Chapter 2

SOUTH-WESTERN LITTLE SANDY DESERT STUDY AREA

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ABSTRACT

The south-western Little Sandy Desert study area is located in the south-western portion of the Little Sandy Desert Biogeographical Region. The study area represents about 8.2% of the biogeographical region. Topographically the study area is dominated by eolian red sand dunes and sand sheets which overlay the Savory Basin geological structure. Expressions of the constituent sedimentary rocks of this Basin are evident throughout the study area in the form of sandstone ridges, breakaways and hills. Paleodrainage channels and their associated playas are also conspicuous landscape features within the study area. The climate of the study area is described as desert tropical with temperatures ranging from 15.8° C to 30.8° C. Rainfall averages approximately 250 mm per annum most of which falls during the summer months. The study area is dominated by hummock grass associations with Acacia *shrubs and emergent bloodwood eucalypts on eolian sand substrates while mulga dominated woodlands are prevalent on the heavier soils. Shrub mallee associations,* Melaleuca *heaths, open forests of desert oak and samphire flats are also common vegetation associations. The study area is principally Unallocated Crown Land, has negligible access and is uninhabited.*

Fifteen biological survey sites, located in three focal areas across the latitudinal extent of the study area were established in October 1995 to sample, with replication, the surface and habitat types typical of the south-western Little Sandy Desert. Each of these biological survey sites encompasses an area of approximately 100 ha in which sampling sites are replicated once. An additional 23 floristic survey sites were established across the study area to document land surfaces and habitat types not captured in the 15 biological survey sites. Only plants were recorded from these 23 sites. During a Landscope *Expedition in September 1999 two supplementary sites at Yanneri Lake and two at Dreamtime Gully were sampled for fauna.*

Characterisation of the survey sites in terms of their edaphic properties was undertaken and indicates considerable variation across the study area. Most of this variation is attributed to heterogeneity in the chemical and textural characteristics of the soils from survey sites associated with paleodrainage channels and playas. Such soils are noticeably different from the eolian sands or those derived in situ *from sandstones, a feature which is attributed to the calcareous and/or gypsiferous nature of these soils and the influence such properties have on exchangeable cations, soil pH and electrical conductivity.*

STUDY AREA DESCRIPTION

The south-western Little Sandy Desert study area (24° 25' 10" S, 120° 19' 43" E) occupies the south-western corner of the Little Sandy Desert Biogeographical Region (Figure 2.1). The study area encompasses 9 119 km^2 or approximately 8.2% of this Biogeographical Region. The study area is bounded by Savory Creek and the Ashburton Biogeographical Region to the north, in the east by longitude 120° 50' E, in the south by latitude 25° 00' S and the northern edge of the Carnarvon Range and by the Ashburton Biogeographical Region to the west (Figure 2.2). The study area predominantly occurs on the Bullen (SG51-1) 1:250 000 map sheet although the northern portion of the area abutting Savory Creek is captured on the Robertson (SF51-13) 1:250 000 sheet and the western margin is on the Collier (SG50-4) 1:250 000 sheet.

Topographically the study area is broadly rolling and dominated by well vegetated sand dunes which typically trend between 190° to 210°. The dunes are characteristically the longitudinal type although braided and anastomosing sets of chain dunes are common. Extensive sand sheets occupy significant areas between the dunes as do widespread rolling plains of lateritic, calcareous and colluvial deposits. Numerous rocky uplands, hills and breakaway systems are dispersed across the study area. These rocky features are typically comprised of sandstone and to a lesser extent weathered doleritic intrusions. Broad valley floors are occupied by a complex network of paleodrainage lines which are dominated by lacustrine, gypsiferous and calcareous deposits. Drainage traverses the study area in an east-north-easterly direction. Topographical relief across the study area ranges by about 140 m from a high of 670 m.

Significant topographical features within the study area are few, especially for rocky upland areas, with Bullen Hill and the Dean and Jilyili Hills being the only named upland features. Most of the major drainage features however, are named and include Savory Creek, Ilgarari Creek, Yanneri Lake, Terminal Lake, Ten Mile Lake, Beyondie Lakes, Lake Sunshine, Cooma Well, Moffettah Well, Canning Well, Bullen Well and Rowe Soak (Figure 2.2).

No meteorological stations are located within the study area, however the climate can be regarded as desert tropical with most rainfall occurring in summer (Beard 1975). The closest climatic recording station is located at the settlement of Mundiwindi, some 60 km north of the study area. The climatic record for this locality spans 66 years and is exceptional in that 99% of the record is continuous and without missing data (Clewett *et al.* 1999). Based on temperature estimates at Mundiwindi the study area can expect to experience an average maximum temperature of 30.8° C and an average minimum of 15.8° C. These averages vary from a maxima of 38.8° C in January to a minima of 5.8° C in July (Figure 2.3). Extremes attaining a maxima of 45.5° C in January and –4.9° C in July have been recorded at Mundiwindi and can be expected in the study area. Frosts are also known to occur in the study area (van Leeuwen, personal observation).

Rainfall at Mundiwindi averages 267 mm per annum, an estimate which appears reasonable for the study area given the presence of the 250 mm isohyet as depicted in Figure 1.2. Rainfall is most prolific in February when the average monthly maximum is 50 mm while September

