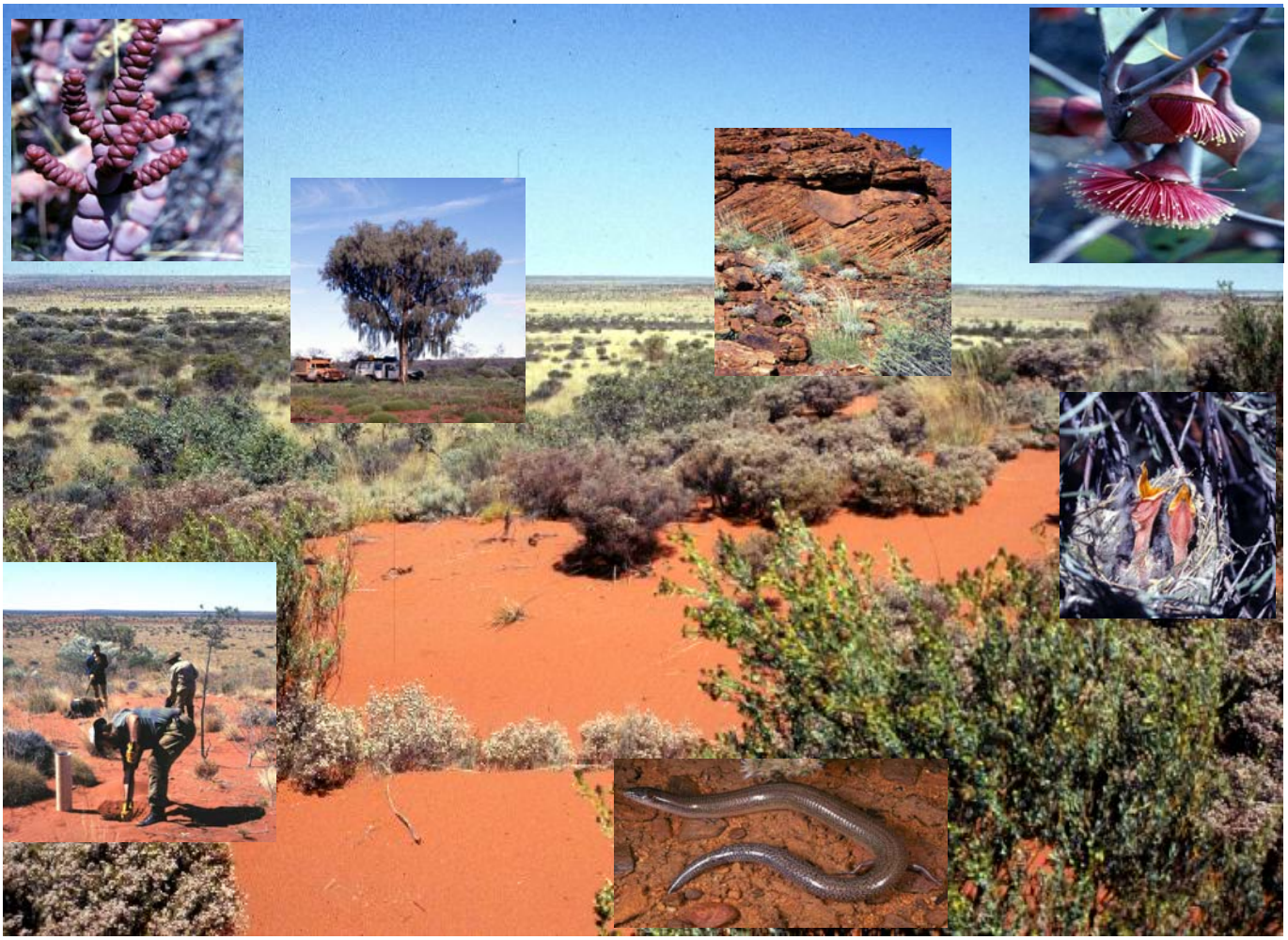
Biological survey of the south-western Little Sandy Desert

NATIONAL RESERVE SYSTEM PROJECT N706

FINAL REPORT – JUNE 2002



EDITED BY

STEPHEN VAN LEEUWEN

SCIENCE DIVISION

DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT

Government of Western Australia

DEPARTMENT OF Conservation AND LAND MANAGEMENT
Conserving the nature of WA

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Parks Australia
Environment Australia
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CANBERRA ACT 2601
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or

Dr Stephen van Leeuwen
Science and Information Division
Conservation and Land Management
PO Box 835
KARRATHA WA 6714
AUSTRALIA

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EXECUTIVE SUMMARY

The Little Sandy Desert is biologically a poorly known natural region in arid north-western Australia. The Desert is characterised by extensive red sand dunes and plains interspersed with resistant sandstone uplands. Overall, the biogeographical region is inadequately represented on the conservation estate with less than 5% reservation. This reservation is biased and consequently does not afford the biota comprehensive and adequate representation. This biological survey documents the flora and fauna of the south-western Little Sandy Desert and makes justified recommendations for reservation.

The flora of the south-western Little Sandy Desert is diverse with 522 taxa. Many taxa are of biological and conservation significance and several were not previously recorded in the scientific literature. Many taxa are at the limits of their distributional range and are disjunct outliers of otherwise mostly northern or southern ranges. In broad terms the flora is dominated by central arid zone elements although southern and tropical arid zone groups are present. Floristic communities are readily distinguishable and their arrangement across the landscape appears to be controlled by topographic and edaphic considerations. The location of the study area in a transitional zone between major phytogeographic elements in the Australian flora together with heterogeneity in land surface types and soils is advanced as justification for the botanical diversity recorded. This diversity differs notably from other areas in the biogeographical region.

The herpetofauna of the south-western Little Sandy Desert comprises 87 species (5 amphibians, 1 turtle, 9 agamids, 15 geckos, 5 pygopodids, 30 skinks, 9 varanids, 3 typhlopid, 1 boid and 9 elapids). It is highly likely that other species will be located within the study area as an additional 22 species are known from the biogeographical region. Most species are distributed widely in the northern or central arid zones although a significant number do not appear to pass beyond the fringes of the Desert, particularly on the western and southern margins.

Surveys of the avifauna of the south-western Little Sandy Desert revealed the presence of 116 bird species (61 passerines, 55 non-passerines). A total of 42 species were recorded breeding after summer and winter-spring rains. Most birds recorded are typical of arid zone habitats in Australia, although 20 species of waterbird were recorded along Savory Creek. The birds tend to form weak assemblages which correspond to the main landform and vegetation types in the study area. Most birds however were ubiquitous because of their mobility, with the exception of a group favouring mulga woodlands.

The terrestrial mammal fauna of the south-western Little Sandy Desert is comprised of 28 extant indigenous and seven exotic species. Given the evidence of past occurrences of three now locally or regionally extinct mammals in the study area, the indigenous fauna encompasses all but one of the mammals known from the biogeographical region. Spatially minor land surfaces are disproportionately important for mammals but differ in their relevance for indigenous and exotic species. Sandstone uplands have the richest indigenous fauna with six species restricted to this habitat. Loam and clay surfaces have the richest exotic faunas.

Unequivocally, the south-western Little Sandy Desert supports a rich and diverse biota encompassing both ubiquitous and rare species, many of which are not known from the conservation reserve network. Consequently, to redress deficiencies in the comprehensiveness, adequacy and representativeness of the conservation reserve network in the biogeographical region, a proposal is tendered for the creation of the Giles Nature Reserve. This proposed nature reserve epitomises the physiogeographical character of Little Sandy Desert and is intrinsically representative of the biota of the region. Accordingly, the declaration of this proposed nature reserve would be a substantial gain for conservation.

Chapter 1

THE LITTLE SANDY DESERT

S.J. van Leeuwen and R.N. Bromilow

Science Division, Department of Conservation and Land Management, Karratha.

ABSTRACT

The Little Sandy Desert is biologically a poorly known natural region in north-western Australia. The Desert experiences an arid tropical climate typified by hot summers and cool winters with mostly summer rainfall which averages 200 mm to 250 mm per annum. The salient characters of the Desert are resistant sedimentary uplands of mostly sandstone rising above extensive rolling eolian red sand dunes and sand plains. Significant uplands, typified by the Carnarvon Range are present, however relief is generally subdued. Drainage is mostly internal, easterly to north-easterly trending and along paleodrainage channels. The Desert is situated upon several geological structures most of which are Precambrian sedimentary basins. The Savory Basin is the most important of these sedimentary features and is completely encompassed within the Desert. Overlaying these sediments are Cainozoic deposits dominated by eolian sands although numerous examples of calcariferous, gypsiferous and lateritic deposits are also present. The Desert is mainly vegetated by Acacia*,* Grevillea *and ericoid shrubs over hummock grasses although not insignificant woodlands of* Eucalyptus*,* Allocasuarina *and* Acacia *persist.* Melaleuca *and samphire heaths dominate most of the drainage features. The majority of the region is Unallocated Crown Land, although some parts of the Desert are within well-known reserves such as the Rudall River National Park and Canning Stock Route. At this time the region has limited financial prowess although the potential for hydrocarbons in the Savory Basin and the significant mineralisation associated with the Paterson Orogen in the Rudall River area may alter this situation in the future.*

Biological investigations in the Little Sandy Desert have been limited, mainly being confined to the Canning Stock Route and Rudall River areas. This situation was exemplified by the rediscovery of the only presumed extinct Eucalyptus (E. rameliana) *in the southern portion of the Desert in 1991. This survey aims to address this knowledge deficiency by systematically documenting and reporting the flora and fauna of the south-western Little Sandy Desert. Management recommendations designed to ensure that the flora and fauna of the Desert are adequately conserved on reserve land and protected from threatening processes are tendered.*

INTRODUCTION

The Little Sandy Desert (24° 46' S, 122° 09' E) is located to the east and south of Newman in the Pilbara region of Western Australia. The Desert lies between latitudes 21° 30' S and 26° 00' S and longitudes 119° 50' E and 124° 30' E and occupies an area of 111 137 km^2.

(Figure 1.1). This desert region is one of the most inaccessible and biologically poorly known areas within Western Australia.

The Desert was first identified as a distinct biogeographical (natural) region in 1969 (Beard 1970) and officially recognised as a distinct region in 1987 (Department of Land Administration 1987). Prior to 1969 the desert was considered part of the much larger Great Sandy Desert (Pianka 1969, Jennings and Mabbutt 1986). The Little Sandy Desert was principally differentiated from the Great Sandy Desert on the grounds of underlying geology (Precambrian *vs* Mesozoic) and sand dune physiography with the dunes of the Little Sandy Desert differencing in both morphology and provenance from those of the Great Sandy Desert (Williams 1992). Inherently these geological and edaphic differences, together with the more southerly position of the Little Sandy Desert, confer significant floristic differences between the two desert (Beard 1975). Beard (1970, 1980) named the biogeographical region the Keartland Botanical District after George Keartland a naturalist with the ill-fated Wells (Calvert Scientific Exploring Expedition) expedition of 1896. Subsequently, following the Biogeographical Regionalisation of Australia (Thackway and Cresswell 1995) the contemporary name applied to the region is Little Sandy Desert. At present the region is partitioned into two sub-regions. The northern (LSD1) encompasses the highly mineralised Throssell and Broadhurst Ranges in the Rudall River area and comprise approximately 9% of the Desert. The remainder of the Desert is within the LSD2 sub-region.

The principal characters defining the Little Sandy Desert are the sand plains and sand dunes covering approximately 90% of the region, which have evolved *in situ* and are derived from the breakdown of Late Proterozoic sandstones (Williams 1992). To the north the Desert is demarcated from the sands of the Great Sandy Desert by the Throssell, Broadhurst and McKay Ranges while to the east the demarcation occurs where the sands give way to the lateritic plains of the Gibson Desert. To the south the Desert is defined by the acquiescence of the dunes and the replacement of spinifex (*Triodia*) hummock grass by the wattle (*Acacia*) dominated scrub of the Gascoyne Biogeographical Region. In this south-east this transition coincides with the Carnegie Salient while in the south-west the transition coincides with the Gascoyne Ranges (Williams 1995). In the west the demarcation is associated with the replacement of sands by the rocky pediments of the Pilbara and Gascoyne Biogeographical Region as exemplified by the Kumarina Hills.

The climate of the Little Sandy Desert can be described as arid tropical with principally summer rainfall (Beard 1975). No meteorological stations are located within the Desert so climatic averages have been interpreted from the nearby stations at Telfer, Mundiwindi, and Earaheedy (Bureau of Meteorology 2002a). Average annual maximum temperatures range from 34° C in the north to 30° C in the south while over the same latitudinal extent average annual minima range from 19° C to 15° C. Typically the summers are hot, varying between 37° and 41° C while winters are mild to cool varying from 5° C to 10° C. Temperature extremes likely to be experienced in the Desert range from –5° C to 48° C. Frosts are common, occurring from June to early September.

Rainfall across the Desert is erratic and highly variable (Beard 1975). As demonstrated by the isohyets in Figure 1.2, the annual average varies from 200 mm or below in the east to about 250 mm in the west (Waters and Rivers Commission, 2002) although the accuracy of these isopleths is questionable as Telfer on the northern edge of the Desert receives an annual average of 312 mm (Bureau of Meteorology 2002a). Typically most rainfall occurs in summer (49%) and is undoubtedly associated with the dissipation of tropical depressions and

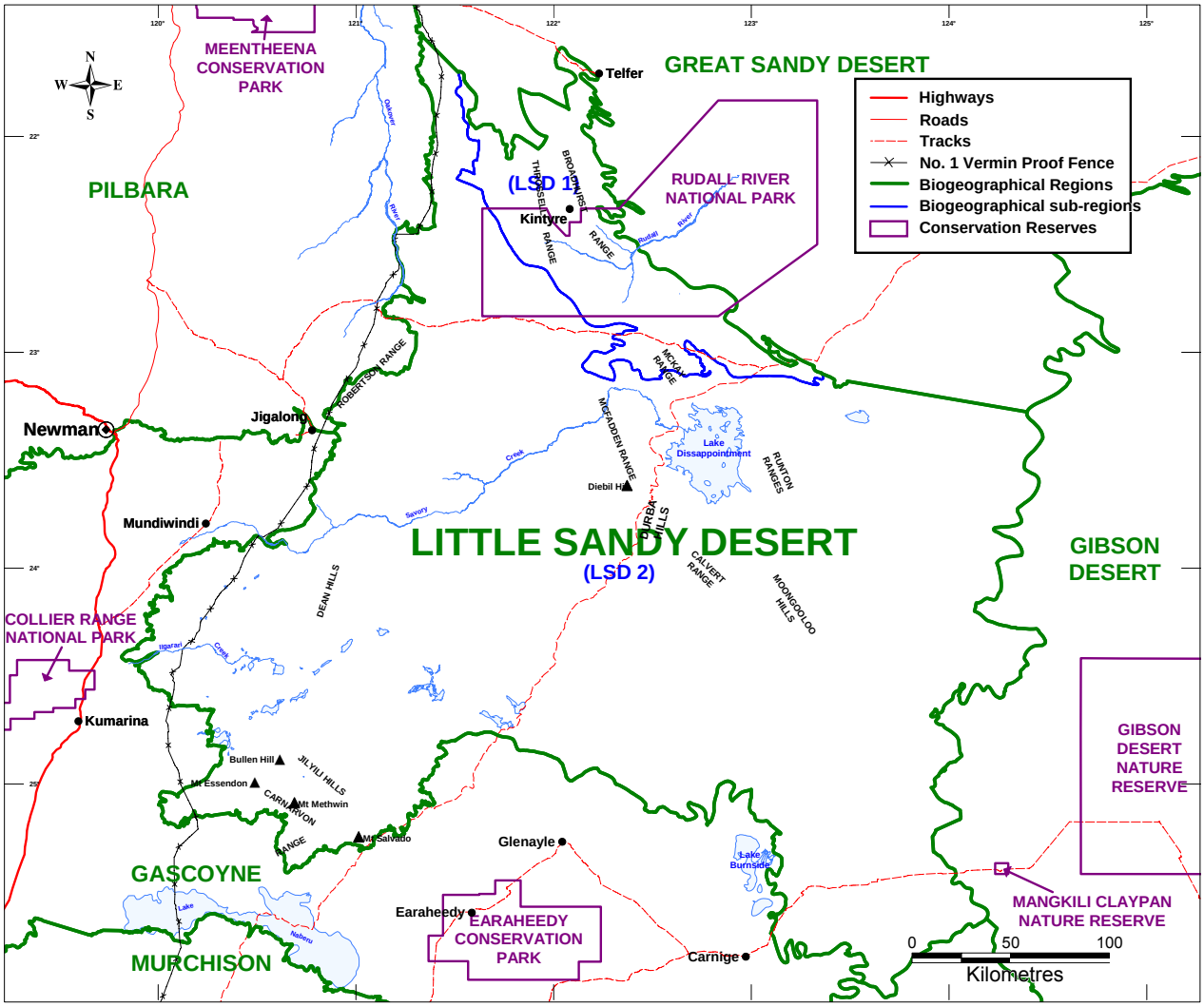

Figure 1.1 Regional setting of the Little Sandy Desert Biogeographical Region.

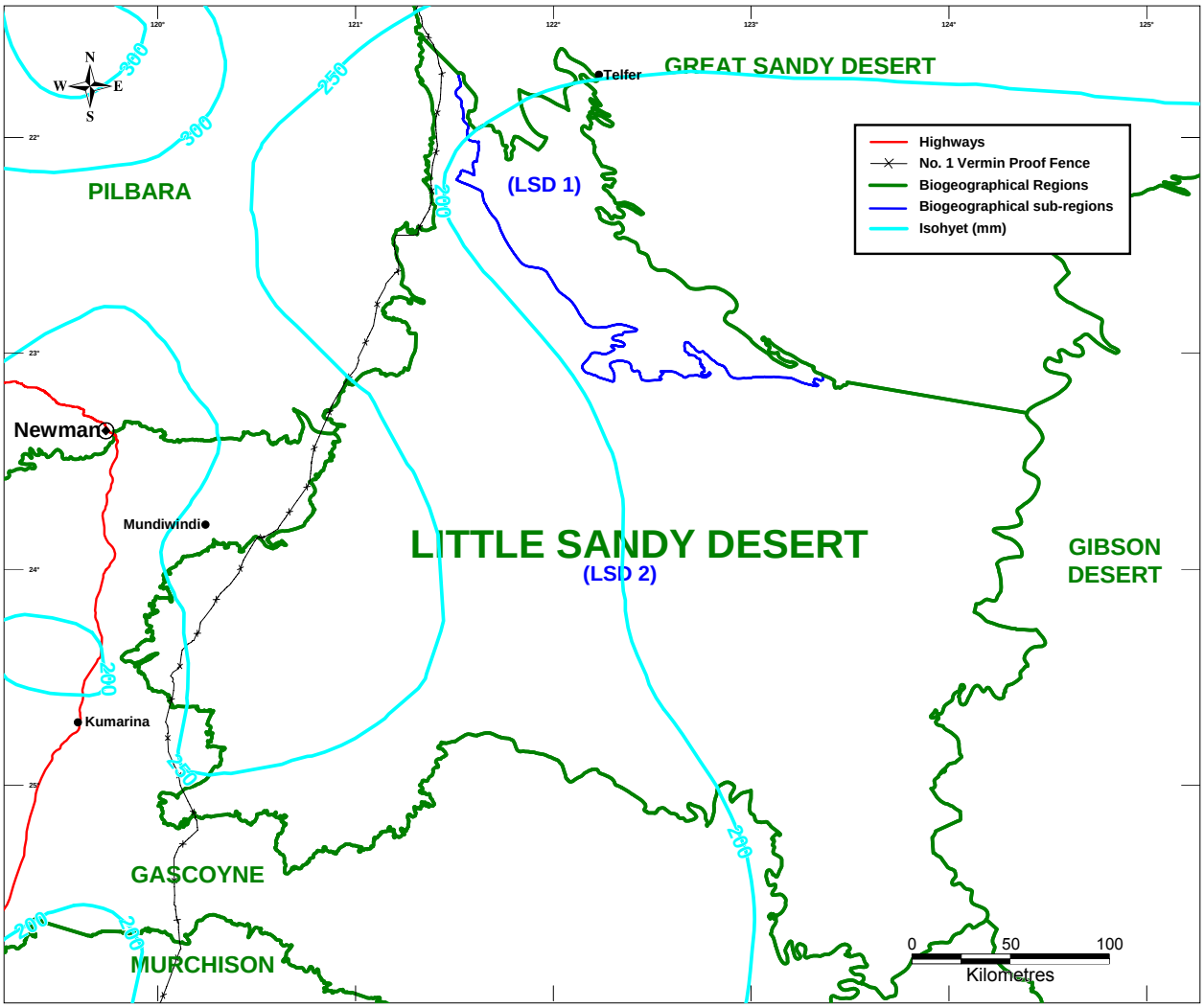

Figure 1.2 Isohyets of the Sandy Desert Biogeographical Region.

monsoonal lows. Winter rainfall is usually low (14% of annual average) although as noted by Williams (1995) it can be considerable as a consequence of baroclinicity associated with the interaction between north-west cloud bands and low pressure systems passing through the south of the State. Annual potential evaporation ranges from 3 600 mm in the north-west of the Desert to 4 200 mm in the south-east (Australian Bureau of Statistics 1989) while actual areal evapotranspiration ranges from 300 mm in the north to 200 mm in the south-east. (Bureau of Meteorology 2002b).

The Little Sandy Desert is dominated by broadly rolling sand dunes interspersed with extensive eolian plains, abrupt sedimentary mountain systems, sandstone ranges, rolling lateritic hills and extensive paleodrainage channels. Relief across the Desert varies from 910 m on Mt Essendon in the Carnarvon Range to 320 m at Lake Disappointment. Typically local relief is less than 50 m although the peaks of the Carnarvon Range are up to 320 m above the surrounding terrain. Conspicuous topographical features of the Desert are the 'whaleback' ranges, ridges, hills and breakaways which rise above a sea of red sand. These features include the Robertson Range, Throssell Range, Broadhurst Range, Hanging Rock, Diebil Hills, McFadden Range, Durba Hills, Runton Range, Constance Hedland, Calvert Range and the peaks of the Carnarvon Range such as Mt Essendon, Mt Salvado and Mt Methwin.

The red sand dunes of the Little Sandy Desert are the most striking feature of the biogeographical region. These dunes are smaller but more complex than the dunes of the Great Sandy Desert and range from sinuous longitudinal dunes through to chain dunes which often anastomose to forming a net-dune complex (Crowe 1975). Star dunes and pimple or pyramidal dunes are also present (Williams 1995). Longitudinal dunes may be up to 30 km long and 20 m high although the average is 5 km to 10 km long and 8 m to 10 m high. The swales between dunes vary from less than 100 m to over 1 km. The dunes trend mostly in an easterly direction and parallel to the prevailing winds which vary from south-easterly in the east to north-easterly in the west of the region. The dunes fringing many of the playas and lakes in the Desert are lunette and comprised of gypsiferous material, in particular kopi.

Drainage in the Desert is principally internal, trending east to north-east into Lake Disappointment, saline and associated with paleodrainage channels. Exceptions to this flow pattern are associated with the Rudall River which drains into Lake Dora, the Oakover River which is part of the De Grey River catchment and Jigalong Creek which is part of the Fortescue River catchment. In the south drainage on the southern side of the Carnarvon Ranges is into Lake Naberru and Kahrban Creek. The most prominent drainage feature of the Little Sandy Desert is Lake Disappointment and its associated network of playas and clay pans. Other large lakes include White Lake, Lake Aerodrome, Ten Mile Lake, Terminal Lake, Lake Wilderness and Lake Sunshine. The largest drainage channel in the region is Savory Creek which flows through the middle of the Desert into Lake Disappointment. Ilgarari Creek is another prominent drainage channel which flows into Yanneri and Terminal Lakes. Other paleodrainage channels are associated with the Durba Hills and the Disappointment Paleoriver (van der Graaff *et al.* 1977, Williams 1992). Numerous springs, soaks and developed wells are located throughout the Desert including Durba Spring, Curran Curran Rockhole, Bullen Well and Wells 11 to 21 along the Canning Stock Route.

Geologically the Little Sandy Desert is comprised of a number of geological structures the most significant of which are sedimentary basins (Williams 1990, 1992). These sedimentary basins are the Officer Basin in the east, the Bangemall Basin in the west, the Bangemall and Nabberu Basins in the south and most importantly, the Savory Basin. The Savory Basin is a

Precambrian (Late Proterozoic) sedimentary basin which has only recently been described (Williams 1987, 1992, 1995, William and Tyler 1991). It is captured entirely within the Little Sandy Desert Biogeographic Region and occupies approximately 48% of the Desert. Throughout the Desert the rocks of the Savory Basin are expressed as sandstone breakaways, ridges, hills and ridgelines. Interspersed amongst these sandstone features are mafic intrusions expressed as weather doleritic features. Another geological structure impinging upon the biogeographical region is the Late Precambrian Paterson Orogen which is comprised of metamorphic, sedimentary and igneous rocks that have a common tectonic history. This geological structure occupies the north-eastern portion of the Desert. Minor expressions of the Fortescue and Hamersley Group of the Hamersley Basin, which is part of the Archaean Pilbara Craton, are also captured within the Desert, primarily in the north-western corner of the region.

Throughout the Desert the sedimentary rocks are expressed as resistant upland features in a sea of unconsolidated or semi-consolidated Cainozoic deposits. Typically these deposits form a thin or skeletal veneer over the Precambrian rocks, however on the plains, dunefields and in valley floors they may attain depths of 20 m (Williams and Tyler 1991). The Quaternary (Holocene) eolian sands of the dunefields and sand plains are the most ubiquitous expression of these deposits. Other examples of these deposits include pebble strewn colluvial deposits which are usually down slope and adjacent to decomposing sandstone regolith. Where sandstone is absent such deposits tend to be lateritic and support a ferruginous or siliceous duricrust. Unconsolidated alluvial deposits of silts, sand and gravels are also present, mostly in close proximity to the active paleodrainage channels such as Savory Creek. Calcareous deposits are also common and are indicative of extant paleodrainage channels. These deposits are the remains of fluvial valley-fill sediments converted to chemical limestone by the subsurface replacement and cementation of calcium carbonate (Williams 1992). In many instances these calcareous deposits are expressed as outcropping cap rock overlain by 2 m to 3 m of eolian sand (Bagas *et al*. 2000). A final Cainozoic deposit is that associated with the playas and lake systems of the Desert. These deposits are generally saline, gypsiferous and comprised of black to red-brown to grey clay material (Williams 1995).

In broad terms the vegetation of the Little Sandy Desert can be described as shrub steppe dominated by *Acacia* and *Grevillea* species over hummock grasses (*Triodia* spp.) with scattered woodlands of desert oaks (*Allocasuarina decaisneana*) and mulga (*A. aneura*) (Beard 1975, 1990). Specifically, sand plains and expansive swales between the dunes are dominated by shrublands of *Acacia* and ericoid shrubs, in particular *Aluta maisonneuvei,* over hummock grasses*.* Mallee shrub of *Eucalyptus kingsmillii, E. gamophylla E. rameliana* and *E. pachyphylla* dominate over smaller wattles and hummock grasses when these sand plains overlay degrading sandstone and doleritic regolith. With progression up slope onto the dunes, grevilleas tend to replace the wattles and the sand dune bloodwood (*Corymbia chippendalei*) becomes conspicuous*.* On the consolidated colluvial soils and some of the calcareous and ferruginous hardpan deposits *Acacia* woodlands dominated by mulga in association with gidgee (*A. pruinocarpa*) and beefwood (*G. striata*) over perennial tussock grasses and ephemeral herb are prevalent. Some of the calcareous deposits, especially those overlain by eolian sands support dense groves of desert oak*.* The paleodrainage channels and their associated plains are dominated by shrubs and heaths of *Melaleuca* and *Acacia* species over scattered hummock grasses. The more active paleodrainage channels (Savory Creek) are often lined with dense thickets of *Melaleuca* and in areas of fresh water or on adjacent expansive calcareous pediments, coolibahs (*E. victrix*) and occasional river red gums (*E. camaldulensis*) may be present*.* When hypersaline conditions are encountered the eucalypts are replaced by groves of black oak (*Casuarina pauper*). The vegetation fringing the playas and lake beds tends to be a

samphire health dominated by species of *Halosarcia*. On the rocky pediments *Acacia* shrubs dominate, often with emergent desert bloodwoods (*C. deserticola*) and beefwood. Minni-ritchi wattles such as *A. rhodophloia* and other species like *G. spinosa* and *E. oldfieldii* are also common on such substrates, usually occurring as emergents from open hummock grass.

Conspicuous elements in the flora tend to be the desert oak, spear wattles (e.g. *A. melleodora*), desert kurrajong (*Brachychiton gregorii*), desert grass-tree (*Xanthorrhoea thorntonii*) and when flowering, the hummock grasses and brightly coloured, floriferous grevilleas (*G. spinosa, G. eriostachya G. stenobotrya*). Variation in the composition of the vegetation across the Desert has been reported by Beard (1975) who noted the gradual disappearance of the desert bloodwood and conversely increasing abundance of *Eremophila* shrubs with progression to the south. Similarly an increase in the abundance of mulga woodlands was also noted, a phenomenon which was explained with reference to the phytogeographically important *Acacia-Triodia* line which traverses the region (Beard 1975). Beard (1975) and Williams (1992) also noted an increase in the abundance and distribution of ericoid shrubs (e.g. *A. maisonneuvei*) with progression into southern parts of the Desert. In areas south of Ilgarari Creek, *A. maisonneuvei* tends to occur continuously across the topographical sequence growing on both northern and southern facing dune slopes and across the intervening swales while in the north, towards Rudall River, this shrub is typically confined to southern facing dune slopes. The abundance of the desert grass-tree also appears to be greatest in southern and western portions of the Desert (Williams 1992).

The Little Sandy Desert is mostly uninhabited with the exception of a few scattered aboriginal communities in the vicinity of Jigalong and the Rudall River. A mineral exploration camp is also located at Kintyre in the Throssell Range. The closest noteworthy settlement to the region is the mining community of Telfer which is 50 km north of Kintyre. The closest commercial centre to the region is Newman in the Pilbara, some 105 km west of the region. The Little Sandy Desert is flanked by pastoral leases to the south and west, namely Wandanya, Balfour Downs, Robertson Range, Walagunya, Weelarrana, Kumarina, Marymia, Glenayle and Carnegie. The Desert falls within the administrative boundaries of the East Pilbara, Wiluna and Meekatharra shires. The Region is also within the Pilbara and Goldfields administrative regions of the Department of Conservation and Land Management. Ninety-seven percent of the Desert is captured within the bounds of five registered Native Title Claims by the Birrilburu (WC98-068), Martu (WC96-078), Ngalia (WC97-003), Njamal (WC99-008) and Nyiyaparli (WC99-004) claimant groups.

The majority (*ca*. 90%) of the Desert is Unallocated Crown Land although some significant reserves are present. Among these the Canning Stock Route, which traverses the central and north-eastern parts of the region, is perhaps the most renowned. Other reserves are associated with the abandoned No. 1 Vermin Proof Fence (↑ 12297). and the Jigalong Aboriginal Reserve. Perhaps the most noteworthy reserve impinging on the Desert is the Rudall River National Park (↑ 34607, Class 'A'), the largest national park in Western Australia. Approximately 40% of the Rudall River National Park occurs within the Little Sandy Desert. Another two conservation reserves encompassing the Carnarvon Range and Lake Disappointment areas are proposed for the Desert, however these recommendations have not come to fruition (Environmental Protection Authority 1975, Conservation and Land Management 1994).

Access to the region is very limited and mostly confined to unsealed graded road or four-wheel-drive tracks such as the Talawana-Windy Corner track, Canning Stock Route, Gunbarrel Highway and the service track associated with the abandoned No. 1 Vermin Proof

Fence. The region currently has limited financial prowess, although nature-based and four-wheel-drive tourism associated with the Canning Stock Route and Rudall River National Park is considerable. Pastoralism may also contribute somewhat to the financial stature of the region, however its influence would be minimal given no leases actually occur within the region, instead merely impinging upon the western and southern margins. The potential for mineral wealth in the region is considerable but varies markedly across geological structures. Exceptional prospectivity is associated with the Paterson Orogen in the northern part of the Desert as demonstrated by extensive mineralisation in the Throssell and Broadhurst Ranges (Bagas *et al*. 1995). The Carnarvon Range is also considered to be prospective for mineral resources (Bunting *et al*. 1982). The Savory Basin, particularly in the north-east is considered to provide a potentially favourable environment for hydrocarbons although further exploration is required to verify this proposition (Williams 1992).

The Little Sandy Desert is one of the least understood and appreciated areas in Western Australia with respect to its biota and natural history. This shortcoming in our knowledge can principally be attributed to the remoteness of the region and lack of convenient access. The first biological work undertaken in the Desert was by Earnest Giles in 1876 during his expedition from Perth in Western Australia to Peake in South Australia (Giles 1889). During this expedition Giles collected several plants which were subsequently passed to the government botanist of Victoria, Baron F. von Mueller. Not unexpectedly many of the plants collected by Giles represented new species and were subsequently described by Mueller. The most noteworthy and subsequently legendary of these plants was *E. rameliana*, which until its rediscovery in the Little Sandy Desert in July 1991, was presumed to be the only extinct *Eucalyptus* in Australia (Hopper 1992). Other examples of plants collected by Giles in the Little Sandy Desert and subsequently named by Mueller include *Stemodia linophylla* and *Hannafordia bissillii* subsp. *bissillii*. The Calvert Scientific Exploring Expedition of 1896 was next to visit parts of the Desert and make observations on the biota (Wells 1902). Over the next 70 years the Desert remained largely unexplored biologically with the exception of expeditions and collecting trips along the Canning Stock Route (e.g. Otto Lipfert in 1930) and along the No. 1 Vermin Proof Fence (e.g. R.D. Royce in 1947).

Contemporary interest in the natural history of the Desert was sparked in the mid-1970s as a consequence of the recommendations of the Conservation Through Reserve Committee for the establishment of new conservation reserves in the region (Conservation Through Reserve Committee, 1974). Consequently biological surveys were undertaken in the Carnarvon Range, Lake Disappointment and Rudall River areas of the Little Sandy Desert (McKenzie and Burbidge 1979, Burbidge and McKenzie 1983). The biological survey of the Rudall River area was the prologue to the creation of the national park and precursor to extensive biological investigations in the northern part of the Desert during the mid 1980s and throughout the 1990s. These investigations were mainly associated with the Kintyre project in the Throssell and Broadhurst Range but extended far and wide to cover the entire Rudall River National Park and areas of adjacent Unallocated Crown Land (e.g. Martinick and Associates 1986, 1987, Davis and Whittles 1988). In the 1990s the southern portion of the Little Sandy Desert and arguably the least known area in the region, as exemplified through the rediscovery of *E. rameliana*, began to attract biological interest. Most of this interest was in the picturesque Carnarvon Range (e.g. Kenneally 2002) although it quickly became apparent to land management agencies that the south-western portion of the Desert abutting the Gascoyne Biogeographical Region was one of the least known areas in the State with respect to its biota (Hopper 1992). This survey was initiated and designed to address this shortcoming.

SCOPE AND PURPOSE OF SURVEY

The principal objective of this biological survey was to comprehensively, systematically and quantitatively document the flora and fauna of the south-western Little Sandy Desert. Other objectives were to investigate the community arrangement of biota, identify how these communities are partitioned across the landscape and assess the biological and conservation significance of the species and communities encountered. The survey involved a rigorous and comprehensive field program supported by herbarium, museum and laboratory analyses.

The fundamental deliverable is an inventory of the flora and fauna of the south-western Little Sandy Desert. Commensurate with this output are contributions to inventories for the biogeographical region, and an assessment of the distributional, biological and conservation significance of plants and animals within the Desert. The inventories are also used to substantiate recommendations on the conservation status of species and provide the foundation for assessment of the comprehensiveness, adequacy and representativeness of the existing conservation reserve system in the Little Sandy Desert. Outputs from the survey are also used to justify recommendations for augmentation of the Little Sandy Desert conservation reserve network.

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Chapter 2

SOUTH-WESTERN LITTLE SANDY DESERT STUDY AREA

S.J. van Leeuwen and R.N. Bromilow

Science Division, Department of Conservation and Land Management, Karratha.

