Open Dwarf Scrub C over *Calandrinia* sp. and *Ptilotus* sp. Very Open Herbs.

28, 240 m, 27°46'57.0"S, 114°53'19.0"E
Emergent *Actinostrobus arenarius* over *Allocasuarina campestris* and *Grevillea candelabroides* Open Low Scrub B over *Conospermum stoechadis* and *Thryptomene* sp. Open Dwarf Scrub C over Myrtaceous spp. Open Dwarf Scrub D.

29, 250 m, 27°48'7.9"S, 114°53'33.0"E
Emergent *Banksia sceptrum* over *Allocasuarina campestris* and *Actinostrobus arenarius* Open Low Scrub A over Myrtaceous spp. Open Dwarf Scrub C.

30, 257 m, 27°51'29.2"S, 114°54'50.0"E
Rare emergent *Eucalyptus oldfieldii* Mallee to 3 m over *Actinostrobus arenarius* Open Low Woodland B over *Lamarchea hakeifolia* Open Low Scrub A over *Calothamnus* sp. Open Dwarf Scrub C over *Plectrachne* sp. Open Grass over *Ecdeiocolea monostachya* Open Scrub.

31, 257 m, 27°51'45.0"S, 114°54'58.0"E
Scattered emergent *Eucalyptus rigidula* and *E. eudesmoides* to 4 m over *Allocasuarina campestris* Scrub over Melaleuca sp., *Conospermum* and *Calothamnus* sp. Dwarf Scrub C over *Ecdeiocolea monostachya* Very Open Tall Sedges.

32, 260 m, 27°56'3.1"S, 115°8'38.0"E
Emergent *Eucalyptus oldfieldii* over *Acacia* sp. Scrub over Myrtaceous spp. Open Dwarf Scrub C.

33, 266 m, 27°41'24.0"S, 115°11'34.1"E
Emergents of *Callitris glaucophylla* and *Eucalyptus sheathiana* over *Eucalyptus mannensis* with rare *Eucalyptus eudesmoides* Very open Tall Mallee over *Acacia* spp. and rare *Allocasuarina acutivalvis* Open Scrub over *Eremophila* sp. and scattered *Olearia* sp. Open Low Scrub.

34, 258 m, 27°43'10.9"S, 115°13'36.1"E
Emergent *Eucalyptus eudesmoides* and *E. jucunda* over *Allocasuarina acutivalvis* and *Acacia* spp. Scrub over Myrtaceous spp. Open Low Scrub B over *Calytrix* spp. Open Dwarf Scrub C.

35, 253 m, 27°51'15.8"S, 115°9'2.9"E
Eucalyptus oldfieldii Very Open Tall Mallee over *Ecdeiocolea monostachya* Very Open Tall Sedges.

36, 257 m, 27°55'55.9"S, 114°56'17.2"E
Emergent *Eucalyptus loxophleba* over *Acacia* spp., *Melaleuca* spp. and *Eremophila* sp. Open Scrub over *Melaleuca uncinata* Open Low Scrub B over *Scaevola* sp. and *Ptilotus obovatus* Open Dwarf Scrub D over *Maireana* sp. Open Herbs.

37, 257 m, 27°55'3.0"S, 114°56'22.9"E
Eucalyptus obtusiflora Very open Tall Mallee over *Thryptomene* sp. Low Scrub B over *Plectrachne* sp. Open Grass over *Ecdeiocolea monostachya* Very Open Tall Sedges.

38, 205 m, 27°36'2.9"S, 114°26'8.9"E
Scattered emergent *Xylomelum angustifolium* over *Banksia* sp., *Grevillea candelabroides* and *Acacia* sp. Open Scrub over *Allocasuarina campestris, Daviesia* sp. and *Conospermum stoechadis* Low Heath C over *Calytrix* sp. Open Dwarf Scrub D over *Ecdeiocolea monostachya* Very Open Sedges.

39, 125 m, 27°40'50.2"S, 114°14'30.1"E
Emergent *Grevillea eriostachya* to 2.5 m over emergent *Banksia attenuata* to 1.5 m over *Eremaea* sp. and *Isopogon* sp. Low heath D over Very Open Herbs and Very Open Sedges.

40, 192 m, 27°44'19.0"S, 114°20'51.0"E
Rare emergent *Banksia attenuata* and *Acacia* sp. over *Melaleuca* sp., *Calytrix* sp. and *Banksia* sp. Dwarf Scrub C over *Eremaea* sp. Open Dwarf Scrub D over Open Herbs and *Ecdeiocolea monostachya* Very Open Tall Sedges.

41, 234 m, 27°37'58.1"S, 114°33'56.2"E
Rare emergent *Actinostrobus arenarius* over *Scholtzia* sp. Low Scrub A over Myrtaceous spp. Dwarf Scrub C over Open Herbs and *Ecdeiocolea monostachya* and *Mesomelaena* sp. Open Sedges.

42, 253 m, 27°43'1.9"S, 114°37'8.0"E
Emergent *Eucalyptus jucunda* and *Eucalyptus gittinsii* over *Actinostrobus arenarius* and *Banksia sceptrum* Scrub over Myrtaceous spp. Open Dwarf Scrub D over *Ecdeiocolea monostachya* Open Low Sedges.

43, 248 m, 27°53'20.0"S, 114°32'3.8"E
Scattered emergent *Banksia attenuata* and *Xylomelum angustifolium* over *Calothamnus* sp. Low Scrub A over *Melaleuca* sp. Open Low Scrub B over *Conospermum stoechadis*, Myrtaceous spp. Open Dwarf Scrub C over *Ecdeiocolea monostachya* and *Mesomelaena* sp. Open Sedges.

46, 220 m, 27°29'21.1"S, 114°42'52.9"E
Emergent *Actinostrobus arenarius* over *Allocasuarina campestris* and *Grevillea candelabroides* Open Low Scrub A over Myrtaceous spp. Open Dwarf Scrub D over Myrtaceous spp. Open Dwarf Scrub D over *Ecdeiocolea monostachya* Very Open Low Sedges.

47, 220 m, 27°27'52.9"S, 114°41'57.1"E
Rare emergents of *Grevillea candelabroides* to 2 m over *Acacia* spp., *Conospermum stoechadis, Allocasuarina campestris* Open Low Scrub B over *Allocasuarina campestris* and Myrtaceous sp. Open Dwarf Scrub C over *Amphipogon* sp. Open Grass and *Ecdeiocolea monostachya* Open Sedges.

48, 149 m, 26°56'17.2"S, 114°38'48.8"E
Rare emergent *Eucalyptus jucunda* and *Eucalyptus* sp. over *Lamarchea hakeifolia* Open Scrub over *Baeckea* sp. Low Scrub A over *Ptilotus polystachyus, Podotheca* sp. and *Schoenia* sp. Open Herbs.

49, 25 m, 26°38'51.0"S, 113°47'58.9"E
Banksia ashbyi Low Woodland B over *Hakea* sp., *Calothamnus* sp. and *Baeckea* sp. Open Low Scrub A over *Melaleuca* sp. and *Baekaea* sp. Open Dwarf Scrub C over *Plectrachne drummondii* Very Tall Open Grass.

50, 50 m, 26°32'30.8"S, 113°58'14.2"E
Rare emergent *Eucalyptus eudesmoides* and *E. roycei* 2-5 m over *Lamarchea hakeifolia* and *Hakea* sp. Open Low Scrub B over *Lechenaultia* sp., *Eremaea* sp. and *Acacia* spp. Open Dwarf Scrub C over *Plectrachne drummondii* Very Tall Open Grass over *Ptilotus* sp. and *Brassica* sp. Open Herbs.

51, 35 m, 26°31'16.0"S, 114°0'11.2"E
Banksia sceptrum and *Eucalyptus eudesmoides* Open Low Woodland B over scattered *Calothamnus* sp. to 2 m

emergent in *Acacia* spp. and *Baeckea* sp. Open Low Scrub B over *Calytrix* sp. Open Dwarf Scrub D over *Plectrachne drummondii* Open Grass over *Calandrinia* sp. Open Herbs.

52, 45 m, 26°30'15.8"S, 114°1'54.1"E
Eucalyptus eudesmoides and *E. mannensis* Very Open Tall Mallee over *Melaleuca* sp. Open Scrub over *Plectrachne drummondii* Very Tall Open Grass.

53, 60 m, 26°30'29.9"S, 114°3'19.1"E
Rare emergent mallees *Eucalyptus eudesmoides* to 4 m over *Acacia ramulosa* and *A. linophylla* Scrub over *Lamarchea hakeifolia* Open Low Scrub A over *Ptilotus* sp. Open Herbs.

54, 139 m, 26°42'27.0"S, 114°34'19.9"E
Rare emergent *Eucalyptus mannensis* to 6 m over *Acacia ramulosa* Low Woodland B over *Dicratstylis linearifolia* Open Low Scrub A over *Calandrinia, Wurmbea* and *Dianella* Open Herbs.

55, 165 m, 27°39'37.1"S, 114°18'14.0"E
Emergent *Banksia prionotes* and *Xanthorrhoea preissii* over *B. prionotes* Open Low Scrub A over *B. attenuata*, Myrtaceous spp. Dwarf Scrub C over *Calytrix* spp., *Mirbelia spinosa* Open Dwarf Scrub D over Open Herbs and *Ecdeiocolea monostachya* Very Open Low Sedges.

56, 186 m, 27°18'58.0"S, 114°35'4.9"E
Rare emergents of *Eucalyptus mannensis* to 5 m over *Acacia* spp., *Banksia* sp., *Melaleuca* sp. and *Grevillea* sp. Scrub over *Acacia* sp., *Hakea* sp. and *Baeckea* sp. Open Low Scrub over *Hibbertia conspicua* Open Dwarf Scrub D.

57, 196 m, 27°17'17.2"S, 114°28'54.8"E
Rare emergents of *Eucalyptus griffithsii* to 6 m over *Grevillea candelabroides* Open Scrub over *Conospermum stoechadis*, *Calothamnus* sp. and *Melaleuca* sp. Dwarf Scrub C over *Petrophile* sp. and *Mirbelia* sp. Open Dwarf Scrub D over *Ecdeiocolea monostachya* Very Open Sedges.

58, 145 m, 27°15'29.9"S, 114°8'33.0"E
Rare emergent *Banksia ashbyi* to 3 m over Myrtaceous spp. Heath B over Myrtaceous spp. Dwarf Scrub C over *Stylidium macrocarpum*, *Isotropis* sp. and *Acanthocarpos* sp. Open Herbs and *Ecdeiocolea monostachya* Open Sedges.

59, 139 m, 27°15'29.2"S, 114°8'12.8"E
Rare mallees *Eucalyptus eudesmoides* to 2.5 m over Acacia sp. Low Woodland A over *Hakea* sp. and *Olearia* axillaris Open Scrub over Melaleuca sp. and *Pimelea microcephala* Open Low Scrub B over *Calandrinia* sp. and *Tetragonia diptera* Dense Herbs.

60, 115 m, 27°1'55.9"S, 114°7'31.1"E
Melaleuca sp. and *Hakea stenophylla* Open Low Woodland A over *Rhagodia* sp. and *Olearia axillaris* Open Scrub over Open Dwarf Scrub C over *Stylidium* sp. *Zygophyllum* sp. and *Brassica tournfortei* Open Herbs.

61, 115 m, 27°2'30.1"S, 114°7'30.0"E
Scattered emergent *Acacia* spp. to 5 m over *Banksia lindleyana*, *Grevillea* sp., *Acacia* sp. and *Melaleuca* sp. Open Low Scrub A over *Thryptomene* sp., *Banksia lindleyana*, *Mirbelia* sp. and *Olearia axillaris* Heath B over *Olearia axillaris* Open Dwarf Scrub D.

62, 159 m, 27°7'26.0"S, 114°14'34.1"E
Emergent *Eucalyptus roycei* over *Banksia sceptrum* and rare *Actinostrobus arenarius* Open Low Woodland B over *Grevillea* sp., *Verticordia* sp. and *Allocasuarina campestris* Thicket over *Grevillea eriostachya* and *Acacia* sp. Heath A over *Conostephium* sp., *Allocasuarina* Open Low Scrub B.

63, 200 m, 27°19'21.0"S, 114°38'34.1"E
Emergent *Eucalyptus eudesmoides, E. mannensis* and *Callitris glaucophylla* over *Lamarchea hakeifolia* and *Acacia* sp. Open Scrub over *Dicratystylis linearifolia* Open Low Scrub A over *Cassia* sp., *Calytrix* sp. and *Acacia* sp. Open Dwarf Scrub C over *Podotheca* sp. and *Waitzia* Open Herbs.

64, 188 m, 27°4'39.0"S, 114°37'49.1"E
Emergent *Callitris glaucophylla* and mallee *Eucalyptus mannensis* over *Acacia* sp., *Acacia roycei* and *Lamarchea hakeifolia* Scrub over *Eremophila* sp. and rare *Acacia tetragonophylla* Open Low Scrub B over *Helichrysum* sp. and *Waitzia citrina* Open Herbs.

65, 178 m, 27°0'1.1"S, 114°43'57.0"E
Acacia neurophylla Scrub over *Acacia roycei* and *Stylobasium spathulatum* Open Low Scrub B over *Waitzia* sp. and *Podolepis* sp. Open Herbs.

66, 182 m, 27°12'28.8"S, 114°45'0.0"E
Emergent *Callitris glaucophylla* over *Eucalyptus eudesmoides* and *E. mannensis* Very Open Tall Mallee over *Acacia* spp. 2-2.5 m. Open Scrub over *Ecdeiocolea monostachya* Very Open Low Sedges and *Ptilotus* sp. Open Herbs.

67, 214 m, 27°15'54.0"S, 114°44'58.9"E
Acacia linophylla, A. longispinea Scrub over *Baeckea pentagonantha* Low Heath C over *Leucochrysum fitzgibbonii* Very Open Herbs.

68, 200 m, 27°15'54.0"S, 114°43'24.2"E
Lamarchea hakeifolia Open Scrub over *Baeckea pentagonantha* Low Scrub B over *Patersonia* sp. Very Open Herbs.

69, 170 m, 27°0'13.0"S, 114°36'47.2"E
Acacia ramulosa, Allocasuarina corniculata and rare *Callitris glaucophylla* Scrub over *Calytrix* sp. and rare *Dianella* Open Dwarf Scrub C over *Gilberta tenuifolia, Brachycome* sp. Open Herbs.

70, 136 m, 26°50'15.0"S, 114°37'13.1"E
Acacia ramulosa, A. grasbyi and *A. tetragonophylla* Open Scrub over *Acacia* spp. and *Senna* spp. Open Low Scrub A over *Ptilotus obovatus* and *Rhagodia latifolia* Open Dwarf Scrub C over *Ptilotus* sp. Open Herbs.

71, 15 m, 25°48'31.0"S, 113°40'28.9"E
Acacia ramulosa, A. tetragonophylla and *Acacia* sp. Open Low Scrub A over *Dodonaea* and *Chenopodium* Open Dwarf Scrub C over *Brassica* sp. Very Open Herbs.

72, 20 m, 25°51'6.8"S, 113°36'52.9"E
Acacia spp. Open Scrub over *Exocarpos* sp., *Acacia tetragonophylla, Chenopodium* Open Dwarf Scrub C over *Ptilotus obovatus* Open Dwarf Scrub D over Very Open Herbs.

73, 30 m, 25°43'57.0"S, 113°33'18.0"E
Acacia linophylla and *Lamarchea hakeifolia* Open Scrub over *Scaevola* sp. and *Rhagodia* sp. Open Low Scrub A over *Ptilotus obovatus* Open Dwarf Scrub D over *Aristida contorta* Open Grass over Open Herbs.

74, 20 m, 26°15'56.2"S, 113°50'37.0"E
Emergent *Acacia tetragonophylla* to 2 m over emergent *A. rostellifera* over *Stylobasium spathulatum, Scaevola* sp. and *Baeckea* sp. Open Dwarf Scrub D over *Plectrachne* sp. Very Tall Open Grass over *Brachycome* sp. Open Herbs.

75, 30 m, 26°16'54.8"S, 113°52'52.0"E
Acacia rostellifera, *Hakea* sp., *Grevillea candelabroides* and *Stylobasium spathulatum* Open Dwarf Scrub C over *Mirbelia* sp. Open Dwarf Scrub D over *Plectrachne* sp. Open Grass.

76, 35 m, 26°19'49.1"S, 113°55'32.2"E
Acacia spp. Thicket over *Acacia* sp., *Scaevola spinescens* and *Ptilotus obovatus* Open Dwarf Scrub C over *Aristida* sp. Open Herbs.

77, 20 m, 26°24'15.8"S, 114°2'2.0"E
Acacia spp. and *Lamarchea hakeifolia* Scrub over *Scaevola* sp. and *Malleostemon pedunculatus* Low Scrub A over *Ptilotus obovatus* Open Dwarf Scrub C over Open Herbs.

78, 220 m, 27°20'24.0"S, 115°6'6.8"E
Emergent *Callitris glaucophylla* and *Santalum acuminatum* over *Acacia ramulosa* and *A. roycei* Scrub over Grevillea sp. and *Eremophila* sp. Open Dwarf Scrub C over *Calandrinia spathulata* Very Open Herbs.