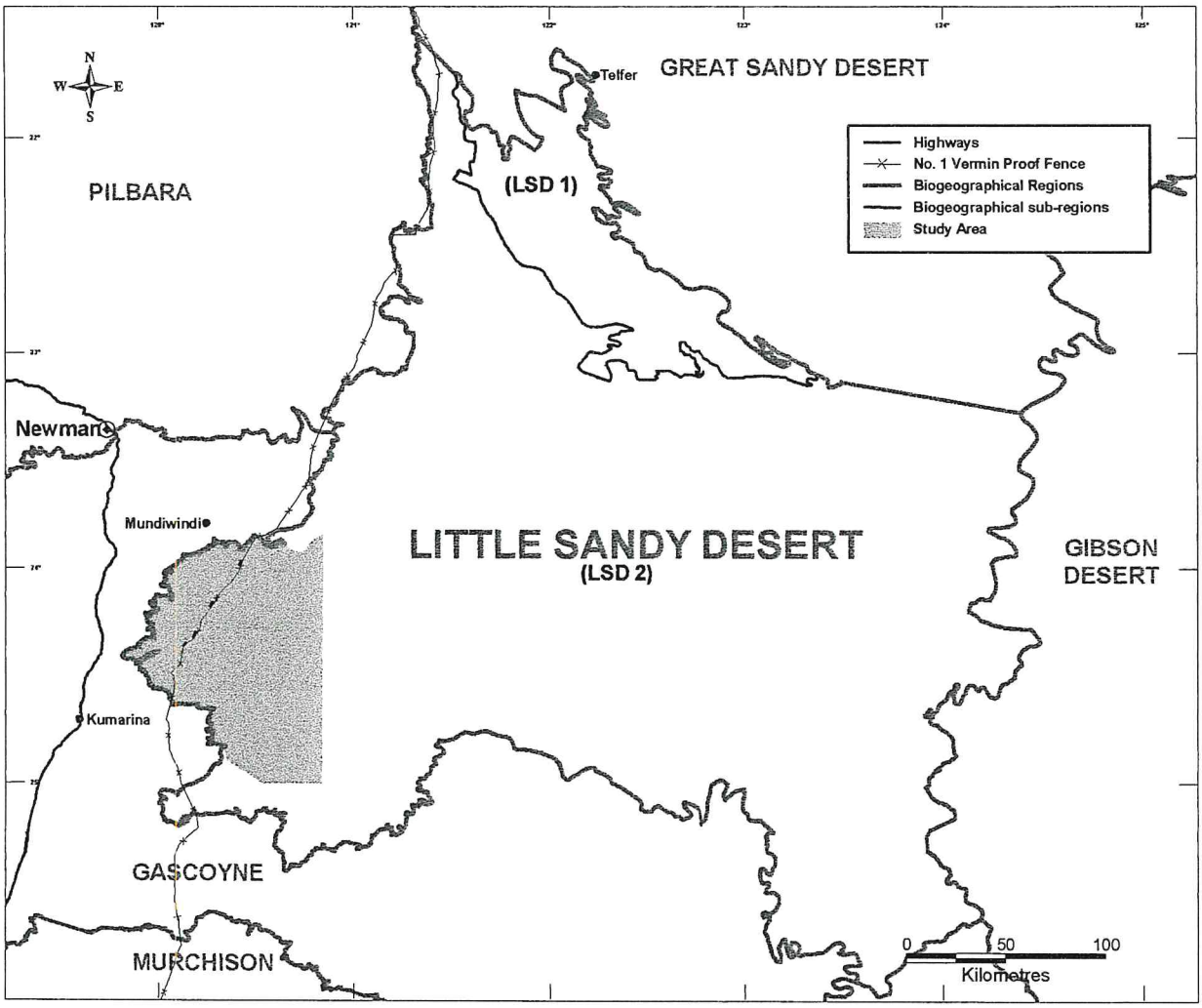

Figure 2.1 Location of the south-western Little Sandy Desert study area within the biogeographical region.

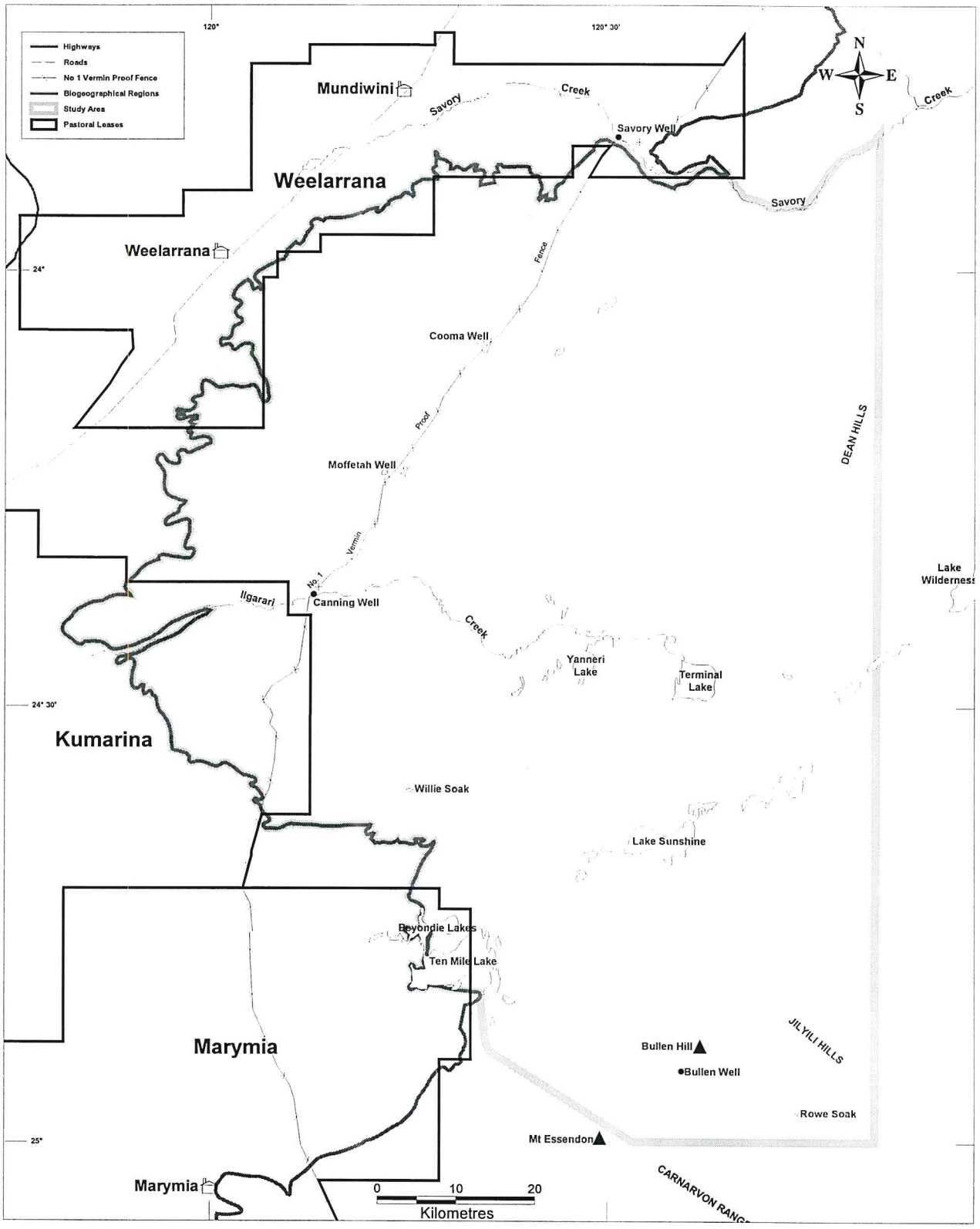

Figure 2.2 Topographical and cadastral setting of the south-western Little Sandy Desert study area.