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

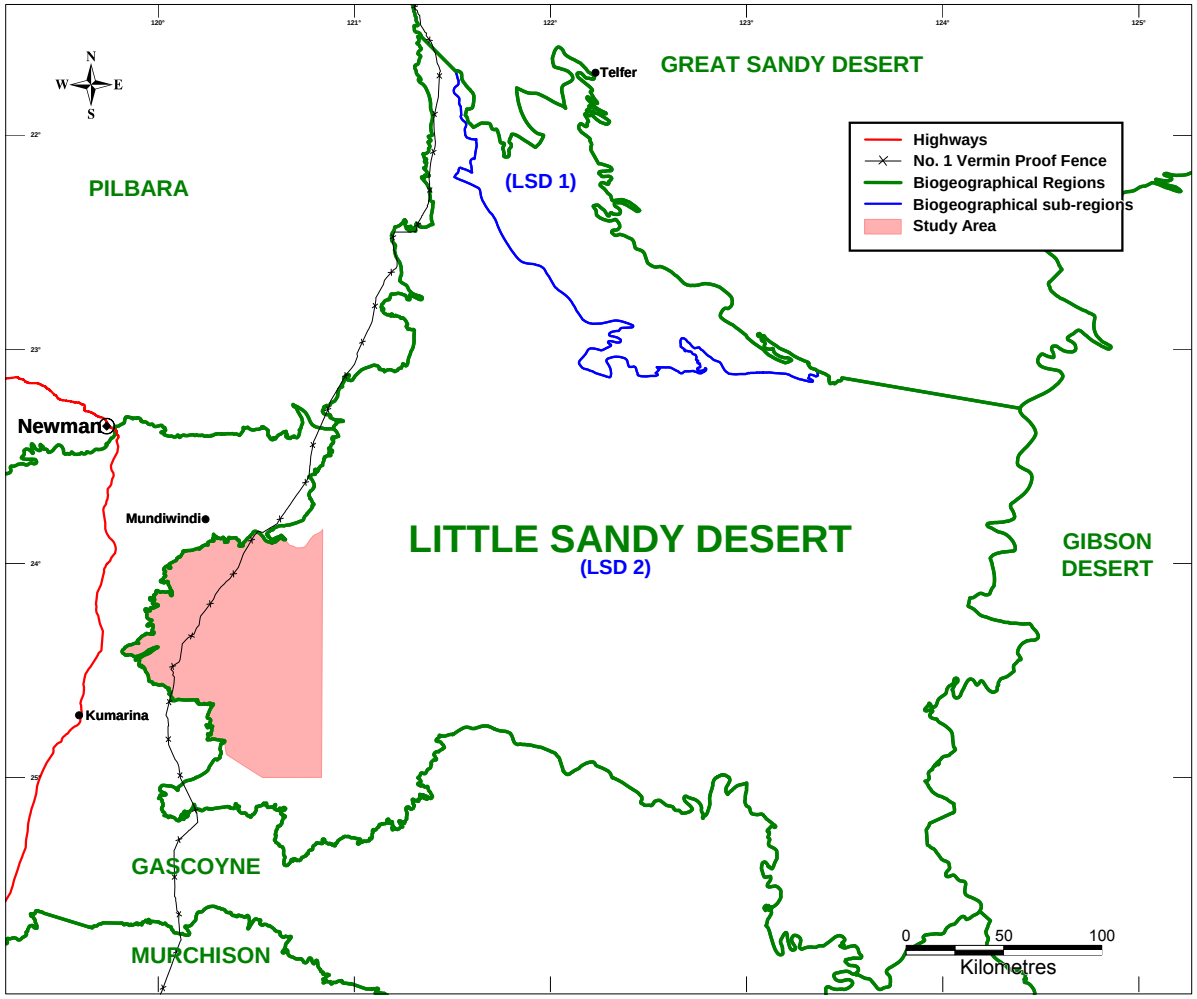

Figure 2.1 Location of the south-western Little Sandy Desert study area within the biogeographical region.

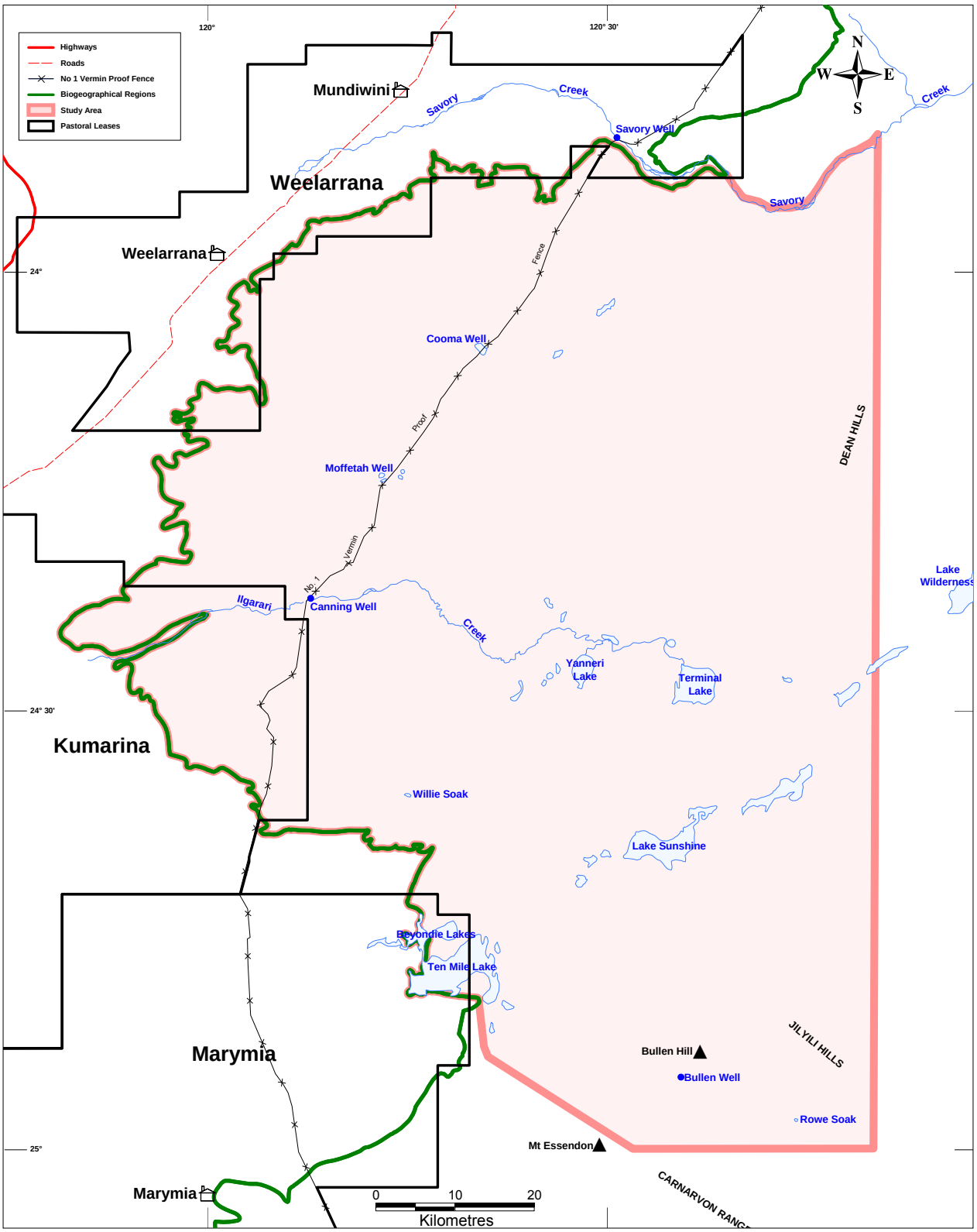

Figure 2.2 Topographical and cadastral setting of the south-western Little Sandy Desert study area.

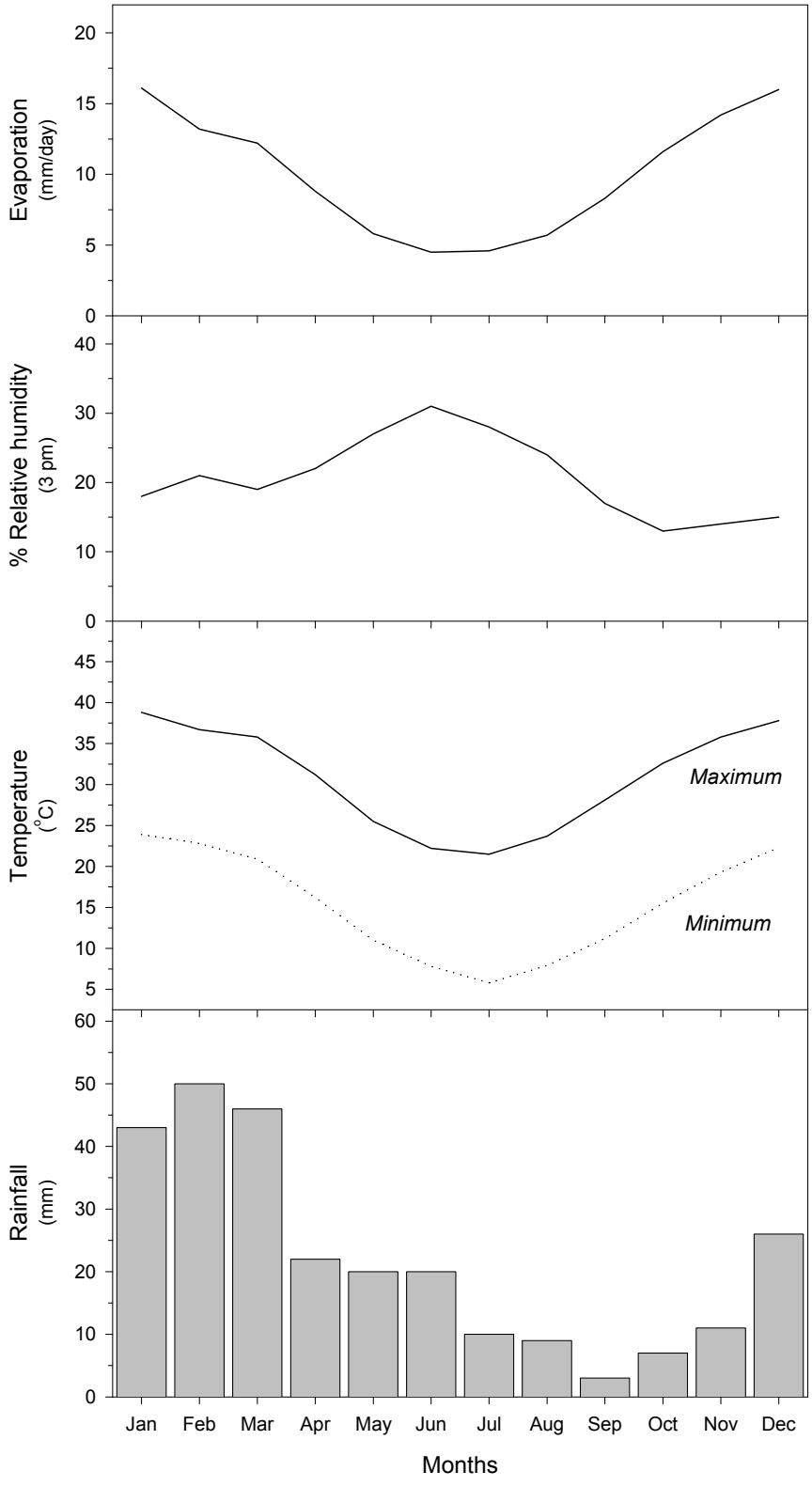

Figure 2.3 Mean monthly minimum and maximum temperatures (°C), % relative humidity (3 pm) and pan evaporation (mm/day) at Mundiwindi (Clewett *et al*. 1999).

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

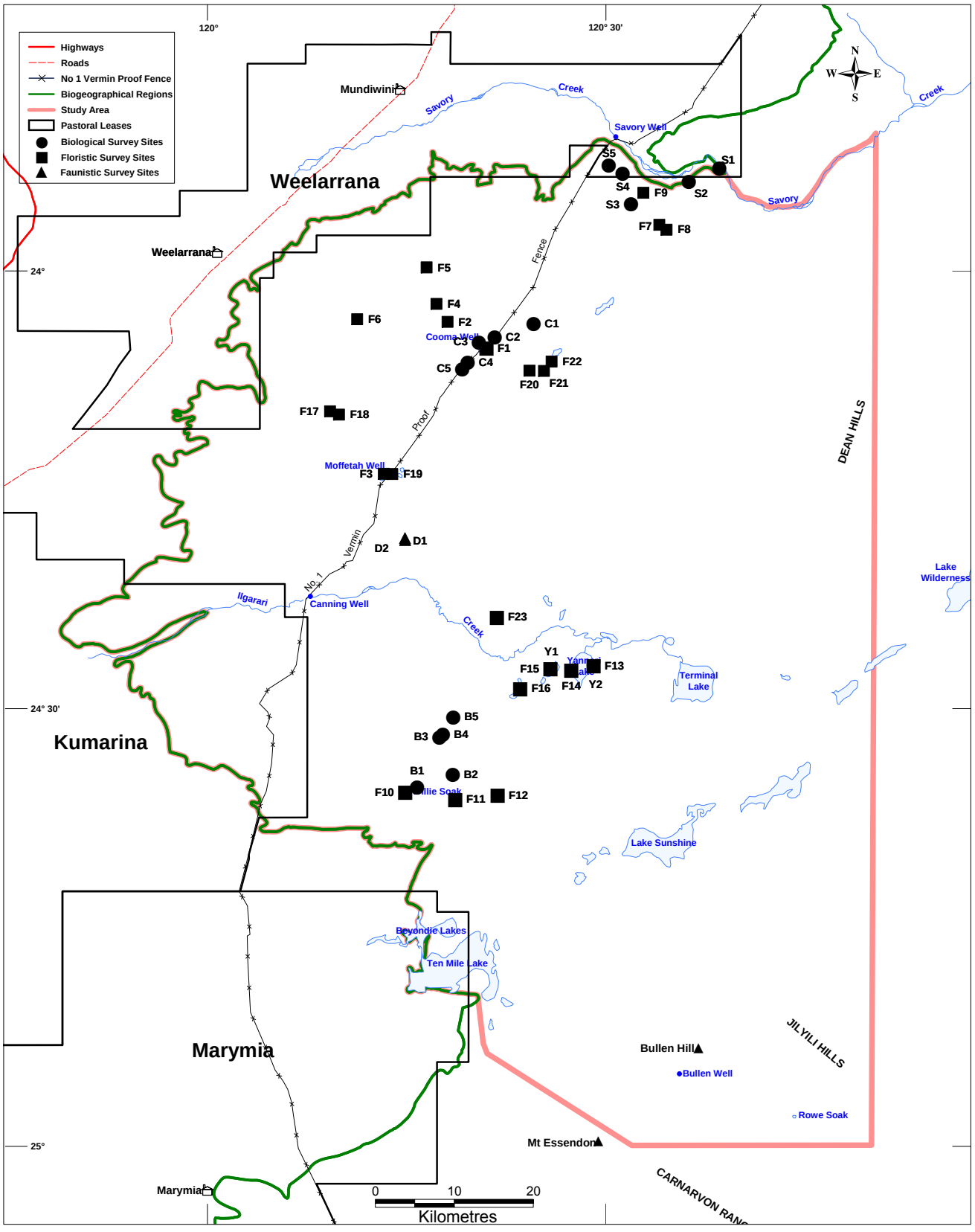

Figure 2.4 Location of the biological and florist survey sites throughout the south-western Little Sandy Desert study area.

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

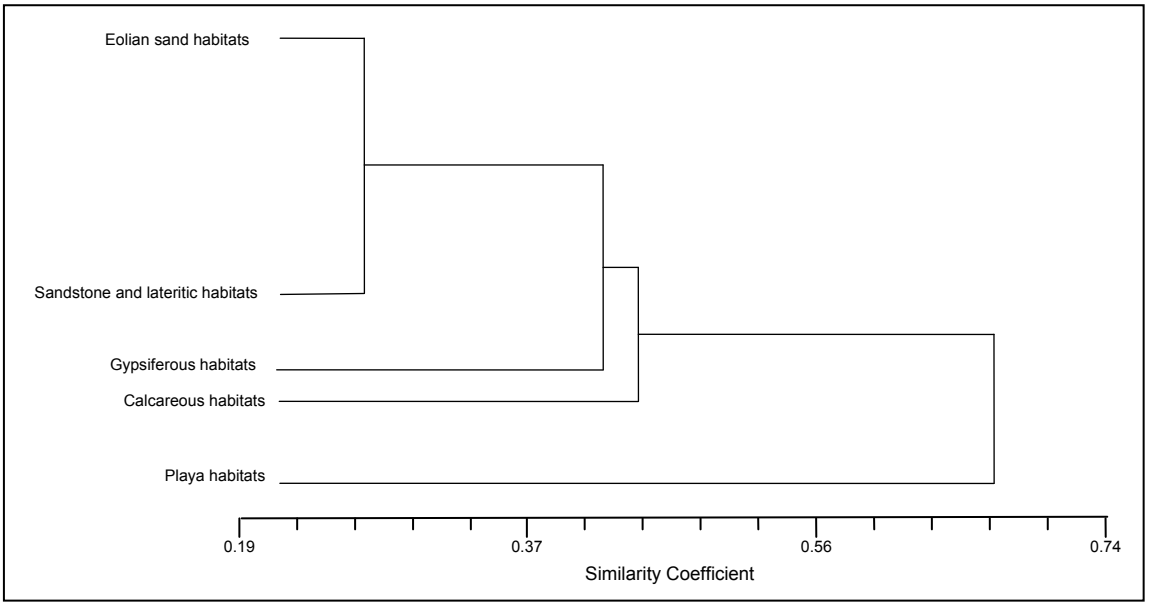

Figure 2.5 Dendrogram of south-western Little Sandy Desert survey quadrats classified according to similarities in the status of their macro-nutrients. (The clustering procedure employed the Bray-Curtis similarity coefficient and the UPGMA fusion method (β = -0.1).)

ACKNOWLEDGMENTS

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We acknowledge David Allen and colleagues from the Agricultural Chemistry Laboratory at the Chemistry Centre of Western Australia for the chemical and mechanical analysis of our soil samples. Phil Fuller is acknowledged for his assistance in the field. Finally, we are grateful to Regina Flugge for her comments on this composition.

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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

Chapter 3

FLORA OF THE SOUTH-WESTERN LITTLE SANDY DESERT

S.J. van Leeuwen and R.N. Bromilow

Science Division, Department of Conservation and Land Management, Karratha.

ABSTRACT

The flora of the south-western Little Sandy Desert is diverse with 522 taxa. Many taxa are of biological and conservation significance and several were not previously recorded in the scientific literature. Many taxa are at the limits of their distributional range and are disjunct outliers of otherwise mostly northern or southern ranges. In broad terms the flora is dominated by central arid zone elements although southern and tropical arid zone groups are present. Floristic communities are readily distinguishable and their arrangement across the landscape appears to be controlled by topographic and edaphic considerations. The placement of the study area in a transitional zone between major phytogeographic elements in the Australian flora together with heterogeneity in land surface types and soils is advanced as justification for the botanical diversity recorded. This diversity differs notably from other areas in the biogeographical region and hence the study area warrants consideration for conservation.

INTRODUCTION

The flora of the Little Sandy Desert is a botanical unknown with very little survey and documentation having been undertaken. Earnest Giles in 1876 was the first to collect plants from the region, the most celebrated being *Eucalyptus rameliana* (Hopper 1992). Unfortunately, no account is available of the other plants that Giles collected on this expedition although the TYPE specimens for four species in addition to *E. rameliana* appear to have been collected by Giles in the Desert. These species are *Hakea rhombales*, *Hannafordia bissillii* subsp. *bissillii*, *Helichrysum gilesii* and *Stemodia linophylla*. Other early visitors to the region, notably John Forrest, Frank Hann, Lawrence Wells and William Rudall appeared to have paid only cursory attention to the plants, being mainly concerned by the presence of stock poisons such as *Gyrostemon ramulosa* and *Gastrolobium grandiflorum*. It is unclear if plants were collected as part of the ill-fated Calvert Scientific Exploring Expedition of 1896. Alfred Canning was another early visitor to the region, surveying and supervising construction of both the Canning Stock Route and the now abandoned No. 1 Vermin Proof Fence. His interest in the flora was limited, extending primarily to the obstacle it presented with respect to the alignment of the Fence and

its utility particularly for the supply of timber necessary for wells, fence posts and yard construction. In 1947 Robert Royce made a extensive plant collection from an area on the edge of this Little Sandy Desert when he travelled north from Jigalong along the route of the No. 1 Vermin Proof Fence to Eighty - Mile Beach (Royce 1948). In total he collected 436 vouchers during this journey although the actual number from the Little Sandy Desert is unclear as the alignment of the fence is mostly outside the western boundary of the Desert north of Jigalong.

Contemporary botanical exploration of the Desert commenced in the late 1970s to early 1980's as a consequence of the realisation by government agencies of a need for conservation reserves in the Great Sandy, Little Sandy and Gibson Deserts (CTRC 1974). Initially survey effort in the Little Sandy Desert was in the Carnarvon Range and Lake Disappointment areas (McKenzie and Burbidge 1979) however localities in the Rudall River area (Muir 1982, George and Mitchell 1983) were also targeted for investigation. These surveys were the forerunners to extensive and protracted investigations in the Rudall River area as a consequence of the activities of resource development companies (Martinick, 1986, 1987, Hart 1990, 1993). In recent times the botanical focus has shifted to the Canning Stock Route (Stephen Hopper, pers. comm.) and localities like the Carnarvon Range (Kenneally *et al.* 2002, Daphne Edinger pers. comm.).

In the early 1990's botanical attention was drawn to the south-western Little Sandy Desert as a consequence of the rediscovery of *E. rameliana* by bushman Nic Foot (Hopper 1992). Early visits to this part of the Desert indicated that the flora was diverse and undocumented, a fact not only clearly demonstrated by the abundance of *E. rameliana* but also by the collection of several poorly known species (e.g. *Stemodia linophylla*), together with species which were at their distributional range ends (e.g. *Calothamnus aridus*) and taxa which were apparently novel having not been reported in the scientific literature previously (e.g. *Sida* sp. nov. Little Sandy Desert (SVL 2489)).

This chapter reports the results of a botanical survey of the south-western Little Sandy Desert conducted over a decade of investigation. A species inventory obtained from systematic and opportunistic sampling throughout the study area is presented together with an analysis on how the flora is arranged into communities. Discussion is forthcoming on the floristics and botanical significance of the study area and recommendations are tendered for conservation.

METHODS

SAMPLING

The sampling regime developed for the botanical survey aimed to sample the dominant surface types typical of the study area as defined in Chapter 2. Initially this objective was accomplished through sampling the flora at each of the five pairs of permanent biological survey quadrats replicated in three localities across the survey area as described in Chapter 2. Subsequently, additional flora sampling sites were also established throughout the study area to sample surface and vegetation types not previously represented.

One hectare quadrats were established at each of the survey sites and all vascular plants within each quadrat were systematically recorded. Sampling time within a quadrats was standardised to two-person hours. All constituent floristic quadrats of the permanent biological survey sites were sampled on three occasions in June 1996, October 1996 and August 1997. All supplementary floristic quadrats were sampled on two occasions although the remoteness of some quadrats (e.g. F23) ensured that they were sampled only once. Quadrats are permanently marked on all corners and photographic records were captured from a fixed point. Orientation and geographical locality were also recorded using a compass and GPS.

In addition to the systematic sampling, considerable opportunistic sampling of the flora was undertaken. Such sampling typically occurred during vehicle traverses across the study area and primarily focused on taxa not previously cited or recorded during the survey. A summary of the sampling events and days of effort is provided in Table 3.1.

Table 3.1 Botanical sampling events and effort expressed as days in the field.

Date	Sampling effort (days in field)	Sampling strategy
August 1991	2	opportunistic
May 1992	7	opportunistic
July 1995	6	opportunistic
October 1995	8	opportunistic
June 1996	17	systematic - opportunistic
October 1996	17	systematic - opportunistic
April 1997	7	opportunistic
August 1997	17	systematic - opportunistic
September 1999	9	opportunistic
August 2001	8	opportunistic

Plant specimens were collected for most taxa encountered during the survey. These specimens were processed in the field and pressed in conventional herbarium plant presses for drying under ambient atmospheric conditions. Details on habit, abundance, locality, habitat, vegetation type and associated species were recorded for each collected specimen. Sufficient material was collected from each sample to facilitate the lodgement of voucher specimens in the Western Australian Herbarium (PERTH) and Pilbara Regional Herbarium (KARR). Duplicate material was also supplied to other Australian herbaria. Specimen identification was performed with reference to standard published floras applicable to the deserts of Western Australia, generic taxonomic treatments or through liaison with taxonomists at the PERTH and Eastern States herbaria. The classification of plants conforms to that currently employed by the Western Australia Herbarium as portrayed in Paczkowska and Chapman (2000) or with that promoted by subsequent taxonomic and systematic treatments.

ANALYSIS

For analytical purposes each quadrat was treated as an independent sampling site culminating in a floristic dataset which comprised 53 quadrats. Floristic composition and patterning was assessed using analytical routines provided in the PATN program (Belbin 1994). These analyses were performed on a presence/absence matrix generated using all taxa recorded from two or more quadrats during the survey. Annuals and ephemerals were included

in the analyses as field sampling was considered sufficiently adequate and comprehensive to document the presence of such plants.

Quadrats were classified according to similarities in taxa using the Czekanowski metric (Faith *et al.* 1987) and the unweighted pair grouped arithmetic averaging clustering strategy (UPGMA, β = -0.1, Belbin 1994). The veracity of the resulting clustering outcome with respect to the initial association matrix was subjectively investigated through the cophenetic correlation (Rohlf 2000). Similarly, deviation from randomness of the relationship between matrices was tested via the normalised Mantel statistic (Z) where the one-tailed probability of $Z = 0$ was determined from 9 999 random permutations (Rohlf 2000). Subsequently accord between the clustering outcome and the similarity matrix was also investigated by the construction of a two-way table of the Species Assemblages and Quadrats Groups using the two-step routine outlined by Belbin (1991).

RESULTS

FLORISTICS COMPOSITION

A total of 552 vascular plant taxa are recorded from the southern Little Sandy Desert during this survey (Appendix 3.1). These taxa comprise six ferns or fern allies and 546 flowering plants. A total of 3 960 quadrat occurrence records are obtained for 345 taxa recorded in the 53 quadrats. Specimens were collected from 203 localities throughout the study area. In total 1 049 voucher specimens representing the 552 taxa were collected.

The recorded flora represented 206 genera from 67 families. As anticipated for an arid sandy desert flora, dominant families in terms of taxonomic representation are the Poaceae (52 taxa), Asteraceae (46), Mimosaceae (46), Chenopodiaceae (35) and Goodeniaceae (34) which combined represent over 39% of the taxa encountered. Twenty-two families are represented by only one taxon while the number of families with five or less taxa is 44. At the generic level the taxonomically dominant groups are *Acacia* (46 taxa), *Eremophila* (21), *Ptilotus* (17), *Goodenia* (17), *Eucalyptus* (14) and *Sida* (13) while the majority of genera (118) are represented by only one taxon. Richness at the generic level is greatest in the families Asteraceae (21), Poaceae (11) and Papilionaceae (13).

Many significant botanical collections were made during the survey. While further taxonomic research is required to confirm exact numbers it appears that several taxa not previously recorded in the Western Australia Herbarium or cited in the scientific literature were collected during the survey. Noteworthy examples of such novel taxa are listed below.

Acacia sp. nov. Little Sandy Desert (SVL 4991)
This undescribed distinctive wattle was collected for the first time during this botanical survey. It appears endemic to sandstone rises east of Willie Soak. The taxon is a member of the Juliflorae and is possibly related to *A. wanyu* (Bruce Maslin, PERTH, pers. comm.).

Goodenia sp. nov. 4463 Little Sandy Desert (SVL 4463)
This undescribed *Goodenia* was collected for the first time during this botanical survey. It does not confirm suitably with any described species concept for a *Goodenia* in Western Australia. Currently is appears endemic to the Little Sandy Desert having been collected near Savory Creek and in a mulga woodland near Willie Soak (Leigh Sage, PERTH, pers. comm.).

Halosarcia sp. Yanneri Lake (SVL 3002)
This spectacular undescribed samphire, which has affinities to the *H. indica* complex, was first collected during this botanical survey. The taxon is endemic to the Yanneri-Terminal Lakes area where it is known from several populations encompassing several hundred-thousand plants (Kelly Shepherd, PERTH, pers. comm.).

Sida sp. nov. Little Sandy Desert (SVL 2666)
This undescribed *Sida* was collected for the first time during this botanical survey. It has close affinities to *S. cardiophylla,* however differs significantly in habit and the density of tomentosum on the branchlets. This taxon may be endemic to the Little Sandy Desert (Robyn Barker, AD, pers. comm.).

Another noteworthy record obtained during the survey is for *Synaptantha tillaeacea* var. *hispidula*. The collection of this taxon from the Ilgarari Creek wash west of Yanneri Lake represents the first record of this taxon in Western Australia. Previously this taxon was known from eastern Central Australia occurring in the Tanami Desert of the Northern Territory across into south-western Queensland, western New South Wales and into the Flinders Ranges of South Australia. Other noteworthy records were obtained for taxa of conservation significance or for those at the edge of their distributional ranges, as discussed below.

Three naturalised weeds (Bipinnate Beggartick (*Bidens bipinnata*), Whorled-Pigeon Grass (*Setaria verticillata*), Kapok (*Aerva javanica*)) were recorded during the survey. The first two taxa are typically short-lived annuals or ephemeral biennials while Kapok is a long-lived perennial. All weed species have a ubiquitous distribution throughout north-western Australia and are not unexpected in the study area. In the study area these weeds are typically found in areas experiencing considerable grazing pressure from livestock and feral animals (donkeys and rabbits) such as the flood plain of Savory Creek and the calcareous dunes and apron fringing Cooma and Moffettah Wells. Indeed, Kapok may have been introduced to the Wells as a consequence of maintenance camps situated at these sites to service the now abandoned No. 1 Vermin Proof Fence.

DISTRIBUTIONAL STATUS

The majority of taxa recorded during the survey have ubiquitous distributions across arid north-western and central Australia . Most species are typically recorded from the adjacent biogeographical regions, in particular the Pilbara, Great Sandy Desert and Gascoyne. The more widespread taxa have distributions which extend throughout the Eremaean Botanical Province and into the South-West Interzone. Many taxa also extend across the Great Victoria and Gibson Deserts into the Northern Territory and northern South Australia.

It appears that endemics to the Little Sandy Desert are limited. Apart from the four new taxa cited previously the only other endemic is *Eucalyptus rameliana*, which is currently known from 33 populations encompassing in excess of *ca* 200 000 plants over a geographical area of *ca*. 3 600 km^2. Most of these populations are with the current study area. Several other taxa are near-endemics (e.g. *Ptilotus aphyllus*, *P. stipitatus*), however they also occur in the neighbouring Pilbara and Gascoyne Biogeographical Regions.

Two-hundred and two taxa (37%) are recorded for the first time in the Little Sandy Desert Biogeographical Region during this survey (Appendix 3.1). Most of these records represent taxa which are distributed ubiquitously throughout the arid zone and interestingly, many are species associated with mulga woodland communities. Many range extensions are recorded and in numerous instances these extensions are substantial. Consequently, the populations identified in the study area represent disjunct outliers for 83 of the taxa recorded. Noteworthy examples of such taxa include the following:

Atriplex spongiosa
This small biennial shrub of samphire flats is sparsely distributed throughout the southern rangelands of Western Australia. Several populations were located during the survey on samphire flats associated with the Ilgarari Creek paleodrainage feature. These populations are 400 km north of the next known population in the Murchison Biogeographical Region.

Comesperma pallidum
This erect shrub is recorded from a number of sand dunes in the study area. It has a sparse distribution throughout the northern Great Sandy Desert and hence the populations located during this survey are 550 km south of the previously documented distributional range of this taxon.

Drosera burmanni
This pygmy sundew is recorded from a number of sites throughout the study area, principally habitats at the base of breakaways or in swales where soils are damp. The populations in the study area are the first recorded for the biogeographic region. These populations are 500 km removed from the next known population and over 1 000 km distant from the typical distributional range of the taxon which is in the northern Kimberley.

Goodenia gypsicola
This recently described small tufted perennial herb was collected from the lunette dunes of kopi adjacent to a number of the playas in the study area. These populations are over 700 km north of the only other known population in Western Australia near Menzies.

Goodenia modesta
This prostrate rambling herb was previously known from several localities in central-eastern West Australia. The populations on Savory Creek, near Yanneri Lake and adjacent to Willie Soak, represent a significant (600 km) westerly range extension for the taxon.

Lechenaultia striata
An erect biennial shrub of sand dune habitats this taxon has a distribution throughout the southern deserts and Central Ranges of Western Australia. The single population located during the survey is some 700 km removed from the next nearest known population west of Neale Junction in the Great Victoria Desert.

Numerous taxa recorded during the survey are at the limits of their distributional range (Appendix 3.1). Such taxa are typically at the southern limits of their range (61 taxa) although many are at their northern, eastern and western limits (32, 7 and 13 respectively). Notable examples of such taxa include the following:

Lomandra leucocephala subsp. *robusta*
The rhizomatous, robust, tussock-forming perennial herb is recorded from many sand dune sites throughout the study area. The taxon has a distribution typically in the Great Victoria Desert and Murchison Biogeographical Region. The populations identified during this survey are at the extreme northern limits of the distributional range for the taxon.

Casuarina pauper
This dioecious tree was recorded around a number of the playas in the study area (e.g. Moffettah Well, Terminal Lake) and is also prolific along Ilgarari Creek where it is intercepted by the abandoned No. 1 Vermin Proof Fence. These populations are at the extreme northern limits of the distributional range for the taxon which is mainly centred on the Goldfields and southern Murchison Biogeographical Regions.

Pimelea trichostachya

This semi-woody annual herb was collected on numerous occasions in mulga communities throughout the study area. These populations are at the extreme northern edge of the distributional range for the taxon, which is principally throughout the Murchison Biogeographical Region.

Acacia adoxa var*. adoxa.*

Several populations of the procumbent spreading shrub are recorded from sandstone rises and breakaway habitats throughout the study area. These populations are the most southern known for the taxon which has a distribution throughout northern Western Australia, mostly above latitude 23° 30' S.

Eucalyptus pachyphylla

Within the study area this mallee is recorded on sand plain habitats over lateritic duricrust west of the abandoned No. 1 Vermin Proof Fence. These populations represent the westerly extent of the distributional range for the taxon which is typically throughout the Gibson, Great Sandy and Tanami Deserts.

CONSERVATION STATUS

Sixteen taxa of conservation significance, as defined by the Department of Conservation and Land Management (Conservation and Land Management 2001), are recorded in the study area (Appendix 3.1). No Declared Rare Flora were identified. The 16 taxa of conservation significance are four Priority 1 species, three Priority 2 species, eight Priority 3 species and one Priority 4 taxon. (see Appendix 3.1 for definitions of Conservation Codes). Details on the taxa of conservation significance follows:

Acacia balsamea **Priority 3**

This taxon was collected on three occasions during the survey. Prior to this survey the species was known from ten localities in the Pilbara, northern Little Sandy Desert and Gibson Desert. The species is known to occur in the Gibson Desert Nature Reserve. Given the areal extent of this distribution it seems likely that this species is poorly collected rather than genuinely rare. Accordingly, a conservation classification of Priority 4 would seem more appropriate for this taxon and is consequently recommended.

Comesperma viscidulum **Priority 2**

This shrub was collected on five occasions from sand dune and swale habitats during the survey. Previously, in Western Australia the taxon was known from only one location near Giles in the Central Ranges Biogeographical Region. Recently it has been collected from four other locations, two on the western edge of the Great Victoria Desert and two from the Carnarvon Range area. This taxon appears to be widely distributed throughout arid central Western Australia as is probably poorly collected rather than genuinely rare. Consequently it is recommended that the conservation status of this species be revised to a Priority 4 classification.

Dampiera ramosa **Priority 2**

This tufted perennial herb was collected at five locations during the survey and recorded on another 16 occasions. In all instances the populations are moderately sized (25+ plants) and growing on the lower slopes of red sand dunes. Prior to this survey this species was known from six locations thorough central southern Western Australia and at least one of these populations is on a conservation reserve. Given the abundance of this taxon in the study area it appears to be poorly collected rather than genuinely rare. It is recommended that this species be removed from the Priority Flora list.

Daviesia arthropoda **Priority 1**

This spiny shrub was collected on a single occasion during the survey from a sand plain habitat west of Cooma Well. This taxon is now known from four localities in Western Australia, two of which are in the Carnarvon Range. This taxon has also been collected in the Northern Territory. Given our poor knowledge on the distributional status of this species it would be appropriate for the taxon to retain a Priority 1 conservation ranking.

Daviesia eremaea **Priority 3**

This rounded shrub was recorded from 20 populations during the survey. These populations are very extensive and comprise many thousands of plants. Prior to the survey this taxon was only known from a single location in the Hamersley Range, Pilbara Region, Western Australia, although the taxonomic status of plants from the Pilbara is unclear (van Leeuwen, unpublished data). The taxon is also known from the Central Ranges of the Northern Territory prior to this survey and subsequently has been collected from east of the Canning Stock Route in the Little Sandy Desert. Given the abundance of this taxon in the study area and its occurrence elsewhere in the Little Sandy Desert it appears that this taxon is poorly collected rather that rare and threatened. Therefore, it is recommended that this taxon be removed from the Priority Flora list.

Eucalyptus rameliana **Priority 4**

The rediscovery of this mallee in the Little Sandy Desert provided the impetuous for this survey which has consequently and conclusively demonstrated that this taxon is neither extinct nor biologically rare. The taxon was recorded from over 30 localities during the survey with populations ranging in size from a few individuals to those comprising several thousand plants. Current estimates indicate than in excess of 200 000 plants occur within the study area. Several additional populations of this mallee have also been located outside the study area in the dunefields abutting the northern apron of the Carnarvon Range. As a consequence of a vastly improved appreciation of the habitat requirement of this mallee it is recommended that the taxon be removed from the Priority Flora list.

Fimbristylis sieberiana **Priority 3**

This rhizomatous grass-like sedge was recorded on only one occasion during the survey. This population is the first to be recorded in the Little Sandy Desert and represents a disjunct outlier from a typically Pilbara and southern Kimberley distribution. This new populations confers little additional information to our appreciation of the conservation status of this taxon and therefore the current conservation ranking is supported.

Frankenia glomerata **Priority 1**

This small shrub was recorded on one occasion during the survey. Prior to the survey the taxon was known from four localities in the southern rangelands of Western Australia. This new population confers little additional information to our appreciation of the conservation status of this species and therefore the current conservation ranking is supported.

Goodenia modesta **Priority 3**

This trailing perennial herb was recorded on numerous occasions during the survey particularly in shallow deflation basins associated with mulga woodlands and calcareous soils. The populations recorded during this survey are the first for the Little Sandy Desert and are significantly removed from the typical distributional range of the taxon which is in the western Gibson and Great Sandy Deserts. Some uncertainly exists as to the taxonomic status of this taxon and its relationship to *G. lyrata*, itself a Priority 1 taxon. Consequently as a result of taxonomic uncertainty and insufficient knowledge it is recommended that this taxon retain its current conservation ranking.

Goodenia pascua **Priority 3**

This erect to ascending herb of heavy soils was collected on a single occasion within the study area during the survey. Prior to this collection the taxon was known from six populations in the central and western Pilbara. Considerable confusion exists as to the taxonomic status of this taxon and how the specimens collected from the Little Sandy Desert conform to the G. pascua species concept. Consequently, as a result of this taxonomic uncertainty and insufficient knowledge it is recommended that this taxon retain its current conservation ranking.