79, 218 m, 27°29'1.0"S, 114°51'18.0"E
Emergent Eucalyptus *flocktoniae* over *Acacia tetragonophylla* and *A. roycei* Scrub over *Acacia* sp., *Olearia axillaris* Low Scrub B over *Ptilotus obovatus* Open Dwarf Scrub C over *Calandrinia lehmanii* Open Herbs.

80, 220 m, 27°25'32.9"S, 114°49'27.1"E
Scattered emergents of *Bursaria occidentalis*, *Callitris glaucophylla* and *Acacia* sp. over *Eucalyptus oldfieldii* and *E. eudesmoides* with *E. jucunda* Very open Tall Mallee over *Malleostemon* sp. Open Low Scrub B over *Amphipogon* sp. Open Grass.

BB1a, 9 m, 25 °07'34"S, 113 °49'22"E
Atriplex vesicaria, *Frankenia pauciflora* and *Maireana* sp. Dwarf Scrub D over *Calandrinia polyandra* Very Open Herbs.

BB1b, 9 m, 25 °07'34"S, 113 °49'22"E
Acacia spp., *Hakea preissii* and *Acacia tetragonophylla* Open Scrub over *Atriplex vesicaria* Open Dwarf Scrub C over *Eragrostis setifolia* Very Open Low Grass.

EL3, 60 m, 26 °24'45"S, 113 °18'30"E
Westringia dampieri, *Frankenia pauciflora* and *Carpobrotus* sp. Dwarf Scrub D over *Senecio lautus* Very Open Herbs.

ZU6, 178 m, 27°15'25.9"S, 114°22'25.7"E
Eucalyptus eudesmoides emergent over *Melaleuca cardiophylla* and *Hakea stenophylla* Scrub over *Tetragonia diptera* Open Herbs.

ZU7, 178 m, 27°14'56.4"S, 113°58'32.9"E
Diplolaena grandiflora, *Acacia ligulata* and *Olearia axillaris* Heath B over *Westringia dampieri* Open Dwarf Scrub D over mixed spp. including *Waitzia suaveolens* Very Open Herbs.

ZU8, 178 m, 27°14'31.6"S, 113°59'17.2"E
Acacia ligulata Open Scrub over *Pimelea microcephala*, *Alyxia buxifolia* and *Scaevola tomentosa* Open Low Scrub B over *Olearia axillaris*, *Pimelea microcephala* and *Melaleuca cardiophylla* Low Heath C over *Dioscorea hastifolia* Open Herbs.

ZU9, 200 m, 27°10'29.3"S, 113°57'24.8"E
Acacia spathulifolia, *Melaleuca acerosa* and *Malleostemon* sp. Dwarf Scrub C over *Plectrachne danthonioides* Open Tall Grass over *Ecdeiocolea monostachya* and *Schoenus clandestinus* Open Low Sedges.

ZU10, 200 m, 27°10'43.0"S, 113°56'56.8"E
Melaleuca cardiophylla Scrub over *Ricinocarpus* sp. Open Low Scrub B over Mixed spp. including *Erodium cicutarium* Open Herbs.

ZU11, 170 m, 27°10'22.4"S, 113°58'0.1"E
Eucalyptus erythrocorys Open Tree Mallee over *Melaleuca acerosa* Dwarf Scrub C over *Mesomelaena psuedostygia*, *Ecdeiocolea monostachya*, and *Schoenus clandestinus* Open Low Sedges.

REFERENCE

Muir, B.G. (1977). Biological Survey of the Western Australian Wheatbelt. Part 2. Vegetation and habitat of Bendering Reserve. *Records of the Western Australian Museum* Supplement No. 3.

Appendix C

Location (latitude and longitude) and altitude of the 58 aquatic sites sampled in the biogeographic survey of the southern Carnarvon Basin. Latitudes and longitudes were determined by GPS, using the Australian Geodetic Datum 1984; precision at the time was about ± 100 m. See Halse *et al.* (this volume) for further explanation and for biological and physical data collected at each site.

Quadrat	Altitude (m)	Latitude degrees S	Latitude Minutes	Latitude seconds	Longitude degrees E	Longitude minutes	Longitude seconds
CB4	180	27	53	10.7	114	34	4.1
CB5	190	27	49	3.7	114	46	31.1
CB6a1	205	27	31	25.7	115	4	20.3
CB6a2	205	27	31	26	115	5	49.9
CB6b	200	27	31	29.3	115	5	14.3
CB9	10	26	45	12.6	113	42	33.5
CB9a	15	26	44	30.5	113	42	36.7
CB15	18	26	23	4.9	113	20	8.5
CB16	15	26	14	19.7	113	23	56.4
CB20	20	26	25	39.7	114	11	33
CB25	10	26	2	7.1	114	19	50.5
CB27a	230	26	4	49.1	115	27	9.7
CB27b1	264	26	15	22	115	27	58
CB27b2	264	26	15	31	115	28	18.1
CB27c	260	26	18	54	115	30	49.7
CB29a	3	25	36	0.7	113	28	10.2
CB30	40	25	39	29.9	114	25	19.9
CB34	120	25	39	54	114	50	53.9
CB35a	17	25	40	52.3	114	13	13.8
CB36	2	24	57	51.1	113	42	16.2
CB38	150	25	11	46.7	114	57	2.5
CB38a	125	25	4	16.7	115	1	48
CB42	115	25	0	31.7	114	56	51.7
CB43	128	25	4	17.4	115	3	29.9
CB44	48	25	45	23.4	114	8	8.5
CB49	8	24	42	20.9	113	41	10.3
CB51	7	24	44	21.1	113	43	13.8
CB54	5	24	33	9.7	113	45	35.3
CB54a	4	24	34	43.7	113	43	13.1
CB56	25	24	38	34.1	113	59	29.4
CB56a	25	24	38	19.3	113	59	34.8
CB58b	62	24	48	8.3	114	16	14.9
CB58c	50	24	47	44.5	114	10	4.8
CB58d	50	24	47	37.7	114	9	13.7
CB58e	50	24	47	34.8	114	9	14.4
CB62	160	24	53	26.5	114	57	29.5
CB62a	160	24	46	27.5	114	56	17.5
CB62b	190	24	40	46.2	114	56	11.4
CB62c	160	24	46	31.1	114	56	19.7
CB67a	200	24	14	40.2	114	52	10.9
CB67b	180	24	18	7.2	114	50	28.3
CB68	92	24	17	46.3	114	29	47.4
CB70b	98	24	25	40.8	114	32	53.9
CB73	3	24	28	37.9	113	40	36.1
CB75a	45	24	28	24.6	114	13	27.1
CB75b	55	24	28	18.5	114	18	7.9
CB75c	90	24	25	59.9	114	27	18
CB76	5	23	57	38.9	113	36	39.6
CB77	5	23	54	52.9	113	39	22.7
CB78	5	23	52	19.2	113	42	43.2
CB79	10	23	47	16.1	113	44	43.8
CB82	4	23	52	4.1	113	58	43.7
CB93	250	25	37	34.3	115	31	27.5
CB93a	260	25	34	31.8	115	36	1.1
CB93c	240	25	52	35.4	115	30	8.3
CB93d	245	25	51	45	115	31	53.4
CB93f	180	25	47	31.2	115	17	26.5
CB93g	160	25	44	28.7	115	6	58.7

Appendix D

Soil chemical data for the 63 terrestrial quadrats sampled for all attributes in the biogeographic survey of the southern Carnarvon Basin. See below for descriptions of analysis methods and units, and see Wyrwoll, Stoneman, Elliott and Sandercock (this volume) for context. Quadrat (site) locations are provided in Appendix A and further explanation in Burbidge, McKenzie and Harvey (this volume). Missing values are denoted by -999. Reported values of <0.02 for exchangeable cations were treated as 0.01 me% for all statistical/multivariate analyses in Keighery *et al.* (this volume) and Gibson, Burbidge, Keighery and Lyons (this volume).

Site	EC	pH (H_2O)	pH ($CaCl_2$)	stones	sand (%)	silt (%)	clay (%)	C (%)	N (%)	P (ppm)	P (HCO_3) ppm	K (HCO_3) ppm	$CaCO_3$ (%)	Cl_6 (%)	Ex. meth.	CEC (me%)	exCa (me%)	exNa (me%)	exK (me%)	exMg (me%)
BB1	35	7.2	6.6	0	95	2.5	2.5	0.15	0.016	150	8	170	0	0.04	a	2	1.07	0.23	0.38	0.68
BB2	4	7.6	6.7	0	97	0.5	2.5	0.25	0.022	200	8	120	1	0	a	2	1.63	0.04	0.3	0.44
BB3	280	9.2	8.5	0	69.5	12.5	18	0.6	0.067	240	29	260	11	0.02	c	8	3.57	0.61	0.62	2.47
BB4	3	7.3	6.5	0	98	0.5	1.5	0.21	0.016	130	12	66	0	0	c	3	0.81	0.03	0.11	0.37
BB5	15	9.3	8.5	0	97	1	2	0.48	0.039	77	12	29	3	0	c	3	1.63	0.28	0.05	0.8
BO1	5	8.5	7.8	0	93	2.5	4.5	0.24	0.025	160	15	190	1	0	c	4	1.38	0.09	0.36	0.41
BO2	8	9.4	8.7	0	92.5	3	4.5	0.18	0.021	120	8	160	1	0	c	3	1.1	0.22	0.32	0.58
BO3	7	9.1	8.4	0	90.5	1.5	8	0.24	0.026	130	11	210	1	0	c	4	2.69	<0.02	0.44	0.38
BO4	2	7.4	6.8	0	92.5	1	6.5	0.2	0.020	150	8	150	1	0	a	3	1.47	0.03	0.34	0.44
BO5	2	7	6	0	95.5	0.5	4	0.14	0.014	100	6	110	0	0	a	2	0.85	0.02	0.28	0.37
CU1	707	8.5	8.4	2	85	6	9	0.72	0.069	280	21	300	46	0.73	c	7	9.35	1.75	0.51	4
CU2	13	8.9	8.3	2	94.5	0.5	5	0.32	0.028	73	7	98	1	0	c	4	2.15	0.03	0.18	0.33
CU3	6	9.4	8.5	0	96	0.5	3.5	0.26	0.022	42	4	37	1	0	c	2	1.62	0.01	0.03	0.13
CU4	7	9.2	8.4	2	92.5	2	5.5	0.41	0.038	110	3	72	14	0	c	3	2.4	0.12	0.13	0.24
CU5	7	9	8.3	2	94	1	5	0.36	0.032	85	3	68	3	0	c	3	2.25	<0.02	0.12	0.16
CU6	7	9.6	8.4	0	96.5	0.5	3	0.18	0.012	540	13	27	70	0	c	2	0.99	0.12	0.04	0.27
EL1	9	8.8	8	0	90	3.5	6	0.81	0.07	581	18	27	84	0	c	3	2.92	0.1	0.09	0.36
EL2	10	8.8	8	0	90	2.5	7	0.87	0.075	622	21	48	79	0	c	4	3.82	0.14	0.13	0.38
GJ1	10	7.8	7.3	5	88	5	7	0.15	0.016	120	8	250	1	0	a	4	2.21	0.16	0.5	0.87
GJ2	2	7.1	6.2	0	91.5	2.5	6	0.11	0.011	120	7	140	0	0	a	2	0.93	0.02	0.32	0.57
GJ3	2	6.2	4.9	0	89.5	2.5	8	0.23	0.021	140	8	170	0	0	b	1	0.52	0.03	0.32	0.31
GJ4	111	6.7	6.4	1	87	5	8	0.15	0.017	170	8	220	0	0.12	a	4	1.03	0.62	0.37	2.66
GJ5	2	7.2	6.1	0	92.5	2.5	5	0.17	0.013	130	11	160	0	0	a	3	1.5	0.03	0.24	0.93
KE1	1	6.8	5.8	0	97	0.5	2.5	0.11	0.008	45	1	30	0	0	a	1	0.54	<0.02	0.06	0.11
KE2	1	5.9	4.7	0	93	1	6	0.15	0.012	57	2	33	0	0	b	1	0.3	<0.02	0.06	0.14
KE3	9	7	5.9	5	82.5	6.5	11	0.37	0.032	170	4	320	0	0	a	7	2.62	0.94	0.69	2.24
KE4	2	6.9	5.6	1	91	3	5.5	0.23	0.021	120	4	180	0	0	a	4	1.4	0.04	0.36	0.62
KE5	1	6	4.6	0	93.5	2.5	4	0.26	0.021	160	4	78	0	0	b	1	0.35	<0.02	0.17	0.14
MD1	2	7.5	6.4	0	93	2	5	0.09	0.01	160	10	120	0	0	a	2	0.93	0.03	0.21	0.57
MD2	2	7.8	6.4	0	90	1	9	0.13	0.01	140	9	120	0	0	a	3	1.49	0.14	0.26	0.92
MD3	5	7.8	6.9	0	92	1.5	6.5	0.41	0.031	140	15	330	0	0	a	4	2.9	0.02	0.59	1.15
MD4	2	6.9	5.7	0	92	1	7	0.18	0.017	110	6	120	0	0	a	2	0.62	0.04	0.27	0.28
MD5	3	5.8	4.7	0	92	1	7	0.31	0.019	120	4	88	0	0	b	1	0.32	0.08	0.18	0.12
MR1	9	8.5	7.7	2	91	3	6	0.19	0.023	165	10	250	1	0	a	6	2.63	0.04	0.5	0.53
MR2	1	6.4	5.1	0	90.5	2	7.5	0.21	0.019	110	4	81	0	0	a	1	0.78	0.03	0.24	0.35
MR3	1	6.8	6	0	96.5	0.5	3	0.14	0.011	80	3	55	0	0	a	2	0.86	<0.02	0.11	0.2

Appendix D (cont.)

Site	EC	pH (H_2O)	pH ($CaCl_2$)	stones	sand (%)	silt (%)	clay (%)	C (%)	N (%)	P (ppm)	P (HCO_3) ppm	K (HCO_3) ppm	$CaCO_3$ (%)	Cl_6 (%)	Ex. meth.	CEC (me%)	exCa (me%)	exNa (me%)	exK (me%)	exMg (me%)
MR4	1	6.7	5.6	0	93.5	1	5.5	0.12	0.011	100	4	75	0	0	a	2	0.98	0.02	0.14	0.31
MR5	2	6	5	0	91.5	1	7.5	0.2	0.017	120	3	84	0	0	b	1	0.81	0.02	0.17	0.27
NA1	1052	8.4	8.3	0	82	7.5	10.5	0.54	0.046	160	11	520	32	1.7	c	4	3.35	0.81	0.51	2.4
NA2	6	8.6	8	0	95	0.5	4.5	0.26	0.019	56	4	35	1	0	c	2	1.42	0.03	0.06	0.15
NA3	12	8.4	7.7	0	96	0.5	3.5	0.48	0.026	33	2	24	1	0	c	3	1.92	0.08	0.03	0.25
NA4	6	8.5	7.8	0	95.5	0.5	4	0.32	0.018	35	2	31	1	0	c	4	2.04	0.03	0.05	0.24
NA5	6	8.6	7.9	0	95.5	0.5	4	0.43	0.028	38	2	32	1	0	c	4	2.47	0.02	0.04	0.29
NE1	1	5.6	4.5	0	94	0.5	5.5	0.32	0.013	51	1	19	0	0	b	1	0.17	0.02	0.04	0.08
NE2	1	5.8	4.7	0	94	0.5	5.5	0.32	0.012	51	1	14	0	0	b	1	0.28	0.02	0.03	0.07
NE3	1	5.2	4.4	0	91	1	8	0.26	0.013	73	2	12	0	0	b	1	0.06	<0.02	0.02	0.04
NE4	2	5.6	4.7	0	90.5	1	8.5	0.37	0.017	70	2	25	0	0	b	1	0.44	0.02	0.06	0.14
NE5	1	5.7	5	0	90.5	1.5	8	0.48	0.021	66	2	24	0	0	b	1	0.64	0.03	0.05	0.14
PE1	1824	9.4	9.2	2	-9999	-9999	-9999	0.46	0.032	160	13	660	5	2.55	c	2	6.06	29.2	1.21	4.81
PE2	19	9.2	8.5	0	92	2	6	0.36	0.031	66	6	95	2	0	c	4	2.53	0.03	0.21	0.32
PE3	8	9.2	8.4	0	94.5	1	4.5	0.44	0.033	82	5	75	3	0	c	4	2.78	0.05	0.13	0.29
PE4	3	7.4	6.7	0	94	1.5	4.5	0.39	0.03	87	3	96	1	0	a	3	1.91	0.13	0.22	0.44
PE5	8	9.2	8.4	0	94	2	4	0.47	0.042	170	23	56	18	0	c	3	2.47	0.09	0.12	0.27
WO1	2	5.7	4.8	0	91	1	8	0.35	0.025	130	4	78	0	0	b	1	0.42	0.04	0.13	0.12
WO2	2	6.6	5.6	0	91	1.5	7.5	0.3	0.021	120	7	92	0	0	a	2	0.8	0.03	0.18	0.23
WO3	2	7.3	6.2	2	91.5	1	7.5	0.18	0.016	140	9	120	0	0	a	2	1.14	0.03	0.28	0.45
WO4	7	9	8.3	3	88	6	6	0.2	0.025	120	12	240	4	0	c	5	2.72	0.09	0.54	0.48
WO5	7	7.4	7.1	0	92	2.5	5.5	0.12	0.014	140	7	160	0	0	a	3	0.94	0.22	0.37	0.65
ZU1	1	6.6	5.2	4	93	1	6	0.52	0.029	39	2	26	0	0	a	3	1.48	0.04	0.05	0.3
ZU2	2	6.7	5.8	4	96	0.5	3.5	0.45	0.018	28	1	19	0	0	a	2	0.99	<0.02	0.04	0.24
ZU3	2	6.7	5.7	0	94.5	0.5	5	0.6	0.039	53	1	40	0	0	a	3	2.5	0.02	0.08	0.25
ZU4	2	6.4	5.3	0	96.5	0.5	3	0.31	0.016	28	1	19	0	0	b	1	0.74	0.02	0.04	0.18
ZU5	1	6.4	5.4	0	97	0.5	2.5	0.35	0.015	22	1	13	0	0	b	1	0.5	<0.02	0.02	0.1

Field Sampling
Samples for analysis were based on composite (bulked) samples taken from the floristic quadrat at each survey quadrat. Thirty sub-samples were taken from a regular grid covering each 30 x 30 metre quadrat. Sub-samples were taken from the A1 horizon at a uniform depth between 5-15 centimetres. Bulked samples each about 2 kg were air dried in the field prior to delivery to the laboratory.

Chemical Analysis Methods
All analyses were conducted by the Agricultural Chemistry Laboratory, Western Australian Chemistry Centre, Department of Minerals and Energy, Perth.

Stones
Qualitative estimate. 0 - , 1 - , 2 -

CEC (me%)
Cation Exchange Capacity extracted in 1M NH4Cl.
Rayment, G.E. and Higginson, F.R. (1992). Ion-exchange Properties. In: *Australian Laboratory Handbook of Soil and Water Chemical Methods:* 138–145. Inkata Press, Melbourne.

Cl_6 (%)
Soil titrated potentimetrically with standardised silver nitrate in the presence of dilute nitric acid, using a silver/ silver nitrate electrode. Only samples with EC(1:5) values greater than 20mS.m were analysed for Chloride.

EC (1:5) mS/m
Measured by conductivity meter at 25° C on a 1:5 extract of soil and deionised water.
Rayment, G.E. and Higginson, F.R. (1992). Electrical Conductivity (Method 3A1). In: *Australian Laboratory Handbook of Soil and Water Chemical Methods*: 15–16. Inkata Press, Melbourne.

pH (H_2O)
Measured by pH meter on a 1:5 extract of soil in deionised water.
Rayment, G.E. and Higginson, F.R. (1992). Soil pH (Method 4A1). In: *Australian Laboratory Handbook of Soil and Water Chemical Methods*: 17–18. Inkata Press, Melbourne.

pH ($CaCl_2$)
Measured by pH meter on a 1:5 extract of soil in 1M $CaCl_2$

Total N (%)
Measured by Kjeldahl digestion of soil.
Rayment, G.E. and Higginson, F.R. (1992). Soil pH (Method 7A2). In: *Australian Laboratory Handbook of Soil and Water Chemical Methods*: 41–43. Inkata Press, Melbourne.

Total P (%)
Measured by colorimetry on the Kjeldahl digest for total N using a modification of the Murphy & Riley molybdenum blue procedure.
Murphy, J. and Riley, J.P. (1962). A modified single solution method for the determination of phosphate in natural waters. *Analytica Chimica Acta* **27**: 31-36.

C (%)
Determined by the method of Walkley and Black.
Walkley, A. and Black, I.A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science* **37**: 29-38.

$CaCO_3$ (%)
Calcium carbonate extractable in dilute acid

K (HCO_3) ppm
Extracted in 0.5M $NaHCO_3$ (1:100) using the procedure of Jefferey.
Jefferey R. (1982). *Measurement of Potassium in 0.5M $NaHCO_3$ extracts of soil by flame AAS*. Annual Technical Report No. 2, Agricultural Chemistry Laboratory, Government Chemical Laboratories, Western Australia.

P (HCO_3) ppm
Extracted in 0.5M $NaHCO_3$ (1:100) using the procedure of Colwell.
Colwell, J.D. (1963). The estimation of phosphorus fertilizer requiremnets on wheat in souther New South Wales, by soil analysis. *Australian Journal of Agriculture and Animal Husbandry* **3**: 190-197.

Particle Sizing (% sand, silt, clay)
Determined by modified 'plummet' procedure. Soil dispersed with a solution of Calgon - sodium hydroxide, then silt (0.002 - 0.020 mm) and clay (<0.002 mm) was measured by density measurements using a plummet after standard settling times.
Loveday, J. (ed) (1974). Methods for analysis of irrigated soils. Commonwealth Bureau of Soils, Technical Communication No. 54.

Exchangeable Cations: Ca, Mg, K, Na, Al, Mn (me%)
Cations (Ca, Mg, Na, K, Mn, Al) were measured by Inductively coupled plasma - atomic emission spectrophotometry (ICP-AES). Soluble salts were removed from soils with EC (1:5) >20 mS/m by washing with glycol-ethanol. Cations analysed using one of three extraction methods:

a)
1M NH_4Cl at pH 7.0 - Used for neutral soils (pH between 6.5 & 8.0).
Rayment, G.E. and Higginson, F.R. (1992) Ion-exchange Properties (Method 15A1, 15A2). In: *Australian Laboratory Handbook of Soil and Water Chemical Methods*: 138–145. Inkata Press, Melbourne

b)
0.1M $BaCl_2$ (unbuffered) - Used for acidic soils only (pH <6.5)
Unpublished WA Agricultural Chemistry Laboratory procedure.
Cations (Ca, Mg, Na, K, Al and Mg) were measured by ICP-AES.

c)
1M NH_4Cl at pH 8.5 - Used for calcareous soils
Modified method from Rayment, G.E. and Higginson, F.R. (1992) Ion-exchange Properties (Method 15C1). In: *Australian Laboratory Handbook of Soil and Water Chemical Methods*: 148–154. Inkata Press, Melbourne.

Appendix E

Soil chemical data for sites not listed in Appendix D, i.e. those sites sampled only for vascular plants during the biogeographic survey of the southern Carnarvon Basin. See Appendix D for description of analytical methods and units. Site locations are given in Appendix B. Missing values are denoted by -999. Reported values of <0.02 for exchangeable cations were treated as 0.001 me% for all statistical/multivariate analyses in Gibson, Burbidge, Keighery and Lyons (this volume).

Site	Sand %	Silt %	Clay %	EC 1:5	pH H_2O	pH $CaCl_2$	C w/b %	N tot %	P tot %	P HCO_3	K HCO_3	Ex meth.	Ca ex me%	Mg ex me%	Na ex me%	K ex me%
01	90.5	1	8.5	2	5.5	4.6	0.3	0.019	90	5	32	b	0.24	0.1	<0.02	0.06
02	89.5	2	8.5	3	5.7	4.8	0.31	0.025	95	6	69	b	0.53	0.1	<0.02	0.08
03	89.5	1.5	9	2	5.7	4.6	0.42	0.026	98	5	48	b	0.44	0.1	<0.02	0.07
04	92	1	7	1	5.9	4.7	0.32	0.021	73	4	36	b	0.34	0.09	<0.02	0.07
05	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
06	91.5	1	7.5	1	6.2	5.1	0.39	0.023	50	3	44	b	0.9	0.18	<0.02	0.06
07	91	1.5	7.5	1	5.3	4.4	0.4	0.025	61	3	27	b	0.24	0.05	<0.02	0.03
08	90.5	1.5	8	1	6.2	5	0.25	0.015	45	3	36	b	0.6	0.16	<0.02	0.05
09	91.5	1.5	7	1	6.3	5.2	0.33	0.023	74	4	72	b	0.71	0.17	<0.02	0.11
10	92.5	1	6.5	1	5.6	4.6	0.28	0.015	38	2	24	b	0.38	0.13	0.02	0.04
11	89.5	3	7.5	3	7.9	6.9	0.27	0.026	67	7	224	a	2.88	1.16	0.06	0.34
16	92	1	7	1	5.3	4.4	0.3	0.018	39	2	18	b	0.14	0.04	<0.02	0.02
17	90.5	1.5	8	1	5.8	4.7	0.46	0.021	39	2	22	b	0.47	0.12	<0.02	0.04
18	93	1.5	5.5	1	6	4.9	0.22	0.012	27	2	9	b	0.46	0.11	<0.02	0.02
19	92	1.5	6.5	1	5.8	4.7	0.32	0.016	31	2	18	b	0.35	0.14	<0.02	0.03
20	93.5	1.5	5	1	6	4.8	0.47	0.021	37	2	27	b	0.6	0.22	<0.02	0.04
21	90.5	2	7.5	1	6.1	5	0.58	0.029	38	2	22	b	1.08	0.14	<0.02	0.04
22	89	2.5	8.5	2	5.6	4.5	0.67	0.032	48	2	42	b	0.4	0.1	<0.02	0.06
23	89	2.5	8.5	2	6.3	5	0.5	0.036	80	3	118	b	1.11	0.36	0.02	0.2
24	88.5	3	8.5	2	7	5.7	0.48	0.037	72	3	191	a	2.45	0.68	0.04	0.32
25	94	1.5	4.5	1	6.5	5.4	0.28	0.014	26	2	10	a	0.69	0.12	<0.02	<0.02
26	95	1	4	1	6.4	5.2	0.17	0.008	20	0.5	8	b	0.38	0.08	<0.02	0.02
27	92	1.5	6.5	3	6.5	5.6	0.58	0.033	64	4	51	a	1.34	0.25	0.03	0.04
28	92.5	1.5	6	1	6.6	5.4	0.27	0.012	26	0.5	15	a	0.62	0.16	<0.02	<0.02
29	94	1.5	4.5	1	6.5	5.3	0.38	0.013	24	0.5	11	b	0.56	0.1	<0.02	<0.02
30	94.5	1	4.5	1	5.9	4.8	0.27	0.012	24	0.5	23	b	0.45	0.11	<0.02	0.04
31	91	2	7	1	6.1	4.8	0.28	0.016	29	0.5	23	b	0.5	0.18	<0.02	0.05
32	93	1.5	5.5	1	5.9	4.8	0.4	0.017	30	0.5	16	b	0.45	0.1	<0.02	0.03
33	89.5	2	8.5	1	6.4	5.3	0.36	0.019	51	3	28	b	0.92	0.17	<0.02	0.04
34	91	1.5	7	1	5.9	4.8	0.62	0.026	45	3	24	b	0.73	0.19	<0.02	0.05
35	91.5	1.5	7	1	5.9	4.7	0.38	0.017	32	0.5	32	b	0.47	0.17	<0.02	0.06
36	83	5.5	11.5	2	6.8	5.4	0.54	0.041	79	7	233	a	2.46	1.93	0.1	0.42
37	93	1.5	5.5	1	6.2	5	0.31	0.013	25	0.5	20	b	0.48	0.09	<0.02	0.03
38	96	1.5	2.5	2	6.3	5.2	0.33	0.013	17	0.5	10	b	0.72	0.17	<0.02	0.03
39	98	1	1	4	6.8	5.9	0.43	0.016	17	0.5	18	a	1.87	0.24	0.02	<0.02
40	95	2	3	2	6.5	5.3	0.29	0.014	17	0.5	21	a	0.83	0.17	<0.02	<0.02
41	93	1.5	5.5	1	6.2	4.8	0.27	0.014	18	0.5	18	b	0.45	0.14	<0.02	0.04
42	95	1.5	3.5	2	6.4	5.2	0.37	0.015	21	0.5	14	b	0.82	0.21	<0.02	0.03
43	95.5	1.5	3	1	6.3	5	0.33	0.014	17	0.5	16	b	0.56	0.14	<0.02	0.04
46	93	1.5	4.5	1	6.1	4.8	0.29	0.015	32	0.5	24	b	0.39	0.15	<0.02	0.05
47	93	1.5	5.5	1	6.1	4.9	0.23	0.014	28	0.5	18	b	0.32	0.12	<0.02	0.04
48	96.5	1	2.5	1	6.6	5.4	0.29	0.017	53	3	41	a	0.84	0.2	<0.02	0.02
49	95.5	1.5	3	8	8.7	8	0.42	0.027	35	3	52	c	2.48	0.45	0.08	0.09
50	94.5	1.5	4	6	8.9	8.1	0.31	0.019	36	4	35	c	1.88	0.2	0.02	0.05
51	96.5	1	2.5	8	8.2	7.5	0.39	0.022	32	3	34	c	1.88	0.27	0.04	0.05
52	95	1	4	5	8.1	7.3	0.26	0.016	35	3	36	c	1.83	0.3	0.04	0.06
53	94	1.5	4.5	3	6.7	5.8	0.38	0.021	43	4	48	b	1.39	0.31	<0.02	0.07
54	92	1.5	6.5	2	5.6	4.7	0.37	0.022	72	3	35	b	0.49	0.1	0.04	0.05
55	95	2	3	2	6.6	5.6	0.34	0.016	17	0.5	18	a	0.86	0.19	0.02	<0.02
56	93.5	2	4.5	1	6.4	5.3	0.36	0.021	30	2	22	b	0.82	0.18	<0.02	0.04
57	93	1.5	5.5	1	6	4.8	0.25	0.013	24	0.5	22	b	0.3	0.14	<0.02	0.04
58	97.5	1	1.5	2	6.4	5.3	0.38	0.02	20	0.5	19	b	0.86	0.2	0.02	0.03
59	96	1.5	2.5	4	7.3	6.5	0.57	0.052	47	4	45	a	3.16	0.26	<0.02	0.03
60	96.5	1	2.5	8	7.8	7.1	0.52	0.041	69	12	44	a	4.33	0.31	0.06	0.02
61	97	0.5	2.5	5	6.4	5.5	0.32	0.02	35	2	28	b	1.03	0.27	0.02	0.04
62	96.5	1	2.5	7	6.6	5.8	0.52	0.025	19	0.5	22	a	1.93	0.45	0.12	<0.02

Site	Sand %	Silt %	Clay %	EC 1:5	pH $H^{2}O$	pH $CaCl^{2}$	C w/b %	N tot %	P tot %	P HCO^{3}	K HCO^{3}	Ex meth.	Ca ex me%	Mg ex me%	Na ex me%	K ex me%
63	93.5	1.5	5	1	6.2	5	0.33	0.017	33	2	31	b	0.55	0.16	0.03	<0.02
64	93	1.5	5.5	1	6.5	5.4	0.42	0.023	54	3	46	b	0.88	0.2	<0.02	0.07
65	91	2	7	2	5.6	4.6	0.31	0.022	65	3	43	b	0.42	0.11	<0.02	0.08
66	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999		-999	-999	-999	-999
67	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999		-999	-999	-999	-999
68	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999		-999	-999	-999	-999
69	92	1.5	6.5	1	6.4	5.2	0.32	0.019	47	2	34	b	0.62	0.15	<0.02	0.05
70	84.5	5	10.5	3	7.5	6.5	0.28	0.036	132	10	303	a	2.95	1.18	0.06	0.58
71	93.5	1.5	5	5	8	7.2	0.22	0.021	64	7	117	a	2.3	0.47	0.04	0.14
72	95.5	1	3.5	7	7.4	6.8	0.25	0.022	47	6	95	a	2.14	0.35	0.03	0.08
73	96	0.5	3.5	7	7.9	7.2	0.33	0.026	44	7	109	a	2.63	0.58	0.06	0.13
74	95.5	1	3.5	4	7.6	6.7	0.22	0.016	39	4	105	a	2.01	0.48	0.05	0.13
75	95	1	4	5	8.3	7.5	0.18	0.015	35	3	60	c	1.49	0.3	0.06	0.09
76	94	1.5	4.5	5	7.4	6.6	0.42	0.035	55	4	100	a	2.51	0.46	0.05	0.14
77	96.5	0.5	3	11	6.8	6.2	0.46	0.029	51	5	57	a	2.34	0.54	0.07	0.07
78	91.5	1.5	7	1	6.1	5	0.4	0.025	73	3	42	b	0.61	0.16	0.13	0.08
79	93	1.5	5.5	2	5.9	5	0.7	0.032	56	3	44	b	1.07	0.21	0.22	0.07
80	92.5	1.5	6	2	6	5	0.42	0.018	30	0.5	18	b	0.6	0.13	<0.02	0.04
81	93	1.5	5.5	1	6.2	5	0.44	0.021	36	0.5	24	b	0.58	0.18	<0.02	0.05
zu06	96	0.5	3.5	6	7.6	7.1	0.29	0.022	61	5	52	a	1.78	0.27	0.03	0.1
zu07	90	3	6.5	16	8.8	8.1	1.27	0.084	430	11	42	c	4.36	1	0.34	0.12
zu08	95	1	4	11	8.4	7.8	1.05	0.08	112	4	87	c	4.88	0.54	0.14	0.25
zu09	96	1	3.5	2	6.4	5.4	0.41	0.024	33	1	31	b	0.92	0.22	0.04	0.04
zu10	84	5.5	10	21	8.4	7.9	2.38	0.188	325	9	175	c	8.48	1.4	0.34	0.52
zu11	95	1	4	3	7.1	6.6	0.46	0.023	56	1	29	a	1.2	0.36	0.02	0.06

Appendix F

Climatic estimates derived from ANUCLIM (McMahon *et al.*, 1995) for the 63 terrestrial sites sampled during the biogeographic survey of the southern Carnarvon Basin. Quadrat codes consist of two alpha characters signifying the 'campsite' [see Burbidge, McKenzie and Harvey (this volume) for explanation], followed by a number.
Key to column labels: T = temperature, P = precipitation, Rd = radiation, MI = moisture index; see McMahon *et al.* (1995) for further explanation.

Quadrat	T_ann	T_diurnR	Isotherm	T_seas	MaxTwarP	MinTcldP	T_annRa	T_WetQ	T_DryQ	T_WarQ	T_cldQ	P_ann	P_wetP	P_dryP	P_seas	P_wetQ	P_dryQ
BB1	2.40	12.60	0.50	2.00	35.30	10.30	25.00	18.10	23.70	28.10	16.90	224.00	50.00	0.00	87.00	129.00	0.00
BB2	22.40	12.70	0.50	2.00	35.40	10.20	25.20	18.10	23.70	28.10	16.80	225.00	50.00	0.00	87.00	131.00	0.00
BB3	22.30	12.30	0.50	1.00	34.90	10.40	24.60	18.20	23.50	27.90	17.00	227.00	52.00	0.00	90.00	134.00	0.00
BB4	22.30	12.50	0.50	2.00	35.10	10.30	24.80	18.10	23.60	28.00	16.90	228.00	52.00	0.00	89.00	134.00	0.00
BB5	22.40	12.50	0.50	2.00	35.10	10.30	24.80	18.20	23.60	28.00	17.00	225.00	51.00	0.00	89.00	132.00	0.00
BO1	22.90	12.20	0.50	1.00	35.30	11.10	24.20	18.80	21.70	28.30	17.50	239.00	52.00	0.00	85.00	129.00	0.00
BO2	22.90	12.20	0.50	1.00	35.30	11.10	24.20	18.80	21.70	28.30	17.50	239.00	52.00	0.00	84.00	128.00	0.00
BO3	22.90	12.20	0.50	1.00	35.30	11.10	24.30	18.80	21.70	28.40	17.50	238.00	51.00	0.00	84.00	127.00	0.00
BO4	22.90	12.30	0.50	1.00	35.40	11.10	24.40	18.70	21.70	28.40	17.50	238.00	50.00	0.00	83.00	125.00	0.00
BO5	23.00	12.40	0.50	2.00	35.50	11.00	24.50	18.70	21.80	28.50	17.50	238.00	49.00	0.00	82.00	124.00	0.00
CU1	23.00	12.00	0.50	1.00	35.20	11.30	23.90	18.90	21.70	28.40	17.60	246.00	55.00	0.00	86.00	134.00	0.00
CU2	23.00	12.00	0.50	1.00	35.20	11.30	24.00	18.80	21.70	28.40	17.60	248.00	56.00	0.00	87.00	136.00	0.00
CU3	22.90	12.20	0.50	2.00	35.60	11.10	24.50	18.60	21.80	28.50	17.40	251.00	56.00	0.00	86.00	137.00	0.00
CU4	22.90	12.20	0.50	2.00	35.50	11.10	24.40	18.70	21.70	28.50	17.40	252.00	57.00	0.00	87.00	139.00	0.00
CU5	23.00	12.30	0.50	2.00	35.70	11.10	24.70	18.60	21.80	28.60	17.40	254.00	57.00	0.00	86.00	139.00	0.00
CU6	23.00	12.30	0.50	2.00	35.90	11.10	24.80	18.60	24.50	28.70	17.30	256.00	57.00	0.00	86.00	139.00	0.00
EL1	21.30	13.20	0.50	2.00	35.20	9.00	26.20	16.80	25.10	27.50	15.50	294.00	78.00	0.00	103.00	188.00	0.00
EL2	21.30	13.20	0.50	2.00	35.30	9.00	26.30	16.70	25.20	27.50	15.40	299.00	79.00	0.00	102.00	191.00	0.00
GJ1	23.50	15.50	0.51	2.00	39.40	9.10	30.30	17.40	22.80	30.50	16.10	206.00	33.00	0.00	70.00	86.00	0.00
GJ2	23.60	15.50	0.51	2.00	39.40	9.20	30.10	17.60	22.90	30.40	16.30	204.00	32.00	0.00	71.00	86.00	0.00
GJ3	23.60	15.50	0.51	2.00	39.30	9.30	30.10	17.60	22.90	30.50	16.30	205.00	33.00	0.00	71.00	86.00	0.00
GJ4	23.60	15.40	0.51	2.00	39.30	9.40	30.00	17.70	22.90	30.40	16.40	205.00	33.00	0.00	71.00	87.00	0.00
GJ5	23.60	15.30	0.52	2.00	39.20	9.40	29.80	17.70	22.90	30.40	16.40	206.00	33.00	0.00	71.00	88.00	0.00
KE1	23.30	14.70	0.49	2.00	38.90	9.10	29.80	30.20	22.70	30.40	15.80	239.00	39.00	0.00	70.00	98.00	0.00
KE2	23.40	14.80	0.49	2.00	39.10	9.20	29.90	30.30	22.80	30.50	16.00	236.00	38.00	0.00	70.00	97.00	0.00
KE3	23.70	15.10	0.50	2.00	39.40	9.50	29.90	30.50	23.10	30.60	16.40	229.00	38.00	0.00	71.00	94.00	0.00
KE4	23.70	15.10	0.50	2.00	39.40	9.50	29.90	17.70	23.10	30.60	16.40	228.00	37.00	0.00	71.00	94.00	0.00
KE5	23.70	15.10	0.51	2.00	39.40	9.60	29.80	17.70	23.10	30.60	16.40	226.00	37.00	0.00	71.00	93.00	0.00
MD1	22.70	14.60	0.51	2.00	37.70	9.30	28.50	17.40	21.80	29.20	16.10	207.00	38.00	0.00	72.00	102.00	0.00
MD2	22.70	14.60	0.51	2.00	37.70	9.30	28.30	17.40	21.80	29.20	16.20	206.00	38.00	0.00	72.00	101.00	0.00
MD3	22.70	14.50	0.51	2.00	37.50	9.30	28.10	17.40	21.70	29.10	16.20	206.00	39.00	0.00	73.00	103.00	0.00
MD4	22.70	14.50	0.51	2.00	37.50	9.30	28.20	17.40	21.60	29.10	16.10	207.00	39.00	0.00	73.00	104.00	0.00
MD5	22.60	14.50	0.51	2.00	37.50	9.30	28.20	17.30	21.60	29.10	16.10	207.00	40.00	0.00	73.00	104.00	0.00
MR1	23.70	14.60	0.51	2.00	38.80	10.10	28.70	18.20	22.90	30.20	16.90	225.00	37.00	0.00	73.00	97.00	0.00
MR2	23.70	14.30	0.51	2.00	38.40	10.30	28.10	18.30	22.80	30.00	17.00	228.00	38.00	0.00	74.00	99.00	0.00
MR3	23.70	14.40	0.51	2.00	38.50	10.30	28.20	18.30	22.80	30.00	17.00	229.00	38.00	0.00	73.00	100.00	0.00
MR4	23.70	14.20	0.51	2.00	38.30	10.40	27.90	18.40	22.80	29.90	17.10	229.00	38.00	0.00	74.00	100.00	0.00
MR5	23.60	14.20	0.51	2.00	38.20	10.40	27.80	18.40	22.80	29.90	17.10	230.00	39.00	0.00	74.00	101.00	0.00

NA1	21.90	14.10	0.51	2.00	36.60	8.90	27.60	16.90	23.50	28.20	15.70	235.00	58.00	0.00	93.00	142.00	0.00
NA2	21.70	14.00	0.51	2.00	36.20	8.80	27.40	16.70	23.30	28.10	15.50	242.00	60.00	0.00	92.00	145.00	0.00
NA3	21.60	13.90	0.51	2.00	36.10	8.80	27.30	16.80	23.20	28.00	15.50	247.00	62.00	0.00	94.00	151.00	0.00
NA4	21.60	13.80	0.51	2.00	36.00	8.80	27.20	16.70	23.10	27.90	15.50	253.00	64.00	0.00	96.00	155.00	0.00
NA5	21.60	13.70	0.51	2.00	35.80	8.90	26.90	16.80	23.00	27.80	15.60	260.00	67.00	0.00	99.00	163.00	0.00
NE1	21.20	14.30	0.51	2.00	36.30	8.20	28.10	16.10	23.20	27.80	14.80	255.00	60.00	0.00	86.00	145.00	0.00
NE2	21.20	14.30	0.51	2.00	36.40	8.20	28.10	16.10	23.20	27.80	14.80	256.00	59.00	0.00	85.00	145.00	0.00
NE3	21.30	14.40	0.51	2.00	36.50	8.20	28.30	16.10	23.30	27.90	14.80	248.00	55.00	0.00	81.00	137.00	0.00
NE4	21.30	14.40	0.51	2.00	36.60	8.10	28.40	16.00	23.30	27.90	14.70	248.00	55.00	0.00	80.00	135.00	0.00
NE5	21.30	14.50	0.51	2.00	36.60	8.10	28.50	16.00	23.40	28.00	14.70	247.00	54.00	0.00	79.00	134.00	0.00
PE1	21.90	12.90	0.50	2.00	35.30	9.70	25.60	17.50	23.20	27.80	16.20	256.00	66.00	0.00	98.00	161.00	0.00
PE2	21.90	13.00	0.50	2.00	35.40	9.60	25.80	17.40	23.20	27.80	16.20	256.00	66.00	0.00	98.00	161.00	0.00
PE3	21.90	13.00	0.50	2.00	35.50	9.60	25.90	17.40	23.20	27.90	16.10	257.00	65.00	0.00	97.00	160.00	0.00
PE4	21.90	13.10	0.50	2.00	35.50	9.60	26.00	17.40	23.30	27.90	16.10	252.00	64.00	0.00	96.00	156.00	0.00
PE5	21.80	13.10	0.50	2.00	35.50	9.50	26.00	17.30	23.20	27.90	16.00	259.00	66.00	0.00	98.00	162.00	0.00
WO1	22.20	14.60	0.51	2.00	37.20	8.80	28.40	16.90	24.10	28.70	15.60	208.00	42.00	0.00	72.00	106.00	0.00
WO2	22.20	14.50	0.51	2.00	37.20	8.80	28.30	16.90	24.10	28.70	15.60	208.00	42.00	0.00	72.00	107.00	0.00
WO3	22.20	14.50	0.51	2.00	37.20	8.90	28.30	17.00	24.10	28.70	15.70	208.00	42.00	0.00	73.00	107.00	0.00
WO4	22.20	14.50	0.51	2.00	37.20	8.90	28.30	17.00	24.10	28.70	15.70	208.00	43.00	0.00	74.00	108.00	0.00
WO5	22.20	14.40	0.51	2.00	37.10	8.90	28.20	17.00	24.00	28.60	15.70	211.00	44.00	0.00	76.00	112.00	0.00
ZU1	20.80	13.60	0.50	2.00	35.50	8.30	27.20	16.00	25.10	27.20	14.60	333.00	85.00	0.00	99.00	205.00	0.00
ZU2	20.80	13.60	0.50	2.00	35.40	8.30	27.10	16.00	25.00	27.20	14.70	331.00	85.00	0.00	100.00	204.00	0.00
ZU3	20.80	13.60	0.51	2.00	35.10	8.50	26.70	16.20	24.90	27.10	14.90	323.00	83.00	0.00	100.00	200.00	0.00
ZU4	20.80	13.70	0.51	2.00	35.40	8.30	27.10	16.10	25.10	27.20	14.80	317.00	80.00	0.00	98.00	194.00	0.00
ZU5	20.90	13.80	0.51	2.00	35.50	8.30	27.20	16.10	25.10	27.20	14.80	314.00	79.00	0.00	97.00	191.00	0.00

Appendix F (cont.)

Quadrat	P_warQ	P_cldQ	Rd_ann	Rd_hghP	Rd_lowP	Rd_seas	Rd_wetQ	Rd_dryQ	Rd_warQ	Rd_cldQ	MI_ann	MI_hghP	MI_lowP	MI_seas	MI_hghQ	MI_lowQ	MI_warQ	MI_cldQ
BB1	52.00	107.00	21.90	28.40	14.20	23.00	15.30	27.10	25.50	16.00	0.16	0.44	0.01	91.00	0.37	0.02	0.14	0.32
BB2	52.00	109.00	21.90	28.40	14.20	23.00	15.30	27.10	25.50	16.00	0.16	0.45	0.01	92.00	0.38	0.02	0.14	0.33
BB3	50.00	112.00	21.90	28.40	14.20	23.00	15.40	27.10	25.40	16.00	0.16	0.46	0.01	94.00	0.39	0.02	0.14	0.34
BB4	50.00	112.00	21.90	28.40	14.20	23.00	15.30	27.10	25.40	16.00	0.16	0.46	0.01	94.00	0.39	0.02	0.14	0.34
BB5	51.00	110.00	21.90	28.40	14.20	23.00	15.30	27.10	25.50	16.00	0.16	0.45	0.01	93.00	0.38	0.02	0.14	0.33
BO1	73.00	102.00	22.10	28.20	14.70	22.00	15.80	25.30	25.40	16.50	0.16	0.45	0.01	87.00	0.36	0.02	0.19	0.30
BO2	73.00	102.00	22.10	28.20	14.70	22.00	15.80	25.30	25.40	16.50	0.16	0.45	0.01	86.00	0.36	0.02	0.19	0.30
BO3	74.00	100.00	22.10	28.30	14.70	22.00	15.80	25.30	25.40	16.50	0.16	0.44	0.01	85.00	0.35	0.02	0.19	0.29
BO4	75.00	99.00	22.10	28.30	14.70	22.00	15.80	25.30	25.40	16.50	0.16	0.43	0.01	84.00	0.35	0.02	0.20	0.29
BO5	76.00	98.00	22.10	28.30	14.70	22.00	15.80	25.30	25.40	16.50	0.16	0.43	0.01	84.00	0.34	0.02	0.20	0.29
CU1	75.00	106.00	22.10	28.20	14.70	22.00	15.90	25.30	25.30	16.60	0.17	0.47	0.01	88.00	0.37	0.02	0.20	0.31
CU2	75.00	107.00	22.10	28.20	14.80	22.00	15.90	25.30	25.30	16.60	0.17	0.48	0.01	89.00	0.37	0.02	0.20	0.31
CU3	76.00	108.00	22.10	28.20	14.80	22.00	15.90	25.30	25.30	16.60	0.17	0.49	0.01	88.00	0.38	0.02	0.20	0.32
CU4	75.00	110.00	22.10	28.20	14.80	22.00	15.90	25.30	25.30	16.60	0.17	0.49	0.01	89.00	0.38	0.02	0.20	0.32
CU5	76.00	110.00	22.10	28.20	14.80	22.00	15.90	25.30	25.30	16.60	0.17	0.49	0.01	89.00	0.39	0.02	0.20	0.32
CU6	77.00	110.00	22.10	28.20	14.80	22.00	15.90	27.10	25.30	16.70	0.17	0.49	0.01	88.00	0.39	0.02	0.20	0.32
EL1	29.00	172.00	21.30	28.70	13.00	27.00	14.10	28.10	25.60	14.70	0.22	0.74	0.01	113.00	0.59	0.03	0.08	0.57
EL2	30.00	175.00	21.30	28.70	13.00	27.00	14.10	28.10	25.60	14.70	0.23	0.76	0.01	112.00	0.60	0.03	0.08	0.59
GJ1	60.00	70.00	21.90	28.50	14.10	24.00	15.20	25.30	27.10	15.90	0.14	0.30	0.02	71.00	0.25	0.02	0.16	0.21
GJ2	60.00	69.00	21.90	28.50	14.10	24.00	15.20	25.30	27.10	15.90	0.14	0.29	0.02	72.00	0.24	0.02	0.16	0.20
GJ3	61.00	70.00	21.90	28.50	14.20	24.00	15.30	25.30	27.10	15.90	0.14	0.29	0.02	72.00	0.24	0.02	0.16	0.21
GJ4	61.00	70.00	21.90	28.50	14.20	24.00	15.30	25.30	27.10	16.00	0.14	0.29	0.02	72.00	0.24	0.02	0.16	0.20
GJ5	61.00	70.00	21.90	28.50	14.20	24.00	15.30	25.30	27.10	16.00	0.14	0.30	0.02	72.00	0.25	0.02	0.16	0.21
KE1	74.00	76.00	22.10	28.40	14.60	23.00	25.40	25.50	27.00	16.40	0.16	0.34	0.03	70.00	0.27	0.03	0.19	0.23
KE2	73.00	75.00	22.10	28.40	14.60	23.00	25.40	25.50	27.00	16.40	0.16	0.33	0.02	70.00	0.27	0.03	0.19	0.22
KE3	71.00	74.00	22.10	28.40	14.60	23.00	25.40	25.50	27.00	16.40	0.15	0.32	0.02	71.00	0.26	0.02	0.18	0.22
KE4	70.00	74.00	22.10	28.40	14.60	23.00	15.60	25.50	27.00	16.40	0.15	0.32	0.02	71.00	0.26	0.02	0.18	0.22
KE5	69.00	74.00	22.10	28.40	14.50	23.00	15.60	25.50	27.00	16.30	0.15	0.32	0.02	71.00	0.26	0.02	0.18	0.22
MD1	63.00	86.00	21.80	28.60	13.80	25.00	15.00	25.10	25.50	15.60	0.15	0.35	0.02	76.00	0.30	0.03	0.17	0.26
MD2	62.00	85.00	21.80	28.60	13.80	25.00	15.00	25.10	25.50	15.60	0.14	0.35	0.02	76.00	0.30	0.03	0.17	0.26
MD3	60.00	87.00	21.80	28.60	13.80	25.00	14.90	25.10	25.50	15.50	0.15	0.36	0.02	77.00	0.30	0.03	0.16	0.27
MD4	60.00	88.00	21.80	28.60	13.80	25.00	14.90	25.10	25.50	15.50	0.15	0.36	0.02	77.00	0.31	0.03	0.16	0.27
MD5	60.00	89.00	21.70	28.70	13.70	25.00	14.90	25.10	25.50	15.50	0.15	0.36	0.02	78.00	0.31	0.03	0.16	0.27
MR1	88.00	77.00	22.10	28.40	14.60	23.00	15.70	25.40	25.40	16.40	0.15	0.33	0.02	73.00	0.27	0.02	0.23	0.22
MR2	88.00	78.00	22.10	28.30	14.60	22.00	15.70	25.40	25.40	16.50	0.15	0.33	0.02	74.00	0.27	0.02	0.23	0.23
MR3	89.00	79.00	22.10	28.30	14.60	22.00	15.70	25.40	25.40	16.50	0.15	0.34	0.02	74.00	0.28	0.02	0.23	0.23
MR4	89.00	79.00	22.10	28.30	14.70	22.00	15.80	25.40	25.40	16.50	0.15	0.34	0.02	74.00	0.28	0.02	0.23	0.23
MR5	89.00	79.00	22.10	28.30	14.70	22.00	15.80	25.40	25.40	16.50	0.15	0.34	0.02	74.00	0.28	0.02	0.23	0.23
NA1	36.00	127.00	21.40	28.90	13.10	27.00	14.20	27.20	25.70	14.80	0.17	0.53	0.02	102.00	0.44	0.03	0.10	0.41
NA2	36.00	130.00	21.40	28.90	13.10	27.00	14.20	27.20	25.70	14.80	0.18	0.55	0.02	102.00	0.46	0.03	0.10	0.43
NA3	35.00	136.00	21.40	28.90	13.00	27.00	14.20	27.20	25.70	14.70	0.19	0.57	0.02	105.00	0.48	0.03	0.10	0.45