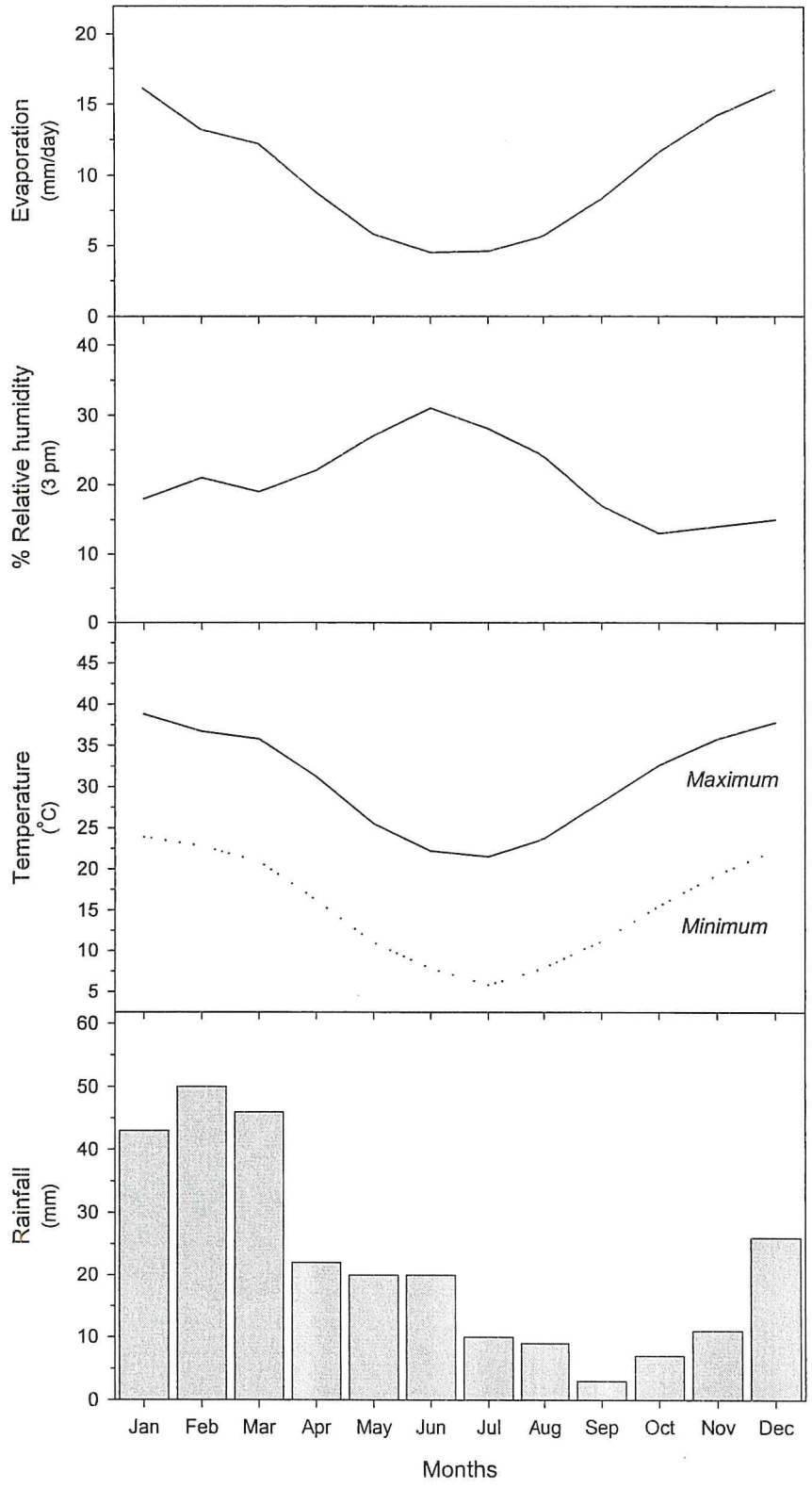

Figure 2.3 Mean monthly minimum and maximum temperatures (°C), % relative humidity (3 pm) and pan evaporation (mm/day) at Mundiwindi (Clewett *et al.* 1999).

is the driest month receiving on average only 3 mm (Figure 2.3). The highest monthly rainfall at Mundiwindi of 325 mm occurred in February while January experiences the highest number of rain days with five. Forty-four percent of the rainfall received at Mundiwindi falls in summer (December to January) while only 7% occurs in spring (September to November). Pan evaporation rates ranges from a high of 16.1 mm/day in January to 4.5 mm/day in June with a yearly average of 10.2 mm/day (Clewett *et al.* 1999). Williams (1995) reported a potential evaporation gradient across the study area which varied from 3 800 mm in the north-west to 4 000 mm in the south-east.

Geologically the entire study area falls within the bounds of the Late Precambrian (Proterozoic) Savory Basin which is situated between the Pilbara and Yilgarn Cratons and unconformably overlies the eastern part of the Middle Proterozoic Bangemall sedimentary basin (Williams 1992). The Savory Basin comprises 13 formations of which four occur in the study area. These four are the Glass Spring, Jilyili, Spearhole and Mundadjini Formations. In the field these formations are expressed as sandstones which vary from fine- to course-grained in texture. Mafic dyke intrusions, the youngest rock types of the Savory Basin, are also present in the study area. These intrusions are expressed as fine- to medium-grained dolerites which have been converted to saprolite and/or kaolinized through weathering (Williams 1995).

Overlaying this sedimentary and igneous geology are superficial deposits of Cainozoic origin which can be partitioned into three types. Firstly, there are the unconsolidated Holocene deposits (drainage, lacustrine and eolian in origin) of which the eolian sand dunes are the most obvious (Williams 1992). These wind blown sands occur in sheets up to 10 m thick on the plains while dunes can attain a height of 20 m within the study area. In some situations the sand plains may be covered by a thin veneer of ironstone pebble which are lag deposits indicative of an eroding underlying or nearby lateritic surface. Other significant unconsolidated Holocene deposits are associated with the paleodrainage systems of the study area and comprise silt and sand filled channels, salt marshes, lake beds, claypans and playas. These features are mostly gypsiferous and many of the larger lakes, playas and functional paleodrainage features are hypersaline. Typically the larger lake beds and playas are surrounded by lunette dunes comprised of kopi.

The second group of superficial deposits consists of consolidated colluvium, lateritic duricrust and calcrete deposits. This material is typically found adjacent to old paleodrainage valleys or along the edge of erosional features such as breakaways. Speculatively these deposits are Tertiary in origin. The third group of superficial deposits, comprising unconsolidated colluvium and alluvium primarily on run-on areas, is not very frequent within the study area. These deposits, which typically contain large proportions of wind-blown sand, are characteristic of grove-intergrove mulga woodlands or other banded vegetation types. They comprise resource rich vegetated strips interspersed with bare, deflated and sometimes interlocking pebble-veneered flats.

Vegetatively the study area could broadly be described as a mosaic of hummock (*Triodia* spp.) grass dominated habitats characterised by sand and sandy pediments in association with mulga (*Acacia aneura*) woodlands on alluvials and colluvium and *Acacia* and *Grevillea* shrublands on the sandstone rises. However, the simplistic approach to the vegetation ignores other significant vegetation associations in the study area. These associations are the extensive shrub heaths of *Aluta maisonneuvei* which dominate most swales in the dunefields; the open shrub mallee communities on the sandy veneers which persist over lateritic duricrusts or decomposing sandstones; the low *Melaleuca* heaths of the alluvial wash areas adjacent to

Ilgarari Creek; the open forests of desert oak (*Allocasuarina decaisneana*) on the sandy veneers over calcrete; and the extensive samphire flats associated with playas.

Beard (1975) identified and mapped five vegetation associations in the study area. These associations, in decreasing order with respect to their areal extent, are described in Table 2.1. Inherently the dominant vegetation mapped by Beard (1975) was the type associated with eolian dunes and sand plains which was described as a hummock grass mosaic in which *Corymbia chippendalei* was the most obvious species. Two of Beard's other vegetation associations were dominated by hummock grasses while the remainder were dominated by acacias. Beard (1975) also identified the presence of desert oak woodlands but fails to delimit the low *Melaleuca* heaths and samphire flats associated with drainage features in the study area.

Table 2.1 Vegetation associations of the south-western Little Sandy Desert study area as mapped by Beard (1975).

Association No.	Vegetation Description
134	Mosaic: Hummock grasslands, open low tree steppe; sand dune bloodwood (*C.chippendalei*) and feathertop spinifex (*T. schinzii*).
178	Hummock grasslands, grass steppe; hard spinifex (*T. basedowii*).
18	Low woodland; mulga (*A. aneura*).
95	Hummock grasslands, shrub steppe; *Acacia* and *Grevillea* over *T. basedowii.*
29	Sparse low woodland; mulga, discontinuous in scattered groups.

The study area is principally Unallocated Crown Land although one unvested Crown reserves associated with the abandoned No. 1 Vermin Proof Fence (↑ 12297) occurs in the area. Three pastoral leases (Weelarrana, Kumarina and Marymia) abut the study area. In addition to these leases the entire area is covered by an Occupation Licence for the purposes of harvesting camels which was issued by the Western Australian Department of Land Administration. A large proportion of the study area is also encompassed within the boundary of three Native Title Claims (WC96-078, WC98-068 and WC99-004).

The study area is uninhabited with no permanent or temporary settlements present. The closest township is Newman some 80 km north-west of the study area while the nearest settlement of any noticeable size is the Kumarina Roadhouse, which is 40 km to the west-south-west. Homesteads associated with pastoral operations are located on the Weelarrana, Marymia and Kumarina pastoral leases while a small community also exists at Mundiwindi. Access to the study area is very limited with no sealed or formed roads traversing the area. One four-wheel-drive track traverses the study area along the route of the abandoned No. 1 Vermin Proof Fence. Another track is located adjacent to Savory Creek following its margins east until Boondawari Creek. The study area occurs within the shires of Meekatharra and Wiluna and is also captured within the Pilbara and Goldfields administrative regions of the Department of Conservation and Land Management. Apart from trivial camel harvesting operations and four-wheel-drive adventure tourism along the abandoned No. 1 Vermin Proof Fence, the study area is economically inconsequential. There are no known economic mineral deposits in the study area although substantial deposits of salt and gypsum are present along many of the paleodrainage lines and in playas.