Goodenia schwerinensis **Priority 3**

This ascending and spreading shrub was collected on three occasions during the survey and recorded on another 11 in sand dune habitats. The taxon appears to be frequent throughout the study area. The species is also known from another nine localities throughout the central interior of Western Australia where it is commonly found in sand dune terrain. It would appear that this taxon is poorly collected rather than genuinely rare and accordingly it should be removed from the Priority Flora list.

Mimulus repens **Priority 3**

This prostrate creeping herb was collected on three occasions during the survey from alluvial wash areas adjacent to Savory Creek. These three localities represent the first record for this taxon in the Little Sandy Desert. The taxon is also known from seven other localities, principally to the south-west of the study area. The populations recorded during this survey are threatened by grazing and trampling from stock and feral animals. Consequently it is recommended that the taxon be retained on the Priority Flora list at its current conservation ranking.

Ptilotus aphyllus **Priority 3**

This open low shrub was collected on 10 occasions in the study area and recorded from numerous other localities during the survey. The taxon is not uncommon to broad swales and lateritic rises with red sand in the south-western portion of the Little Sandy Desert. The taxon is also known from four collections and numerous other localities south of McCameys Monster in the Pilbara. The current conservation ranking for this taxon appears inappropriate. Consequently it is recommended that the taxon be removed from the Priority Flora list.

Ptilotus stipitatus **Priority 1**

This erect low shrub or biennial herb was recorded on numerous occasions during the survey, principally from *Acacia* shrubland communities on sandy soils and occasionally amongst hummock grasses on lateritic rises. The taxon is not uncommon in the study area. The taxon is also known from five other populations, three of which are in or adjacent to the Little Sandy Desert and outside the current study area boundary. The current conservation ranking for this taxon appears inappropriate and consequently it is recommended that a conservation ranking of Priority 4 is be more appropriate.

Ptilotus tetrandrus **Priority 2**

This upright annual herb was collected on a single occasion during the survey from a burnt *Aluta maisonneuvei* dominated swale south of Willie Soak. This population, which is comprised of just a few individuals is the second recorded for the taxon. The TYPE specimen was collected on Glenorn Station in the southern Murchison in 1974. Given that extensive botanical survey work throughout the southern Murchison - northern Goldfield over the past 20 years has failed to record this taxon it may indeed be genuinely rare. Therefore it is recommended that the conservation status of this taxon be raised to a Priority 1 ranking.

Stemodia linophylla **Priority 1**

Prior to this survey this small upright aromatic herb was known from only two collections in Western Australia, apart from the TYPE which was collected by Giles somewhere 'Trans montes Alfred and Marie's Range' which broadly translated means 'beyond the Alfred and Marie Range'. Coincidentally this is the same locality description provided on the TYPE specimen of *E. rameliana*. Therefore it came as no surprise that this taxon was recorded in the study area, although its abundance and ubiquitous distribution across the landscape was astonishing. Approximately 80 populations of this herb were recorded during the survey over the entire latitudinal extent of the study area. Populations range in size from a few individuals fringing small playas to several thousand plants in calcareous soil depressions to several hundred-thousand plants in recently burnt sand plain habitat fringing both Savory and Ilgarari Creeks. The taxon has also recently been collected near Kintyre in the Rudall River area, near Telfer in the Great Sandy Desert and at Patients Well in the Gibson Desert. Clearly this species is far more common and widespread than previously appreciated. It is recommended that the species is removed from the Priority Flora list.

In addition to the taxa of conservation significance mentioned above, results from this survey indicate that several taxa should be considered for addition to the Priority Flora List. These taxa and justifications for the recommendations are provided below.

Halosarcia sp. Yanneri Lake (SVL 3002)

This novel taxon is a narrow endemic to samphire flats fringing playas and gypsiferous lake beds at the end of Ilgarari Creek. The species was not recorded from Lake Sunshine or the small plays north of Ilgarari Creek such as a Cooma and Moffettah Wells. The taxon appears to be genuinely rare although locally common. Obviously, no populations are known from land reserved for conservation. As threats are currently minimal it is recommended that this taxon is assigned a Priority 2 conservation code. It would not be inappropriate to considered this *Halosarcia* for gazettal as Declared Rare Flora as it appears genuinely rare and the stringent

survey requirement for gazettal have probably been achieved given the botanical survey effort in the south-western Little Sandy Desert over the past decade.

Comesperma pallidum

This erect shrub was known from four localities in the Little and Great Sandy Deserts prior to this survey. During the current survey it was recorded from two localities comprising populations of only a few (< 5) plants. When present the taxon is conspicuous as a consequence of its habit and hence it is unlikely to be overlooked by botanists. Therefore given the low number of known populations despite considerable survey effort associated with the Canning Stock Route and mineral development projects like Telfer and Kintyre in the Little and Great Sandy Deserts in recent times, this taxon may genuinely be rare. Therefore it is recommended that this taxon be assigned a Priority 2 conservation ranking.

FLORISTIC RICHNESS AND PATTERNING

The floristic richness of sample sites varies from eight to 74 taxa per quadrat with a mean of 33.7 ± 14.4 (SE). The least specious quadrats tend to be those associated with the samphire communities fringing playas while the most specious tend to be those on the sandstone ridges and breakaways. Three-hundred and forty-five taxa are recorded from quadrats with the most frequently encountered taxon being *Aristida contorta* which is recorded from 28 (53%) sites. Other frequently encountered taxa are *A. ligulata*, *Hakea lorea*, *A. maisonneuvei*, *P. obovatus*, *Scaevola parvifolia* subsp. *pilbarae* and *Solanum lasiophyllum* which are all recorded from a minimum of 20 quadrats. Conversely, 71 (21%) taxa are recorded from one quadrat only and overall 232 (67%) taxa are recorded from five or fewer quadrats.

The dataset employed to undertake PATN analysis comprises 274 entities or 79% of the taxa recorded in quadrats. This dataset consisted of annuals and ephemeral taxa as sampling effort was considered adequate to consistently record such species and exploratory data analysis indicates that their exclusion has no impact on the resulting similarity matrix and thus clustering outcome. The 71 singletons, taxa recorded from only one quadrat, are excluded from the analysis as previous investigations indicate that they add little to the definition of cluster groups (Gibson *et al*. 1997, Keighery *et al*. 2000).

In the clustering routine, partitioning ceased at seven quadrat groups as valid ecological interpretations could be provided at this level (Figure 3.1). Subdivision beyond this level was ecological problematic although it is clear from Figure 3.1 that sub-groups exists within some of the primary quadrats groupings. The cophenetic correlation (r = 0.92) between the ultrametric values matrix used to generate the clustering outcome and the similarity matrix indicate that the clustering outcome is an excellent fit of the original similarity matrix. Inherently, this association between matrixes differs significantly from random (t = 21.21, P = 0.002). Appendix 3.2 depicts the distribution of the seven Quadrat Groups across the study area. No patterns associated with latitudinal or environmental gradients are evident.

Nine Species Assemblages are identified in the two-step species classification routine (Table 3.2). The cophenetic correlation (r = 0.73) subjectively indicates that the clustering outcome which facilitates the identification of these nine Species Assemblages is a ‘poor fit’ (Rohlf 2000) of the original similarity matrix. Nevertheless the two-step species classification provides valuable insight into the species composition of the Quadrats Groups and the fidelity of taxa to these community types.

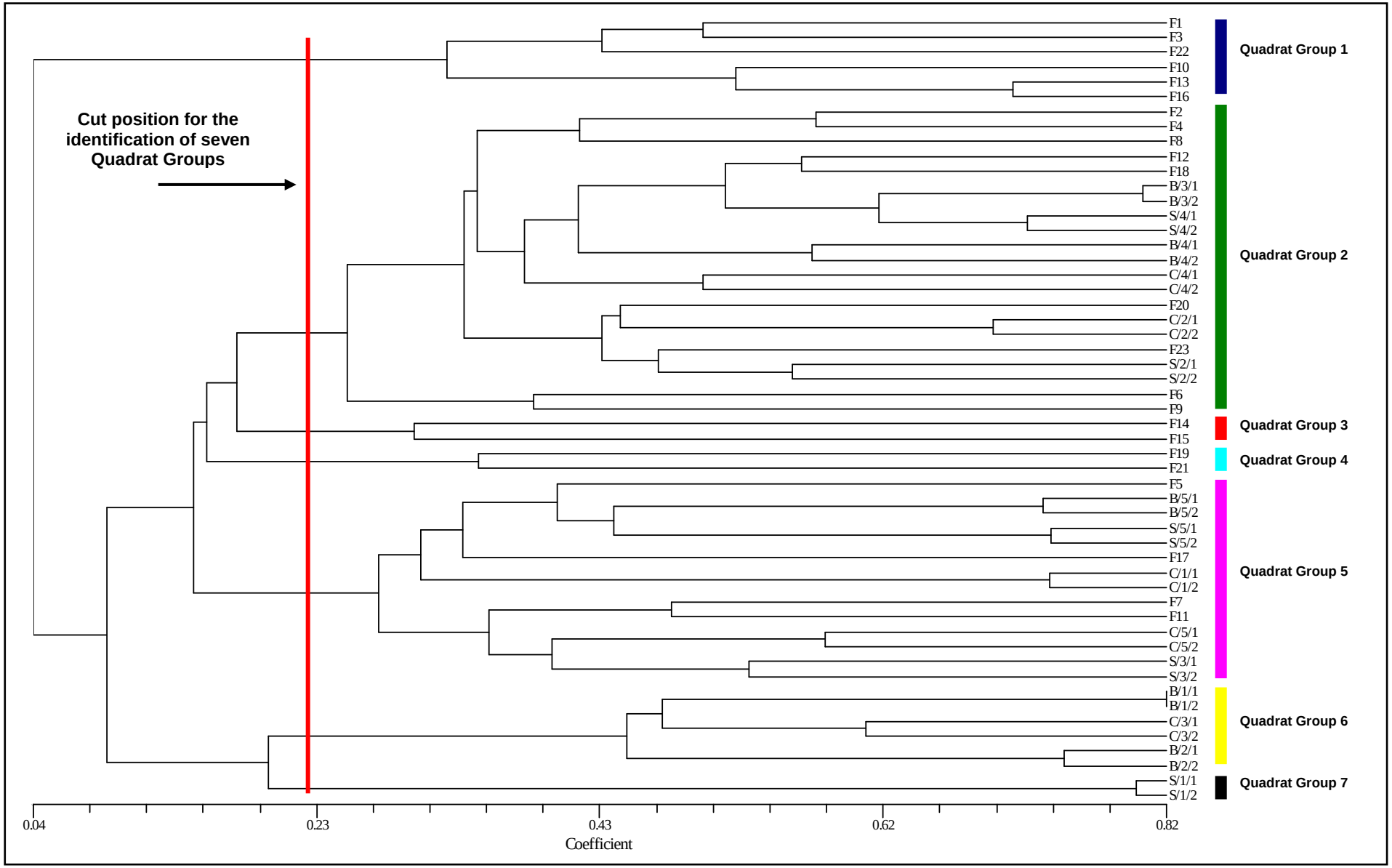

Figure 3.1 Dendrogram of 53 quadrats from the south-western Little Sandy Desert classified by their vascular flora using the Czekanowski metric and unweighted pair grouped arithmetic averaging clustering strategy (UPGMA, β = -0.1).

The ecological interpretation for the seven Quadrat Groups identified is uncomplicated and essentially is associated with geological and edaphic factors which are expressed in the field as differences among quadrats in topography and land surface types. Fundamentally the 53 quadrats are differentiated into seven cluster groups as a consequence of their topographical position and soil type. The primary dichotomy is between quadrats associated with playa and lake surfaces with hypersaline soils and those higher in the topographical sequence with mostly non-saline soils. This primary dichotomy is clearly evident in the two-way table classifying Quadrat Groups and Species Assemblages (Table 3.2). The next division in the dendrogram (Figure 3.1) distinguishes quadrats high in the topographic sequence where sandy pediments dominated from those lower in the landscape where heavy soils are encountered. Subsequent discrimination segregates the sandy pediment into those characterised by eolian sands, rocky sand pediments and gypsiferous or calcareous pediments. A description of the seven Quadrat Groups follows:

Quadrat Group 1

Characteristically located at the bottom of the topographic sequence and expressed as playa or lake bed habitats with hypersaline soil conditions. Vegetation of this Quadrat Group is best described as samphire heath dominated by *Halosarcia* and *Sclerolaena* taxa in conjunction with other halophytic plants. Eleven taxa are only recorded from this community which is best defined by taxa in Species Assemblage I (Table 3.2). This community type has the lowest floristic richness estimate of 14.3 ± 1.8 taxa per hectare.

Quadrat Group 2

This group of quadrats is dominated by eolian red sands and includes both sand dune and sand plain habitats. Potentially the group could be divided into two sub-groups based on these habitat types although the placement of some sand plain quadrats (F2, F4 and B4) within the greater dune cluster (quadrats F2 to C4) is problematic. Plants from Species Assemblages C, F and G are most frequently encountered in these eolian sand communities, particularly those from the latter Species Assemblage which display high fidelity (Table 3.2). Frequently encountered taxa are *A. maisonneuvei, A. melleodora, A. ligulata* and *Grevillea eriostachya* while loyal taxa are *Stylidium humphreysii, Corymbia chippendalei, Phyllota luehmannii* and *Goodenia xanthosperma*.

Quadrat Group 3

These quadrats are gypsiferous being located on lunette kopi dunes which are adjacent to playas. Constituent taxa recorded from these quadrats are principally derived from Species Assemblages F, G and I although the members of no particular Species Assemblage dominated (Table 3.2). Most of the constituents are ubiquitous taxa occurring in at least one other Quadrat Group although two taxa (*Eremophila glabra*, *Templetonia egena*) are endemic to this Quadrat Group.

Quadrat Group 4

The two sites that comprise this Quadrat Group are described as being on calcareous pediments with a veneer of eolian sand. Visually both quadrats are dominated by *Melaleuca* heaths and hummock grasses. As with Quadrat Group 3 the constituent taxa of these quadrats are mostly ubiquitous (Table 3.2). This point is clearly demonstrated by infidelity in all taxa recorded from this community with the exception of *Maireana* sp. nov. Little Sandy Desert (SVL 3243).

Quadrat Group 5

This group of quadrats comprises sites on rocky pediments as exemplified by sandstone ridges and breakaways together with rolling lateritic hills. This Quadrat Group could effortlessly and with minimal compromise be subdivided into two sub-groups expressed as sandstone uplands (B5 to C1) and lateritic hills (F7 to S3). Unfortunately the placement of the lateritic F5 quadrats in the Sandstone upland sub-group is somewhat problematic. Sites within this Quadrat Group are dominated by low mulga and mixed Acacia woodlands. Fidelity to this type of community was greatest for taxa of Species Assemblage A with all constituent species being recorded from this community type only. Many other taxa in Species Assemblages B, D and E are also exclusive to this floristic community. Other Species Assemblages with notable contribution of

Table 3.2 Sorted two-way table of the seven Quadrat Groups and nine Species Assemblages identified from 274 plants recorded from 53 quadrats in the south-western Little Sandy Desert Study area.

Quadrat Groups

	Taxon	1						2																					3		4		5														6						7	
		F1	F3	F22	F10	F13	F16	F2	F4	F4	F12	F18	B3/1	B3/2	S4/1	S4/2	B4/1	B4/2	C4/1	C4/2	F20	C2/1	C2/2	F23	S2/1	S2/2	F6	F9	F14	F15	F19	F21	F5	B5/1	B5/2	S5/1	S5/2	F17	C1/1	C1/2	F7	F11	C5/1	C5/2	S3/1	S3/2	B1/1	B1/1	C3/1	C3/2	B2/1	B2/2	S1/1	S1/2
Species Assemblage A	*Acacia hilliana*																																				*	*																
Species Assemblage A	*Hibiscus coatsii*																																				*	*																
Species Assemblage A	*Dodonaea pachyneura*																																				*	*																
Species Assemblage A	*Sida arenicola*																																				*	*																
Species Assemblage A	*Corchorus sidoides*																																				*	*																
Species Assemblage A	*Rulingia* sp. SVL 2376																																				*	*																
Species Assemblage A	*Cassytha filiformis*																																				*	*																
Species Assemblage A	*Triodia pungens*																																				*	*																
Species Assemblage B	*Grevillea striata*																																				*								*									
Species Assemblage B	*Senna glutinosa x luerssenii*																																			*	*	*								*								
Species Assemblage B	*Dodonaea petiolaris*																																				*	*			*	*												
Species Assemblage B	*Eucalyptus pachyphylla*																				*																*						*											
Species Assemblage B	*Hibiscus sturtii truncatus*																																	*	*	*	*	*																
Species Assemblage B	*Heliotropium chrysocarpum*																																	*	*	*	*	*																
Species Assemblage B	*Grevillea wickhamii aprica*									*																								*	*		*	*					*											
Species Assemblage B	*Halgania solanacea hirsuta*																				*	*												*	*	*	*	*																
Species Assemblage B	*Eucalyptus mannensis*																						*														*																	
Species Assemblage B	*Senna glutinosa pruinosa*																																*				*	*																
Species Assemblage B	*Eremophila exilifolia*																																				*	*	*														
Species Assemblage B	*Dampiera candicans*																																*					*	*														
Species Assemblage B	*Acacia spondylophylla*																																*				*	*	*	*													
Species Assemblage B	*Senna glutinosa glutinosa*																																*			*	*	*	*	*													
Species Assemblage B	*Vittadinia arida*																																				*		*	*													*	
Species Assemblage B	*Ptilotus macrocephalus*																						*					*										*		*						*								
Species Assemblage B	*Scaevola browniana*																										*						*		*			*							*									
Species Assemblage B	*Indigofera monophylla*																										*						*		*		*	*	*	*													
Species Assemblage B	*Gompholobium polyzygum*																				*						*						*		*		*	*		*			*											
Species Assemblage B	*Acacia pruinocarpa*																																					*	*	*			*	*	*	*								
Species Assemblage B	*Acacia adsurgens*																										*						*	*			*	*	*	*			*			*					*			
Species Assemblage B	*Tribulus suberosus*																										*						*				*	*	*	*				*	*	*						*		
Species Assemblage B	*Cheilanthes brownii*																																				*		*	*	*	*												
Species Assemblage B	*Eremophila petrophila*																																	*			*		*	*	*	*												
Species Assemblage B	*Eriachne mucronata*																																	*			*	*	*	*	*			*										
Species Assemblage B	*Dysphania rhadinostachya*																																		*	*	*	*	*	*	*	*												
Species Assemblage B	*Solanum phlomoides*																				*														*	*	*	*	*	*	*	*												
Species Assemblage B	*Trachymene bialata*																*																				*		*	*	*				*									
Species Assemblage B	*Hybanthus aurantiacus*																			*														*	*		*	*			*	*												
Species Assemblage B	*Sida* sp. nov. SVL 2666																					*												*	*	*	*		*		*	*	*											
Species Assemblage B	*Senna helmsii*																					*												*	*		*				*	*	*	*	*	*								
Species Assemblage B	*Psydrax latifolia*																*			*															*		*	*	*	*	*	*		*		*								
Species Assemblage B	*Acacia rhodophloia*										*						*			*	*												*		*		*	*	*	*	*	*			*	*								
Species Assemblage B	*Santalum lanceolatum*											*															*						*	*	*		*	*	*	*	*	*						*						
Species Assemblage B	*Senna artemisioides olig.*																				*	*	*				*						*		*	*		*	*	*	*					*								
Species Assemblage B	*Eremophila latrobei glabra*																											*							*	*	*	*	*	*	*	*	*								*	*		
Species Assemblage C	*Grevillea striata*											*																										*																
Species Assemblage C	*Acacia bivenosa*													*																							*	*																
Species Assemblage C	Genus nov. sp. nov. SVL 3275													*	*																						*																	
Species Assemblage C	*Porana commixta*																						*												*																			
Species Assemblage C	*Dodonaea coriacea*																						*		*										*																			
Species Assemblage C	*Jacksonia aculeata*																								*										*																			
Species Assemblage C	*Corymbia deserticola*									*											*												*	*					*															
Species Assemblage C	*Acacia ramulosa ramulosa*									*											*	*					*													*														
Species Assemblage C	*Eriachne aristidea*																*										*												*		*	*												
Species Assemblage C	*Marsdenia australis*																				*						*	*													*	*												
Species Assemblage C	*Dampiera dentata*												*								*				*									*				*																
Species Assemblage C	*Petalostylis cassioides*																			*			*		*	*		*					*	*					*															
Species Assemblage C	*Paraneurachne muelleri*																						*	*	*		*	*						*	*		*																
Species Assemblage C	*Goodenia azurea*			*												*				*					*			*				*	*		*		*	*							*									
Species Assemblage C	*Amphipogon carinatus*																			*					*		*	*						*		*	*	*	*	*					*	*								
Species Assemblage C	*Dicrastylis georgei*									*								*			*			*	*		*	*					*	*			*	*	*	*														
Species Assemblage C	*Ptilotus schwartzii*																*		*	*					*	*	*	*					*	*	*	*	*	*							*	*								
Species Assemblage C	*Goodenia triodiophylla*								*								*			*			*	*	*	*					*	*		*	*	*	*	*	*	*					*	*								
Species Assemblage C	*Acacia kempeana*										*						*				*		*										*		*		*		*															
Species Assemblage C	*Triodia lanigera*												*	*	*	*							*	*	*									*	*	*	*	*	*															
Species Assemblage C	*Triodia schinzii*											*	*				*	*					*	*			*	*			*						*	*	*	*	*	*													
Species Assemblage C	*Keraudrenia* sp. SVL 2376							*		*	*	*					*	*	*	*			*				*						*		*		*	*	*	*															
Species Assemblage C	*Calytrix carinata*							*	*	*	*	*				*	*		*	*		*			*	*	*	*					*	*			*	*	*	*															
Species Assemblage C	*Anthobolus leptomerioides*																*					*						*	*				*		*		*	*					*	*		*								
Species Assemblage C	*Eremophila citrina*																*	*			*									*			*	*	*								*	*	*	*								
Species Assemblage C	*Brunonia australis*								*								*				*														*					*	*				*	*			*					
Species Assemblage C	*Eragrostis xerophila*								*	*	*						*						*	*								*			*	*	*		*	*	*	*	*									*	*		
Species Assemblage C	*Euphorbia boophthona*																*		*			*	*				*	*							*	*	*		*	*		*												*	*
Species Assemblage C	*Polygala isingii*																*								*	*	*	*			*			*	*			*	*	*	*						*	*						
Species Assemblage C	*Eremophila forrestii*									*					*		*				*	*				*	*	*							*	*								*	*	*				*	*			
Species Assemblage C	*Solanum lasiophyllum*	*		*								*			*		*	*					*		*	*	*						*	*	*	*		*			*	*	*	*		*	*	*		*	*	*		
Species Assemblage C	*Ptilotus polystachyus*												*	*			*		*				*	*		*	*	*							*	*			*	*					*	*	*	*		*	*			
Species Assemblage C	*Aristida contorta*								*		*	*	*	*	*	*	*	*	*				*	*	*	*	*	*						*	*					*					*	*	*	*	*	*	*	*	*	
Species Assemblage D	*Trianthema glossostigma*																																		*										*	*								
Species Assemblage D	*Waitzia acuminata*												*																						*										*	*								
Species Assemblage D	*Eremophila latrobei*									*																									*	*				*				*		*								
Species Assemblage D	*Senna glaucifolia*																																	*		*					*		*	*	*	*								
Species Assemblage D	*Acacia ayersiana*																																		*	*						*	*	*	*	*								
Species Assemblage D	*Acacia aneura microcarpa*																																		*	*				*			*	*			*	*						
Species Assemblage D	*Hibiscus burtonii*																																			*					*					*				*				
Species Assemblage D	*Maireana planifolia*																		*																	*										*			*	*				
Species Assemblage D	*Psydrax attenuata*									*											*						*																*	*		*				*				
Species Assemblage D	*Psydrax suaveolens*																							*			*									*	*						*	*	*					*				

Quadrat Groups

Taxon	1						2																				
	F1	F3	F22	F10	F13	F16	F2	F4	F4	F12	F18	B3/1	B3/2	S4/1	S4/2	B4/1	B4/2	C4/1	C4/2	F20	C2/1	C2/2	F23	S2/1	S2/2	F6	F9
Species Assemblage D (cont.)																											
Amaranthus mitchellii																							*		*	*	*
Acacia aneura sp. SVL 2545																											
Maireana villosa	*																										
Senna artemisioides x *artem.*																						*					*
Acacia coriacea sericophylla																		*	*								
Acacia tetragonophylla	*																						*		*	*	*
Acacia aneura aneura																				*	*				*	*	*
Ptilotus obovatus									*													*					
Scaevola spinescens			*				*									*										*	*
Velleia glabrata																											
Stenopetalum anfractum																											
Calocephalus Pilbara-Deserts																*											
Ptilotus exaltatus														*													
Haloragis gossei		*	*	*	*							*															
Eremophila longifolia																*											*
Rhyncharrhena linearis																										*	*
Species Assemblage E																											
Prostanthera albiflora																											
Sida pilbarensis																											
Lysiana casuarinae																											
Sida excedentifolia																				*							
Phyllanthus lacunellus																											
Stackhousia intermedia																											
Calotis hispidula																											
Wahlenbergia tumidifructa																											
Chenopodium saxatile																											
Solanum horridum																											
Cheilanthes sieberi sieberi																											
Nicotiana benthamiana																											
Polycarpaea holtzei																											
Hibiscus sp. SVL 2489																											
Acacia cuthbertsonii																											
Synaptantha tillaeacea till.																											
Thysanotus exiliflorus																									*		
Acacia eriopoda																										*	
Genus nov. sp. nov. SVL 3256																						*					
Gonocarpus eremophilus																											
Eriachne pulchella pulchella																											
Eucalyptus oldfieldii																											
Acacia daviesioides																											
Wurmbea deserticola												*	*														
Pimelea trichostachya												*	*			*											
Podolepis canescens												*				*											
Species Assemblage F																											
Eucalyptus sp. SVL 2457							*	*																		*	*
Diplopeltis stuartii																										*	*
Acacia stowardii																										*	*
Velleia connata							*						*													*	*
Leptosema chambersii																			*					*		*	*
Indigofera georgei								*												*		*				*	*
Acacia maitlandii								*										*	*			*			*	*	*
Lamarchea sulcata																		*	*								
Triodia wiseana											*							*	*			*			*		
Stylobasium spathulatum																						*					
Ptilotus sp. SVL 3248																						*					
Acacia sp. SVL 2397							*	*	*											*		*					
Alyogyne pinoniana	*									*												*	*				
Clerodendrum tomentosum											*				*												
Lomandra leucocephala rob.											*																
Eucalyptus rameliana									*	*	*																
Senna pleurocarpa								*	*	*	*												*				
Frankenia fecunda			*							*																	
Microcorys macredieana											*	*	*							*		*					
Acacia validinervia								*			*	*	*						*							*	
Eragrostis olida								*		*		*	*	*	*		*					*		*			
Eriachne ovata									*		*	*	*	*	*	*	*							*			
Grevillea stenobotrya									*	*	*	*	*	*	*	*	*	*	*					*	*	*	*
Acacia melleodora							*	*	*	*	*	*	*	*		*	*	*	*	*		*	*	*	*	*	
Aluta maisonneuvei							*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*
Scaevola parvifolia pilbarae							*	*	*	*	*	*	*	*	*		*	*			*	*	*	*	*	*	*
Bonamia pannosa							*	*	*			*	*	*	*		*	*	*	*	*	*		*	*	*	*
Grevillea eriostachya								*	*	*	*	*	*	*	*	*	*	*	*				*	*		*	*
Acacia ligulata	*							*		*	*	*	*	*	*			*	*	*	*	*	*		*	*	*
Brachychiton gregorii										*	*			*						*		*					*
Acacia jamesiana							*	*	*	*				*		*		*				*				*	
Calandrinia polyandra								*				*				*						*				*	*
Eucalyptus gamophylla										*	*					*		*			*	*	*			*	*
Acacia abrupta										*		*				*				*		*	*			*	*
Solanum centrale								*	*	*	*		*		*	*			*	*		*	*		*	*	*
Hakea lorea									*	*	*	*			*				*	*	*	*	*	*	*	*	*
Capparis spinosa							*	*	*	*														*			*
Species Assemblage G																											
Dysphania kalpari	*															*											
Prostanthera wilkieana																*	*										
Xerochrysum sp. SVL 1831																*	*										
Acacia dictyophleba												*				*	*	*									
Corchorus sp. SVL 2383												*	*			*	*		*								
Pityrodia loricata							*	*				*	*			*	*										
Comesperma pallidum											*	*	*			*											
Kennedia prorepens										*		*				*	*	*									*
Xanthorrhoea thorntonii							*				*					*	*										
Dicrastylis sp. *Kumarina*							*	*			*				*	*	*	*	*								
Ptilotus aphyllus									*						*	*	*	*			*						
Corynotheca micrantha div.												*	*														
Dicrastylis sp. SVL 2937											*	*	*														
Dampiera ramosa												*	*	*													
Eragrostis eriopoda												*	*	*	*												
Pityrodia loxocarpa												*	*	*	*												

Taxon	3		4		5														6						7	
	F14	F15	F19	F21	F5	B5/1	B5/2	S5/1	S5/2	F17	C1/1	C1/2	F7	F11	C5/1	C5/2	S3/1	S3/2	B1/1	B1/1	C3/1	C3/2	B2/1	B2/2	S1/1	S1/2
Species Assemblage D (cont.)																										
Amaranthus mitchellii			*														*	*				*				
Acacia aneura sp. SVL 2545									*							*	*		*							
Maireana villosa	*						*	*	*							*					*					
Senna artemisioides x *artem.*	*		*						*	*						*							*	*		
Acacia coriacea sericophylla	*						*		*	*					*				*	*			*	*		
Acacia tetragonophylla	*	*			*		*		*	*									*	*	*		*	*		
Acacia aneura aneura			*				*	*	*	*			*	*	*		*	*	*		*	*	*			
Ptilotus obovatus	*		*		*			*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*		
Scaevola spinescens	*	*							*	*									*	*					*	*
Velleia glabrata									*										*	*	*	*				
Stenopetalum anfractum							*												*	*		*		*		
Calocephalus Pilbara-Deserts							*			*									*			*		*		
Ptilotus exaltatus								*		*						*	*		*	*	*	*	*	*		
Haloragis gossei									*		*						*	*	*	*	*	*	*			
Eremophila longifolia																			*	*	*					
Rhyncharrhena linearis																	*						*	*		
Species Assemblage E																										
Prostanthera albiflora													*	*												
Sida pilbarensis													*	*												
Lysiana casuarinae														*	*											
Sida excedentifolia														*		*										
Phyllanthus lacunellus													*												*	
Stackhousia intermedia						*					*		*				*									*
Calotis hispidula							*					*	*	*					*					*	*	*
Wahlenbergia tumidifructa												*		*												
Chenopodium saxatile												*		*												
Solanum horridum												*	*	*												
Cheilanthes sieberi sieberi												*	*	*												
Nicotiana benthamiana											*	*		*												
Polycarpaea holtzei											*	*	*	*												
Hibiscus sp. SVL 2489							*					*		*												
Acacia cuthbertsonii							*				*		*	*				*								
Synaptantha tillaeacea till.							*				*	*	*	*												
Thysanotus exiliflorus											*															
Acacia eriopoda								*			*															
Gonocarpus eremophilus											*	*														
Eriachne pulchella pulchella											*	*														
Genus nov. sp. nov. SVL 3256											*	*														
Eucalyptus oldfieldii						*					*	*														
Acacia daviesioides					*	*					*	*														
Wurmbea deserticola											*	*														
Pimelea trichostachya											*	*														
Podolepis canescens											*	*											*	*		
Species Assemblage F																										
Eucalyptus sp. SVL 2457																										
Diplopeltis stuartii																										
Acacia stowardii					*																					
Velleia connata																										
Leptosema chambersii																										
Indigofera georgei																										
Acacia maitlandii			*																							
Lamarchea sulcata																										
Triodia wiseana			*	*		*																				
Stylobasium spathulatum		*																								
Ptilotus sp. SVL 3248				*																						
Acacia sp. SVL 2397																										
Alyogyne pinoniana	*																									
Clerodendrum tomentosum																										
Lomandra leucocephala rob.		*																								
Eucalyptus rameliana																										
Senna pleurocarpa																										
Frankenia fecunda																										
Microcorys macredieana					*																					
Acacia validinervia						*													*							
Eragrostis olida		*					*	*																		
Eriachne ovata				*			*	*	*																	
Grevillea stenobotrya																										
Acacia melleodora																*										
Aluta maisonneuvei		*	*																							
Scaevola parvifolia pilbarae		*				*												*								
Bonamia pannosa						*	*																			
Grevillea eriostachya	*	*					*			*																
Acacia ligulata	*	*	*	*	*	*																				
Brachychiton gregorii												*														
Acacia jamesiana												*														
Calandrinia polyandra												*					*									
Eucalyptus gamophylla	*				*		*					*														
Acacia abrupta		*	*	*							*	*														
Solanum centrale					*		*	*			*				*			*								
Hakea lorea			*		*	*	*	*			*	*					*		*	*						
Capparis spinosa	*								*																	
Species Assemblage G																										
Dysphania kalpari																										
Prostanthera wilkieana																										
Xerochrysum sp. SVL 1831																										
Acacia dictyophleba																										
Corchorus sp. SVL 2383																										
Pityrodia loricata																										
Comesperma pallidum																										
Kennedia prorepens																										
Xanthorrhoea thorntonii																										
Dicrastylis sp. *Kumarina*																										
Ptilotus aphyllus																										
Corynotheca micrantha div.																										
Dicrastylis sp. SVL 2937																										
Dampiera ramosa																										
Eragrostis eriopoda																										
Pityrodia loxocarpa																										

Quadrat Groups

	Taxon	1						2																					3		4		5														6						7	
		F1	F3	F22	F10	F13	F16	F2	F4	F4	F12	F18	B3/1	B3/2	S4/1	S4/2	B4/1	B4/2	C4/1	C4/2	F20	C2/1	C2/2	F23	S2/1	S2/2	F6	F9	F14	F15	F19	F21	F5	B5/1	B5/2	S5/1	S5/2	F17	C1/1	C1/2	F7	F11	C5/1	C5/2	S3/1	S3/2	B1/1	B1/1	C3/1	C3/2	B2/1	B2/2	S1/1	S1/2
Species Assemblage G (cont.)	*Dicrastylis doranii*								*				*	*		*																																						
	Grevillea juncifolia								*				*	*	*															*																								
	Sida sp. sand dunes										*			*	*	*																																						
	Ptilotus stipitatus										*			*	*	*									*																													
	Crotalaria cunninghamii										*	*		*	*	*			*																																			
	Pomax sp. *desert*										*	*	*	*	*	*																																						
	Calotis erinacea										*	*	*	*	*	*			*																																			
	Stackhousia megaloptera											*	*	*	*	*													*																									
	Trichodesma zeylanicum										*		*	*	*	*			*																					*														
	Gyrostemon ramulosus							*	*		*		*	*					*										*																									
	Dampiera cinerea	*						*	*				*	*	*	*							*		*																													
	Phyllota luehmannii							*	*		*	*	*	*	*			*				*			*																													
	Corymbia chippendalei										*	*	*	*	*	*	*			*																																		
	Goodenia xanthosperma										*	*	*	*	*	*	*	*		*								*																										
	Eremophila platythamnos										*		*	*	*	*	*	*											*																									
	Stylidium humphreysii										*		*	*	*	*	*	*							*	*																												
	Eragrostis setifolia									*	*		*	*			*	*						*	*	*				*																								
Species Assemblage H	*Setaria dielsii*																																																	*			*	
	Gnephosis brevifolia																																														*	*					*	*
	Rhodanthe stricta																																														*	*					*	*
	Nicotiana rosulata rosulata			*																																											*						*	*
	Calandrinia ptychosperma																																														*	*	*	*		*	*	
	Rhodanthe sterilescens																																														*	*	*	*		*	*	*
	Enchylaena tomentosa			*																																											*	*	*		*	*	*	*
	Rhagodia eremaea																												*															*			*	*			*	*	*	*
	Swainsona kingii														*																																*		*	*	*	*	*	*
	Lepidium muelleri-ferdinandii																																																			*	*	
	Lepidium oxytrichum																																																			*	*	*
	Digitaria brownii																																																		*	*		*
	Eremophila falcata			*																												*																				*		
	Zygophyllum tesquorum	*	*	*			*																																											*	*	*	*	
	Melaleuca uncinata																														*																				*			
	Acacia balsamea																														*																				*	*		
	Enneapogon polyphyllus																												*																						*			
	Abutilon sp. SVL 2630																																																		*	*		
	Myriocephalus rudallii																																																		*	*		
	Eremophila eriocalyx																																																		*	*		
	Menkea sphaerocarpa																																																		*	*		
	Rhodanthe humboldtiana																																																		*	*		
	Grevillea nematophylla																																															*			*			
	Goodenia wilunensis																																															*			*	*		
	Stenopetalum velutinum																																															*				*		
	Menkea villosula																																														*					*		
	Eucalyptus victrix																																														*	*			*			
	Rhodanthe floribunda																																														*	*			*			
	Portulaca oleracea																																														*	*				*		
	Vittadinia eremaea																																																*	*	*	*		
	Salsola tragus	*																																																*	*	*		
	Lepidium phlebopetalum																																														*			*	*	*		
	Sclerolaena cornishiana																																														*		*	*	*	*		
	Goodenia prostrata																																														*	*	*	*	*	*		
	Ptilotus aervoides																																														*	*	*	*	*	*		
	Ptilotus helipteroides																																													*	*	*	*	*	*	*		
	Enneapogon caerulescens																																								*										*	*		
	Euphorbia australis																																								*									*	*	*	*	
	Eremophila maculata																																														*	*						
	Eremophila sp. SVL 2615																																														*	*						
	Chenopodium melanocarpum																																														*	*						
	Calandrinia eremaea																																														*	*						
	Maireana triptera																													*														*			*	*						
Species Assemblage I	*Acacia nyssophylla*			*																												*																						
	Maireana sp. SVL 3243																														*	*																						
	Halosarcia sp. Yanneri Lake						*																							*																								
	Melaleuca glomerata	*	*																											*																								
	Eremophila glabra																												*	*																								
	Templetonia egena																												*	*		*																						
	Sclerolaena fimbriolata					*	*																																															
	Lawrencia helmsii					*	*																																															
	Halosarcia calyptrata					*	*																																															
	Trianthema turgidifolia					*	*																																															
	Halosarcia indica				*	*	*																																															
	Melaleuca xerophila				*		*																																															
	Halosarcia halocnemoides				*		*																																															
	Eragrostis sp. SVL 2830	*	*	*			*																																															
	Sclerolaena sp. SVL 2945	*	*	*	*	*	*																									*																						
	Podolepis capillaris	*	*		*	*	*																																															
	Scaevola collaris	*		*		*	*																						*																									
	Halosarcia pterygosperma				*	*	*																																														*	*
	Eragrostis dielsii	*	*	*		*																																															*	*
	Lawrencia glomerata	*		*		*	*																						*																								*	*
	Acacia synchronicia	*											*																																									*
	Senna artemisioides petiolaris									*				*															*																						*	*	*	
	Cyperus bulbosus																																																				*	*
	Cullen pustulatum																																																				*	*
	Ptilotus carinatus																																																				*	*
	Goodenia modesta																																																				*	*
	Rhodanthe charsleyae																																																				*	*
	Senecio magnificus																																																				*	*
	Trigonella suavissima																																																				*	*
	Rhodanthe propinqua			*																																																	*	*
	Frankenia laxiflora					*																																															*	*
	Stenopetalum decipiens																					*																															*	*

taxa are C and F (Table 3.2). Characteristic taxa are *A. rhodophloia, Solanum lasiophyllum*, *E. latrobei* var. *glabra* and *Psydrax latifolia*. Floristically, quadrats within this community type are the most specious.