NA4	34.00	140.00	21.40	28.90	13.00	27.00	14.20	27.20	25.70	14.70	0.19	0.59	0.02	106.00	0.49	0.03	0.09	0.46
NA5	31.00	148.00	21.40	28.90	12.90	27.00	14.10	27.10	25.70	14.60	0.20	0.62	0.02	108.00	0.51	0.03	0.09	0.49
NE1	40.00	135.00	21.30	29.20	12.60	29.00	13.80	27.30	25.80	14.20	0.20	0.59	0.03	98.00	0.48	0.04	0.11	0.47
NE2	40.00	135.00	21.30	29.20	12.60	29.00	13.80	27.30	25.80	14.20	0.20	0.59	0.03	98.00	0.48	0.04	0.11	0.47
NE3	44.00	127.00	21.30	29.30	12.60	29.00	13.70	27.40	25.80	14.20	0.19	0.55	0.04	94.00	0.45	0.04	0.12	0.44
NE4	44.00	126.00	21.30	29.30	12.60	29.00	13.70	27.40	25.80	14.20	0.19	0.54	0.04	93.00	0.44	0.04	0.12	0.43
NE5	45.00	125.00	21.30	29.30	12.60	29.00	13.70	27.40	25.80	14.20	0.19	0.54	0.04	92.00	0.44	0.04	0.12	0.43
PE1	36.00	143.00	21.60	28.60	13.50	25.00	14.70	27.00	25.50	15.30	0.19	0.58	0.01	106.00	0.49	0.03	0.10	0.45
PE2	37.00	142.00	21.60	28.60	13.50	25.00	14.70	27.00	25.50	15.30	0.19	0.58	0.01	106.00	0.49	0.03	0.10	0.45
PE3	38.00	142.00	21.60	28.50	13.60	25.00	14.80	27.00	25.50	15.40	0.19	0.58	0.01	105.00	0.49	0.03	0.10	0.45
PE4	38.00	138.00	21.60	28.60	13.60	25.00	14.70	27.10	25.50	15.40	0.18	0.57	0.01	104.00	0.47	0.03	0.11	0.44
PE5	36.00	145.00	21.60	28.60	13.50	26.00	14.60	27.00	25.50	15.20	0.19	0.59	0.01	106.00	0.50	0.03	0.10	0.46
WO1	53.00	93.00	21.60	28.80	13.30	26.00	14.50	27.20	25.60	15.00	0.15	0.39	0.04	80.00	0.33	0.04	0.14	0.30
WO2	53.00	93.00	21.60	28.80	13.30	26.00	14.50	27.20	25.60	15.00	0.15	0.39	0.03	80.00	0.33	0.04	0.14	0.30
WO3	52.00	94.00	21.60	28.80	13.30	26.00	14.50	27.20	25.60	15.10	0.15	0.39	0.03	81.00	0.33	0.04	0.14	0.30
WO4	51.00	94.00	21.60	28.80	13.30	26.00	14.50	27.20	25.60	15.10	0.15	0.40	0.03	82.00	0.33	0.04	0.14	0.30
WO5	50.00	98.00	21.60	28.80	13.30	26.00	14.50	27.20	25.60	15.10	0.15	0.41	0.03	84.00	0.34	0.04	0.13	0.31
ZU1	30.00	197.00	21.10	29.10	12.40	29.00	13.50	28.50	25.80	14.00	0.26	0.87	0.03	110.00	0.70	0.04	0.08	0.70
ZU2	30.00	196.00	21.10	29.10	12.40	29.00	13.50	28.50	25.80	14.00	0.26	0.87	0.03	110.00	0.69	0.04	0.08	0.69
ZU3	29.00	192.00	21.20	29.10	12.40	29.00	13.50	28.50	25.80	14.00	0.25	0.84	0.03	111.00	0.67	0.04	0.08	0.67
ZU4	31.00	186.00	21.20	29.20	12.40	29.00	13.50	28.50	25.80	14.00	0.25	0.83	0.03	110.00	0.65	0.04	0.09	0.65
ZU5	32.00	183.00	21.20	29.20	12.40	29.00	13.50	28.50	25.80	14.00	0.25	0.81	0.03	109.00	0.64	0.04	0.09	0.64

Reference

McMahon, J.P., Hutchinson, M.F., Nix, H.A. and Ord, K.D. (1995). *ANUCLIM Users Guide, Version 1.* Centre for Resource and Environmental Studies, Australian National University, Canberra, Australia.

Appendix G

Climatic estimates derived from ANUCLIM (McMahon *et al.*, 1995) for the terrestrial sites sampled only for vascular plants in the floristic survey (Gibson, Burbidge, Keighery and Lyons, this volume) forming part of the biogeographic survey of the southern Carnarvon Basin. Key to column labels: T = temperature, P = precipitation, Rd = radiation, MI = moisture index; see McMahon *et al.* (1995) for further explanation.

Quadrat	T_ann	T_diurnR	Isotherm	T_seas	MaxTwarP	MinTcldP	T_annRa	T_WetQ	T_DryQ	T_WarQ	T_cldQ	P_ann	P_wetP	P_dryP	P_seas	P_wetQ	P_dryQ
01	21.80	14.70	0.51	2.00	37.10	8.40	28.80	16.40	23.90	28.40	15.10	218.00	45.00	0.00	73.00	112.00	0.00
02	21.70	14.70	0.51	2.00	37.20	8.30	28.90	16.30	23.90	28.50	14.90	220.00	45.00	0.00	72.00	112.00	0.00
03	21.70	14.70	0.51	2.00	37.30	8.20	29.10	16.20	24.00	28.50	14.90	219.00	44.00	0.00	71.00	110.00	0.00
04	21.40	14.60	0.50	2.00	37.10	7.80	29.30	15.70	23.80	28.40	14.40	233.00	46.00	0.00	70.00	117.00	0.00
06	21.00	14.60	0.50	2.00	36.70	7.60	29.00	15.50	23.30	27.90	14.20	251.00	51.00	0.00	72.00	128.00	0.00
07	21.00	14.60	0.50	2.00	36.70	7.60	29.10	15.50	23.30	28.00	14.10	248.00	49.00	0.00	70.00	126.00	0.00
08	21.00	14.60	0.50	2.00	36.60	7.60	29.00	15.40	23.20	27.90	14.10	254.00	51.00	0.00	72.00	130.00	0.00
09	20.90	14.60	0.50	2.00	36.50	7.50	29.00	15.40	23.20	27.80	14.10	257.00	51.00	0.00	71.00	131.00	0.00
10	20.90	14.60	0.50	2.00	36.50	7.60	28.90	15.40	23.20	27.80	14.10	257.00	52.00	0.00	71.00	131.00	0.00
11	20.90	14.60	0.50	2.00	36.50	7.60	28.90	15.50	23.20	27.80	14.10	257.00	52.00	0.00	72.00	132.00	0.00
16	20.90	14.60	0.51	2.00	36.50	7.70	28.90	15.50	23.20	27.80	14.20	256.00	52.00	0.00	72.00	131.00	0.00
17	20.90	14.40	0.50	2.00	36.40	7.60	28.80	15.40	23.10	27.70	14.10	266.00	56.00	0.00	75.00	140.00	0.00
18	20.90	14.40	0.50	2.00	36.40	7.70	28.70	15.50	23.00	27.70	14.20	270.00	57.00	0.00	76.00	143.00	0.00
19	20.80	14.40	0.50	2.00	36.40	7.70	28.70	15.50	23.00	27.70	14.10	272.00	58.00	0.00	77.00	144.00	0.00
20	20.80	14.40	0.50	2.00	36.40	7.70	28.70	15.40	23.00	27.70	14.10	274.00	58.00	0.00	77.00	145.00	0.00
21	20.80	14.30	0.50	2.00	36.20	7.80	28.50	15.50	22.90	27.50	14.20	279.00	60.00	0.00	79.00	150.00	0.00
22	20.80	14.30	0.51	2.00	36.10	7.80	28.30	15.60	22.80	27.40	14.30	281.00	61.00	0.00	80.00	153.00	0.00
23	20.70	14.30	0.50	2.00	36.10	7.80	28.30	15.50	22.80	27.40	14.20	289.00	63.00	0.00	81.00	157.00	0.00
24	20.80	14.30	0.51	2.00	36.00	7.90	28.20	15.70	22.80	27.40	14.30	283.00	62.00	0.00	80.00	154.00	0.00
25	20.60	14.30	0.50	2.00	36.10	7.60	28.50	15.30	22.80	27.40	14.00	292.00	62.00	0.00	78.00	156.00	0.00
26	20.60	14.30	0.50	2.00	36.10	7.60	28.50	15.30	22.80	27.40	14.00	292.00	62.00	0.00	78.00	156.00	0.00
27	21.30	14.60	0.50	2.00	37.00	7.70	29.20	15.60	23.70	28.30	14.30	237.00	48.00	0.00	71.00	120.00	0.00
28	20.70	14.30	0.50	2.00	36.10	7.70	28.40	15.50	22.80	27.40	14.20	289.00	63.00	0.00	80.00	157.00	0.00
29	20.70	14.30	0.50	2.00	36.10	7.70	28.40	15.40	22.80	27.40	14.10	291.00	63.00	0.00	80.00	157.00	0.00
30	20.70	14.30	0.50	2.00	36.10	7.70	28.50	15.40	22.80	27.40	14.00	293.00	63.00	0.00	79.00	158.00	0.00
31	20.70	14.30	0.50	2.00	36.10	7.60	28.50	15.40	22.80	27.40	14.00	293.00	63.00	0.00	79.00	158.00	0.00
32	20.70	14.40	0.50	2.00	36.30	7.60	28.70	15.30	22.90	27.50	14.00	280.00	58.00	0.00	75.00	147.00	0.00
33	20.90	14.50	0.50	2.00	36.50	7.60	28.90	15.40	23.20	27.80	14.10	259.00	53.00	0.00	73.00	134.00	0.00
34	20.90	14.50	0.50	2.00	36.50	7.60	28.90	15.40	23.20	27.80	14.10	258.00	52.00	0.00	72.00	133.00	0.00
35	20.80	14.50	0.50	2.00	36.30	7.60	28.70	15.40	23.00	27.60	14.10	272.00	56.00	0.00	74.00	142.00	0.00
36	20.60	14.30	0.50	2.00	36.10	7.60	28.40	15.30	22.70	27.40	14.00	297.00	64.00	0.00	79.00	160.00	0.00
37	20.60	14.30	0.50	2.00	36.10	7.60	28.40	15.30	22.70	27.40	14.00	295.00	64.00	0.00	79.00	159.00	0.00
38	20.70	13.90	0.50	2.00	35.60	8.00	27.60	15.70	25.20	27.20	14.40	337.00	81.00	0.00	93.00	199.00	0.00
39	20.50	13.50	0.51	2.00	34.70	8.30	26.40	16.00	24.50	26.60	14.70	371.00	93.00	0.00	100.00	227.00	0.00
40	20.50	13.80	0.51	2.00	35.30	8.10	27.20	15.70	24.90	26.90	14.40	369.00	91.00	0.00	96.00	221.00	0.00
41	20.70	14.10	0.50	2.00	35.90	7.90	28.00	15.60	25.40	27.30	14.30	324.00	76.00	0.00	89.00	186.00	0.00
42	20.60	14.10	0.50	2.00	35.90	7.80	28.10	15.50	25.40	27.30	14.10	326.00	75.00	0.00	88.00	186.00	0.00
43	20.50	13.90	0.50	2.00	35.60	7.80	27.90	15.40	25.10	27.10	14.10	367.00	86.00	0.00	91.00	212.00	0.00

46	20.90	14.20	0.50	2.00	36.20	7.90	28.20	15.70	22.90	27.50	14.40	288.00	66.00	0.00	85.00	161.00	0.00
47	20.90	14.20	0.50	2.00	36.20	7.90	28.20	15.70	22.90	27.50	14.40	287.00	66.00	0.00	85.00	162.00	0.00
48	21.40	14.40	0.51	2.00	36.50	8.30	28.10	16.30	23.30	28.00	15.00	239.00	54.00	0.00	83.00	134.00	0.00
49	21.40	13.50	0.51	2.00	35.50	9.00	26.50	16.80	25.30	27.60	15.50	274.00	72.00	0.00	101.00	173.00	0.00
50	21.60	13.80	0.51	2.00	36.00	8.80	27.20	16.70	23.20	27.90	15.50	252.00	64.00	0.00	95.00	154.00	0.00
51	21.70	13.90	0.51	2.00	36.20	8.80	27.30	16.80	23.20	28.00	15.50	246.00	62.00	0.00	95.00	150.00	0.00
52	21.70	14.00	0.51	2.00	36.20	8.80	27.40	16.80	23.30	28.00	15.50	243.00	61.00	0.00	93.00	148.00	0.00
53	21.60	14.00	0.51	2.00	36.20	8.80	27.40	16.70	23.30	28.00	15.50	243.00	60.00	0.00	92.00	146.00	0.00
54	21.60	14.40	0.51	2.00	36.70	8.50	28.20	16.40	23.50	28.20	15.10	224.00	50.00	0.00	81.00	124.00	0.00
55	20.60	13.70	0.51	2.00	35.20	8.20	27.00	15.90	24.80	26.90	14.50	362.00	90.00	0.00	98.00	219.00	0.00
56	21.00	14.20	0.51	2.00	36.10	8.10	27.90	15.90	22.90	27.50	14.60	283.00	66.00	0.00	88.00	162.00	0.00
57	21.00	14.10	0.51	2.00	36.00	8.10	27.90	15.90	22.90	27.50	14.60	291.00	70.00	0.00	90.00	170.00	0.00
58	20.80	13.70	0.51	2.00	35.40	8.40	27.00	16.10	25.00	27.20	14.80	318.00	81.00	0.00	98.00	195.00	0.00
59	20.80	13.70	0.51	2.00	35.40	8.40	27.00	16.10	25.00	27.20	14.80	318.00	81.00	0.00	99.00	195.00	0.00
60	21.10	13.80	0.51	2.00	35.60	8.50	27.10	16.30	25.20	27.40	15.00	286.00	73.00	0.00	98.00	176.00	0.00
61	21.10	13.80	0.51	2.00	35.50	8.50	27.10	16.30	25.20	27.40	15.00	288.00	73.00	0.00	98.00	177.00	0.00
62	21.00	13.90	0.51	2.00	35.80	8.30	27.50	16.10	25.40	27.50	14.80	291.00	73.00	0.00	95.00	176.00	0.00
63	21.00	14.20	0.51	2.00	36.20	8.10	28.10	15.90	23.00	27.60	14.60	279.00	64.00	0.00	86.00	158.00	0.00
64	21.20	14.30	0.51	2.00	36.40	8.20	28.20	16.10	23.20	27.80	14.70	255.00	59.00	0.00	84.00	144.00	0.00
65	21.40	14.40	0.51	2.00	36.60	8.20	28.40	16.10	23.40	28.00	14.80	242.00	54.00	0.00	81.00	133.00	0.00
66	21.20	14.40	0.51	2.00	36.40	8.10	28.20	16.00	23.20	27.80	14.70	257.00	58.00	0.00	82.00	143.00	0.00
67	21.10	14.40	0.51	2.00	36.40	8.00	28.40	15.90	23.20	27.80	14.50	265.00	60.00	0.00	82.00	147.00	0.00
68	21.10	14.30	0.51	2.00	36.30	8.10	28.30	15.90	23.10	27.70	14.60	266.00	60.00	0.00	83.00	148.00	0.00
69	21.30	14.30	0.51	2.00	36.40	8.30	28.20	16.20	23.30	27.90	14.80	248.00	57.00	0.00	84.00	140.00	0.00
70	21.50	14.40	0.51	2.00	36.50	8.40	28.10	16.40	23.40	28.00	15.10	231.00	52.00	0.00	82.00	129.00	0.00
71	22.00	13.10	0.50	2.00	35.50	9.60	25.90	17.50	23.30	28.00	16.20	245.00	61.00	0.00	95.00	151.00	0.00
72	21.90	13.00	0.50	2.00	35.50	9.60	25.90	17.40	23.30	27.90	16.20	251.00	63.00	0.00	96.00	156.00	0.00
73	21.90	12.90	0.50	2.00	35.40	9.70	25.70	17.50	23.30	27.90	16.20	252.00	64.00	0.00	97.00	157.00	0.00
74	21.80	13.70	0.51	2.00	36.00	9.10	26.90	17.00	23.30	28.10	15.80	248.00	62.00	0.00	95.00	152.00	0.00
75	21.80	13.80	0.51	2.00	36.10	9.10	27.10	17.00	23.40	28.10	15.70	247.00	61.00	0.00	94.00	150.00	0.00
76	21.80	13.80	0.51	2.00	36.20	9.00	27.20	16.90	23.40	28.10	15.70	245.00	61.00	0.00	93.00	149.00	0.00
77	21.90	14.00	0.51	2.00	36.50	8.90	27.60	16.90	23.50	28.20	15.60	237.00	58.00	0.00	92.00	143.00	0.00
78	21.20	14.60	0.51	2.00	36.70	7.90	28.80	15.80	23.40	28.00	14.50	243.00	50.00	0.00	74.00	126.00	0.00
79	21.00	14.40	0.51	2.00	36.30	7.90	28.40	15.70	23.00	27.60	14.40	272.00	60.00	0.00	81.00	148.00	0.00
80	21.00	14.40	0.51	2.00	36.30	7.90	28.40	15.80	23.10	27.70	14.40	271.00	60.00	0.00	81.00	149.00	0.00
ZU6	21.00	14.00	0.51	2.00	35.90	8.20	27.60	16.00	25.40	27.40	14.70	297.00	73.00	0.00	93.00	176.00	0.00
ZU7	20.80	13.60	0.50	2.00	35.40	8.30	27.10	16.00	25.00	27.20	14.70	335.00	86.00	0.00	100.00	207.00	0.00
ZU8	20.80	13.60	0.50	2.00	35.40	8.30	27.10	16.00	25.00	27.20	14.70	333.00	85.00	0.00	100.00	206.00	0.00
ZU9	20.80	13.60	0.50	2.00	35.60	8.30	27.30	15.90	25.20	27.30	14.60	328.00	84.00	0.00	99.00	203.00	0.00
ZU10	20.80	13.60	0.50	2.00	35.50	8.30	27.20	15.90	25.20	27.30	14.60	330.00	84.00	0.00	99.00	204.00	0.00
ZU11	20.80	13.60	0.50	2.00	35.40	8.40	27.10	16.10	25.10	27.20	14.70	325.00	83.00	0.00	100.00	201.00	0.00

Appendix G (cont.)

Quadrat	P_warQ	P_cldQ	Rd_ann	Rd_hghP	Rd_lowP	Rd_seas	Rd_wetQ	Rd_dryQ	Rd_warQ	Rd_cldQ	MI_ann	MI_hghP	MI_lowP	MI_seas	MI_hghQ	MI_lowQ	MI_warQ	MI_cldQ
01	51.00	101.00	21.50	29.10	13.00	27.00	14.10	27.30	25.70	14.60	0.16	0.43	0.04	83.00	0.36	0.04	0.14	0.33
02	52.00	101.00	21.50	29.10	12.90	27.00	14.10	27.30	25.70	14.60	0.16	0.43	0.04	83.00	0.36	0.04	0.14	0.34
03	37.00	99.00	21.50	29.10	12.90	27.00	14.10	27.30	27.80	14.60	0.16	0.42	0.04	81.00	0.35	0.04	0.10	0.33
04	38.00	108.00	21.40	29.30	12.60	29.00	13.80	27.40	28.00	14.20	0.18	0.46	0.04	83.00	0.39	0.05	0.10	0.37
06	36.00	121.00	21.20	29.60	12.20	30.00	13.40	27.50	28.20	13.80	0.19	0.53	0.04	86.00	0.43	0.05	0.10	0.43
07	37.00	118.00	21.20	29.60	12.20	30.00	13.40	27.60	28.30	13.80	0.19	0.52	0.05	85.00	0.42	0.05	0.10	0.42
08	36.00	122.00	21.20	29.70	12.20	30.00	13.30	27.60	28.30	13.70	0.20	0.54	0.05	86.00	0.44	0.05	0.10	0.44
09	36.00	123.00	21.20	29.70	12.10	31.00	13.20	27.60	28.30	13.60	0.20	0.55	0.05	86.00	0.44	0.05	0.10	0.44
10	36.00	124.00	21.20	29.70	12.10	31.00	13.20	27.60	28.30	13.60	0.20	0.55	0.05	86.00	0.44	0.05	0.10	0.44
11	36.00	124.00	21.20	29.70	12.10	30.00	13.30	27.60	28.30	13.60	0.20	0.55	0.05	87.00	0.45	0.05	0.10	0.44
16	36.00	124.00	21.20	29.70	12.10	30.00	13.30	27.60	28.30	13.70	0.20	0.55	0.05	87.00	0.44	0.05	0.10	0.44
17	34.00	133.00	21.20	29.60	12.10	30.00	13.30	27.50	28.30	13.70	0.21	0.60	0.05	90.00	0.48	0.05	0.10	0.48
18	34.00	137.00	21.20	29.60	12.10	30.00	13.30	27.50	28.20	13.70	0.21	0.62	0.05	92.00	0.49	0.05	0.09	0.49
19	33.00	138.00	21.20	29.60	12.10	30.00	13.30	27.50	28.20	13.70	0.21	0.63	0.05	92.00	0.50	0.05	0.09	0.50
20	33.00	139.00	21.20	29.60	12.10	30.00	13.30	27.50	28.20	13.70	0.22	0.63	0.05	92.00	0.50	0.05	0.09	0.50
21	32.00	144.00	21.20	29.60	12.10	30.00	13.20	27.50	28.20	13.60	0.22	0.65	0.04	94.00	0.52	0.05	0.09	0.52
22	44.00	147.00	21.20	29.60	12.10	31.00	13.20	27.50	26.00	13.60	0.22	0.66	0.04	95.00	0.53	0.05	0.12	0.53
23	31.00	152.00	21.10	29.60	12.00	31.00	13.20	27.50	28.30	13.60	0.23	0.69	0.04	96.00	0.55	0.05	0.09	0.55
24	44.00	148.00	21.10	29.60	12.10	31.00	13.20	27.50	26.00	13.60	0.22	0.67	0.04	95.00	0.53	0.05	0.12	0.53
25	33.00	150.00	21.10	29.70	11.90	31.00	13.10	27.60	28.40	13.40	0.23	0.69	0.05	94.00	0.55	0.06	0.09	0.55
26	33.00	151.00	21.10	29.70	11.90	31.00	13.00	27.60	28.40	13.40	0.23	0.70	0.05	94.00	0.56	0.06	0.09	0.56
27	37.00	112.00	21.30	29.40	12.50	29.00	13.70	27.50	28.00	14.10	0.18	0.48	0.04	84.00	0.40	0.05	0.10	0.39
28	32.00	152.00	21.10	29.60	12.00	31.00	13.20	27.50	28.30	13.50	0.23	0.69	0.04	95.00	0.55	0.05	0.09	0.55
29	32.00	152.00	21.10	29.60	12.00	31.00	13.10	27.50	28.30	13.50	0.23	0.70	0.04	95.00	0.56	0.06	0.09	0.56
30	32.00	152.00	21.10	29.70	11.90	31.00	13.10	27.50	28.30	13.50	0.23	0.70	0.04	95.00	0.56	0.06	0.09	0.56
31	32.00	153.00	21.10	29.70	11.90	31.00	13.10	27.50	28.30	13.50	0.23	0.70	0.04	95.00	0.56	0.06	0.09	0.56
32	34.00	140.00	21.10	29.80	11.90	31.00	13.10	27.60	28.40	13.40	0.22	0.64	0.05	91.00	0.51	0.06	0.10	0.51
33	35.00	126.00	21.20	29.60	12.10	30.00	13.30	27.60	28.30	13.70	0.20	0.57	0.05	88.00	0.45	0.05	0.10	0.45
34	36.00	125.00	21.20	29.70	12.10	30.00	13.30	27.60	28.30	13.70	0.20	0.56	0.05	87.00	0.45	0.05	0.10	0.45
35	34.00	135.00	21.20	29.70	12.00	31.00	13.10	27.60	28.30	13.50	0.21	0.61	0.05	90.00	0.49	0.06	0.10	0.49
36	32.00	155.00	21.10	29.70	11.90	31.00	13.00	27.50	28.40	13.40	0.24	0.72	0.05	95.00	0.57	0.06	0.09	0.57
37	32.00	154.00	21.10	29.70	11.90	31.00	13.00	27.50	28.30	13.40	0.24	0.71	0.05	95.00	0.57	0.06	0.09	0.57
38	35.00	194.00	21.10	29.40	12.10	30.00	13.20	28.80	25.90	13.70	0.27	0.86	0.04	105.00	0.70	0.05	0.10	0.70
39	30.00	223.00	21.00	29.40	12.00	31.00	13.10	28.70	25.90	13.60	0.29	0.93	0.03	109.00	0.79	0.04	0.08	0.79
40	33.00	218.00	21.00	29.40	12.00	31.00	13.10	28.80	25.90	13.50	0.30	0.93	0.04	107.00	0.79	0.05	0.09	0.79
41	38.00	182.00	21.10	29.50	12.10	30.00	13.20	28.80	25.90	13.60	0.26	0.82	0.04	103.00	0.66	0.06	0.11	0.66
42	40.00	181.00	21.10	29.50	12.00	31.00	13.20	28.90	26.00	13.60	0.26	0.83	0.04	102.00	0.67	0.06	0.11	0.67
43	37.00	209.00	21.00	29.60	11.80	31.00	13.00	28.90	26.00	13.40	0.30	0.92	0.04	103.00	0.77	0.06	0.10	0.77
46	41.00	155.00	21.20	29.40	12.20	30.00	13.40	27.40	25.90	13.80	0.23	0.70	0.04	99.00	0.55	0.05	0.11	0.55
47	41.00	155.00	21.20	29.40	12.30	30.00	13.40	27.40	25.90	13.80	0.23	0.70	0.04	99.00	0.55	0.05	0.11	0.55
48	42.00	123.00	21.40	29.10	12.70	28.00	13.90	27.30	25.80	14.30	0.18	0.52	0.03	95.00	0.43	0.04	0.12	0.41

49	30.00	158.00	21.30	28.80	12.90	27.00	14.00	28.20	25.70	14.60	0.21	0.67	0.01	111.00	0.54	0.03	0.08	0.52
50	34.00	139.00	21.40	28.90	13.00	27.00	14.20	27.20	25.70	14.70	0.19	0.59	0.02	106.00	0.49	0.03	0.09	0.46
51	34.00	135.00	21.40	28.90	13.00	27.00	14.20	27.20	25.70	14.70	0.18	0.56	0.02	105.00	0.47	0.03	0.10	0.45
52	35.00	132.00	21.40	28.90	13.00	27.00	14.20	27.20	25.70	14.70	0.18	0.55	0.02	103.00	0.47	0.03	0.10	0.44
53	36.00	131.00	21.40	28.90	13.00	27.00	14.20	27.20	25.70	14.70	0.18	0.55	0.02	103.00	0.46	0.03	0.10	0.43
54	44.00	111.00	21.40	29.00	12.90	28.00	14.10	27.30	25.70	14.60	0.17	0.48	0.03	92.00	0.40	0.04	0.12	0.37
55	32.00	215.00	21.00	29.40	12.00	30.00	13.20	28.70	25.90	13.60	0.29	0.92	0.03	108.00	0.77	0.05	0.09	0.77
56	39.00	155.00	21.20	29.30	12.40	29.00	13.50	27.40	25.90	14.00	0.22	0.69	0.04	101.00	0.54	0.05	0.11	0.54
57	37.00	162.00	21.20	29.30	12.40	29.00	13.50	27.30	25.80	14.00	0.23	0.73	0.04	103.00	0.57	0.05	0.10	0.57
58	31.00	187.00	21.20	29.20	12.40	29.00	13.50	28.50	25.80	14.00	0.25	0.83	0.03	110.00	0.65	0.04	0.09	0.65
59	30.00	187.00	21.20	29.20	12.40	29.00	13.50	28.50	25.80	14.00	0.25	0.83	0.03	110.00	0.65	0.04	0.08	0.65
60	31.00	165.00	21.20	29.10	12.60	29.00	13.70	28.40	25.80	14.20	0.22	0.73	0.02	109.00	0.57	0.04	0.09	0.57
61	31.00	166.00	21.20	29.10	12.60	29.00	13.70	28.40	25.80	14.20	0.22	0.73	0.02	109.00	0.57	0.04	0.09	0.57
62	33.00	166.00	21.20	29.10	12.50	29.00	13.70	28.50	25.80	14.10	0.23	0.74	0.03	107.00	0.58	0.04	0.09	0.58
63	40.00	151.00	21.20	29.30	12.40	29.00	13.50	27.40	25.90	14.00	0.22	0.67	0.04	100.00	0.53	0.05	0.11	0.53
64	41.00	134.00	21.30	29.20	12.60	29.00	13.70	27.30	25.80	14.20	0.20	0.58	0.04	97.00	0.47	0.04	0.11	0.46
65	44.00	123.00	21.30	29.20	12.70	28.00	13.80	27.40	25.80	14.30	0.18	0.52	0.04	93.00	0.43	0.04	0.12	0.42
66	43.00	134.00	21.30	29.30	12.50	29.00	13.60	27.40	25.80	14.10	0.20	0.58	0.04	96.00	0.47	0.04	0.12	0.46
67	43.00	138.00	21.30	29.30	12.40	29.00	13.60	27.40	25.90	14.00	0.20	0.61	0.04	96.00	0.49	0.05	0.12	0.48
68	42.00	140.00	21.30	29.30	12.40	29.00	13.60	27.40	25.90	14.00	0.21	0.62	0.04	97.00	0.49	0.04	0.12	0.49
69	41.00	129.00	21.30	29.20	12.60	28.00	13.80	27.30	25.80	14.30	0.19	0.56	0.03	97.00	0.46	0.04	0.11	0.44
70	42.00	117.00	21.40	29.10	12.80	28.00	14.00	27.30	25.80	14.40	0.17	0.50	0.03	93.00	0.41	0.04	0.12	0.39
71	40.00	133.00	21.60	28.60	13.60	25.00	14.80	27.10	25.50	15.40	0.18	0.54	0.01	102.00	0.45	0.03	0.11	0.42
72	38.00	138.00	21.60	28.60	13.60	25.00	14.70	27.10	25.50	15.30	0.18	0.56	0.01	104.00	0.47	0.03	0.11	0.44
73	39.00	138.00	21.60	28.50	13.70	25.00	14.80	27.00	25.50	15.50	0.18	0.57	0.01	104.00	0.47	0.03	0.11	0.44
74	36.00	136.00	21.50	28.70	13.20	26.00	14.40	27.10	25.60	15.00	0.18	0.56	0.02	104.00	0.47	0.03	0.10	0.44
75	37.00	134.00	21.50	28.70	13.20	26.00	14.40	27.10	25.60	14.90	0.18	0.56	0.02	103.00	0.47	0.03	0.10	0.44
76	37.00	133.00	21.50	28.80	13.20	26.00	14.30	27.10	25.60	14.90	0.18	0.55	0.02	103.00	0.46	0.03	0.10	0.43
77	37.00	127.00	21.50	28.80	13.10	27.00	14.30	27.20	25.60	14.80	0.18	0.53	0.02	101.00	0.45	0.03	0.10	0.42
78	35.00	118.00	21.30	29.40	12.40	29.00	13.60	27.50	28.10	14.00	0.19	0.51	0.04	87.00	0.42	0.05	0.10	0.41
79	44.00	142.00	21.20	29.50	12.30	30.00	13.40	27.50	25.90	13.80	0.21	0.63	0.04	95.00	0.50	0.05	0.12	0.50
80	44.00	142.00	21.20	29.40	12.30	30.00	13.50	27.40	25.90	13.90	0.21	0.63	0.04	95.00	0.50	0.05	0.12	0.50
ZU6	35.00	168.00	21.20	29.20	12.40	29.00	13.50	28.60	25.80	14.00	0.23	0.75	0.03	106.00	0.59	0.05	0.10	0.59
ZU7	29.00	199.00	21.10	29.10	12.40	29.00	13.50	28.50	25.80	14.00	0.26	0.88	0.03	111.00	0.70	0.04	0.08	0.70
ZU8	30.00	197.00	21.10	29.10	12.40	29.00	13.50	28.50	25.80	14.00	0.26	0.87	0.03	111.00	0.70	0.04	0.08	0.70
ZU9	30.00	193.00	21.20	29.10	12.40	29.00	13.60	28.40	25.80	14.10	0.26	0.86	0.03	110.00	0.69	0.04	0.08	0.69
ZU10	30.00	194.00	21.20	29.10	12.40	29.00	13.60	28.40	25.80	14.10	0.26	0.87	0.03	110.00	0.69	0.04	0.08	0.69
ZU11	30.00	192.00	21.20	29.10	12.40	29.00	13.60	28.40	25.80	14.10	0.25	0.85	0.02	111.00	0.67	0.04	0.08	0.67

Reference

McMahon, J.P., Hutchinson, M.F., Nix, H.A. and Ord, K.D. (1995). *ANUCLIM Users Guide, Version 1.* Centre for Resource and Environmental Studies, Australian National University, Canberra, Australia.

Appendix H

Climatic estimates derived from ANUCLIM (McMahon *et al.*, 1995) for the aquatic sites sampled (Halse *et al.*, this volume) in the biogeographic survey of the southern Carnarvon Basin. Key to column labels: T = temperature, P = precipitation, Rd = radiation, MI = moisture index; see McMahon *et al.* (1995) for further explanation.

Quadrat	T_ann	T_diurnR	Isotherm	T_seas	MaxTwarP	MinTcldP	T_annRa	T_WetQ	T_DryQ	T_WarQ	T_cldQ	P_ann	P_wetP	P_dryP	P_seas	P_wetQ	P_dryQ
CB4	20.50	13.90	0.51	2.00	35.30	8.00	27.30	15.70	24.90	26.90	14.40	356.00	84.00	0.00	91.00	207.00	0.00
CB5	20.60	14.10	0.51	2.00	35.70	7.90	27.80	15.70	22.50	27.10	14.40	306.00	69.00	0.00	84.00	171.00	0.00
CB6a1	21.00	14.50	0.51	2.00	36.40	7.90	28.50	15.80	23.10	27.70	14.50	254.00	53.00	0.00	76.00	134.00	0.00
CB6a2	21.10	14.50	0.51	2.00	36.40	7.90	28.60	15.80	23.20	27.70	14.50	252.00	53.00	0.00	75.00	132.00	0.00
CB6b	21.10	14.50	0.51	2.00	36.40	7.90	28.50	15.80	23.10	27.70	14.50	252.00	53.00	0.00	76.00	133.00	0.00
CB9	21.30	13.20	0.51	2.00	35.00	9.10	26.00	16.90	25.00	27.40	15.60	290.00	77.00	0.00	104.00	186.00	0.00
CB9a	21.30	13.30	0.51	2.00	35.10	9.00	26.10	16.80	25.10	27.40	15.60	289.00	77.00	0.00	103.00	185.00	0.00
CB15	21.40	12.80	0.50	2.00	34.80	9.40	25.40	17.10	25.00	27.40	15.90	297.00	80.00	0.00	105.00	193.00	0.00
CB16	21.60	12.90	0.50	2.00	35.00	9.50	25.50	17.20	25.10	27.50	16.00	283.00	75.00	0.00	104.00	183.00	0.00
CB20	21.90	14.30	0.51	2.00	36.90	8.80	28.10	16.80	23.60	28.40	15.60	225.00	53.00	0.00	88.00	131.00	0.00
CB25	22.30	14.20	0.51	2.00	36.90	9.20	27.70	17.20	24.00	28.60	16.00	211.00	45.00	0.00	79.00	115.00	0.00
CB27a	22.60	15.20	0.50	2.00	38.50	8.40	30.10	16.60	21.70	29.60	15.30	208.00	35.00	0.00	66.00	94.00	0.00
CB27b1	22.30	15.10	0.50	2.00	38.30	8.10	30.10	16.30	21.50	29.50	15.00	209.00	36.00	0.00	65.00	95.00	0.00
CB27b2	22.30	15.10	0.50	2.00	38.30	8.10	30.10	16.30	21.50	29.50	15.00	209.00	36.00	0.00	65.00	95.00	0.00
CB27c	22.30	15.10	0.50	2.00	38.30	8.10	30.10	16.30	21.40	29.40	15.00	208.00	36.00	0.00	65.00	94.00	0.00
CB29a	22.00	12.50	0.50	2.00	35.00	10.00	25.00	17.80	23.20	27.70	16.50	252.00	65.00	0.00	99.00	158.00	0.00
CB30	22.60	14.20	0.51	2.00	37.00	9.40	27.60	17.50	24.40	28.90	16.30	209.00	42.00	0.00	76.00	109.00	0.00
CB34	22.80	14.80	0.51	2.00	38.00	9.10	28.90	17.20	21.80	29.40	16.00	207.00	37.00	0.00	70.00	99.00	0.00
CB35a	22.40	13.80	0.51	2.00	36.60	9.50	27.00	17.60	24.10	28.60	16.30	214.00	46.00	0.00	81.00	118.00	0.00
CB36	22.40	12.20	0.50	1.00	34.80	10.50	24.30	18.30	23.50	27.90	17.10	226.00	52.00	0.00	89.00	133.00	0.00
CB38	23.20	15.00	0.51	2.00	38.70	9.40	29.30	17.50	22.40	29.90	16.20	211.00	36.00	0.00	70.00	95.00	0.00
CB38a	23.40	15.10	0.51	2.00	38.80	9.60	29.30	17.80	22.70	30.00	16.50	208.00	34.00	0.00	71.00	92.00	0.00
CB42	23.50	14.90	0.51	2.00	38.70	9.70	29.10	17.80	22.70	30.00	16.60	209.00	35.00	0.00	72.00	93.00	0.00
CB43	23.50	15.10	0.51	2.00	38.90	9.50	29.30	17.80	22.70	30.10	16.50	208.00	34.00	0.00	71.00	91.00	0.00
CB44	22.30	13.90	0.51	2.00	36.60	9.40	27.30	17.30	24.00	28.60	16.10	221.00	49.00	0.00	82.00	124.00	0.00
CB49	22.60	12.10	0.50	1.00	35.00	10.70	24.20	18.50	23.80	28.10	17.30	230.00	51.00	0.00	87.00	131.00	0.00
CB51	22.60	12.20	0.50	1.00	35.00	10.70	24.30	18.50	23.80	28.10	17.30	228.00	50.00	0.00	86.00	129.00	0.00
CB54	22.80	12.30	0.50	1.00	35.30	10.90	24.40	18.60	21.60	28.30	17.40	233.00	49.00	0.00	83.00	125.00	0.00
CB54a	22.70	12.20	0.50	1.00	35.20	10.90	24.30	18.60	21.50	28.20	17.40	233.00	50.00	0.00	85.00	127.00	0.00
CB56	22.90	12.90	0.51	2.00	36.00	10.60	25.40	18.50	21.80	28.70	17.20	226.00	43.00	0.00	79.00	116.00	0.00
CB56a	22.90	12.90	0.51	2.00	36.00	10.60	25.40	18.50	21.80	28.70	17.20	226.00	43.00	0.00	79.00	116.00	0.00
CB58b	23.10	13.70	0.51	2.00	37.10	10.20	26.90	18.20	22.10	29.20	16.90	220.00	40.00	0.00	75.00	108.00	0.00
CB58c	23.00	13.40	0.51	2.00	36.70	10.30	26.40	18.20	21.90	29.00	17.00	221.00	41.00	0.00	77.00	111.00	0.00
CB58d	23.00	13.40	0.51	2.00	36.70	10.30	26.40	18.20	21.90	28.90	17.00	221.00	41.00	0.00	77.00	111.00	0.00
CB58e	23.00	13.40	0.51	2.00	36.70	10.30	26.40	18.20	21.90	28.90	17.00	221.00	41.00	0.00	77.00	111.00	0.00
CB62	23.50	15.10	0.51	2.00	39.10	9.60	29.50	17.70	22.80	30.20	16.40	215.00	35.00	0.00	71.00	93.00	0.00
CB62a	23.60	15.10	0.51	2.00	39.20	9.70	29.50	17.80	22.90	30.30	16.50	217.00	35.00	0.00	72.00	93.00	0.00
CB62b	23.70	15.10	0.51	2.00	39.30	9.60	29.70	17.80	23.00	30.50	16.50	222.00	35.00	0.00	71.00	93.00	0.00
CB62c	23.60	15.10	0.51	2.00	39.20	9.70	29.50	17.80	22.90	30.30	16.50	217.00	35.00	0.00	72.00	93.00	0.00

CB67a	24.00	15.10	0.51	2.00	39.60	9.90	29.70	30.70	23.40	30.80	16.80	233.00	41.00	0.00	73.00	99.00	0.00
CB67b	24.00	15.00	0.51	2.00	39.60	10.00	29.60	30.60	23.30	30.70	16.80	231.00	40.00	0.00	73.00	97.00	0.00
CB68	23.80	14.30	0.51	2.00	38.50	10.50	28.00	18.50	23.00	30.10	17.20	231.00	38.00	0.00	74.00	99.00	0.00
CB70b	23.70	14.40	0.51	2.00	38.50	10.30	28.20	18.30	22.90	30.00	17.10	227.00	38.00	0.00	74.00	98.00	0.00
CB73	22.80	12.20	0.50	1.00	35.20	11.00	24.20	18.70	21.60	28.30	17.50	237.00	52.00	0.00	85.00	129.00	0.00
CB75a	23.30	13.50	0.51	2.00	37.00	10.60	26.40	18.50	22.30	29.30	17.30	230.00	41.00	0.00	75.00	107.00	0.00
CB75b	23.40	13.70	0.51	2.00	37.40	10.60	26.80	18.50	22.50	29.40	17.20	229.00	40.00	0.00	75.00	104.00	0.00
CB75c	23.60	14.20	0.51	2.00	38.20	10.40	27.80	18.40	22.80	29.90	17.10	229.00	38.00	0.00	74.00	101.00	0.00
CB76	23.30	12.10	0.50	1.00	35.60	11.50	24.10	19.10	22.10	28.70	17.80	248.00	52.00	0.00	84.00	129.00	0.00
CB77	23.30	12.20	0.50	1.00	35.80	11.60	24.20	19.10	22.20	28.80	17.90	247.00	51.00	0.00	83.00	126.00	0.00
CB78	23.40	12.30	0.51	2.00	35.90	11.60	24.30	19.10	22.30	28.90	17.90	246.00	50.00	0.00	82.00	124.00	0.00
CB79	23.50	12.40	0.51	2.00	36.10	11.60	24.50	19.20	22.50	29.00	17.90	246.00	49.00	0.00	82.00	122.00	0.00
CB82	23.60	12.70	0.51	2.00	36.50	11.50	24.90	19.20	22.60	29.20	18.00	241.00	45.00	0.00	80.00	112.00	0.00
CB93	23.00	15.30	0.50	2.00	38.90	8.60	30.40	16.80	22.30	30.10	15.50	210.00	34.00	0.00	67.00	91.00	0.00
CB93a	23.00	15.30	0.50	2.00	39.00	8.60	30.50	16.80	22.30	30.20	15.60	209.00	34.00	0.00	67.00	90.00	0.00
CB93c	22.70	15.20	0.50	2.00	38.70	8.50	30.20	16.70	22.00	29.80	15.40	210.00	35.00	0.00	67.00	93.00	0.00
CB93d	22.80	15.30	0.50	2.00	38.70	8.40	30.30	16.70	22.00	29.90	15.40	209.00	35.00	0.00	67.00	93.00	0.00
CB93f	22.80	15.20	0.51	2.00	38.60	8.80	29.80	17.00	22.00	29.70	15.70	209.00	36.00	0.00	68.00	95.00	0.00
CB93g	22.80	15.10	0.51	2.00	38.40	8.90	29.50	17.10	21.90	29.60	15.80	208.00	36.00	0.00	69.00	96.00	0.00

Appendix H (cont.)

Quadrat	P_warQ	P_cldQ	Rd_ann	Rd_hghP	Rd_lowP	Rd_seas	Rd_wetQ	Rd_dryQ	Rd_warQ	Rd_cldQ	MI_ann	MI_hghP	MI_lowP	MI_seas	MI_hghQ	MI_lowQ	MI_warQ	MI_cldQ
CB4	36.00	203.00	21.00	29.60	11.90	31.00	13.00	28.90	26.00	13.40	0.28	0.89	0.04	103.00	0.74	0.05	0.10	0.74
CB5	41.00	166.00	21.10	29.60	12.00	31.00	13.10	27.50	26.00	13.50	0.24	0.75	0.04	99.00	0.60	0.06	0.11	0.60
CB6a1	34.00	127.00	21.20	29.50	12.30	30.00	13.40	27.50	28.20	13.80	0.20	0.55	0.04	90.00	0.45	0.05	0.09	0.44
CB6a2	34.00	125.00	21.20	29.50	12.30	30.00	13.40	27.50	28.20	13.80	0.19	0.54	0.04	89.00	0.44	0.05	0.10	0.44
CB6b	34.00	126.00	21.20	29.50	12.30	30.00	13.40	27.50	28.20	13.80	0.19	0.54	0.04	89.00	0.44	0.05	0.09	0.44
CB9	27.00	172.00	21.30	28.90	12.80	28.00	13.90	28.20	25.70	14.50	0.22	0.73	0.01	113.00	0.58	0.03	0.08	0.57
CB9a	27.00	171.00	21.30	28.90	12.80	28.00	13.90	28.20	25.70	14.50	0.22	0.73	0.01	113.00	0.58	0.03	0.08	0.57
CB15	28.00	177.00	21.40	28.60	13.10	27.00	14.20	28.00	25.60	14.80	0.22	0.75	0.01	114.00	0.60	0.02	0.08	0.58
CB16	30.00	166.00	21.40	28.60	13.20	26.00	14.40	27.90	25.60	15.00	0.21	0.69	0.01	112.00	0.56	0.03	0.08	0.54
CB20	39.00	116.00	21.50	28.90	13.10	27.00	14.30	27.20	25.70	14.80	0.17	0.49	0.02	97.00	0.41	0.03	0.11	0.38
CB25	49.00	100.00	21.60	28.70	13.50	26.00	14.60	27.20	25.60	15.20	0.15	0.41	0.03	86.00	0.35	0.03	0.13	0.31
CB27a	46.00	82.00	21.70	28.80	13.50	26.00	14.60	25.00	27.40	15.20	0.15	0.34	0.03	71.00	0.29	0.03	0.13	0.26
CB27b1	46.00	83.00	21.60	28.90	13.30	26.00	14.50	25.00	27.50	15.10	0.15	0.35	0.03	71.00	0.29	0.03	0.13	0.27
CB27b2	46.00	83.00	21.60	28.90	13.30	26.00	14.50	25.00	27.50	15.10	0.15	0.35	0.03	71.00	0.29	0.03	0.13	0.27
CB27c	46.00	83.00	21.60	28.90	13.30	26.00	14.50	25.00	27.50	15.00	0.15	0.35	0.03	71.00	0.29	0.03	0.12	0.27
CB29a	38.00	139.00	21.70	28.50	13.80	25.00	14.90	27.00	25.50	15.60	0.18	0.57	0.01	105.00	0.47	0.02	0.11	0.43
CB30	56.00	93.00	21.70	28.60	13.80	25.00	14.90	27.20	25.50	15.50	0.15	0.38	0.02	81.00	0.32	0.03	0.15	0.28
CB34	65.00	84.00	21.80	28.60	13.80	25.00	14.90	25.10	25.50	15.50	0.15	0.34	0.02	74.00	0.29	0.03	0.17	0.26
CB35a	52.00	100.00	21.70	28.60	13.80	25.00	14.90	27.20	25.50	15.50	0.15	0.41	0.02	86.00	0.35	0.03	0.14	0.31
CB36	53.00	109.00	21.90	28.40	14.30	23.00	15.40	27.10	25.40	16.10	0.16	0.45	0.01	93.00	0.38	0.02	0.14	0.33
CB38	55.00	78.00	21.90	28.50	14.10	24.00	15.20	25.30	27.20	15.90	0.15	0.32	0.02	72.00	0.27	0.02	0.15	0.23
CB38a	78.00	74.00	21.90	28.50	14.20	24.00	15.30	25.30	25.40	16.00	0.14	0.31	0.02	72.00	0.26	0.02	0.20	0.22
CB42	79.00	75.00	22.00	28.50	14.30	23.00	15.40	25.30	25.40	16.00	0.14	0.31	0.02	73.00	0.26	0.02	0.21	0.22
CB43	58.00	74.00	21.90	28.50	14.20	24.00	15.30	25.30	27.10	16.00	0.14	0.31	0.02	72.00	0.26	0.02	0.15	0.22
CB44	50.00	106.00	21.70	28.60	13.70	25.00	14.80	27.10	25.50	15.50	0.16	0.44	0.02	89.00	0.37	0.03	0.14	0.33
CB49	61.00	105.00	22.00	28.30	14.50	23.00	15.60	27.10	25.40	16.30	0.16	0.45	0.01	90.00	0.37	0.02	0.16	0.31
CB51	61.00	104.00	22.00	28.30	14.40	23.00	15.60	27.10	25.40	16.30	0.16	0.44	0.01	89.00	0.36	0.02	0.16	0.31
CB54	70.00	100.00	22.00	28.30	14.60	22.00	15.70	25.30	25.40	16.40	0.16	0.43	0.01	85.00	0.35	0.02	0.18	0.29
CB54a	68.00	102.00	22.00	28.30	14.60	22.00	15.70	25.30	25.40	16.40	0.16	0.44	0.01	87.00	0.36	0.02	0.18	0.30
CB56	71.00	92.00	22.00	28.30	14.50	23.00	15.60	25.30	25.40	16.40	0.15	0.38	0.01	80.00	0.32	0.02	0.19	0.27
CB56a	72.00	91.00	22.00	28.30	14.50	23.00	15.60	25.30	25.40	16.40	0.15	0.38	0.01	80.00	0.32	0.02	0.19	0.27
CB58b	73.00	86.00	22.00	28.40	14.40	23.00	15.50	25.30	25.40	16.20	0.15	0.35	0.01	77.00	0.30	0.02	0.19	0.25
CB58c	70.00	88.00	22.00	28.40	14.40	23.00	15.50	25.30	25.40	16.20	0.15	0.36	0.01	79.00	0.31	0.02	0.19	0.26
CB58d	70.00	89.00	22.00	28.40	14.40	23.00	15.50	25.30	25.40	16.20	0.15	0.36	0.01	79.00	0.31	0.02	0.19	0.26
CB58e	70.00	89.00	22.00	28.40	14.40	23.00	15.50	25.30	25.40	16.20	0.15	0.36	0.01	79.00	0.31	0.02	0.19	0.26
CB62	61.00	75.00	22.00	28.40	14.30	23.00	15.40	25.40	27.10	16.10	0.15	0.31	0.02	72.00	0.26	0.02	0.16	0.22
CB62a	64.00	74.00	22.00	28.40	14.40	23.00	15.50	25.40	27.10	16.20	0.15	0.31	0.02	72.00	0.26	0.02	0.17	0.22
CB62b	66.00	74.00	22.00	28.40	14.50	23.00	15.60	25.40	27.10	16.30	0.15	0.32	0.02	72.00	0.26	0.02	0.17	0.22
CB62c	64.00	74.00	22.00	28.40	14.40	23.00	15.50	25.40	27.10	16.20	0.15	0.31	0.02	72.00	0.26	0.02	0.17	0.22
CB67a	75.00	72.00	22.20	28.30	14.70	22.00	25.40	25.50	27.00	16.60	0.16	0.32	0.02	73.00	0.26	0.02	0.19	0.21
CB67b	73.00	73.00	22.10	28.30	14.70	22.00	25.40	25.50	27.00	16.50	0.15	0.32	0.02	73.00	0.26	0.02	0.19	0.21
CB68	92.00	77.00	22.10	28.30	14.70	22.00	15.80	25.50	25.40	16.60	0.15	0.33	0.02	74.00	0.27	0.02	0.24	0.22

CB70b	89.00	77.00	22.10	28.30	14.60	22.00	15.70	25.40	25.40	16.50	0.15	0.33	0.02	74.00	0.27	0.02	0.23	0.22
CB73	71.00	102.00	22.10	28.30	14.60	22.00	15.70	25.30	25.40	16.50	0.16	0.45	0.01	87.00	0.36	0.02	0.19	0.30
CB75a	83.00	84.00	22.10	28.30	14.60	22.00	15.70	25.40	25.40	16.50	0.15	0.36	0.01	76.00	0.29	0.02	0.22	0.24
CB75b	84.00	83.00	22.10	28.30	14.60	22.00	15.70	25.40	25.40	16.50	0.15	0.35	0.01	75.00	0.29	0.02	0.22	0.24
CB75c	88.00	79.00	22.10	28.30	14.60	22.00	15.70	25.40	25.40	16.50	0.15	0.34	0.02	74.00	0.28	0.02	0.23	0.23
CB76	82.00	100.00	22.20	28.20	14.90	22.00	16.00	25.40	25.30	16.80	0.17	0.44	0.01	84.00	0.35	0.02	0.21	0.28
CB77	84.00	97.00	22.20	28.20	14.90	22.00	16.00	25.50	25.30	16.80	0.17	0.43	0.01	84.00	0.34	0.02	0.22	0.28
CB78	85.00	95.00	22.20	28.20	15.00	21.00	16.10	25.50	25.30	16.80	0.16	0.42	0.01	83.00	0.33	0.02	0.22	0.27
CB79	87.00	93.00	22.20	28.20	15.00	21.00	16.10	25.50	25.30	16.90	0.16	0.41	0.01	82.00	0.33	0.02	0.22	0.26
CB82	91.00	86.00	22.20	28.20	15.00	22.00	16.10	25.50	25.30	16.80	0.16	0.38	0.01	79.00	0.30	0.02	0.23	0.24
CB93	53.00	78.00	21.80	28.60	13.80	25.00	14.90	25.20	27.30	15.60	0.15	0.32	0.02	70.00	0.27	0.03	0.14	0.24
CB93a	55.00	76.00	21.80	28.60	13.90	25.00	15.00	25.20	27.20	15.60	0.15	0.31	0.02	69.00	0.26	0.03	0.15	0.23
CB93c	49.00	81.00	21.70	28.70	13.60	25.00	14.80	25.10	27.40	15.40	0.15	0.33	0.03	70.00	0.28	0.03	0.13	0.25
CB93d	49.00	80.00	21.70	28.70	13.70	25.00	14.80	25.10	27.30	15.40	0.15	0.33	0.03	70.00	0.28	0.03	0.13	0.25
CB93f	47.00	82.00	21.70	28.70	13.70	25.00	14.80	25.10	27.30	15.40	0.15	0.33	0.02	72.00	0.28	0.03	0.13	0.25
CB93g	47.00	82.00	21.70	28.70	13.70	25.00	14.90	25.10	27.30	15.50	0.15	0.33	0.02	72.00	0.29	0.03	0.13	0.25

Reference

McMahon, J.P., Hutchinson, M.F., Nix, H.A. and Ord, K.D. (1995). *ANUCLIM Users Guide, Version 1.* Centre for Resource and Environmental Studies, Australian National University, Canberra, Australia.

Appendix I

Inter-correlations between the physical attributes of the 63 primary terrestrial quadrats sampled (Kendall's tau). * = p. < 0.05, ** = p. < 0.01 and *** = p. < 0.001.

	gaover 63	gsover 63	txshst 57	Tann 63	TdiurRa 63	TannR 63	TwetQ 63	TwarQ 63	TcldQ 63	Pann 63	Pseas 63	PwetQ 63	PwarQ 63	PcldQ 63	EC 63
gs_over	0.94 ***														
tx_shst	0.20	-0.18													
Tann	0.28 **	-0.28 **	0.30 ***												
TdiurRa	0.43 ***	-0.40 ***	0.20 *	0.13											
TannR	0.39 ***	-0.36 ***	0.18 *	0.10	0.95 ***										
TwetQ	0.07	-0.08	0.15	0.65 ***	-0.19 *	-0.23 **									
TwarQ	0.38 ***	-0.37 ***	0.36 ***	0.73 ***	0.39 ***	0.37 ***	0.39 ***								
TcldQ	0.05	-0.06	0.16	0.60 ***	-0.27 **	-0.31 ***	0.87 ***	0.31 ***							
Pann	-0.42 ***	0.39 ***	-0.38 ***	-0.45 ***	-0.40 ***	-0.34 ***	-0.16	-0.61 ***	-0.18 *						
Pseas	-0.40 ***	0.38 ***	-0.39 ***	-0.53 ***	-0.53 ***	-0.50 ***	-0.25 **	-0.77 ***	-0.15	0.63 ***					
PwetQ	-0.40 ***	0.39 ***	-0.40 ***	-0.64 ***	-0.46 ***	-0.41 ***	-0.34 ***	-0.84 ***	-0.27 **	0.74 ***	0.81 ***				
PwarQ	0.11	-0.10	0.32 ***	0.73 ***	0.07	0.06	0.59 ***	0.60 ***	0.58 ***	-0.32 ***	-0.51 ***	-0.54 ***			
PcldQ	-0.41 ***	0.39 ***	-0.41 ***	-0.68 ***	-0.42 ***	-0.37 ***	-0.38 ***	-0.87 ***	-0.31 ***	0.71 ***	0.81 ***	0.95 ***	-0.58 ***		
EC	-0.02	0 1.00	0.01	-0.00 0.966	-0.29 ***	-0.30 ***	0.16	-0.13	0.22 *	0.02	0.25 **	0.16	-0.08	0.14	
pH(H2O)	-0.03	0.04	-0.06	0.00 0.962	-0.40 ***	-0.41 ***	0.22 *	-0.13	0.29 ***	0.11	0.27 **	0.19 *	0.01	0.17 *	0.59 ***
sand	-0.25 *	0.27 *	-0.45 ***	-0.13	-0.26 **	-0.27 **	0.01	-0.22 *	-0.01	0.27 **	0.28 ***	0.26 **	-0.06	0.25 **	-0.15
silt	0.27 *	-0.26 *	0.48 ***	0.25 **	0.18 *	0.18 *	0.15	0.26 **	0.17	-0.29 ***	-0.23 *	-0.29 ***	0.10	-0.28 **	0.34 ***
clay	0.21 *	-0.23 *	0.39 ***	0.08	0.24 **	0.25 **	-0.04	0.17 *	-0.03	-0.21 *	-0.25 **	-0.20 *	0.06	-0.20 *	0.03
C	-0.22 *	0.17	-0.25 **	-0.41 ***	-0.27 ***	-0.26 **	-0.26 **	-0.47 ***	-0.22 **	0.43 ***	0.55 ***	0.57 ***	-0.43 ***	0.51 ***	0.24 **
N	-0.17	0.12	-0.05	-0.14	-0.30 ***	-0.31 ***	0.01	-0.25 **	0.06	0.23 **	0.37 ***	0.30 ***	-0.19 *	0.29 ***	0.48 ***
P	-0.18	0.16	0.32 ***	0.26 **	0.03	0.01	0.23 **	0.23 **	0.29 ***	-0.31 ***	-0.17	-0.24 **	0.18 *	-0.24 **	0.32 ***
P(HCO3)	0.19	-0.16	0.25 **	0.18 *	-0.11	-0.14	0.23 **	0.10	0.32 ***	-0.29 ***	-0.02	-0.11	0.09	-0.12	0.45 ***
K(HCO3)	0.32 **	-0.31 **	0.45 ***	0.38 ***	0.05	0.01	0.34 ***	0.34 ***	0.38 ***	-0.43 ***	-0.26 **	-0.34 ***	0.23 **	-0.36 ***	0.35 ***
Ca(HCO3)	-0.22 *	0.20	-0.12	-0.09	-0.45 ***	-0.44 ***	0.13	-0.25 **	0.19 *	0.29 **	0.42 ***	0.35 ***	-0.08	0.32 ***	0.62 ***
CEC	0.11	-0.13	0.03	0.07	-0.20 *	-0.23 *	0.17	-0.04	0.23 *	-0.01	0.16	0.07	-0.03	0.05	0.58 ***
exCa	-0.06	-0.09	-0.05	-0.04	-0.28 ***	-0.28 ***	0.10	-0.16	0.15	0.13	0.31 ***	0.21 *	-0.10	0.19 *	0.58 ***
exNa	0.05	-0.06	0.13	0.02	-0.09	-0.11	0.08	-0.01	0.11	-0.12	0.08	0.02	-0.08	0.02	0.56 ***
exK	0.29 **	-0.29 **	0.46 ***	0.34 ***	0.06	0.03	0.31 ***	0.30 ***	0.35 ***	-0.41 ***	-0.23 **	-0.33 ***	0.20 *	-0.33 ***	0.33 ***
exMg	0.33 **	-0.31 **	0.22 *	0.22 *	-0.05	-0.07	0.23 **	0.15	0.28 ***	-0.29 ***	-0.06	-0.18 *	0.06	-0.18 *	0.44 ***
Alt	0.23 *	-0.24 *	-0.00 0.950	0.02	0.58 ***	0.63 ***	-0.27 ***	0.28 ***	-0.38 ***	-0.04	-0.35 ***	-0.24 **	0.02	-0.22 **	-0.49 ***
Lat	-0.07	0.07	-0.17 *	-0.69 ***	0.15	0.17 *	-0.83 ***	-0.45 ***	-0.81 ***	0.16	0.26 **	0.33 ***	-0.73 ***	0.38 ***	-0.12
Long	0.41 ***	-0.39 ***	0.20 *	0.16	0.80 ***	0.79 ***	-0.12	0.39 ***	-0.20 *	-0.45 ***	-0.57 ***	-0.52 ***	0.10	-0.48 ***	-0.36 ***

0.05																
0.13	-0.64 ***															
-0.16	-0.81 ***	0.41 ***														
0.12	-0.03	-0.00 0.995	0.07													
0.34 ***	-0.17	0.25 **	0.12	0.65 ***												
0.22 *	-0.39 ***	0.53 ***	0.27 **	-0.06	0.17 *											
0.44 ***	-0.28 ***	0.46 ***	0.15	-0.05	0.23 **	0.67 ***										
0.22 **	-0.42 ***	0.56 ***	0.31 ***	-0.17 *	0.15	0.52 ***	0.54 ***									
0.67 ***	-0.03	0.18	-0.06	0.38 ***	0.58 ***	0.24 *	0.40 ***	0.11								
0.52 ***	-0.22 *	0.38 ***	0.12	0.17	0.41 ***	0.25 **	0.40 ***	0.42 ***	0.48 ***							
0.61 ***	-0.15	0.27 **	0.07	0.32 ***	0.54 ***	0.24 **	0.39 ***	0.32 ***	0.62 ***	0.71 ***						
0.32 ***	-0.30 ***	0.46 ***	0.17	0.13	0.33 ***	0.43 ***	0.43 ***	0.39 ***	0.39 ***	0.41 ***	0.35 ***					
0.20 *	-0.46 ***	0.60 ***	0.34 ***	-0.15	0.15	0.54 ***	0.51 ***	0.89 ***	0.10 ***	0.40 ***	0.30 ***	0.41				
0.31 ***	-0.31 ***	0.50 ***	0.18 *	-0.07	0.17 *	0.45 ***	0.53 ***	0.63 ***	0.20 *	0.53 ***	0.45 ***	0.52 ***	0.64 ***			
-0.50 ***	-0.10	-0.02	0.14	-0.13	-0.31 ***	-0.18 *	-0.38 ***	-0.25 **	-0.47 ***	-0.36 ***	-0.38 ***	-0.31 ***	-0.22 **	-0.30 ***		
-0.20 *	0.00 0.956	-0.14	0.02	0.28 ***	0.02	-0.23 **	-0.22 **	-0.31 ***	-0.13	-0.13	-0.06	-0.05	-0.28 ***	-0.17 *	0.20 *	
-0.49 ***	-0.24 **	0.14	0.24 **	-0.30 ***	-0.39 ***	-0.04	-0.17 *	0.07	-0.58 ***	-0.26 **	-0.37 ***	-0.16	0.08	-0.03	0.54 ***	0.12
pH(H2O) 63	sand 62	silt 62	clay 62	C 63	N 63	P 63	P(HCO3) 63	K(HCO3) 63	Ca(HCO3) 63	CEC 63	exCa 63	exNa 63	exK 63	exMg 63	Alt 63	Lat 63