SURVEY SITES

Fifteen survey sites were established to undertake the biological survey of the south-western Little Sandy Desert. The 15 sites are located in three disjunct focal areas situated across the latitudinal extent of the study area (Figure 2.4). These three focal areas are Savory Creek, Cooma Well and Beyondie. The survey sites were selected after three field inspections (August 1991, May 1992, July 1995) and followed a review of the vegetation (Beard 1970, 1975), topography (1:250 000 sheets: Bullen, Collier, Robertson) and geology (Leech and Brakel 1980, Williams 1992, 1995, Williams and Tyler 1991) of the southern Little Sandy Desert. Principal considerations that influenced the selection of the biological survey sites were the need to ensure:

- All major surface and vegetation types within the study area were sampled; and
- Replication in sampling effort with respect to the major habitat types, particularly given the potential latitudinal gradient across the study area.

Biological survey sites were established in October 1995. The size of the site is typically 1 km x 1 km square (100 ha) as uniformity in landform and vegetation type is expected within this area. Replicated pairs of sampling quadrats and trapping grids were located within each biological survey site.

In addition to the 15 biological survey sites, 23 supplementary flora survey sites were also established (Figure 2.4). These flora survey sites represent major landform and/or vegetation types not adequately sampled by the 15 replicated biological survey sites. Only floristic data was collected from these supplementary survey sites.

As part of a *Landscope* Expedition to the study area in September 1999, four supplementary fauna sampling sites were established in areas not previously sampled. Two of these sites are on the western margin of Yanneri Lake and two are in the sandstone amphitheatre at Dreamtime Gully. Only faunistic data was collected from these supplementary survey sites.

The 15 biological and 23 flora survey sites were established as permanent sites. Posts demarcated all corners of the quadrat and signage identifying each survey site was erected to identify the on-ground location. The location of each survey site was fixed with a GPS. Survey sites were established as permanent fixtures to facilitate repeated sampling during the course of the survey program and to provide an opportunity for future monitoring designed to document long-term temporal change.

Further details on the layout of the survey sites and the design of the sampling regime employed for each biotic group sampled during the survey is provided in the relevant Chapters.

SITE TOPOGRAPHY AND VEGETATION

Appendix 2.1 provides a summary of the location of each survey site and describes the landforms and vegetation present. Topographically, survey sites were located across the entire catenary sequence from the tops of breakaways and sandstone rises through expansive rolling gibber pediments, sand plains and dunefields to playas and paleodrainage lines at the basement of the sequence. Soils ranged from skeletal red gritty material derived *in situ* from sandstone to deep red eolian deposits in the dunefields to shallow eolian and colluvium

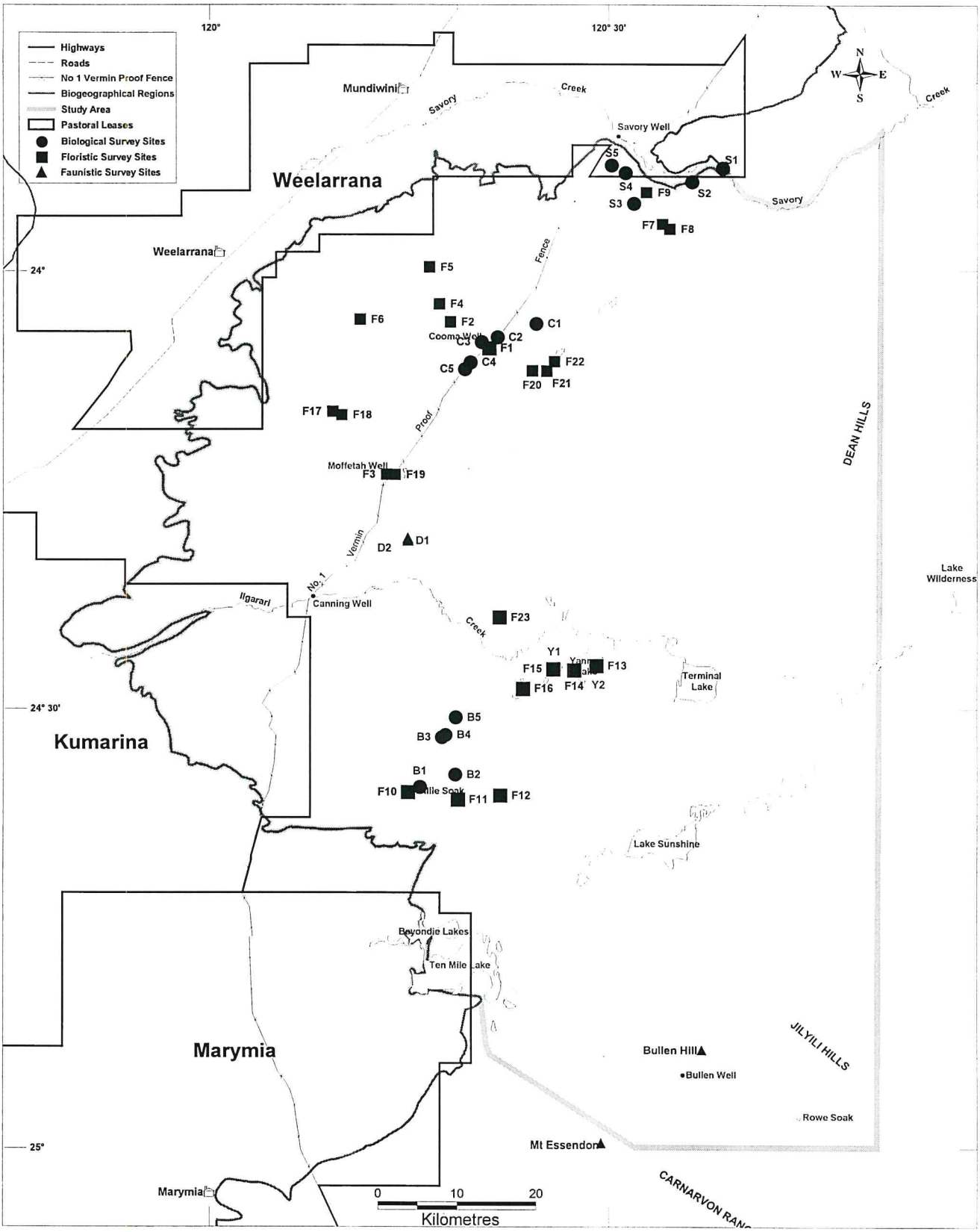

Figure 2.4 Location of the biological and florist survey sites throughout the south-western Little Sandy Desert study area.

deposits over calcareous and lateritic pediments and finally gypsiferous and hypersaline heavy clays.

The vegetation of the survey sites structurally ranged from open *Allocasuarina* forests through to *Acacia* woodlands and *Eucalyptus* mallee shrubs to low *Melaleuca* heath and finally samphire (*Halosarcia*) flats. Typically the lowest vegetation storey was dominated by hummock grasses (*Triodia*) although ephemeral herbs and perennial grasses dominated sites at the bottom of the catenary sequence (Appendix 2.1).

EDAPHIC CORRELATES

The chemical and textural properties of the soils from each of the 15 biological and 23 flora survey sites were characterised to assist with subsequent analyses and the classification of sites. To facilitate this characterisation two, 500 g samples were collected from the upper 10 cm of the soil profile at the origin and opposing diagonal corner of each 1 ha quadrat at each of the survey sites. These samples were subsequently bulked and analysed by the Western Australian Chemistry Centre (Department of Minerals and Petroleum Resources) to determine macro-nutrient status and textural composition.