Quadrat Group 6

Quadrats which are dominated by mulga woodlands on clay-loam soils are the feature of this community type. Taxa which dominate the Quadrat Group principally belong to Species Assemblage H although many representatives from Species Assemblages D and to a minor extent C are also present (Table 3.2). Dominant taxa are *Aristida contorta*, *P. obovatus*, *P. exaltatus*, *P. helipteroides*, *P. aervoides* and *Goodenia prostrata*. The later two taxa are the most faithful of a suite of 21 taxa recorded only in these mulga woodland communities.

Quadrat Group 7

This Quadrat Group comprises the two sample sites located adjacent to Savory Creek. Both sites are dominated by a low samphires over annual herbs and grasses. The quadrats are also degraded as a consequence of flooding, grazing and trampling by livestock. Taxa from Species Assemblages H and I dominate in this community although minor elements of Groups B, C D and E are also present (Table 3.2). Seven taxa in Species Assemblage I are restricted to this community while a further 24 from other Species Assemblages are common to both quadrats.

Interestingly and reassuringly, floristic quadrats which were replicated at each biological survey site are always more closely associated to each other than to any other quadrat.

DISCUSSION

The floristic diversity and richness of the south-western Little Sandy Desert is noteworthy and somewhat unexpected given the subdued relief and uniformity in landforms. Although data is generally lacking for other arid desert areas a richness value of 57.2 species per 1 000 km^2 obtained from this survey is similar to that reported in the Rudall River area (54.5) for a study area of similar size (Hart 1993). The composition of the flora is dominated by arid zone elements as indicated by the preponderance of Poaceae, Goodeniaceae and Asteraceae taxa. This arid zone influence is partitioned between typically central dry-arid elements and those derived from southern arid areas although a small suite of taxa are representative of a tropical desert flora.

Unfortunately no comprehensive botanical species list is available for the Little Sandy Desert however current estimates suggest a flora in the vicinity of 800 to 900 species (van Leeuwen, unpublished data). The Western Australian Herbarium (PERTH) houses some 920 vouchers representing 460 taxa which cite the Little Sandy Desert as their collection locality. The majority of these specimens are from the Carnarvon Range although a proportion originates from the Canning Stock Route and Rudall River areas. Similarly the Pilbara Regional Herbarium (KARR) houses a collection of 490 species collected in the Rudall River area by resource development proponents. Considerable redundancy exists in these two floral inventories which is repeated in the inventory obtained from the current study area. Much of this repetition is associated with taxa from sand dune and sand plain habitats and tends to be those species which have ubiquitous distributions throughout the deserts of inland Western Australian, if not the entire arid zone (e.g. *Ptilotus obovatus*, *Aristida contorta*, *Acacia ancistrocarpa*).

Obvious deficiencies in the floral inventory of the current study area, as supported by the inventories compiled from specimens housed in both the Western Australian and Pilbara

Regional Herbaria, are related to taxa associated with major drainage features, dissected geologically heterogeneous hills and finally abrupt refugial mountain ranges. Basically the study area lacks floral elements typical of inland freshwater features such as Rudall River (e.g. *E. camaldulensis*, *Melaleuca leucadendra*), dissected hills such as the Throssell Range (*Dicrastylis cephalantha*, *Ficus opposita*) and abrupt mountains such as Mt Essendon in the Carnarvon Range (e.g. *Thysanotus manglesianus*, *Tetratheca chapmanii*). Conversely, the flora of the study area is enhanced by the presence of significant brackish to hypersaline paleodrainage features and their associated samphire and *Melaleuca* heaths. Similarly, the persistence of extensive *Acacia* (mulga) woodlands which are mostly absent from the remainder of the region also augment the flora of the study area.

The presence of mulga woodlands in the study area is phytogeographically important and associated with the juxtaposition of the *Acacia-Triodia* line (Beard 1975) in the region. To the west of the Little Sandy Desert this important phytogeographically boundary is roughly aligned with the junction of the Pilbara and Gascoyne Biogeographical Regions while to the east the boundary traverses the northern Gibson Desert. In the Little Sandy Desert this phytogeographically boundary drops south along the western margin of the sedimentary basin and onto the apron of Lake Nabberu, a feature clearly demonstrated through the rapid replacement of hummock grasses by *Acacia* woodlands. The study area fortuitously straddles this transitional zone and consequently contains significant areas of mulga woodland (Table 2.1) interspersed amongst the vegetation communities characterised by hummock grasses on the sedimentary land surfaces.

The high number of taxa at their distributional range-end within the study area is also an expression of the transitional nature of this part of the Little Sandy Desert. Among the sixty-one taxa at their southern limits, the majority is typically sandy desert specialists. As the study area coincides with the replacement of the desert sands by rocky and heavy pediments this result is not unexpected. A similar pattern is observed amongst the thirteen taxa at the western limits of their distributional range. The number of taxa at the northern end of their distributional range within the study area was perhaps not a great as anticipated given the large representation of taxa with typically southern arid zone affinities. This result may be attributed to the fact the rocky and heavy soil pediments upon which most taxa of southern affinities occur extend beyond the study area north into the Gascoyne and Pilbara. The frequency of these distributional range-end taxa in the flora commensurate with the occurrence of both central and southern arid zone floral elements indicate that that south-western Little Sandy Desert is a botanical change-over zone, a proposition that conforms neatly with the area also being a phytogeographic transitional zone.

The arrangement of the flora into communities across the landscape within the study area appears to be under topographic and edaphic control. The faithfulness of most taxa to a single community type is an obvious expression of this control and is clearly evident in the study area. Topographic and edaphic control over the arrangement of desert plant communities has been reported elsewhere in the Australian arid zone (Burbidge 1945, 1959, Griffin 1990). The mulga woodland community (Quadrat Group 5) contains the highest botanical diversity, an attribute undoubtedly attributed to the run-on nature of such habitats and thus their more favourable moisture regime. Such habitats also tend to be nutrient sinks and thus offer more favourable conditions for plant growth than the surrounding spinifex dominated plains. (Tongway and Ludwig 1994, Hodgkinson 2001, van Etten 1988). The least specious community type (Quadrat Group 1) is associated with the most hostile environment for plant growth with respect to

ecophysiology as conferred through hypersaline conditions and high surface reflectance which would impact on evapotranspiration.

Environmental gradients appear to have had little influence on the arrangement of floristic communities however this proposition may simply be related to a issue of scale in respect of the small size of the study area. Similarly, the apparent absence of any gradients may also be a reflection of inadequate sampling effort. This failure to identify any deterministic environmental gradients was not unexpected given the location of all sample sites with the same natural region and geological structure.

No significant threats impinging upon the flora of the study area are identified. Obviously, grazing by livestock and donkeys along Savory Creek is of concern, however is not unexpected given contemporary pastoral land management practices in the Western Australian rangelands. As livestock and donkeys tend to be restricted to areas close to free water the impacts of such grazing animals are generally insignificant over the remainder of the study area. However, what is of considerable concern is the impacts of grazing and trampling by camels. Evidence of camel grazing is indisputably manifested in the umbrella-shape canopy of most desert kurrajongs (*Brachychiton gregorii*). This shape is attained by camels browsing on the low branches of the tree until a maximum browse height (camel reach height) is achieved, thereby giving the tree the appearance of having a neatly trimmed, horizontal lower canopy. While this browsing does not appear to adversely affect the plant, the fringing and under-canopy vegetation is dramatically impacted through trampling. Characteristically, this fringing and under-canopy vegetation tends to be dominated by bird dispersed and clonal plants which form 'bush clumps'. The plants of these 'bush clumps' tend not to occur in other habitats or in association with other trees and hence are substantially impacted by this trampling. Another noticeable consequence of this preference of camels for kurrajong foliage is the presence of many dead juvenile trees which speculatively is caused by overgrazing to a point beyond the ability of the plant to regenerate. Insidiously, the complete absence of any kurrajong seedlings is also a product of camel grazing. The inability of the desert kurrajong to recruit new individuals into the population pool of the south-western Little Sandy Desert will have marked consequences for the long term survival of this species in the study area and consequently those plants which are restricted to the 'bush clumps' they harbour.

The study area has considerable botanical and conservation value as a consequence of its transitional nature with respect to a major phytogeographic boundary, the coincidental convergence of southern and central arid zone floral elements and a subdued, although heterogeneous land surface and soil environment. This actuality is further substantiated by the presence of many taxa which are at their distributional range-ends, are poorly known, are of conservation significance or are apparently new and await formal description. As noted by Thackway and Cresswell (1995), the Little Sandy Desert Biogeographical Region has a biased conservation reserve system which is confined to the northern portion of the Desert (Rudall River National Park) and is unrepresentative of features such as salt lakes. The inclusion of a large portion of the study area in a new conservation reserve would substantially reduce this regional reservation bias. Such a reserve would capture many land surface types and inherently, floristic communities and their constituent taxa which are not represented on the existing conservation estate and are of considerable biological, taxonomic and or conservation significance.

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APPENDIX 3.1

List of vascular plants recorded from the south-western Little Sandy Desert, their Department of Conservation and Land Management conservation code, frequency of occurrence within the Little Sandy Desert Biogeographical Region, geographic distribution and frequency of occurrence in 53 quadrats established within the study area.

EXPLANATION OF CODES

* Introduced or naturalised taxon.

Conservation Status:

Conservation status of taxa as defined by the Western Australian Department of Conservation and Land Management (2001).

1: Priority One - Poorly known Taxa
Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

2: Priority Two - Poorly Known Taxa
Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

3: Priority Three - Poorly Known Taxa
Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but are in need of further survey.

4: Priority Four - Rare Taxa
Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

Little Sandy Desert frequency:

Y: Denotes taxa recorded during for the first time in the Little Sandy Desert Biogeographical Region during this botanical survey.

Geographical Distribution:

N: Denotes taxa at the northern end of their distributional range.
S: Denotes taxa at the southern limits of their distributional range.
E: Denotes taxa at the eastern limits of their distributional range.
W: Denotes taxa at the western limits of their distributional range.
NE: Denotes taxa at the north-eastern limits of their distributional range.
NW: Denotes taxa at the north-western limits of their distributional range.
SW: Denotes taxa at the south-western limits of their distributional range.
SE: Denotes taxa at the south-eastern limits of their distributional range.
D: Denotes taxa which are disjunct outliers from typical species distribution.

Quadrat occurrences:

Y: Denotes number of quadrats a taxon was recorded from during the botanical survey. Maximum number possible is 53. Blank cells denote taxa not recorded from quadrats.

FAMILY *Taxon*	Conservation code	First record for region	Distributional range-ends	Frequency in quadrats
OPHIOGLOSSACEAE				
Ophioglossum lusitanicum		Y		
ADIANTACEAE				
Cheilanthes brownii			S	5
Cheilanthes lasiophylla				
Cheilanthes sieberi subsp. *pseudovellea*		Y	S	
Cheilanthes sieberi subsp. *sieberi*				3
MARSILEACEAE				
Marsilea hirsuta				1
TYPHACEAE				
Typha domingensis		Y		
POTAMOGETONACEAE				
Ruppia maritima		Y	D	
JUNCAGINACEAE				
Triglochin nana				
POACEAE				
Amphipogon caricinus				12
Aristida contorta				28
Aristida holathera				
Aristida sp. Little Sandy Desert (SVL 3047) = Aristida holathera				
Brachyachne prostrata				
Chrysopogon fallax		Y		
Cymbopogon ambiguus				1
Cymbopogon bombycinus		Y	S	
Cymbopogon obtectus		Y		
Dichanthium sericeum subsp. *humilius*		Y		
Digitaria brownii				3
Enneapogon caerulescens				3
Enneapogon polyphyllus				2
Eragrostis desertorum			D	1
Eragrostis dielsii				6
Eragrostis eriopoda				4
Eragrostis olida			S, D	12
Eragrostis setifolia		Y		10
Eragrostis xerophila				17
Eragrostis sp. Little Sandy Desert (SVL 2491)				1
Eragrostis sp. Little Sandy Desert (SVL 2830)				4
Eriachne aristidea				5
Eriachne mucronata				7
Eriachne ovata		Y	N, D	13
Eriachne pulchella subsp. *pulchella*		Y		2
Eulalia aurea				
Iseilema eremaeum		Y		
Iseilema membranaceum			S	1
Paraneurachne muelleri				8
Paspalidium clementii		Y		
Paspalidium rarum				
Setaria dielsii				2
* *Setaria verticillata*		Y		
Sporobolus australasicus			S	1
Themeda triandra				
Tragus australianus				
Triodia angusta		Y	S	
Triodia brizoides		Y	S, D	
Triodia lanigera		Y	S	13
Triodia longiceps			S	
Triodia melvillei		Y	S	
Triodia pungens			S	2
Triodia schinzii				15
Triodia wiseana				8
Triodia sp. Little Sandy Desert (aff. *lanigera*) (SVL 4935)				
Tripogon loliiformis				1
Triraphis mollis				
Xerochloa laniflora			S	
Genus nov. sp. nov. Little Sandy Desert (SVL 3070) = Schizachyrium fragile				
Genus nov. sp. nov. Little Sandy Desert (SVL 3126)				
Genus nov. sp. nov. Little Sandy Desert (SVL 3256) = Paspalidium reflexum				3
Genus nov. sp. nov. Little Sandy Desert (SVL 5009) = Paractaenum novae-				1

FAMILY *Taxon*	Conservation code	First record for region	Distributional range-ends	Frequency in quadrats
hollandiae				
CYPERACEAE				
Bulbostylis barbata				
Cyperus bulbosus				2
Cyperus centralis			N	
Cyperus squarrosus				
Cyperus sp. Little Sandy Desert (SVL 4470)				
Cyperus sp. Little Sandy Desert *(*SVL 4914) = Cyperus blakeanus				
Cyperus sp. Little Sandy Desert *(*SVL 5016) = Cyperus rigidellus				
Eleocharis sp. Little Sandy Desert (SVL 3055 = *Bulbostylis barbata*				
Fimbristylis dichotoma				
Fimbristylis sieberiana	P3	Y	S, D	
CENTROLEPIDACEAE				
Centrolepis eremica		Y	N	
DASYPOGONACEAE				
Lomandra leucocephala subsp. *robusta*			N	2
XANTHORRHOEACEAE				
Xanthorrhoea thorntonii		Y	N	4
ANTHERICACEAE				
Corynotheca micrantha var. *divaricata*			W, D	2
Thysanotus exiliflorus			W, D	2
COLCHICACEAE				
Wurmbea deserticola				4
CASUARINACEAE				
Allocasuarina decaisneana			W	1
Casuarina pauper			N	1
MORACEAE				
Ficus brachypoda			S	1
PROTEACEAE				
Grevillea eriostachya				20
Grevillea eriostachya x *spinosa*				
Grevillea juncifolia				5
Grevillea nematophylla		Y	N, D	2
Grevillea pterosperma				
Grevillea spinosa			W	1
Grevillea stenobotrya				15
Grevillea striata				2
Grevillea wickhamii subsp. *aprica*				6
Hakea lorea				24
Hakea preissii		Y	N, D	
Hakea rhombales				
SANTALACEAE				
Anthobolus leptomerioides				11
Exocarpos sparteus				
Santalum lanceolatum				12
LORANTHACEAE				
Amyema bifurcata		Y	S, D	
Amyema fitzgeraldii		Y		1
Amyema gibberula var. *gibberula*				
Amyema hilliana			S	
Amyema miquelii				1
Amyema sanguinea var. *pulcher*			S	1
Lysiana casuarinae				2
CHENOPODIACEAE				
Atriplex spongiosa		Y	N, D	
Atriplex vesicaria				1
Chenopodium melanocarpum		Y		10
Chenopodium saxatile		Y		2
Dysphania kalpari				2
Dysphania rhadinostachya				8
Dysphania sphaerosperma		Y	S, D	
Enchylaena tomentosa				8
Halosarcia calyptrata				2
Halosarcia halocnemoides				2
Halosarcia indica				3
Halosarcia pterygosperma subsp. *pterygosperma*		Y	N, D	5
Halosarcia sp. Yanneri Lake (SVL 3002*)* = *Tecticornia bibenda*		Y		2
Halosarcia sp. Little Sandy Desert (SVL 4973) = Tecticornia laevigata				
Maireana georgei				
Maireana luehmannii		Y	D	1
Maireana melanocoma				

FAMILY *Taxon*	Conservation code	First record for region	Distributional range-ends	Frequency in quadrats
Maireana planifolia				5
Maireana thesioides		Y		
Maireana tomentosa				
Maireana triptera				4
Maireana villosa				7
Maireana sp. Little Sandy Desert (SVL 2985) = *Maireana tomentosa*				
Maireana sp. Little Sandy Desert (SVL 3243) = Sclerolaena parviflora				2
Rhagodia eremaea				8
*R*hagodia sp. Little Sandy Desert (SVL 2984) = Atriplex vesicaria				1
Salsola tragus				4
Sclerolaena alata		Y	N	
Sclerolaena cornishiana				5
Sclerolaena cuneata				1
Sclerolaena eriacantha				
Sclerolaena fimbriolata		Y	N, D	2
Sclerolaena sp. Little Sandy Desert (SVL 2945) = Sclerolaena clelandii				7
Sclerolaena sp. Little Sandy Desert (SVL 3568) = ?? Goodenia cusackiana				1
Sclerostegia disarticulata		Y		
AMARANTHACEAE				
* *Aerva javanica*		Y	S	
Amaranthus cuspidifolius		Y	D	1
Amaranthus mitchellii				8
Amaranthus sp. Little Sandy Desert (SVL 3348)				
Hemichroa diandra		Y		
Ptilotus aervoides		Y		6
Ptilotus aphyllus	P3	Y	S	6
Ptilotus astrolasius				1
Ptilotus calostachyus			S	
Ptilotus carinatus		Y	S, D	2
Ptilotus exaltatus				11
Ptilotus fusiformis			S	1
Ptilotus gaudichaudii		Y		
Ptilotus helipteroides				7
Ptilotus macrocephalus				5
Ptilotus obovatus				21
Ptilotus polystachyus				19
Ptilotus rotundifolius		Y	E	1
Ptilotus schwartzii				15
Ptilotus stipitatus	P1		S	5
Ptilotus tetrandrus	P2	Y	N, D	
Ptilotus sp. Little Sandy Desert (SVL 2884) = Ptilotus stipitatus				2
NYCTAGINACEAE				
Boerhavia coccinea		Y		
GYROSTEMONACEAE				
Codonocarpus cotinifolius				
Gyrostemon ramulosus				7
AIZOACEAE				
Trianthema glossostigma		Y		3
Trianthema triquetra				1
Trianthema turgidifolia			S	2
PORTULACACEAE				
Calandrinia eremaea			N	2
Calandrinia polyandra		Y		8
Calandrinia ptychosperma				6
Portulaca filifolia		Y	S, D	
Portulaca oleracea		Y		3
CARYOPHYLLACEAE				
Polycarpaea holtzei		Y	S, D	4
Polycarpaea involucrata			S, D	
LAURACEAE				
Cassytha filiformis		Y	S	2
Cassytha sp. Little Sandy Desert (SVL 3233) = *Cassytha filiformis*				2
CAPPARACEAE				
Capparis lasiantha		Y	S	1
Capparis spinosa				8
Cleome oxalidea		Y	S, D	
BRASSICACEAE		Y		
Lepidium echinatum				1
Lepidium muelleri-ferdinandii				2
Lepidium oxytrichum				3
Lepidium pedicellosum				4

FAMILY *Taxon*	Conservation code	First record for region	Distributional range-ends	Frequency in quadrats
Lepidium phlebopetalum				1
Menkea villosula		Y		2
Menkea sphaerocarpa		Y		2
Stenopetalum anfractum		Y		5
Stenopetalum decipiens			S, D	3
Stenopetalum pedicellare		Y		
Stenopetalum velutinum		Y	N, D	2
Stenopetalum sp. Little Sandy Desert *(*SVL 4964) = Stenopetalum decipiens				
DROSERACEAE				
Drosera burmanni		Y	S, D	
Drosera indica				
PITTOSPORACEAE				
Pittosporum angustifolium		Y	N, D	1
SURIANACEAE				
Stylobasium spathulatum				2
MIMOSACEAE				
Acacia abrupta				13
Acacia adoxa var. *adoxa*			S	
Acacia adsurgens		Y	S	10
Acacia ancistrocarpa			S	
Acacia aneura var. *aneura*				19
Acacia aneura var. *microcarpa*		Y		7
Acacia aneura var. *pilbarana*		Y	E, D	1
Acacia aneura var. (SVL 2545)				4
Acacia ayersiana		Y		7
Acacia balsamea	P3		W	3
Acacia bivenosa			S	3
Acacia citrinoviridis		Y		1
Acacia coriacea subsp. *pendens*		Y	SE	
Acacia coriacea subsp. *sericophylla*				11
Acacia cuthbertsonii				5
Acacia daviesioides			N, D	4
Acacia dictyophleba				4
Acacia eriopoda			S	3
Acacia hilliana			S	2
Acacia inaequilatera			S	1
Acacia jamesiana		Y	N	10
Acacia kempeana				8
Acacia ligulata				23
Acacia maitlandii				8
Acacia marramamba		Y		
Acacia melleodora				19
Acacia minyura		Y		
Acacia nyssophylla		Y	N, D	2
Acacia oswaldii		Y	N, D	1
Acacia pachyacra				
Acacia paraneura		Y		
Acacia prainii		Y	N	1
Acacia pruinocarpa				7
Acacia ramulosa var. *linophylla*		Y		
Acacia ramulosa var. *ramulosa*		Y	N	5
Acacia rhodophloia				14
Acacia spondylophylla			S	5
Acacia stowardii				3
Acacia synchronicia				3
Acacia tetragonophylla				16
Acacia validinervia			D	8
Acacia aff. *validinervia* (SVL 3234) = *Acacia sp. Lake Disappointment (S. van Leeuwen 2865)*				
Acacia wanyu				
Acacia sp. Little Sandy Desert (SVL 2397)				5
Acacia sp. Little Sandy Desert (SVL 3338)				
Acacia sp. Little Sandy Desert *(SVL 4991) = Acacia sp.Juliflorae - terete*				
Eremaean Region				
CAESALPINIACEAE				
Petalostylis cassioides				8
Senna artemisioides subsp. *helmsii*				10
Senna artemisioides subsp. *oligophylla*				12
Senna artemisioides subsp. *petiolaris*		Y	N, D	6
Senna artemisioides subsp. x *artemisioides*		Y		9
Senna artemisioides subsp. x *sturtii*		Y		1
Senna glaucifolia				7

FAMILY *Taxon*	Conservation code	First record for region	Distributional range-ends	Frequency in quadrats
Senna glutinosa subsp. *glutinosa*				6
Senna glutinosa subsp. *pruinosa*				3
Senna glutinosa subsp. x *luerssenii*				4
Senna notabilis				
Senna pleurocarpa var. *angustifolia*		Y		5
Senna sp. Meekatharra (E. Bailey 1-26)		Y		
PAPILIONACEAE				
Crotalaria cunninghamii				6
Cullen pustulatum			S, D	2
Daviesia arthropoda	P1	Y	W, D	1
Daviesia eremaea	P3	Y	D	
Daviesia grahamii		Y	N	
Gastrolobium grandiflorum		Y	S	
Gompholobium polyzygum				8
Indigofera georgei				5
Indigofera monophylla				7
Isotropis atropurpurea				
Isotropis forrestii		Y		
Jacksonia aculeata			S	2
Kennedia prorepens				6
Leptosema chambersii				4
Mirbelia viminalis		Y		
Muelleranthus trifoliolatus				1
Phyllota luehmannii		Y	N, D	10
Swainsona formosa				
Swainsona kingii				8
Swainsona microphylla				
Swainsona sp. Little Sandy Desert *(*SVL 5017)				
Templetonia egena		Y		3
Tephrosia sp. Little Sandy Desert *(*SVL 4966) = Tephrosia sphaerospora				
Tephrosia sp. Little Sandy Desert (SVL 3195)				1
Trigonella suavissima		Y	NE	2
Genus nov. sp. nov. Little Sandy Desert (SVL 2645)				
Genus nov. sp. nov. Little Sandy Desert *(*SVL 3275) = Swainsona microphylla				3
ZYGOPHYLLACEAE				
Tribulus astrocarpus				1
Tribulus occidentalis				1
Tribulus platypterus				
Tribulus suberosus				10
Zygophyllum aurantiacum		Y		
Zygophyllum compressum				1
Zygophyllum iodocarpum				1
Zygophyllum simile		Y		
Zygophyllum tesquorum		Y	NW	8
POLYGALACEAE				
Comesperma pallidum			W, D	4
Comesperma viscidulum	P2	Y	NW, D	
Polygala isingii				14
EUPHORBIACEAE				
Adriana tomentosa var. *hookeri*				1
Euphorbia alsiniflora				
Euphorbia australis				5
Euphorbia boophthona				14
Euphorbia coghlanii			S	
Euphorbia stevenii		Y	S, D	
Monotaxis luteiflora				
Phyllanthus lacunellus				2
CELASTRACEAE				
Maytenus sp. Mt Windell (SVL 846)		Y	SE, D	
STACKHOUSIACEAE				
Macgregoria racemigera				
Stackhousia clementii			D	
Stackhousia intermedia				5
Stackhousia megaloptera		Y	N	6
Stackhousia sp. Little Sandy Desert (SVL 4426)				
SAPINDACEAE				
Diplopeltis stuartii var. *stuartii*				2
Dodonaea coriacea			S	3
Dodonaea pachyneura		Y	E	2
Dodonaea petiolaris				4
Dodonaea viscosa subsp. *angustissima*		Y	N	1
Dodonaea viscosa subsp. *spatulata*		Y	N	1

FAMILY *Taxon*	Conservation code	First record for region	Distributional range-ends	Frequency in quadrats
TILIACEAE				
Corchorus obtectus ms				
Corchorus sidoides			S	2
Corchorus tectus ms		Y	S, D	
Corchorus sp. Little Sandy Desert (SVL 2383)				5
Corchorus sp. Little Sandy Desert *(*SVL 4978) = Corchorus sidoides				
MALVACEAE				
Abutilon dioicum ms		Y	S, D	
Abutilon leucopetalum				
Abutilon sp. Little Sandy Desert (SVL 2630)				2
Alyogyne pinoniana				5
Hibiscus burtonii				4
Hibiscus coatesii				2
Hibiscus gardneri ms		Y		
Hibiscus leptocladus		Y	S	
Hibiscus sturtii var. *truncatus*				5
Hibiscus sp. Little Sandy Desert (SVL 2489)				3
Lawrencia glomerata		Y	D	7
Lawrencia helmsii		Y	N, D	2
Sida arenicola		Y	S, D	2
Sida cardiophylla				
Sida chrysocalyx ms		Y	N	1
Sida echinocarpa		Y	E	
Sida excedentifolia ms		Y		3
Sida pilbarensis ms		Y	S, D	2
Sida subarticulata ms		Y	S, D	1
Sida tescorum ms		Y	S, D	1
Sida sp. sand dunes (A.A. Mitchell PRP1208)			S	4
Sida sp. nov verrucose glands (F.H. Mollemans 2423) Sida sp. verrucose glands (F.H. Mollemans 2423)		Y	S, D	1
Sida sp. Little Sandy Desert (SVL 2489)				
Sida sp. Little Sandy Desert (SVL 2666)				9
Sida sp. (SVL 3227)				
STERCULIACEAE				
Brachychiton gregorii				7
Hannafordia bissillii subsp. *bissillii*			W, D	
Keraudrenia sp. Little Sandy Desert (SVL 2376)				16
Rulingia aff. *luteiflora*				2
ELATINACEAE				
Bergia trimera				
FRANKENIACEAE				
Frankenia fecunda		Y	N, D	2
Frankenia glomerata	P1	Y	N, D	
Frankenia interioris		Y	N, D	
Frankenia laxiflora		Y	N	3
Frankenia punctata		Y	N, D	
VIOLACEAE				
Hybanthus aurantiacus			S	7
THYMELAEACEAE				
Pimelea ammocharis				
Pimelea trichostachya		Y	N	5
MYRTACEAE				
Aluta maisonneuvei				22
Calothamnus aridus		Y	N, D	1
Calytrix carinata				20
Corymbia ? *aspera*			S	1
Corymbia chippendalei				8
Corymbia deserticola				5
Corymbia hamersleyana		Y	E	
Eucalyptus gamophylla				13
Eucalyptus kingsmillii subsp. *kingsmillii*				
Eucalyptus lucasii		Y		
Eucalyptus mannensis subsp. *mannensis*		Y		2
Eucalyptus oldfieldii			N	3
Eucalyptus pachyphylla			W	3
Eucalyptus rameliana	P4			3
Eucalyptus repullulans		Y	E, D	
Eucalyptus semota		Y	N	
Eucalyptus socialis				1
Eucalyptus victrix				1
Eucalyptus sp. Little Sandy Desert (SVL 2471)				4

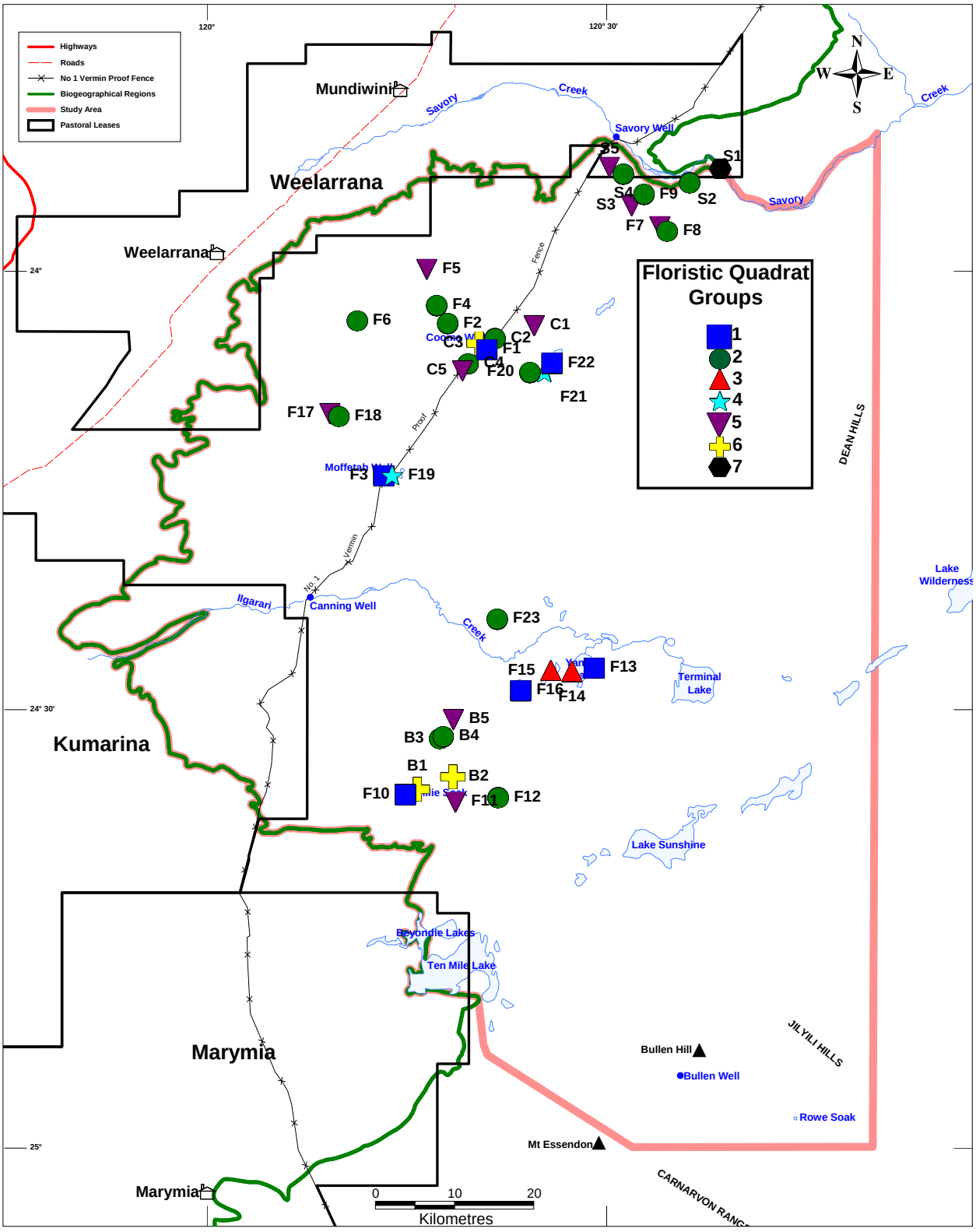
FAMILY *Taxon*	Conservation code	First record for region	Distributional range-ends	Frequency in quadrats
Eucalyptus sp. Little Sandy Desert (SVL 2932) Eucalyptus socialis subsp. eucentrica				1
Eucalyptus sp. Little Sandy Desert (SVL 3001) *Eucalyptus eremicola subsp. peeneri*				1
Lamarchea sulcata			W	2
Melaleuca eleuterostachya				
Melaleuca glomerata				3
Melaleuca lasiandra			SW	
Melaleuca linophylla		Y	E	1
Melaleuca uncinata = interioris (SVL 6/6/08)				2
Melaleuca xerophila		Y		2
Micromyrtus flaviflora				
HALORAGACEAE				
Gonocarpus eremophilus		Y	W	2
Haloragis gossei				14
Haloragis odontocarpa forma *rugosa*		Y	N	
APIACEAE				
Daucus glochidiatus		Y	NE	
Trachymene bialata		Y		6
Trachymene glaucifolia		Y	N	
Trachymene oleracea			S	
PRIMULACEAE				
Samolus sp. Little Sandy Desert (SVL 2912) = Samolus sp. Millstream (M.I.H. Brooker 2076)				1
OLEACEAE				
Jasminum calcarium		Y		
GENTIANACEAE				
Centaurium spicatum		Y	E, D	
ASCLEPIADACEAE				
Cynanchum floribundum				
Marsdenia australis		Y	NE	5
Rhyncharrhena linearis		Y		5
Sarcostemma viminale subsp. *australe*				1
CONVOLVULACEAE				
Bonamia pannosa			S	19
Evolvulus alsinoides			S	
Porana commixta				2
BORAGINACEAE				
Halgania cyanea var. *latisepala* ms			N	1
Halgania glabra		Y	W	
Halgania gustafsenii		Y	E	1
Halgania solanacea var. *hirsuta* ms				7
Heliotropium chrysocarpum		Y		5
Heliotropium curassavicum				
Trichodesma zeylanicum var. *zeylanicum*			S	7
LAMIACEAE				
Clerodendrum tomentosum var. *lanceolatum*		Y	S, D	2
Dicrastylis cordifolia var. *cordifolia*		Y	S, D	
Dicrastylis doranii			W	4
Dicrastylis exsuccosa		Y	W, D	
Dicrastylis georgei				13
Dicrastylis sp. Kumarina (A.A. Mitchell 623) = Dicrastylis kumarinensis				8
Dicrastylis sp. Little Sandy Desert (SVL 2937) = Dicrastylis beveridgei				3
Microcorys macredieana		Y	N	6
Newcastelia cladotricha				
Newcastelia spodiotricha			W	
Pityrodia loricata			W	6
Pityrodia loxocarpa				4
Prostanthera albiflora		Y	E, D	2
Prostanthera wilkieana		Y	N	2
SOLANACEAE				
Duboisia hopwoodii				1
Nicotiana benthamiana			S	3
Nicotiana rosulata subsp. *rosulata*				4
Solanum centrale				20
Solanum cleistogamum		Y		
Solanum gabrielae			S	
Solanum horridum		Y	S, D	3
Solanum lasiophyllum				25
Solanum phlomoides		Y	S	9
Solanum sturtianum				1

FAMILY *Taxon*	Conservation code	First record for region	Distributional range-ends	Frequency in quadrats
SCROPHULARIACEAE				
Buchnera linearis			S	
Mimulus gracilis		Y	S	
Mimulus repens	P3	Y	N	
Peplidium sp. C Evol. Fl. Fauna Arid Aust. (N.T. Burbidge & A. Kanis 8158)		Y		
Peplidium sp. E Evol. Fl. Fauna Arid Aust. (A.S. Weston 12768)		Y	S	
Peplidium sp. Little Sandy Desert (SVL 4986)				
Stemodia linophylla	P1	Y	W, D	
MYOPORACEAE				
Eremophila citrina ms		Y	N	11
Eremophila clarkei		Y		
Eremophila eriocalyx		Y	N	2
Eremophila exilifolia				3
Eremophila falcata		Y	N	3
Eremophila forrestii				15
Eremophila fraseri subsp. *galeata* ms		Y		
Eremophila glabra subsp. *glabra* ms			N	2
Eremophila lanceolata ms			S	
Eremophila latrobei subsp. *filiformis* ms		Y		
Eremophila latrobei subsp. *glabra* ms				12
Eremophila latrobei subsp. *latrobei* ms				6
Eremophila longifolia				5
Eremophila maculata		Y		2
Eremophila pachomai ms			S	
Eremophila petrophila subsp. *petrophila* ms		Y	E	6
Eremophila phyllopoda subsp. *phyllopoda* ms		Y	E, D	
Eremophila platythamnos			NW	8
Eremophila punctata		Y	NW	
Eremophila sp. Little Sandy Desert (SVL 2615)				2
Eremophila sp. Little Sandy Desert (SVL 4959) = Eremophila deserti				
RUBIACEAE				
Oldenlandia crouchiana			S	
Pomax sp. desert (A.S. George 11968)				6
Psydrax attenuata ms		Y	D	7
Psydrax latifolia ms				11
Psydrax suaveolens ms		Y		8
Synaptantha tillaeacea var *hispidula*				
Synaptantha tillaeacea var. *tillaeacea*				5
CUCURBITACEAE				
Mukia maderaspatana				
CAMPANULACEAE				
Wahlenbergia tumidifructa				2
LOBELIACEAE				
Lobelia heterophylla		Y		1
GOODENIACEAE				
Brunonia australis				9
Dampiera candicans			S	3
Dampiera cinerea				9
Dampiera dentata				5
Dampiera ramosa	P2	Y	N, D	3
Dampiera roycei		Y	N, D	
Goodenia azurea			W	11
Goodenia gypsicola		Y	N, D	1
Goodenia lamprosperma			S	
Goodenia microptera			S	1
Goodenia modesta	P3	Y	E, D	2
Goodenia pascua	P3	Y	S, D	
Goodenia prostrata				6
Goodenia schwerinensis	P3	Y	N	
Goodenia stobbsiana			S	
Goodenia triodiophila				18
Goodenia wilunensis		Y		3
Goodenia xanthosperma		Y	N, D	10
Goodenia sp. Little Sandy Desert (SVL 2926) = Goodenia lamprosperma				
Goodenia sp. Little Sandy Desert (SVL 3004) = Goodenia sp. Beyondie (L.W. Sage & S. van Leeuwen LWS 2518)				
Goodenia sp. Little Sandy Desert (SVL 3293) = Goodenia vilmoriniae				
Goodenia sp. Little Sandy Desert (SVL 4463)				
Lechenaultia striata		Y	N, D	
Scaevola amblyanthera var. *centralis*			S	
Scaevola basedowii			W	
Scaevola browniana subsp. *browniana*			S, D	5

FAMILY *Taxon*	Conservation code	First record for region	Distributional range-ends	Frequency in quadrats
Scaevola collaris		Y		5
Scaevola parvifolia subsp. *pilbarae*				21
Scaevola sericophylla				1
Scaevola spinescens				13
Velleia connata				4
Velleia glabrata				5
Velleia panduriformis			SW	
STYLIDIACEAE				
Levenhookia chippendalei				
Stylidium desertorum			SW	
Stylidium humphreysii			W	9
Stylidium inaequipetalum		Y	SW, D	
ASTERACEAE				
Actinobole uliginosum		Y	D	
Angianthus cyathifer		Y	W, D	
Angianthus milnei		Y	E, D	
Angianthus tomentosus		Y		
Angianthus sp. Little Sandy Desert (SVL 2911) = Angianthus tomentosus				1
* *Bidens bipinnata*				
Brachyscome iberidifolia		Y		
Calocephalus knappii				
Calocephalus sp. Pilbara-Desert (M.E. Trudgen 11454)				6
Calotis erinacea			N	7
Calotis hispidula				8
Chrysocephalum eremaeum				
Chrysocephalum sp. Little Sandy Desert (SVL 4899)				
Erymophyllum ramosum subsp. *ramosum*		Y		
Gnephosis brevifolia		Y	NE	4
Ixiochlamys cuneifolia		Y	S	
Kippistia suaedifolia		Y	N, D	1
Minuria multiseta		Y	W, D	
Minuria sp. Little Sandy Desert 1 (SVL 4919)				
Myriocephalus rudallii		Y		2
Olearia incana ms		Y	N, D	1
Olearia stuartii		Y		
Olearia sp. Little Sandy Desert (SVL 3335)				
Pluchea dentex				
Pluchea tetranthera			S	
Podolepis canescens		Y		6
Podolepis capillaris				5
Pterocaulon sphacelatum				1
Rhodanthe charsleyae				2
Rhodanthe floribunda				3
Rhodanthe humboldtiana				2
Rhodanthe pollackii		Y	SE	
Rhodanthe propinqua		Y		3
Rhodanthe sterilescens		Y		7
Rhodanthe stricta				4
Rhodanthe tietkensii			SW	
Rutidosis helichrysoides				2
Schoenia cassiniana		Y		
Senecio magnificus		Y		2
Streptoglossa bubakii		Y	S	
Streptoglossa cylindriceps		Y		
Streptoglossa decurrens			S	1
Vittadinia arida		Y	E, D	4
Vittadinia eremaea		Y		4
Waitzia acuminata var. *acuminata*		Y	N	4
Xerochrysum sp. Beyondie (SVL 1831)				2

`APPENDIX 3.2

Map of the south-western Little Sandy Desert study area showing the distribution of the seven Quadrat Site groups amongst the 53 quadrats.