The macro-nutrient status of the soil samples was assessed by determining Electrical Conductivity, pH, Organic Carbon, Total Nitrogen, Total Phosphorus, Available Phosphorus and the concentrations of exchangeable cations, namely Aluminium (Al), Calcium (Ca), Magnesium (Mg), Manganese (Mn), Potassium (K) and Sodium (Na). The textural attributes assessed were the fractions of Sand, Silt and Clay present in a soil sample. A summary of the analytical methods used to determine these soil macro-nutrients and textural properties is provided in Appendix 2.2.

Table 2.2 provides a summary of the soils from the study area while Appendix 2.3 provides analytical results for each site. Typically, the soils are non-saline with the exclusion of those obtained from quadrats associated with playas and paleodrainage features. Soils also tend to be neutral to slightly alkaline although, once again, those associated with playas and paleodrainage features are highly alkaline due to the presence of calcareous and gypsiferous material. Concentrations of exchangeable cations are similarly influenced by the presence of calcareous and gypsiferous materials and vary considerably across the survey sites. Sand dominates as the characteristic soil textural type although clays are in abundance at sites associated with playas and paleodrainage features.

Associations between survey sites based on the macro-nutrient status of their soils was examined using a clustering routine. Range standardised soil macro-nutrient values were examined for association using the Bray-Curtis similarity coefficient and the unweighted pair grouped arithmetic averaging fusion method (UPGMA, β = -0.1, Belbin 1994). Results from this exploratory analysis differentiate five quadrat site groups (Figure 2.5). These groups appear to be segregating on topographical and inherently geological considerations such that quadrats dominated by eolian sands are noticeably different from quadrats dominated by calcrete and gypsiferous substrates. Survey sites on sandstone and lateritic substrates are most similar in macro-nutrient status to those dominated by eolian sands.

Table 2.2 Mean (± SE) and range statistics for edaphic correlates determined from 53 survey sites located throughout the south-western Little Sandy Desert survey area.

Edaphic correlates	Mean ± SE	Range
Electrical Conductivity (mS/m)	72.06 ± 34.04	1.00 - 1592.00
pH	5.98 ± 0.19	4.40 - 8.80
Organic Carbon (%)	0.23 ± 0.03	0.04 - 1.22
Total N (%)	0.02 ± 0.01	0.003 - 0.09
Total P (ppm)	94.91 ± 7.03	38.00 - 261.00
Available P (ppm)	4.51 ± 0.71	2.00 - 34.00
Exchangeable Ca (me%)	1.43 ± 0.32	0.02 - 9.90
Exchangeable Mg (me%)	0.53 ± 0.13	0.02 - 4.51
Exchangeable Na (me%)	0.37 ± 0.16	0.02 - 7.40
Exchangeable K (me%)	0.11 ± 0.08	0.02 - 3.65
Exchangeable Al (me%)	0.14 ± 0.02	0.02 - 0.46
Exchangeable Mn (me%)	0.03 ± 0.01	0.02 - 0.08
Sand fraction (%)	88.50 ± 1.41	56.50 - 98.50
Silt fraction (%)	3.55 ± 0.68	0.50 - 23.00
Clay fraction (%)	8.02 ± 0.91	1.50 - 38.00

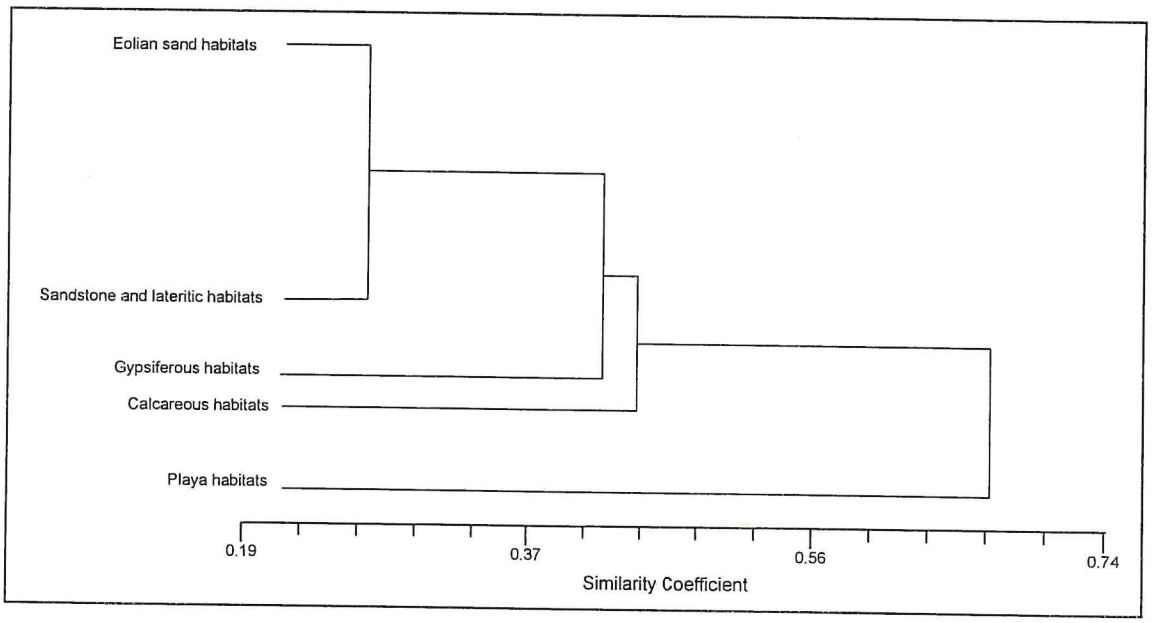

Figure 2.5 Dendrogram of south-western Little Sandy Desert survey quadrats classified according to similarities in the status of their macro-nutrients. (The clustering procedure employed the Bray-Curtis similarity coefficient and the UPGMA fusion method (β = -0.1).)

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APPENDIX 2.1

Descriptive overview of the 15 biological and 23 floristic sampling sites located throughout the south-western Little Sandy Desert study area.

Survey Site	Site Code	Coordinates		Landform and Vegetation description
		Latitude	Longitude	
Beyondie 1	B1	24° 35' 33" S	120° 15' 47" E	Lateritic ferruginous and calcareous red clay loam plain with deflation areas, flat terrain low in landscape, *Acacia aneura* woodland over *Eremophila maculata* over ephemeral herbs.
Beyondie 2	B2	24° 34' 30" S	120° 18' 28" E	Red gritty loam with calcrete rises and outcrops, *A. aneura* and *Grevillea striata* woodland over tussock grasses and ephemeral herbs.
Beyondie 3	B3	24° 31' 55" S	120° 17' 28" E	Red sand dune and interdunal deflation basin, high in landscape, open *Corymbia chippendalei* woodland over open *Aluta maisonneuvei* shrub over *Triodia* grassland.
Beyondie 4	B4	24° 31' 45" S	120° 17' 44" E	Eolian sand plain, low in landscape, *Xanthorrhoea thorntonii* and *Acacia* shrub over *Triodia* grassland.
Beyondie 5	B5	24° 30' 33" S	120° 18' 30" E	Proterozoic fine-grained sandstone (Jilyili Formation) plateau and breakaway, high in landscape, *Eucalyptus oldfieldii* open mallee with *G. spinosa* shrub over *Triodia grassland.*
Cooma 1	C1	24° 03' 13" S	120° 24' 24" E	Proterozoic medium-grained sandstone (Spearhole Formation) breakaway and gorge, high in landscape, *A. aneura*, *A. rhodophloia*, *A. pruinocarpa* low to open woodland and shrub over scattered hummock (*Triodia*) grasses.
Cooma 2	C2	24° 04' 31" S	120° 21' 38" E	Eolian sand plain with scattered doleritic gibber, *E. gamophylla* shrub mallee over *A. abrupta* heath over *Triodia* grassland.
Cooma 3	C3	24° 04' 46" S	120° 20' 15" E	Eolian gritty loam and sand sheets with outcropping calcrete rises, low in landscape, open *A. aneura* woodland over open *Acacia* sp. shrub and tussock grasses.
Cooma 4	C4	24° 06' 17" S	120° 19' 30" E	Eolian sand plain and dunes with some ferruginous pebbles, high in landscape, *A. maisonneuvei* over *Triodia* grassland with scattered emergent *C. chippendalei*.
Cooma 5	C5	24° 06' 41" S	120° 19' 10" E	Tertiary rolling lateritic rise, high in landscape, *A. aneura, A. cuthbertsonii, A. pruinocarpa* woodland over *Triodia* grassland.
Savory 1	S1	23° 52' 57" S	120° 38' 33" E	Quaternary clay loam alluvial wash on apron of creek, low in landscape, *Halosarcia* and associated samphires

Survey Site	Site Code	Coordinates		Landform and Vegetation description
		Latitude	Longitude	
				with open *Triodia* and tussock grasses.
Savory 2	S2	23° 53' 52" S	120° 36' 15" E	Eolian sand plain, low in landscape, *Hakea* and *Grevillea* heath over *Triodia* grassland.
Savory 3	S3	23° 55' 24" S	120° 31' 53" E	Tertiary rolling lateritic hills, high in landscape, open *A. aneura* woodland over *Triodia* grassland.
Savory 4	S4	23° 53' 18" S	120° 31' 18" E	Eolian red sand dune, high in landscape, open *C. chippendalei* woodland over *G. stenobotrya* shrub over *Triodia* grassland.
Savory 5	S5	23° 52' 46" S	120° 30' 12" E	Proterozoic course-grained sandstone (Glass Spring Formation) breakaway with skeletal red sand, high in landscape, *A. rhodophloia* and *A. aneura* scrub over *Triodia* grassland.
LSD 1	F1	24° 05' 14" S	120° 21' 02" E	Eolian red sand plain, low in landscape, *A. synchronicia* and *Melaleuca* shrub over tussock grasses.
LSD 2	F2	24° 03' 29" S	120° 18' 03" E	Eolian red sand plain, low in landscape, *X. thorntonii*, *A. maisonneuvei* scrub over *Triodia* grassland.
LSD 3	F3	24° 13' 54" S	120° 13' 18" E	Calcareous paleodrainage line and playa, low in landscape, *Casuarina pauper* over samphires and open tussock grasses.
LSD 4	F4	24° 02' 09" S	120° 16' 55" E	Eolian red sand plain, low in landscape, *Acacia* shrub over *Triodia* grassland.
LSD 5	F5	23° 59' 45" S	120° 16' 30" E	Tertiary rolling lateritic hills, high in landscape, *E. gamophylla* mallee over *A. cuthbertsonii* over *Triodia* grassland.
LSD 6	F6	24° 03' 19" S	120° 11' 16" E	Eolian red sand plain, high in landscape, *E. pachyphylla* mallee over *Acacia* shrub over *Triodia* grassland.
LSD 7	F7	23° 56' 50" S	120° 34' 01" E	Tertiary rolling lateritic hills, low in landscape, *A. aneura* and *G. stenobotrya* shrub over perennial tussock grasses.
LSD 8	F8	23° 57' 10" S	120° 34' 34" E	Eolian sand dune, high in landscape, *E. rameliana* over *H. rhombales* scrub over *Triodia* grassland.
LSD 9	F9	23° 54' 38" S	120° 32' 49" E	Eolian red sand sheet over course-grained sandstone (Glass Spring Formation), high in landscape, *G. wickhamii* and *H. rhombales* shrub over *Triodia* grassland.
LSD 10	F10	24° 34' 43" S	120° 14' 54" E	Gypsiferous playa, low in landscape, samphire shrubland with tussock grasses.
LSD 11	F11	24° 36' 11" S	120° 18' 28" E	Tertiary colluvium and lateritic rolling rises, high in landscape, low *A. aneura* and *A. pruinocarpa* woodland over open *Triodia* grassland.
LSD 12	F12	24° 35' 56" S	120° 21' 51" E	Eolian red sand dune, high in landscape, *E. gamophylla*, *E. rameliana* shrub mallee over *H. rhombales* and *A. maisonneuvei* over *Triodia* grassland.
LSD 13	F13	24° 27' 03" S	120° 29' 03" E	Gypsiferous playa, low in landscape, samphire shrubland.
LSD 14	F14	24° 27' 21" S	120° 27' 24" E	Eolian red sand and lunette dune field of kopi, high in landscape, shrub mallee over low *A. ligulata* shrub over herbs and scattered hummock grasses.
LSD 15	F15	24° 27' 16" S	120° 25' 49" E	Eolian sand plain, low in landscape, *Melaleuca* heath with *Daviesia eremaea* over *Triodia* grassland.
LSD 16	F16	24° 28' 36" S	120° 23' 34" E	Gypsiferous playa, low in landscape, *Melaleuca* heath over samphire shrubland and herbs.
LSD 17	F17	24° 09' 37" S	120° 09' 53" E	Eolian sand dune over course-grained sandstone (Glass Spring Formation), high in landscape, *E. rameliana* and

Survey Site	Site Code	Coordinates		Landform and Vegetation description
		Latitude	Longitude	
				E. gamophylla shrub mallee over *A. maisonneuvei* over *Triodia* grassland.
LSD 18	F18	24° 09' 51" S	120° 09' 53" E	Eolian sand dune over course-grained sandstone (Glass Spring Formation), high in landscape, *E. rameliana* and *E. gamophylla* shrub mallee over *A. maisonneuvei* over *Triodia* grassland.
LSD 19	F19	24° 13' 55" S	120° 13' 53" E	Eolian sand plain over outcropping calcrete, low in landscape, *Melaleuca* heath over *A. abrupta* over *Triodia* grassland.
LSD 20	F20	24° 06' 50" S	120° 24' 15" E	Undulating eolian sand plain with outcropping calcrete, low in landscape, open forest of *Allocasuarina decaisneana* over shrub mallee of *E. gamophylla* over *Triodia* grassland.
LSD 21	F21	24° 06' 51" S	120° 25' 20" E	Undulating eolian sand plain with outcropping calcrete, low in landscape, shrub mallee of *E. gamophylla* over *Melaleuca* heath and *Triodia* grassland.
LSD 22	F22	24° 06' 12" S	120° 25' 54" E	Gypsiferous playa, low in landscape, samphire shrubland with *Lawrencia glomerata* over perennial tussock grasses.
LSD 23	F23	24° 23' 44" S	120° 21' 47" E	Eolian sand plain with scattered outcropping calcrete, low in landscape, shrub mallee of *E. gamophylla* over scrub of *A. abrupta* over *Triodia* grassland.
Yanneri Lake 1	Y1	24° 27' 20" S	120° 27' 24" E	Lunette dune of gypsiferous (kopi) material, high in landscape, shrub mallee over open scrub of *A. ligulata* over low tussock grasses and open herbs.
Yanneri Lake 2	Y2	24° 27' 21" S	120° 27' 27" E	Saline red brown damp clayey soil with saline crust, low in landscape, samphire flat fringing dry lake bed, some tussock grasses and open herbs.
Dreamtime Gully 1	D1	24° 18' 19" S	120° 14' 52" E	Red sand plain overlaying sandstone bedrock at depth, mid-slope, dense shrub of *Acacia* and *Grevillea* over low scrub, *A. maisonneuvei over* hummock grassland.
Dreamtime Gully 2	D2	24° 18' 26" S	120° 14' 53" E	Proterozoic medium-grained sandstone (Spearhole Formation) bluff and breakaway system with skeletal soil, high in landscape, *Acacia* shrub (*A. rhodophloia, A. aneura*) over scattered *Triodia* grassland.