Chapter 4

HERPETOFAUNA OF THE SOUTH-WESTERN LITTLE SANDY DESERT

P.G. Kendrick

Pilbara Region, Department of Conservation and Land Management, Karratha.

ABSTRACT

A survey of herpetofauna of the south-western Little Sandy Desert was undertaken between the years 1995 and 1997. This survey recorded a total 87 species (5 amphibians, 1 turtle, 9 agamids, 15 geckos, 5 pygopodids, 30 skinks, 9 varanids, 3 typhlopid, 1 boid and 9 elapids). An additional 22 species (5 amphibians, 1 agamid, 3 geckos, 8 skinks, 1 typhlopid, 1 boid and 3 elapids) are known from other collections elsewhere in the biogeographical region, giving a known total of 109 species for the Desert. It is highly likely that other species will be located within the Desert, if intensive survey effort is ever undertaken in other parts of the region. Most species are distributed widely in the northern or central arid zone. A significant number of species do not appear to pass beyond the fringes of the Desert, particularly on the western and southern margins. There is a small set of endemic species within the Little Sandy Desert, several of which are not yet described.

INTRODUCTION

This paper reports the results of collections of reptiles and amphibians undertaken between 1995 and 2001, by staff of the Western Australian Department of Conservation and Land Management (CALM) in the Little Sandy Desert Biogeographical Region, north-western Australia. This work concentrated upon the south-western part of the Little Sandy Desert, an area that had received almost no attention from biologists prior to this work. This paper also reports herpetofauna collections from the broader region, based upon data held in the collections of the Western Australian Museum. Consideration of these additional records provides some regional perspective for the present survey and allows a presentation of our current state of knowledge of the fauna of this remote and poorly known Desert.

METHODS

CALM SURVEY SAMPLING

The CALM survey concentrated on the south-western margin of the Little Sandy Desert, the area abutting the Weelarrana, Kumarina and Marymia pastoral leases as depicted in Figure 2.1. Fifteen vertebrate survey sites were established (Figure 2.3), in three clusters of five sites. Each cluster of sites represented five surface types typical of the area, defined mainly by substrate, but also by vegetation (Appendix 2.3).

VERTEBRATE SURVEY

Each survey site consisted of an array of 12 pit traps, ten 60cm deep PVC tubes and 2 20 litre PVC buckets. Vertebrate survey trap arrays were operated for a minimum of five consecutive nights. Elliott traps were also set, with numbers depended upon the total number of traps available.

Foraging and night searches were undertaken at all trapping sites. Other locations were searched on an opportunistic basis.

Additional survey work not directly related to this survey was undertaken during two Landscope Expeditions (van Leeuwen *et al.* 2000, Kenneally *et al*. 2002). These trips undertook opportunistic collecting and trapping of herpetofauna. van Leeuwen *et al*. (2000) visited the south-western parts of the Little Sandy Desert in September 1999, including Yanneri Lake and other localities in that vicinity of Ilgarari Creek. Kenneally *et al.* (2002) visited the Carnarvon Ranges in 2001.

The CALM survey undertook systematic and opportunistic collections of vertebrates during the following visits.

Reconnaissance:	24 July - 02 August 1995
Installation:	18 October - 27 October 1995
Trip 1 (Sampling)	04 June - 22 June 1996
Trip 2 (Sampling)	08 October - 26 October 1996
Trip 3 (Invertebrates only)	12 April - 18 April 1997
Trip 4 (Sampling)	11 August - 28 August 1997

INVERTEBRATE TRAPPING

Invertebrates were sampled from all sites and some vertebrates were captured inadvertently in the invertebrate pits. Permanent invertebrate pits were small 10 l buckets, established in June 1996 and maintained until August 1997 (440 days). Three buckets were established at each of the 15 vertebrate sampling sites. These traps were serviced at four to five month

intervals. Invertebrate pits were designed such that most vertebrates were excluded from the pit by a 1 cm^2 wire mesh. However, small vertebrates did enter the pits and were preserved in a ethylene glycol/formalin solution. In addition, temporary invertebrate traps were open for four nights at each site for each visit. These were small plastic cups containing Galt's solution and they also occasionally captured vertebrates.

OTHER DATA SOURCES

The collections of the Western Australian Museum were used to provide vertebrate data for the rest of the Little Sandy Desert Biogeographical Region and on general distribution data for herpetofauna species. Numerous collections had been made by biologists in various parts of the Little Sandy Desert previous to the current CALM survey. The notable collections are listed below.

- W.H. Butler: 1964, 1971 and 1976 - Canning Stock Route (CSR) and Durba Hills; 1972 Rudall River National Park and Talawana Track.
- Christchurch Grammar School: 1966 - southern CSR.
- M. DeGraaf: 1968 to 1972 - CSR.
- The (then) Western Australia Department of Fisheries and Wildlife and Western Australian Museum: 1966 - Talawana Track and CSR; 1975 to 1976 - Carnarvon Range and Durba Hills; 1979 - Rudall River National Park.

NOMENCLATURE

Nomenclature used here is that of Aplin and Smith (2001).

RESULTS

Species identified during the survey are listed below. Annotations indicate the locations from which they were taken, and any other relevant information.

Abbreviations:

CSR	Canning Stock Route.
WAM	Western Australian Museum of Natural History.
R	Reptile prefix on WAM register accession numbers.
B	Beyondie sites, followed by site number 1-5, or 'nog' for 'not on grids' (not from established survey sites).
C	Cooma Well sites, followed by site number, or 'nog' for 'not on grids'.
S	Savory Creek sites, followed by site number, or 'nog' for 'not on grids'.
(#)	Number of records from sites.

AMPHIBIA

Family Hylidae (Tree frogs)

Cyclorana australis

Not collected during the present survey, despite heavy rains and apparently suitable habitats. The previous collections from Rudall River National Park (in 1971) appear to represent the southern known limits of C. australis geographic range. Widespread to the north and north-west of the Little Sandy Desert.

Cyclorana maini B1 (1), B4 (1), C3 (5), S1 (3).

Several juveniles were recovered from invertebrate pit traps in a variety of surface types (mulga, sand plain and samphire). Two adults were trapped in vertebrate pit traps on samphire (S1) in June 1996. This species is probably widespread, but would only be commonly encountered after significant rain. It has been previously collected from Rudall River National Park, Durba Springs, various locations along the CSR and from the Carnarvon Range.

Litoria rubella C3 (2), S1 (8), S4 (1), S5 (14), Snog (1).

Most frequently collected from sites in the vicinity of Savory Creek. Adult *L. rubella* were collected only from pools in Savory Creek (close to S1) or from the dry water course itself. All other records are from invertebrate pits and probably show local dispersal from Savory Creek following significant rainfall. The sandstone breakaway areas and spinifex sand plains would support these animals only for as long as humidity remained high in sheltered microhabitats. Previously collected from the vicinity of the Talawana Track, Rudall River National Park and along the CSR. It is also now present in the water supplies of many desert communities and even in isolated water bores.

Family Myobatrachidae (Australasian ground-frogs)

Limnodynastes spenceri C4 (1), S1 (1).

Found beneath damp litter against pit trap drift fence on a samphire flat close to Savory Creek and an adult active on the C4 dune at night in August 1997. Previously collected from near the Rudall River.

Neobatrachus aquilonius B4(1).

An adult active at night on *Triodia* sand plain (August 1997). Previously recorded from Rudall River National Park, Durba Springs and Glenayle Station (immediately to the south of Little Sandy Desert). This species is probably more widely distributed, but would only be readily observed following heavy rains. Access to this country after heavy rain is difficult, resulting in general under-representation of burrowing frogs in this survey.

Neobatrachus sutor

Previously collected from Karri Karri Pool, near Mount Essendon, in the south-western part of the Little Sandy Desert. The distribution of this frog appears to be to the south of the Little Sandy Desert, so it is unlikely that its range extends further north than this. See comments under *N. aquilonius* regarding general problems with recording burrowing frogs in the arid interior.

Neobatrachus wilsmorei

Collected from Karri Karri Pool, near Mount Essendon, in the south-western part of the Little Sandy Desert. The distribution of this frog appears to be confined to the southern Little Sandy Desert, so it is unlikely that its range extends further north than this. See comments under *N. aquilonius* regarding general problems with recording burrowing frogs in the arid interior.

Unidentified *Neobatrachus* spp. B4 (2), S1 (1), S3 (2).

Specimens were dehydrated to the point where specific identification was impossible.

Notaden nichollsi B3 (2).

Pit trapped among sand dunes. This species is widely distributed across the northern and central arid zone. Although collections are sparse, it is probably present throughout the Little Sandy Desert in suitable habitat. Has been previously collected from Rudall River National Park and Carnegie Homestead immediately to the south of the Desert.

Uperoleia sp. (probably *U. russelli*).

Not collected in the present survey. However, previous collections have been taken from Rudall River National Park.

REPTILIA

Family Cheluidae (Fresh-water turtles)

Chelodina steindachneri S1 (1).

A mature individual burnt from a large clump of spinifex, approx. 0.5 km from Savory Creek. Up to 15 *C. steindachneri* were observed in pools along Savory Creek on single occasions. A carapace was also found in Savory Creek where the abandoned No. 1 Vermin Proof Fence crosses the creek. This locality is just outside the boundary of the Little Sandy Desert Biogeographical Region. Apparently widely distributed along Savory Creek. A further specimen is known from Mount, collected in 1964. Other records are known from the western and southern margins of the Little Sandy Desert.

Family Agamidae (Dragons)

Ctenophorus caudicinctus caudicinctus *B5 (3), C1 (12), Cnog (1), S5 (5).*

Common among sandstone boulders. Immature animals captured in June 1996, but apparently not common in the study area. Noted at numerous locations by van Leeuwen *et al.* (2000) in the south-western part of the Little Sandy Desert. Many previous records from Old Talawana, CSR, Weld Spring and the Rudall River. Also collected from the Carnarvon Range.

Ctenophorus isolepis gularis B2 (1), B3 (2), B4 (3), B5 (5) C2 (8), C3 (5), C4 (5), C5 (5), S2 (3), S3 (2), S4 (2), S5 (5).

Common and conspicuous on sandy substrates, including dune slopes and crests and sand plains in the southern parts of the Little Sandy Desert. Several juveniles were taken from invertebrate pits in April and August 1997. This species was recorded at numerous locations by van Leeuwen *et al.* (2000) in the south-western part of the Desert and also from many locations along the CSR between Weld Spring and the Durba Hills. Note the distribution of *C. i. isolepis* below.

Ctenophorus isolepis isolepis

Common on sandy country in the northern and central parts of the Little Sandy Desert, this subspecies was not recorded during the present survey. Previous records include Talawana Track, Rudall River area and Well 23 on CSR, which is just outside the biogeographical region.

Ctenophorus nuchalis B3 (1), B4 (1), C3 (1), C5 (1), S1 (1).

Dug from burrows on Cooma Well claypan, close to C3, and from gravelly soil at B3 and B4. Not commonly observed, but probably widespread. Previous collections indicate that this species is widely distributed and common. It has been recorded from numerous locations on the CSR between Weld Spring and the Durba Hills, as well as along the western margin of the Desert. Also known from the Rudall River and Talawana areas in the northern Little Sandy Desert.

Ctenophorus reticulatus B1 (2).

Two juveniles were taken from invertebrate pits in April and August 1997. Otherwise, appeared to be much less common in the Little Sandy Desert than in adjacent areas to the west, such as Kulonoski

Well and Mundiwindi. Also recorded from various locations along the CSR between Weld Spring and the Durba Hills.

Ctenophorus scutulatus B1 (1), B2 (2), S3 (2), Savory Camp (1).

Always restricted to mulga woodlands. A fairly cryptic species, it was probably more common than the few records suggest. All four specimens were taken in Oct 1996. This species is widely distributed to the south and west of the Little Sandy Desert, the records obtained by this survey extend the known range to the north-east.

Ctenophorus sp.

Known from a single specimen from Lake Disappointment and similar to *C. salinarum*, which is common in the southern interior of Western Australia. This undescribed species requires more specimens to confirm taxonomic status. Although not recorded in this survey, it may occur in salt lake habitats elsewhere in the Little Sandy Desert.

Diporiphora winneckei B3 (3), C4 (3), Cnog (1), S4 (5).

Collected from dune habitats only. Common and widespread in suitable habitat. Numerous collections have been made along the CSR between Weld Spring and the Durba Hills and along Talawana Track in the northern Little Sandy Desert. This species has a very wide distribution in the northern arid zone and probably extends across the whole Desert.

Lophognathus longirostris B1 (1), B3 (1), C2 (1), C4 (1), S4 (4).

Collected from sand plain, sand dune and mulga habitats. Commonly observed resting or foraging within *Eucalyptus* litter, or up in foliage. Apparently widespread and fairly common. Previously collected from various localities along the CSR between the Durba Hills and Pierre Spring, from mulgas in the south-western part of the Desert and from various localities in the Rudall River National Park. This species is very widely distributed in the central arid zone and is distributed across the entire Little Sandy Desert.

Moloch horridus Bnog (2).

One animal found on sand plain 1.5 km west of B1 and another collected from a dune swale several kilometres east of B4. Also recorded by van Leeuwen *et al*. (2000) from sand plains in the south-western quarter of the Desert and from Talawana Track in the north. Probably common and widespread on sandy surfaces throughout the region, but was not commonly encountered during this survey.

Pogona minor minor B1 (2), B2 (5), B3 (1), B4 (3), B5 (1), C2 (2), C3 (9), C5 (1), S2 (1), S3 (1), S5 (2).

Pit trapped or observed in mulga or sand plain habitats. Probably widely distributed in the study area, although apparently not common. Previously collected from the southern and western margins of the Little Sandy Desert (Mt Nossiter and Savory Creek) and from the Durba Hills. Recorded from mulga and sand dune habitats by van Leeuwen *et al*. (2000) in the south-western part of the Desert.

Family Gekkonidae (Geckos)

Diplodactylus conspicillatus B1 (2), B2 (1), B4 (4), C2 (4), C5 (1), S2(2).

Only encountered on sand plain and mulga habitats. Records were obtained for both pit traps and observed at night. A juvenile was also obtained from an invertebrate trap. Recorded by van Leeuwen *et al*. (2000) from sand dune habitat at Yanneri Lake. Previous collections have been made at locations along the CSR near Terrace Hill and the Durba Hills, from the Talawana Track and at Mount Davis and in the Carnarvon Range. This species is very widely distributed in the northern arid zone and almost certainly occurs across the entire Little Sandy Desert.

Diplodactylus fulleri

Currently known only from two specimens, both collected from the vicinity of Lake Disappointment. Was not recorded during the present survey. It is likely to be restricted in distribution to the Lake Disappointment area.

Diplodactylus pulcher B1 (1).

Pit trapped from mulga on laterite. A single record indicates that this species is not common in the area. Previously known from a single individual taken from Well 9 on the CSR, which is just outside the southern boundary of the Little Sandy Desert Biogeographical Region.. Although widely distributed to the south of the Little Sandy Desert, it is unlikely that this species extends far beyond the southern parts of the region.

Diplodactylus stenodactylus B3 (2), C2 (1), C3 (1), C4 (2), S2 (1).

Widespread and relatively common, being recorded from dunes, sand plains and mulga. Several specimens were taken while head torching on dune crests, others in pit traps. Previously known in the Little Sandy Desert only from collections along the extreme south-west of the region in the vicinity of the Carnarvon Ranges and from the Talawana Track in the north. This species inhabits a very broad distribution throughout north-west and central Western Australia and it almost certainly extends across the entire Little Sandy Desert. The low numbers of collections indicate that it may be uncommon. By contrast, in other parts of the species distributional range it is often a highly conspicuous member of the gecko fauna (eg. the Pilbara).

Gehyra pilbara

Previously collected from Well 12 on the CSR, the Durba Hills and along the Talawana Track in the north Little Sandy Desert. This species was not recorded during the present survey, possible because of an absence of large termitaria. The wide distribution of *G. pilbara* throughout the northern half of Western Australia indicates that it may be present within the Little Sandy Desert, although it appears so far to be restricted to northern part of the Desert.

Gehyra punctata B5 (3).

All three animals collected from beneath sandstone slabs around rocky breakaways. Apparently common in suitable habitat, this species was recorded by van Leeuwen *et al*. (2000) from sandstone habitats in the south-western Little Sandy Desert. Previously collected from Mount Davis, near the southern margins of the Desert, the distribution of *G. punctata* indicates that it may occur only within western parts of the Little Sandy Desert.

Gehyra purpurascens B3 (2), B4 (6), C2 (2), C3 (3), C4 (3), C5 (4), Cnog (3), S2 (2), S4 (1).

Collected from mulga, dune, sand plain and claypan habitats, usually from beneath tree bark or other cover. One animal taken from an invertebrate pit trap. Previously collected from Talawana Track, Wells 11 and 12 on the CSR, and from the Durba Hills. This common and widespread species is widely distributed throughout the arid zone of Western Australia.

Gehyra variegata B1 (4), B2 (5), B5 (2), C1 (11), C2 (2), C3 (4), C5 (2), S1 (1), S2 (1), S3 (4), S5 (4), Snog (1).

Collected from mulga, rocky breakaways, sand plain and samphire habitats, as well as within Savory Creek. Previously collected from Old Talawana, Rudall River National Park, Carnarvon Range, the Durba Hills, Calvert Range, McConky Hill, Wells 11 and 14 on the CSR and many other localities in the Little Sandy Desert. Common and widespread, it appears to favour most habitats except dune fields.

Heteronotia binoei B1 (1), B2 (2), B3 (1), B4 (3), C1 (2), C3 (1), C5 (1), Cnog (1), S1 (3), S3 (1), S4 (1), S5 (8).

Collected from mulga, sand plain, sand dune, sandstone breakaways and claypan samphire. Common and widespread throughout the study area. Mostly found through foraging, but eight were taken in invertebrate pit traps. Previously collected from Rudall River National Park, Talawana Track,

at various locations along the CSR between Well 11 and Durba Springs. Also known from the Carnarvon Range. Common and widespread, occurring throughout the Little Sandy Desert.

Heteronotia spelea

Recorded from a cave in a sandstone outcrop by van Leeuwen *et al.* (2000) in the south-western Little Sandy Desert. The known distribution of this species indicates that it will occur in suitable habitats only in western parts of the region.

Nephrurus laevissimus B3 (1), C1 (1), C4 (2), S4 (2).

Usually pit trapped or observed at night on sand dunes, although one animal was pit trapped on a sandstone breakaway. Previously collected from various locations along the CSR (White Lake, Wells 12, 13), and Durba Hills. Also known from Talawana Track and from the Carnarvon Range. This species is probably common on suitable sandy surfaces throughout the Desert, as it ranges extensively through the northern and southern arid zone.

Nephrurus levis levis C2 (2), S2 (1).

Pit trapped on sand plain sites. Also recorded by van Leeuwen *et al*. (2000) from sand dune habitats near the Carnarvon Range in the south-western Little Sandy Desert. Also collected from Wells 12 and 15 on the CSR. Widely distributed in the arid interior, this sub-species probably occurs across the Desert. This sub-species appears to occur in sympatry with *N. levis pilbaraensis* along the boundary of the Little Sandy Desert and Pilbara Biogeographical Regions. The extent of overlap of these forms is unclear.

Oedura marmorata B5 (1), C1 (3), S5 (1).

Captured while foraging at night on sandstone boulders. Apparently common in suitable habitat. A series of collections were made of this species from the Carnarvon Range. The wider distribution of this species and it's apparent absence from sandstone features such as the Calvert Range and Durba Hills indicates that *O. marmorata* may only extend into the western parts of the Little Sandy Desert.

Rhynchoedura ornata B1 (1), C2 (1), C3 (1), C4 (1), Cnog (1), S2 (1), S3 (1).

Most recorded taken from pit traps, on mulga, sand plain or sand dune habitats or observed at night. Previously collected from the vicinity of the Talawana Track and the Durba Hills. The extensive distribution of this species throughout the arid zone indicates that it is present and probably common throughout the Little Sandy Desert.

Strophurus ciliaris aberrans C5 (1), S2 (1), S3 (1), S4 (1).

Taken from pit traps (vertebrate and invertebrate) and found active while foraging at night. Found in mulga habitats as well as sand plains and sand dune areas. Moderately common and widespread. This species has been previously collected from the Talawana Track, the Durba Hills and from localities along the CSR. It appears to be common throughout the Little Sandy Desert.

Strophurus elderi B2 (1), C1 (1), C2 (1), C3 (1), C4 (4), C5 (1), S1 (8), S2 (1), S3 (1), S4 (2).

Taken from samphire, sandstone breakaways, mulga, sand plain and sand dune habitats. It is widespread and probably common in a wide range of habitats. Three animals were taken from invertebrate pit traps. Other records were either pit trapped or found while foraging (many were burnt from spinifex). Collected previously from Rudall River National Park, the Durba Hills, Warri Soak and Savory Creek (near the western margins of the Little Sandy Desert). The distribution of the species indicates that it is widespread and abundant throughout the region.

Strophurus jeanae S4 (1), C4 (1).

Collected only from invertebrate pit traps. Previously collected from Weld Spring. The distribution of this species indicates that it may occur throughout the Little Sandy Desert. Appears to be uncommon.

Strophurus wellingtonae S3 (1).

Found under a rotting log in a drainage line. Previously collected from the Carnarvon Range. The wider distribution of this species indicates that it will probably only occur in the south-western and western parts of the Little Sandy Desert. Apparently uncommon.

Family Pygopodidae (Legless lizards)

Delma haroldi C4 (1), S2 (1).

Captured while foraging or pit trapped. Previous collections are sparsely distributed over the northern arid zone. Although none have been previously taken from within the Little Sandy Desert, there are several collections from areas immediately to the north, east and west of the region. It probably occurs throughout the Desert.

Delma nasuta C1 (1) , B1 (1), S2 (2).

Pit trapped or captured while foraging on a variety of surface types, including mulga, sand plain and rocky breakaways. Also recorded by van Leeuwen *et al.* (2000) from *Casuarina* litter in the south-western Little Sandy Desert. Although none have been previously taken from within the Little Sandy Desert, there are many collections from areas immediately to the north, east and west. It is probably found throughout the Desert.

Delma pax C4 (1), C5 (1).

Collected while foraging in mulga on laterite and among dunes. Also recorded by van Leeuwen *et al.* (2000) from Casuarina litter in the south-western Little Sandy Desert. Although none have been previously taken from within the Little Sandy Desert, there are a number of collections from areas immediately to the east and west. It is probably found throughout the Desert.

Lialis burtonis B3 (3), C3 (1), C4 (1), S1 (3), S2 (1), S3 (1).

Taken from mulga, dune and sand plain habitats. Recorded by van Leeuwen *et al.* (2000) from samphire habitat in the south-western Little Sandy Desert. Widespread, but not commonly encountered during the present survey. Previously collected from Rudall River National Park and several locations along the CSR between Well 13 and the Durba Hills.

Pygopus nigriceps C3 (1), S4 (1).

Collected while foraging in mulga and sand dune habitats. One animal apparently foraging along a dune crest when captured. Previously collected from the Rudall River National Park and Carnarvon Range. It is probably widely distributed throughout the Desert.

Family Scincidae (Skinks)

Carlia triacantha B1 (1), B5 (1), C1 (1), C5 (2).

Two animals burnt from spinifex and one found in an invertebrate pit trap. Others were pit trapped or observed on sandstone boulders. Distributed widely in the north of Western Australia, other records of *C. triacantha* are known only from the western margins of the Little Sandy Desert.

Cryptoblepharus carnabyi Snog (1).

One animal (R102723) was collected from leaf litter while foraging in Savory Creek at the abandoned No. 1 Vermin Proof Fence crossing. This locality is outside the boundary of the Little Sandy Desert. Otherwise this skink is known only from the western margins of the Little Sandy Desert., although widely distributed throughout Western Australia.

Cryptoblepharus plagiocephalus B1 (1), B3 (1), Cnog (1), S2 (1).

Two animals retrieved from invertebrate pit traps (B1 and S2, August 1997). Observed 6 km south-east of Cooma Well on trunk of *Hakea lorea* among sand dunes. Unidentified *Cryptoblepharus* were observed on rocks near Savory Creek at S1 and running in litter at Yanneri Lake (specific identity

was unclear, but probably *C. plagiocephalus*). Previous collections have been made from the Durba Hills and the Carnarvon Ranges.

Ctenotus ariadnae B5 (1), C2 (1), S3 (2), S5 (2).

Three juveniles trapped in invertebrate traps (S3 and S5, August 1997). Most of the others were taken from pit traps. Otherwise known from the southern Great Sandy and Great Victoria Deserts and previously collected from the Talawana Track just south of Rudall River National Park. Probably distributed throughout the Little Sandy Desert.

Ctenotus brooksi brooksi B3 (2), B5 (1), S4 (11).

All records of this species were pit trapped. Eight juveniles were taken in invertebrate pit traps in April and August 1997. Adults were collected in pit traps in October 1996. This species appears to be common on dune habitats, although one juvenile was taken from sandstone breakaway habitat lying above a sand dune field. Has been previously collected from the Talawana Track south of Rudall River National Park, Weld Spring and from Well 12 on the CSR. Widely distributed in the arid interior of Western Australia and probably common throughout the Little Sandy Desert.

Ctenotus calurus B3 (1), B4 (2), C2 (3), C4 (2), S2 (3).

Juveniles were taken in invertebrate pits in April and August 1997, while adults were trapped or collected by foraging. Common on sand plain or sand dune surfaces. Recorded from sand plain habitats by van Leeuwen *et al*. (2000) in the south-western part of the Little Sandy Desert. Previously collected from Talawana Track, from various locations on the CSR and from the Carnarvon Range. Widely distributed in the arid interior and probably present throughout the Desert.

Ctenotus dux B3 (9), C4 (9), S4 (11).

Twenty of these animals were taken from invertebrate pit traps. All other records were obtained from pit traps on sand dune surfaces where it is apparently common. Previously collected from Talawana Track, the Carnarvon Range and Carnegie Homestead (just south of the Little Sandy Desert). Not clear whether this species occurs in eastern parts of the Desert.

Ctenotus grandis grandis B4 (9), C2 (2), C5 (2), S2 (6).

Eleven of these were taken from invertebrate pit traps in April and August 1997. Most adult captures were in Elliott traps, although a few were collected during foraging. All records indicate a preference for sand plain locations, with a cover of spinifex. Previously collected from the Talawana Track, the Rudall River National Park, Carnarvon Range and Durba Spring. Widely distributed in the northern arid interior and occurring throughout the Little Sandy Desert.

Ctenotus hanloni

Not collected during this survey. This species has been previously collected from Talawana Track, just south of Rudall River National Park. Although well collected from the north-west, this species is poorly known from the arid interior and may not occur beyond the north-western parts of the Little Sandy Desert.

Ctenotus helenae B3 (1), B4 (2), B5 (8), C1 (9), C2 (3), C3 (1), C5 (1), S1 (2), S2 (3), S3 (1), S4 (2), S5 (2).

Common and widespread, on most surface types sampled. A large number of records (28) were taken from invertebrate pit traps. Most other records were taken in vertebrate pit traps. Previously collected from Talawana Track, Rudall River National Park, Mount Davis (east of the Carnarvon Range), Well 14 on the CSR and the Durba Hills. Very widely distributed throughout arid Western Australia and the central Northern Territory. This species is common throughout the Little Sandy Desert.

Note that collections from the Carnarvon Range appear to be morphologically intermediate between typical *C. helenae* and *C. saxatilis*. Further taxonomic and molecular work is required to resolve the specific identity of these populations.

Ctenotus leae B3 (2), C4 (2), S4 (1).

Recorded only from sand dune sites. Two records were juvenile animals taken from invertebrate pit traps. Apparently uncommon. Previously recorded from Well 24 on the CSR (northern margins of the region in Great Sandy Desert). This species is sparsely distributed across the arid interior and it's distribution within the Little Sandy Desert is unclear.

Ctenotus leonhardii S1 (3).

Collected from invertebrate pit traps set on a samphire flat at S1. Previously collected from the Fame Range (extreme south east of Desert), Weld Spring and Wells 11 and 16 on the CSR. Widely distributed across the arid interior, details of it's distribution in the Little Sandy Desert is unclear.

Ctenotus nasutus B3 (1), C2 (1), C4 (3), S4 (1).

Apparently common on sandy substrates, particularly dunes. Only one record obtained from an invertebrate pit trap (C4). A gravid animal with two eggs was collected in October 1997 (R102704). Previously recorded from the Talawana Track, south of the Rudall River National Park. The species is restricted to sandy deserts of the northern interior.

Ctenotus pantherinus ocellifer B3 (3), B4 (13), B5 (1), C1 (2), C2 (2), C4 (2), C5 (2), S2 (4), S3 (14), S4 (4), S5 (2).

Common and widespread, occurring on most surface types sampled. A large number of records were taken from invertebrate pit traps (37, in April 1997). Recorded from a variety of habitat types by van Leeuwen *et al*. (2000), from the south-western part of the Desert. Previous collections have been taken from Talawana Track, Rudall River National Park, Carnarvon Range, and various wells on the CSR between Pierre Spring and Durba Hills. This species is very widely distributed across northern Western Australia and occurs throughout the Little Sandy Desert.

Ctenotus piankai C4 (2), S2 (1).

Uncommon, from sandy substrates (sand plain or sand dune). Recorded by van Leeuwen *et al*. (2000) from sand plain habitats in the south-western Desert. Previously recorded from Well 12 on the CSR. Distributed mainly though sandy deserts of the northern arid interior, it probably occurs throughout the Little Sandy Desert.

Ctenotus quattuordecimlineatus B3 (4), B4 (6), C2 (3), C4 (3), C5 (1), S4 (1).

Common on sand plains and sand dunes, although one was recovered from an invertebrate pit trap located at C5 (mulga on laterite). Recorded from sand plain habitat by van Leeuwen *et al*. (2000) in the south-western part of the Desert and from Talawana Track and Rudall River National Park. Broadly distributed though the central arid zone and probably widespread in the Little Sandy Desert.

Ctenotus saxatilis

A series of animals collected from the Carnarvon Range (R53620-21, R53636-42, R53662-663) appear similar to *C. saxatilis*, but with reduced pattern. In this regard, they resemble *C. helenae*. No boldly-patterned typical *C. saxatilis* were collected from any sites during the survey, indicating that this generally common and conspicuous species is absent from the study area. The exact relationships of the Carnarvon Range population to 'true' *C. saxatilis* requires further investigation. *Ctenotus saxatilis* has previously been collected from Rudall River National Park and from areas to the south and west of the Little Sandy Desert.

Ctenotus schomburgkii B1 (1), B2 (3), B4 (1).

Only recorded from the southern Beyondie sites. Apparently uncommon, but most frequently encountered on sandy substrate. Two animals, including one taken from mulga on laterite were recovered from invertebrate pit traps. Previously known from the Rudall River National Park and Carnarvon Range. Widespread throughout the southern arid interior of Western Australia. Possibly occurs throughout the Little Sandy Desert, but further collections are required to confirm this.

Ctenotus uber uber

Collected from the Carnarvon Range in 1971. Not detected during the present survey, but the species is widely distributed through the southern arid interior of Western Australia.

Cyclodomorphus melanops melanops B2 (1).

Also recorded from mulga (*Acacia aneura*) and black oak (*Casuarina pauper*) habitats by van Leeuwen *et al*. (2000), from the south-western Desert. Previously collected from Rudall River National Park, Weld Spring and Carnarvon Range and along the far southern and south-western margins of the Desert. This species is widely distributed in the arid zone, although it's poor representation in this survey indicates that if it does occur throughout the Little Sandy Desert, it may be uncommon.

Egernia depressa B1 (15), B2 (3).

Taken from mulga habitats at the southern Beyondie sites. Apparently common in suitable habitat, where they sheltered in tree hollows. Also trapped in pit and Elliott traps at these locations. Previous records from the Desert are limited to a single specimen from the Carnarvon Range. The distribution of the species indicates that it does not extend across the entire Little Sandy Desert, but is restricted to the western and perhaps southern margins.

Egernia formosa

Although not collected during the present survey, a single record is known from the Carnarvon Range. Similarly to *E. depressa*, the distribution of the species indicates that it does not extend across the entire Little Sandy Desert, but is restricted to the western and southern margins.

Egernia striata B3 (2), B4 (2), C2 (1), S2 (1).

Five of these records were from animals recovered from invertebrate pit traps. One other was taken in an Elliott trap. All were taken from sand plain or sand dune habitats. The species appears to be common and widespread. A series of specimens were collected from the Carnarvon Range in the 1970's. The broad distribution of this species through the central arid zone indicates that it probably occurs throughout the Little Sandy Desert.

Eremiascincus fasciolatus B2 (6), B3 (4), C4 (1), S2 (1), S4 (8).