APPENDIX 2.2

Analytical regime used to determine the physical and chemical properties of the 53 soil samples collected from throughout the south-western Little Sandy Desert.

Electrical Conductivity

Measured by conductivity meter at 25°C on a 1:5 extract of soil and deionised water (Rayment and Higginson 1992, Method 3A1).

pH

Measured with a pH meter using a glass electrode in a 1:5 extract of soil and 0.01 M $CaCl_2$ (Rayment and Higginson 1992, Method 4B1).

Organic Carbon Content

Determined by a modification of the wet oxidation procedure of Walkley and Black (1934), as described by Walkley (1947). Samples of finely ground soil (<0.2 mm) were treated with sulphuric acid and potassium dichromate. The resulting chromium III ions were measured spectrophotometrically at 600 nm using a 1 cm cell.

Total Nitrogen

Measured by Kjeldahl digestion of soil (copper sulphate - potassium sulphate catalyst). Total nitrogen is assessed as ammonium-N by automated colorimetry through the nitroprusside.dichloro-S-triazine modification (Blakemore *et al.* 1987) of the Berthelot indophenol reaction (Searle 1984).

Total Phosphorus

Measured by colorimetry on the Kjeldahl digest for Total N using a modification of the Murphy and Riley (1962) molybdenum blue procedure.

Available Phosphorus

Phosphate soluble in 0.5 M sodium bicarbonate was determined using the method of Colwell (1963, 1965). Samples of soil (1 g) were extracted with 100 mL of 0.5 M $NaHCO_3$ (pH 8.5) for 16 hours at 23°C by end-over-end shaking (10 rpm).

Exchangeable Cations

Exchangeable Cations were assessed by three procedures:

a. 1 M NH_4Cl at pH 7.0.

Used for neutral soils (pH between 6.5 and 8.0 as measured by the pH (H_2O) method (glass electrode in a 1:5 extract of soil and deionised water)). Cations (Ca, Mg, Na and K) were measured by Inductively Coupled Plasma - Atomic Emission Spectrometry (ICP-AES). Soluble salts were removed from soil samples with electrical conductance >20 mS m^{-1} by washing with glycol-ethanol (Rayment and Higginson 1992).

b. 0.1 M $BaCl_2$ (unbuffered).

Used for acidic soils only (pH (H_2O) <6.5). Cations (Ca, Mg, Na, K, Al and Mg) were measured by ICP-AES. Soluble salts were removed from soils with electrical conductance >20 mS m^{-1} by washing with glycol-ethanol (David Allan, Agricultural Chemistry Laboratory, Chemistry Centre of Western Australia, unpublished procedure).

c. 1 M NH_4Cl at pH 8.5 (used for calcareous soils).

This is a modification of the 15C1 Method proposed by Rayment and Higginson (1992). Cations (Ca, Mg, Na and K) were measured by flame Atomic Absorption Spectrophotometry.

Particle Sizing

Determined by a modified 'plummet' procedure and expressed as percentage sand, silt and clay. Soil samples were dispersed with a solution of Calgon (sodium hydroxide) then silt (0.002 - 0.020 mm) and clay (<0.002 mm) fractions were measured by density using a plummet after standard settling times (Loveday 1974).

APPENDIX 2.3

Chemical and textural properties of the soils from 15 biological and 23 floristic sampling sites located throughout the south-western Little Sandy Desert study area. (* Data for each of the two replicated sampling sites for the 15 biological survey sites is presented.)

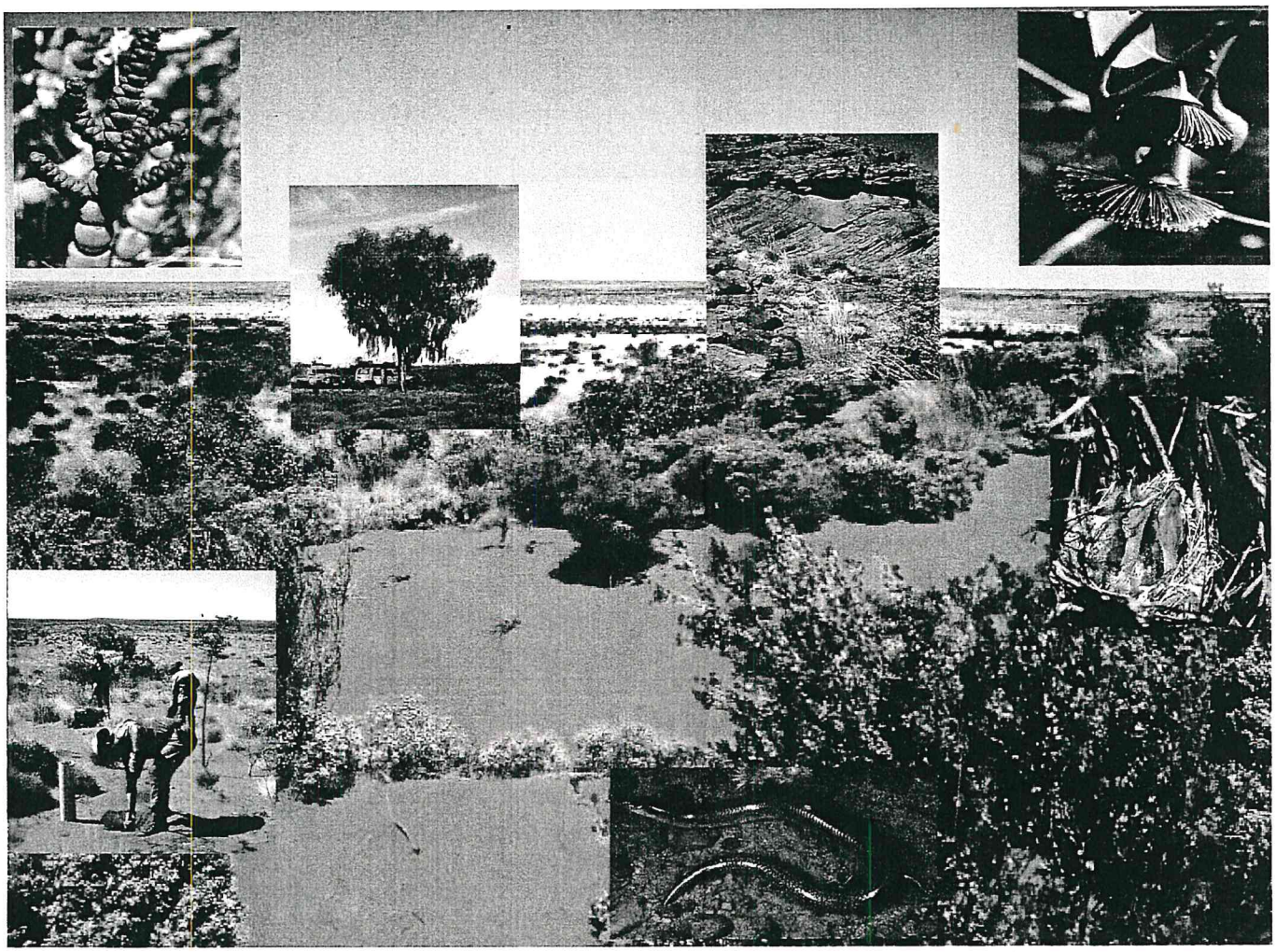
Survey Site *	EC (mS/m)	pH	Org C (%)	Total N (%)	Total P (ppm)	Available P (ppm)	Exch. Ca (me%)	Exch. Mg (me%)	Exch. K (me%)	Exch. Na (me%)	Exch. Al (me%)	Exch. Mn (me%)	Sand (%)	Silt (%)	Clay (%)
B1/1	3	6.7	0.27	0.034	246	8	4.04	3.08	0.84	0.06	-	-	60.0	16.5	23.5
B1/2	2	5.9	0.16	0.023	261	12	2.35	2.70	0.58	<0.02	<0.02	0.02	63.0	15.5	21.5
B2/1	8	8.7	0.53	0.056	114	9	3.84	0.65	0.46	<0.02	-	-	92.0	5.0	3.0
B2/2	7	8.7	0.39	0.040	146	8	3.74	0.76	0.83	0.04	-	-	85.5	5.5	9.0
B3/1	1	4.9	0.18	0.010	60	< 2	0.18	0.04	0.03	<0.02	0.13	0.04	95.0	0.5	4.5
B3/2	1	4.6	0.17	0.008	62	2	0.02	<0.02	<0.02	<0.02	0.17	0.02	96.5	0.5	3.0
B4/1	1	4.6	0.14	0.009	86	< 2	0.26	0.06	0.05	<0.02	0.16	0.04	92.0	1.0	7.0
B4/2	1	4.7	0.16	0.011	69	2	0.09	0.03	0.03	<0.02	0.23	0.02	94.0	1.0	5.0
B5/1	1	5.1	0.08	0.012	78	2	0.43	0.37	0.10	0.06	0.05	0.07	84.5	2.5	13.0
B5/2	1	5.1	0.29	0.026	102	3	0.64	0.22	0.15	<0.02	0.07	0.07	90.0	2.5	7.5
C1/1	2	4.4	0.13	0.012	163	6	0.10	0.03	0.04	<0.02	0.46	<0.02	85.5	4.5	10.0
C1/2	2	4.4	0.48	0.025	115	4	0.31	0.03	0.08	<0.02	0.26	<0.02	94.0	1.0	5.0
C2/1	1	5.1	0.11	0.009	78	2	0.38	0.19	0.08	<0.02	0.16	0.03	89.0	1.0	10.0
C2/2	<1	5.5	0.11	0.008	68	2	0.56	0.34	0.08	<0.02	0.02	0.02	91.5	1.0	7.5
C3/1	4	7.1	0.19	0.022	134	3	2.25	1.82	0.66	0.02	-	-	81.0	8.5	10.5
C3/2	6	7.1	0.40	0.041	150	11	3.20	1.39	0.52	<0.02	-	-	85.0	8.0	7.0
C4/1	<1	5.4	0.14	0.009	64	<2	0.27	0.11	0.04	<0.02	0.07	0.02	96.5	0.5	3.0
C4/2	1	5.0	0.10	0.008	76	2	0.16	0.06	0.05	<0.02	0.14	0.05	93.0	1.0	6.0
C5/1	1	4.9	0.12	0.011	111	2	0.14	0.03	0.06	<0.02	0.41	<0.02	89.0	3.0	8.0
C5/2	2	5.0	0.13	0.014	117	3	0.71	0.42	0.13	<0.02	0.17	0.04	80.5	3.5	16.0
S1/1	404	7.9	0.43	0.038	126	13	9.90	4.51	1.50	0.53	-	-	82.0	11.0	7.0
S1/2	71	8.3	0.30	0.036	132	14	7.50	2.03	2.18	0.22	-	-	61.0	23.0	16.0
S2/1	1	4.9	0.08	0.007	78	<2	0.18	0.08	0.04	<0.02	0.14	0.03	92.5	0.5	6.5