This species appears to be common and widespread in sand plain and sand dune sites throughout the survey. However, all but one record were taken from invertebrate pit traps, including those collected from mulga over calcrete at B2. This is not a habitat usually associated with this species. Previously collected from Talawana Track south of Rudall River National Park. The broad distribution of this species across the northern arid zone indicates that it occurs throughout all of the Little Sandy Desert.

Eremiascincus richardsoni B2 (2).

From mulga on calcrete substrate. One pit trapped, the other from an invertebrate pit trap. Apparently not common, although reported by van Leeuwen *et al*. (2000) from mulga and sand plain habitats in the south-western Desert. Previously collected from the Durba Hills and from the southern and western margins of the Desert. It's broad distribution across the State indicates that this species occurs throughout the Little Sandy Desert.

Lerista bipes B2 (7), B3 (8), B4 (6), B5 (1), Bnog (4), C1 (6), C2 (5), C4 (4), C5 (1), S1 (2), S2 (9), S3 (4), S4 (14), S5 (2).

Collected from sand dune, sand plain, mulga, sandstone breakaways and samphire habitats. *Lerista. bipes* was one of the most generally distributed reptile species observed during the survey. When found in sandstone habitats the species was always in small pockets of sandy soil derived from the local parent rock or beneath loose slabs of rock. Similarly, in mulga areas this species was present under leaf litter in patches of lighter soils. Very common and widespread. Many were retrieved from invertebrate pits. Previously known within the Desert only from Rudall River National Park and Terrace Hill on the CSR. This species undoubtedly occurs across all suitable habitats in the Little Sandy Desert.

Lerista desertorum

Previously collected from Durba Spring and the Carnarvon Range, this species was not recorded during the present survey. Previous collections indicate that this species may occur throughout the Little Sandy Desert.. However, given the relative ease with which this species is usually captured, it appears to be replaced within the study area by *L. macropisthopus remota*.

Lerista ips B3 (1), C4 (3), S4 (1).

Collected from sand dune sites only. Animals were pit trapped, dug from loose sand or located while burrowing in loose sand at night. Apparently common and widespread in dune habitats, there were no previous collections of this species from the Little Sandy Desert. Wider distribution records indicate that it would occur throughout the Little Sandy Desert.

Lerista macropisthopus remota B1 (6), B2 (2), B3 (3), B5 (1), Bnog (1), C1 (3), C2 (6),C3 (1), C4 (3), C5 (3), S2 (2), S4 (2), S5 (1).

A widely distributed and common species, collected from mulga, sand dune, sand plain and sandstone breakaways. Apparently widespread and common. While occasionally pit trapped in vertebrate and invertebrate pit traps, most records were obtained by digging animals out of deep litter beds beneath shrubs or trees. No previous records had been collected from the Desert prior to the present survey. This species appears to be restricted to the western parts of the Little Sandy Desert.

Lerista muelleri B1 (3), B2 (6), B3 (1), B5 (1), C1 (6), C3 (4), S1 (3).

All collected while foraging, in mulga, samphire and sandstone breakaway habitats or from invertebrate traps. Probably common and widespread in suitable habitats. Previous collections of this species had been made from the Talawana Track and from the southern part of the CSR, between Weld Spring and Well 11. The wider distribution of *L. muelleri* within the western arid zone indicates that it may be restricted to the western half of the Little Sandy Desert. Further collections are required.

This species is currently under taxonomic review, and it is likely that a large number of specific taxa will be recognised. It is believed that at least two species will be described from animals collected during this survey (L. A. Smith, WAM. pers. comm.).

Lerista neander S1 (2), S2 (1), S5 (1).

All collected while foraging beneath litter on samphire, sand plain or sandstone breakaway sites. Always found under thick litter, or in relatively sheltered micro-habitats. Also recorded by van Leeuwen *et al.* (2000) from sand plain habitats in the south-western Desert. While not previously collected from the Little Sandy Desert, the distribution of this species indicates that it extends only into the western third of the region.

Lerista xanthura

Known previously from the northern parts of the Little Sandy Desert, the only record taken during the present survey was from Yanneri Lake (van Leeuwen *et al*. 2000). This species is cryptic, and probably uncommon. It is likely to occur in suitable sandy habitats throughout the Desert.

Menetia greyii B1 (3), B2 (2), B3 (1), B4 (2), B5 (3), Bnog (1), C1 (2), C2 (1), C3 (2), C4 (5), C5 (1), Cnog (1), S2 (1), S3 (3), S4 (2), S5 (1).

Mostly taken while running in leaf litter or in vertebrate pit traps. Also commonly taken in invertebrate pit traps, this species occurred in mulga, sand dunes, sand plain and sandstone breakaway habitats. Common throughout the study area and also collected from Yanneri Lake. Previously collected from the Rudall River National Park and the CSR in the vicinity of Lake Aerodrome and Lake Disappointment. This species occurs widely throughout the Little Sandy Desert.

Menetia surda surda

Not recorded during the present survey. Previously known from a single specimen collected from the Rudall River National Park.

Morethia ruficauda ruficauda B1 (1), B4 (2), B5 (1), C1 (2), C2 (6), C4 (5), S1 (2), S3 (1), S5 (3).

Collected or observed on sandstone breakaways, sand plains, sand dunes and mulga habitats. Previously collected from the CSR at Durba Spring and at Warri Soak. Also collected from the Carnarvon Range, this species is clearly widespread and common.

Notoscincus ornatus ornatus B4 (1).

Taken from an invertebrate pit trap, set in sand plain country. Apparently uncommon in the study area, as only one individual of this species was recorded. The wider distribution of this species indicates that it may be present only in the northern and western parts of the Little Sandy Desert. Previously collected from the Rudall River National Park.

Proablepharus reginae

Not recorded during this survey. A single collection from Rudall River National Park. Otherwise known from widely scattered collections in the arid interior and from the Pilbara.

Tiliqua multifasciata C2 (1).

A predated individual (just the top of the skull intact) was found on sand plain habitat. Previously recorded from the Rudall River National Park, Carnarvon Ranges, Durba Springs, Weld Spring and Warri Soak. The broader distribution of this species indicates that it is widely distributed across the Little Sandy Desert.

Family Varanidae (Goannas and monitors)

Varanus acanthurus B5 (3), C1 (3), S5 (4).

Captured from beneath sandstone slabs among sandstone outcrops or observed active among spinifex near sandstone outcrops. One animal was retrieved from the stomach of a feral cat, captured at C1. Previously collected from the Rudall River National Park, Durba Spring and also from various localities around the margins of the Little Sandy Desert. The wider distribution indicates that, within habitats offering suitable shelter (rocks, trees), this species should occur throughout the region.

Varanus brevicauda B4 (2), C2 (1), C4 (1), S2 (2), S4 (2).

Taken from vertebrate and invertebrate pit traps and captured while foraging, from sand plain or sand dune sites. Probably common in suitable habitats. While not previously recorded from the Little Sandy Desert, the distribution of this species on all margins of the region indicates that it probably occurs throughout the Little Sandy Desert.

Varanus caudolineatus B1 (1), S3 (1).

Both animals found under tree bark, in mulga habitat. Also recorded by van Leeuwen *et al.* (2000) from sandstone outcrop habitats in the south-western Little Sandy Desert. Previously recorded from Weld Spring, jus outside the Little Sandy desert in the Gascoyne Biogeographical Region.. The known distribution of *V. caudolineatus* indicates that it may not extend further into the Desert than along the western and southern margins of the region. Probably common in suitable habitat.

Varanus eremius B3 (1), C1 (1), C2 (1), C4 (2), S2 (1), S4 (2).

Pit trapped or dug from burrows, or observed active among dunes. Previously recorded from the Carnarvon Range and Well 12 on the CSR. This species has a very wide distribution throughout the southern and northern arid zone and probably occurs throughout the Little Sandy Desert, on sandy substrates.

Varanus giganteus B2 (1), C3 (1), S1 (1).

Observed while active during the day. A large animal was found dead near Savory Creek, in a small cave on a sandstone outcrop. Previously recorded from the Carnarvon Range. Although collection

records of this species are generally sparse, the wider distribution indicates that *V. giganteus* occurs throughout the Little Sandy Desert. This species was not encountered during the present survey.

Varanus gilleni B1 (2), B2 (2), C3 (1), S3 (1).

All located while foraging in mulga habitats. Sometimes observed while basking, on dead mulga timber. Apparently common in suitable habitat. The wider distribution of *V. gilleni* indicates that it occurs throughout the Desert.

Varanus gouldii C2 (1), C3 (1), Cnog (1).

Juvenile animals observed active during the day and one adult dug from a burrow on sand plains north-west of C1. Previously recorded from the Talawana Track south of Rudall River National Park, Carnarvon Range and various localities around the western and southern margins of the region. This species has a very wide distribution across Western Australia and certainly occurs throughout the Little Sandy Desert. It appears to be particularly common on sand plain habitats in the northern part of the Desert. In areas along the Talawana track and along roads leading to Aboriginal communities, it is commonly hunted for food.

Varanus panoptes rubidus S1 (1).

Observed active on sandstone outcrop, close to Savory Creek. Previously collected from Rudall River National Park and Carnarvon Range. This species may extend only as far as the western and northern margins of the Little Sandy Desert.

Varanus tristis tristis B3 (1), C3 (1).

Found inside mulga hollows or pit trapped. Previously recorded from the Rudall River National Park and Durba Hills. Given the wide distribution of this species, it is certain to occur throughout the Little Sandy Desert Biogeographical Region.

Family Typhlopidae (Blind snakes)

Ramphotyphlops endoterus Bnog (2), C4 (4), S4 (2), S5 (1).

Dug from beneath litter in sandy soils or captured while active on the surface of sand dune crests at night. The individual taken from sandstone breakaway country was pit trapped. Active animals were observed moving rapidly over the sandy surface for considerable distances (up to 100 metres) at night. Tracks visible in sand indicated that this animal was common in the area and very active at night at this time (October 1996). This species has a wide distribution across the interior and probably occurs throughout the Little Sandy Desert. Apparently common in suitable habitat.

Ramphotyphlops grypus B5 (1), C2 (1), S3 (1).

Pit trapped or found while foraging from sandstone breakaways, sand plain and mulga sites. Previously collected from the Durba Hills. The wider distribution of this species appears to indicate that it may extend only as far as the western half of the Little Sandy Desert Biogeographical Region.

Ramphotyphlops hamatus

Not recorded during the present survey, but previously collected from Jigalong, on the western boundary of the Little Sandy Desert in the Gascoyne Biogeographical Region.

Ramphotyphlops waitii B1 (1).

Pit trapped in mulga on heavy clay soil. Not previously recorded from the Little Sandy Desert. At extreme north-eastern limits of known range.

Family Boidae (Pythons)

Antaresia perthensis S5 (1).

A juvenile animal, pit trapped in June 1996, on Savory Creek. Previously collected from just outside the Little Sandy Desert at Well 24 on the CSR and from the far north of the Little Sandy Desert. Otherwise widely distributed in the Pilbara and north-west of Western Australia.

Antaresia stimsoni stimsoni

Early collections from Well 11 on the CSR and from the Durba Hills in the early 1970's. Also known from immediately north and west of the Little Sandy Desert. Widely distributed in the arid interior of Western Australia. Not recorded during the present survey.

Family Elapidae (Front-fanged snakes)

Brachyurophis approximans

Not recorded during the present survey but previously collected from the Rudall River National Park. More commonly known from areas to the west of the Little Sandy Desert.

Brachyurophis fasciolata fasciata S4 (1).

Pit trapped in dune habitat. A poorly known subspecies, it is known from a few collections from the Great Victoria and Great Sandy Deserts. It appears to be present in the Little Sandy Desert, but appears to be uncommon.

Demansia psammophis cupreiceps B1 (1), B2 (1).

Observed active during the day. Not previously known from the Little Sandy Desert, it is common and widespread to the west. It may only occur in western parts of the region.

Demansia rufescens B4 (1), B5 (1), S2 (2).

Encountered on sand plain and rocky breakaway sites. Two juveniles recovered from invertebrate pit traps and one adult pit trapped. Probably widely distributed.

Demansia aff*. rufescens* B4 (2), B5 (1), S2 (2).

Two adults taken from inside a rotten *Xanthorrhoea* trunk, two juveniles taken from invertebrate pit traps on sand plain and an adult pit trapped on a rocky breakaway. These specimens appear to be distinct from typical *D. rufescens* and may represent a new taxon.

Furina ornata B2 (1), C3 (1), S2 (1).

All specimens found while foraging, one killed by vehicle traffic. Recorded by van Leeuwen *et al*. (2000) from sandstone outcrops in the south-western Desert. Found in mulga and sand plain habitats. Previously recorded from the Durba Hills and the western margins of the region (Mundiwindi), it is likely that this species occurs throughout the Little Sandy Desert. The wider distribution of this species indicates that it may only occur in the southern parts of the Little Sandy Desert.

Parasuta monachus B1 (1).

Found in soil beneath rotting log. Previously collected from the Well 6 on the CSR and from Mundiwindi on the western margins of the Desert. Both these locality are in the Gascoyne Biogeographical Region.

Pseudechis australis

Previously collected from Well 17 on the CSR and from the Carnarvon Range. This species is certainly distributed throughout the Little Sandy Desert. That it was not recorded in the present survey indicates the chancy nature of encounters with large elapids.

Pseudonaja modesta B1 (1), B5 (1), C3 (1), Cnog (1), S3 (1), S5 (1).

Found while foraging in mulga habitats or active at night. While not previously collected from the Little Sandy Desert, it has been taken from locations near the western and southern margins of the region (Beyondie, Jigalong and Glenayle). It is certainly distributed throughout the Little Sandy Desert.

Pseudonaja nuchalis B3 (1), S2 (1).

Collected while foraging on sand plain and dune habitats. Previously collected from Well 16 on the CSR. It has also been recorded from Mundiwindi and Weelarrana. Previous collection records indicate that this species is not as common in the interior as elsewhere.

Simoselaps anomalus Bnog (1), C4 (3), S4 (2).

Usually taken from pit traps or when foraging on dune habitats or from sandy habitats near dunes. Collected while active at night and from invertebrate pit traps. A gravid female (2 eggs) was collected in October 1996. This distribution of this snake appears to indicate that it occurs throughout the Little Sandy Desert. Apparently common and widespread in suitable sandy habitat, but usually displaying highly cryptic behaviour, which would tend to under-represent it's true abundance.

Simoselaps bertholdi S4 (1).

Collected while foraging, dug from beneath litter on a sand dune. Previously collected from the western margins of the Little Sandy Desert (Mundiwindi). The wider distribution of this species indicates that it is unlikely to extend past the south-western margins of the Desert.

Suta fasciata

Previously collected from Weld Spring on the southern margins of the Little Sandy Desert, the Rudall River National Park and from Mundiwindi and Kulonoski East Wells on the western margins of the Desert. Collections from the Gibson Desert to the east indicate that this species may occur throughout the Little Sandy Desert, but this is yet to be confirmed.

DISCUSSION

Because of the previously low levels of collecting in the south-western Little Sandy Desert prior to this survey, the absence of many species from the Western Australia Museum records was often because of lack of collection rather than the absence of the species from the area. Relatively intense collections have been restricted to the routes of regional roads and tracks.

A total of 109 species of herpetofauna are known from the Little Sandy Desert, of which 87 were collected during the present survey (Table 4.1). This is a rich fauna, primarily composed of desert elements or species with very wide distribution within the north-west and interior. Some parts of the Little Sandy Desert are further enriched by a set of species, which appear to extend into the region from the west, and sometimes the south and/or north, but which do not occur throughout the entire region. Considering the low level of intensive collections within the biogeographical region, the herpetofauna of the Desert area is now relative well understood.

Amphibians were not a conspicuous component of the fauna encountered during the present survey. However, intermittently flowing watercourses such as Savory Creek, which contain permanent and semi-permanent pools, clearly support large populations of *Litoria rubella*. This species is a very capable disperser across the interior and north-west, as witnessed by collections made from sandstone hill habitats near Savory Creek (S5). Only one other species

of Hylidae was collected by the present survey (*Cyclorana maini*) and appears to be widely distributed through the Little Sandy Desert. *Cyclorana. australis* is known only in the northern parts of the Little Sandy Desert, near the Rudall River National Park.

Table 4.2 Numbers of species for each Family of herpetofauna known from the Little Sandy Desert and the number of species recorded during the CALM survey of the south-western portion of the biogeographical region.

Group	Total known in Little Sandy Desert	Recorded by CALM survey
Hylidae	3	2
Myobatrachidae	7	3
Cheluidae	1	1
Agamidae	10	9
Gekkonidae	18	15
Pygopodidae	5	5
Scincidae	38	30
Varanidae	9	9
Typhlopidae	4	3
Boidae	2	1
Elapidae	12	9

Burrowing frogs, particularly the Myobatrachidae, are usually only conspicuous following heavy rain. Access to the entire Little Sandy Desert region becomes impossible following such events and observers would need to be at the right place and time to see these animals. Other records from close to the study area suggest that several Myobatrachids are present in the southern Little Sandy Desert, although they were not detected during the present survey. Some severely dehydrated *Neobatrachus* may be *N. aquilonius*, although specific identification is impossible.

Ctenophorus species appear to conform to a couple of general patterns. Some are generally common and widespread across the Little Sandy Desert (*C. isolepis, C nuchalis*), while others are either at the edge of their otherwise extensive *distributions (C caudicinctus, C reticulatus, C. scutulatus*), or they are species with very restricted distributions (*Ctenophorus* sp. from Lake Disappointment). Other Agamid genera are widely distributed throughout the central arid zone, and throughout the Little Sandy Desert. *Moloch* and *Diporiphora* are restricted to sandy substrates, while *Pogona* and *Lophognathus* are more generally distributed. Note that *Caimanops amphiboluroides* was not recorded from mulga habitats within the Little Sandy Desert, although it has been collected from very close to the western boundary (at Mundiwindi). Similarly, *Tympanocryptis cephala* has been collected from Mundiwindi and Glenayle, on the western and southern margins of the region, respectively, but not within the Little Sandy Desert.

Of the *Diplodactylus* species collected, only *D. stenodactylus* was abundant and widespread. *Diplodactylus conspicillatus* was uncommon and *D. pulcher* was rare. *Diplodactylus fulleri* has a very restricted geographic range (Lake Disappointment). Two species of *Gehyra* (*G. purpurascens* and *G. variegata*) are very abundant and widespread throughout the Little Sandy Desert. However, *Gehyra pilbara* only extends into the northern margins of the Desert, while *G. punctata* just enters the western margins. Similarly, *Heteronotia binoei* was widely distributed in many different habitat types, while *H. spelea* appears to be restricted to sandstone habitats on the western margins of the region. While less commonly encountered, both species of *Nephrurus* appear to be widely distributed across the Little Sandy Desert. The western

margin of the Little Sandy Desert appears to be the western limit of *N. levis levis*, where it overlaps with *N. levis pilbarensis*, however the interaction of these two sub-species is unclear. Note that *Nephrurus wheeleri cinctus* is known from the western margins of the Little Sandy Desert, but does not appear to extend into the region. *Oedura* appears to be restricted to the western parts of the Little Sandy Desert. *Strophurus ciliaris* and *S. elderi* appear to be common and widespread in the Little Sandy Desert, while both *S. jeanae* and *S. wellingtonae* are much less common and in the case of the latter, restricted to the south-western margins of the Desert. *Rhynchoedura ornata* is common throughout.

Pygopodids were poorly known from the Little Sandy Desert prior to this survey. Three species of *Delma* (*D. haroldi*, *D. pax* and *D. nasuta*) were unknown from the region previous to this survey. Note that while *Delma butleri* is not yet known from the Little Sandy Desert, they have been collected from localities close to the margins of the region. *Lialis* and *Pygopus* also appear to occur throughout the Little Sandy Desert.

A large skink fauna was recorded, mainly species typical of the central desert regions of Western Australia. *Carlia* is represented only by *C. triacantha*, restricted to the western margins of the region. Similarly, *Cryptoblepharus carnabyi* is limited to the western margins, unlike *C. plagiocephalus*, which is widely distributed in the Little Sandy Desert, although not common.

Among *Ctenotus*, most species were widely distributed members of a typical desert fauna, known to occur throughout the Little Sandy Desert and adjacent biogeographical regions. Exceptions to this pattern included *C. dux, C. hanloni, C. leae, C. leonhardii*, *C. nasutus* and *C. uber*. The taxonomic status of *C. saxatilis* from the Little Sandy Desert is also unclear and the weakly patterned animals referrable to this species do not appear to be widely distributed in the region.

Egernia depressa and *E. formosa* are only known from the south-western parts of the Desert, unlike *E. striata*, which is more widely distributed in the sandy habitats of the region. *Egernia inornata* is known from the southern margins of the Little Sandy Desert (at Glenayle station), but not yet from the region. Both species of *Eremiascincus* are also found within the Little Sandy Desert, with *E. fasciolatus* common on sandy surfaces. Among *Lerista*, *L. bipes*, *L. muelleri*, *L. macropisthopus, L. ips* and *L. xanthura* are widely distributed in the Little Sandy Desert. Others, such as *L. desertorum* and *L. neander* appear to be restricted to the heavier soils on the western margins. The status of *L. muelleri* is under review (L.A. Smith, WAM. pers. comm.). This is likely to result in a large number of new species, at least two of which will occur in the Little Sandy Desert.

Menetia greyii and *Morethia ruficauda* are common and widespread, while *Tiliqua multifasciata* is probably widespread, despite being encountered rarely. *Menetia surda* and *Notoscincus ornatus* are known from one and two specimens respectively from the entire Little Sandy Desert. Similarly, *Proablepharus reginae* is known from a single specimen from the Rudall River National Park.

Of the nine species of Varanid known from the Desert, only two are unlikely to be found throughout the region. *Varanus caudolineatus* and *V. panoptes* do not appear to occur past the western margins of the Little Sandy Desert. Other varanids have very wide geographic ranges, and are typical elements of the arid zone fauna in central and north-western Australia.

Four species of *Ramphotyphlops* are known from the Little Sandy Desert. Of these, only *R. endoterus* is widespread and common. The others seem to be restricted to western parts and it is possible that *R. hamatus* does not actually occur within the western margins of the Little Sandy Desert. However, these animals can be inconspicuous and further collections are required to finalise distributions.

Only two boid species are known from the Little Sandy Desert and both are uncommon. *Antaresia stimsoni* seems particularly so, as this species is often conspicuous in the derelict wells of the CSR further north in the Great Sandy Desert. It is also possible that *Aspidites melanocephalus* is also present, but as yet undetected within the region.

Generally, elapids were poorly represented, although 10 of the 14 species known from the region were encountered during the survey. The absence of *Acanthophis* is unexpected. The known range of *A. wellsi* stops on the western margin of the Little Sandy Desert, while *A. pyrrhus* is not known to extend into the Desert from the north. The taxonomic status of the *Demansia* aff. *rufescens* collected during this survey is uncertain. *Vermicella snelli* have been collected from immediately to the west of the region Little Sandy Desert at Mundiwindi, but are so far unknown from within the Little Sandy Desert.

ACKNOWLEDGMENTS

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Chapter 5

BIRDS OF THE SOUTH-WESTERN LITTLE SANDY DESERT

P.J. Fuller and A.A. Burbidge

Western Australian Wildlife Research Centre, Department of Conservation and Land Management, Perth.

ABSTRACT

Surveys of the avifauna of the south-western Little Sandy Desert study area between 1995 and 1999 revealed the presence of 116 bird species (61 passerines, 55 non-passerines). Pattern analysis of counts on quadrats selected to sample the main landform and vegetation types showed the presence of four quadrat and four species groups however, the association between these groups was weak. The largest species group (34 species) included ubiquitous species and the second largest (20 species) included birds associated with mulga woodland. Quadrats were grouped into mulga, sandstone, sand dune and sandplain areas. The weak association is probably due to the study area being arid and lying within a single natural region and to birds being mobile and less bound to specialised habitats than some other groups of organisms. A total of 42 species were recorded breeding after summer and winter-spring rains. Most birds recorded are typical of arid zone habitats in Australia, although 20 species of waterbird were recorded along Savory Creek, an intermittent drainage channel.

INTRODUCTION

Knowledge of avian community structure and composition in arid Australia is rudimentary. In Western Australia species assemblage data have been published for some sites, for example, on the Nullarbor Plain (Burbidge *et al*. 1987) and the Eastern Goldfields (Burbidge *et al*. 1995). Information is particularly scant from the widespread desert sandy surfaces dominated by spinifex (*Triodia* spp.) hummock grasslands and scattered shrubs and trees. Some studies have reported on birds of mulga (*Acacia aneura*) communities (eg, Cody 1994, Recher and Davis 1997); however, mulga is sparse and patchy in the sandy deserts.

Annotated species lists for tropical sandy deserts have been published for the Great Sandy Desert (Start And Fuller 1983), the Tanami Desert (Gibson 1986) and the northern Simpson Desert (Gibson and Cole 1988). Lists for the Great Victoria Desert can be found in McKenzie and Burbidge (1979) and Black and Badman (1986). The latter authors provide comparisons between vegetation associations, but these are not based on rigorous data collection.

A detailed analysis of birds of the southern Carnarvon Basin (Burbidge *et al*. 2000) includes some habitats similar to sandy desert habitats.

We are not aware of any previous detailed studies on the birds of the Little Sandy Desert of Western Australia, particularly the south-western portion of the area.

METHODS

Visits to the study area when birds were recorded, together with type of data collected, were as follows (dates are inclusive):

Trip 1	25 July 1995 to 30 July 1995	opportunistic
Trip 2	19 October 1995 to 26 October 1995	opportunistic
Trip 3	6 June 1996 to 22 June 1996	quadrat and opportunistic
Trip 4	10 October 1996 to 26 October 1996	quadrat and opportunistic
Trip 5	13 April 1997 to 19 April 1997	quadrat and opportunistic
Trip 6	13 August 1997 to 28 August 1997	quadrat and opportunistic
Trip 7	14 September 1999 to 19 September 1999	opportunistic

Climatic features of the study area are provided in Chapter 2.

QUADRAT DATA COLLECTION

Elsewhere within this publication is a full description of the area surveyed together with descriptions of each survey site (Chapter 2). Appendix 2.3 provides a list of the five bird survey sites that were surveyed near each of the three focal areas across the latitudinal extent of the study area.

During each survey, each of the five quadrats within the three focal areas was sampled on three occasions over a five-day period. Two surveys were conducted each morning, the first commencing shortly before sunrise, the second on completion of the first count, about two hours after sunrise and the third in the late afternoon. During each trip, each site was surveyed once at each start time.

About 1.5 hours was spent on census work on each quadrat on each visit. In total, 4.5 hours of actual census time was spent on each of the 15 quadrat during each survey. The quadrats were unbounded - the single observer could wander anywhere on the quadrat, depending on where he saw birds or decided to search for them. While the size of the quadrat was not restricted, the observer was required to limit all census work to the confines of the vegetation and landscape-soil types described for that particular site. Outside these areas, records were classed as opportunistic. The observer carried a pair of 8 x 56 binoculars.

For each species observed, the following data were recorded:

- numbers of individuals, plus, where possible, age and sex;

- activity (e.g. whether feeding, on the ground, in vegetation, flying overhead); and
- whether breeding - for all breeding observations, we recorded breeding stage, from individuals carrying nesting material, to eggs, to adults feeding chicks, to recently flying young.

During each census, information on wind, temperature, cloud cover and rain were recorded. However, this information has not been used in the analyses described below.

Nocturnal observations were made while camping at each survey site (at least once per trip) as well as during spotlighting and head torching for nocturnal animals. The evening work and overnight stays proved very beneficial for bird data, as many nocturnal species (i.e. Nightjars, Owls, Bush Stone-curlew) were recorded.

In some instances, observations included sightings of fresh tracks, mainly Emu and Australian Bustard. On other occasions, particularly in areas of dense scrub, bird whistles (Audubon bird call) were used to attract some species. These bird callers were also beneficial on sandplains and dunes, when working in areas of thick spinifex (*Triodia* spp.).

OPPORTUNISTIC DATA COLLECTION

In addition to the census survey of each site, all members of the survey team made opportunistic bird observations from any area within the general region under survey.

QUADRAT DATA ANALYSES

Matrices were generated from quadrat data, showing presence/absence of bird species by quadrat. Before analysis we filtered the data to remove records of:

- all birds recorded overhead that did not land within the quadrat,
- waterbirds,
- *Corvus* spp. not identified to species, and
- species recorded on only a single quadrat.

Community composition and the relationship between the 15 survey sites was examined using pattern analyses on presence/absence data via the computer package PATN (Belbin 1994). Survey sites were associated according to similarities in their bird fauna using the Czekanowski metric (Faith *et al*. 1987) and the unweighted pair grouped arithmetic averaging clustering strategy (UPGMA, β = -0.1). Singletons were excluded from the presence/absence matrices prior to analysis. The veracity of the clustering dendrogram with respect to the association matrix was subjectively investigated using the cophenetic correlation. Subsequently accord between the clustering dendrogram and the association matrix was investigated by the construction of a two-way table of the species and trapping grid classifications using the routine outlined by Belbin (1991).

RESULTS

A total of 116 bird species (61 passerines, 55 non-passerines) were recorded in the study area (Table 5.1). Twenty species of waterbirds were recorded; nineteen of them on S1, which included part of Savory Creek. Some 85 species were recorded on quadrats; of these 11 species were recorded on only one quadrat (Table 5.2).

QUADRAT CLASSIFICATION

The dendrogram of quadrat classification for the 15 survey sites on the basis of the 74 bird species recorded on more than one quadrat is given in Figure 5.1. The dendrogram of species classification is given in Figure 5.2. The association between quadrats was weak, as indicated by a cophenetic correlation of $r = 0.67$. After inspection of the dendrograms we based further analyses on four quadrat groups and four species groups. These are presented in a two-way table (Table 5.3) while the distribution of the four quadrat groups across the survey area is presented in Appendix 5.1.

Comments on these groups are presented below:

- Quadrat group 1 (B1, C3, B2 and S1) comprise mainly mulga-dominated quadrats, but also includes S1, which is dominated by samphire (*Halosarcia*), but has some small trees, habitat used by birds such as Australian Magpie, while other species were attracted to the drinking water in the creek (e.g. Australian Ringneck, Little Corella).
- Quadrat group 2 includes the sandstone-dominated habitats of B5 and C1, but also included C5, which has mulga on heavy soils.
- Quadrat group 3 includes the two sand dune quadrats - B3 and S4.
- Quadrat group 4 includes all sandplain quadrats (B4, C4, C2 and S2) plus S3 (laterite and mulga) and S5 (sandstone).
- Species group 1 birds (15 species) are typical of the sandplain habitats, but were found almost equally elsewhere.
- Species group 2 (4 species) includes a few birds located only or mostly on dunes. These were Grey-headed Honeyeater, White-backed Swallow, Striated Pardalote and Spinifexbird.
- Species group 3 (20 species) birds are mainly found in mulga-dominated quadrats, and includes mulga and other tree specialists such as Australian Magpie, Little Corella, Cockatiel, Mulga Parrot, Australian Ringneck, Southern Boobook, Whistling Kite, Southern Whiteface, Grey-crowned Babbler, Varied Sittella and Western Gerygone.
- Species group 4 (34 species) contains ubiquitous birds found in all habitats sampled by the quadrats.

Quadrat group 2 (mainly sandstone, but including C5) is typified by the absence of birds associated with mulga and dunes.

Table 5.1 Phylogenetic list of bird species recorded in study area, 1995 – 1999; scientific and common names follow Christidis and Boles (1994).

Scientific name	Common name
Dromaius novaehollandiae (Latham, 1790)	Emu
Cygnus atratus (Latham, 1790)	Black Swan
Tadorna tadornoides (Jardine & Selby, 1828)	Australian Shelduck
Chenonetta jubata (Latham, 1801)	Australian Wood Duck
Anas superciliosa Gmelin, 1789	Pacific Black Duck
Anas gracilis Buller, 1869	Grey Teal
Malacorhynchus membranaceus (Latham, 1801)	Pink-eared Duck
Aythya australis (Eyton, 1838)	Hardhead
Poliocephalus poliocephalus (Jardine & Selby, 1827)	Hoary-headed Grebe
Anhinga melanogaster Pennant, 1769	Darter
Phalacrocorax melanoleucos (Vieillot, 1817)	Little Pied Cormorant
Egretta novaehollandiae (Latham, 1790)	White-faced Heron
Ardea pacifica Latham, 1801	White-necked Heron
Ardea alba Linnaeus, 1758	Great Egret
Elanus axillaris (Latham, 1801)	Black-shouldered Kite
Hamirostra melanosternon (Gould, 1841)	Black-breasted Buzzard
Milvus migrans (Boddaert, 1783)	Black Kite
Haliastur sphenurus (Vieillot, 1818)	Whistling Kite
Circus assimilis Jardine & Selby, 1828	Spotted Harrier
Accipiter fasciatus (Vigors & Horsfield, 1827)	Brown Goshawk
Accipiter cirrhocephalus (Vieillot, 1817)	Collared Sparrowhawk
Aquila audax (Latham, 1801)	Wedge-tailed Eagle
Hieraaetus morphnoides (Gould, 1841)	Little Eagle
Falco berigora Vigors & Horsfield, 1827	Brown Falcon
Falco longipennis Swainson, 1837	Australian Hobby
Falco cenchroides Vigors & Horsfield, 1827	Nankeen Kestrel
Fulica atra Linnaeus, 1758	Eurasian Coot
Ardeotis australis (Gray, 1829)	Australian Bustard
Turnix velox (Gould, 1841)	Little Button-quail
Tringa glareola Linnaeus, 1758	Wood Sandpiper
Actitis hypoleucos (Linnaeus, 1758)	Common Sandpiper
Burhinus grallarius (Latham, 1801)	Bush Stone-curlew
Himantopus himantopus (Linnaeus, 1758)	Black-winged Stilt
Recurvirostra novaehollandiae Vieillot, 1816	Red-necked Avocet
Charadrius ruficapillus Temminck, 1822	Red-capped Plover
Elseyornis melanops (Vieillot, 1818)	Black-fronted Dotterel
Stiltia isabella (Vieillot, 1816)	Australian Pratincole
Phaps chalcoptera (Latham, 1790)	Common Bronzewing
Ocyphaps lophotes (Temminck, 1822)	Crested Pigeon
Geophaps plumifera Gould, 1842	Spinifex Pigeon
Geopelia cuneata (Latham, 1801)	Diamond Dove
Cacatua roseicapilla Vieillot, 1817	Galah
Cacatua sanguinea Gould, 1843	Little Corella
Nymphicus hollandicus (Kerr, 1792)	Cockatiel
Barnardius zonarius (Shaw, 1805)	Australian Ringneck
Psephotus varius Clark, 1910	Mulga Parrot
Melopsittacus undulatus (Shaw, 1805)	Budgerigar
Cuculus pallidus (Latham, 1801)	Pallid Cuckoo
Chrysococcyx basalis (Horsfield, 1821)	Horsfield's Bronze-Cuckoo
Ninox novaeseelandiae (Gmelin, 1788)	Southern Boobook
Podargus strigoides (Latham, 1801)	Tawny Frogmouth
Eurostopodus argus Hartert, 1892	Spotted Nightjar
Aegotheles cristatus (Shaw, 1790)	Australian Owlet-nightjar
Todiramphus pyrrhopygia (Gould, 1841)	Red-backed Kingfisher
Merops ornatus Latham, 1801	Rainbow Bee-eater
Malurus lamberti Vigors & Horsfield, 1827	Variegated Fairy-wren
Malurus leucopterus Dumont, 1824	White-winged Fairy-wren
Stipiturus ruficeps Campbell, 1899	Rufous-crowned Emu-wren
Amytornis striatus (Gould, 1840)	Striated Grasswren
Pardalotus striatus (Gmelin, 1789)	Striated Pardalote
Pyrrholaemus brunneus Gould, 1841	Redthroat

Scientific name	Common name
Smicrornis brevirostris (Gould, 1838)	Weebill
Gerygone fusca (Gould, 1838)	Western Gerygone
Acanthiza apicalis Gould, 1847	Inland Thornbill
Acanthiza uropygialis Gould, 1838	Chestnut-rumped Thornbill
Acanthiza robustirostris Milligan, 1903	Slaty-backed Thornbill
Acanthiza chrysorrhoa (Quoy & Gaimard, 1830)	Yellow-rumped Thornbill
Aphelocephala leucopsis (Gould, 1841)	Southern Whiteface
Aphelocephala nigricincta (North, 1895)	Banded Whiteface
Acanthagenys rufogularis Gould, 1857	Spiny-cheeked Honeyeater
Manorina flavigula (Gould, 1840)	Yellow-throated Miner
Lichenostomus virescens (Vieillot, 1817)	Singing Honeyeater
Lichenostomus keartlandi (North, 1895)	Grey-headed Honeyeater
Lichenostomus penicillatus (Gould, 1837)	White-plumed Honeyeater
Lichmera indistincta (Vigors & Horsfield, 1827)	Brown Honeyeater
Phylidonyris albifrons (Gould, 1841)	White-fronted Honeyeater
Certhionyx niger (Gould, 1838)	Black Honeyeater
Certhionyx variegatus Lesson, 1830	Pied Honeyeater
Epthianura tricolor Gould, 1841	Crimson Chat
Epthianura aurifrons Gould, 1838	Orange Chat
Microeca fascinans (Latham, 1801)	Jacky Winter
Petroica goodenovii (Vigors & Horsfield, 1827)	Red-capped Robin
Melanodryas cucullata (Latham, 1801)	Hooded Robin
Pomatostomus temporalis (Vigors & Horsfield, 1827)	Grey-crowned Babbler
Pomatostomus superciliosus (Vigors & Horsfield, 1827)	White-browed Babbler
Cinclosoma cinnamomeum Gould, 1846	Cinnamon Quail-thrush
Daphoenositta chrysoptera (Latham, 1801)	Varied Sittella
Oreoica gutturalis (Vigors & Horsfield, 1827)	Crested Bellbird
Pachycephala rufiventris (Latham, 1801)	Rufous Whistler
Colluricincla harmonica (Latham, 1801)	Grey Shrike-thrush
Grallina cyanoleuca (Latham, 1801)	Magpie-lark
Rhipidura fuliginosa (Sparrman, 1787)	Grey Fantail
Rhipidura leucophrys (Latham, 1801)	Willie Wagtail
Coracina novaehollandiae (Gmelin, 1789)	Black-faced Cuckoo-shrike
Coracina maxima (Rüppell, 1839)	Ground Cuckoo-shrike
Lalage sueurii (Vieillot, 1818)	White-winged Triller
Artamus personatus (Gould, 1841)	Masked Woodswallow
Artamus cinereus Vieillot, 1817	Black-faced Woodswallow
Artamus minor Vieillot, 1817	Little Woodswallow
Cracticus torquatus (Latham, 1801)	Grey Butcherbird
Cracticus nigrogularis (Gould, 1837)	Pied Butcherbird
Gymnorhina tibicen (Latham, 1801)	Australian Magpie
Corvus bennetti North, 1901	Little Crow
Corvus orru Bonaparte, 1851	Torresian Crow
Chlamydera guttata Gould, 1862	Western Bowerbird
Mirafra javanica Horsfield, 1821	Singing Bushlark
Anthus novaeseelandiae (Gmelin, 1789)	Richard's Pipit
Taeniopygia guttata (Vieillot, 1817)	Zebra Finch
Emblema pictum Gould, 1842	Painted Finch
Dicaeum hirundinaceum (Shaw, 1792)	Mistletoebird
Cheramoeca leucosternus (Gould, 1841)	White-backed Swallow
Hirundo nigricans Vieillot, 1817	Tree Martin
Hirundo ariel (Gould, 1843)	Fairy Martin
Eremiornis carteri North, 1900	Spinifexbird
Cincloramphus mathewsi Iredale, 1911	Rufous Songlark
Cincloramphus cruralis (Vigors & Horsfield, 1827)	Brown Songlark

Table 5.2 Bird species recorded on only one quadrat (does not include waterbirds recorded at S1).

Scientific name	Common name
Elanus axillaris (Latham, 1801)	Black-shouldered Kite
Burhinus grallarius (Latham, 1801)	Bush Stone-curlew
Malurus lamberti Vigors & Horsfield, 1827	Variegated Fairy-wren
Amytornis striatus (Gould, 1840)	Striated Grasswren
Lichenostomus penicillatus (Gould, 1837)	White-plumed Honeyeater
Epthianura tricolor Gould, 1841	Crimson Chat
Microeca fascinans (Latham, 1801)	Jacky Winter
Mirafra javanica Horsfield, 1821	Singing Bushlark
Hirundo ariel (Gould, 1843)	Fairy Martin
Cincloramphus mathewsi Iredale, 1911	Rufous Songlark
Cincloramphus cruralis (Vigors & Horsfield, 1827)	Brown Songlark

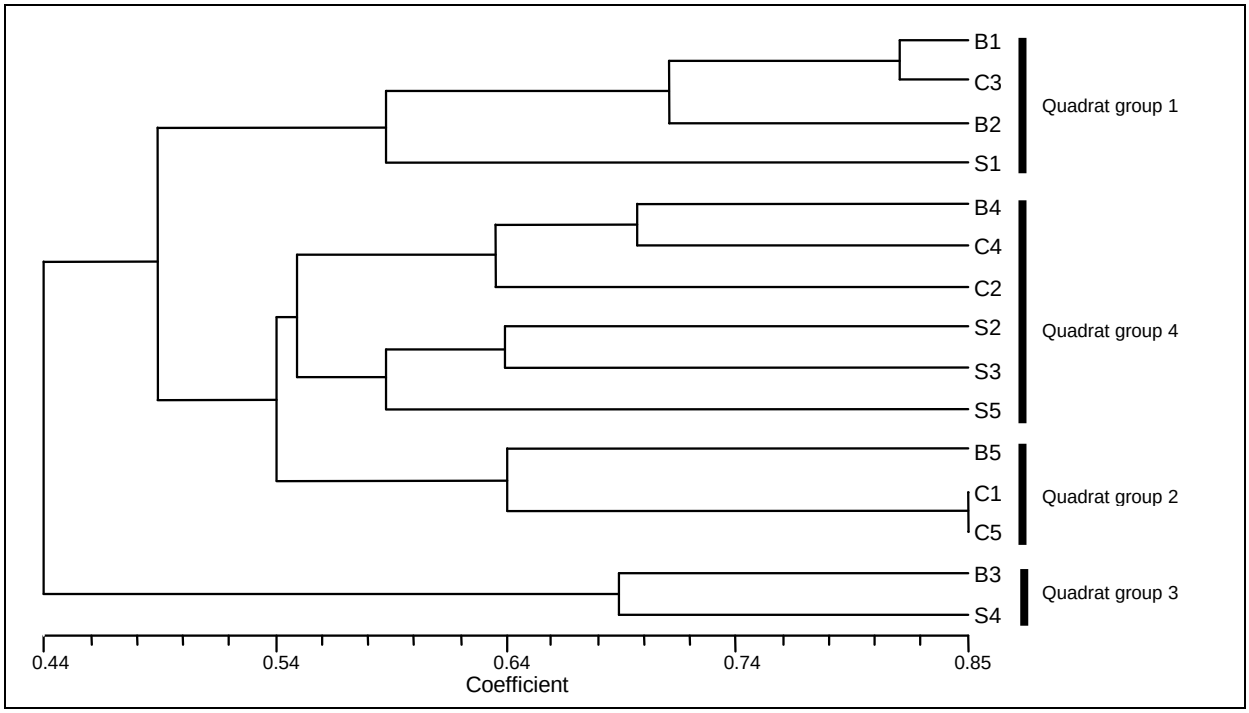

Figure 5.1 Dendrogram of quadrat classification based on the presence/absence of 74 bird species recorded at fifteen sites. (The clustering procedure employed the Czekanowski association measure and the flexible UPGMA agglomerative strategy (β = -0.1). Association between quadrats depicted in dendrogram is not very strong as indicated by a cophenetic correlation of r = 0.67. Values less than 0.7 are indicative of 'poor fit' (Rohlf 2000).

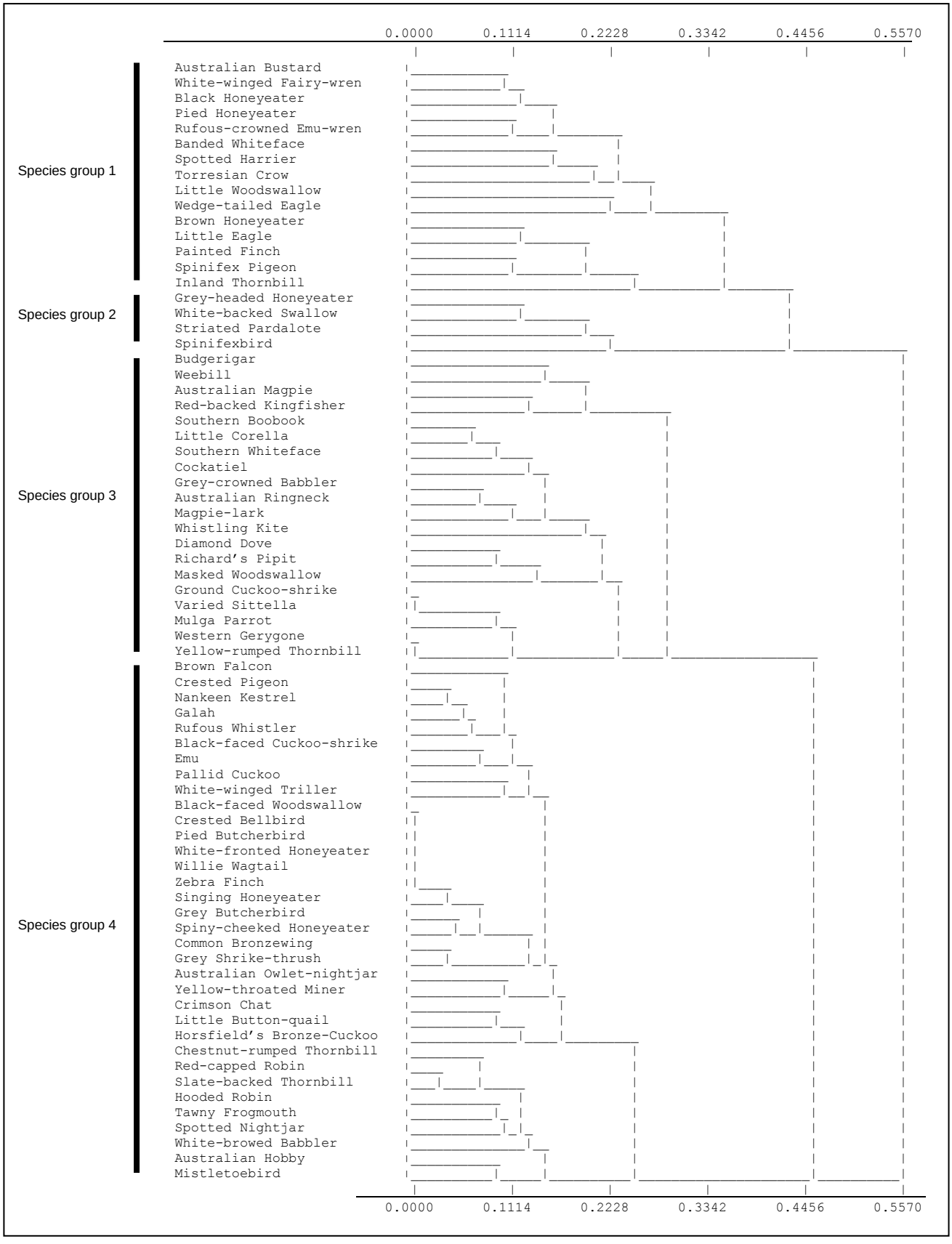

Figure 5.2. Dendrogram of species classification. See Table 5.1 for scientific names. The clustering procedure employed a two-way association measure and the flexible UPGMA agglomerative strategy (β = -0.1) (Belbin 1991).

Table 5.3 Two-way table of bird species recorded at quadrats in the south-western Little Sandy Desert study area (waterbirds and singletons excluded). See Table 5.1 for scientific names.

Species Groups	Bird species	Quadrat Groups														
		Group 1				Group 2			Group 3		Group 4					
		B1	C3	B2	S1	B5	C1	C5	B3	S4	B4	C4	C2	S2	S3	S5
Group 1	Australian Bustard			*							*	*	*	*	*	*
	White-winged Fairy-wren				*			*			*	*	*	*	*	
	Black Honeyeater						*	*		*	*			*	*	*
	Pied Honeyeater					*	*				*			*		
	Rufous-crowned Emu-wren					*		*	*		*	*	*	*		
	Banded Whiteface													*	*	
	Spotted Harrier		*								*			*	*	
	Torresian Crow													*		*
	Little Woodswallow					*	*									*
	Wedge-tailed Eagle					*						*				
	Brown Honeyeater				*										*	
	Little Eagle				*									*		
	Painted Finch				*											*
	Spinifex Pigeon				*	*										*
	Inland Thornbill				*		*	*								
Group 2	Grey-headed Honeyeater								*	*	*	*				
	White-backed Swallow								*	*						
	Striated Pardalote				*				*	*						
	Spinifexbird									*					*	
Group 3	Budgerigar	*	*						*	*				*		
	Weebill	*							*	*		*	*			
	Australian Magpie	*								*						
	Red-backed Kingfisher		*							*						
	Southern Boobook	*	*		*					*						
	Little Crow	*	*	*	*					*						
	Southern Whiteface	*	*	*						*						
	Cockatiel	*			*					*						
	Grey-crowned Babbler	*		*	*											
	Australian Ringneck	*	*	*	*											
	Magpie-lark	*			*											
	Whistling Kite		*		*											
	Diamond Dove	*	*										*			*
	Richard's Pipit	*	*		*											*
	Masked Woodswallow	*														*
	Ground Cuckoo-shrike	*	*	*												
	Varied Sittella	*	*	*												
	Mulga Parrot	*		*												
	Western Gerygone	*	*													
	Yellow-rumped Thornbill	*	*													
Group 4	Brown Falcon		*	*	*	*		*	*					*		
	Crested Pigeon	*	*	*	*	*	*	*	*	*						*
	Nankeen Kestrel	*	*	*	*		*	*	*	*		*		*		*
	Galah	*	*	*	*	*	*	*		*		*		*		
	Rufous Whistler	*	*	*	*		*	*	*	*			*		*	
	Black-faced Cuckoo-shrike	*	*	*	*				*	*		*	*	*		
	Emu	*	*		*				*	*	*	*		*		*
	Pallid Cuckoo	*	*		*	*						*	*			*
	White-winged Triller	*	*		*	*	*							*		
	Black-faced Woodswallow	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Crested Bellbird	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Pied Butcherbird	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	White-fronted Honeyeater	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Willie Wagtail	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Zebra Finch	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Singing Honeyeater	*	*		*	*	*	*	*	*	*	*	*	*	*	*
	Grey Butcherbird	*	*	*	*	*	*	*			*	*	*	*		*
	Spiny-cheeked Honeyeater	*	*	*	*	*	*	*		*		*	*	*	*	*
	Common Bronzewing		*	*	*	*	*	*						*	*	*
	Grey Shrike-thrush		*	*	*	*	*	*					*	*	*	*
	Australian Owlet-nightjar	*		*		*	*	*	*							
	Yellow-throated Miner	*		*		*	*	*	*	*	*	*	*			
	Crimson Chat	*		*						*	*				*	*
	Little Button-quail	*	*	*		*				*	*		*	*	*	*
	Horsfield's Bronze-Cuckoo	*	*	*										*	*	*
	Chestnut-rumped Thornbill	*	*	*			*	*					*		*	
	Red-capped Robin	*	*	*	*		*	*					*		*	
	Slaty-backed Thornbill	*	*	*	*		*	*					*	*		
	Hooded Robin	*	*	*			*	*								*
	Tawny Frogmouth	*	*				*	*					*			
	Spotted Nightjar	*	*			*	*									*
	White-browed Babbler		*	*			*	*								
	Australian Hobby	*	*	*				*								
	Mistletoebird	*	*					*	*							

BREEDING SPECIES

A total of 42 species (141 records) were recorded breeding in the study area (Table 5.3). Nineteen species were recorded breeding in autumn after reasonable summer rains, 34 in winter/spring after winter rains and 12 in both. Autumn refers to Trip 5 while winter/spring refers to Trips 1, 2, 3, 4, 6 and 7; thus effort was much greater for winter and spring than for autumn. An addled egg of a Red-necked Avocet was found at Yanneri Lake on 10 September 1999, however, a breeding date can not be allocated for it and it is not included in Table 5.3.

Table 5.4 Birds recorded breeding in the south-western Little Sandy Desert study area, with season and number of breeding records. See Table 5.1 for scientific names.

Species	Autumn	Winter/Spring	Total
Emu	1		1
Black Swan	1		1
Grey Teal		1	1
Wedge-tailed Eagle		1	1
Brown Falcon		1	1
Australian Hobby		3	3
Nankeen Kestrel		2	2
Little Button-quail	2	4	6
Common Bronzewing	1	1	2
Galah		2	2
Budgerigar	1		1
Pallid Cuckoo		1	1
Horsfield's Bronze-Cuckoo		2	2
Tawny Frogmouth		2	2
Australian Owlet-nightjar		1	1
White-winged Fairy-wren	2	1	3
Chestnut-rumped Thornbill	2	5	7
Southern Whiteface		1	1
Banded Whiteface		8	8
Spiny-cheeked Honeyeater	4	9	13
Yellow-throated Miner		3	3
Singing Honeyeater	2		2
Grey-headed Honeyeater		1	1
White-fronted Honeyeater	7	16	23
Black Honeyeater	1		1
Red-capped Robin	2	3	5
Hooded Robin	2		2
Grey-crowned Babbler		2	2
White-browed Babbler	1	2	3
Crested Bellbird		4	4
Rufous Whistler	1	1	2
Grey Shrike-thrush		1	1
Magpie-lark		1	1
Black-faced Cuckoo-shrike		1	1
Ground Cuckoo-shrike	1		1
Black-faced Woodswallow		1	1
Little Woodswallow		1	1
Pied Butcherbird	1	2	3
Richard's Pipit	1	1	2
Zebra Finch	3	18	21
White-backed Swallow		1	1
	19 species (36 records)	34 species (104 records)	41 species (140 records)

DISCUSSION

QUADRAT DATA

Birds are mobile and less bound to particular habitat types than some other types of organisms. Additionally, being in an arid, single natural region, the south-western Little Sandy Desert study area had comparatively little variation in landforms and vegetation between quadrats and relatively few species of bird were recorded on quadrats. Thus, the weak cophenetic correlation between quadrats after species classification was not unexpected. There were limited differences between the avifaunas of quadrat groups.

We would have expected a clearer grouping of mulga-dominated habitats; however, even with this habitat the grouping was not as clear as might be expected. Mulga (*Acacia aneura*) low woodland was present at S3, C3, C5, B1 and B2 with some present also at C1; however, only B1, B2 and C3 (and the samphire-dominated S1) grouped clearly with mulga birds. The absence of mulga or tree birds such as parrots, Grey-crowned Babbler and the Western Gerygone from C5 was possibly due to the mulga at this quadrat being very dense, preventing these species flying below the canopy. Also there was a dense ground cover of *Triodia*, adding spinifex birds to the quadrat's list of species. The quadrats in Group 1 had more open mulga and an open ground cover, mainly of soft tussock grasses. Quadrat S3 was only a small area of mulga (it also included a creek line with spinifex - hence the record of the Spinifexbird), whereas B1, B2 and C3 were located in extensive mulga woodland areas.

The grouping of sand dune habitats (B3 and S4) was due to the presence of the White-backed Swallow, Grey-headed Honeyeater and Striated Pardalote. The first of these is attracted to dune slopes for breeding, while the latter two were attracted to the *Corymbia chippendalei* trees on the crest of the dunes.

BREEDING BIRDS

The 41 breeding species recorded would all be expected to breed in the study area. The different number of species and records between autumn and winter/spring is due largely to the much lower sampling effort during autumn however, in this area, some birds would breed only in spring, (e.g. raptors, cockatoos and most parrots, but not the Budgerigar).

TOTAL SPECIES LIST

The bird species recorded in the study area are typical of arid Western Australia, although the 20 species of waterbird would only be recorded here in suitable habitat after heavy rainfall. Most were recorded along Savory Creek, an intermittent major drainage of the eastern Pilbara, which flows east into Lake Disappointment. The 116 bird species (61 passerines, 55 non-

passerines) recorded would be close to the maximum expected for this area, particularly with the amount of effort possible. With additional effort up to a further 22 species of non-waterbirds might be expected. These are listed in Table 5.4.

Many species of waterbird and waders may occur briefly after heavy rainfall, particularly along Savory Creek, (eg Australian Pelican (P*elecanus conspicillatus*), Ibises, spoonbills, cormorants, Black-tailed Native-hen (*Gallinula ventralis*), lapwings, dotterels and sandpipers, and the Gull-billed (*Sterna nilotica*) and Whiskered (*Chlidonias hybridus*) Terns).

Table 5.4 Birds species expected to occur in the Little Sandy Desert but not recorded during this survey.

Species	Scientific name	Comments
Square-tailed Kite	*Lophoictinia isura*	
Black Kite	*Milvus migrans*	
Grey Falcon	*Falco hypoleucos*	A rare species in this area
Peregrine Falcon	*Falco peregrinus*	May not be present because of the absence of cliffs or large trees
Peaceful Dove	*Geopelia striata*	
Princess Parrot	*Polytelis alexandrae*	May not occur in the Desert due to limited Desert Oak (*Allocasuarina decaisneana*) woodlands
Bourke's Parrot	*Neopsephotus bourkii*	At its northern limit
Black-eared Cuckoo	*Chrysococcyx osculans*	
Barking Owl	*Ninox connivens*	
Barn Owl	*Tyto alba*	
Fork-tailed Swift	*Apus pacificus*	
Blue-winged Kookaburra	*Dacelo leachii*	Only likely along Savory Creek
Sacred Kingfisher	*Todiramphus sanctus*	
Black-tailed Treecreeper	*Climacteris melanura*	Only likely along Savory Creek
Chiming Wedgebill	*Psophodes occidentalis*	
Rufous Fieldwren	*Calamanthus campestris*	
Slender-billed Thornbill	*Acanthiza iredalei*	
Grey-fronted Honeyeater	*Lichenostomus plumulus*	
Grey Honeyeater	*Conopophila whitei*	
Red-Browed Pardalote	*Pardalotus rubricatus*	
Splendid Fairy-wren	*Malurus splendens*	
Welcome Swallow	*Cheramoeca leucosternus*	

Several species recorded were near the periphery of their ranges (Blakers ***et al***. 1984, Johnstone and Storr 1998). Species recorded near their northern limit were the Mulga Parrot, Ground Cuckoo-Shrike, Jack Winter (another race in the Kimberley), Cinnamon Quail-thrush, White-browed Babbler, Redthroat, Yellow-rumped Thornbill and Southern Whiteface. Species near the southern limit of their range were the Singing Bushlark (in Western Australia), Spinifexbird, Rufous-crowned Emu-wren and Grey-headed Honeyeater (extends further south in central Australia).

The Action Plan for Australian birds (Garnett and Crowley 2000) lists two of the species recorded in the study area as 'near threatened'; these are Australian Bustard and Bush Stone-curlew. No threatened species were recorded.

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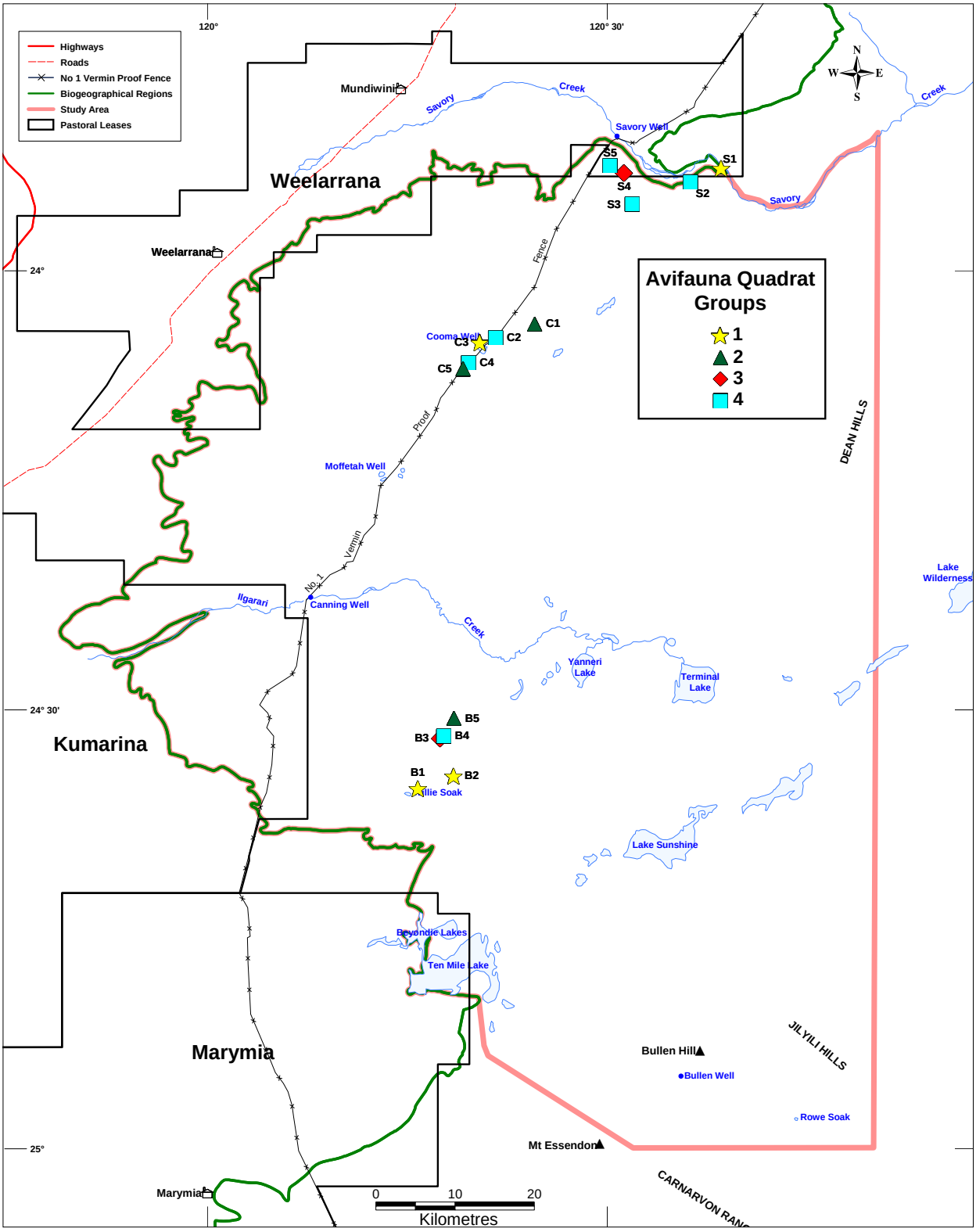
APPENDIX 5.1

Map of the south-western Little Sandy Desert study area showing the distribution of avifauna quadrat groups.



Chapter 6

MAMMALS OF THE SOUTH-WESTERN LITTLE SANDY DESERT

A.N. Start

Western Australian Wildlife Research Centre, Department of Conservation and Land Management, Perth.

ABSTRACT

The terrestrial mammal fauna of the south-western Little Sandy Desert was systematically surveyed during three visits to three focal areas in which five sites representing the array of landscape surfaces were trapped and searched. A fourth, less systematic, expedition added to data for one of the survey sites and sampled two additional areas. Twenty-eight extant native species and evidence of past occurrence by three locally or regionally extinct indigenous species as well as seven exotic species were recorded. This represents all but one of the indigenous species known to inhabit the whole biogeographical region. Nine CWR mammals that once occurred in the biogeographical region are presumed extinct. Spatially minor surfaces were disproportionately important but differed in their relevance to indigenous and exotic species. Sandstone uplands had the richest indigenous faunas and six species were restricted to that habitat. Loam and clay surfaces had the richest exotic faunas.

INTRODUCTION

A biological survey of the south-western Little Sandy Desert commenced with a reconnaissance trip in July 1995. The scope of the study was: *To conduct a comprehensive biological survey of the south-western Little Sandy Desert, Keartland Botanical District, to facilitate an evaluation of the nature conservation values of the region and make recommendations for reservation.*

Sampling infrastructure (including capped pit traps) were established in October 1995 and information on the mammal fauna of the study area was collected during four subsequent sampling trips (Table 6.1). This chapter reports the survey results for mammals in the form of an annotated species list. Information on preferred habitats is included where relevant.

METHODS

FIELD WORK

Terrestrial mammal sampling trips are detailed in Table 6.1.

Table 6.1 Itinerary of trips on which information about the terrestrial mammals of the south-western Little Sandy Desert was collected.

Trip	Duration	Principal Field workers
Sampling Trip 1 (Routine)	1996 – 4 to 22 June	A.N. Start, A. Chapman
Sampling Trip 2 (Routine)	1996 – 8 to 26 October	P. Kendrick
Sampling Trip 3 (Routine)	1997 – 11 to 28 August	A.N. Start, D. Knowles
Sampling Trip 4 (Landscope Expedition)	1999 – 11 to 22 September	A.N. Start

SAMPLING SITES

In each of three focal areas, Beyondie (B), Cooma Well (C) and Savory Creek (S), five sites were selected to represent as many of the characteristic landforms as possible. All sites were sampled systematically on each of the first three trips. Four of five Beyondie sites (B1, B3, B4, B5) and two sites at each of two additional focal areas, namely Yanneri Lake (Y) and Dreamtime Gully (D) (Figure 2.4), were sampled less systematically on a *Landscope* Expedition in September 1999. The surface types, coordinates and vegetation of all sites are described in Appendix 2.1 and summarised in Table 6.2. Additional data were recorded opportunistically throughout the project area.

SAMPLING METHODS

Terrestrial mammals - traps

At Beyondie, Cooma Well and Savory Creek, two trap lines were operated for five days on trips 1, 2 and 3. Each trap line consisted of:

- Six pits lined by 60 cm lengths of 15 cm diameter PVC pipe spaced at five metre intervals and interconnected by a continuous 30 cm high aluminium fly-wire drift fence;
- Two pits lined by 20 l PVC buckets, each placed between two five metre long drift fences, and
- 20 medium Elliott traps baited with a mixture of peanut paste and rolled oats.

All pit traps were left *in situ,* but capped, between trips. Drift fences were also left in place between trips.

Table 6.2 A summary of landforms and surfaces sampled for mammals during the botanical survey of the south-western Little Sandy Desert.

Landform	Summary description	Sample sites
Sandstones	Generally, hills with precipitous dry gullies and skeletal sandy soils. Low trees and shrubs over hummock grasses.	B5, C1, S5, D2
Lateritic uplands	Generally rolling uplands with incised dry gullies. Hummock grass and mulga along gullies.	C5, S3 (see B1 below)
Lunette dune	A gypsum (kopi) ridge, largely overlain by eolian red sand, bordering a dry saline playa. Low *Eucalyptus* woodland over shrubs and hummock grasses.	Y1
Red sand dunes	Generally steep, linear (sometimes complex) dunes. Sparse bloodwoods on the crests; patchy shrubs, forbs and hummock grasses amongst wind-excavated bare areas.	B3, C4, S4
Red sand plains	Generally extensive red sand plains supporting scattered (sometimes clumped) mallees and/or shrubs over hummock grass.	B2 (broad swale), C2, S2, D1
Calcareous loams	Generally, relatively flat, low sites on which loams or sandy loams overlay calcrete. Open mulga woodlands and, mostly annual, tussock grasses.	B1 (some lateritic gravel), B2, C3
Loamy clay	Fluvial deposit adjacent to Savory Creek and immediately upstream of a rock bar. Halophytes, low shrubs. Some patchy hummock grass on overlying eolian sand.	S1
Saline clay	Vegetated shore of a saline playa, in part overlain by eolian sand. Samphires, hummock and tussock grasses.	Y2

All pits at three Beyondie sites (B1, B4, B5) and half the pits at a fourth site (B3) were opened for two nights on the Landscope Expedition of September 1999. Elliott traps set each night on that trip were B1~20, B3~50, B4~25 and B5~25. At Yanneri Lake and Dreamtime Gully trap lines consisted of a variable number of Elliott traps and six or seven 20 l buckets spaced at five metre intervals and interconnected by 30 cm high nylon flywire drift fences. Total trap effort is summarised in Table 6.3.

Besides traps set to catch terrestrial vertebrates, at each study site six pit traps (10 l bucket) to sample invertebrates was filled with preservative and left *in situ* between trips. Wire mesh grids prevented access by most mammals but, occasionally, very small individuals were caught.

Terrestrial mammals - Incidental records

All records of larger mammals (e.g. echidnas, macropods and most exotic species including dingos) are based on sightings of live animals, tracks, droppings, warrens or found remains.

Bats

Bats were sampled by using mist nets, harp traps, shooting and searching likely roost sites. In addition, Anabat II (Titley Electronics, Australia) or D940 (Pettersson Elektronik, Sweden) ultrasound detectors were used to obtain calls which were transformed (divided by 16 or 10 respectively) and recorded on TDK XG60 Metal IV cassette tapes through Sony Walkman Professional (WMD6C) tape recorders. McKenzie *et al*. (*in press*) have incorporated these results with other records in an analysis of the bats of the Little Sandy Desert. While bats were sought at all study areas, efforts were not always directed at study sites. Thus, records of bats from all study areas (but not individual study sites) are listed in the results section of this report. Information on foraging strategies is taken from McKenzie and Bullen (*in press*) and McKenzie *et al*. (*in press*).

Voucher specimen and nomenclature

Voucher specimens of most dasyurid, rodent and bat species were fixed in 5% formaldehyde solution and preserved in 70% ethyl alcohol. They have been deposited in the Western Australian Museum, Perth where Ms. Norah Cooper has confirmed field determinations. Liver samples were taken from representative dasyurid and rodent specimens and preserved in 70% ethyl alcohol for future genetic study. Scientific nomenclature is that used by McKenzie and Burbidge (2002).

Table 6.3 Trapping effort expressed as trap nights at each site sampled in the south-western Little Sandy Desert study area.

Trapping site	Sampling effort		
	Elliott traps	15 cm diameter PVC pipes	20 l Buckets
Beyondie			
B1	640	204	68
B2	600	180	60
B3	650	192	64
B4	650	204	68
B5	700	204	68
Cooma Well			
C1	600	180	60
C2	600	180	60
C3	600	180	60
C4	600	180	60
C5	600	180	60
Savory Creek			
S1	600	180	60
S2	600	180	60
S3	600	180	60
S4	600	180	60
S5	600	180	60
Yanneri Lake			
Y1	120	0	12
Y2	100	0	22
Dreamtime Gully			
D1	135	0	42
D2	225	0	0
TOTAL	**9820**	**2772**	**1004**

RESULTS

Twenty eight extant indigenous, one apparently locally and two presumed regionally extinct species were recorded in the project area. Extant indigenous species included a monotreme, eleven dasyurid and two macropodid marsupials, six rodents and eight bats. Exotic species included a rodent, two carnivores, three large herbivores and a rabbit. Table 6.4 summarises

the number of species recorded in each of the study areas. Details are presented in an annotated list (below) and Appendix 6.3.

Table 6.4 Summary of the extant mammal species recorded in the south-western Little Sandy Desert study area.

Mammals	Trapping Sites					
	Beyondie	Cooma Well	Savory Creek	Yanneri Lake	Dreamtime Gully	Elsewhere
Indigenous						
Echidna	1	1	1	1	1	1
Dasyurids	8	4	7	1	2	0
Macropods	2	2	2	0	1	2
Rodents	4	2	4	2	3	0
Bats	7	8	8	0	1	0
Total indigenous	**22**	**17**	**22**	**4**	**8**	**3**
Exotic						
Rodents	1	1	1	1	0	0
Carnivores	2	2	2	1	1	3
Herbivores	3	2	3	1	1	3
Rabbits	1	1		1		
Total exotics	**7**	**6**	**6**	**4**	**3**	**6**
TOTAL MAMMAL SPECIES	**29**	**23**	**28**	**8**	**11**	**9**

MONOTREMES

Tachyglossidae

Tachyglossus aculeatus (Short-beaked Echidna) B5, C1, S1, D2.

Records are based on droppings and at Dreamtime Gully, quills in a cave. Probably more widespread than these records indicate. Diggings probably made by Echidnas were seen at several locations, but not recorded without corroborating evidence.

MARSUPIALS

Dasyuridae

Antechinomys laniger (Kultarr) B1.

One specimen, recovered from a long-term invertebrate pit trap.

Dasycercus cristicauda (Mulgara) C4.

One, captured on a swale vegetated with a mid-dense low shrubland and hummock grassland of *Aluta* and *Triodia*.

Dasykaluta rosamondae (Little Red Kaluta, Little Red Antechinus) S1, S3, S5.

Captured at three locations in the Savory Creek study area. The gravely and stony upland surfaces at S3 and S5 are similar to stony slopes on which it is commonly caught in the Pilbara Biogeographical

Region but, there, it is seldom taken from surfaces like that at S1 (A.N. Start, personal observations). However, there was a rocky ridge very close to S1 from where the animal may have come.

Dasyurus geoffroyi (Chuditch) D2.

A skull with some fur and dried tissue attached was recovered from a cave at Dreamtime Gully. This species was once widespread through the central and western deserts, where it may have been still present until the 1950s or 1960s (Burbidge *et al*. 1988). It is presumed regionally extinct (*Burbidge et al.* 1988, Maxwell *et al.* 1996).

Ningaui ridei (Wongai Ningaui) B1, B3, B4, C1, C2, D1.

Widespread and usually associated with hummock grass habitats.

Planigale maculata (Common Planigale) B5, S5.

See discussion under *Planigale* species 2.

Planigale species 2 B5.

Three planigales representing two taxa were collected on sandstone surfaces. Two have been attributed to *P. maculata* but taxonomic treatment of Western Australian arid zone planigales is unsatisfactory and subject to revision (Norah Cooper, Western Australian Museum, pers. comm.).

Pseudantechinus woolleyae (Wolley's Antechinus) C1, S5.

Uncommon. Only recorded on rugged sandstone surfaces.

Sminthopsis longicaudata (Long-tailed Dunnart) B5, S5.

Uncommon. Only recorded on rugged sandstone surfaces.

Sminthopsis macroura (Stripe-faced Dunnart) B1, B2, C2, S1.

Fairly common. Associated loamy soils.

Sminthopsis ooldea (Ooldea Dunnart) B2, B4, C3, C5, S3.

Fairly common. Except at B4, associated with mulga on lateritic and calcrete surfaces.

Sminthopsis youngsoni (Lesser Hairy-footed Dunnart) B1, B3, B4, C2, S3, S4, D1, Y1.

Common. Usually caught on sandy surfaces.

Macropodidae

Bettongia lesueur (Boodie) B1, B2, C3, various.

All records are based on the remains of former warrens (which are still clearly visible in limestone, calcrete and lateritic country of the Great and Little Sandy, Gibson and Tanami Deserts (*Burbidge et al.* 1988, Andrew Burbidge, CALM, pers. comm.)). Large warrens, now occupied by rabbits, at B1, B2 and C3 were characterised by extensive tunnelling under calcrete slabs and large piles of excavated soil, which sometimes formed peripheral moats. Elsewhere, warrens were most visible in gravely soils where they appeared as mounds several metres in diameter, usually crowned by forbs and annual grasses in contrast to the ubiquitous hummock grasses of the surrounding terrain.

This species was once widespread and abundant in the central deserts where it is now presumed extinct, although it persisted until about 1935 and perhaps as recently as about 1960 (Maxwell *et al*. 1996, Burbidge *et al*. 1988).

Macropus robustus (Euro) B5, C1, S5, D2.

Euros were frequently seen in rocky habitats where scrapes and droppings indicated that they used numerous overhangs and small caves for resting.

Macropus rufus (Red Kangaroo) B1, B2, B3, B4, C2, C4, S1, S4.

Droppings of large macropods were widespread throughout the study area and those on non-rocky surfaces were probably deposited by Red Kangaroos. Animals were seldom seen.

Petrogale sp. (Rock Wallaby) D2.

Faecal pellets of a Rock Wallaby (probably *P. lateralis*) were abundant in a cave at Dreamtime Gully.

EUTHERIANS

Muridae

* *Mus domesticus* (House Mouse) B1, B2, B3, B4, B5, C1, C2, C3, C5, S1, S3, S5, D1, D2, Y1, Y2.

Common. Usually ubiquitous in all habitats.

Leporillus apicalis (Djooyalpi, Lesser Stick-nest Rat) B5, C1, S1, D2.

The species is presumed extinct (Lee 1995). Our records are based on old stick nests containing 'amberat' placed in rocky breakaways and caves. They are attributed to *L. apicalis* because only that species is known to have occurred as far north as the Little Sandy Desert. (Robinson 1995a, 1995b).

Notomys alexis (Tarrkawarra, Spinifex Hopping-mouse) B3, B4, C2, C4, S2, S3, S4, S5, D1, Y1.

Common. Captured at all sandy sites. Tracks were seen on sandy surfaces throughout the study area. Occasionally trapped on other surfaces in the Savory Creek study area.

Pseudomys chapmani (Ngadji, Western Pebble-mound Mouse) S5.

Mounds (mostly not active; see Start (2000) for a discussion of active and inactive pebble-mounds) were located on the lower slope of a sandstone hill adjacent to a shrub-lined creek. Animals were trapped higher up the same hill at the S5 study site. Information on pebble size-range from mounds at this site is given by Start (2000). Extensive searches were made for mounds on sandstone ranges at Cooma Well, Beyondie and Dreamtime Gully and on upland, gravely, laterite surfaces at Savory Creek and Cooma Well. None were found.

Pseudomys desertor (Wildjin, Desert Mouse) B3, B5, S2.

Usually rare. Sandy surfaces in the Savory Creek (sandplain) and Beyondie (swale) survey sites but also on sandstone at the latter. Only one was captured before 1999 (Savory Creek) but six were taken at Beyondie that year. Most were subadult. Their abundance at Beyondie in 1999 probably reflects seasonal conditions.

Pseudomys hermannsburgensis (Mingkiri, Sandy Inland Mouse) B1, B2, B3, B4, B5, C1, C2, C3, C4, C5, S1, S2, S3, S4, S5, D1, D2, Y1, Y2.

Very common and ubiquitous. Specimens showed considerable variation. On some individuals, the white underside was sharply divided from the brown dorsum on the cheeks and flanks but gradual on others. Some individuals had blackish pigmentation in the foot skin, where others had white or pale pink feet. Tail length also varied. Similar variation has been noted in the east Pilbara (A.N. Start, personal observation). One specimen resembles an entity known from the Pilbara that may represent a distinct taxon (Norah Cooper, Western Australian Museum, pers. comm.). This taxon warrants further study.

Zyzomys argurus (Djoorri, Common Rock-rat) B5, D2.

Recorded from sandstone habitats at Beyondie and Dreamtime Gully. Only one was captured before 1999 (at Beyondie) but ten were caught at Dreamtime Gully that year (including pregnant females and

subadults). Their abundance at Dreamtime Gully in 1999 may reflect temporal (seasonal conditions) rather than geographical factors.

Molossidae

Mormopterus beccarii (Beccari's Freetail Bat) Beyondie, Cooma Well, Savory Creek.

Apparently common and widespread, recorded foraging in relatively open airspace a little above or alongside canopies.

Tadarida australis (White-striped Freetail Bat) Cooma Well, Savory Creek.

Apparently uncommon, but possibly a migrant absent from the area at times. Foraging recorded in open air space high above tree canopies.

Emballonuridae

Saccolaimus flaviventris (Yellow-bellied Sheathtail Bat) Beyondie Cooma Well, Savory Creek.

Sometimes common, foraging in open air space high above tree canopies.

Taphozous georgianus (Common Sheathtail Bat) Cooma Well, Savory Creek.

Apparently uncommon. Foraging in open air space above tree canopies.

Vespertilionidae

Chalinolobus gouldii (Gould's Wattled Bat) Beyondie, Cooma Well, Savory Creek.

Widespread and common, foraging in open air just above or alongside canopies. One disturbed in daylight from a narrow, hollow bloodwood (*Corymbia* sp.) branch entered another similar one about 100 m distant

Nyctophilus geoffroyi (Lesser Long-eared Bat) Beyondie, Cooma Well, Savory Creek.

Widespread and common, particularly in mulga woodland where it foraged below the canopy within the stands. Roosting bats (usually alone, but up to four pregnant females) were located at Cooma Well and Beyondie in hollow, dead mulga stems, sometimes below disused nests of Chestnut-rumped Thornbills (*Acanthiza uropygialis*).

Scotorepens greyii (Little Broad-nosed Bat) Beyondie, Cooma Well, Savory Creek.

Widespread and common, foraging in open air just above or alongside canopies.

Vespadelus finlaysoni (Finlayson's Cave Bat) Beyondie, Cooma Well, Savory Creek, Dreamtime Gully.

Widespread and common near sandstone hills, foraging in cluttered airspace close against canopies or within mulga stands. Roosting colonies were located in caves at Savory Creek and Dreamtime Gully.

Canidae

* *Canis lupus dingo* (Dingo) Vicinity of B1, B3, B4, C1, C2, C3, C4, S1, S2, S3, S4, D1, Y1, Y2.

Dingoes but more commonly, their scats and tracks were seen throughout the study area. Set dingo traps were found near Beyondie and they are, no doubt, hunted for scalp money within and beyond the pastoral leases that fringe or extend into the project area. Apparent absence from some rocky and gravely sites may reflect poor track visibility on hard surfaces.

Felidae

* *Felis catus* (Cat) Vicinity of B1, B3, B4; C2, C4, C5, S1, S2, S4 D1 Y1, Y2.

Common. Occasionally cats but more commonly scats and tracks were seen on soft surfaces throughout the project area. Apparent absence from rocky and gravely sites probably reflects poor track visibility on hard surfaces.

Equidae

* *Equus asinus* (Donkey) Vicinity of B1 C1 S1, S2, S3, S4, S5, Ilgarari Creek.

Tracks indicated that donkeys were widespread but generally scarce except in the vicinity of Savory and Ilgarari Creeks, where dependable water probably sustained them.

Bovidae

* *Bos taurus* (European Cattle) Vicinity of B1, S1, S2.

Cattle were permanently present along Savory Creek and on adjacent sand plains. Elsewhere, they may be itinerant visitors from unfenced, adjacent pastoral leases when water is available. The Beyondie record was of old tracks although van Leeuwen (CALM, pers. comm.) reported a small herd foraging on Willie Soak in April 1997.

Camelidae

* *Camelus dromedarius* (Dromedary, One-humped Camel) Vicinity of B1, B2, B3, B4, B5, C1, C2, C3, C4, C5, S1, S2, S3, S4, S5, D1, Y1, Y2.

Camels or their tracks and scats were common throughout the study area except in uplands, particularly more-rugged sandstone hills. Carcasses indicated that they are hunted on occasions, probably for meat but also by sporting shooters and as part of feral animal control programs.

Leporidae

* *Oryctolagus cuniculus* (European Rabbit) B1, B2, C3, Y1, Y2

Rabbits were common on loamy soils overlying calcrete at Beyondie and Cooma Well, where they occupied large warrens that had originally been constructed by Burrowing Bettongs (see above). They were also common on clay pans and the fringes of playas and salt lakes but not recorded on Savory or Ilgarari Creeks.

DISCUSSION

There have been no previous surveys of the mammals of the study area. However, McKenzie and Youngson (1983), Burbidge *et al*. (1988) and McKenzie and Burbidge (n.d.) provide information on European records and Aboriginal knowledge of mammal distributions pertinent to the Little Sandy Desert Biogeographical Region.

Twenty-eight species of indigenous mammals still occur in the study area. At least two more mammals may occur in the study area. The Northern Marsupial Mole, *Notoryctes caurinus,* is widespread in Australia's more northern sandy deserts but seldom encountered because of its fossorial habits and the Bilby, *Macrotis lagotis* is still patchily distributed in adjacent biogeographical regions. Another species, the Black-footed Rock-wallaby survives elsewhere in

the Little Sandy Desert (e.g. Calvert Range) and was probably the rock-wallaby once present but apparently now extinct in the project area.

At least seven species that are now presumed regionally or totally extinct are known or likely to have occurred in the Little Sandy Desert. They are Chuditch (*Dasyurus geoffroyi*), Burrowing Bettong (*Bettongia lesueur*), Woylie (*Bettongia penicillata*), Spectacled Hare-wallaby (*Lagorchestes conspicillatus*), Rufous Hare-wallaby (*Lagorchestes hirsutus*), Golden Bandicoot (*Isoodon auratus*) and Pig-footed Bandicoot (*Chaeropus ecaudatus*). During the survey evidence was found which indicated that two of them, the Chuditch and Burrowing Bettong, occurred in the study area. The causes and patterns of decline in Australian mammals have been discussed by many authors (e.g. Burbidge and McKenzie 1989, McKenzie and Burbidge 2002, Morton 1990, Short and Smith 1994, Smith and Quinn 1996) and are beyond the scope of this report except to note consistency with the general pattern; that is CWR (critical weight range), non-volant mammals have experienced the greatest decline.

Thus, the indigenous mammal fauna of the biogeographical region probably comprised at least 38 species at European settlement. At least nine (24%) are presumed extinct at the regional scale but 29 (74%) and possibly 31 (79%) are still extant. Within the study area, at least 28 species persist (i.e. 90% of those possibly and 97% of those known to be extant within the Little Sandy Desert). In summary, the study area has experienced the same level of loss as the rest of the Little Sandy Desert, but it retains a rich and diverse indigenous mammal fauna, which includes all but one of the species known to be extant in the biogeographical region.

Seven exotic species are established in the study area and an eighth, the Red Fox has been recorded on Weelarrana Station (the pastoral lease that extends into the study area along Savory Creek) and Kumarina Station (in the catchment of Ilgarari Creek) (King and Smith 1985). Foxes, which followed rivers through the Pilbara (Start 2000), may have accessed the study area along these drainage lines. The impact of feral mammals on indigenous species in the study area is not known but foxes and cats may have had a significant impact.

Some species were widespread and abundant in all habitats (e.g. Sandy Inland Mice, House Mice and some of the tree roosting bats) however, most species were not ubiquitous to all habitats. Their distributions were influenced by a variety of physical and temporal environmental parameters.

Water

There was no evidence that the distribution of indigenous species was influenced by the need to access fresh water. However, donkeys and cattle were. Donkeys were abundant on Ilgarari and Savory Creeks. Along the latter, they used all habitats including sandstone hills. However, cattle did not venture far from Savory Creek (they were not recorded on Ilgarari Creek) or use upland areas. Nevertheless, the ability of both species to venture further from dependable water in good seasons was evidenced by old tracks at Beyondie.

Vegetation and roosting habitat

Although highly mobile, the distribution of bats in the landscape may be restricted by specific roost requirements and the distance they can travel from roosts to forage. For example, Common Sheathtail Bats and Finlayson's Cave Bats require caves or large rock crevices and cannot utilise areas of sandy desert far from ranges supporting such habitats. Similarly, mulga provides both suitable roost sites and foraging habitat for the Lesser Long-eared Bat. However,

tree roosting bats that forage in open air above tree canopies such as Yellow-bellied Sheathtail Bats are able to use the entire study area.

Land surfaces

Land surfaces are critical to the distribution and diversity of the non-volant mammal fauna in the study area. Differences in surface types are related to landscape position. Thus, sandy surfaces occur in mid-altitudes throughout the project area but they are punctuated by isolated lateritic uplands and occasional sandstone ranges as well as by low-lying loams and clays associated with calcretes, playas and paleodrainage lines. The occurrence of species on primary land-surface types is substantially different to the contribution of those surfaces to the landscape (Table 4).

Table 6.5 The number of non-volant, extant mammals recorded on each of four major land surfaces. Values in parenthesis in brackets show the number of species recorded only on that land surface. (Single records of species on surfaces other than those on which they are common are treated as vagrant and were omitted.)

Non-volant extant mammals	Land surface types			
	Sandstone ranges	Lateritic uplands	Sandy surfaces	Loam - clay surfaces
Indigenous species (N=20)	11 (6)	5 (0)	8 (1)	8 (1)
Exotic species (N=7)	3 (0)	5 (0)	5 (0)	7 (2)
Total	**14 (6)**	**10 (0)**	**13 (1)**	**15 (3)**

Amongst indigenous species, only eight were recorded on sandy surfaces and only one of them, the Mulgara, was not recorded on other surfaces. Sandstone ranges with eleven species, six of which were restricted to them, were particularly important and loam or clay surfaces were as rich as sandy surfaces. The reason for the importance of the ranges may be found in the considerable structural complexity of the terrain and vegetation compared to the other surfaces. The relatively low diversity on lateritic uplands may be attributed to their position as run-off sites in combination with their structural simplicity.

Use of these surfaces by exotic species is quite different. All seven exotics used loam and clay surfaces and all except rabbits and cattle used sandy surfaces (although cattle occasionally ventured into sandy areas close to Savory Creek) and lateritic uplands. Lack of cat records in sandstone ranges is probably misleading; they are cryptic, usually nocturnal and the habitat is not conducive to preserving tracks. Thus, it appears that only rabbits, cattle and (usually) camels avoided the ranges.

Fire

Mammal populations in Australia's deserts are known to be affected by fire, which has been mooted as one of the most important factors affecting CWR mammal populations (e.g. Burbidge and McKenzie 1989) although the effects on populations of different species are poorly understood. Little is known of fire regimes in the study area but it is reasonable to assume that, since Aboriginal people departed, fire frequency has changed and burn areas have increased. There may also be fewer cool fires than there used to be, but that is speculative.

Certainly, most of the project area is fire prone and there was widespread evidence of fires throughout. Fires are probably most frequent and extensive in vegetation dominated by

hummock-grass communities, particularly extensive sand plains. In most other habitats some areas escape all but the most severe fires. Thus, in dune fields bare sand can protect patches and even prevent fires crossing into adjacent swales. In sandstone ranges, bare rock inhibits fire, particularly at the Cooma Well site. In low-lying areas and in mulga woodlands, halophytes made poor fuels and annual grasses and ephemeral forbs limit exposure during periods of high fire-risk. Mulga patches were generally long-unburnt.

Despite the existence of these refugia, fire is of considerable concern. Species such as Desert Mice, which are most common in hummock grasslands, are thought to require mature vegetation (Kerle 1995) and to be uncommon except in good seasons. Thus, frequent extensive fires could lead to a series of local extinctions and, without opportunity for recolonisation, regional extinction.

Climate

Two rodents that were rare throughout the study, demonstrated the capacity of arid-zone rodents to increase in good seasons. Only one Desert Mouse was captured, in the Savory Creek study area, prior to the *Landscope* expedition of 1999 when six, including five subadults were caught on sandy (four at B3) and sandstone (two at B5) surfaces at Beyondie. Similarly, before 1999, only one Common Rock-rat was caught (at B5) but nine, including reproductive females and subadults were caught in a 225 Elliott trap-nights limited trapping session at Dreamtime Gully. Interestingly none were taken at Beyondie on that trip, despite the abundance of Desert Mice.

Given the capacity of small desert mammals to persist at low (often undetected) numbers but respond to resource abundance flowing from good seasons (e.g. Dickman 1999) and our poor knowledge of population trends brought about by post-fire vegetation succession, it is difficult from our data to determine the long-term conservation status of species. However some such as the Mulgara are apparently rare. Others occur as isolated populations in specialised habitats, and not all seemingly suitable sites support populations of them. They may also be rare and subject to regional decline as a consequence of localised extinctions. Again, dasyurids inhabiting sandstone habitats provide examples, including Long-tailed Dunnarts, Wolley's Antechinus and two planigales.

Whilst rodents like the Common Rock-rat may fluctuate in numbers, the Ngadji appears to be genuinely rare in the study area. Unlike rodents that make simple burrows and may be almost undetected by trapping in poor seasons, pebble-mounds persist for many decades after the animals have disappeared (Start *et al.* 2000) and are easily found by experienced observers. Despite extensive searches in five areas of potentially suitable habitat, mounds and mice were only located at S5 where there were few mounds and many of those were disused. Nevertheless, Ngadji are known from other sites in the Little Sandy Desert (Start 2000).

Conclusions

- The wave of CWR mammal extinctions that has affected Australia's deserts has caused extinctions in the study area comparable to the rest of the Little Sandy Desert Biogeographical Region.
- There is still a rich and diverse mammal fauna within the study area. It includes all but one of the mammals known to be extant in the Little Sandy Desert.
- Minor habitats support a disproportionate component of the mammal fauna and sandstone ranges are outstanding in this regard.

- Some species are rare and potentially susceptible to local extinction. Those events could translate into significant regional declines.
- Seven species of feral mammals occur within the region including feral cats. Foxes may have occurred in the study area in the past, and are possibly still present albeit in low numbers.
- The use of major surface types by feral mammals differs significantly from that of extant indigenous species and only (two) feral species are restricted by the availability of free surface water.
- Loamy or clay soils low in the landscape are used by all exotic species while (probably) only four use sandstone habitats.

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APPENDIX 6.1

Presence/absence matrix showing the recorded occurrence of all mammal species by trapping site.

Where species were recorded at survey sites, but not at any of the trapping grids within that site, they are listed under *X (where * is the letter representing to the survey sites). The survey sites were Beyondie (B), Cooma Well (C), Savory Creek (S) Dreamtime Gully (D) and Yanneri Lake (Y). Because bats were sampled widely within Study areas, records are all attributed to *X, and not particular trapping grid. Note that there was very limited effort at Yanneri Lake and Dreamtime Gully compared with other sites.

Names proceeded by an asterisk (*) are exotic species and those preceded by a hash (#) are presumed extinct in the study area or regionally.

Mammal species	Trapping grids																								Total
	B1	B2	B3	B4	B5	BX	C1	C2	C3	C4	C5	CX	S1	S2	S3	S4	S5	SX	D1	D2	DX	Y1	Y2	YX	
Monotremes																									
Tachyglossus aculeatus					*		*						*							*					4
Dasyurids																									
Antechinomys laniger	*																								1
Dasycercus cristicauda										*															1
Dasykaluta rosamondae													*		*		*								3
# *Dasyurus geoffroyi*																				*					1
Ningaui ridei	*		*	*			*	*											*						6
Planigale maculata					*												*								2
Planigale sp					*																				1
Pseudantechinus woolleyae						*										*									2
Sminthopsis longicaudata				*												*									2
Sminthopsis macroura	*	*						*					*												4
Sminthopsis ooldea		*		*					*		*				*										5
Sminthopsis youngsoni	*		*	*				*							*	*			*			*			8
Macropods																									
# *Bettongia lesueur*	*	*							*									*							4
Macropus robustus					*		*										*			*					4
Macropus rufus	*	*	*	*				*		*			*			*					*			*	9
# *Petrogale (?) lateralis*																				*					1
Rodents																									
* *Mus domesticus*	*	*	*	*	*		*	*	*		*		*		*		*		*	*		*	*		16
Leporillus apicalis					*		*											*		*					4
Notomys alexis			*	*				*		*				*	*	*	*		*			*			10
Pseudomys chapmani																	*								1
Pseudomys desertor			*		*									*											3
Pseudomys hermannsburgensis	*	*	*	*	*		*	*	*	*	*		*	*	*	*	*		*	*		*	*		19
Zyzomys argurus					*															*					2
Bats																									
Mormopterus beccarii						*						*						*							3
Tadarida australis												*						*							2
Saccolaimus flaviventris						*						*						*							3
Taphozous georgianus												*						*							2
Chalinolobus gouldii						*						*						*							3
Nyctophilus geoffroyi						*						*						*							3
Scotorepens greyii						*						*						*							3
Vespadelus finlaysoni						*						*						*		*					4
Dogs																									
* *Canis lupus dingo*	*		*	*			*	*	*	*			*	*	*	*			*			*	*		14
Cats																									
* *Felis catus*	*		*	*				*		*	*		*	*		*			*			*	*		12
Horses																									
* *Equus asinus*	*						*						*	*	*	*	*								7
Cattle																									
* *Bos taurus*	*												*	*											3
Camels																									
* *Camelus dromedarius*	*	*	*	*	*		*	*	*	*	*		*	*	*	*	*		*			*	*		18
Rabbits																									
* *Oryctolagus cuniculus*	*	*							*													*	*		5

Chapter 7

CONCLUSIONS AND RECOMMENDATION

S.J. van Leeuwen

Science Division, Department of Conservation and Land Management, Karratha.

Knowledge of the flora and the fauna of the Little Sandy Desert Biogeographical Region is rudimentary. The Desert is one of the least accessible and undoubtedly one of the least known natural regions in Western Australia. Most of what biological knowledge is available has been obtained from localities that have attracted substantial scientific and public interest because of their mineral prospectivity, scenic grandeur, historical significance or charisma with respect to nature-based tourism. Such localities include Lake Disappointment, the Rudall River National Park, the Canning Stock Route and its associated wells, springs and ranges and the Throssell, Broadhurst and Carnarvon Ranges. Interestingly, what biological information is known for the Desert is concentrated on its northern and southern margins and a central corridor, although arguably the biota in eastern parts of the region is somewhat appreciated given the State's knowledge of the Gibson and south-eastern Great Sandy Deserts. An obvious knowledge gap in the Little Sandy Desert is to be found along its western and south-western margins. This shortcoming was eloquently and unequivocally illustrated in 1991 when Australia's only presumed extinct eucalypt (*Eucalyptus rameliana*) was rediscovered and shown to be a ubiquitous and dominant component of dune field and sand plain communities on the western fringe of the Desert (Hopper 1992). This biological survey is the outcome of this rediscovery and the synchronous realisation that as a natural region, the Little Sandy Desert is a high priority for biological inquiry to redress issues of inadequacy and bias in conservation reservation (Thackway and Cresswell 1995),

The south-western portion of the natural region epitomises the remainder of the Desert in respect to the preponderance of eolian sand dunes and sand plains interspersed with resistant sandstone uplands and rolling lateritic rises. These features are vegetated broadly by scattered emergent eucalypts, low *Acacia* woodlands, mallee, *Acacia*, *Grevillea* and ericoid shrubland, and extensive hummock (*Triodia*) grasslands. Atypically for the Desert, this south-western portion also harbours extensive paleodrainage features which confer land surfaces such as kopi dunes, gypsiferous playas and hypersaline lake beds that are not well represented elsewhere in the region, perhaps with the exception of the Lake Disappointment environs. Low *Melaleuca* heaths with hummock grasslands and samphire (*Halosarcia*) flats dominate these biologically interesting land surfaces. Similarly, the occurrence of heavy clay-loam soils in the south-western portion of the Desert enables the persistence of regionally significant mulga woodlands, a vegetation type mostly absent from the region.

Phytogeographically, this south-western portion of the Desert is part of the transitional zone between the *Acacia* dominated communities of arid southern Australia and the hummock grasslands of arid tropical northern Australia (*Acacia-Triodia* line, Beard 1975). Concurrently, and conceivably not independently, this portion of the Desert is always a physiogeographic transition zone between the sandy pediments of the central Australian deserts and the rocky pediments of the arid Pilbara and Gascoyne Biogeographical Regions.

The heterogeneity of land surfaces in the south-western Little Sandy Desert and its juxtaposition in respect to major deterministic influences controlling the distribution of Australian biota confers significant potential for prowess and richness in the diversity of biota in this portion of the Desert. Results from this biological survey substantiate this proposition.

The south-western Little Sandy Desert has an identified flora comprising some 522 taxa, many of which are ubiquitous species throughout the Western Australian arid zone, although a number are characterised by restricted distributions and at least two are very narrow endemics. A large proportion of the flora represents disjunctly distributed or range-end taxa, a result which was not unforeseen given the transitional predicament of the study area, a rudimentary appreciation of the flora of Little Sandy Desert prior to the survey and the coalescence of floral elements from central, southern and tropical desert regions. Deficiencies in our comprehension of the flora of the region is illustrated by the large number of first time records obtained during the survey for the biogeographical region and the collection of several novel taxa which have not been previously reported in the scientific literature. There appears to be substantial overlap in the flora of the study area with that recorded from other parts of the Little Sandy Desert, particularly for the ubiquitous sand dune and sand plain habitats. However, persistent mulga woodland communities and the floristic assemblages associated with the unique paleodrainage land surfaces in the study area have bestowed the south-western Little Sandy Desert with a distinctive flora. This flora partitions into readily distinguishable floristic communities under control exerted by land surface and edaphic influences.

The herpetofauna of the Little Sandy Desert is well represented within the study area by 87 species. Many of these species are ubiquitous, occurring throughout the arid zone, although a few, including several that are not yet described, are endemics. As with the flora many records obtained during the survey are symptomatic of range-end distributions in that species recorded in the study area do not appear to pass beyond the western and southern fringes of the Desert. A similar range-end distributional pattern was detected amongst some of the 116 birds recorded in the study area. Most of these birds are typical of arid zone habitats although the 20 species of waterbird recorded on Savory Creek is somewhat atypical. As with the plants, the birds form species assemblages that are controlled by land surface considerations. The mammal fauna of the south-western Little Sandy Desert epitomises the extant mammal fauna of the biogeographical region with only one species known from the latter not being recorded in the study area. Most mammals tend to be ubiquitous although a few were at their extant range-ends. As with the rest of the Little Sandy Desert and arid inland parts of Australia (Burbidge and McKenzie 1989), the study area has experienced a significant loss of mammal species and an influx of exotics.

RESERVATION STATUS

The reservation status of the Little Sandy Desert for conservation purposes is considered to be inadequate and unrepresentative of the biogeographical region (Thackway and Cresswell

1995). Only one conservation reserve impinging on the Desert (40% of the Rudall River National Park) and this reserve captures only 4.6% of the region. Being situated across the northern margin of the region and capturing mostly the rocky ranges of the Rudall River area this reserve is biased in it representation of the biogeographical region. This bias is clearly illustrated by the fact that 37% of the LSD1 sub-region, the sub-region which conforms to the rocky ranges of the northern Little Sandy Desert, is represented within this national park while only 1.3% of the LSD2 sub-region is captured. Basically, the sand dunes and sand plains which epitomise the Little Sandy Desert are unrepresentative in the national park occupying only 18% of the conservation reserve which falls within the biogeographical region. The inadequacy and unrepresentative of land reservation for conservation purposes in the Little Sandy Desert is further demonstrated by the realisation that less that 1.6% of the *ca*. 86 688 km^2 of eolian sand dune and sand plain country in the region is reserved.

Other conservation reserves have been proposed for the Little Sandy Desert however they have not come to fruition. The first was proposed in 1962 by the Western Australian Sub-Committee of the Australian Academy of Science Committee on National Parks (Anon. 1965). This first reserve proposal encompassed the whole of Lake Disappointment, its fringing apron and extended westward along Savory Creek to the abandoned No. 1 Vermin Proof Fence (Burbidge and McKenzie 1979). This first reserve never received official approval and consequently has not been acted upon. In 1974 the Conservation Through Reserves Committee proposed the creation of the Lake Disappointment and Carnarvon Range Class 'A' conservation reserves (Conservation Through Reserves Committee 1974). These proposals were submitted to government by the Environmental Protection Authority in 1975 as they 'considered it undesirable not to have such a habitat represented in a scheme of reserves' (Environmental Protection Authority 1975). State Cabinet subsequently endorsed these proposals in February 1996 (McKenzie *et al*. 1983). Today these proposals are unfulfilled but still remain desirable acquisitions to the conservation estate of Western Australia (Conservation and Land Management 1994). The proposed 6 120 km^2 Lake Disappointment Nature Reserve has many unresolved issues related to Native Title and aboriginal land access and is also considered highly prospective for gold and uranium while the proposed 3 907 km^2 Carnarvon Range Conservation Park is also entangled in Native Title issues and is considered highly prospective for diamonds and base metals (Environmental Protection Authority 1993, Conservation and Land Management 1994).

Contemporary conservation and management planning by the Western Australian Water and Rivers Commission in conjunction with Environment Australia has identified the Lake Disappointment catchment, which encompasses Savory Creek and the Rudall River catchment, as potential Wild River candidates. The general principles and Code of Management for Wild Rivers (Environment Australia 1998) is unlikely to confer any additions to the conservation estate in the Little Sandy Desert (Susan Worley, Water and Rivers Commission, pers. comm).

RESERVATION RECOMMENDATION

The principal aim of this survey was to comprehensively document the flora and fauna of the south-western Little Sandy Desert. This has been achieved. Apart from the resources and biological inventories generated by this survey, one of the main outputs planned since conception of the survey was the submission of recommendations for conservation reservation to redress inadequacies and bias in the existing system of the biogeographical region. To this end the following recommendation is submitted and justifications provided.

The Recommendation

A nature reserve should be gazetted which encompasses the majority of the south-western Little Sandy Desert as described in this survey. The boundary of the proposed nature reserve is depicted in Figure 7.1. The boundaries of the proposed nature reserve should be at latitude 23° 57' 33" S in the north, longitude 120° 50' E in the east, latitude 24° 43' 55" S in the south and to the west the reserve should abut the Weelarrana, Kumarina and Marymia pastoral leases. The reserve encompasses an area of 6 250 km^2 or about 5.6% of the biogeographical region.

The nature reserve should be a declared Class "A" for the Conservation of Flora and Fauna and vested with the Conservation Commission of Western Australia. It is suggested that the nature reserve be called the 'Giles Nature Reserve' in honour of Earnest Giles, the first European to collect biological specimens in the region and whom ultimately was the impetus for this biological survey.

Justifications

The justifications submitted to substantiate this nature reserve proposal are:

- The documentation of considerable biological diversity in the study area as demonstrated by 522 plant, 5 amphibian, 82 reptile, 166 bird and 28 native mammal species;
- An appreciation that the biota of the proposed nature reserve is representative of the biogeographical region (e.g. all but one of the mammals and 18 of the reptiles known from the Desert were recorded in the study area);
- An appreciation that the biota of the proposed nature reserve includes plants and animals that are apparently new to science (*Halosarcia* sp. Yanneri lake (SVL 3002), *Planigale* sp. 2), poorly known (e.g. *Lerista xanthura*, *Antechinomys laniger*), endemic (*E. rameliana*, *Strophurus wellingtonae*) or of conservation significance (*Sminthopsis longicaudata*, *Stemodia linophylla*);
- The realisation that the proposed nature reserve encompasses possibly two biogeographical transition zone as evident by the persistence of many range-end or disjunctly distributed plants and animals;
- The heterogeneity in land surfaces and soil types which control the distribution of plant communities and inherently defines faunal distributions;
- The significant representation of eolian sand dune and sand plain habitats which epitomise the biogeographical region; and
- The representation of paleodrainage land surface features (e.g. gypsiferous playas, hypersaline lake beds, lunette dunes) and mulga woodlands which are both not well represented in the desert or in the existing conservation reserve network within the biogeographical region.

The above biological information collected during the biological survey overwhelmingly substantiates the proposition that the proposed nature reserve will redress issue of comprehensiveness, adequacy and representativeness with respect to the conservation reserve network within the biogeographical region. The

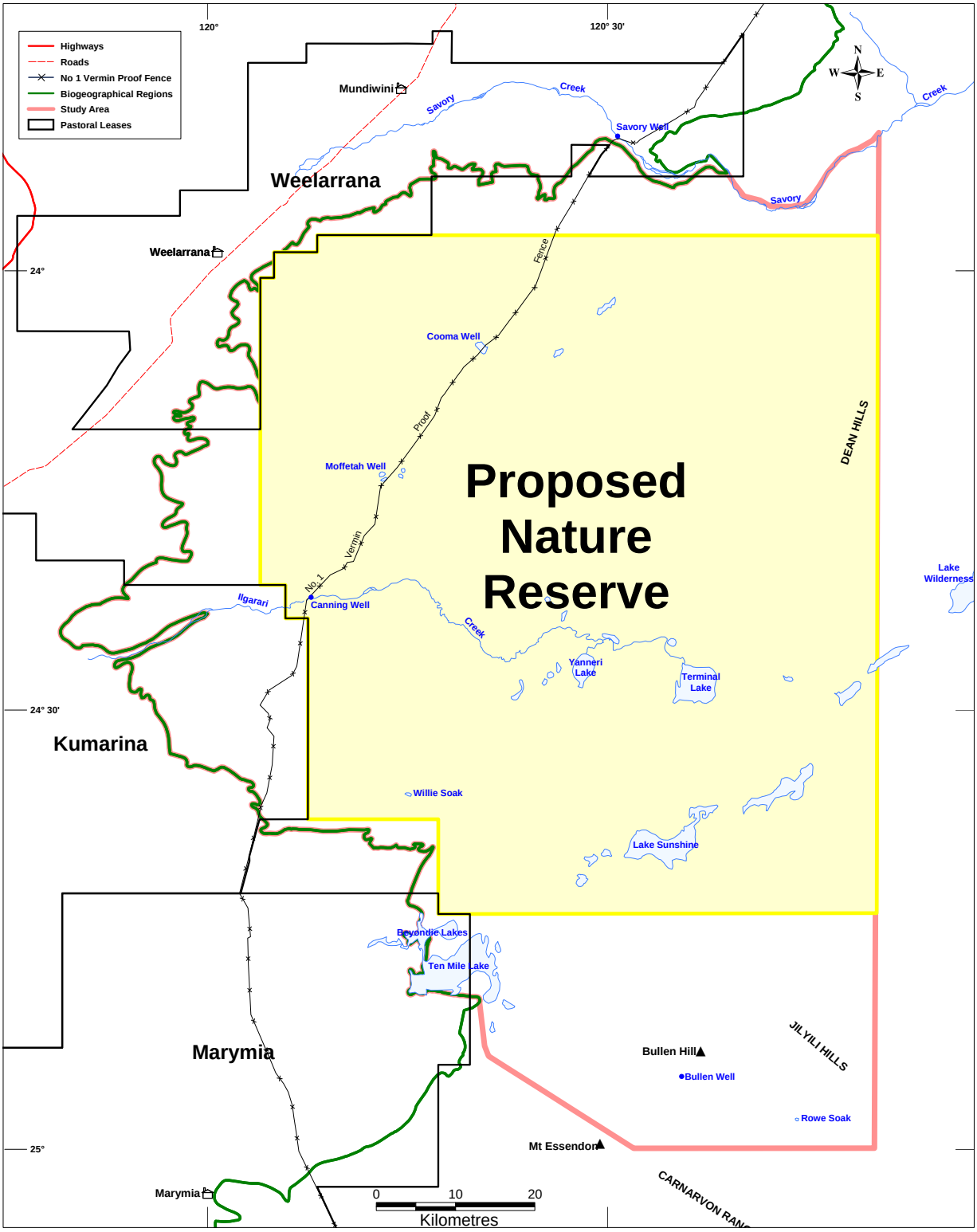

Figure 7.1 Location of the proposed Giles Nature Reserve in the south-western Little Sandy Desert.

implementation of this nature reserve proposal will be an increase in conservation reservation within the region to 10.3% overall and for the LSD1 sub-region this increase will be from the current level of 1.4% to 7.6%.

This northern portion of the south-western Little Sandy Desert study area was excluded from this nature reserve proposal in order to negate problematical management issues related to the control of livestock and feral animals, as grazing by such animals is not an acceptable activity on a nature reserve. While it is acknowledged that this area has biological value (e.g. 20 species of waterbird recorded from Savory Creek and only locality for *Pseudomys chapmani* and *Chelodina steindachneri*) the difficulty and financial impost of managing grazing pressures, livestock and feral animals in this remote region was considered an unnecessary burden for the management agency.

The southern portion of the south-western Little Sandy Desert study area was not included in the boundary of the nature reserve proposal as biological data on this area was not available to substantiate its inclusion. The southern boundary of the proposed nature reserve is approximately 15 km north of the northern boundary of the proposed 'C' Class Carnarvon Range Conservation Park.

Considerations for Reservation

The entire area encompassed within the proposed nature reserve is Unallocated Crown Land with the exception of the abandoned No. 1 Vermin Proof Fence (↑ 12297). Some negotiation with adjacent pastoral leaseholders may be necessary to ascertain to the most appropriate and rational alignment of abutting boundaries. For example, the owners of Weelarrana Station (John and Debbie Anick) have indicated that they wish to straighten their pastoral lease boundary in the area adjacent to the north-western corner of the proposed nature reserve (van Leeuwen, pers. comm.).

Mineral interests in the area are minimal with only one small exploration lease (E69/1817) active over part of the proposed nature reserve (Department of Minerals and Petroleum Resources 2002). This lease is held by Western Australian based Sipa Resources. The area is considered to be of low to possibly moderate prospectivity for economically viable mineral deposits, in particular gold (Williams 1995). The area is also encompassed in an petroleum exploration permit (EP418).

Control of fire and feral animals is an issue for future management within the proposed nature reserve. Strategies employed and refined by the Department of Conservation and Land Management in the administration of several other desert nature reserves should be appropriate and transferable to this proposal.

The commercial harvesting of camels under licence from the Department of Land Administration is an issue for the management of this proposed nature reserve. Currently the proposed nature reserve is encompassed within the bounds of an Occupation Licence for the purpose of harvesting camels held by Nic and Heather Foote. This licence is renewed annually with advice from the Department of Conservation and Land Management. Current licence conditions preclude the establishment and development of infrastructure and facilities in the area covered by

the Occupation Licence and grants the holders no formal tenure, occupation rights or a registrable interest in the land. These conditions should be maintained on the Occupation Licence for the term of its currency.

Nature-based and four-wheel drive tourism along the abandoned No. 1 Vermin Proof Fence may be an issue for future management. This should be administered through a management plan or guidelines similar to those established for the Canning Stock Route and other remote parts of the State where tourism and camping occurs on nature reserves.

Impediments to the implementation of this nature reserve proposal will primarily relate to the negotiation of satisfactory land access agreements with the three Native Title aspirant (WC96-078, WC98-068, CW99-004) with claims over areas encompassed by the nature reserve proposal. Undoubtedly negotiation will also be required with the mineral resources industry and the Western Australian Department of Mineral and Petroleum Resources.

An opportunity exists to augment the comprehensiveness, adequacy and representativeness of the conservation reserve system in the Little Sandy Desert. The proposed Giles Nature Reserve supports substantial biodiversity and is offered as the instrument to achieve this outcome, an outcome that will be a gain for conservation.

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