Survey Site *	EC (mS/m)	pH	Org C (%)	Total N (%)	Total P (ppm)	Available P (ppm)	Exch. Ca (me%)	Exch. Mg (me%)	Exch. K (me%)	Exch. Na (me%)	Exch. Al (me%)	Exch. Mn (me%)	Sand (%)	Silt (%)	Clay (%)
S2/2	<1	5.1	0.08	0.005	70	2	0.19	0.11	0.03	<0.02	0.05	0.02	94.0	0.5	5.5
S3/1	1	4.9	0.10	0.011	109	3	0.41	0.18	0.14	0.03	0.12	0.06	88.0	3.0	9.0
S3/2	1	4.8	0.17	0.016	136	4	0.42	0.28	0.14	<0.02	0.20	0.08	82.5	4.0	13.5
S4/1	<1	5.3	0.06	0.005	47	<2	0.19	0.05	0.03	<0.02	0.02	<0.02	98.0	<0.5	2.0
S4/2	1	5.5	0.07	0.003	49	<2	0.25	0.07	0.02	<0.02	<0.02	<0.02	98.0	<0.5	2.0
S5/1	4	5.7	1.05	0.069	107	5	3.56	0.78	0.20	<0.02	<0.02	0.08	90.0	4.0	6.0
S5/2	1	5.2	0.18	0.020	99	2	0.71	0.38	0.19	<0.02	0.10	0.06	85.0	3.0	12.0
F1	18	8.7	0.36	0.036	58	4	6.70	1.19	0.30	<0.02	-	-	85.5	7.0	7.5
F2	1	4.9	0.09	0.006	60	2	0.14	0.07	0.04	<0.02	0.06	0.05	95.5	<0.5	4.5
F3	514	8.8	0.46	0.046	76	4	-	-	-	-	-	-	-	-	-
F4	5	4.9	0.16	0.010	70	2	0.66	0.30	0.08	0.04	0.06	0.05	95.0	0.5	4.5
F5	2	4.7	0.13	0.013	102	2	0.15	0.06	0.08	<0.02	0.37	0.02	89.5	2.0	8.5
F6	1	5.2	0.16	0.011	62	2	0.38	0.12	0.05	<0.02	0.03	0.04	93.5	0.5	6.0
F7	1	4.9	0.32	0.016	111	4	0.18	0.04	0.10	<0.02	0.31	<0.02	90.0	2.5	7.5
F8	1	5.0	0.15	0.008	49	3	0.13	0.03	0.11	<0.02	0.10	<0.02	96.5	1.0	2.5
F9	<1	5.6	0.09	0.005	91	3	0.48	0.14	0.05	<0.02	<0.02	0.02	95.5	<0.5	4.5
F10	505	8.8	0.80	0.079	156	6	4.21	0.67	7.40	3.65	-	-	81.0	13.0	6.0
F11	2	4.6	0.21	0.016	239	6	0.37	0.13	0.12	0.02	0.40	<0.02	80.5	5.0	14.5
F12	1	6.3	0.06	0.003	43	<2	0.38	0.06	0.03	0.05	-	-	98.5	<0.5	1.5
F13	246	8.4	0.14	0.016	73	10	-	-	-	-	-	-	-	-	-
F14	84	7.4	0.08	0.004	49	3	6.31	0.03	0.08	0.04	-	-	95.5	<0.5	4.5
F15	5	5.0	0.16	0.006	50	2	0.34	0.09	0.04	<0.02	0.04	<0.02	97.5	<0.5	2.5
F16	1592	8.3	1.22	0.092	145	34	-	-	-	-	-	-	-	-	-
F17	1	5.4	0.1	0.008	73	2	0.1	0.02	0.04	0.02	0.34	0.03	90.5	1.5	8
F18	0	5.8	0.04	0.005	38	2	0.06	0.04	0.02	0.02	0.04	0.02	98.5	0.5	1.5
F19	1	7.3	0.13	0.008	41	2	1.09	1.28	0.12	0.04	-	-	91	2	7
F20	1	6.1	0.11	0.006	50	2	0.32	0.09	0.02	0.02	0.05	0.02	96	0.5	3.5
F21	1	6.6	0.09	0.005	44	2	0.75	0.59	0.06	0.05	-	-	96.5	0.5	3
F22	230	8	0.19	0.02	53	2	-	-	-	-	-	-	56.5	5.5	38
F23	1	5.9	0.05	0.005	44	2	0.42	0.2	0.06	0.02	0.04	0.03	93.6	0.5	6

Biological survey of the south-western Little Sandy Desert

NATIONAL RESERVE SYSTEM PROJECT N706

FINAL REPORT – JUNE 2002



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Government of Western Australia

DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA