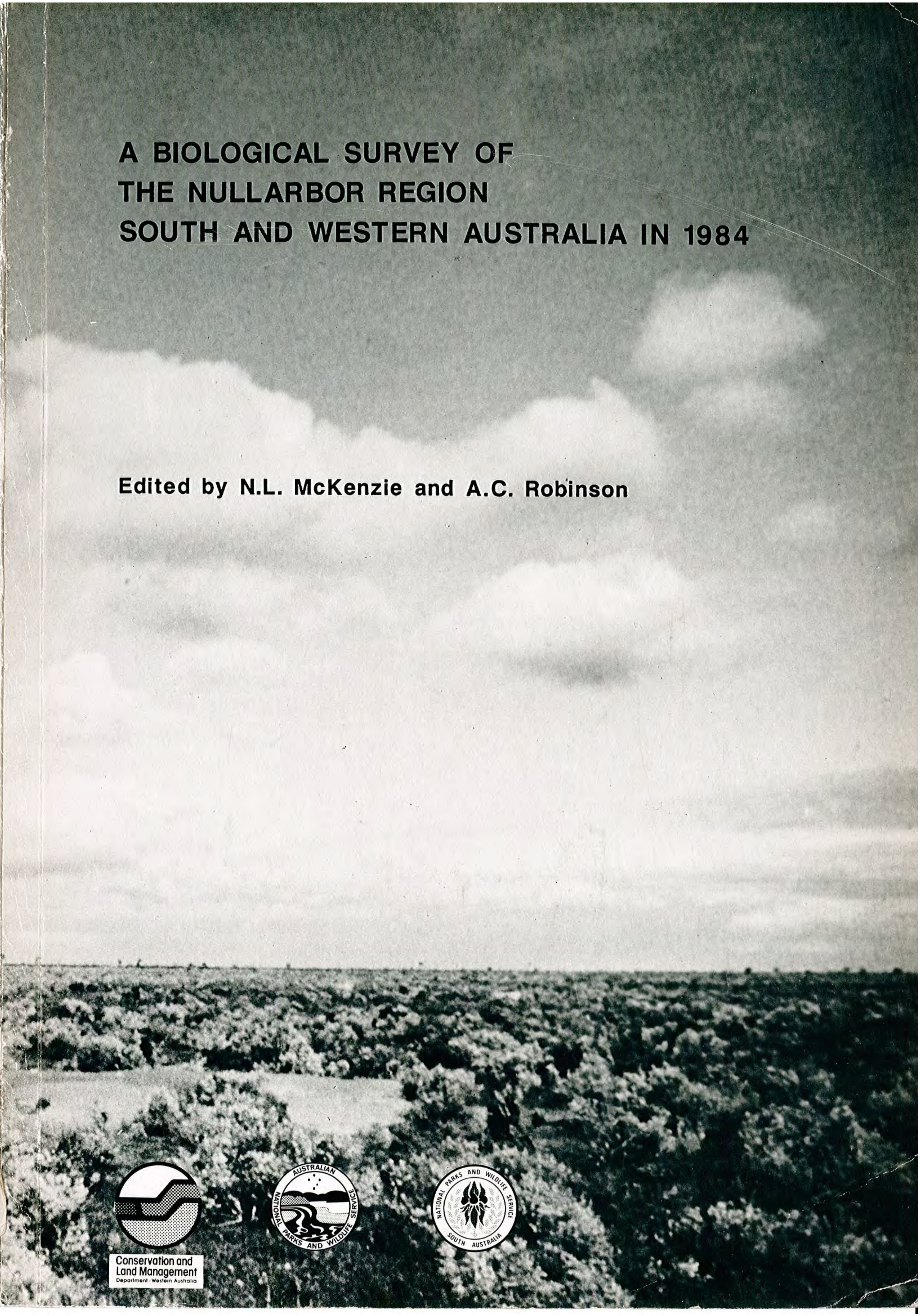
A BIOLOGICAL SURVEY OF THE NULLARBOR REGION SOUTH AND WESTERN AUSTRALIA IN 1984



Edited by N.L. McKenzie and A.C. Robinson

Conservation and Land Management
Department - Western Australia

AUSTRALIAN NATIONAL PARKS AND WILDLIFE SERVICE

NATIONAL PARKS AND WILDLIFE SERVICE SOUTH AUSTRALIA

A BIOLOGICAL SURVEY OF THE NULLARBOR REGION SOUTH AND WESTERN AUSTRALIA IN 1984

Edited by N.L. McKenzie and A.C. Robinson

South Australian Department of Environment and Planning
Western Australian Department of Conservation and Land Management
Australian National Parks and Wildlife Service

MARCH 1987

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PEOPLE INVOLVED

No biological survey of this magnitude can be undertaken without the involvement of a considerable number of people, each of whom bring different skills to the team.

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   L.J. Boscacci, K.D. Casperson, B.H. Downing, N.L. McKenzie, A.C. Robinson.

2. Fieldwork:
   Vegetation; P.D. Canty, B.H. Downing, G.J. Keighery, A.C. Robinson.
   Vertebrates; All people listed collected data on all groups sampled, so we have indicated the particular vertebrate group that each person focussed on (M: Mammals, B: Birds, R: Reptiles). J. Allen (B), L.J. Boscacci (M), A.A. Burbidge (B), J. Burt (R), D.B. Carter (R), K.D. Casperson (B), A. Chapman (B), B. Cohen (B), G. Curry (R), S. Doyle (R), P.J. Fuller (B), S. Hayes (B), K. Higginbottom (M), L. Jansen (M), C.M. Kemper (M), N.L. McKenzie (M), K. Mallet (M), S.A. Moore (R), A.C. Napier (R), J.K. Rolfe (R), T.A. Smith (R), B.A. Wells (B), A.G. Wells (B), A.A.E. Williams (R).

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   Mammals; C.M. Kemper, D.J. Kitchener. N.L. McKenzie.
   Birds; people nominated above and S.A. Parker.
   Reptiles; A. Edwards, J.K. Rolfe, T.D. Schwaner.
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ABSTRACT

The vertebrate fauna and vegetation of a 32 000 000 ha Study Area encompassing the Nullarbor region in Western and South Australia was surveyed in April and September 1984. The species of plants and vertebrates were systematically recorded from an array of fixed quadrats centred on sixteen campsites distributed across the Study Area. The quadrats were selected to represent the biological diversity of the Nullarbor and provide a data base of assemblage descriptions amenable to quantitative analyses for ecological pattern. All previous biological work carried out on the Nullarbor was summarised and an extensive bibliography provided.

The patterns of the plant, mammal, bird and reptile sub-sets of the assemblages were described using the numerical taxonomy package NTP and the biological gradients identified were related to environmental variation across the Study Area. Finally the total presence/absence data base was analysed and eleven distinctive community-types recognised in relation to three major axes of change in the district's biota. In turn, these were correlated with climatic and geochemical scalars of the physical environment. An expanded conservation reserve system was designed to encompass the identified biotic variation of the whole Nullarbor region.

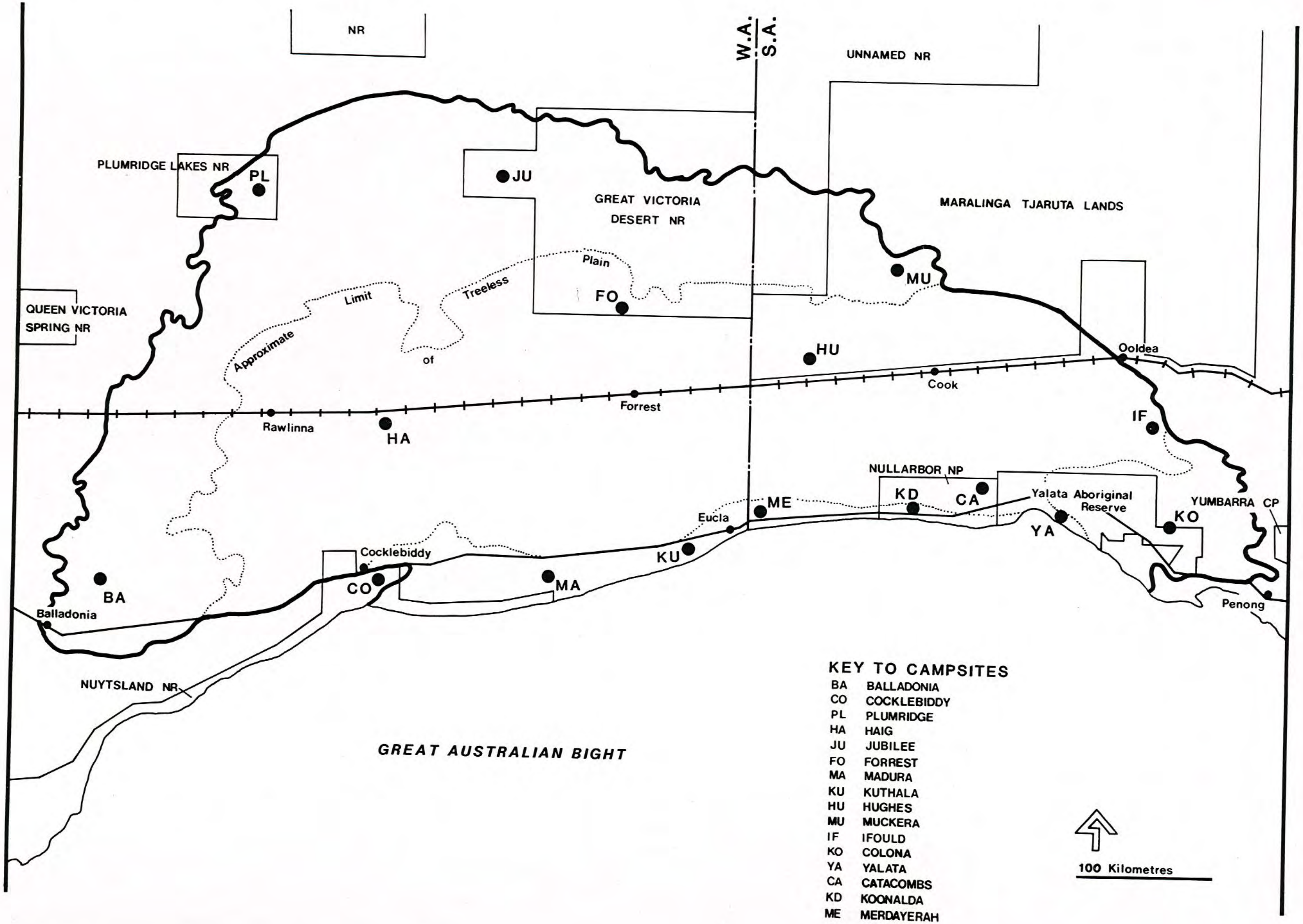


Figure 1
THE STUDY AREA

ACKNOWLEDGEMENTS

This study was very largely supported by grants from the Community Employment Programme and the Australian National Parks and Wildlife Services States Assistance Programme. We are grateful to the Commonwealth Government for providing these funds.

For permission to enter and work on their land, the project supervisors appreciate the co-operation of the Yalata and Cundelee Aboriginal Communities and the owners of various pastoral stations. The assistance of Rod Campbell of Kybo Station and the co-operation of Australian National Railways was particularly important.

Contributions of a scientific nature were made by Laurie Anderson, Barbara Bowen, Alan Burbidge, Tony Milewski, J. Reid, Bert and Babs Wells, South Australian Museum and Herbarium staff and Western Australian Museum and Perth Herbarium staff.

INTRODUCTION

BACKGROUND AND AIMS

A.C. Robinson & N.L. McKenzie

The Nullarbor Plain is one of the largest continuous karst areas in the world and is therefore of national significance to Australia. In December 1983 funds from the States Assistance Scheme and Community Employment Program were made available through the Australian National Parks and Wildlife Service to support a co-operative biological survey of the Nullarbor. The survey was undertaken by the South Australian National Parks and Wildlife Service (Department of Environment and Planning) and the then Western Australian Department of Fisheries and Wildlife (now Department of Conservation and Land Management). A portion of these funds was used for the temporary employment of five biologists: Brian Downing, the co-ordinating botanist, and five graduate assistants (Jim Allen, Louise Boscacci, George Curry, Karen Higginbottom and Katy Mallet).

The South Australian National Parks and Wildlife Service:

(i) selected and administered the four graduate assistants, two of whom were based in Western Australia.

(ii) stored the data collected during the survey on the Department of Environment and Planning Environmental Survey Branch computer and provided format manipulations and analyses of the data base as needed.

(iii)were responsible for printing the data sheets and the preliminary report, and for design and drafting of the final report to be printed by the South Australian Government Printer.

The Western Australian Department of Conservation and Land Management was responsible for:

(i) the survey design.

(ii) the employment and supervision of the co-ordinating botanist.

(iii)the selection and establishment (Fig. 19, 20) of an array of sampling quadrats representing the biological diversity of the Nullarbor, though general campsite locations were selected by the relevant State Department.

The Australian National Parks and Wildlife Service:

(i) provided Dave Carter who in addition to being a herpetologist on both field trips, co-ordinated the Canberra end of the survey.

All organizations involved provided staff and logistical support during the fieldwork. The report was written by the editors or as otherwise specified. People and authors specified reflect the various roles performed by those taking part in the study. Technical queries should be addressed to the senior author of each chapter.

The area defined for the purposes of the survey included the majority of the Eucla Basin. The study area boundaries are those previously designated in Western Australia as the Eucla Botanical Province (Beard 1975) and in South Australia as the Nullarbor Environmental Region (Laut et al. 1977). These boundaries are outlined in Fig. 1. It should be noted that the 32,000,000 hectare study area included a range of vegetation associations (see Figs. 2, 3, 4 and 5); it was not simply confined to the treeless plain.

No detailed systematic collection of plants and animals has previously been carried out on the Nullarbor, but available data from a variety of sources indicated its biological distinctiveness.

The original terms of reference of the study outlined in conjunction with the Australian National Parks and Wildlife Service were:

(a) To make an inventory of the vegetation and vertebrate fauna of the Nullarbor Plain with a view to assessing the significance of the area in national and international terms.

(b) To make recommendations on further studies that would enable a proper assessment to be made of the significance of the area.

Because the study was to be conceived and carried out within twelve months, it was designed with the following aims:

1. To observe collect and identify the species of plants and vertebrates present in the study area in 1984.
2. To document the patterning of species and communities across the study area and seek correlates with parameters of the physical environment.
3. To select and sample an array of fixed quadrats representing the biological diversity of the Nullarbor and provide a data base amenable to analyses involving direct ecological comparisons between assemblages (quadrats). The data base format is to be capable of expansion with subsequent sessions of sampling to provide a measure of changes in assemblage species composition such as those caused by seasonal effects, less predictable disturbances such as fire, or ongoing ecological processes - a data base appropriate for future monitoring programs.
4. To evaluate the conservation status of species and communities typical of the Nullarbor as a basis for recommending amendments to the existing conservation reserve system.
5. To provide relevant state Herbaria and Museums with collections representative of the diversity of plants and vertebrates in the study area circa 1984 and to provide material for taxonomic and other scientific studies relevant to wildlife conservation.

The Nullarbor cliffs looking northwards in the vicinity of The Koonalda site.
Photo A. Robinson.

Wind-pruned coastal heath at the cliff edge - Koonalda site. Photo P. Canty.

Figure 2
THE NULLARBOR COAST

The treeless plain north of the Catacombs site. Photo A. Robinson.

Chenopod shrubland at the Catacombs site. Photo P. Canty.

Figure 3
THE CENTRAL NULLARBOR

The northern edge of the plain looking north into the dune systems of the Great Victoria Desert. Photo A. Robinson.

Mulga woodland in an interdune area at the Muckera site. Photo A. Robinson.

Figure 4
THE NORTHERN TRANSITION

Mallee woodland at the Yalata site looking south. Photo A. Robinson.

Open mallee woodland - Yalata site. Photo A. Robinson.

Figure 5
THE FRINGING WOODLANDS

6. To consolidate, in the form of an extensive bibliography, previous biological information on the Nullarbor study area within a single report.

7. To detail the biological significance (biogeographic affinities) of the study area in relation to the surrounding natural districts.

The theme of this study is to define 'what lived where on the Nullarbor' in 1984.

CLIMATE
G. Curry

According to the Meigs' (1953 In Mitchell, McCarthy and Hacker 1979) classification, the Nullarbor has a semi-arid climate. In the Koppen climate classification, the warm semi-arid coastal belt is of the Bsh type, while the interior is a hot desert of the Bwh type (Lowry and Jennings 1974).

Summer weather on the Nullarbor is patterned by anti-cyclone systems moving from west to east across southern Australia. It is generally characterised by several hot days associated with air movements from the continental interior, alternating with several cooler days influenced by air flow from the Southern Ocean. Daytime maximum temperatures can exceed 50°C in summer.

Summer rainfall comes from rain-bearing depressions that occasionally pass through the area; these are remnants of cyclonic activity in northern Australia (Mitchell et al. 1979). They bring heavy showers, but are unreliable, usually localised, and occur only two or three times every other year.

The anti-cyclone belt moves northwards during winter thereby facilitating a more northerly path for low pressure systems crossing the Nullarbor. Usually it is only the more intense of these low pressure rain-bearing depressions that provide winter rain; most are devoid of rain by the time they reach the Nullarbor. Depressions moving in an east-north-easterly direction from the Great Australian Bight are exceptions (Mitchell et al. 1979). Most of the winter rainfall results from the convergence of depressions with moist, warm air masses from the north. Heavy, but unreliable falls of rain are received at the interface of the two air streams.

In summary the coastal area of the Nullarbor has a winter rainfall semi-arid climate; its interior has an arid climate with a uniform rainfall distribution. Since evaporative demand is high in both areas during summer, winter rainfall is generally more effective in terms of vegetation growth. The occasional heavy falls in mid to late summer from the remnants of tropical cyclones are exceptions. While a seasonal pattern of rainfall can be discerned along the coast, rainfall overall tends to be very variable. The modifying effects on climate attributable to oceanic influences are generally confined to the southern fringe of the Nullarbor but rapidly diminish with distance from the sea (Mitchell et al. 1979).

The climate of the study area during the 1984 sampling period indicates the type of variability that occurs over this vast area.

The mean monthly temperatures and the rainfall figures for Eucla, Ceduna, Forrest and Cook are shown on Figs. 6 and 8. A comparison of the 1984 rainfall totals for these four stations with their mean values since recording began is shown in Table 1 below.

TABLE 1: A COMPARISON OF RAINFALL IN 1984 WITH MEAN ANNUAL RAINFALL AT SOME RECORDING STATIONS IN THE NULLARBOR AREA

	Eucla	Ceduna	Forrest	Cook
Mean Rainfall (mm)	257	315	187	172
1984 Rainfall (mm)	259	275	188	160

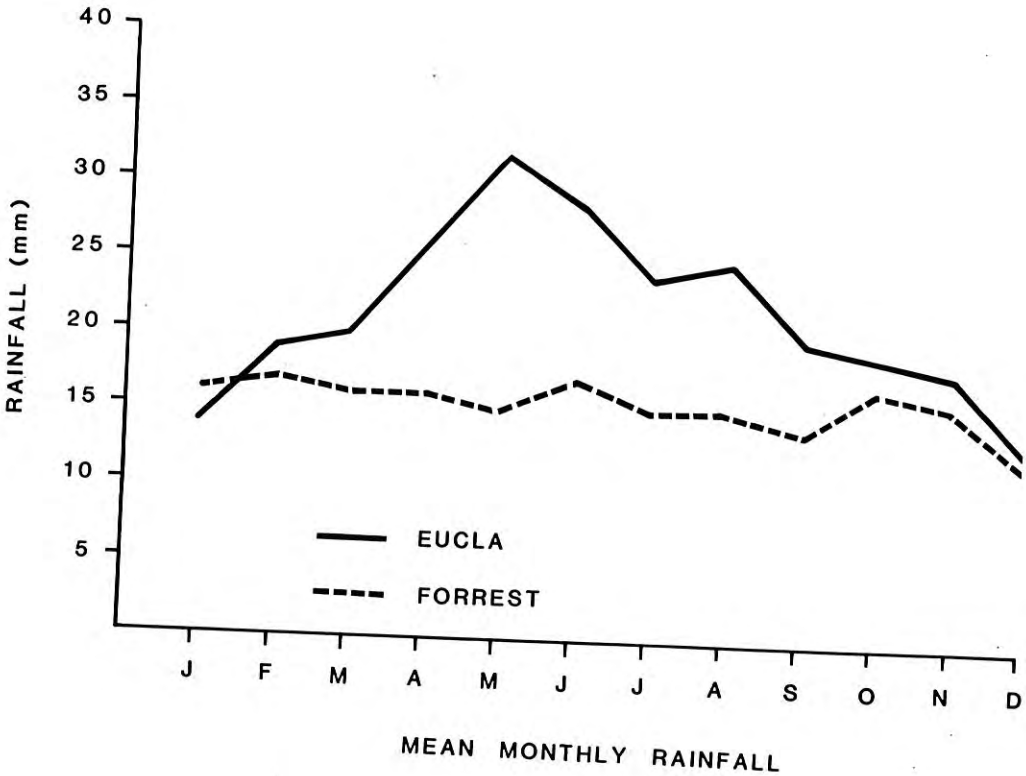
Cold winter weather results from winds off the Southern Ocean or from radiation frosts caused by high pressure systems producing cloudless nights. Winds blowing off the land mass tend to create milder winter conditions (Mitchell et al. 1979).

There are marked differences between coastal and inland areas of the Nullarbor in terms of average annual rainfall, minimum winter temperatures and maximum summer temperatures. Although the boundary is diffuse between the two areas, Mitchell et al. (1984) have arbitarily located the boundary in Western Australia about 20 to 30 km north of the Hampton Range while in South Australia the boundary is probably even closer to the coast. The inland region is characterised by very low and erratic rainfall with hot summers and cold winters. However, in the coastal belt extremes of aridity and temperature are modified by oceanic influences.

Average annual rainfall is as high as 300 mm at Eyre but declines northwards, with most of the Nullarbor receiving less than 250 mm. In the north of the Plain near the Jubilee and Muckera campsites, rainfall is as low as 150 mm per year (Lowry and Jennings 1974).

Mean monthly rainfall figures for Eucla, Ceduna, Forrest and Cook are presented in Fig. 6. Eucla and Ceduna, on the coast, receive an annual average of 257 mm and 315 mm respectively, with the greatest proportion falling during winter. Forrest and Cook, in the interior, receive a mean annual rainfall of only 187 mm and 172 mm respectively but have a more even distribution throughout the year.

Beard (1975) maintains that in the arid regions, it is usual to find that the lower the rainfall the less is its reliability, so that average figures become less meaningful. In a study of the Gibson Desert (Beard 1968 in Beard 1975) he showed that most falls of rain are too light to be effective and that vegetation is maintained by sporadic



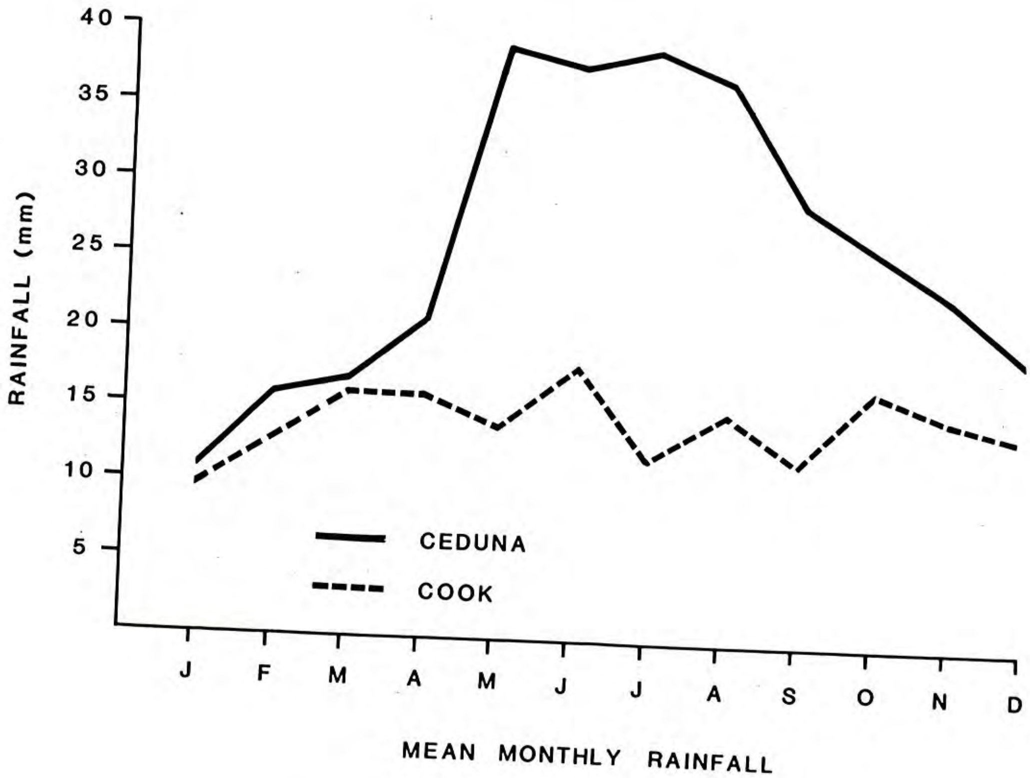


Figure 6
MEAN MONTHLY RAINFALL
Eucla,Forrest,Ceduna,Cook

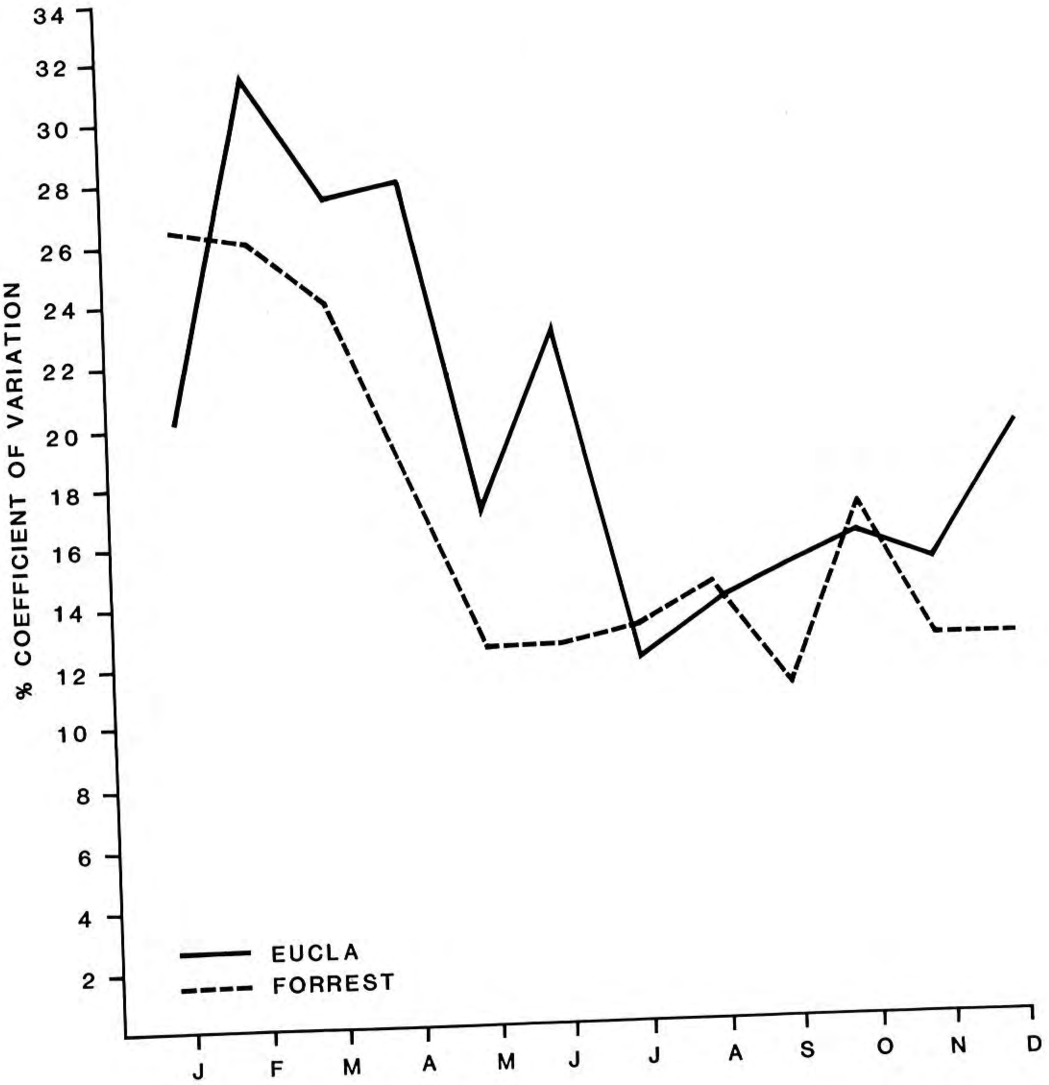
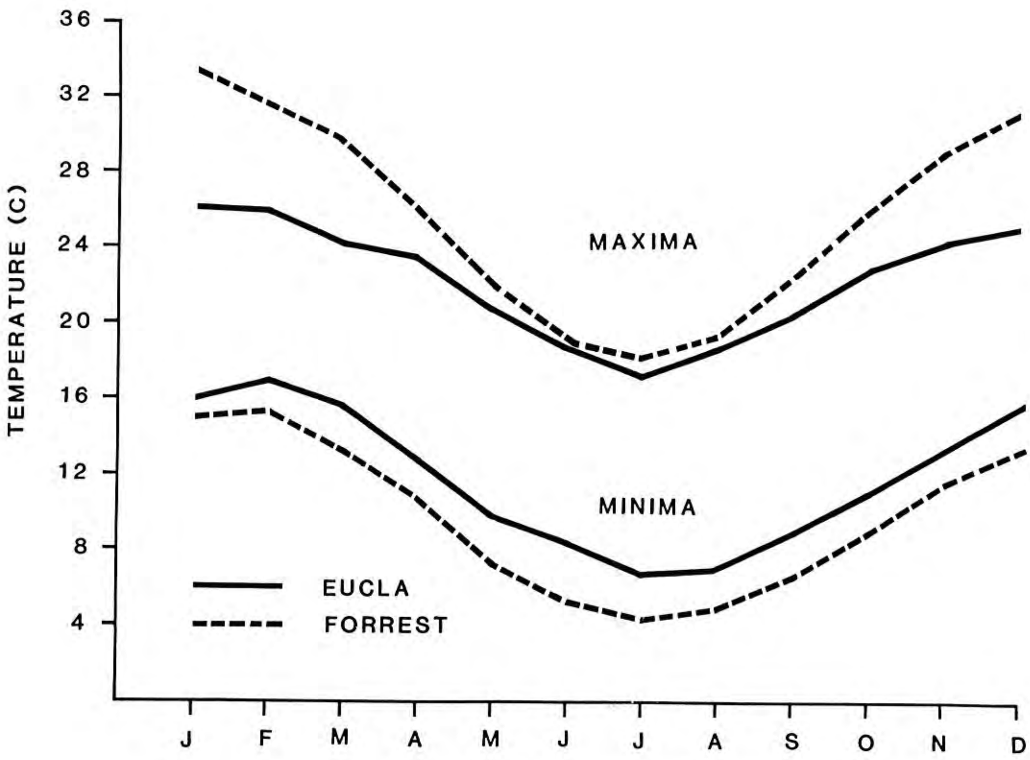


Figure 7
RAINFALL VARIATION
Eucla,Forrest



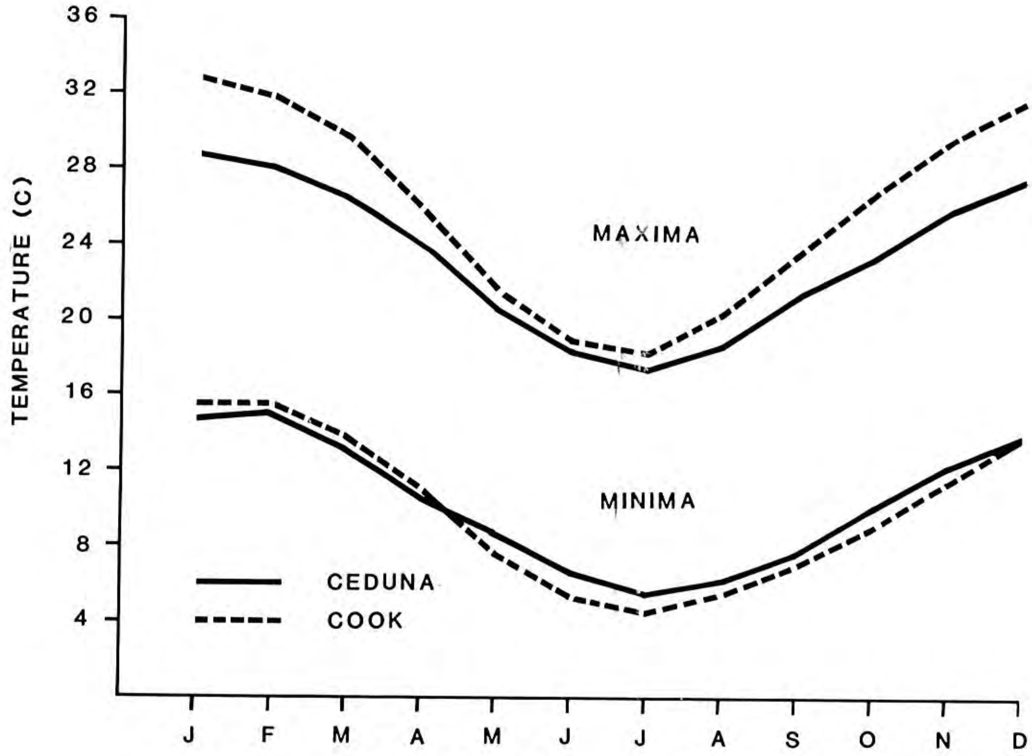


Figure 8
MEAN MONTHLY TEMPERATURE
Eucla, Forrest, Ceduna, Cook

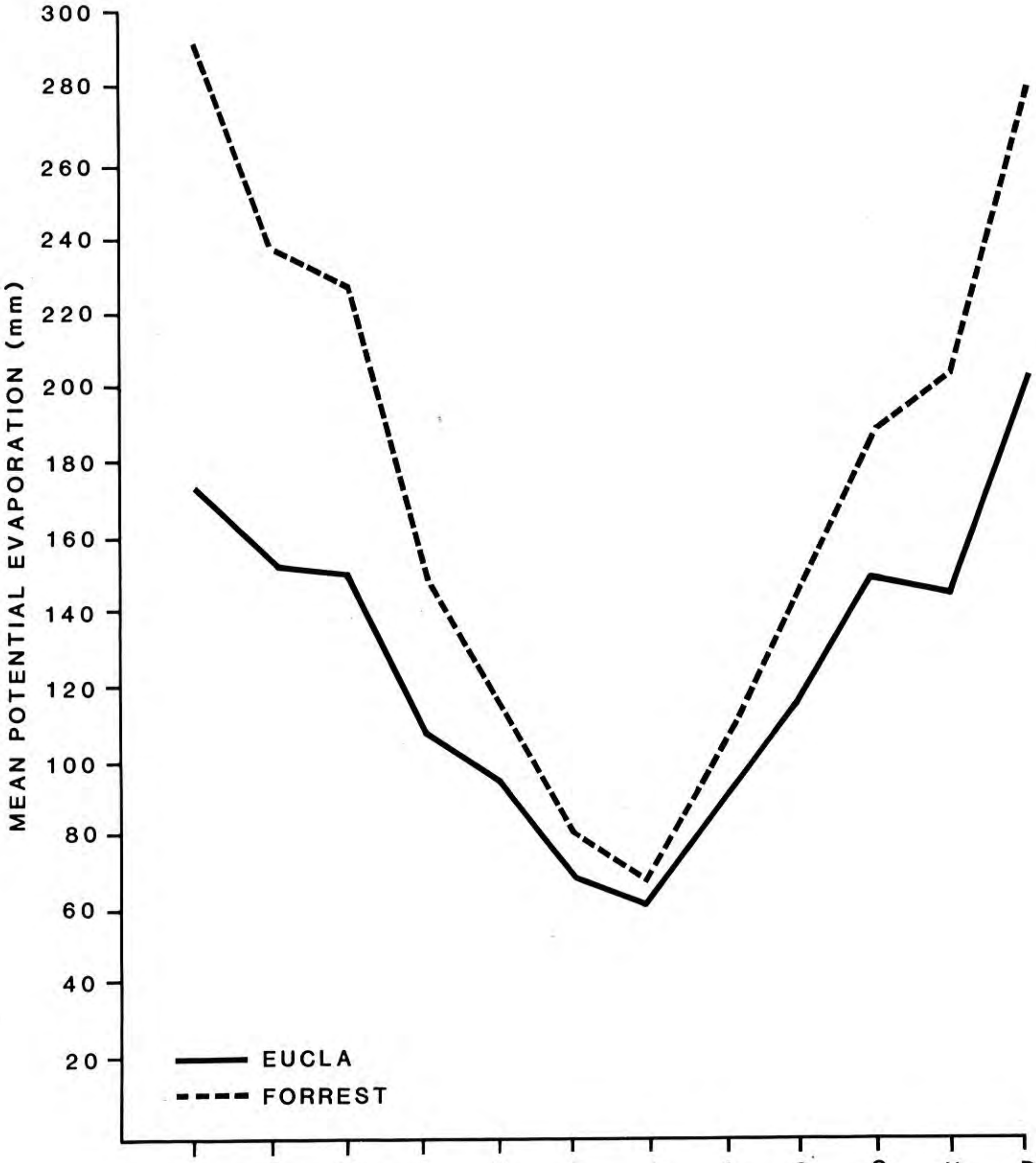
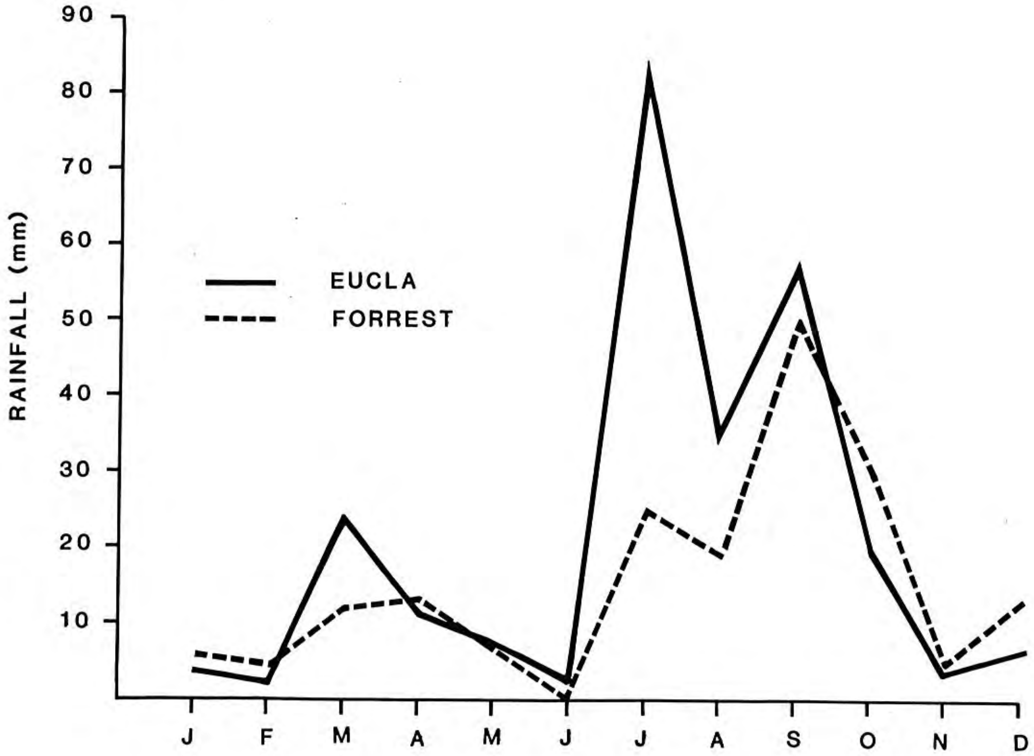


Figure 9
POTENTIAL MEAN MONTHLY EVAPORATION
Eucla,Forrest



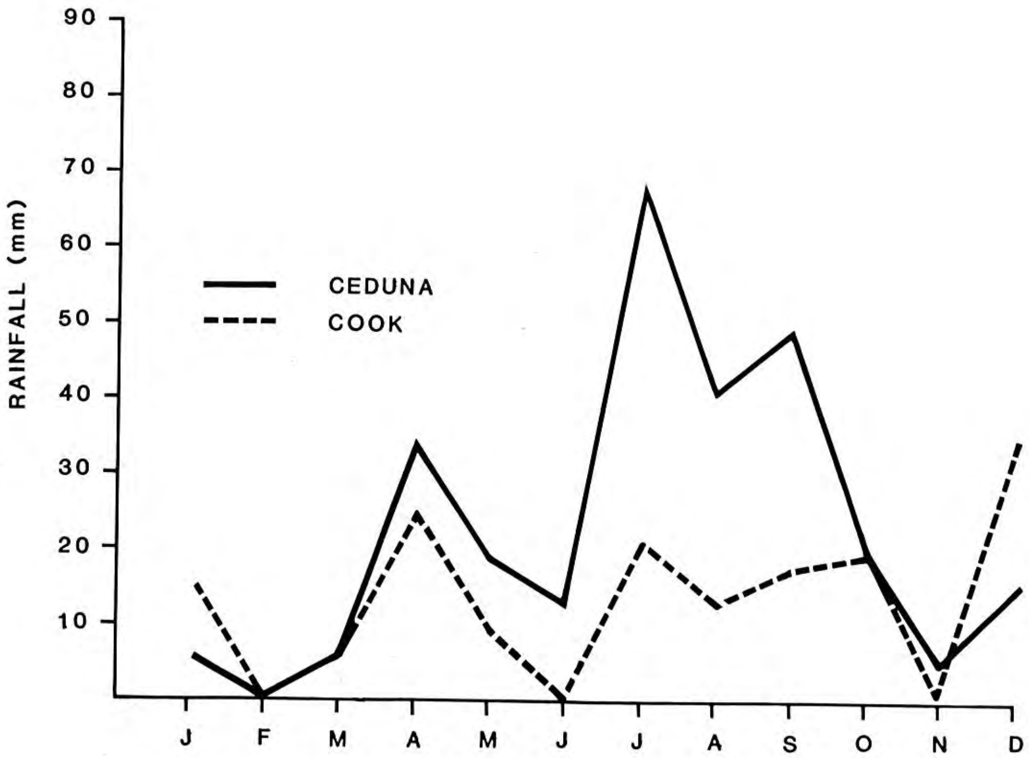
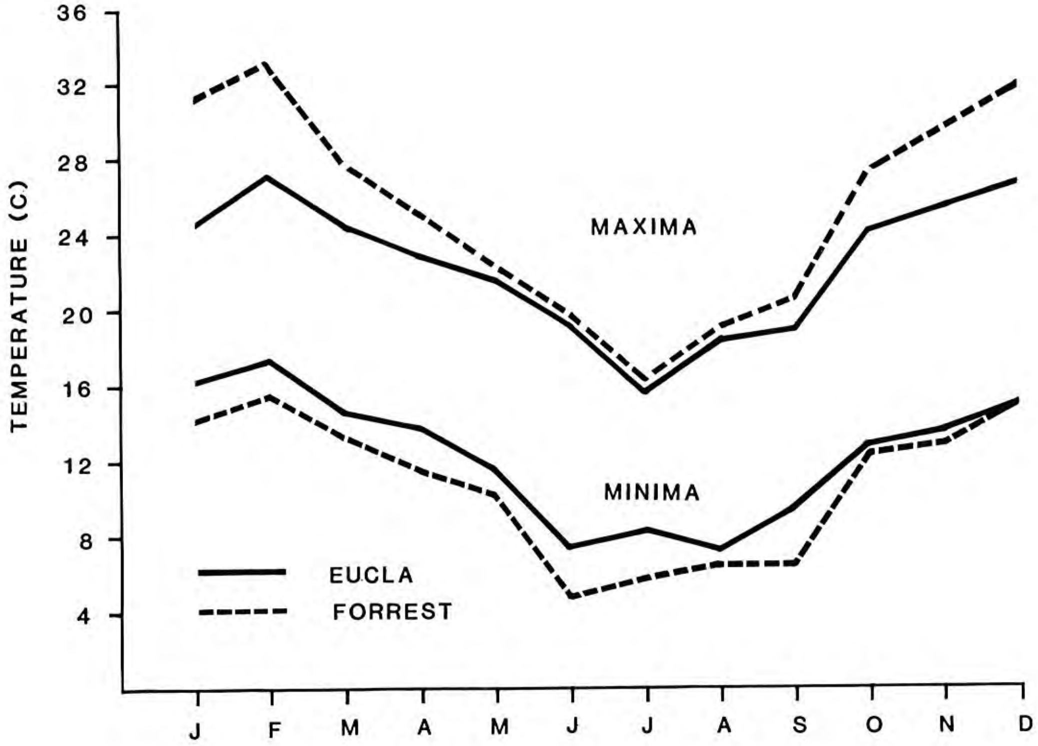


Figure 10
1984 RAINFALL
Eucla,Forrest,Ceduna,Cook



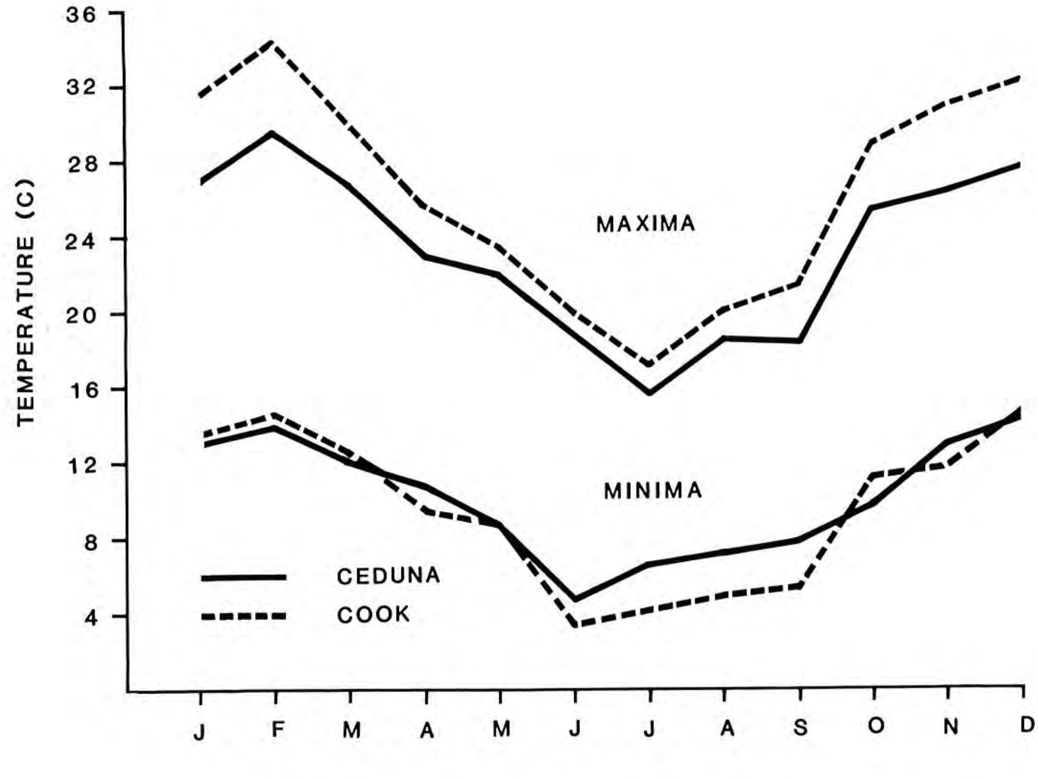
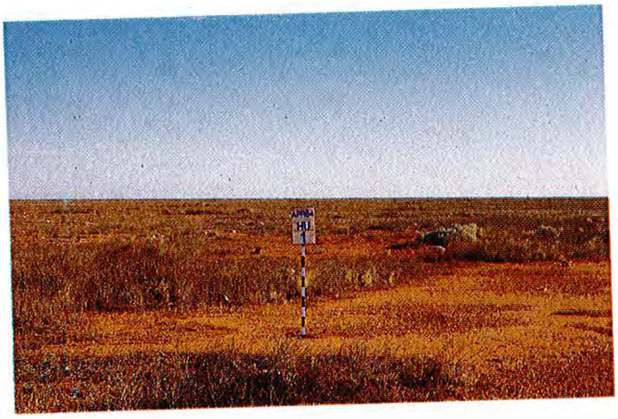


Figure 11

1984 TEMPERATURE
Eucla,Forrest,Ceduna,Cook,



April 1984

September 1984

Vegetation response at the HU1 Photopoint

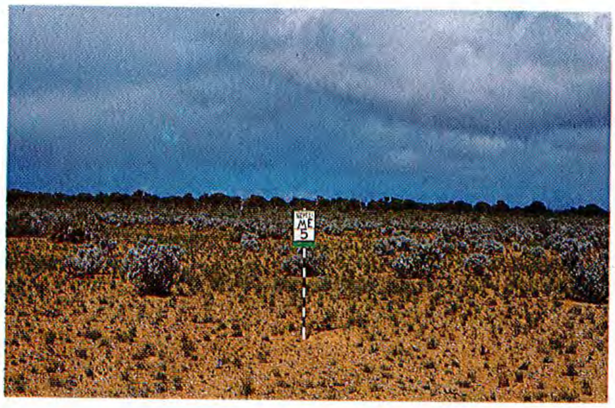
April 1984

September 1984

Vegetation response at the MU4 Photopoint

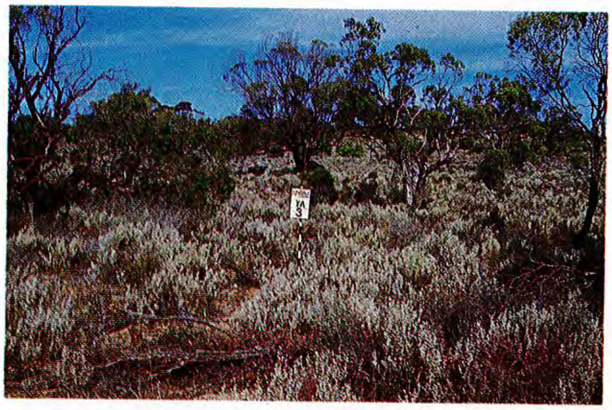
Figure 12
VEGETATION GROWTH AT HU1 AND MU4

April 1984

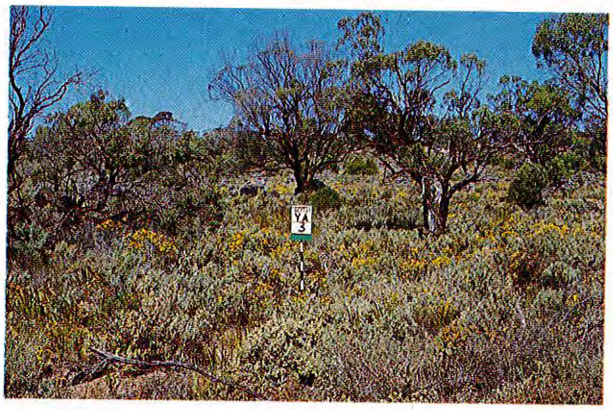


September 1984

Vegetation response at the ME5 Photopoint



April 1984



September 1984

Vegetation response at the YA3 Photopoint

Figure 13
VEGETATION GROWTH AT ME5 AND YA3

heavy falls in excess of 20 mm. These sporadic falls could be expected to occur about three times a year, although droughts of up to a year are fairly common. Beard (1975) provides some data on drought from the inland Nullarbor - twelve periods of drought that exceeded a year's duration were recorded at Rawlinna between 1922 and 1967.

The January to March coefficients of variation in rainfall are high relative to the September-December period for both Eucla and Forrest (Fig. 7). This reflects the intrusion of cyclonic rain-bearing depressions into the area in mid to late summer, while the early part of summer is more consistently dry.

The coefficients of variation for Eucla and Forrest are relatively high indicating great variability in monthly rainfall. The low annual rainfall of the inland region, combined with high coefficients of variation in monthly rainfall, indicate that there is no assured growing season.

Mean monthly maximum temperatures on the coast range from 26°C in January to 18°C in July at Eucla and from 28°C in January to 17°C in July at Ceduna (Fig. 8). The corresponding figures both for Forrest and Cook are 33°C and 18°C. Mean monthly minimum temperatures at Eucla range from 17°C in February to 7°C in July, and at Ceduna from 15°C in February to 6°C in August, while the minimum figures for Forrest and Cook are 15°C and 4°C respectively. Due to the ameliorating influences of greater cloud cover, sea breezes, and high relative humidity, the coastal areas have a less extreme maximum and minimum monthly temperature range than do the inland stations.

The estimated annual free surface evaporation ranges from 1250 mm at Israelite Bay to 2500 mm in the extreme north of the Nullarbor (Lowry and Jennings 1984).

Potential mean monthly evaporation at Eucla and Forrest is plotted in (Fig. 9). Throughout the year, potential evaporation is greater at Forrest (inland) than at Eucla (coastally) and measurably more so during the summer months. This is a reflection of the higher daytime temperature, decreased cloud cover and lower relative humidity associated with the inland areas (Mitchell et al. 1969).

In 1984 the western portion of the Nullarbor represented by the Eucla and Forrest sites experienced average rainfall whereas the inland eastern portion of the area represented by Cook had below average rainfall (Fig. 10), particularly when it is considered that 35 mm of its total fell in December 1984. Ceduna, representing the eastern coastal portion of the Nullarbor, also received below average rainfall. Mean monthly temperatures in 1984 were close to the mean values (Fig. 11).

The rainfall patterns however were more complex than data from these widely scattered recording stations suggests and the response (or lack of response) of the vegetation at our Nullarbor sample quadrats between the April and September sampling trips was quite dramatic. These responses are shown in the photo points in Figs. 12 and 13. At the first quadrat associated with the Hughes campsite (HU4) there was clearly insufficient rainfall for vegetation growth between April and September and in fact rabbit grazing had removed even the dry vegetation evident in April. Further east at MU4 however there had been significant winter rain and a good growth of ephemeral plants was evident in September. At ME5 and YA3, in spite of the fact that rainfall at Eucla (representing ME5) was average and at Ceduna (representing YA3) was below average there was significant winter vegetation growth at both sites.

In summary the coastal area of the Nullarbor has a winter-rainfall semi-arid climate; its interior has an arid climate with a uniform rainfall distribution. Since evaporative demand is high in both areas during summer, winter rainfall is generally more effective in terms of vegetation growth. The occasional heavy falls in mid to late summer from the remnants of tropical cyclones are exceptions. While a seasonal pattern of rainfall can be discerned along the coast, rainfall overall tends to be very variable. The modifying effects on climate attributable to oceanic influences are generally confined to the southern fringe of the Nullarbor but rapidly diminish with distance from the sea (Mitchell et al. 1979).

GEOLOGY AND GEOMORPHOLOGY

G. Curry

General Description

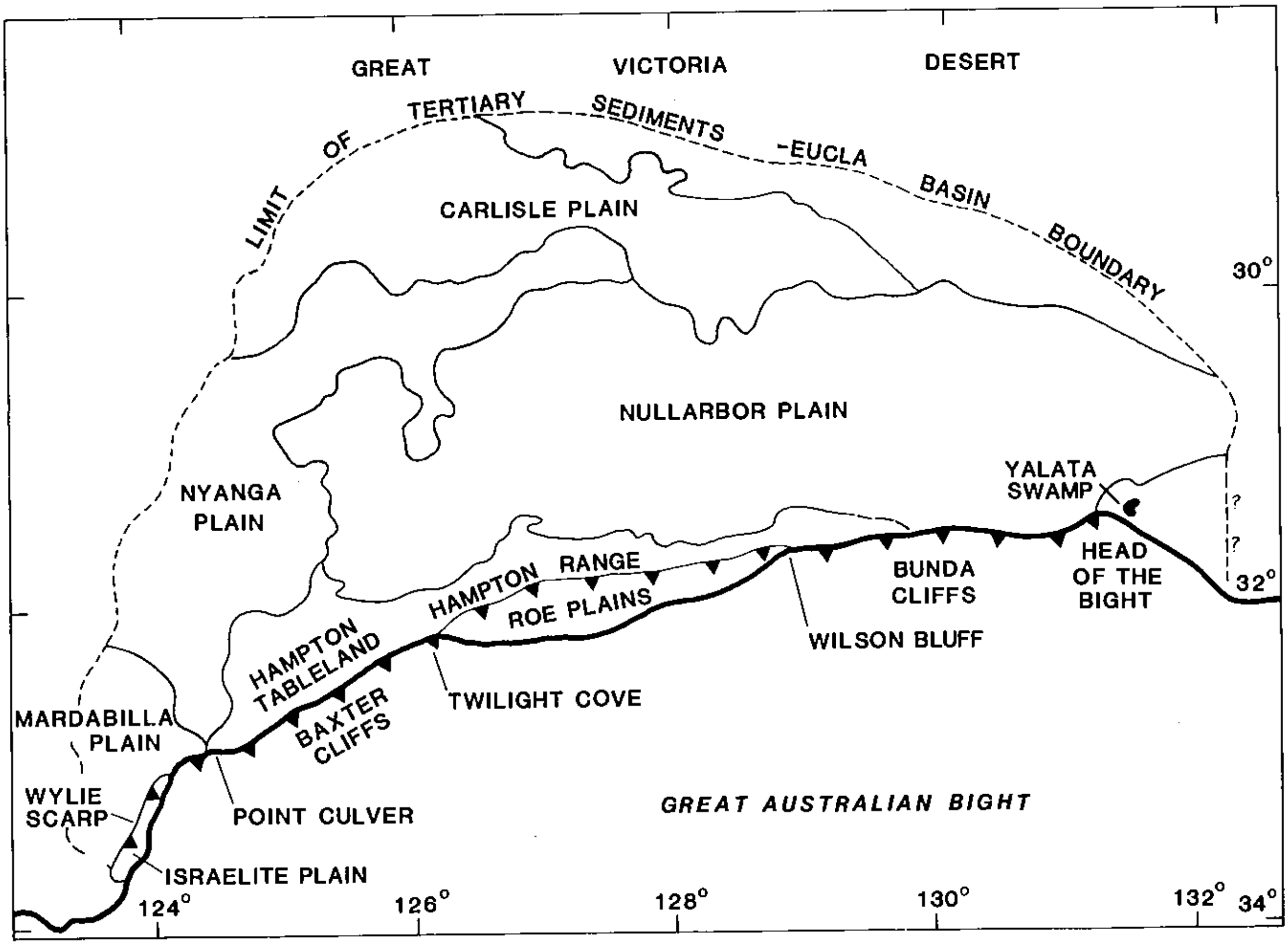
The onshore part of the Eucla Basin (Fig. 14) is one of the largest karst regions in the world comprising an area of more than 250,000 km^2, with two-thirds of this area in Western Australia and the remainder in South Australia (Jennings 1969). That part of the basin inland of the active and stranded sea cliffs is called the Bunda Plateau.

In its north-western part, the Bunda Plateau attains an elevation of 240 m. It slopes gently southwards and eastwards. In the southward direction the decline is in the order of 1 in 200, while from west to east it is about 1 in 10,000 (Jennings 1969). This gradual decline southwards and eastwards ends abruptly at the coast as the Bunda Cliffs in the east (40-75 metres high) and as the Baxter Cliffs in the west (60-90 metres high). Separating these two lengths of marine cliffs is the Roe Plain - a coastal lowland plain up to 40 km wide backed by the Hampton Range. This scarp is an emerged and degraded cliff linking the Baxter and Bunda Cliffs (Lowry and Jennings 1974). On the western extremity of the Bunda Plateau, the Wylie Scarp backs the much smaller Israelite Plain, while Yalata Swamp, an even smaller coastal plain at the eastern end, has its former marine cliff buried beneath coastal dunes (Jennings 1967b).

On the northern edge of the Eucla Basin, the limestone is replaced by calcareous sandstone (the Colville Sandstone) which, in turn, is buried beneath the quartz sand dunes of the Great Victoria Desert. On the western side of the plateau the Tertiary rocks wedge out against the rising irregular surface of the crystalline basement. On the eastern margin, the plateau is buried by coastal dune limestone reaching far inland from the coast; further north from this, the plateau finishes as a scarp at the Lake Ifould depression (Lowry and Jennings 1974).

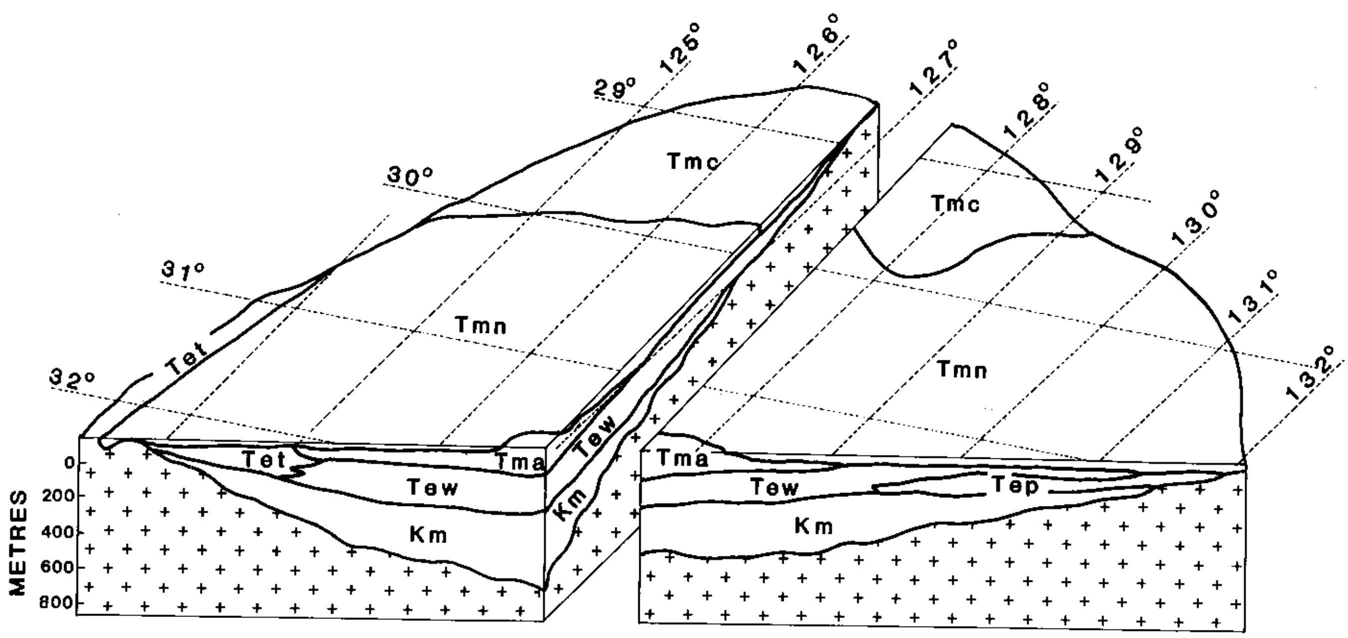
Karst landforms such as solution sculpturing of outcrops, dolines, underground drainage systems, and cavens are, by world standards, comparatively rare in the Eucla Basin (Lowry and Jennings 1974).

Nevertheless, the development of karst features in this arid setting is of considerable international interest (Balazs 1974, Bleahu 1974, Gams 1974, Grodzicki 1985, Jennings 1962, 1971, 1983A, 1985, Maksimovich 1962, Nicod 1972, Renault 1970, Rodet 1981, 1982, Stelcl 1976, Sweeting 1973, Trimmel 1968).



100 Km

Figure 14
PHYSIOGRAPHIC DIVISIONS OF EUCLA BASIN
Source :After Lowry and Jennings (1974)



LEGEND

MIDDLE MIOCENE	Tmn	NULLARBOR LIMESTONE
	Tmc	COLVILLE SANDSTONE
LOWER	Tma	ABRAKURRIE LIMESTONE
UPPER EOCENE	Tet	TOOLINNA LIMESTONE
	Tew	WILSON BLUFF LIMESTONE
	Tep	PIDINGA SANDS & CLAYS
CRETACEOUS	Km	MADURA FORMATION

Vertical exaggeration x125

100Kilometres

Figure 15

BLOCK DIAGRAM OF EUCLA BASIN SHOWING PRINCIPAL STRATIGRAPHIC UNITS

Source: After Lowry and Jennings (1974)

The most abundant and widespread karst phenomena are shallow solution dolines (Lowry 1970, Lowry & Jennings 1974). These take two distinct forms - packed rectilinear ridges and corridors, and scattered circular dongas (see "Physiographic Regions" below).

Another class of smaller-scale landforms which are also very common are small circular blowholes. These are the result of weathering enlargement to the surface from cavities below (Lowry 1968B, 1969).

Steep-sided collapse dolines and extensive caves are relatively uncommon, but many of them are of great interest. There are several hundred of these in total, mostly in the southern (wetter) part of the region. Some of the caves (a score or so) are of impressively large size, in some cases with many kilometres of spacious passages. A few of the deeper caves contain remarkable lakes and extensive underwater passages.

Previous Geological Studies

The earliest remarks on the geology of the Eucla Basin were the scattered observations made by Matthew Flinders and Edward Eyre of the coastal part of the basin. It was not until 1879 after Ralph Tate travelled by camel from Fowler's Bay in S.A. to Eucla, that the first systematic geological description was made. He included a description of three limestone units, together with comments on the physiography and this stood as the best description of the surface geology of the Eucla Basin for more than 70 years (Lowry 1970).

The first geological map of the area was produced by Gibson (1909), after he traversed the western part of the basin, but he provided little stratigraphic information. Structural details of the Basin, including information on the concealed Cretaceous beds, was obtained when boring for water for the Trans-Australian Railway (Maitland 1904, 1911, 1915; Fairbridge 1953). Comments on the ages of the limestones by Glaessner (1953), Singleton (1954), Crespin (1956), and in King (1949), improved information on the tertiary stratigraphy, and Ludbrook's (1958a, 1958b, 1960, 1963, 1967a, 1967b) contributions on both Tertiary and Cretaceous beds, further extended this knowledge (Lowry 1970). Important information has also become available as a result of oil exploration, marine seismic surveys, and a little onshore geophysical exploration (Playford, Cofe, Cockbain, Low and Lowry 1975).

Geological maps for the W.A. portion of the Eucla Basin are available at a scale of 1:250,000, and preliminary maps at the same scale have been printed for the S.A. side. Recent examples are van de Graaff and Bunting (1977), Lowry (1971, 1972) and Firman (1978). See Resource Material and Bibliography for complete details.

Geological History

Precambrian granite, gneiss, and quartzite, with folded proterozoic sedimentary rocks in some northern and eastern areas, constitute the predominant basement rocks of the Eucla Basin (Lowry and Jennings 1974) (Fig. 16).

In the Lower Cretaceous the Eucla Basin began to subside and non-marine conglomeratic sandstone, siltstone and shale was deposited (Lowry and Jennings 1974). Marine deposition of galuconitic and carbonaceous sandstones followed as the sea entered the Basin from the south, and deposition continued into the Lake Cretaceous.

Following a break in deposition, downwarping of the Basin recommenced in the Middle Eocene, and continued to the end of the Eocene period (Lowry 1970b). With this resumption of downwarping in the Middle Eocene (Fig. 15), marine sandstone and marl was deposted, which formed the lower part of the Wilson Bluff Limestone. The upper part of the Wilson Bluff Limestone (a chalky bryozoan limestone) (Fig. 16) was deposited across most of the Basin in quiet water in the Late Eocene, with the exception of the better-sorted Toolinna Limestone which was formed in a higher energy environment in the south-west (Lowry and Jennings 1974). Sea level at that time is thought to have been about 250 metres higher than at present, as indicated by a wave-cut bench on the slopes of Mount Ragged (Lowry 1970b).

Near the end of the Upper Eocene, the sea retreated and marine transgression did not recur until the Lower Miocene, with deposition of bryozoan calcarenite and calcirudite (the Abrakurrie Limestone), in the centre of the Basin. Then the sea spread across the Basin, depositing foraminiferal and algal calcarenite (the Nullarbor Limestone) over most of the Basin, and calcareous sandstone (the Colville Sandstone) on its northern margin (Lowry and Jennings 1974). Younger marine sediments are absent from the plateau, suggesting that after the Basin was uplifted to become land in the later part of the Miocene, no more marine transgressions occurred (Lowry and Jennings 1974).

Lowry and Jennings (1974), state that the sea level fluctuations in the Eucla Basin were probably caused by both epeirogenic and eustatic movements, and whichever was of greater significance is of little consequence for most aspects of subsequent geomorphic development.

Since the uplifting of the plateau, weathering has produced a variety of calcareous soils containing sheet and nodules of indurated concretionary calcium carbonate. The surface limestone below these soils is patchily indurated, or is variably weathered to porous and recrystallised to microcrystalline calcite forming a hard capping to the underlying limestone (Lowry and Jennings 1974).

During the Pleistocene, the sea rose by a maximum of 36 metres above present sea level, and it was probably during this period that the coastal lowland plains (Israelite Plain, Roe Plains and Yalata Swamp) were carved in the Tertiary limestone by marine erosion (Lowry 1970). On the Roe Plains, a thin, shelly Pleistocene calcarenite called the Roe Calcarenite was deposited (Lowry and Jennings 1974). The coastal dunes are dominantly calcareous and Lowry and Jennings (1974) maintain that, on the basis of kankar development, three significant dune building periods can be discerned on all three plains.

Physiographic Regions

For its size the Eucla Basin is extremely homogeneous in terms of surface form. This relative lack of diversity has led some researchers in the past to propose that it is either a planation surface or a structural surface in the sense of a stripped sedimentary surface (Jennings 1967a). Planation can be ruled out because the thin Nullarbor Limestone is present throughout the plateau (except in the south-west), and the absence of remnant younger formations precludes the possibility of a structural surface.

The plateau is now considered to be a Miocene sea-floor that was raised above sea level but modified little since. The perpetuation of its flatness is believed to be the result of low rainfall and high limestone permeability producing regularity of weathering, and because tectonism was negligible throughout the basin (Jennings 1963, 1967a; Lowry 1970).

Crystalline basement outcrop at Pidinga Rockhole. Photo A. Robinson.

Limestone strata in coastal cliffs at the Koonalda site. Photo A. Robinson.

Figure 16

THE CRYSTALLINE BASEMENT AND OVERLYING LIMESTONE

Valleys are extremely rare on the plateau, but near the northern and western margins, a few very shallow meandering valleys run out a little way into the Basin as continuations of valleys in the surrounding desert sand-ridge country (Beard 1973b, Bunting et al. 1974, Jennings 1967a, 1967c, van de Graaf et al. 1977). They can be distinguished from fault and joint related corridors by their meandering courses, their continuation in areas outside the karst, and by virtue of their trend down the gradient of the Basin (Lowry and Jennings 1974). Most of these relief river valleys are now crossed by vegetated, longitudinal dunes in the Great Victoria Desert: when they were active, they were unable to reach the coast because of evaporation and infiltration (Jennings 1967a).

(a) Nullarbor Plain
The Nullarbor Plain, lying at the centre of the Bunda Plateau (Fig. 14), is characterised by a gently undulating rather than a strictly flat surface. The southern part of the plain is characterised by parallel systems of ridges and corridors. Both the ridges and corridors are about one kilometre wide and may extend up to tens of kilometres in length (Jennings 1967c). Their relative relief varies from 1.5 to 3 metres in the west, to 3 to 6 metres in the east. Their pattern is joint controlled (Jennings 1963, 1967c; Lowry 1970; Lowry and Jennings 1974). In some parts, instead of the long ridge and corridor systems, the ridges shorten to become compact low rises, with shorter flats surrounding them in a diamond lattice relief pattern. This relief pattern is due to intersection of two major joint systems of about equal importance (Jennings 1967c).

Towards the north the relatively flat plain surface is interrupted mainly by "dongas" - shallow circular closed depressions with gentle slopes and flat clay floors. They are frequently arranged in chains parallel to neighbouring ridge and corridor systems, but elsewhere they appear to have a random spatial pattern (Jennings 1967c).

All these forms of surface relief are due to differential solution of the limestone surface and are the most abundant and widespread manifestations of karst development in the region.

(b) Hampton Tableland
Ridge and corridor topography is more pronounced in this region, and relative relief reaches 10 metres in places. Proximity to the coast, and hence higher rainfall, results in more solutional work on the limestone.

Rockholes and steep-walled dolines formed by the collapse of cave roofs, although still rare, are more common here than in other parts of the plateau (Lowry 1970).

Soils in this area tend to be thinner with a greater content of limestone and calcrete fragments, and limestone is more commonly exposed on the surface of ridges (Lowry and Jennings 1974).

(c) Nyanga Plain
Lying to the north and west of the Nullarbor Plain, the Nyanga Plain is a particularly featureless region with a thick cover of clay and calcrete. Depressions in the order of 5 to 15 metres in depth are formed by solution of limestone and deflation of clay (Lowry 1970).

(d) Mardabilla Plain
This region in the south-western part of the plateau contains numerous inliers of crystalline basement rock such as Mardabilla Rock, after which the area was named. These outcrops are set within surface depressions. Formation of these depressions is the result of runoff from the crystalline rocks removing solutional products into the groundwater (Lowry and Jennings 1974).

(e) Carlisle Plain
To the north of the Nyanga Plain is the Carlisle Plain with its sandy soils developed on the Colville Sandstone. The area contains closed depressions up to 30 metres deep, and 10 kilometres across. Lowry and Jennings (1974) suggest that the bulk of the former contents must have been sand and clay, and that subsequently they were removed by deflation.

Soils
Soil development in the Eucla Basin has been severely limited by geological and climatic constraints. Due to the uniformity of the underlying parent material, soil properties such as pH, texture and colour, show little variation across the Basin, and profile development has been retarded by the arid climate (Mitchell et al. 1979). The area is listed in the Atlas of Australian Soils as mainly carrying shallow calcareous loamy soils with weak pedologic development.

Beard (1975) described the typical soil type on the Nullarbor Limestone as a pinky brown silt with floury texture, and containing nodular kankar. He adds that limestone is usually found at depths of 30 to 40 centimetres with lumps and slabs often appearing at the surface. The heavier textured soils in depressions are commonly over 90 centimetres deep, and are mostly a greyish-red fine silky clay.

The soils on the ridges at the centre of the plateau are very shallow and rocky, and it is thought that much of the topsoil was lost by deflation during the Pleistocene (Jessup 1961a). Depressions in the area have a thicker soil mantle, with a much more clayey texture.

In the north, on the Colville Sandstone, soils are relatively deep and have a sandy loam texture that is pink in colour. Elsewhere, with the exception of the incoherent white calcareous sand dunes of the coastal lowlands, soils approximate more closely to Beard's description of the typical Nullarbor soil type.

LAND USE, HISTORY
J. Allen

Aboriginal History
The Nullarbor region supported very low Aboriginal populations and the vast treeless portion was virtually unoccupied (Marun 1974). Aborigines inhabited the coastal strip west of the head of the Bight, and peripheral areas of the Nullarbor prior to European colonisation. Although Tindale (1940) documented tribal boundaries, some migration and amalgamation of tribes occurred following early contact with Europeans. Aboriginal communities now living in the Nullarbor region are generally located outside their ancestral homelands, but still retain many aspects of tribal lifestyle.

According to Tindale (1940) the tribes which inhabited the Nullarbor region (and adjoining areas) were as follows:

KOKATA, NGALEA, PINDINI, MURUNITJA, TJERARIDJAL (northern fringe/Great Victoria Desert) MIRNING (coastal strip between Point Culver and the head of the Bight), WIRANGU (east of head of the Bight) and NGADJUNMAIA (west of Point Culver and Naretha).

An important contributor of information of the Aborigines of the Nullarbor and Great Victoria Desert regions was Daisy Bates. From 1919, she lived with tribal Aborigines at Ooldea Soak, an important water resource and gathering place which attracted tribes from the Nullarbor and Great Victoria Desert regions, and even further afield. She left extensive records (published and unpublished) of the daily life and social organisation of these people.

Ooldea Soak is located in sand-ridge country on the eastern edge of the Nullarbor Plain. It was used both as a permanent source of drinking water and a ceremonial and trading centre. With the building of the transcontinental railway, Ooldea became a permanent settlement for workers and Aboriginal people.

Bates also contributed valuable records of flora and fauna (see Previous Biological Studies; this publication) from her long association with the Aborigines at Ooldea.

Early explorers provided only meagre records of encounters with Aborigines (Marun 1974). Current knowledge of the MIRNING people who occupied a coastal strip 60 to 70 kilometres wide, has been summarised by Marun (1974). The MIRNING (and other tribes) were very reluctant to venture northward onto the treeless plain which they believed was the home of a giant mythological snake (GANBA) which killed and devoured humans. The treeless plain was considered to be almost impassable due to lack of available water (Johnston 1941), and some writers maintain that it was never crossed. However, Tindale (1940) mentions that the MIRNING sometimes ventured inland to the inner edge of the open country after good rains.

Possibly 200 to 250 MIRNING (Marun 1974) occupied a territory with extremely scarce supplies of drinking water, just prior to the arrival of Europeans. Wright (1971) lists possible watersources. Water was found in coastal dunes, rock holes, gullies in the Hampton escarpment, and underground lakes. Marun (1974) suggests that in recent times Aborigines did not frequent and seldom descended into deep caves where water could be found.

There is an incomplete record of Aborignal cultural sites on the Nullarbor (Davey 1984). Koonalda Cave in South Australia is regarded as an exceedingly important site. Excavations were commenced by Gallus in 1957. Koonalda Cave contains unusual finger engravings and was considered to be one of the oldest dated Aboriginal cultural sites at the time of the main investigation (Davey 1984). Flint mining occurred here and also at Warbla Cave, Weebubbie Cave, Abrakurrie Cave and Wilsons Bluff (Marun 1974). Flint from these localities was exchanged for native tobacco and other goods at Ooldea Soak.

Another significant site is 'Boundary Dam' discovered by Giles near the State border on the northern Nullarbor Plain, it is an example of an Aboriginal structure designed to trap run off in a gully or claypan.

Aboriginal Reserves

The Nullarbor region contains two Aboriginal Reserves, the Yalata Aboriginal Reserve and Cundeelee Reserve. Yalata was purchased by the Commonwealth Government in 1951 to accommodate Aboriginal people from Ooldea and the Maralinga Prohibited Area. Aborigines were transferred from the Prohibited Area north of the Transcontinental Railway prior to atomic testing. The Yalata Reserve comprises an area of 456,000 hectares in the south-east of the Nullarbor region providing a living area for PITJANJATJARA people whose ancestral home is the Great Victoria Desert south of the Birksgate Ranges. Other groups represented include the NGALEA, KOKATA and ANTAKARINJA.

The Cundeelee Reserve in Western Australia is located north of Zanthus, close to the western edge of the Study Area.

Land north of the Transcontinental Railway in South Australia, formerly part of the Maralinga Prohibited Area, was recently returned to its traditional owners, referred to as the Maralinga Tjarutja. These people include representatives of various tribes originally from the Great Victoria Desert region who moved to the Yalata Reserve in the 1950s.

Under the Maralinga Tjarutja Land Rights Act, 1984, a vast area of western South Australia is vested in the Maralinga Tjarutja. Entry to these lands by persons who are not traditional owners is restricted. However, the Act allows access for specific purposes - mining operations, rabbit shooting, limited recreational use by Cook residents, and travelling use of prescribed roads - and provides for free and unrestricted public access to the Un-named Conservation Park along a road reserve.

European History

Exploration

The south coast of Australia was first explored in 1627 when the Dutch ship <u>Gulden Zeepaard</u> under the command of Francois Thyjssen rounded Cape Leeuwin and followed the coastline for about <u>one thousand</u> miles eastward (Fig. 17). The territory lying north of the Great Australian Bight was named Nuyts Land in honour of the chief passenger, Pieter Nuyts. The shores of the Bight were next sighted by a French expedition under Bruni dé Entrecasteaux in 1792. Ten years later Matthew Flinders carefully charted the entire southern coastline in the 'Investigator'. Flinders was impressed with the tall continuous cliffs which form the edge of the Nullarbor Plain and estimated their height to be 600 feet, an over-estimation of 300 feet (Brown 1919).

Edward John Eyre made the first overland crossing of the Nullarbor in 1841. His journey ranks as one of the greatest feats of Australian exploration. Early travellers who encountered the Nullarbor met with very harsh conditions, but few suffered the degree of hardship experienced by Eyre and his small party. (Mason and Yonge nearly perished from thirst between Boundary Dam and Eucla in 1896, and in 1878 two Europeans disappeared without trace north of Eucla). Eyre followed the coast of the Nullarbor and Roe Plains finding water in dunes at the Head of the Bight, Eucla and Eyre's Sandpatch. Just west of Eyre's Sandpatch, his white overseer, Baxter was murdered by two Aborigines whc made off with most of the provisions. Eyre and an Aboriginal named Wylie, survived an extremely arduous journey to arrive at King George Sound on 7 July 1841. Eyre's was the first east-west crossing between the settled areas of South Australia and Western Australia.

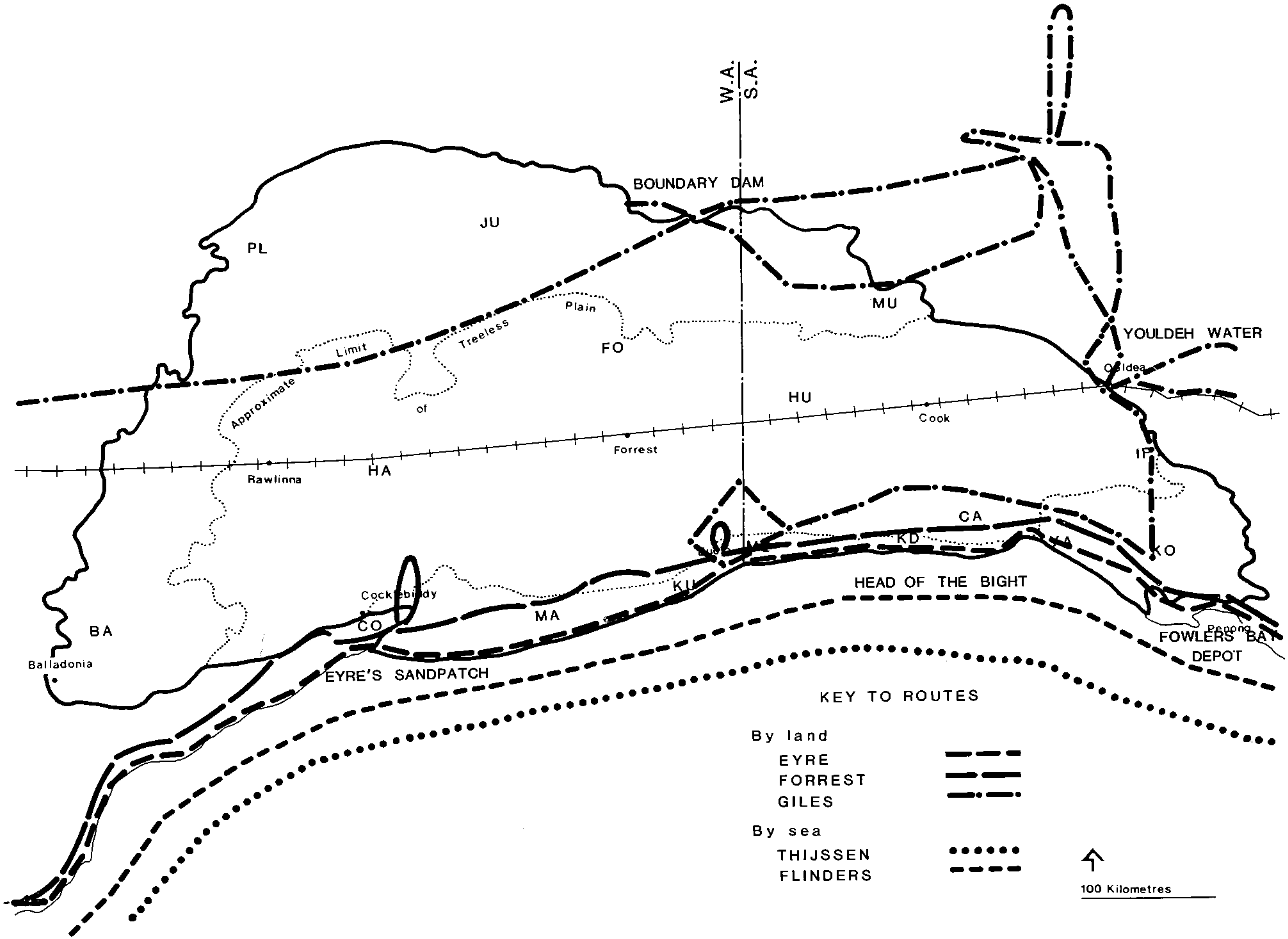


Figure 17
NULLARBOR EXPLORATION

In 1870, John Forrest journeyed from Perth to Adelaide via Eucla. He followed a route along the south coast slightly to the north of that taken by Eyre. The purpose of this expedition was to explore country west of Eucla, and to examine a route for a proposed overland telegraph line. Unlike Eyre, Forrest organised supplies to be dumped from a ship at intervals along the coast between Cape Arid and Fowlers Bay.

Ernest Giles was another notable explorer to visit the Nullarbor region. In 1875 he was commissioned to look for new grazing country west of the Fowlers Bay district. He travelled as far west as Eucla before returning to Colona, an outstation of Yalata Station. From Colona he travelled north to Ooldea Soak, only very recently discovered by Europeans, before heading for Beltana, the starting point for his fifth Expedition. His description of the open plain country encountered north of Colona, and between Pidinga (Lake Ifould) and Ooldea, indicates that significant change in vegetation has occurred since 1875.

> '... at twenty miles north of Colona we reached the edge of a plain that stretched away to the north and being evidently of a very great extent. ... Although this plain was covered with vegetation there was no grass whatever upon it but a growth of broom, two to three feet high, waving in the heated breezes as far as the eye could reach, which gave it a billowy and extraordinary appearance.' (Giles 1880).

Giles reported the same 'broom-bush', later identified as Eremophila scoparia, covering most of the open plain north of Pidinga. Although present, this species is no longer abundant on open plains in these areas, occurring sporadically on rises and dunes.

On his Fourth Expedition (1875) Giles returned to Ooldea Soak to establish a depot. From here he explored northwards and westwards intending to make an east-west crossing of a vast, unexplored part of the western interior. Depleted water stocks forced a retreat from Ooldea, Giles choosing a route which brought him on to the northern edge of the Nullarbor Plain approximately fifty miles south-east of Boundary Dam. Returning to Boundary Dam he decided to advance westward risking certain death if he failed to locate water. The expedition crossed the north-western corner of the Nullarbor Plain before re-entering the Great Victoria Desert, eventually finding water at Queen Victoria Spring. Of the Nullarbor he wrote:

> 'Although the region now was all a plain, no views of any extent could be obtained, as the country still rolled on in endless undulations at various distances apart, just as in the scrubs. It was evident that the regions we were traversing were utterly waterless, and in all the distance we had come in ten days, no spot had been found where water could lodge. It was totally uninhabited by either man or animal, not a single marsupial, emu or wild dog was to be seen, and we seemed to have penetrated into a region utterly unknown to man, and as utterly forsaken by God.' (Giles 1889).

Two bushmen, Miller and Dutton (in 1857) are believed to be the first Europeans to visit the actual treeless plain (Johnston 1941). The expansion of settlement westward to Fowlers Bay led to increasing speculation about the grazing potential of the Nullarbor region. In 1860, Warburton led an expedition to the head of the Bight but did not penetrate much further westwards. Delisser made the first careful examination of the Nullarbor Plain exploring up to 160 kilometres inland. In 1866 Delisser named the treeless plain 'Nullusarbor' meaning no tree. The western edge of the Nullarbor Plain was explored by the Dempster brothers in 1863.

Others who explored the Nullarbor region include Brown, a South Australian Government Geologist (in 1888), Professor Tate (in 1897), Jones (1880), Mason and Yonge (in 1896) and Carnegie (1894).

Development and Settlement

Early visitors to the Nullarbor were interested in its grazing potential. Eyre and Warburton considered that the Nullarbor Plain was unfit for settlement. Others discovered a good covering of grasses and reported enthusiastically about grazing opportunities. In 1896, Mason and Yonge who were sent to investigate the spread of rabbits into Western Australia, reported the discovery of millions of acres of the finest agricultural and pastoral country in the world, but with an entire absence of surface water (Beard 1975).

Pioneers who attempted to settle the region found the opportunities for pastoral development were very limited because of the lack of water for stock or human consumption. However, in the southern Nullarbor, pastoralists settled in areas where palatable borewater was located.

Yalata Station near Fowlers Bay was established by William Robert Swan who arrived in 1858. The Station eventually stocked a large tract of country west to near Head of the Bight, and an outstation was established as far west as White Well. Mundrabilla Station was established in 1871, followed by Moopina (1873), Madura (1876) and Balladonia (1880). There was further pastoral development in the Western Australian Nullarbor in the 1960s (Trotman 1974).

In 1874 work commenced on the overland telegraph line. A repeater station was built roughly halfway along the line at Eucla. Eucla was declared a town-site in 1885, and was for many years the only township in the Nullarbor region. The telegraph line followed a rough track which served as a stock route for the pastoralists on the southern fringe of the plain. This route was upgraded in 1941 and became the Eyre Highway (Fuller 1970). The highway was bitumised in Western Australia in 1965-69, and in South Australia, where it follows a new alignment, in 1967-76.

The standard gauge railway link from Port Augusta and Kalgoorlie was opened in 1915 (Bolam 1923). A Trans-Australian Railway was a condition of Western Australia joining the Federation and in 1901, Muir in Western Australia and Stewart in South Australia were sent to survey a route across the Nullarbor. The line passes close to the Ooldea Soak, where water was obtained for the workers and locomotives. The 'Trans-line' is famous for its 480 kilometre straight section across the flat, featureless plain - the longest 'straight' in the world.

LAND USE

Pastoralism

A relatively small area of the Nullarbor is occupied by pastoral leases (Fig. 18). The Western Australian portion was largely unalienated before 1955, but considerable pastoral development occurred during the 1960s (Trotman 1974). There are twenty-one pastoral leases in Western Australia covering a total of 5,445,770 hectares, mostly south of the Transcontinental Railway (Trotman 1974).

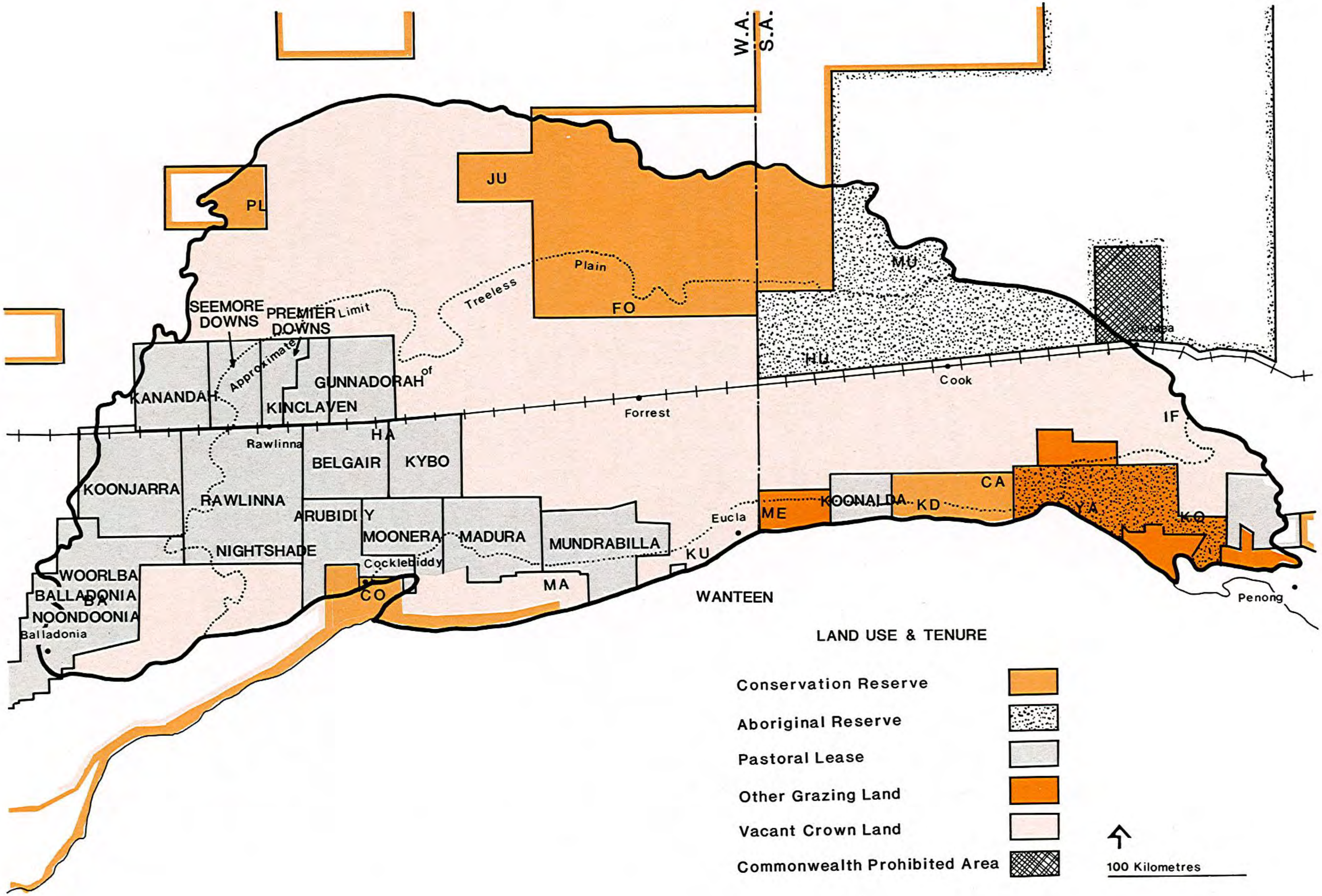


Figure 18
NULLARBOR LAND TENURE

The future of pastoralism in the Nullarbor in uncertain. In 1974, the Western Australian Pastoral Appraisement Board commissioned a survey of a portion of the Nullabor Plain comprising (approximately) 47,000 square kilometres (Trotman 1974). From 1969 to 1973, the region was severely affected by drought and serious soil erosion and pasture degradation was reported. The survey report (Trotman 1974) concluded that the poor condition of pasture was due to the combined effects of rabbits, fire and drought. Forty per cent of the survey area was in poor condition. Unalienated crown lands occupying 77 per cent of the survey area was considered to be unsuitable for pastoral development, having negligible potential for pastoral production because of the degraded condition of pastures, low and erratic rainfall and the lack of quality stock water (Trotman 1974).

The pastoral industry in the Nullarbor region is entirely dependent upon the availability of suitable bore water. The natural plant cover of the Nullarbor Plain contains a number of species palatable to stock, but water can only occasionally be found in boreholes and then only at great depths (Beard 1975). Rabbits are considered to be the most significant factor in pasture degradation. The elimination of perennial shrubs such as Maireana sedifolia (Blue Bush) over extensive areas of the plain has been attributed to ringbarking by rabbits (Beard 1975).

Mismanagement of pastoral leases has led to overgrazing in many parts (Conservation Through Reserves Committee 1974). Some leases are no longer viable and further pastoral development is unlikely. In South Australia, the Pastoral Board is opposed to new areas being leased for grazing because of the lack of viable water supplies (S.A. Department for the Environment 1980).

Tourism and Recreation

The vast majority of visitors do not regard the Nullarbor as their primary or secondary destination. Travellers using the Eyre Highway rarely depart from the main road to visit natural or man-made features (Davey 1978). The motel complexes and camping facilities along the Eyre Highway are primarily used by inter-state travellers. The region generates negligible tourist activity, but the potential exists to develop local tours and specific sites. The caves of the Nullarbor are regularly visited by organised groups, and an increase in casual visitation to well-known sites can be expected (Davey 1978).

Conservation

The Study Area contains six reserves of which two are managed specifically for nature conservation under the National Parks and Wildlife Act 1972-81 in South Australia, and three under the Wildlife Conservation Act, 1950 and amendments, in Western Australia (Fig. 18). Other areas, such as land reserved for specific purposes other than nature conservation and vacant Crown Lands, may satisfy certain conservation objectives. However, they are not managed for conservation and conservation is only an incidental land use. Taking into account the above, approximately 18 per cent of the Study Area is set aside for conservation purposes.

The following reserves are part of the conservation park reserve system managed by the National Parks and Wildlife Service of the South Australian Department of Environment and Planning. Beyond legislative protection and occasional visits by staff based at the Streaky Bay N.P.W.S. office, available resources do not permit any active management of these two reserves.

(a) The Unnamed Conservation Park

2,132,600 hectares were dedicated in 1972 making this the largest conservation area in South Australia. The park is a natural wilderness and contains a variety of ecosystems which are unique and relatively unaffected by man. The Ecological Survey Unit of the South Australian Department of Environment and Planning has prepared a report of its survey of the Serpentine Lake Region of the park (Ecological Survey Unit 1979). The Nature Conservation Society of South Australia conducted a biological survey of the same region in 1980. A major portion of the park is in the Great Victoria Desert. The southern part of the park, approximately one-sixth of the area, is included in the Study Area. The Unnamed Conservation Park is listed as a Biosphere reserve.

(b) Nullarbor National Park

This park comprises 231,900 hectares of former pastoral land; it was dedicated in 1979. The park contains typical Nullarbor Plain topography with caves, coastal cliffs and a large area of treeless plain. It falls entirely within the present Study Area.

Four conservation reserves exist in the Western Australian Nullarbor. They are vested in the National Parks and Nature Conservation Authority and are of Class A. In international terms they would be classified as 'Strict Natural areas' (Dasman 1973). Direct human intervention is forbidden in natural ecological processes. However, necessary management to minimise the effects of man-induced disturbances is allowable. Beyond legislative protection and occasional inspections by staff, available resources do not permit any active management of the two reserves in the north (Fig. 18).

(c) Nuytsland Nature Reserve No. A27632

This 625,322 hectare reserve was declared in 1965 and proclaimed Class A in 1969. The 30 per cent of this reserve that lies within the Study Area represents environments of the coastal strip of the Nullarbor and includes consolidated sand dunes and beach environments typical of the western end of the Roe Plain. It includes a section of the Hampton Escarpment and penetrates the southern edge of the treeless plain near Cocklebiddy. It includes a research facility (Eyre Bird Observatory) that is maintained and staffed by the Royal Australian Ornithologists Union.

(d) Great Victoria Desert Nature Reserve No. A30490

This, the largest reserve in Western Australia, was declared in 1970. Nearly 80 per cent of its 2,495,777 hectare area represents environments in the driest part of the Nullarbor. It straddles the inland fringe (60 per cent) and penetrates the treeless plain (20 per cent). The other 20 per cent lies in the Great Victoria Desert. Subtantial areas of most of the plant formations distinguished in the inland fringe by Beard (1975) are included. Most of the reserve is inaccessible because tracks are few.

(e) Plumridge Lakes Nature Reserve No. A34605

This nature reserve comprises 308,990 hectares. It was declared in 1977. Forty-five per cent of its area represents environments of the north-western corner of the study area, particularly Myall over Bluebush formations, areas of Mulga and extensive woodlands of sheoak.

(f) Eucla National Park No. A36205
This small national park (3342 ha) is situated between the coast and Eucla townsite. It encompasses a small area of mallee on the Hampton Range as well as coastal dune surfaces.

Other Land Uses

Other land use categories include aboriginal land, unalienated crown land and the Maralinga Prohibited Area (see Fig. 18).

Vertebrate Pests

The importance of the Nullarbor region as a buffer between the agricultural districts of South Australia and Western Australia in the event of invasion by pest species is recognised by pest control authorities. The Agricultural Protection Board of Western Australia has undertaken a vigorous eradication program to prevent the spread of the common Starling (Sturnus vulgaris) into Western Australia. The arid Nullarbor environment has discouraged colonisation by this widespread pest, but small groups are occasionally encountered along the coastal strip west of Koonalda. A large-scale Starling invasion of Western Australia would undoubtedly have a serious economic impact on agriculture.

The role of the Rabbit (Oryctolagus cuniculus) in Nullarbor environments relates to land use in several ways. During the field study in April and September 1984 it was apparent that rabbit shooting was a significant economic activity in certain parts of the plain and indeed, along with fox, cat and limited kangaroo shooting, the only (direct) economic use of otherwise unoccupied land. The most significant impact of rabbits, however, is the destruction of vegetation. The effect of rabbits on Nullarbor vegetation associations is discussed by Beard (1975) and effects on pastoralism by Trotman (1974).

PREVIOUS BIOLOGICAL STUDIES

K. Higginbottom

The earliest records of the biota of the Nullarbor were obtained by explorers and surveyors. Botanical collections were made by members of the seaborne expeditions of d'Entrecasteaux in 1792 and of Flinders in 1802 (Beard 1975). Specimens were subsequently collected by members of the overland expeditions led by Delisser in 1861 and 1865, by Roe in 1848 and 1849, by Forrest in 1870, and by Giles in 1889. Most of the plant specimens collected are housed in the National Herbarium, Victoria (Willis 1959). Other notable collections of the last century were made by local inhabitants (especially T. Richards and I.D. Batt). More detailed accounts of the activities of early collectors are given by Willis (1959), Nelson (1974) and Beard (1975). Superficial impressions of the biology of the Nullarbor and its environs are reported in the accounts of various early expeditions (e.g. Giles 1889, Mueller and Tate 1896, Anon 1917-18).

The first substantial account of the natural history of a part of the Nullarbor was published by Tate (1879), who travelled along the coastal strip between the Head of the Bight (S.A.) and Wilson Bluff (W.A.). He produced a general description of the vegetation of that area and a list of plants, vertebrates and invertebrates with notes on their local distribution. Since this work no attempt has been made to study the whole biology of any area of the Nullarbor.

The biological work of this century that is relevant to the Nullarbor can be divided into four main categories:

(i) studies of particular taxa;

(ii) studies of cave biota;

(iii) general surveys in neighbouring or overlapping areas;

(iv) reviews or assessments.

Work on particular taxa can be further subdivided into that dealing with plants, mammals, reptiles/amphibians, birds and invertebrates.

Studies of Particular Taxa

(a) Plants
The main sources of species records for the plants of the Nullarbor Plain are the State herbaria.

Thousands of Nullarbor specimens are housed at the S.A. Herbarium in Adelaide (S.A.H.) and the W.A. Herbarium in Perth (W.A.H.). Prior to 1940, most S.A. Herbarium records were obtained along the trans-continental railway, particularly around Ooldea. The major collectors were Daisy Bates (see Land Use History, this publication), E.H. Ising, and S.A. White; all renowned amateur naturalists. Other early specimens from various localities were donated by R. Tate and by N.B. Tindale, an anthropoligist working in the area.

In the last 40 years, various collectors associated with herbaria (especially R.J. Chinnock, N.N. Donner, T.N.R. Lothian, J.Z. Weber, D. Whibley and P. Wilson) and universities (T.G.B. Osborn, D. Symon) have contributed. P. Aitken (S.A. Museum), O.H. Turner (local naturalists) and L.D. Williams (Ecological Survey Unit) have collected extensively at Maralinga, and J.B. Cleland has donated many specimens obtained between Yalata and the Head of the Bight. Other main areas of collection have been along the Eyre Highway, around Nullarbor and Koonalda Stations, the Pidinga/Lake Ifould area, and along the road from Cook to Vokes Hill Corner.

Beard (1975) provides an account of early collectors on the Western Australian Nullarbor. J.S. Beard accompanied by A.S. George (W.A.H.) in 1966, E. Wittwer in 1967, P.G. Wilson (W.A.H.) in 1968 and L. Wende in 1970, made extensive collections during transects for vegetation mapping between 1966 and 1970. A.M. Baird (University of W.A.) collected extensively around Forrest in 1930 and 1955; her collections are lodged in the University of Western Australian Botany Department. Burbidge (in RAOU 1982) lists recent collections at Eyre (near Cocklebiddy) made by a variety of people - R.F. Parsons, E.C. Nelson, B.C. Crisp, G.J. Keighery, A.H. Burbidge, J. Seabrook, M. McCallum-Webster and S.D. Hopper. E.C. Nelson collected extensively along the southern Nullarbor in 1973. M. Trudgen and T.E.H. Aplin (W.A.H.) collected along the Trans-Australian Railway Line in 1974.

The vegetation of several areas within the Nullarbor has been surveyed. Adamson and Osborne (1922) conducted a six day study of the vegetation of the Ooldea district on the north-east boundary of the Nullarbor. They describe the vegetation of both the plain and sandhill habitats with comments on ecology, and give a complete list of the plants which had been found in the area to that time. Similarly, Parsons (1970) surveyed the mallee vegetation in the coastal strip from the head of the Bight to Caiguna. He discusses distribution patterns in relation to soil and climatic factors. Nelson (1974) collected specimens from several isolated dune systems between Point Culver and Twilight Cave, W.A. He postulates certain geological events as accounting for the disjunct distribution of some species.

The only detailed botanical description for the central Nullarbor is that of the Forrest area by Johnson and Baird (1970). They describe the vegetation of several different habitat types, and list 105 species of flowering plants collected.

Several attempts have been made to classify and map the overall vegetation of the Nullarbor. Beard's (1975) vegetation map of W.A. provides the most detailed vegetation classification system presently available for the area. Most of the Nullarbor coincides with the Eucla Phytogeographic District defined as an area with a characteristic vegetation related to its climate, geology, landforms and soils (Beard 1980). Plant formations within this region are mapped and described in some detail. These descriptions are the result of extensive surveying as well as collation of previously available information, unlike previous attempts at classification (e.g. Diels 1906, Clarke 1926, Gardner and Bennetts (1956). Traverses were made by taxonomists along a variety of routes, and information from the unpublished notes of several botanists were incorporated. Aerial photography of two-thirds of the Nullarbor was interpreted in the light of the ground surveys and used to compile maps. However, while Beard's map is the most comprehensive presently available, it appears that at least one area (S.E. of Plumridge Lakes) needs to be re-mapped (Burbidge, McKenzie, Chapman and Lambert 1976). Further field work is desirable to verify this map in other areas which Beard did not traverse.

The Western Australian part of the Nullarbor has been surveyed and classified with particular reference to its pastoral potential (Mitchell, McCarthy and Hacker 1979). The survey involved work on the ground and from the air, spread over three months. However, due to technical problems, the resulting report is restricted to the eastern third of that area, where there are several long-settled pastoral properties. Nineteen distinct plant associations are described in terms of species present, spatial distribution, lifeforms and associated soil types.

Vegetation mapping and classification for the South Australian portion of the Nullarbor remains superficial. South Australia's vegetation has been mapped by the S.A. Pastoral Board (1975) based on available information and ground survey, by Specht (1972) based on surveys by the Department of Lands, by Boomsma and Lewis (1980) using a review of previous information, and has been partially mapped by Douglas (1980) using satellite imagery. In each case only a few zones are distinguished within the Nullarbor and the descriptions associated with them are very brief. As part of the C.S.I.R.O.'s system of classification of the 'Environmental Regions' of S.A. (Laut et al. 1977), the Nullarbor region was split into six environmental associations, for each of which vegetation was very briefly described along with physical and land use characteristics. Although 'LANDSAT' imagery was used to help in distinguishing associations, it appears that no ground survey work was conducted.

(b) Mammals

Mammal records for the Nullarbor are scant, and specimens have been obtained from only a few localities. This is probably because of the difficulty of collecting mammals opportunistically in comparison with other vertebrates.

In the South Australian Museum, 24 species are recorded from the Nullarbor and environs. Virtually all small mammal specimens have been obtained from the Ooldea/Maralinga area. Until the 1960s, most records are attributable to Daisy Bates and to Professor Wood Jones (University of Adelaide), collecting around Ooldea. Finlayson (1939) lists early contributions to the taxonomic knowledge of the Muridae derived from specimens obtained in this area. More recently the main collectors in the Ooldea area have been P. Aitken and A. Fischer. In addition, a number of collectors have obtained small mammals and bats from various caves (most notably H. Mincham from S.A.M.) and large diurnal mammals have been collected from Nullarbor Station by W.P. Crowcroft (S.A.M.). Finally, a few specimens have been obtained from the Yalata region and from the area north of Cook (N.C.S. survey group).

The Western Australian Museum houses 21 species of mammals collected from the Nullarbor. Again most of the early specimens are from the Ooldea area (D. Bates, D.L. Glauert of W.A.M., and unknown collectors). Since 1960, records are attributable to a large number of collectors, each contributing no more than a few species. The main collecting localities in W.A. have been near sidings along the transcontinental railway, along the Eyre Highway and near the coast. In addition, specimens have been obtained from the northern edge of the Nullarbor by W.H. Butler, and by the W.A. Opeartment of Fisheries and Wildlife.

Another important source of mammal records for the Nullarbor has been bone deposits from caves, probably derived from owl pellets. A number of such findings are reported by Lundelius (1963) and Archer (1972-74), and summarised by Davey (1979) and Baynes (this report). The most comprehensive mammal species list currently available for the Nullarbor is given by Baynes (this report).

Detailed studies of the mammals of the Nullarbor are restricted to a few species of particular applied or taxonomic interest.

For example, the Hairy-nosed Wombat (Lasiorhinus latifrons) has been thought to compete directly with pastoral land use (Loffler and Margules 1980). Its distribution has been investigated by field observations (Jenkins 1962, Lowry 1967, Aitken 1971) and by satellite imagery (Loffler and Margules 1980). The species is also of interest because of its relatively restricted distribution, the Nullarbor being where it occurs most abundantly.

Several studies have included observations on the abundance and distribution of Rabbits (Oryctolagus cuniculus) (e.g. Jessup 1951, Beard 1972, Brooker 1977). This interest has been generated by their apparently devastating effect on much of the district's vegetation.

As part of an assessment of the effects of residual radiation on the Maralinga atomic testing site, nineteen rabbits and a dingo were investigated for the uptake of Plutonium (Ecological Survey Unit 1977). The results indicated that Plutonium was present in body tissues, but it was not established whether these levels constituted any danger.

Investigations of the Stick-nest Rat (Leporillus conditor) on the Nullarbor are of great importance since the species is apparently now extinct on mainland Australia. Field observations were made in the Ooldea and Fisher areas early this century (Troughton 1923, 1924).

Finally, opportunistic observations of mammals have been recorded in the course of other work. Notably, Brooker (1977) reports observations of eight native mammals in the Rawlinna (W.A.) area as well as seven introduced species, with comments on their apparent abundance and impact.

(c) Reptiles and Amphibians
Knowledge of the herpetofauna of the Nullarbor is more extensive than that of its mammals, but again is restricted to a few localities.

In the S.A.M. over 60 species of reptiles (but no frogs) are recorded for the Nullarbor. As is the case with mammals, most early specimens were obtained from the Ooldea area (D. Bates, A.M. Lea (S.A.M.) and J.C. Ash. Since 1960, most collecting at Ooldea has been conducted by visiting amateur naturalists (J. Fischer, S.A. Herpetology Group, P. Mirtschin et al.) and museum curators (C. and T. Houston et al., P. Aitken et al.). Other major collecting areas have been Maralinga (P. Aitken et al., T. Dennis and G. Coombe of S.A.N.P.W.S.), along the transcontinental railway between Barton and Watson (J. Fischer, C. & T. Houston et al.), from Cook northwards (T. Dennis and G. Coombe, N.C.S. Survey), Nullarbor Station (P. Crowcroft and W. Head of S.A.M.), Yalata (N.B. Tindale of S.A.M., P. Bird of Vertebrate Pest Control Authority) and along the Eyre Highway (B. Miller).

The main collectors and collecting localities for the herpetofauna of the area of the Western Australian Nullarbor lying south of the Eyre Highway are listed by Storr, Hanlon and Harold (1981). The authors summarise the local distribution and habitat preference of each species, and state that they believe that the herpetofauna of this coastal strip is now almost completely known.

A fairly extensive collection of reptiles and frogs obtained opportunistically from various localities in the West Australian part of the Nullarbor is described by Brooker and Wombey (1978). They report 27 species of reptiles, and one species of frog as occurring on the 'plain proper' (excluding mallee areas).

Apart from these collections, and other recorded in the W.A.M. that are yet to be researched, there appear to have been no biological studies of reptiles or amphibians on the Nullarbor.

(d) Birds
Bird records from the Nullarbor are from more widespread localities than are those of terrestrial vertebrates.

In the S.A.M., there are specimens of only about 40 species. J.B. Cleland and D. Bates collected at Dooldea early this century, and in the 1960s specimens were obtained by the Harold Hall expedition of the British Musuem and by W. Head of S.A.M. at Nullarbor Station.

Observations and collections of birds were made on several of the exploration and biological expeditions mentioned earlier. Additional records appear in reports and annotated lists published in the ornithological journals 'Emu', 'South Australian Ornithologist' and 'Australian Bird Watcher'.

Several accounts of ornithological work in the Nullarbor area were published early this century. The assistant Government Geologist of Western Australia, C.G. Gibson, listed 111 species (excluding sea birds) sighted on a journey from Kalgoorlie to Eucla in 1908 (Gibson 1909). Whitlock (1922) and Collins (1934) provide more comprehensive notes on the avifauna of the western Nullarbor. Le Souef, who found the country 'teeming with wildlife', published a bird list from the Rawlinna area in 1928. S.A. White made four journeys along the Transcontinental Railway to investigate westward movement of Sparrows (Passer domesticus), and published the first detailed bird list for the eastern Nullarbor (White 1919).

Some recent surveys were more methodical. Quantitative, distribution, habitat and breeding data were recorded for birds at sites in the north-western Nullarbor Plain by Brooker et al. (1979) between 1967 to 1978, and Ford and Sedgwick (1967) in 1967. The former provide a systematic account of 135 bird species observed during the course of an ecological study of Aquila audax. Ford (1969, 1971) discusses the distribution and taxonomy of southern species recorded in the Great Victoria Desert and mallee-woodland habitat around the edge of the Nullarbor.

McColl (1929) gives a general account of his bird observations from the Hampton Escarpment and other areas. Reilly et al. (1975) recorded birds while searching for breeding penguins (Eudyptula minor) along the coast between Twilight Cove and Point Culver in the south-west of the Study Area. McGilp (1932) discusses the distribution of several species in south-western South Australia.

Several ornithologists have unpublished lists from recent expeditions to the Nullarbor (e.g. Auricht et al., J. Reid). Much of this material awaits publication, or may have been incorporated in the Australian Bird Atlas (Davies 1984) prepared by the Royal Australian Ornithologists Union. This Atlas is a compilation of records from the period 1975-82, providing listings for 1^{o} and 10' grid blocks.

Cave Fauna and Invertebrates
The largest body of biological work on the Nullarbor is that which is devoted to cave fauna.

However, cave fauna was not specifically included in this survey although some cave bats were collected opportunistically. Reviews of the known extant vertebrate fauna of the Nullarbor caves are presented by Hamilton-Smith (1967), Richards (1971) and Davey (1978). Knowledge of the fossil remains found in Nullarbor caves is summarised by Davey (1978) and Baynes (this report). Finally, unconfirmed reports of blind fish inhabiting cave pools are discussed by Hill (1969), Bridge (1969) and Glover (1977). Further references on cave fauna are listed in the bibliography.

Studies of the invertebrate fauna of the Nullarbor are also outside the scope of this report. However, apart from those concerning the inhabitants of caves and those conducted in peripheral areas, to our knowledge there have been no studies of surface invertebrates on the Nullarbor.

Biological Studies of Surrounding Areas
General biological surveys conducted in areas near to and overlapping the Nullarbor should provide useful bases for comparison with the results of the present survey. Such investigations have been conducted in the Unnamed Conservation Park (S.A.) and in the Plumridge Lakes Nature Reserve and Eastern Goldfields of W.A.

The Unnamed Conservation Park is on the western edge of the South Australian section of the Nullarbor (Fig. 1). The Ecological Survey Unit, S.A. Department for the Environment (Douglas, William and Lewitzke 1979), used ground survey and satellite imagery ('LANDSAT') to map and describe the vegetation of the area. Opportunistic observations and some pit-trapping resulted in a brief faunal list. Data obtained in this survey was of a purely descriptive nature.

An Ecological Survey of the Great Victoria Desert in South Australia was conducted by the Nature Conservation Society of S.A. (Greenslade et al. 1986), and the results of the previously cited survey have been incorporated in the resulting report. The southern extremity of the study area was 132 km north of Cook, which is close to the northern extremity of the present survey. The study included work on the physical environment, plants, vertebrates and invertebrates.

Plant sampling was conducted on a quantitative basis at five localities. Many interesting additions were made to the floristic list for the area, and vegetation patterns for each site were described. Correlations were calculated between plant species, soil type and landform; and between the presence of different species.

Mammals and reptiles were collected using a variety of traps and other techniques. About a third of the mammal species were obtained on the road north of Cook, and south of Wyola Lakes, while some reptiles were captured from the Nullarbor itself. A number of interesting species records were made, but no quantative data was obtained on terrestrial fauna. Birds were observed between Muckera Rockhole and Vokes Hill Junction, east of the junction, and in the Barton Sandhills area near Ooldea. Statistical analyses were used to identify habitat preferences (in terms of vegetation) for individual species. A number of interesting records were obtained and a total species list for the Great Victoria Desert was produced.

The Eastern Goldfields of Western Australia abutt the western edge of the Nullarbor. The area was extensively surveyed between 1978 and 1982 (Biological Survey Committee of W.A. 1984) and to some extent the approaches therein were used as a model for the present survey. Information on plants and physical environment was obtained at up to 150 sites in each of the 12 cells into which the study area was divided. An extensive species list and vegetation classifications were obtained. Vegetation was related to geology, geomorphology and soils. Vertebrates were sampled at at least 10 of these sites in each cell, the vertebrate sites being selected to represent 'all major vegetation types' using a variety of trapping and opportunistic techniques. Once again, data on vertebrates was in the form of quadrat species lists, with notes on species' habitat and distribution.

In 1976 the W.A. Fisheries and Wildlife Department produced a report that included an account of the wildlife on the Plumridge Lakes Nature Reserve, one of the three reserves which extend into the Nullarbor (Plumridge Lakes Nature Reserve, Great Victoria Desert Nature Reserve and Nuytsland Nature Reserve). It was based on a field survey that lasted for only three days. Collecting effort was concentrated on mammals (using a variety of traps): all vertebrate groups were observed or collected opportunistically. The survey resulted in faunal lists and brief descriptions of vegetation and soil types.

The present state of knowledge of the fauna of the Great Victoria Desert Nature Reserve is contained in a report by the Conservation through the Reserves Committee (1974), a faunal list compiled during a patrol by two wildlife officers of the Western Australian Department of Fisheries and Wildlife, and notes on the vegetation in Beard (1975). Data on Nuystland Nature Reserve is more substantial; annual reports by the Royal Australian Ornithological Union on work carried out at the Eyre Bird Observatory since 1977 include detailed analyses of the bird fauna as well as notes on vegetation, reptiles and mammals observed (R.A.O.U. 1982).

(a) Reviews and Assessments
Biological work includes not only data collection but also an assessment of its significance. A few studies have attempted to use the available biological information on the Nullarbor as a basis for management.

In S.A. a collation by the S.A. Department for the Environment (Jensen and Wilson 1980) which included the Nullarbor region was conducted in order to form 'a basis of assessment of impacts associated with proposed developments' (p. xvii), particularly mining. Distributions of fauna and flora are summarised, and endangered species and associations are discussed. However, little of this information is specifically applicable to the Nullarbor.

Conservation of the Nullarbor region of S.A. is specifically dealt with by Laut et al. (1977). However they cover the region's conservation needs in one paragraph - perhaps reflecting the lack of baseline biological survey data available on which to base such assessments.

A more comprehensive assessment of the nature and importance of reserves in the Western Australian portion of the Nullarbor has been conducted (Davey 1978). The impacts of man, directly and through introduced animals, upon the vegetation and fauna of the plain are discussed. Davey (1984) has produced a similar report for the South Australian Nullarbor, but the only biological information contained concerned cave biota.

Summary
Most of the biological information available on the Nullarbor has been obtained from collections or observations taken at particular localities, or consists of very general descriptions. Some vegetation surveys have been conducted and general biological surveys have been carried out in adjacent areas. However to date no survey of both plants and animals has been carried out that samples the array of communities typical of the Nullarbor. There have also been no surveys covering both W.A. and S.A. sections.

FORMAT

In Methods, the overall strategies of sampling and analysis are described.

The initial chapters of Results deal specifically with vegetation, mammals, birds, reptiles and discuss the community patterns derived from these separate group analyses in relation to the previous knowledge of these groups from the Nullarbor and adjacent regions. There is a specially commissioned paper on quarternary mammals which is inserted as a self-contained contribution within the results section. In view of the fact that the mammals have suffered the most dramatic decline in species diversity since European settlement of Australia, the paper on the Late Quarternary mammal fauna was included to give some indication of the immediately pre-European mammal communities of the Nullarbor. The final chapter of the results discusses the biophysical patterns derived from an analysis of this complete data set.

Finally, the conservation implications of the study are discussed and recommendations for the management of representative samples of the biological diversity revealed across the Nullarbor Study Area are made.

METHODS

N.L. McKenzie, A.C. Robinson, A. Gunjko & D.L. Belbin

Design

The large size of the study area in relation to the number of biologists involved and the time available for the study determined our approach to the survey. The design was a standardised site-specific sampling program for vegetation and vertebrates carried out over an interval of time sufficiently brief to justify the assumption that all quadrats were sampled simultaneously. The concepts underlying this approach to biological survey are discussed in detail elsewhere (McKenzie 1984, Biological Survey Committee, W.A. 1984). The sites sampled (quadrats) were selected to represent the geographic extent of the Nullarbor (Fig. 1) and to sample as much of the biological diversity of this district as available resources permitted.

For planning purposes 16 campsites were selected using available maps; in particular the superficial geological maps that cover the whole area at a scale of 1:250 000 were consulted. The South Australian portion of the Nullarbor was also examined from the air. The final location of all campsites, and associated quadrats, was determined during a field reconnaisance that began in February (Fig. 19).

The campsites selected provided ready access to the array of discrete vegetation units and surface types (= land units) distinguished on the available maps. Five quadrats were selected and traplines established (Appendix I) within a 20 km radius of each campsite. Relative effort (number of quadrats) was apportioned between the land-units according to their areal contribution to the Nullarbor estimated using available 1:1 000 000 vegetation (Beard 1975) and 1:250 00 geological maps. Quadrats on the more widespread land units were replicated, both nearby and at geographically remote locations. Homogeneity of quadrats was determined subjectively in terms of landform/land surface characteristics, and vegetation physiognomy and floristic composition of the prominent species in each stratum.

The size of the quadrats was 2 km x 2 km. The large size of these quadrats in relation to those adopted for the survey of the Eastern Goldfields (B.S.C.W.A. 1984) was considered necessary to offset the relatively low standing biomass of Nullarbor communities.

Patchiness was apparent in many Nullarbor land units, sometimes at a very fine scale, so it was anticipated that quadrats of the above size should often encompass a mosaic of several patch-types. The survey strategy demanded that vertebrate and vegetation sampling within the quadrats recognised their patchiness and that all observations were related to a particular patch-type thereby providing assemblage data. Appendix I shows the range of quadrats selected around a given campsite to represent all major patch types recognised.

Four teams each took responsibility for sampling the quadrats at four campsites (Figs. 19, 20). Each team had a core group of four specialist biologists - one plant ecologist, one mammalogist, one ornithologist and one herpetologist. The two teams operating in Western Australia were larger, involving a varying number of additional honorary personnel. Field sampling was carried out in Western Australia from 27 March-16 April and 19 September-9 October 1984 and in South Australia from 2-20 April and 13-30 September 1984. Four days and four nights were spent sampling at each site. The location and a summary description (including photography) of all quadrats are shown in Appendix I.

Sampling Procedure

Physical descriptors and vegetation were described within the area of the quadrat. Separate descriptions were recorded for each patch-type present if the quadrat was considered patchy. Standard photographic monitoring points (NPWS 1982) were established at each quadrat and the location of every drift fence accurately surveyed and permanently marked by the Australian Survey Office (Appendix I). Photopoints were taken from a fixed, labelled, station next to one pit-fence on each quadrat. Each quadrat was sampled for plants and, for four days and nights, for vertebrates (mammals, birds, reptiles and frogs) (Figs. 19, 20). All quadrat observations were recorded on standard data sheets designed for direct transcription into the computerised survey data base. A bulk soil sample was taken from the primary patch type for chemical analysis. This soil sample was not intended for analyses aimed at explaining the biological differences between sites on similar surface-types; it was aimed at providing a quantitative basis for distinguishing between the major categories present: for example, consolidated coastal sands versus alluvia. Results of the soil analysis are given in Appendix IX.

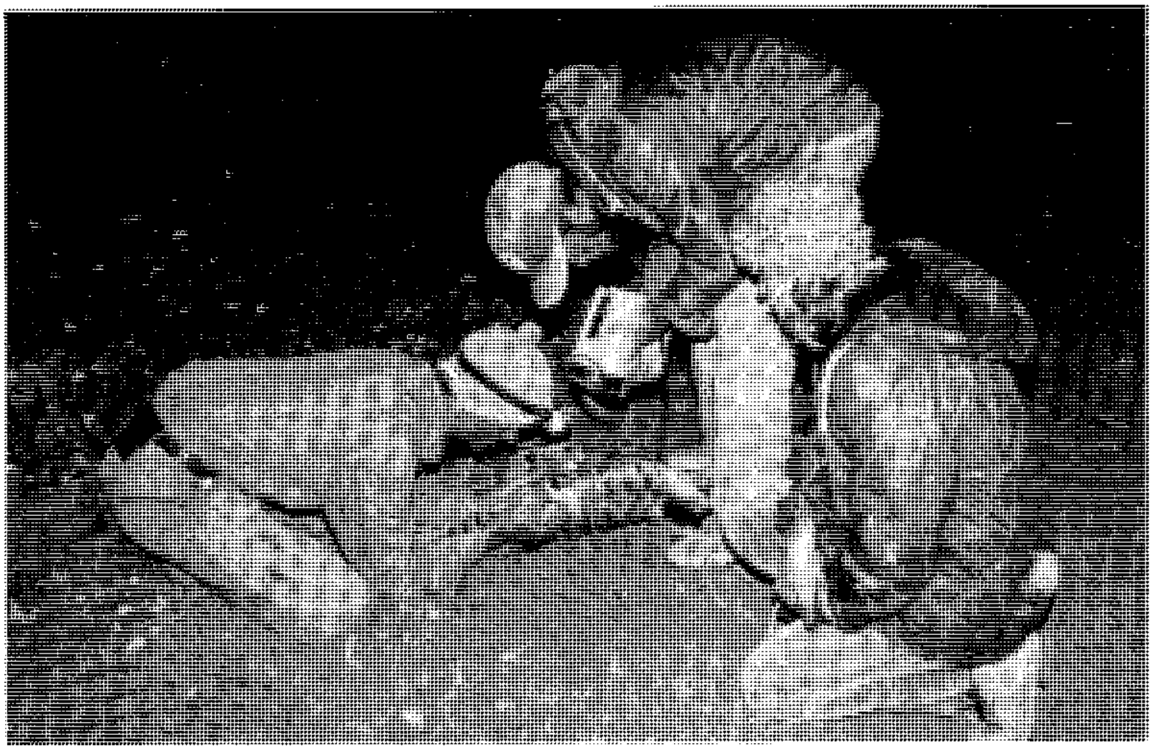
At each quadrat, reptiles and small ground mammals were sampled using two to three fenced pit-lines, each 50 metres long and comprising a line of six pitfall traps, 125 mm in diameter and 600 mm deep (Fig. 20). In patchy quadrats these pit-lines were positioned in representative parts of the most extensive patch-type - the 'primary patch-type', which the quadrat was chosen to sample. Within a quadrat, pit-lines were at least 200 m apart to minimise their possible interaction. At the eight South Australian campsites a separate line of 15 Elliott Traps was run in association with each of the pit-lines. Traplines were checked each morning. Reptiles and mammals were also sampled by searching within each quadrat daily. Searches were also made at night. Each quadrat was sampled for birds before 1000 hours each day, although bird sampling at quadrats continued throughout the day. It was not expected that all parts of a quadrat were searched daily.

Drilling holes to establish pitfall traplines at the Catacombs site. Photo K. Higginbottom.

Preparation time at the Kuthala campsite. Photo W.A. Newspapers.

Figure 19
FIELD SURVEY METHODS

A small trapline in the immensity of the treeless plain at the Hughes site. Photo A. Robinson.



Dissecting a feral cat to examine its stomach contents, sometimes cats and fox stomachs revealed reptiles which were not collected by other methods. Mostly however they contained rabbits or house mice. Photo A. Robinson.

Figure 20
FIELD SURVEY METHODS

In quadrats considered patchy, vertebrate sampling was concentrated on the patch-type for which the quadrat was selected and individual vertebrate observations were relegated to the particular patch type in which they were encountered.

Plants and vertebrates (especially birds and bats) encountered outside quadrats were recorded on special 'opportunistic' data sheets. When combined with data from secondary patch-types from patchy quadrats, these opportunistic records were collected to allow:

1. A more thorough inventory of the biota near each camp, taking in habitats not represented by quadrats and allowing some assessment of species' habitat utilisation of a greater array of habitats around each campsite.

2. Some assessment of variation in biota within habitats beyond that provided by patchy quadrats.

3. Sampling of certain vertebrate groups for which systematic methods were inappropriate e.g. bats. The limited time for sampling prevented any exhaustive inventories of bat communities; bats were mostly collected at sites where they congregated: flyways, caves and drinking sites such as pools and dams. Sites near or within quadrats were favoured.

Collecting Policy

On the April survey only the first specimen of each small mammal and reptile species recorded in the quadrats was preserved as a museum specimen because the quadrats were to be re-sampled later in the year. However, to minimise the risk of the less easily distinguished species being overlooked, all captured specimens were examined by the appropriate specialist (Fig. 19) before being released. Larger series of taxmonomically or biogeographically interesting species were taken as required, particularly during the September survey.

Samples of liver and/or kidney tissue were taken from selected specimens and stored in liquid nitrogen. These samples were subsequently analysed by the Evolutionary Biology Unit of the South Australian Museum. The technique of Allozyme electrophoresis was used to provide an additional set of taxonomic characters to help with species identification. Allozyme electrophoresis involves the use of enzyme loci as taxonomic characters, with the individual character states being electromorphs or enzyme mobility classes. A full discussion of the technique can be found in Richardson et al. 1985. The results of these analyses are given in Appendix VII.

A herbarium specimen of each plant species encountered during quadrat sampling was collected at each campsite. This applied to all species encountered, irrespective of their reproductive condition. During the September survey, plant collecting concentrated on obtaining ephemeral species which had germinated in response to winter rains and on the collection of flowering material of perennial species that were sterile in April.

Opportunistic collecting outside the quadrats was at the discretion of the survey biologists.

All specimens taken were lodged in herbarium/museum collections of the relevant State.

Data Storage

Quadrat data was stored on the South Australian Department of Environment and Planning's Environmental Survey Branch computer. Data entry was done via the Branch's on-line data capture package 'COL' and its successor 'DAM' and then reformatted for input into another package 'NTP' (Numerical Taxonomy Package) the Branch had acquired from CSIRO, Division of Water and Land Resources. This package is designed to display patterns in data usually comprising a matrix of objects (quadrats here) measured for a suite of attributes (Anderberg 1973). The Nullarbor quadrat data was stored as (in effect) a matrix comprising more than 120 columns (including one for the primary patch type of each of the 81 sample quadrats) by up to 500 rows (the biophysical descriptors such as species names and soil attributes); the output from NTP then consisted of:

(i) association measures of similarity/dissimilarity between the biophysical descriptors;

(ii) a set of dendrograms representing the process of clustering; and

(iii) ordinations.

In some groups of reptiles and plants, South Australian and Western Australian biologists adhere to different taxonomic groupings at the species level. Prior to computer storage of data involving such groups, a consistent taxonomy was agreed upon to allow ecological analyses involving comparisons between quadrats from Western Australia and those from South Australia. Where possible this was the taxonomy involving a finer level of species discrimination.

Analysis Pathways

The species presence and absence data from quadrats was analysed using programs from the Numerical Taxonomy Package (Belbin et al. 1984) in the following order and for the following purposes:

DATN - Converts data to NTP format for analysis of quadrats (objects) in terms of species (attributes).
SCAN - To scan the presence/absence data for quadrats with only a single species, and to help locate errors.
MASK - To mask out species occurring in a single quadrat, because these records contribute little to clustering but add considerable "noise" to the numerical taxonomic techniques.
ASO - To calculate a matrix of association measures between quadrats using the Cjekanowski measure (Cjekanowski 1932).
FUST - To create a histogram of association values, providing some notion of the structure of the data and thereby providing a suitable threshold for BIGD (e.g. Fig. 21).
BIGD - Re-estimate the larger associations in the ASO matrix by measuring shortest network pathways for quadrats separated by large gradient distances.
FUST - To inspect the structure resulting from the BIGD matrix (e.g. Fig. 21).
FUSE - An agglomerative hierarchial fusion of objects (quadrats) on associations using the flexible U.P.G.M.A. option.
DEND - Creates a dendogram from FUSE.
GDEF - To summarize groups of quadrats from FUSE.

(a) Association values (Cjekanowski) between quadrats in the ASO matrix.

```
0.175=> 0.217:    3
0.217=> 0.258:    5*
0.258=> 0.299:   16**
0.299=> 0.340:   10*
0.340=> 0.381:   16**
0.381=> 0.423:   25***
0.423=> 0.464:   33*****
0.464=> 0.505:   53*******
0.505=> 0.546:  100**************
0.546=> 0.588:  131******************
0.588=> 0.629:  182*************************
0.629=> 0.670:  262****************************************
0.670=> 0.711:  320*************************************************
0.711=> 0.753:  378**********************************************************
0.753=> 0.794:  429******************************************************************
0.794=> 0.835:  360*******************************************************
0.835=> 0.876:  311***********************************************
0.876=> 0.918:  234************************************
0.918=> 0.959:  187****************************
0.959=> 1.000:  105***************
```

(b) Association values between quadrats in the BIGD matrix (Threshold 0.95).

```
0.175=> 0.249:    7*
0.249=> 0.322:   22**
0.322=> 0.395:   28**
0.395=> 0.468:   56*****
0.468=> 0.541:  128***********
0.541=> 0.615:  263***********************
0.615=> 0.688:  451*****************************************
0.688=> 0.761:  661*************************************************************
0.761=> 0.834:  707******************************************************************
0.834=> 0.907:  494**********************************************
0.907=> 0.980:  216******************
0.980=> 1.054:    0
1.054=> 1.127:    8*
1.127=> 1.200:   15*
1.200=> 1.273:   27**
1.273=> 1.346:   20**
1.346=> 1.420:   22**
1.420=> 1.493:   21**
1.493=> 1.566:    9*
1.566=> 1.639:    5
```

(c) Association values (Two-Step) between species in the ASO matrix.

```
0.000=> 0.019:  121*
0.019=> 0.038:   73*
0.038=> 0.058:  224**
0.058=> 0.077:  689*****
0.077=> 0.096: 1315**********
0.096=> 0.115: 2272*****************
0.115=> 0.135: 3202***********************
0.135=> 0.154: 4391**********************************
0.154=> 0.173: 5785*********************************************
0.173=> 0.192: 7050********************************************************
0.192=> 0.212: 8029****************************************************************
0.212=> 0.231: 8242******************************************************************
0.231=> 0.250: 7591************************************************************
0.250=> 0.269: 6318**************************************************
0.269=> 0.289: 5096****************************************
0.289=> 0.308: 4116********************************
0.308=> 0.327: 2416******************
0.327=> 0.346: 1406**********
0.346=> 0.365:  836******
0.365=> 0.385:  206*
```

(d) Association values between species in the BIGD matrix (Threshold 0.365).

```
0.000=> 0.021:  123*
0.021=> 0.042:   93*
0.042=> 0.064:  392***
0.064=> 0.085:  943******
0.085=> 0.106: 1876***********
0.106=> 0.127: 3001********************
0.127=> 0.148: 4463******************************
0.148=> 0.169: 5905******************************************
0.169=> 0.191: 7582******************************************************
0.191=> 0.212: 8848***************************************************************
0.212=> 0.233: 9125******************************************************************
0.233=> 0.254: 7909********************************************************
0.254=> 0.275: 6737***********************************************
0.275=> 0.296: 5270*************************************
0.296=> 0.318: 3646*************************
0.318=> 0.339: 1917************
0.339=> 0.360: 1121*******
0.360=> 0.381:  223*
0.381=> 0.402:  118*
0.402=> 0.423:   86*
```

Figure 21
HISTOGRAMS OF ASSOCIATION MEASURES USING THE ENTIRE BINARY DATA BASE EXCLUDING: NON-PASSERINE BIRDS, CORVIDS,SNAKES,MONITORS AND QUADRATS HA6,MA6 AND PL6.

GSTA - To estimate the contribution made by species to the classification of quadrat groups defined by GDEF.
GOWC - To apply the Gower correction (Gower 1967) to the association matrix for Principal Co-ordinate Analysis to normalize the association matrix into 'Euclidean' form.
PCA - Principal Co-ordinate Analysis extracts eigenvalues and eigenvectors.
PCR - Rotates the ordination vectors. (VARIMAX option was used).
SCAT - Produces scatter plots of ordination vectors with or without the use of extrinsic attributes.
TPOS - To transpose the data file for analysis of species (objects) in terms of quadrats (attributes).
SCAN
MASK - To mask out quadrats where only a single species was recorded.
ASO - Calculates a matrix of association measures between species using the Two-step similarity measure (Austin and Belbin 1982).
FUST - e.g. (Fig. 21).
BIGD
FUST - e.g. (Fig. 21).
FUSE
DEND
GDEF - Prints groups of species from FUSE.
GSTA
GOWC
PCA
PCR
SCAT
TWAY - Two way re-organisation of the data matrix using row (species) and column (quadrat) output groupings from UPGMA.

Bird, reptile, mammal and plant data from the quadrats were analysed separately because the divergent life-history strategies they represent were expected to cause marked differences in their patterning across the Study Area. In an attempt to encompass this variation, a 'combined' analysis was also undertaken.

A variety of the physical attributes that were expected to influence species patterning within the Study Area were recorded on quadrats during fieldwork. Soil samples were taken for analysis and, from locality and altitude data, a series of BIOCLIM (Nix *et al.* in prep) attributes were calculated. Species richness values for quadrats were also added to this file. By superimposing (as extrinsic attributes) these values on the UPGMA/GDEF groups of the complete attribute set of quadrats, it was possible to search for relationships between each of the biophysical attributes in turn, across the quadrat groupings. At this time we have not analysed the individual bird, reptile, mammal or plant sub-sets in this way.

RESULTS

VEGETATION

G.J. Keighery, A.C. Robinson & B.H. Downing

Introduction

The Nullarbor Plain, in its extreme aridity and calcium rich soils has long been recognised as the major barrier between the temperate floras of south-eastern and south-western Australia (Burbidge 1960). Other Nullarbor studies (see Previous Studies, this publication) have been largely opportunistic for individual species or other taxonomic studies, or collections made during transit to other destinations. This has resulted in a considerable number of herbarium collections, but no complete study of the Eucla Basin has ever been undertaken. Beard (1975) described the distribution of physiognomic types of the western portion of the Eucla Basin, and this can also be applied to the eastern third.

The Eucla Basin consists of a central treeless plain, comprising widespread arid adapted calcifuge species, with little endemism. Surrounding this flat plateau are a series of landform units which contain increasing numbers of species from surrounding districts (the south-east temperate region, the Great Victoria Desert and the south-west interzone) due to the build up of aeolian deposits over the limestone. On the southern margin of the Nullarbor the climate is greatly ameliorated by maritime influences, and the flora is considerably more mesic in character and origin. This is markedly shown by the western portion of the Roe Plain where the siliceous Pleistocene dune flora of this area is placed in the South-Western Botanical Interzone by Beard (1975).

These factors should produce strong biogeographical patterning across the study area despite a general lack of topographic relief, weak climatic gradients, and uniform geology. Within the Nullarbor Plain itself, however, low species richness and patchy distributions can be expected to produce only gradational changes between sites.

Eighty-three quadrats were sampled for plants (Figs. 23, 24) on the Nullarbor study area during 1984 (Fig. 1). Opportunistic collecting was also undertaken, where possible, and these records added to Table 2. Notes on one quadrat (PL6, placed in the Great Victoria Desert; and used for mammal, bird and reptile sampling), not used in the subsequent analysis are given in Appendix VIII.

Voucher collections of all plant species sampled were pressed, and deposited in PERTH or ADELAIDE.

The quadrats were positioned across the study area to provide samples of (i) landform units and (ii) vegetational types (see Introduction, this publication). These quadrats should also enable a study of the effect of adjacent phytogeographic districts and climatic gradients.

A knowledge of the patterning of plants across the study area should enable an objective appraisal of conservation priorities for the flora of this region.

Results

(a) Background

Previous botanical exploration of the region is outlined in Previous Studies (this publication). To document previous data we reviewed the collections held in PERTH, ADELAIDE and UWA (University of Western Australia). These data are presented in Table 2, and include any opportunistic plant records gathered during the 1984 survey. A summary of the list by family, and containing the known flora of five adjacent regions is given in Tables 3 and 4. The results of the March/September surveys (species vs. quadrats) are summarized in Appendix II. Other data recorded on the plant data sheets are stored on computer file.

Previous and opportunistic records clearly show the low species richness found on the Nullarbor Plain (Fig. 22, Table 2). The totals of 167 and 117 species known for the western and eastern sections of the Nullarbor Plain, are markedly lower than any adjacent region (Widgiemooltha-Zanthus region 545 species; South-West Interzone over 1,100 species; Great Victoria Desert 406 species; Gardner-Torrens Region 700, and Eyre Peninsula 1,541 species).

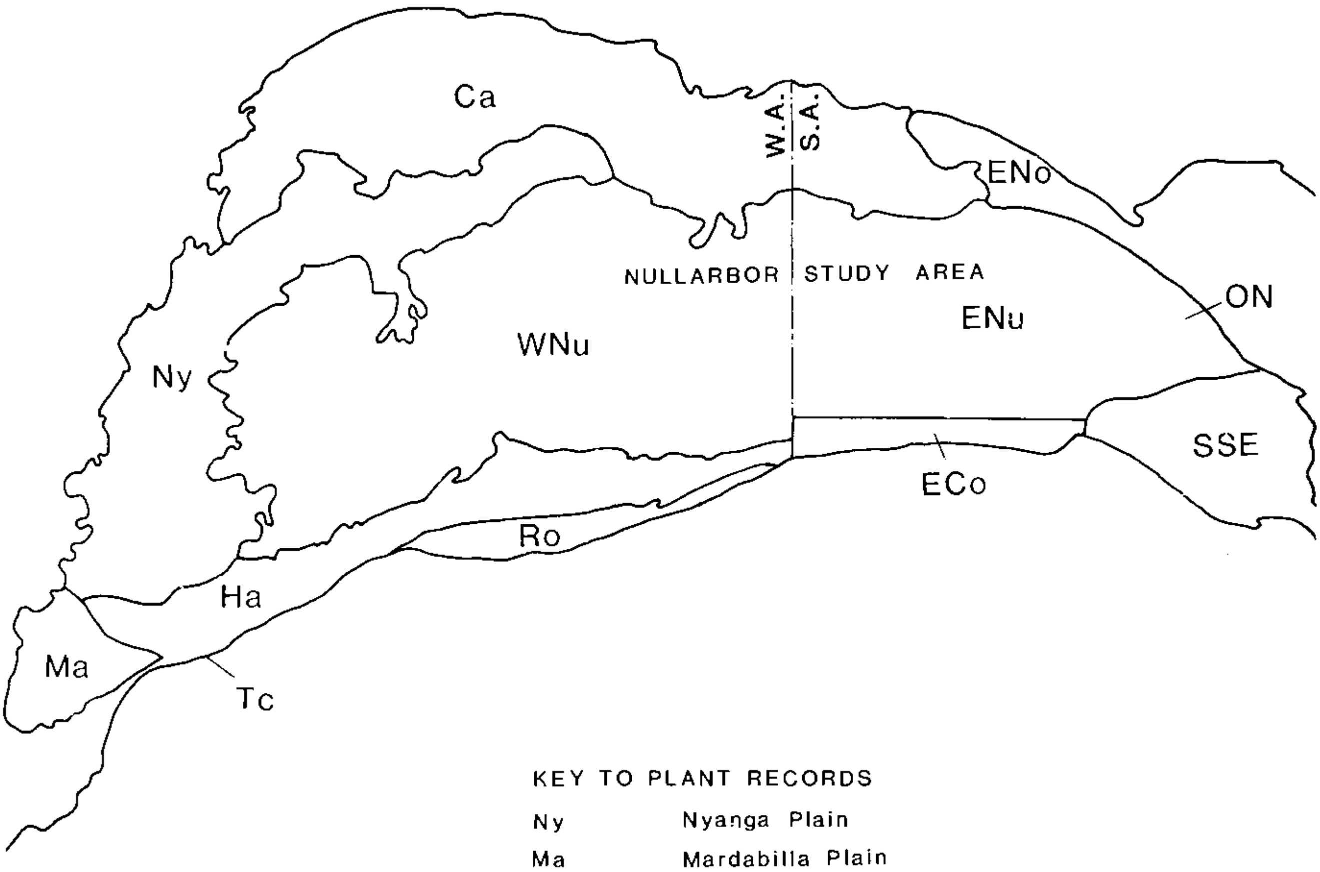
Several regions of the Eucla Basin are considerably undercollected especially the Carlisle Plain (94 species known) and the Mardabilla Plain (103 species). Considering that PL4 (with 61 species) had the highest species' richness of any quadrat in the study area, it is probable that our studies have made a major impact on the knowledge of this region. The Mardabilla Plain, which was not studied in our survey, needs both its flora and conservation needs further documented, as the adjacent Widgiemooltha-Zanthus region has 545 species recorded from it.

The arid environment and uniform soil types have limited the development of many of the characteristic Australian plant groups on the Nullarbor Plain, where the characteristic families are the Poaceae (over 90% of monocotyledons are members of this family); Chenopodiaceae (14% of dicotyledons); Brassicaceae (7%) and Asteraceae (22%). These families comprise over half of the known flora, yet they are often only minor components of temperate and semi-arid Australia. Only species able to cope with loamy calcareous soils and extreme aridity occur (this means the Liliaceae, Restionaceae, Orchidaceae, Proteaceae, Myrtaceae, Epacridaceae and many other families are confined to the sandy surfaces surrounding the Eucla Basin (Table 2) and only marginally penetrate the region where these surfaces occur). This lack of penetration can be demonstrated using the Roe Plain flora which shares 37% of its flora with the South-Western Interzone, 33% occurs also on the southern margin of the Eucla Basin of South Australia, only 18% is shared with the Nullarbor Plain and 12% with the northern margins of the Eucla Basin.

Similarly an analysis of the flora of the eastern third of the Nullarbor Plain (Table 3) shows that the flora is composed of a widespread desertic element found in most regions (NW/GT/EP and NW/EP). This is probably the component forming the typical Nullarbor Plain flora, and adding to this are the peripheral regions. The northern and eastern deserts (NW, GT, NW/GT) share 17.1% of dicots and 27.4% of monocotyledons (this difference being the grasses - see Table 3). The third strong element is the southern mesic component (EP, GT/EP) which gives 36.9% of dicotyledons and 38.7% of monocotyledons of the Nullarbor Flora.

PREVIOUSLY RECORDED FLORA OF EUCLA BASIN

(with abbreviations used in Table 2)



KEY TO PLANT RECORDS

Ny	Nyanga Plain
Ma	Mardabilla Plain
Ha	Hampton Tableland
Ro	Roe Plain
WNu	Western Nullarbor Plain
Ca	Carlisle Plain
ECo	Eastern Coastal
ENu	Eastern Central Nullarbor
ENo	Eastern Northern Fringe
SSe	South Eastern Margin
On	Ooldea to Maralinga
Tc	Toolina Cove

Figure 22
DISTRIBUTION OF KNOWN PLANT RECORDS BY DISTRICT

TABLE 2: PREVIOUSLY RECORDED FLORA OF THE EUCLA BASIN

Key: Nyanga Plain : Ny
Mardabilla Plain; North of Russell Range : Ma
Hampton Tableland : Ha
Roe Plain : Ro
Western Nullarbor Plain : WNu
Carlisle Plain : Ca
Eastern Coastal : ECo
Eastern Central Nullarbor : ENu
Eastern Northern Fringe : ENo
South Eastern Margin : SSE
Ooldea to Maralinga : ON
Toolinna Cove : TC (sandpatch on Hampton Escarpment; see Nelson (1974)

Jessop (1984) indicates recorded for Nullarbor in South Australian Checklist, but no specimen in herbarium at time of survey.

Compiled from Herbarium records
South Australia : K. Higginbottom, AD
Western Australia : G.J. Keighery and J.J. Alford (PERTH, UWA).
Additional plant collection from Roe Plain by S.D. Hopper
Base data held at Western Australian Wildlife Research Centre

TAXON	Ny	Ma	Ha	Ro	WNu	Ca	ECo	ENu	ENo	SSE	ON
PTERIDOPHYTA											
Cheilanthes lasiophylla Pichi-Serm							x				
Marsilea mutica Mett.	x										
Ophioglossum lusitanicum L. ssp coriaceum (A. Cunn.) R.T. Clausen			x								
Pleurosorus rutifolius (R. Br.) Fee.	x	x	x								
GYMNOSPERMS											
Callitris preissii Miq. in Lehm. ssp. verrucosa (A. Cunn. ex Endl.) C.A. Gardn.			TC	x					x	x	
MONOCOTYLEDONS											
ZANNICHELLIACEAE											
Amphibolus antarctica (Labill.) Sond. et Aschers et Aschers				x			x				
ZOSTERACEAE											
Heterozostera tasmanica (Martens ex Aschers) Den Hartog							x			x	
POSIDONIACEAE											
Posidonia sp.				x			x			x	
JUNCAGINACEAE											
Triglochin calcitrapa Hook.	x	x					x				
T. centrocarpa Hook.	x	x							x	x	x

POACEAE

Amphipogon caricinus F. Muell.									x	x	x
Amphipogon strictus R. Br.	x										
Aristida contorta F. Muell.	x				x				x		
*Avena fatua L.				x					x		
Bromus arenarius Labill.			x	x	x				x		
*B. rubens L.										x	
*B. unioloides Kunth.					x						
Danthonia caespitosa Gaud.	x		x	x	x		x	x	x	x	x
D. racemosa R. Br.									x		
D. setacea R. Br.			x				x		x		
Dactyloctenium radulans (R. Br.) Beauv.						x					
Enneapogon avenaceus (Lindl.) C.E. Hubb.									x		
E. caerulescens (Gaud.) N.T. Burbidge								x	x		
E. cylindricus N.T. Burbidge					x						
Eragrostis dielsii Pilger ex Diels et Pritzel	x				x			x	x	x	
E. eriopoda Benth.						x					
E. falcata (Gaud.) Gaud ex Steud.					x	x			x		x
E. laniflora Benth.									x	x	x
E. lanipes C.E. Hubb.									x	x	x
E. setifolia Nees.	x				x			x			
Eriachne helmsii									x	x	
*Hordeum glaucum Steud.	x		x				x			x	
*H. leporinum Link.			x		x						
*H. hystrix Roth.									x		
Iseilema membranaceum (Lindl.) Domin.									x		
*Lolium perenne L.					x						
*Lophochloa pumila (Desf.) Bor.			x	x	x		x	x		x	
Neurachne munroi (F. Muell.) F. Muell.											x
Panicum decompositum R.Br.			Jessop (1984), no record available								
Paractaenum novae-hollandiae P. Beauv.			Jessop (1984), no record available								
*Parapholis incurva (L.) C.E. Hubb.							x				
Paspalidium basicladum Hughes								x			x
P. clementii (Domin.) C.E. Hubb.											x
P. constrictum (Domin.) C.E. Hubb.										x	x
P. gracile (R.Br.) Hughes			Jessop (1984), no record available								
Poa drummondiana Nees			x								
P. fax Willis et Court			x	x							
*Polypogon monspeliensis (L.) Des.					x						
*Schismus barbatus (L.) Thell.	x				x			x			x
Spinifex hirsutus Labill.				x							
Stipa acrociliata Reader	x		x	x			x			x	
S. drummondii Steud.	x		x				x				
S. elegantissima Labill.	x		x				x	x		x	
S. eremophila Reader var eremophila	x		x		x			x			
S. eremophila var fusca (Hubb.) Vickery			x		x						
S. juncifolia Hughes		x									
S. nitida Summerh. et Hubb.					x			x	x		x
S. platychaeta Hughes					x			x	x		
S. puberula Steud.	x		x		x						
S. plumigera Hughes											x
S. scabra Lindl.	x		x								
S. setacea R. Br.								x			
S. variabilis Hughes			x		x				x		
Themeda triandra Forsk.			Jessop (1984), no record available								
Thyridolepis mitchelliana (Nees.) S.T. Blake								x			
Tragus australianus S.T. Blake			Jessop (1984), no record available								
Triodia irritans R.Br.									x	x	
T. lanata J.M. Black										x	
T. scariosa N.T. Burbidge	x		x	x		x			x		x
Triraphis mollis R.Br.										x	

CYPERACEAE											
Gahnia langigera (R.Br.) Benth.			x	x							
Lepidosperma longitudinale Labill.				x							
L. viscidulum R.Br.				x							
Mesomelaena stygia (R.Br.) Nees.				x							
Isolepis marginata (Thunb.) Dietr.	x										
I. nodosa (Rottb.) R. Br.							x				
Schoenus lanatus Labill.			x	x							
S. nitens (R.Br.) Poir			x	x							
S. pleiostemoneus F. Muell.			x	x							
RESTIONACEAE											
Anarthria gracilis R.Br.				x							
Loxocarya flexuosa (R.Br.) Benth.		TC		x							
L. sp. nov.				x							
CENTROLEPIDACEAE											
Centrolepis polygyna (R.Br.) Hieron	x										
JUNCACEAE											
Juncus bufonius L.	x										
LILIACEAE											
*Asphodelus fistulosus L.			x		x						
Caesia lateriflora F. Muell.									x		
Dianella revoluta R.Br.	x		x	x							
Lomandra glauca (R.Br.) Ewart ssp. collina (R.Br.) A. Lee			x	x							
L. hastilis (R.Br.) Ewart		TC		?							
L. leucocephala (R.Br.) Ewart ssp. robusta A. Lee									x	x	x
Stypandra imbricata R.Br.		TC	x								
Thysanotus baueri R.Br.	x		x				x				x
Thysanotus patersonii R.Br.	x	x	x								
Tricoryne elatior R.Br.			x	x							
Wurmbea dioica (R.Br.) F. Muell.							x	x			
W. sinora Macfarlane											
W. tenella (Endl.) Benth.	x		x		?						
ORCHIDACEAE											
Microtis uniflora (Forst.) Reichb.				x							
Prasophyllum macrostachyum R.Br. var ringens (Reichbif) A.S. George			x	x							
P. nigricans R.Br.				x							
Pterostylis aff. mitchellii Lindl.							x				
P. mutica R.Br.			x	x			x	x		x	
P. vittata Lindl.				x							
Thelymitra nuda R.Br.	x		x	x							
DICOTYLEDONS											
CASUARINACEAE											
Allocasuarina helmsii (Ewart) Johnson			x								
A. humilis (Otto et Dietr.) Johnson			TC								
A. huegeliana (Miq. in Lehm.) Johnson	x	x									
Casuarina cristata Miq. ssp pauper (F. Muell. ex Miq.) Johnson	x					x					
URTICACEAE											
*Urtica urens L.							x				
Parietaria debilis G. Forst.		x		x			x		x		x
PROTEACEAE											
Adenanthos cuneata Labill.			TC	x							
A. eyrei Nelson			TC								
A. forrestii F. Muell.		x		x							

Banksia media R.Br.			TC								
Conospermum sp.			TC	x							
Grevillea huegelii S. Moore											x
G. nematophylla F. Muell.					x	x			x		
G. oligantha F. Muell.	x		TC								
G. pterosperma F. Muell.											x
G. sparsiflora F. Muell.			TC	x							
G. stenobotrya F. Muell											x
Hakea corymbosa R.Br.			TC								
H. baxteri R.Br.										x	
H. francisiana F. Muell.											x
H. leucoptera R.Br.							x			x	x
H. nitida R.Br.			TC	x							
Isopogon trilobus R.Br.			TC								
Petrophile teretifolia R.Br.			TC								
Stirlingia sp (tenuifolia)		x									
Synaphaea polymorpha R.Br.			TC	x							
LORANTHACEAE											
Amyema gibberulum (Tate) Danser Danser var gibberulum						x			x		
A. maidenii (Blakely) Barlow									x		
A. melaleucae (Miq.) Tiegh.			x	x			x				
A. miquelii (Lehm. ex Miq.) Tiegh	x	x	x			x	x		x		
A. preissii (Miq.) Tiegh.	x		x	x	x				x		
A. miraculosum (Miq.) Tiegh. ssp. boormanii (Blakely) Barlow			x	x				x			
A. quandang (Lindl.) Tiegh.					x		x	x	x		
Lysiana casuarinae (Miq.) Tiegh.					x	x					
L. exocarpi (Behr.) Tiegh. ssp. exocarpi			x		x	x	x	x	x		
L. murrayi (F. Muell. et Tate) Tiegh.					x	x			x		
SANTALACEAE											
Exocarpus aphyllus R.Br.	x	x	x		x	x	x			x	
E. sparteus R.Br.	x	x	x	x						x	
Leptomeria pachyclada Diels.		x	x	x							
Santalum acuminatum (R.Br.) A.DC.		x	x	x	x	x	x				
S. lanceolatum R.Br.			Jessop (1984), no record available								
S. spicatum (Mitch.) C.A. Gardn.						x	x		x	x	x
VISCACEAE											
Korthasella leucothrix Barlow											x
POLYGONACEAE											
*Emex australis Steinh.	x			x	x						
Muehlenbeckia adpressa (Labill.) Meisn.	x			x							
M. cunninghamii (Meisn.) F. Muell.	x										
*Rumex vesicarius L.					x			x	x	x	
CHENOPODIACEAE											
Atriplex acutibractea R.H. Anderson spp acutibractea	x				x						
A. acutibractea ssp karoniensis Aellen	x		x		x		x	x	x		
A. cinerea Poir				x			x				
A. cordifolia J. Black									x		
A. cryptocarpa Aellen	x		x		x						x
A. eardleyae Aellen	x								x		x
A. holocarpa F. Muell	x		x		x				x		
A. isatidea Moq.				x							
A. limbata Benth.	x										
A. lindleyi Moq. ssp. inflata (F. Muell.) P.G. Wilson	x										
A. morrissii R. Anderson									x		x

Atriplex nummularia Lindl. ssp. spathulata Aellen				x			x				
A. paludosa R. Br. ssp. cordata (Benth.) Aellen				x			x				
A. pumilio R.Br.			x	x			x				
A. spongiosa F. Muell.								x	x	x	x
A. stipitata Benth.				x			x				
A. suberecta I. Verd.	x										
A. vesicaria Heward ex Benth. ssp. appendiculata (Benth.) Parr-Smith	x	x	x	x	x		x	x		x	
A. vesicaria ssp. macrocystidia Parr-Smith							x	x			
A. vesicaria ssp. variabilis Parr-Smith	x						x	x	x	x	x
Chenopodium cristatum (F. Muell.) F. Muell	x				x						x
C. curvispicatum P.G. Wilson	x		x		x	x	x	x	x		
C. desertorum (J. Black) J. Black ssp desertorum						x			x	x	x
C. desertorum ssp. rectum P.G. Wilson						x					
C. gaudichaudianum (Moq.) P.G. Wilson						x			x		
C. melanocarpum (J. Black) J. Black	x								x		x
*C. murale L.	x								x		
Dissocarpus biflorus F. Muell.						x			x		x
D. paradoxus (R.Br.) Ulbr.									x		x
Enchylaena tomentosa R. Br. var tomentosa	x		x	x	x	x	x	x	x	x	x
Eriochiton sclerolaenoides (F. Muell.) F. Muell. ex A.J. Scott						x		x	x	x	x
Halosarcia halocnemoides (Nees.) P.G. Wilson ssp. halocnemoides											x
H. indica (Willd.) P.G. Wilson ssp. bidens (Nees.) P.G. Wilson										x	
H. indica ssp leiostachya (Benth.) P.G. Wilson				x			x				
Halosarcia lylei (Ewart et White) P.G. Wilson									x	x	x
H. pergranulata (J. Black) P.G. Wilson ssp. pergranulata			x	x			x	x			
H. pruinosa (Paulsen) P.G. Wilson							x		x		
H. pterygosperma (J. Black) P.G. Wilson ssp. pterygosperma											
H. syncarpa P.G. Wilson			x	x							
Maireana appressa (J. Black) P.G. Wilson							?			x	x
M. erioclada (Benth.) P.G. Wilson	x		x	x			x			x	
M. georgei (Diels) P.G. Wilson						x			x		
M. integra (P.G. Wilson) P.G. Wilson					x						
M. lobiflora (F. Muell ex Benth.) P.G. Wilson				x	x	x					
M. oppositifolia (F. Muell.) P.G. Wilson	x		x	x	x	x	x	x	x		
M. pentatropis (Tate) P.G. Wilson				x	x	x	x	x	x	x	x
M. radiata (P.G. Wilson) P.G. Wilson			x	x					x	x	x
M. sclerolaenoides (F. Muell.) P.G. Wilson	x		x	x	x	x					
M. sedifolia (F. Muell.) P.G. Wilson	x		x	x	x		x	x	x	x	x
M. tomentosa Moq. ssp. tomentosa	x					x					
M. trichoptera (J. Black) P.G. Wilson			x	x	x	x	x		x	x	x
M. turbinata P.G. Wilson	x		x	x	x		x			x	
M. triptera (Benth.) P.G. Wilson								x			
Rhagodia candolleana Moq. ssp. candolleana							x			x	
R. candolleana ssp argentea P.G. Wilson										x	

Rhagodia crassifolia R.Br.			x	x			x				
R. preissii Moq. ssp. preissii			x	x							
R. spinescens R.Br.					x	x		x	x		x
R. ulicina (Gaud.) P.G. Wilson	x	x									
Salsola kali L.	x		x	x	x		x	x	x	x	x
Sarcocornia blackiana (Ulbr.) A.J. Scott			x	x						x	
Sclerolaena breviflora (Ising) A.J. Scott	x	x			x				x		
S. diacantha (Nees.) Benth.	x		x	x	x			x	x	x	x
S. eriacantha (F. Muell.) Ulbr.											x
S. limbata (J. Black) Ulbr.											x
S. obliquicuspis (R. Anderson) Ulbr.	x		x		x	x			x		x
S. parviflora (R. Anderson) A.J. Scott	x								x	x	x
S. patenticuspis (R. Anderson) Ulbr.	x		x	x	x		x		x	x	
S. uniflora R.Br.	x		x		x		x	x	x		
Sclerostegia arbuscula (R.Br.) P.G. Wilson										x	x
S. disarticulata P.G. Wilson	x		x				x		x		x
S. tenuis (Benth.) P.G. Wilson									x		x
Threlkeldia diffusa R.Br.	x			x			x			x	
AMARANTHACEAE											
*Amaranthus albus L.					x						
Hemichroa diandra R.Br.			x	x				x			
Ptilotus atriplicifolius (A. Cunn. ex Moq.) Benl. var atriplicifolius	x								x		
P. carlsonii F. Muell.	x										
P. drummondii (Moq.) F. Muell. var drummondii	x										
P. exaltatus Nees. in Lehm. var exaltatus	x								x		x
Ptilotus gaudichaudii (Steud.) J. Black var gaudichaudii	x					x			x		x
P. holosericeus (Moq.) F. Muell	x										
P. humilis (Nees.) F. Muell var humilis	x										
P. nobilis (Lindl. ex Mitch.) F. Muell. var nobilis										x	x
P. obovatus (Gaud.) F. Muell. var obovatus	x					x					
P. polystachyus (Gaud.) F. Muell. var polystachyus						x			x	x	x
P. spathulatus (R.Br.) Poir	x										
P. symonii Benl.			x	x							
GYROSTEMONACEAE											
Codonocarpus cotinifolius (Desf.) F. Muell.						x					
Gyrostemon ramulosus Desf.				x							
AIZOACEAE											
Carpobrotus modestus S.T. Blake	x										
C. virescens (Haw.) Schwantes		x		x							
C. rossii (Haw.) Schwantes											x
Disphyma crassifolium (L.) L. Bolus	x	x		x			x		x		
Gunniopsis calcarea Chinnock	x		x	x			x		x		x
G. quadrifida (F. Muell.) Pax.											
G. septifraga (F. Muell.) Chinnock											
*Mesembryanthemum crystallinum L.	x			x							
Sarcozona praecox (F. Muell.) S.T. Blake											
Tetragonia eremaea Ostenf.	x		x		x						
T. implexicoma (Miq.) J.D. Hook.			x	x		x					

PORTULACACEAE											
Calandrinia calyptrata J.D. Hook.	x	x	x								
C. corrigioloides F. Muell.				x							
C. disperma J.M. Black	x								x	x	x
C. eremaea Ewart	x	x	x			x			x	x	x
C. granulifera Benth.				x							
C. polyandra Benth.						x			x	x	x
C. remota J.M. Black									x		
CARYOPHYLLACEAE											
*Spergularia diandra Held. et. Sart.	x		x						x		
LAURACEAE											
Cassytha melantha R.Br.				x					x		
C. micrantha Meisn. in DC.				x							
PAPAVERACEAE											
*Glaucium corniculatum (L.) J.H. Rudolph					x						
*Papaver hybridum L.					?						x
BRASSICACEAE											
Arabidella trisecta (F. Muell.) O.E. Schulz.	x				x	x	x	x	x	x	x
Blennodia canescens R.Br. in Sturt									x		
*Brassica tournefortii Gouan.	x			x	x				x	x	x
*Cakile edentula (Bigelow) Hook.				x			x			x	
*C. maritima Scop.			x	x			x			x	
*Cardaria draba (L.) Desv.										x	
*Carrichterra annua (L.) DC.	x		x		x				x		x
Geococcus pusillus Drumm. ex Harv.										x	
Harmsiodoxa brevipes (F. Muell.) O.E. Schulz var brevipes								x		x	
*Hymenobolus procumbens (L.) Nutt. ex Schinz et Thell.								x			
*Lepidium africanum (N.L. Burm.) DC.			x	x							
Lepidium fasciculatum Thell						x			x		
L. foliosum Desv.										x	
L. oxytrichum Sprague						x			x	x	x
L. pseudohyssopifolium Hewson				x							
L. phlebopetalum (F. Muell.) F. Muell.	x		x		x				x	x	x
L. rotundum (Desv.) DC.	x		x		x		x				
Menkea australis Lehm.											x
Microlepidium pilosulum F. Muell.				x			x			x	
Phlegmatospermum cochlearinum (F. Muell.) O.E. Schulz			x		x		x				
P. richardsii (F. Muell.) E.A. Shaw				x			x				
*Rapistrum rugosum (L.) All					x						
Stenopetalum lineare R.Br. ex DC.	x		x	x	x	x	x	x	x	x	
S. sphaerocarpum F. Muell.										x	x
S. velutinum F. Muell.											x
DROSERACEAE											
Drosera glanduligera Lehm.	x										
D. ramellosa Lehm.	x										
CRASSULACEAE											
Crassula colorata (Nees.) Ostenf. var colorata				x						x	
C. colorata var acuminata (Reader) Toelken				x						x	
C. exserta (Reader) Ostenf.			x	x							
C. natans Thunb. var minus (Ecklon et Zeyher) G. Rowley	x	x									
C. sieberiana (Schultes et Schultes.) Druce ssp. tetramera Toelken	x			x				x		x	

PITTOSPORACEAE

Billardiera bicolor (Putterl.) E.M. Bennett var bicolor			x	x							
Pittosporum phillyraeoides DC var microcarpa S. Moore	x		x		x		x	x	x	x	x
Sollya heterophylla			x	x							

MIMOSACEAE

Acacia acanthoclada F. Muell.										x	
A. anceps DC.				x			x				
A. aneura F. Muell. ex Benth.					x	x			x	x	x
A. brachystachya Benth.										x	x
A. burkittii F. Muell. ex Benth.	x					x			x	x	x
A. camptoclada C. Andrews	x										
A. cochlearis (Labill.) H.L. Wendl.				x							
A. colletioides Benth.										x	x
A. cyclops A. Cunn. ex G. Don		x	x				x			x	
A. dempsteri F. Muell.	x										
A. dermatophylla Benth.	x										
A. desertorum Maiden et Blakely						x					
A. dielsii E. Pritzel	x										
A. eremophila W.V. Fitzg.	x					x					
A. erinacea Benth.	x		x								
A. excentrica Maiden et Blakely	x										
A. fragilis Maiden et Blakely						x					
A. gilesiana F. Muell.									x	x	
A. gonophylla Benth.				x							x
A. hakeoides A. Cunn. ex Benth.				x			x				
A. hemiteles Benth.	x										
A. kempeana F. Muell.						x			x	x	x
A. ligulata A. Cunn. ex Benth.	x										
A. maitlandii F. Muell.									x	x	
A. merrallii Maiden et Blakely	x			x			x				
A. murrayana F. Muell. ex Benth.						x					
A. nitidula Benth.				x							
A. nyssophylla F. Muell.						x			x	x	x
A. oswaldii F. Muell.			x		x	x	x	x	x	x	x
A. papyrocarpa Benth.				x	x	x	x	x	x	x	x
A. prainii Maiden						x			x	x	
A. ramulosa W.V. Fitzg.									x	x	x
A. resinostipulea W.V. Fitzg.	x										
A. rigens A. Gunn. ex G. Don						x					
A. saligna (Labill.) H. Wendl.	x										
A. stowardii Maiden					x						
A. sibina Maslin						x					
A. sulcata R.Br. in Ait.	x										
A. tetragonophylla F. Muell.					x	x		x	x	x	x
A. triptycha F. Muell. ex Benth.	x										
A. victoriae Benth in Mitch. ssp victoriae					x						

CAESALPINIACEAE

Cassia artemisioides Gaud. in DC.	x					x			x		x
C. nemophila A. Cunn ex Vogel				x							
C. pleurocarpa F. Muell.	x										
Labichea lanceolata Benth. in Endl.			TC								

FABACEAE

Bossiaea leptacantha E. Pritzel	x		x	x							
B. walkeri F. Muell.	x	x							x	x	x
Clianthus formosus (G. Don) Ford et Vickery	x		x		x	x			x		x
Daviesia benthamii Meisn. in Lehm.									x		
D. preissii Meisn. in Lehm.				x							
D. ulicifolia Andr.									x		
Eutaxia microphylla (R.Br. in Ait.) J.M. Black			TC				x				
Glycine clandestina Willd.	x		x		x			x	x		
Indigofera australis Willd.	x										
I. brevidens Benth. in Mitch.									x		
Isotropis drummondii Meisn. in Lehm.	x		TC								
*Lotus cruentus Court					x				x		

*Medicago polymorpha L. var polymorpha					x				x		
*M. polymorpha var brevispima (Benth.) Heyn.					x						
*M. truncatula Gaertn.											x
Psoralea cinerea Lindl.					x				x		
P. patens Lindl. in Mitch.										x	
Pultenaea elasticha (F. Muell.) Crisp		x	x				x				
P. obcordata (R.Br.) Benth.			x	x							
Sphaerolobium daviesioides Turcz.			TC	x							
Swainsona burkei F. Muell. ex Benth. ssp acuticarinata A. Lee									x	x	
S. campestris J. Black					x				x		x
S. colutoides F. Muell.									x		x
S. flavicarinata J. Black.					x		x			x	
S. microphylla A. Gray ssp. microphylla	x				x	x					
S. oliveri F. Muell.					x				x		x
S. oroboides F. Muell. ex Benth.					x						
S. phacoides Benth. ssp. phacoides										x	
S. stipularis F. Muell.			x						x	x	x
Templetonia egena (F. Muell.) Benth.									x		
T. retusa (Vent) R.Br. in Ait.			x	x							
T. sulcata (Meisn.) Benth.	x	x									
Trigonella suavissima Lindl.	x				x						
GERANIACEAE											
Erodium angustilobum Carolin	x				x						
*E. aureum Carolin	x				x				x		x
*E. cicutarium (L.) Litter ex Ait.	x		x	x	x			x	x	x	x
*E. botrys (Cav.) Bertol											x
E. crinitum Carolin	x				x				x		
E. cygnorum Nees ssp. cygnorum	x				x				x		x
E. cygnorum ssp. glandulosum Carolin					x						
*E. moschatum (L.) L'Herit											x
Pelargonium drummondii Turcz	x										
P. littorale Huegel				x							
OXALIDACEAE											
Oxalis perennans Haw.			x		x						
ZYGOPHYLLACEAE											
Nitraria billardieri	x		x	x			x		x		
*Tribulus terrestis L.									x		
Zygophyllum apiculatum	x								x	x	x
Z. ammophilum F. Muell.			x	x							
Z. aurantiacum (Lindl.) F. Muell.	x					x	x	x	x	x	x
Z. billardieri DC.			x	x			x				
Z. compressum J.M. Black			TC								
Z. eremaeum (Diels) Ostenf.	x			x		x			x	x	x
Z. fruticulosum DC.	x										
Z. glaucum F. Muell.	x	x	x	x			x				
Z. iodocarpum F. Muell.	x		x	x	x						
Z. ovatum Ewart et White	x		x	x	x	x	x	x	x	x	
Z. tesquorum J. Black									?		?
RUTACEAE											
Boronia baeckeacea F. Muell.	x	x	?TC								
B. coerulescens F. Muell. ssp. coerulescens	x								x	x	x
B. crassifolia Bartl.		x	x	x							
B. inornata Turcz	x										
Correa reflexa (Labill.) Vent. var coriacea P.G. Wilson		x	TC	x			x				
Eriostemon linearis A. Cunn. ex Endl.										x	
Geijera linearifolia (DC.) Black	x	x	x	x	x		x		x	x	
Microcybe multiflora Turcz. var multiflora	x		x				x				
M. multiflora var baccharoides Ewart et Tovey	x	x	x								
M. pauciflora Turcz.		x		x							

POLYGALACEAE											
Comesperma volubile Labill.			x	x							
EUPHORBIACEAE											
Adriana hookeri (F. Muell.) Muell. Arg.									x		x
A. quadripartita (Labill.) Gaud				x							
Beyeria lechenaultii (DC.) Baill. var lechenaultii	x		x	x							
B. opaca F. Muell.									x		x
Euphorbia drummondii Boiss.	x		x		x		x	x	x		x
*E. paralias L.			TC	x							
E. tannensis Sprengel ssp. eremophila (A. Cunn.) Hassall									x	x	x
Monotaxis lurida (Muell. Arg.) Benth.				x							
M. luteiflora F. Muell.	x										
Phyllanthus fuernrohrii F. Muell.			Jessop (1984), no record available								
Poranthera microphylla Brogn.										x	
*Ricinus communis L.	x										
STACKHOUSIACEAE											
Stackhousia muricata Lindl.									x		
S. monogyna Labill.										x	
S. scoparia Benth.				x							
SAPINDACEAE											
Dodonaea amblyophylla Diels	x	x	x								
D. bursariifolia F. Muell.	x	x	x				x			x	
D. lobulata F. Muell.	x		x								x
D. microzyga F. Muell. var acrolobata J.G. West	x										
D. microzyga var microzyga									x	x	x
D. stenozyga F. Muell.	x	x	x	x			x		x	x	
D. viscosa Jacq. ssp. angustissima (DC.) J.G. West										x	x
Heterodendrum oleaefolium Desf.	x				x	x			x	x	x
RHAMNACEAE											
Cryptandra amara Smith.										x	
C. glabriflora Benth.				x							
C. leucophracta Schlecht.		x	TC								
C. tomentosa Lindl.				x							
Pomaderris forrestiana F. Muell	x	x	x								
P. myrtilloides Fenzl. in Endl.		x									
Spyridium denticulifera Diels											
S. globulosum (Labill.) Benth			TC	x							
S. oligocephalum (Turcz.) Benth.			x	x							
S. rotundifolium F. Muell.		x	x	x							
S. parvifolium (Hook.) Benth.			Jessop (1984), no record available							?	
Trymalium myrtillus S. Moore	x										
MALVACEAE											
Abutilon cryptopetalum (F. Muell.) F. Muell.						x					
A. leucopetalum (F. Muell.) F. Muell.									x		
A. otocarpum F. Muell.									x		x
A. oxycarpum (F. Muell ex Benth.)	x										
Alyogyne hakeifolia (Giord.) Alef.	x	x	x	x							
A. huegelii (Endl.) Fryxell	x										x
A. pinoniana (Gaud.) Fryxell									x	x	x
Hibiscus krichauffianus F. Muell.										x	x
Lavatera plebeia Sims	x		x		x				x		x
L. glomerata Hook.	x										
Lawrencia glomerata											
L. incana (J. Black) Melville											
L. squamata (Nees) Lander	x	x		x					x		
L. spicata (Hook.) Benth.	x										
*Malva parviflora L.					x			x	x		x
*Malvastrum americanum (L.) Torrey	x		x		x				x	x	

	Radyera farragei (F. Muell.)	x		x	x							
	Sida ammophila F. Muell. ex J. Willis											x
	S. calyxhymenia J. Gay ex DC	x				x	x					
	S. cardiophylla F. Muell.					x			x			
	S. corrugata Lindl. in Mitch.	x		x	x	x	x			x		x
	S. filiformis A. Cunn. in Mitch.			x	x							
	S. intricata F. Muell.	x					x			x		
	STERCULIACEAE											
	Brachychiton gregorii F. Muell	x										
	Commersonia melanopetala F. Muell	x					x					
	Hannafordia bissillii F. Muell	x					x					
	Rulingia craurophylla F. Muell	x										
	R. luteiflora E. Pritzel	x										
	DILLENIACEAE											
	Hibbertia crispula J. Black											x
	H. exasperata (Steud.) Briq.		x	x	x							
	H. nutans Benth.				x							
	CLUSIACEAE											
	Hypericum gramineum G. Forst.	x										
	CACTACEAE											
	*Opuntia sp					x						
	FRANKENIACEAE											
	Frankenia connata Sprague											x
	F. cinerea DC.									x	x	x
	F. cordata J. Black								x			
	F. densa Summerh.	x	x	x	x			x	x			
	F. desertorum Summerh.	x						x	x			
	F. eremophila Summerh.				x			x			x	x
	F. gracilis Summerh.							x			x	
	F. interioris Ostenf.	x										
	F. irregularis Summerh.	x		x	x							
	F. pauciflora DC.	x	x	x	x	x		x	x		x	x
	F. serpyllifolia Lindl.									x		
	F. sessilis Summerh.	x		x	x	x		x	x	x		
	VIOLACEAE											
	Hybanthus floribundus (Lindl.) F. Muell. ssp curvifolius E.M. Bennett	x										
T	THYMELAEACEAE											
	Pimelea angustifolia R.Br.			TC	x							
	P. microcephala R.Br.	x				x	x			x	x	x
	P. serpyllifolia R.Br.		x	x	x							
	P. simplex F. Muell.									x	x	x
	P. thesioides S. Moore	x										
	MYRTACEAE											
	Astartea heteranthera C.A. Gardn.			x	x							
	Baeckea crispiflora F. Muell.		?									
	Beaufortia empetrifolia (Reichb.) Schau.				x							
	Calytrix tetragona Labill.			x	x							
	C. longiflora (F. Muell.) Benth.									x		
	Calothamnus gracilis R.Br. in Ait.			TC								
	Darwinia vestita (Endl.) Benth.				x							
	Eucalyptus anceps (R.Br. ex Maiden) Blakely	x	x	x	x							
	E. angulosa Schau. in Walp.				x							
E	E. balladoniensis Brooker	?										
	E. calcareana Boomsma				x			x				
	E. calycogona Turcz.	x			x							
	E. cylindriflora Maiden et Blakely	?										

E. concinna Maiden et Blakely						x		x	x	x	
E. conglobata (R.Br. ex Benth.) Maiden			TC								
E. cooperana F. Muell.		x	TC	x							
E. diversifolia Bonpl.			x	x			x				
E. dumosa A. Cunn. ex Schau.		x	x	x							
E. eremophila (Diels) Maiden	x	x									
E. foecunda Schau in Lehm.	x	x		x					x		x
E. gracilis F. Muell.	x	x	x	x			x		x	x	
E. incrassata Labill.	x	x		x							
E. oleosa F. Muell. ex Miq.	x	x	x	x	x	x	x		x	x	x
E. melanoxylon Maiden	x	x		x							
E. longicornis (F. Muell.) F. Muell. ex Maiden	x		x								
E. peeneri (Blakely) L.D. Pryor										x	
E. pimpiniana Maiden									x	x	
E. pileata Blakely				x							
E. rugosa R.Br. ex Blakely		x		x			x				
E. salmonophloia F. Muell.	x										
E. salubris F. Muell.	x										
E. sheathiana Maiden	x										
E. socialis F. Muell. ex Miq.	x	x	x	x			x		x	x	x
E. striaticalyx W.V. Fitzg.									x		
E. transcontinentalis Maiden	x	x			x	x					
E. uncinata Turcz.				?							
E. yalatensis Boomsma		x	x	x			x			x	x
E. youngiana F. Muell.									x		x
E. yumbarrana Boomsma										x	
Leptospermum coriaceum (F. Muell. ex Miq.) Cheel.									x	x	x
*L. laevigatum (Gaertn.) F. Muell.				x							
Melaleuca adnata Turcz.	x									x	
M. coccinea A.S. George	x										
M. eleuterostachya F. Muell.	x										
M. elliptica Labill.	x		TC								
M. lanceolata Otto	x	x	x	x			x		x	x	
M. pauperiflora F. Muell.			x	x			x				
M. pentagona Labill.			TC								
M. preissiana Schau. in Lehm.			TC	x							
M. quadrifaria F. Muell.	x		x	x							
M. uncinata R.Br. in Ait	x									x	x
Thryptomene elliottii F. Muell.								x	x	x	x
T. micrantha Hook.									x	x	x
T. urceolaris										x	x
HALORAGACEAE											
Haloragis acutangula F. Muell.							x				
H. odontocarpa F. Muell.									x		
APIACEAE											
*Bupleurum semicompositum L.			x				x				
Daucus glochidiatus (Labill.) Fisch et Mey	x		x	x	x		x	x			
Hydrocotyle callicarpa Bunge	x										
Trachymene cyanopetala (F. Muell.) Benth.	x										
T. pilosa Sm. in Rees.	x			x							
EPACRIDACEAE											
Acrotriche patula R.Br.							x				
A. cordata (Labill.) R.Br.			x								
Conostephium drummondii (Stschegl.) C.A. Gardn.			TC	x							
Leucopogon aff. squarrosus				x							
Lysinema ciliatum R.Br.			x	x							
Styphelia hainesii F. Muell.			x	x							
PRIMULACEAE											
*Anagallis arvensis L.	x		x	x						x	
Samolus repens (Forst.) Pers.			TC				x				
LOGANIACEAE											
Logania nuda F. Muell.									x		x

Logania sp. nov				x							
GENTIANACEAE											
*Centaurium erythraea Rafn.			x								
APOCYNACEAE											
Alyxia buxifolia R.Br.	x					x			x		
ASCLEDIADAEA											
Leichhardtia australis R.Br.											
in Sturt	x				x						
Rhyncharrhena linearis (DC.)											
K.L. Wilson						x			x		x
CONVOLVULACEAE											
Convolvulus erubescens Sims	x										
Evolvulus alsinoides L. var					x	x			x		x
villosicalyx Ooststr.											
Wilsonia backhousei Hook. f.							x		?		
W. humilis R.Br.	x	x					x				x
BORAGINACEAE											
*Buglossoides arvense (L.) Johnston											
*Echium plantagineum L.					x						x
Halgania andromedifolia Behr. et					x			x	x	x	x
F. Muell.											
H. cyanea Lindl.	x		x	x							
H. lavandulacea Endl.	x		x						x	x	x
Heliotropium asperrimum R.Br.	x			x							
Omphalolappula concava (F. Muell.)											
Brand											
Plagiobothrys australasicus (DC.)			x		x		x				x
I.M. Johnston	x										
CHLOANTHACEAE											
Dicrastylis brunnea Munir											
D. beveridgei F. Muell. var						x					
beveridgei											
D. beveridgei var lanata Munir									x		x
D. doranii F. Muell.									x	x	x
D. lewellini (F. Muell.) F. Muell.						x					
D. nicholasii F. Muell.						x					x
LAMIACEAE											
Prostanthera larricoides A. Cunn.	x	x									
P. semiteres B. Conn.	x										
P. serpyllifolia (R.Br.) Briq. ssp.											
microphylla (R.Br.) Conn.		x	x	x							
P. wilkieana F. Muell.											
*Salvia verbenacea L.						x					
Teucrium corymbosum R.Br.					x						
T. grandisculum F. Muell. et Tate									x		
T. racemosum R.Br.	x										x
T. sessiliflora Benth.	x				x						
Westringia rigida R.Br.	x		x								
W. grevillina F. Muell.			x	x				x	x	x	x
										x	
SOLANACEAE											
Anthocercis genistoides Miers.	x	x									
Duboisia hopwoodii (F. Muell.)											
F. Muell.	x										
Grammosden truncatus (Ising) Haegi									x		
Lycium australe R.Br.									x	x	
*L. ferrocissimum Miers.			x		x			x	x	x	x
*Nicotiana glauca R.A. Grah.					x						
N. goodspeedii Wheeler					x			x	x		
N. occidentalis Wheeler ssp.	x		x	x	x		x	x		x	x
obliqua N.T. Burbidge	x										
N. rostulata (S. Moore) Domin.									x		
ssp. ingulba (Black) Horton	x		x		x						

N. rotundifolia Lindl.	x								x		x
N. velutina Wheeler									x	x	x
Solanum coactiliferum					x			x		x	x
S. ellipticum R.Br.	x										
S. hoplopetalum Bilter. et Summerh.	x						x			x	x
S. hystrix R.Br.	x			x	x		x	x	x	x	x
*S. nigrum L.	x								x	x	x
S. orbiculatum Dunal											
S. plicatile (S. Moore, D.E. Symon	x								x	x	x
S. symonii Hj. Eichler		x		x			x				
SCROPHULARIACEAE											
Glossostigma drummondii Benth. in DC.	x	x									
Limnosella australis R.Br.	x	x									
L. curdieana F. Muell.										x	
MARTYNIACEAE											
*Proboscidea louisianica (Miller) Thell.	x										
MYOPORACEAE											
Eremophila adenotricha (F. Muell. ex Benth.) Benth.	x										
E. alternifolia R.Br. ssp. alternifolia	x		x	x		x	x		x	x	x
E. alternifolia ssp. latifolia F. Muell. ex Benth.			x	x	x	x		x		x	
E. arachnoides Chinnock									?		
E. battii F. Muell.	x										
E. calorhabdos Diels	x										
E. clarkei Oldf. et F. Muell.											x
E. decipiens Ostenf.	x		x						x	x	x
E. delisseri F. Muell.									x		x
E. dempsteri F. Muell.	x	x	x		x						
E. elachantha Diels	x										
E. exotrachys Kraenz.									x	x	
E. glabra (R.Br.) Ostenf.	x		x	x	x		x		x	x	x
E. hillii E.A Shaw										x	x
E. latrobei F. Muell. var latrobei					x	x		x	x		x
E. latrobei var glabra L.S. Smith									x		x
E. longifolia (R.Br.) F. Muell.					x				x		
E. maculata (Ker Gawl.) F. Muell.	x				x	x			x		
E. paisleyi F. Muell.	x				?	x			x	x	x
E. parvifolia J.M. Black	x	x								x	x
E. scoparia (R.Br.) F. Muell.	x		x	x		x	x	x	x	x	x
E. serrulata (A. Cunn. ex DC.) Druce						x			x	x	x
E. veronica (S. Moore) C.A. Gardn.	x		x								
E. verrucosa Chinnock ssp. brevistellata Chinnock											x
E. weldii F. Muell.			x	x			x				x
Myoporum acuminatum R.Br.									x	x	
M. insulare R.Br.			x	x			x				
M deserti A. Cunn. ex Benth.			x	x							
M. parvifolium R.Br.							x				
M. platycarpum R.Br.	x		x		x	x	x	x	x	x	x
PLANTAGINACEAE											
Plantago drummondii Dene			x	x	x			x		x	
P. turrifera Briggs, Corolin et Pulley		x									
RUBIACEAE											
Galium migrans Ehren. et McGillivray			x	x							
*G. murale (L.) All.		x						x			
Pomax umbellata (Sol. ex Gaertn.) Miq.									x	x	x
DIPSACACEAE											
*Scabiosa atropurpurea L.			x								

CUCURBITACEAE											
*Cucumis myriocarpus Naudin					x						
CAMPANULACEAE											
Wahlenbergia communis Carolin	x										
W. gracilenta Lothian			x	x						x	
LOBELIACEAE											
Isotoma petraea F. Muell	x										
GOODENIACEAE											
Coopernookia strophiolata (F. Muell.) Carolin	x	x							x	x	x
Dampiera lanceolata A. Cunn.									x	x	x
D. parvifolia R.Br.		x									
Goodenia affinis De.Vr.		x	x								
G. concinna Benth.	x	x									
G. decursiva W.V. Fitzg.		x									
G. havilandii Maiden et Betche var havilandii									x		
G. havilandii var pauperata J. Black									x		
G. occidentalis Carolin									x	x	
G. pinnatifida Schlecht.					x		x	x	x		x
G. robusta (Benth.) Krause								x			
G. vernicosa J. Black									x		
G. varia R.Br.							x				x
Lechenaultia formosa R.Br.		TC	x	x							
L. tubiflora R.Br.		x		x							
Scaevola crassifolia Labill.		x		x							
S. depauperata R.Br.										x	x
S. myrtifolia (De.Vr.) Krause		x	x	x			x				
S. oxyclona F. Muell.	x										
S. spinescens R.Br.	x				x			x			
Velleia arguta R.Br.		x	x						x		x
V. connata F.Muell.	x								x		
V. paradoxa R.Br.											x
STYLIDIACEAE											
Stylidium pilosum Labill.		x									
S. petiolare Sond. in Lehm.	x	x									
ASTERACEAE											
Actinobole uliginosum (A. Gray) Eichler	x								x		
Angianthus conocephalus (Black) Short							x	x			x
A. tomentosus Wendl.	x						x				
*Arctotheca calendula (L.) Levyns	x										
*A. populifolia (Bergius) T. Nordlindh.				x							
Asteridea athrixioides (Sond. et F. Muell.) Kroner	x		x	x			x				
Brachycome angustifolia A. Cunn. ex DC.							x				
B. ciliaris (Labill.) Less.	x		x	x	x		x	x	x	x	x
B. lineariloba (DC.) Druce	x		x				x	x			x
B. tatei J. Black							x	x			x
B. trachycarpa F. Muell.									x		
Calocephalus brownii (Cass.) F. Muell			TC	x			x				
Calotis breviradiata (Ising) GL Davis	x				x	x	x	x		x	
C. cymbacantha F. Muell.										x	x
C. erinacea Steetz								x	x	x	x
C. hispidula F. Muell.	x				x	x	x	x	x	x	x
C. multicaulis (Turcz.) Druce									x		x
*Carthamus lanatus L.					x						
*Centaurea melitensis L.	x			x	x		x				x
C.solstitialis L.			x					x			x
Centipeda minima (L) A. Braun	x										

Cephalipterum drummondii A. Gray					x		x	x	x	x	x
Chrysocoryne pusilla (Benth.) Endl.	x	x									
Chthonocephalus pseudavax Steetz.	x										
Cotula australis (Sieb. ex Sprengel) Hook.	x										x
C. colutoides (Streetz.) Druce	x	x									
Craspedia pleiocephala F. Muell.	x							x	x	x	
Cratystylis conocephala F. Muell.	x	x	x	x			x	x		x	x
Elachanthus pusillus F. Muell.							x	x			
Erodiophyllum elderi F. Muell.	x				x			x	x		
Gnaphalium sphaericum Willd.			x	x							
Gneophsis skirrophora (Sonder et F. Muell. ex Sonder) Benth.	x										
*Hedypnois rhagadioloides (L) F.W. Schmidt.								x			x
Helichrysum ayersii F. Muell.	x				x						x
H. ambiguum Turcz. var paucisetum J. Black	x										
H. apiculatum (Labill.) D. Don						x			x		x
H. bracteatum (Vent) Andrews	x								x		x
H. cassinianum Gaud.									x		x
H. davenportii F. Muell.									x	x	x
H. monochaetum (F. Muell.) Hj. Eichler									x	x	x
H. obtusifolium		x	x						x	x	
H. semipapposum (Labill.) DC.											
H. tepperi F. Muell.	x	x									X
Helipterum adpressum W.V. Fitzg.	x										
H. australe (A. Gray) Druce	x										
H. battii F. Muell.	x										
H. chlorocephalum (Turcz.) Benth.			x				x		x	x	x
H. demissum (A. Gray). Druce	x										
H. fitzgibbonii F. Muell.	x				x	x					
H. floribundum DC.	x		x		x	x					
H. haigii F. Muell.	x		x								
H. humboltianum (Gaud.) DC.			x		x	x	x	x	x		x
H. hyalospermum F. Muell ex Benth.	x										
Helipterum manglesii (Lindl.) F. Muell. ex Benth.		x									
H. maryonii S. Moore					x						
H. moschatum (A. Cunn. ex D.C.) Benth.											
H. pterochaetum (F. Muell.) Benth					x				x	x	x
H. pygmaeum (DC.) Benth.	x								x	x	
H. roseum (Hook.) Benth.	x						x		x		
H. saxatile P.G. Wilson					x						
H. strictum (Lindl.) Benth.	x	x			x				x		
H. stuartianum Sond. et F. Muell.								x			
H. tenellum Turcz.	x				x			x			
H. tietkensii F. Muell.						x		x			
Isoetopsis graminifolia Turcz.	x	x	x		x		x	x	x		x
Ixiochlamys nana (Ewart et White) Grav.		Jessop (1984)				?	?	?	?	?	? / x
Ixiolaena leptolepis (DC.) Benth.	x				x						
Millotia greevesii F. Muell. ssp. greevesii											
M. greevesii ssp. helmsii									x	x	x
M. greevesii ssp. kempei (F. Muell. et Tate) Schodde									x	x	x
M. myosotidifolia (Benth.) Steetz.	x								x	x	x
M. tenuifolia Cass.	x	x	x								
Minuria cunninghamii (DC.) Benth.	x										
M. denticulata (DC.) Benth.					x			x		x	x
M. gardneri N.S. Lander et R. Barry										x	
M. leptophylla DC.			x		x	x	x		x		x
Myriocephalus rhizocephalus (DC.) Benth. var pluriflorus J. Black											
M rudallii (F. Muell.) Benth.											x
M stuartii (F. Muell et Sond. ex Sond.) Benth.											x
									x		x

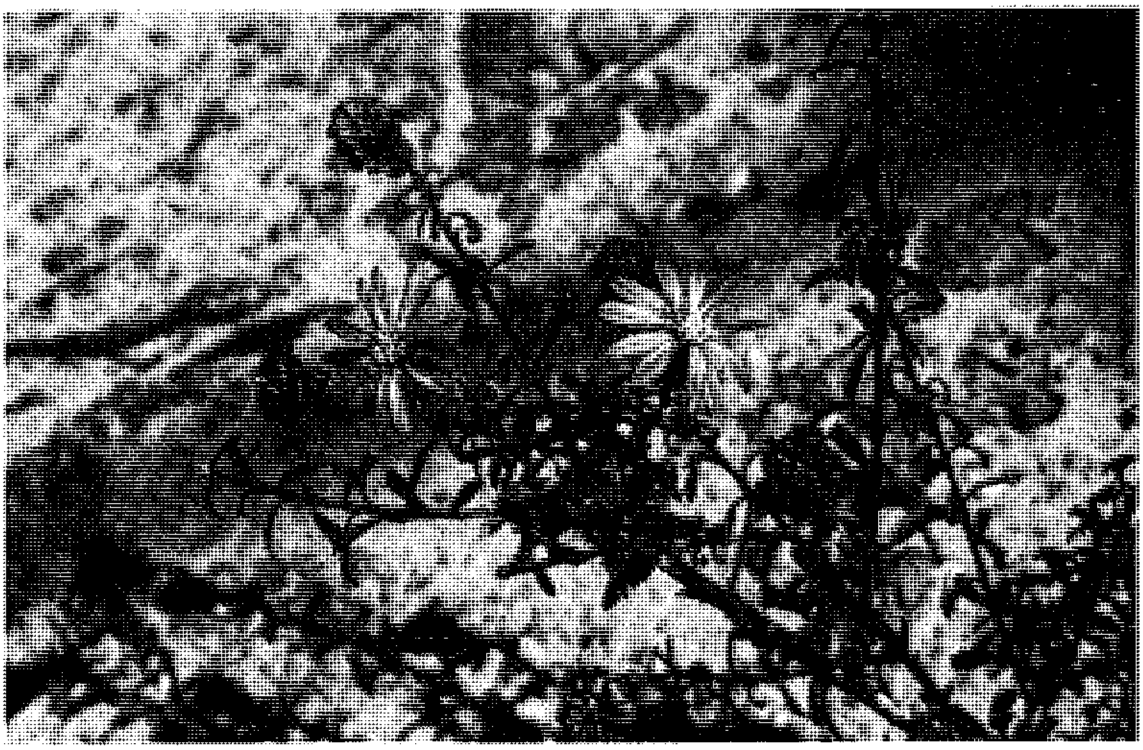
Olearia axillaris (DC.) F. Muell. et Benth.			TC	x							
O. calcarea F. Muell ex Benth.									x		x
O. exiguifolia (F. Muell.) F. Muell. ex Benth.		x	x	x			x	x	x		
O. magniflora (F. Muell.) F. Muell. et Benth.										x	x
O. muelleri (Sond.) Benth.	x	x	x	x			x		x	x	x
O. pimelioides (DC.) Benth.	x								x		
O. ramosissima (DC.) Benth.				x							
O. subspicata (Hook) Benth.	x								x	x	x
*Osteospermum calendulaceum L.					x						
*O. clandestinum (Less.) T. Norlindh.				x						x	
Podolepis canescens A. Cunn. ex DC.					x		x	x	x		x
P. capillaris (Steetz.) Diels	x	x				x					
P. lessonii (Cass.) Benth.	x				x						
P. rugata Labill.	x	x	x	x	x		x	x			
Podotheca angustifolia (Labill.) Less.									x		x
*Pseudognaphalium luteo-album (L) Millard et Bortt	x	x									
Scyphocoronis major (Turcz.) Druce										x	
Senecio glossanthus (Sond.) Belcher			x	x			x	x	x		x
S. gregorii F. Muell.								x	x	x	x
S. lautus Willd. ssp lautus					x		x	x			
S. lautus ssp. maritimus Ali		x		x			x				
S. lautus ssp dissectifolius Ali	x	x	x	x	x		x	x			x
S. magnificus F. Muell.										x	
S. quadridentatus Labill.	x		x								x
*Sonchus asper (L.) Hill ssp glaucescens (Jordan) Ball											
*S. oleraceus L.							x	x			x
*S. tenerrimus L.	x		x		x		x	x	x	x	
Toxanthes perpusillus Turcz.					x						
Vittadinia australasica (Turcz.) N.T. Burbidge											x
V. cervicularis N.T. Burbidge ssp. cervicularis		Jessop (1984)									
V. dissecta (Benth.) N.T. Burbidge var dissecta			x								
V. dissecta var hirta N.T. Burbidge								x		x	
Vittadinia eremaea N.T. Burbidge	x								?		
V. nullarborensis N.T. Burbidge	x				x	x			x	x	x
*Xanthium spinosum L.	x		x	x	x			x			
Waitzia acuminata Steetz.					x						
W. aurea (Benth.) Steetz.	x								x	x	x

Pomaderris myrtilloides an attractive shrub found on the rocks of the Madura escarpment near Cocklebiddy. Photo G. Keighery.

Solanum ellipticum a common plant of the inter-dune areas of the Muckera site. Although there are scattered records from the South West of Western Australia it is near the south western limit of its major range in the Nullarbor study area. Photo A. Robinson.

Figure 23
PLANTS

Gunniopsis calcaraea a succulent plant widespread on the southern treeless plain where it is found in close association with chenopod shrubs. Photo G. Keighery.



Olearia magniflora a purple flowered daisy bush common in the understorey of the eastern mallee woodlands at the Yalata site. Photo A. Robinson.

Figure 24
PLANTS

Thus, the Nullarbor should contain four vegetational elements affecting the study area and producing strong patterning. A widespread desertic element throughout the region, a northern desertic element penetrating on aeolian deposits, and two mesic elements, one from southern Western Australia and one from south-eastern Australia.

Table 2 is also designed to be used as a means to improve the range and coverage of collections from the Eucla Basin. It has been entered onto the computing facilities of both organizations concerned with the survey and can be continually updated.

Surveys based on our relatively small quadrats sampled over few, relatively brief intervals of time can provide meaningful comparisons across the study area but are difficult to compare to the previously known flora because of the extreme stochastic nature of these collections (e.g. 167 species for the western Nullarbor versus 117 for the eastern sector). Comparison of the list presented in Johnson and Baird (1970) of 105 species from the region around Forest suggest we obtained some 70% of this flora. Those missing were largely obtained from large undisturbed dongas during exceptional rainfall years. Many of the records in the known flora are weeds spreading from the railroad line (in fact we added at least six new weeds to the list, and one new record (Caesalpinnia gilesi) for the state of Western Australia largely from opportunistic collecting) and these were not sampled by us. The poorly known nature of the flora of the region, and the large number of range extensions discovered during the survey does not enable any realistic assessment of the coverage of our quadrat based lists to the known flora to be made. However, within our quadrats we obtained over 95% of the perennial plants present and over 75% of the annuals (Keighery pers. comm. based on repeat sampling in 1985).

(b) Endemics

Davis (1952) noted that Calotis breviradiata was confined to the Nullarbor Plain, however subsequent collecting has extended its known range to beyond the margins of the Eucla Basin (Kalgoorlie to Maralinga). There are also two doubtful collections from North Western Australia under this species name in PERTH. The genus is in need of review.

Chinnock (1983) named Gunniopsis calcaraea (Aizoaceae) and noted that it is centred on the southern Eucla Basin, but extends outside to Norseman in Western Australia (Figs 23 & 24). Surprisingly only one species of Chenopodiaceae (Atriplex cryptocarpa) is centred on the Eucla Basin, extending to the northern parts of the Eyre Peninsula (Wilson 1984), although one other species Sclerolaena patenticuspis is noted as having a variant confined to the Eucla Basin, but this is given no formal taxonomic status.

Chippendale and Wolf (1981) show several segregates of Eucalyptus oleosa (E. yalatensis, E. yumbarrana ssp. yumbarrana and E. yumbarrana ssp. striata) that are confined to the margins of the Eucla Basin.

The Roe Plains contain many taxa at the extremes of their ranges, and further study may reveal some evidence of raciation or speciation in this region. Nelson (1978) named Adenanthos eyrei (Proteaceae) from the Toolinna sandpatch, and noted that A. forrestii was confined to the Roe Plains and Toolina sandpatch. Recent collections have found this species on the Mardabilla Plain, and unsorted material at PERTH suggests that this taxon may not be easily distinguishable from A. ileticos.

The Santalum (Santalaceae) populations of the Roe Plains and Hampton escarpment are under review, and are probably an undescribed subspecies of Santalum acuminatum (Keighery and Alford, unpub. obs.).

Several species present in the study area show a complex of forms, some already known to be confined to the region (Santalum, Sclerolaena). Forms confined to the area may be more common than the literature suggests. One (Brassicaceae) example can be given here; Stenopetalum lineare is a widespread annual in arid and semi-arid southern Australia (Hewson 1983). Outside of the Eucla Basin it is a showy annual with large orange-brown flowers, within the study area there are two distinct forms. One restricted to the Hampton escarpment is a slender large flowered perennial, the other found throughout the Eucla Basin is a cleitogamous annual (see Fig. 25). Neither of the two taxonomic studies of the genus Stenopetalum noted any major geographic trends in variation within this species. It is probable that future detailed studies of other widespread annuals present in this region, may also find distinct forms restricted to the study area.

It is likely that resolution of the current confusion in the taxonomy of Stipa (Poaceae) may result in several species being found to be confined to the Eucla Basin; assessment of our collections of Wurmbea (Liliaceae) by Dr. T. Macfarlane indicates that they may prove to be an undescribed species confined to the western part of the Eucla Basin.

In summary the Eucla Basin has low richness and is poor in endemics (5 possibles; Atriplex cryptocarpa, Calotis breviradiata, Adenanthos eyrei, A. forrestii; perhaps Eucalyptus yalatensis). Future studies may reveal variants below the level of species which are confined to the region, especially on the sandplain isolates of the Roe Plain.

(c) Results - Quadrat Data

These data were divided into two groups for purposes of analysis; perennials (excluding all grasses and annuals) and total flora. This was undertaken to ascertain if either provided useful means of discrimination, since perennials are much more ammenable to collection in an arid region, and they are less prone to climatic fluctuations across the study region in the short term.

Species richness of quadrat sites will be considered in the section on total flora.

(i) Perennials

All quadrats contained more than one species of perennial plant, and were included in the subsequent analysis. Sixty-four species were found on only one quadrat and were excluded from the subsequent analysis. Plumridge 6(PL6), a quadrat in the Great Victoria Desert was also excluded (see Appendix VIII). The UPGMA classification of the remaining 82 quadrats, according to the presence or absence of the remaining 132 perennial plant species resulted in the dendrogram presented in Fig. 26.

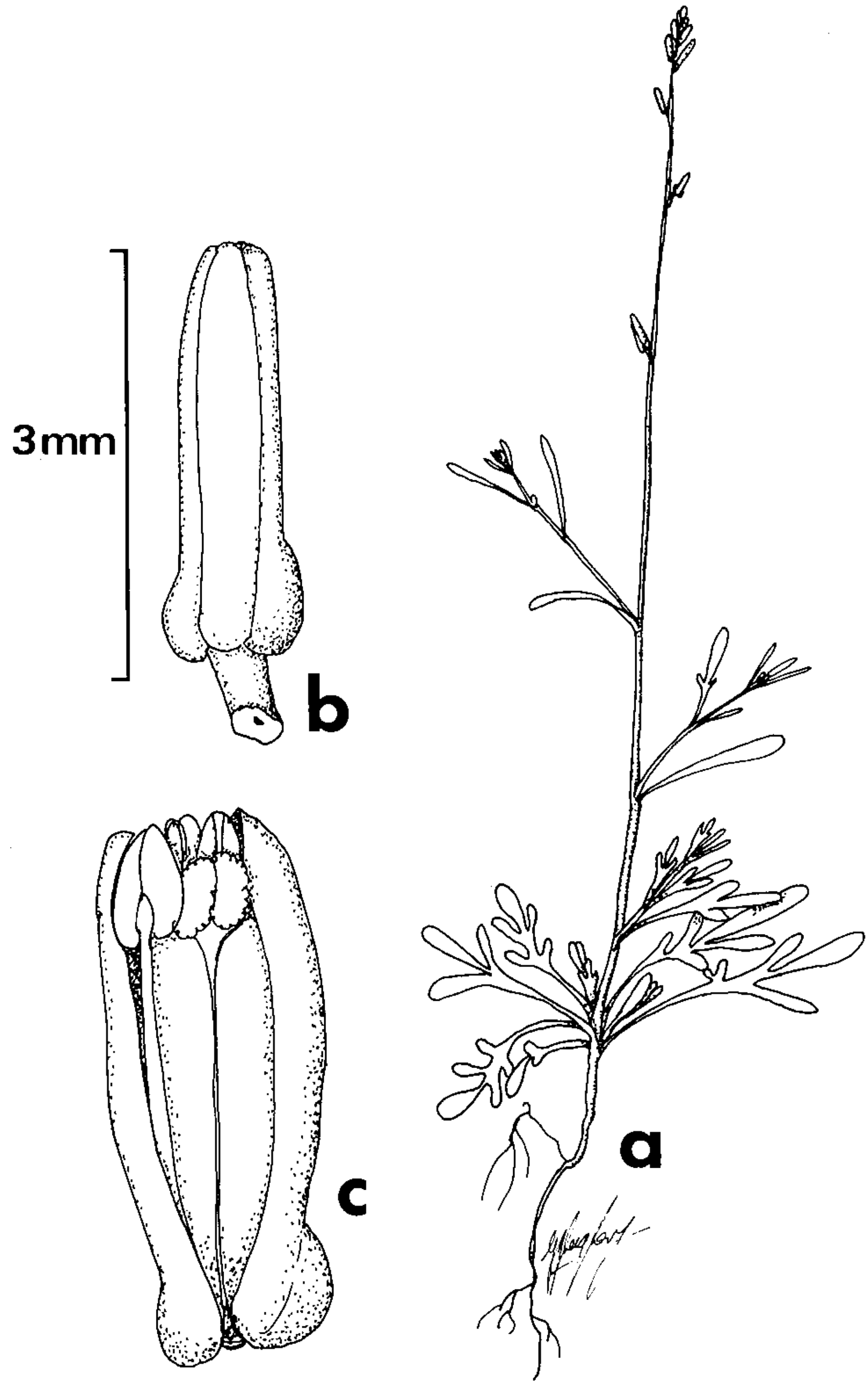


Figure 25
NULLARBOR PLAIN FORM OF *Stenopetalum lineare* R.Br.

The eleven groupings distinguished in the dendrogram, can be characterised ecologically and geographically.

Group 1: (21 quadrats) comprised Eucalypt, Mulga or Casuarina woodlands on the western, north-western and eastern fringes of the Eucla Basin.

Group 2: (12 quadrats) comprised Myall (Acacia papyrocarpa) woodlands and the treeless plain interface with the northern Myall woodlands of the Carlisle Plain.

Group 3: (21 quadrats) comprised treeless plain quadrats, including some southern coastal sites.

Group 4: (9 quadrats) comprised southern low Myall, Melaleuca or Mallee woodlands of western coastal sites on the Hampton tableland.

Group 5: (2 quadrats) comprised unconsolidated dunes of the Roe Plain.

Group 6: (9 quadrats) comprised southern coastal Myall or Mallee woodlands of South Australia.

Group 7: (1 quadrat) comprised a species poor site of treeless coastal plain.

Group 8: (2 quadrats) comprised cliff top coastal sites of South Australia.

Group 9: (1 quadrat) highly disturbed species poor doline of central treeless plain.

Group 10: (2 quadrats) comprised consolidated sub coastal dunes of the Roe Plain.

Group 11: (2 quadrats) comprised near coastal dunes of the Roe Plain.

From the arrangement of quadrats in the above groups two major trends are apparent. The substrate differences of the Roe Plain (highly leached siliceous dunes) cause the most significant levels of dissimilarity (affects Groups 4, 5, 8, 10, 11). The second major trend is a geographical gradient east-west along the coast and north-south through the study area.

The levels of dissimilarity between quadrats (Fig. 26) apart from the Roe Plain sites are gradational. Closely aligned sites are generally more similar to each other, than distant ecologically similar sites, suggesting that distance apart was a major factor in site classification. However, ecologically dissimilar sites within the same area (C01 vs. C02, or C02 vs. C03) have high dissimilarity values much greater than the distance effect.

In Table 5, the quadrat groups recognised in this analysis have been compared with the only published descriptions and maps of Nullarbor land systems (Mitchell et al. 1979) and vegetation variation (Beard 1970). The land classification by Mitchell et al. 1979 is in broad agreement with our classifications at the land zone level but bears little relationship at the level of land system. The vegetation formations recognised by Beard (1970) correspond very closely with our quadrat groups based on the perennial species analysis except in the coastal areas of the Hampton escarpment (Groups 5, 10 and 11) where our level of discrimination was finer than his 1:1 000 000 mapping scale allowed. It is worth reiterating that the basis of the two classifications is quite different. Beard's is based on structural dominance whereas ours gave weights to all species equally irrespective of their relative abundance or contribution to the biomass on our quadrats.

A principal co-ordinate analysis (PCR - see Methods, this publication) was carried out on the perennial plant data to cluster the quadrats in terms of species. This was undertaken as a check on the groups distinguished from UPGMA. The results are presented in Fig. 27, with the UPGMA group boundaries overlaid.

Some discrete clusters are apparent in the scattergrams, these being the Roe Plain sites (Groups 10, 11), and MA5 which is nearly always more closely associated with this grouping than its counterpart (KU5). The substrate difference has a major effect dominating all other groupings or gradients. Nevertheless, the first three axes do discriminate the treeless plain sites (Group 3) and associate the species poor sites (Groups 7 and 9) of the treeless plain closely with this group (Fig. 27a). Secondly the southern coastal sites (Groups 4, 5, 6, 8) are segregated from the woodland sites, but are closely associated with the KO quadrats (Fig. 20a or b). A disturbance gradient may be segregating the FO and HU quadrats of Group 2 from the MU sites which are intermediate between this group and the northern woodland quadrats of PL and JU (Figs. 20a, b). This is not a surprising result as separation of the UPGMA classification to give 15 groups (instead of 11) separates the MU sites as a separate grouping.

Axis I combines a substrate gradient (Roe Plains) and an east-west coastal geographical gradient.

Axis II has a geographical gradient from the southern coastal woodlands to the northern fringe.

Axis III separates the treeless plain species rich quadrats from the species poor quadrats along a gradient from the central portions of the study area to the coastal sites.

To search for groups of perennial plants that consistently co-exist the 132 species recorded on more than one quadrat were classified according to their presence or absence at 82 quadrats. Fifteen groups were distinguished using UPGMA (Fig. 28). These groups can be characterized in terms of the distribution or ecology of their components. In Western Australian areas we have followed species' distribution data from Newbey and Hnatiuk (1984); unpublished records of G.J. Keighery (to be published in Hnatiuk (ed) Census of Australian Plants, A.B.R.S. Canberra); Flora of Central Australia and the list of Vascular Plants of South Australia (Jessup 1984) for South Australia. Northern Territory records (Anon. 1985), New South Wales (Jacobs and Pickard 1983) and Victorian records (Forbes et al. 1984) were obtained from the respective State Checklists. A detailed review of the species composition of adjacent districts was also made (summarized in Tables 3 and 4), and any published distribution map of the relevant species was consulted.

Group 1 consists of 27 species, all very widespread often occurring in all mainland states in arid, semi-arid and temperate regions and extending to tropical regions (examples are Acacia papyrocarpa, Acacia oswaldii, Atriplex nummularia, Lysiana exocarpi, Rhagodia spinescens, Salsola kali, Sclerolaena diacantha). Fewer are confined southern semi-arid and arid Australia (Lycium australe, Maireana erioclada, Maireana sedifolia, Sclerolaena

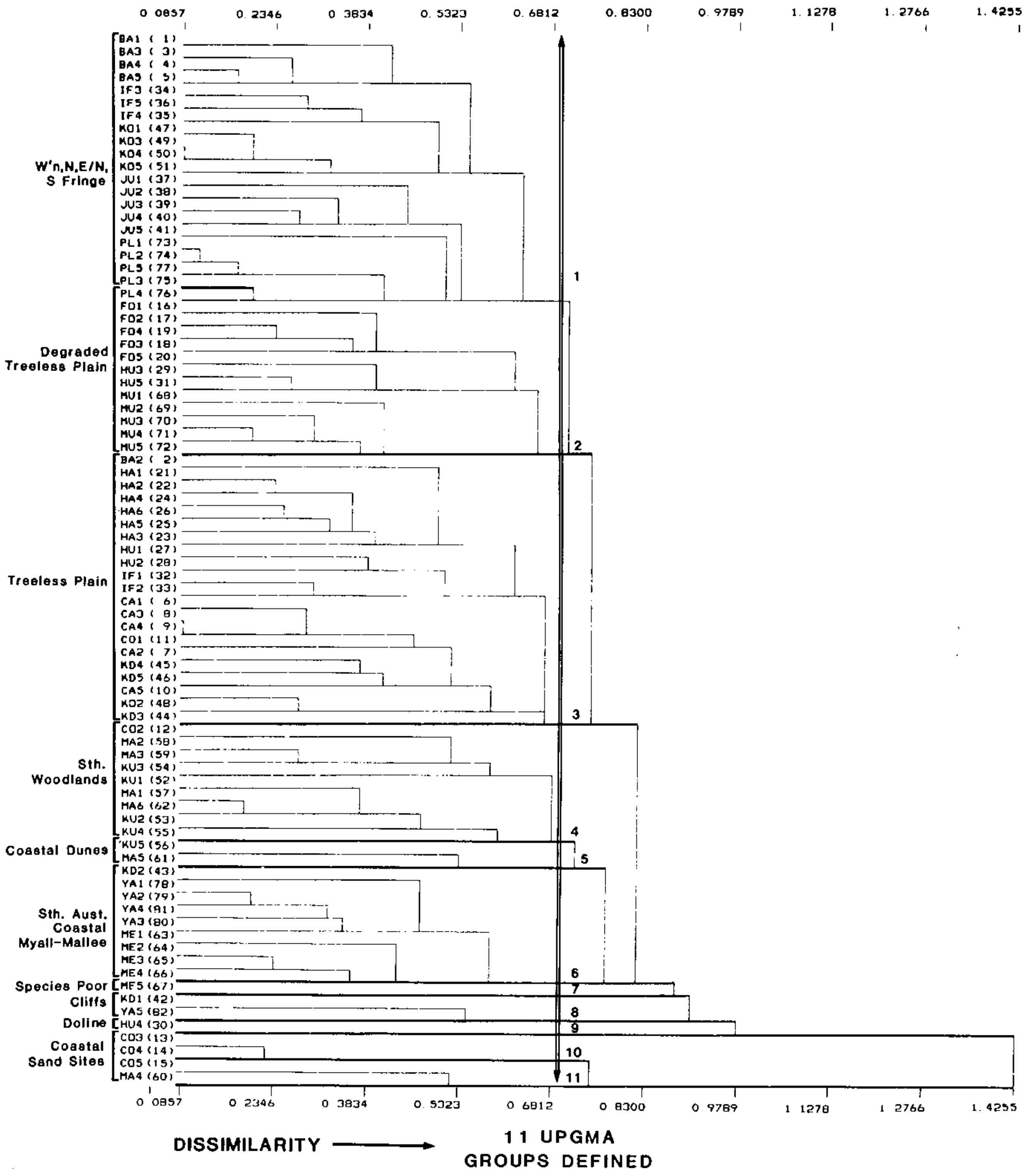
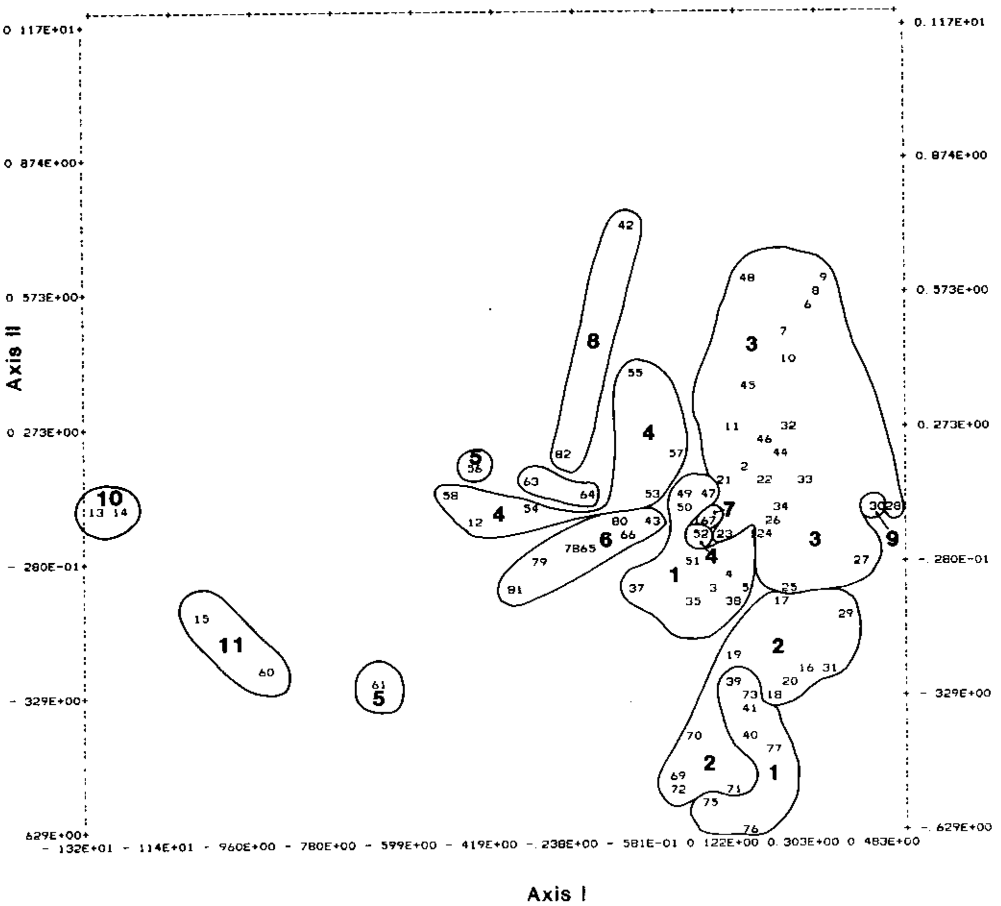
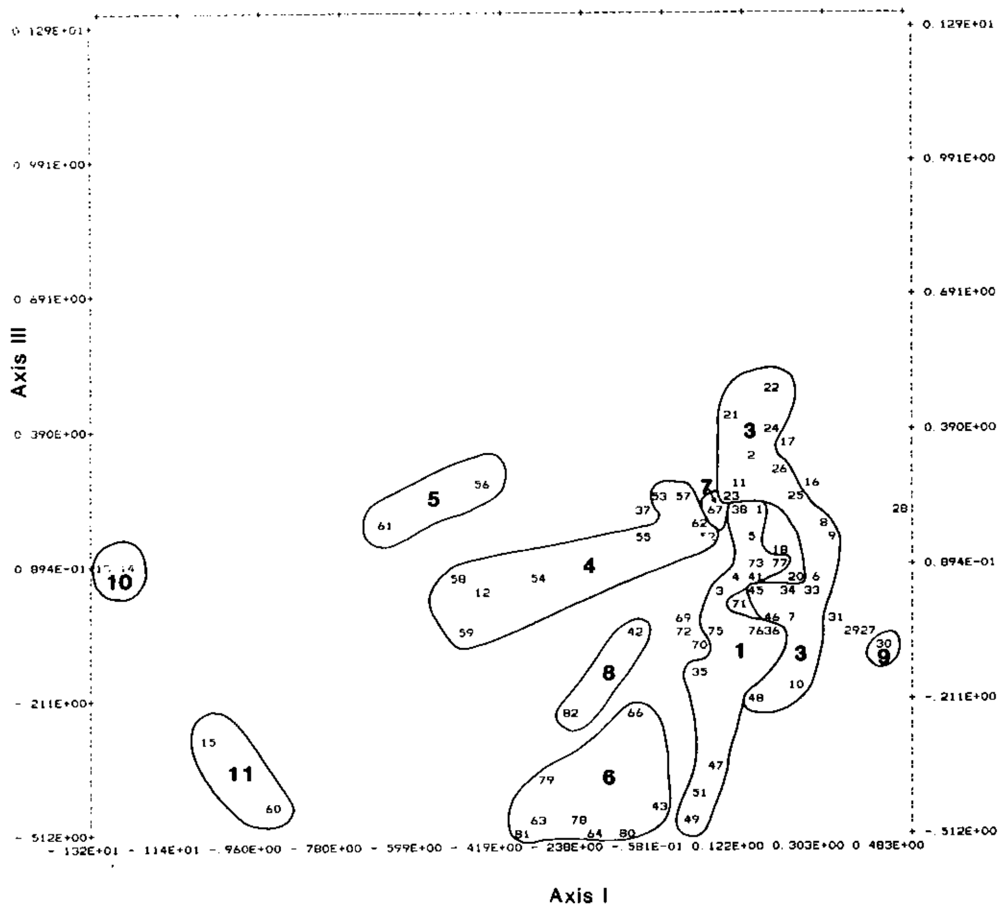


Figure 26
UPGMA QUADRAT CLASSIFICATION ON PERENNIAL PLANT SPECIES (CZEKANOWSKI)



a. Axis I versus Axis II



b. Axis I versus Axis III

Figure 27

SCATTERGRAM FROM ORDINATION OF QUADRATS IN TERMS OF PERENNIAL PLANT SPECIES

UPGMA quadrat group boundaries (bold face numbers) from figure 26 are overlaid

a.

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 82 POINTS
REGRESSIONS : Y = -0.4944E-05 + 0.8848E-02 X
: X = 0.7380E-05 + 0.1304E-01 Y
CORRELATION COEFICIENT (R) = 0.1074E-01

LABEL	SEQ #	X-VALUE	Y-VALUE
BA1	1	0.1525	0.2580E-01
BA2	2	0.1452	0.1804
BA3	3	0.7230E-01	-0.9840E-01
BA4	4	0.1129	-0.5900E-01
BA5	5	0.1463	-0.8510E-01
CA1	6	0.2779	0.5393
CA2	7	0.2301	0.4681
CA3	8	0.3099	0.5691
CA4	9	0.3248	0.5986
CA5	10	0.2401	0.4331
CO1	11	0.1143	0.2789
CO2	12	-0.4522	0.6310E-01
CO3	13	-1.321	0.8920E-01
CO4	14	-1.248	0.9950E-01
CO5	15	-1.063	-0.1506
FO1	16	0.2803	-0.2771
FO2	17	0.2383	-0.1273
FO3	18	0.2036	-0.3388
FO4	19	0.1259	-0.2276
FO5	20	0.2550	-0.3047
HA1	21	0.1128	0.1500
HA2	22	0.1932	0.1485
HA3	23	0.1095	0.2620E-01
HA4	24	0.2025	0.2050E-01
HA5	25	0.2562	-0.8840E-01
HA6	26	0.2158	0.5150E-01
HU1	27	0.4024	-0.2540E-01
HU2	28	0.4830	0.9750E-01
HU3	29	0.3712	-0.1482
HU4	30	0.4386	0.9210E-01
HU5	31	0.3463	-0.2711
IF1	32	0.2535	0.2600
IF2	33	0.2759	0.1544
IF3	34	0.2348	0.7790E-01
IF4	35	0.3290E-01	-0.1195
IF5	36	0.2033	0.6330E-01
JU1	37	-0.8880E-01	-0.7890E-01
JU2	38	0.1218	-0.1271
JU3	39	0.1242	-0.3001
JU4	40	0.1614	-0.4184
JU5	41	0.1670	-0.3503
KD1	42	-0.1137	0.7370
KD2	43	-0.5940E-01	0.7320E-01
KD3	44	0.2342	0.2035
KD4	45	0.1522	0.3629
KD5	46	0.1982	0.2491
KO1	47	0.7450E-01	0.1107
KO2	48	0.1553	0.5953
KO3	49	0.1780E-01	0.1140
KO4	50	0.1970E-01	0.8870E-01
KO5	51	0.3920E-01	-0.1710E-01
KU1	52	0.4600E-01	0.2300E-01
KU2	53	-0.6210E-01	0.1128
KU3	54	-0.3294	0.8810E-01
KU4	55	-0.8940E-01	0.3926
KU5	56	-0.4543	0.1971
MA1	57	0.1800E-02	0.2152
MA2	58	-0.5033	0.1104
MA3	59	-0.4960	0.1163
MA4	60	-0.9268	-0.2824
MA5	61	-0.6735	-0.3072
MA6	62	0.3410E-01	0.1295
ME1	63	-0.3240	0.1486
ME2	64	-0.2079	0.1178
ME3	65	-0.2108	0.1520E-01
ME4	66	-0.1155	0.1980E-01
ME5	67	0.7120E-01	0.4820E-01
MU1	68	0.1410	-0.4082
MU2	69	0.2800E-02	-0.5075
MU3	70	0.4080E-01	-0.4307
MU4	71	0.1213	-0.5332
MU5	72	-0.1030E-01	-0.5519
PL1	73	0.1638	-0.3222
PL2	74	0.1831	-0.3261
PL3	75	0.7390E-01	-0.5598
PL4	76	0.1547	-0.6292
PL5	77	0.2169	-0.4607
YA1	78	-0.2424	-0.4500E-02
YA2	79	-0.3179	-0.2170E-01
YA3	80	-0.1349	0.6200E-01
YA4	81	-0.3730	-0.7970E-01
YA5	82	-0.2603	0.2197

b.

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 82 POINTS
REGRESSIONS : Y = 0.2104E-05 + 0.2127 X
: X = 0.5846E-05 + 0.4018 Y
CORRELATION COEFICIENT (R) = 0.2923

LABEL	SEQ #	X-VALUE	Y-VALUE
BA1	1	0.1525	0.2106
BA2	2	0.1452	0.3228
BA3	3	0.7230E-01	0.2450E-01
BA4	4	0.1129	0.4440E-01
BA5	5	0.1463	0.1597
CA1	6	0.2779	0.5990E-01
CA2	7	0.2301	-0.4270E-01
CA3	8	0.3099	0.1921
CA4	9	0.3248	0.1357
CA5	10	0.2401	-0.1784
CO1	11	0.1143	0.2687
CO2	12	-0.4522	0.2810E-01
CO3	13	-1.321	0.9020E-01
CO4	14	-1.248	0.8520E-01
CO5	15	-1.063	-0.3066
FO1	16	0.2803	0.2804
FO2	17	0.2383	0.3648
FO3	18	0.2036	0.1139
FO4	19	0.1259	0.2582
FO5	20	0.2550	0.6170E-01
HA1	21	0.1128	0.4266
HA2	22	0.1932	0.4872
HA3	23	0.1095	0.2314
HA4	24	0.2025	0.3856
HA5	25	0.2562	0.2477
HA6	26	0.2158	0.3063
HU1	27	0.4024	-0.6790E-01
HU2	28	0.4830	0.2169
HU3	29	0.3712	-0.5030E-01
HU4	30	0.4386	-0.9920E-01
HU5	31	0.3463	-0 1990E-01
IF1	32	0.2535	0.4700E-01
IF2	33	0.2759	0.1730E-01
IF3	34	0.2348	0.2880E-01
IF4	35	0.3290E-01	-0.1488
IF5	36	0.2033	-0.5130E-01
JU1	37	-0.8880E-01	0.2001
JU2	38	0.1218	0.2018
JU3	39	0.1242	0.2091
JU4	40	0.1614	0.2073
JU5	41	0.1670	0.6950E-01
KD1	42	-0.1137	-0.7290E-01
KD2	43	-0.5940E-01	-0.4606
KD3	44	0.2342	0.2470E-01
KD4	45	0.1522	0.2640E-01
KD5	46	0.1982	-0.2040E-01
KO1	47	0.7450E-01	-0.3720
KO2	48	0.1553	-0.2237
KO3	49	0.1780E-01	-0.4677
KO4	50	0.1970E-01	-0.4699
KO5	51	0.3920E-01	-0.4308
KU1	52	0.4600E-01	0.1619
KU2	53	-0.6210E-01	0.2332
KU3	54	-0.3294	0.5230E-01
KU4	55	-0.8940E-01	0.1477
KU5	56	-0.4543	0.2791
MA1	57	0.1800E-02	0.2435
MA2	58	-0.5033	0.6370E-01
MA3	59	-0.4960	-0.4810E-01
MA4	60	-0.9268	-0.4549
MA5	61	-0.6735	0.1905
MA6	62	0.3410E-01	0.1921
ME1	63	-0.3240	-0.4749
ME2	64	-0.2079	-0.4991
ME3	65	-0.2108	-0.5083
ME4	66	-0.1155	-0.2501
ME5	67	0.7120E-01	0.2026
MU1	68	0.1410	0.1435
MU2	69	0.2800E-02	-0.3760E-01
MU3	70	0.4080E-01	-0.9370E-01
MU4	71	0.1213	-0.4300E-02
MU5	72	-0.1030E-01	-0.5720E-01
PL1	73	0.1638	0.7900E-01
PL2	74	0.1831	0.5460E-01
PL3	75	0.7390E-01	-0.7310E-01
PL4	76	0.1547	-0.4970E-01
PL5	77	0.2169	0.9550E-01
YA1	78	-0.2424	-0.4799
YA2	79	-0.3179	-0.3982
YA3	80	-0.1349	-0.5063
YA4	81	-0.3730	-0.5118
YA5	82	-0.2603	-0.2427

Figure 27

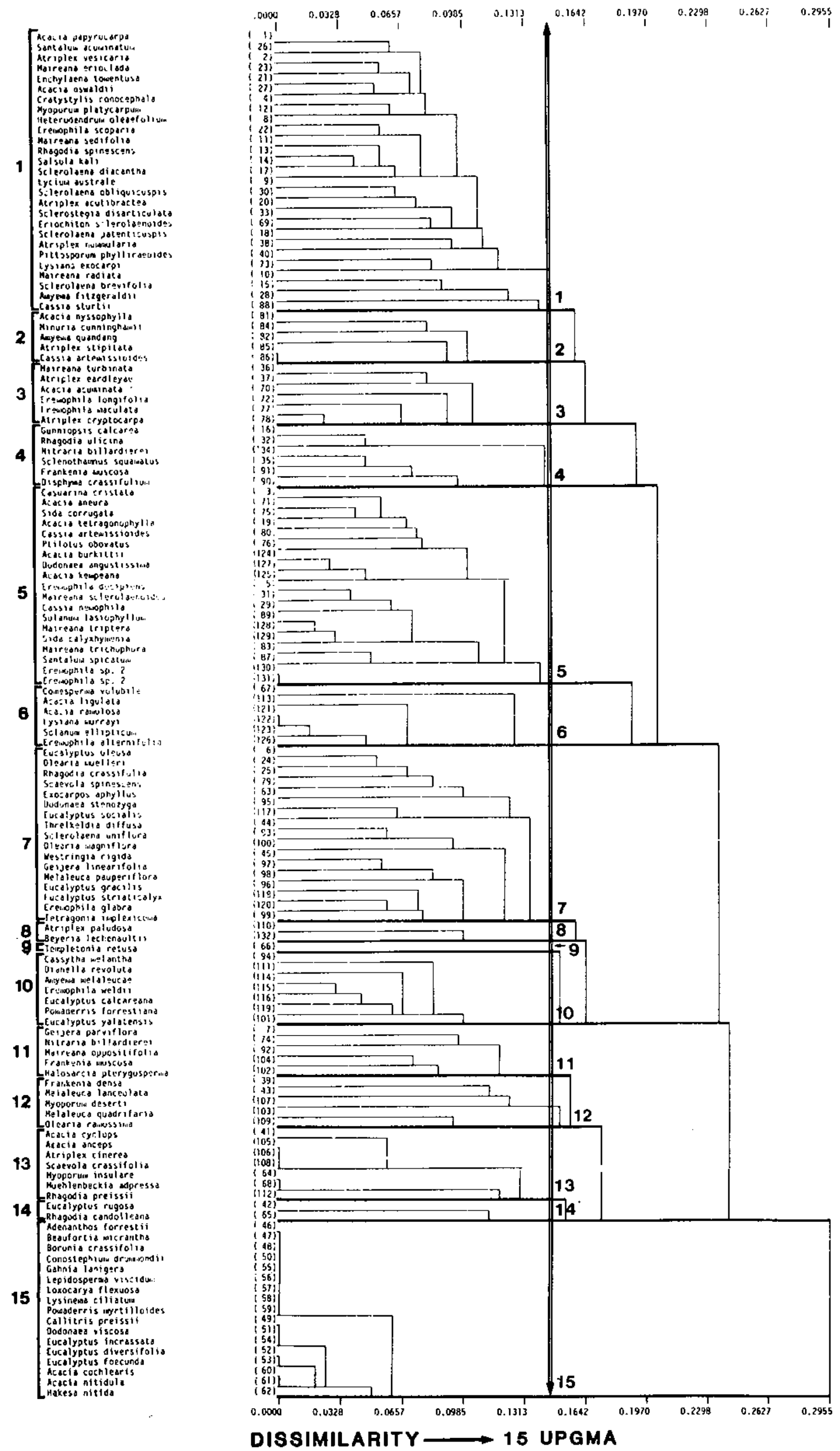


Figure 28

UPGMA OF PERENNIAL PLANT SPECIES CLASSIFICATION IN TERMS OF QUADRAT SIMILARITIES. (TWO-STEP)

brevifolia); and some have distributions between these extremes (Eriochiton sclerolaenoides, Pittosporum phylliraeoides, Santalum acuminatum, Sclerolaena obliquicuspis and Sclerolaena patenticuspis). Only one species Amyema fitzgeraldii is predominantly western in distribution, and none is confined to the survey area.

These species are generally confined to heavy soils and only penetrate the sandy deserts (Great Victoria Desert or Western Sandplains Environmental Region) where these surfaces occur.

Group 2 consists of 5 species, all of which are widespread arid, semi-arid species occurring in temperate areas, however, most are either predominantly eastern in distribution (Acacia nysophylla and Amyema quandang) or only approach the eastern fringes of the study area (Atriplex stipitata).

Group 3 (6 species) are primarily southern temperate eastern Australian in distribution (Atriplex eardleyae and Maireana turbinata). Atriplex cryptocarpa is almost confined to the Eucla Basin.

Group 4 (6 species), are also southern temperate species usually occurring on calcareous loams or rocky limestone (Disphyma crassifolium, Rhagodia ulicina and Selenothamnus squamatus). One Gunniopsis calcarea is confined to the southern Eucla Basin.

Group 5 (19 species) contains widespread arid to semi-arid species occurring on a variety of soil types, but frequently freely draining in nature and often extending into the tropics (Acacia aneura, Acacia tetragonophylla, Acacia kempeana, Acacia burkittii, Maireana trichoptera and Santalum spicatum). These species normally only extend to the coast in areas distant from the study area, hence they are generally widespread in the sandy deserts to the north of the study area.

Group 6 (6 species) contains species essentially similar in distribution and ecology to Group 5 (Acacia ligulata, Acacia ramulosa and Lysiana murrayi), except for Solanum ellipticum which is basically eastern in distribution, and which, like all members of this group, approaches close to the study area only on its eastern margins.

Group 7 (17 species) is a varied group. Eucalyptus oleosa and Eucalyptus gracilis are widespread in temperate, semi-arid and arid southern Australia. Eucalyptus socialis and Eucalyptus striaticalyx extend marginally into the tropics. Rhagodia crassifolia, Threlkeldia diffusa, Tetragonia implexicoma and Sclerolaena uniflora are predominantly coastal throughout their distribution usually on calcareous soils. Exocarpus aphyllus is also predominantly coastal, but extends inland to a considerable degree usually on calcareous soils.

Groups 8 (2 species) and 9 (1 species) are eseentially similar. Atriplex paludosa occurs on coastal regions on stable dunes. Beyeria lechenaultii occurs on sandy soils in temperate Australia, but is restricted to coastal sites in arid areas. Templetonia retusa is predominantly coastal on limestone or dunes in temperate Australia.

Group 10 (7 species) are species able to tolerate calcareous soils usually near coastal in southern Australia (Amyema melaleucae and Dianella revoluta). Several are largely confined to coastal calcareous soils within the study area (Eucalyptus calcareana and Eucalptus yalatensis).

Group 11 (5 species) are heavy soil species primarily of semi-arid temperate Australia, extending chiefly into the study area along the coast (Maireana oppositifolia and Halosarcia pterygosperma). Group 12 (5 species) are essentially similar but occur higher in the landscape in the study area.

Group 13 (7 species) are all temperate species extending from Western Australia to South Australia on coastal or near coastal sites. Most occur only on deep sands (Acacia cyclops, Acacia anceps and Rhagodia crassifolia) or only on deep sands in coastal arid areas (Scaevola crassifolia).

Group 14 (2 species) both coastal (Eucalyptus rugosa and Rhagodia candolleana ssp. candolleana) in southern Australia. A separate subspecies Rhagodia candolleana ssp. argentea occurs on sandy sites near Ifould.

Group 15 (17 species) are sand species of southern Western Australia at their eastern range ends (Adenanthos forrestii, Beaufortia micrantha, Boronia crassifolia, Conostephium drummondii, Hakea nitida, Lysinema ciliatum, Acacia cochlearis and Acacia nitidula) or sand species which occur across southern Australia in disjunct pockets (Eucalyptus angulosa, Eucalyptus diversifolia, Eucalyptus foecunda, Loxocarya flexuosa).

Here there are five major groups (a) Group I: widespread arid taxa able to grow on calcareous loamy soils that are the major components of the central Nullarbor flora. (b) Group 5: species of northern desert affinities. (c) Group 7: woodland-shrubland species. (d) Species restricted to coastal or near coastal environments (Groups 10, 11, 12, 14). (e) Roe Plains deep sand taxa (Groups 8, 9, 13, 15).

A principal co-ordination analysis was carried out on the presence and absence data to classify perennial plant species in terms of quadrats. The results are presented in Fig. 29, with the UPGMA group boundaries superimposed. The 5 major groupings are clearly defined by the three axes. Axis 1 represents a gradient in calcium levels in the soil (with an east-west coastal trend). Axis 2 represents a gradient from the central treeless plain to the surrounding woodlands and shrublands. Axis 3 is a climatic axis from the coast to the northern fringes of the study area.

A Two-Way table was produced as a final stage of the quantitative analysis. This was produced using the UPGMA group boundaries for quadrats (columns) and species (rows).

The species classified in UPGMA Group 1 are widely distributed in arid Australia and occur throughout the study area except on the deep sands of the Roe Plain.

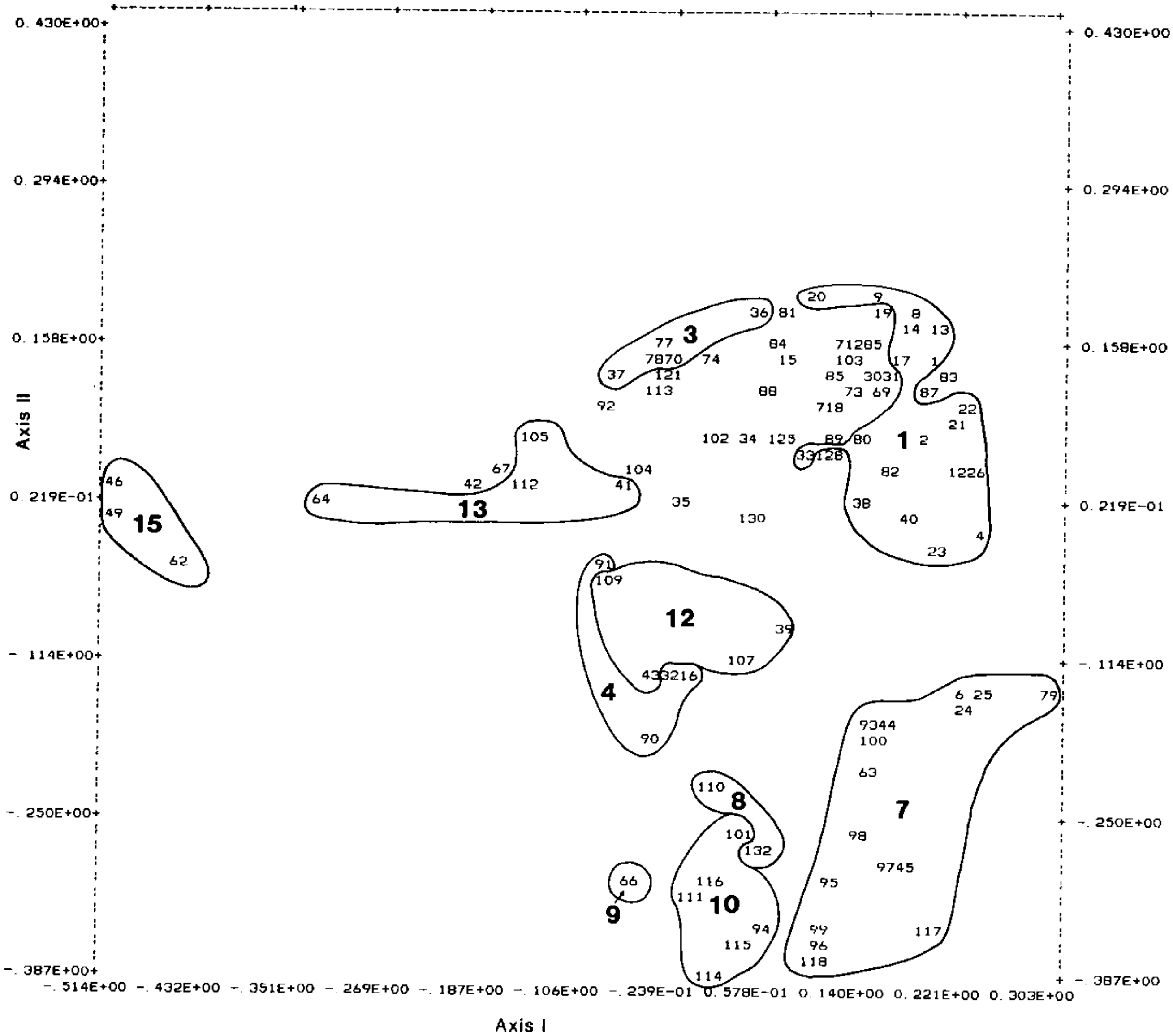
Species Group 2 is similar in distribution but is largely confined to the southern eastern margins of the study area. Group 3 again are widespread calcifuge species, but Eremophila longiflora is largely confined to dongas on the treeless plain.

Group 4 is a southern coastal calcium tolerant group, especially predominant on coastal sites where there are cliffs not sandy beaches.

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 132 POINTS
REGRESSIONS : Y = -0.6027E-05 + -0.2194E-01 X
: X = 0.1262E-05 + -0.4147E-01 Y
CORRELATION COEFICIENT (R) = -0.3016E-01

LABEL	SEQ #	X-VALUE	Y-VALUE
Acacpapy	1	0.2006	0.1439
Atrivesi	2	0.1919	0.7410E-01
Casucris	3	0.1345	0.1382
Cratcono	4	0.2349	-0.6000E-03
Eremdeci	5	0.1517	0.1525
Eucaoleo	6	0.2199	-0.1350
Geijparv	7	0.9940E-01	0.9900E-01
Heteolea	8	0.1843	0.1827
Lyciaust	9	0.1485	0.2011
Mairradi	10	0.1261	0.1456
Mairsedi	11	0.1595	0.1956
Myopplat	12	0.2215	0.5160E-01
Rhagspin	13	0.2061	0.1715
Salskali	14	0.1798	0.1715
Sclebrev	15	0.7730E-01	0.1387
Gunncalc	16	-0.1130E-01	-0.1252
Sclediac	17	0.1691	0.1505
Sclepate	18	0.1128	0.1086
Acactetr	19	0.1544	0.1823
Atriacut	20	0.1022	0.1958
Enchtome	21	0.2210	0.9090E-01
Eremscop	22	0.2262	0.1002
Mairerio	23	0.2034	-0.1450E-01
Oleamuel	24	0.2322	-0.1616
Rhagcras	25	0.2484	-0.1479
Santacum	26	0.2354	0.4750E-01
Acacoswa	27	0.2103	0.5580E-01
Amyefitz	28	0.1412	0.1637
Cassnemo	29	0.1636	0.1446
Scleobli	30	0.1501	0.1336
Mairscle	31	0.1680	0.1245
Rhagulic	32	-0.2660E-01	-0.1332
Scledisa	33	0.8890E-01	0.6510E-01
Nitrbill	34	0.4450E-01	0.7860E-01
Sclesqua	35	-0.1910E-01	0.2550E-01
Mairturb	36	0.4610E-01	0.1856
Atrieard	37	-0.6890E-01	0.1341
Atrinumm	38	0.1416	0.2630E-01
Frandens	39	0.7380E-01	-0.8420E-01
Pittphyl	40	0.1838	0.8900E-02
Acaccycl	41	-0.6420E-01	0.3730E-01
Eucarugo	42	-0.1958	0.2870E-01
Melalanc	43	-0.3860E-01	-0.1334
Thrediff	44	0.1635	-0.1713
Westrigi	45	0.1799	-0.2930
Adenforr	46	-0.5030	0.2960E-01
Beaumicr	47	-0.5030	0.2960E-01
Borocras	48	-0.5030	0.2960E-01
Callprei	49	-0.5140	0.1210E-01
Conodrum	50	-0.5030	0.2960E-01
Dodovisc	51	-0.5140	0.1210E-01
Eucadive	52	-0.4979	0.3600E-02
Eucafoec	53	-0.4979	0.3600E-02
Eucaincr	54	-0.5140	0.1210E-01
Gahnlani	55	-0.5030	0.2960E-01
Lepivisc	56	-0.5030	0.2960E-01
Loxoflex	57	-0.5030	0.2960E-01
Lysicili	58	-0.5030	0.2960E-01
Pomamyrt	59	-0.5030	0.2960E-01
Acaccoch	60	-0.5030	0.3300E-02
Acacniti	61	-0.5030	0.3300E-02
Hakeniti	62	-0.4468	-0.3110E-01
Exocaphy	63	0.1461	-0.2086
Myopinsu	64	-0.3226	0.2010E-01
Rhagcand	65	-0.6690E-01	0.2990E-01
Tempretu	66	-0.5750E-01	-0.3115
Comevolu	67	-0.1704	0.4670E-01
Muehadpr	68	-0.3226	0.2010E-01
Erioscle	69	0.1551	0.1205
Acacacum	70	-0.2120E-01	0.1439
Acacaneu	71	0.1247	0.1572
Eremlong	72	0.4400E-01	0.1843
Lysiexoc	73	0.1339	0.1122
Nitrbill	74	0.5800E-02	0.1380
Sidacorr	75	0.1158	0.1405
Ptilobov	76	0.2224	0.9440E-01
Eremmacu	77	-0.3360E-01	0.1585
Atricryp	78	-0.3900E-01	0.1436
Scaespin	79	0.3029	-0.1470
Cassarte	80	0.1397	0.8160E-01
Acacnyss	81	0.7470E-01	0.1916
Amyequan	82	0.1680	0.4590E-01
Mairtric	83	0.2098	0.1251
Minucunn	84	0.6960E-01	0.1642
Atristip	85	0.1141	0.1356
Cassarte	86	0.1141	0.1356
Santspic	87	0.1999	0.1146
Cassstur	88	0.5690E-01	0.1212
Solalasi	89	0.1138	0.8000E-01
Dispcras	90	-0.3750E-01	-0.1758
Franmusc	91	-0.8030E-01	-0.2850E-01
Mairoppo	92	-0.8030E-01	0.1011
Scleunif	93	0.1486	-0.1630
Cassmela	94	0.5580E-01	-0.3478
Dodosten	95	0.1166	-0.3012
Eucagrac	96	0.1045	-0.3559
Geijline	97	0.1669	-0.2924
Melapaup	98	0.1432	-0.2587
Tetrimpl	99	0.1031	-0.3514
Oleamagn	100	0.1569	-0.1823
Eucayala	101	0.4220E-01	-0.2605
Halopter	102	0.1440E-01	0.8270E-01
Melaquad	103	0.1030E-01	-0.1334
Franmusc	104	-0.5200E-01	0.4580E-01
Acacance	105	-0.1353	0.7460E-01
Atricine	106	-0.1353	0.7460E-01
Myopdese	107	0.4490E-01	-0.1125
Scaecras	108	-0.1353	0.7460E-01
Olearamo	109	-0.7210E-01	-0.4140E-01
Atripalu	110	0.1590E-01	-0.2176
Dianrevo	111	0.2600E-02	-0.3251
Rhagprei	112	-0.1503	0.3870E-01
Acacligu	113	-0.3110E-01	0.1223
Amyemela	114	0.1760E-01	-0.3852
Eremweld	115	0.4000E-01	-0.3598
Eucacalc	116	0.1780E-01	-0.3039
Eucasoci	117	0.2082	-0.3408
Eucastri	118	0.1092	-0.3725
Pomaforr	119	0.2200E-01	-0.3866
Eremglab	120	0.9350E-01	-0.3664
Acacramu	121	-0.2160E-01	0.1276
Lysimurr	122	-0.2160E-01	0.1276
Solaelli	123	-0.2060E-01	0.1261
Acacburk	124	0.1073	0.6920E-01
Acackemp	125	0.7430E-01	0.7240E-01
Eremalte	126	-0.2850E-01	0.1126
Dodoangu	127	0.8000E-01	0.6590E-01
Mairtrip	128	0.1159	0.6860E-01
Sidacaly	129	0.1077	0.6090E-01
Eremsp.	130	0.4820E-01	0.6500E-02
Eremsp.	131	0.4820E-01	0.6500E-02
Beyelech	132	0.5440E-01	-0.2742

Figure 29a



a. Axis I versus Axis II

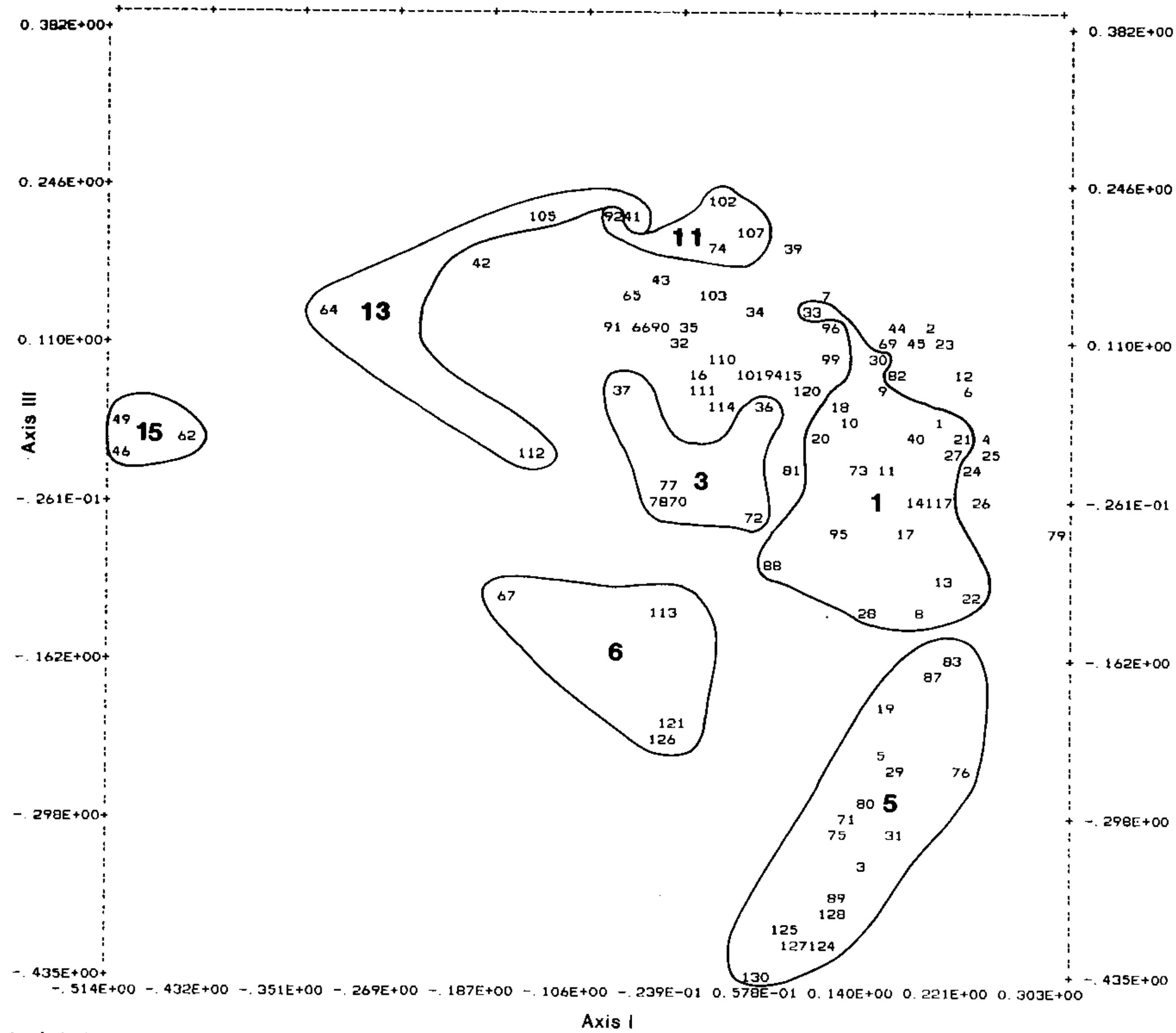
Figure 29a

SCATTERGRAM RESULTING FROM THE ORDINATION OF PERENNIAL PLANT SPECIES IN TERMS OF THEIR FIDELITY FOR THE SAME QUADRATS. UPGMA species group boundaries (bold face) from figure 28 are inserted

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 132 POINTS
REGRESSIONS : Y = -0.5095E-05 + -0.1374
: X = 0.1156E-06 + -0.2635
CORRELATION COEFICIENT (R) = -0.1903

LABEL	SEQ #	X-VALUE	Y-VALUE
Acacpapy	1	0.2006	0.3840E-01
Atrivesi	2	0.1919	0.1201
Casucris	3	0.1345	-0.3353
Cratcono	4	0.2349	0.3130E-01
Eremdeci	5	0.1517	-0.2420
Eucaoleo	6	0.2199	0.6520E-01
Geijparv	7	0.9940E-01	0.1493
Heteolea	8	0.1843	-0.1231
Lyciaust	9	0.1485	0.7170E-01
Mairradi	10	0.1261	0.4050E-01
Mairsedi	11	0.1595	-0.4700E-02
Myopplat	12	0.2215	0.8380E-01
Rhagspin	13	0.2061	-0.8850E-01
Salskali	14	0.1798	-0.2580E-01
Sclebrev	15	0.7730E-01	0.8920E-01
Gunncalc	16	-0.1130E-01	0.7640E-01
Sclediac	17	0.1691	-0.4840E-01
Sclepate	18	0.1128	0.6240E-01
Acactetr	19	0.1544	-0.2076
Atriacut	20	0.1022	0.2740E-01
Enchtome	21	0.2210	0.2860E-01
Eremscop	22	0.2262	-0.1036
Mairerio	23	0.2034	0.1109
Oleamuel	24	0.2322	-0.5000E-02
Rhagcras	25	0.2484	0.1890E-01
Santacum	26	0.2354	-0.2230E-01
Acacoswa	27	0.2103	0.1730E-01
Amyefitz	28	0.1412	-0.1201
Cassnemo	29	0.1636	-0.2610
Scleobli	30	0.1501	0.9870E-01
Mairscle	31	0.1680	-0.3088
Rhagulic	32	-0.2660E-01	0.1038
Scledisa	33	0.8890E-01	0.1375
Nitrbill	34	0.4450E-01	0.1348
Sclesqua	35	-0.1910E-01	0.1242
Mairturb	36	0.4610E-01	0.6000E-01
Atrieard	37	-0.6890E-01	0.6940E-01
Atrinumm	38	0.1416	0.9680E-01
Frandens	39	0.7380E-01	0.1895
Pittphyl	40	0.1838	0.3240E-01
Acaccycl	41	-0.6420E-01	0.2144
Eucarugo	42	-0.1958	0.1845
Melalanc	43	-0.3860E-01	0.1595
Thrediff	44	0.1635	0.1282
Westrigi	45	0.1799	0.1056
Adenforr	46	-0.5030	0.1300E-01
Beaumicr	47	-0.5030	0.1300E-01
Borocras	48	-0.5030	0.1300E-01
Callprei	49	-0.5140	0.4550E-01
Conodrum	50	-0.5030	0.1300E-01
Dodovisc	51	-0.5140	0.4550E-01
Eucadive	52	-0.4979	0.3720E-01
Eucafoec	53	-0.4979	0.3720E-01
Eucaincr	54	-0.5140	0.4550E-01
Gahnlani	55	-0.5030	0.1300E-01
Lepivisc	56	-0.5030	0.1300E-01
Loxoflex	57	-0.5030	0.1300E-01
Lysicili	58	-0.5030	0.1300E-01
Pomamyrt	59	-0.5030	0.1300E-01
Acaccoch	60	-0.5030	0.4600E-01
Acacniti	61	-0.5030	0.4600E-01
Hakeniti	62	-0.4468	0.3170E-01
Exocaphy	63	0.1461	0.9830E-01
Myopinsu	64	-0.3226	0.1361
Rhagcand	65	-0.6690E-01	0.1555
Tempretu	66	-0.5750E-01	0.1203
Comevolu	67	-0.1704	-0.1049
Muehadpr	68	-0.3226	0.1361
Erioscle	69	0.1551	0.1150
Acacacum	70	-0.2120E-01	-0.3100E-01
Acacaneu	71	0.1247	-0.2922
Eremlong	72	0.4400E-01	-0.3660E-01
Lysiexoc	73	0.1339	0.4000E-03
Nitrbill	74	0.5800E-02	0.1889
Sidacorr	75	0.1158	-0.3088
Ptilobov	76	0.2224	-0.2539
Eremmacu	77	-0.3360E-01	-0.1510E-01
Atricryp	78	-0.3900E-01	-0.2660E-01
Scaespin	79	0.3029	-0.5860E-01
Cassarte	80	0.1397	-0.2835
Acacnyss	81	0.7470E-01	0.7300E-02
Amyequan	82	0.1680	0.8230E-01
Mairtric	83	0.2098	-0.1590
Minucunn	84	0.6960E-01	0.8770E-01
Atristip	85	0.1141	0.4460E-01
Cassarte	86	0.1141	0.4460E-01
Santspic	87	0.1999	-0.1748
Cassstur	88	0.5690E-01	-0.7400E-01
Solalasi	89	0.1138	-0.3647
Dispcras	90	-0.3750E-01	0.1290
Franmusc	91	-0.8030E-01	0.1196
Mairoppo	92	-0.8030E-01	0.2141
Scleunif	93	0.1486	0.1123
Cassmela	94	0.5580E-01	0.8960E-01
Dodosten	95	0.1166	-0.5940E-01
Eucagrac	96	0.1045	0.1238
Geijline	97	0.1669	0.1198
Melapaup	98	0.1432	0.9550E-01
Tetrimpl	99	0.1031	0.9210E-01
Oleamagn	100	0.1569	0.6320E-01
Eucayala	101	0.4220E-01	0.8320E-01
Halopter	102	0.1440E-01	0.2260
Melaquad	103	0.1030E-01	0.1522
Franmusc	104	-0.5200E-01	0.2146
Acacance	105	-0.1353	0.2130
Atricine	106	-0.1353	0.2130
Myopdese	107	0.4490E-01	0.2093
Scaecras	108	-0.1353	0.2130
Olearamo	109	-0.7210E-01	0.1229
Atripalu	110	0.1590E-01	0.9630E-01
Dianrevo	111	0.2600E-02	0.6950E-01
Rhagprei	112	-0.1503	0.1750E-01
Acacligu	113	-0.3110E-01	-0.1237
Amyemela	114	0.1760E-01	0.6040E-01
Eremweld	115	0.4000E-01	0.6160E-01
Eucacalc	116	0.1780E-01	0.6680E-01
Eucasoci	117	0.2082	-0.3020E-01
Eucastri	118	0.1092	0.9080E-01
Pomaforr	119	0.2200E-01	0.5210E-01
Eremglab	120	0.9350E-01	0.7020E-01
Acacramu	121	-0.2160E-01	-0.2164
Lysimurr	122	-0.2160E-01	-0.2164
Solaelli	123	-0.2060E-01	-0.2101
Acacburk	124	0.1073	-0.4124
Acackemp	125	0.7430E-01	-0.3919
Eremalte	126	-0.2850E-01	-0.2368
Dodoangu	127	0.8000E-01	-0.4096
Mairtrip	128	0.1159	-0.3787
Sidacaly	129	0.1077	-0.3783
Eremsp.	130	0.4820E-01	-0.4345
Eremsp.	131	0.4820E-01	-0.4345
Beyelech	132	0.5440E-01	0.8130E-01

Figure 29b



b. Axis I versus Axis III

Figure 29b

SCATTERGRAM RESULTING FROM THE ORDINATION OF PERENNIAL PLANT SPECIES IN TERMS OF QUADRAT

UPGMA species group boundaries (bold face) from figure 28 are inserted

Group 5 is a northern component of the sandy or loamy deserts, whereas Group 6 is the subset of this group which is chiefly eastern in its distribution and occurrence in the study area. Part of Group 5 is only located on north-western quadrats, but no obvious western bias can be noted in their total distributions.

Group 7 are southern woodland species, which form a distinct component extending up to the Carlisle Plain in Western Australia and perhaps a southern influence on this area lacking at MU but present at some IF sites.

Groups 10, 11 and 12 are coastal calcium tolerating species usually occurring on heavier soils, and are confined generally to the non-sandy regions of the southern margin of the study area.

Group 13 and 14 are coastal dune or stable dune species only occurring on the Roe Plain where these habitats occur.

Group 15 are mesic species occurring only on the near coastal Roe Plains on consolidated dunes low in calcium levels.

The species of Groups 8-15 are relatively mesic and are confined to the southern margin of the study area, being partitioned by their ability to tolerate alkalinity and heavy soils.

The species of Group 7 are woodland species of southern alliances, whereas the species of Groups 5 and 6 are usually found on freer draining soils to the north, east and west of the study area and are largely confined to its margins.

Groups 1-4 are the widespread components of wide ecological tolerance that form much of the vegetation across the study area. A subset of these groups forms the vegetation of the treeless plain.

(ii) Total Flora
The ephemerals and bunch grasses were then added to the perennial plant data and subjected to the same series of analyses. Because of their high levels of vagility, and distortions in their distributions caused by the unpredictable climate of the study area, it was considered that their influence would be better observed and their level of stochasm reduced if they were run with the perennials rather than alone.

Table 7 documents the species richness of perennials and total flora at all quadrats for the study area. In terms of total flora the degraded treeless plain sites at FO and HU were the poorest (mean = 14 ± 6.7 (SD), n = 10); far below other treeless plain sites (mean = 24 + 8.9 (SD), n = 20). There was considerable variation between treeless plain sites. BA2 on the western margin 38, HA in the central region had a mean species richness of 34, while CO1 had 40 species (10 perennials and 30 non woody species) recorded for the quadrat. Some of these sites were therefore considerably richer than woodland sites (mean = 27 ± 7.4 (SD), n = 36), and suggest that the central plain vegetation assemblages are not as species poor as would first appear.

The richest quadrats were those located on the northern fringes of the study area (PL, JU, MU); these had a mean species richness of 38 ± 11.6 (SO), n = 15. The highest species richness being found at PL3 and 4 (mean of 59 per quadrat).

All quadrats had more than one species recorded from them, and all 82 were used in the analysis. Of the 367 species recorded for the study area, 117 were located on only one quadrat and were not used subsequently in the analysis. These will be considered later under the heading "single records".

Nine groupings were distinguished in the dendrogram resulting from the UPGMA classification of the 250 species according to the presence or absence at the 82 quadrat sites (Fig. 30).

Group 1: (28 quadrats) comprised woodland sites of BA, PL, JU (western margins); the western treeless plain (HA) and sites on the Hampton tableland.

Group 2: (5 quadrats) Muckera sites of the north-eastern margin of the study area.

Group 3: (22 quadrats) comprised the coastal and south-eastern bluebush-Myall shrublands (including those with substantially treeless patches).

Group 4: (10 quadrats) comprised the disturbed treeless plain sites of FO and HU.

Group 5: (8 quadrats) Mallee shrublands of the Hampton Tableland and adjacent regions of South Australia (ME).

Group 6: (2 quadrats) coastal cliff top sites of South Australia.

Group 7: (1 quadrat) ME5, probably too species poor to group.

Group 8: (2 quadrats) Mallee shrublands of the consolidated dunes of the Roe Plain.

Group 9: (4 quadrats) subcoastal or coastal dunes of the Roe Plain.

Compared with the analysis of perennials (Fig. 26) one can note: Group 8/10 (Roe Plain) same.

Group 7 (ME5) still segregated.

The sub-coastal sites (Group 11) and coastal dunes (Group 5) are united into Group 9.

Group 8 equates to Group 6 (cliff top sites).

Group 9 (HU4) is united with the remaining HU sites into Group 4.

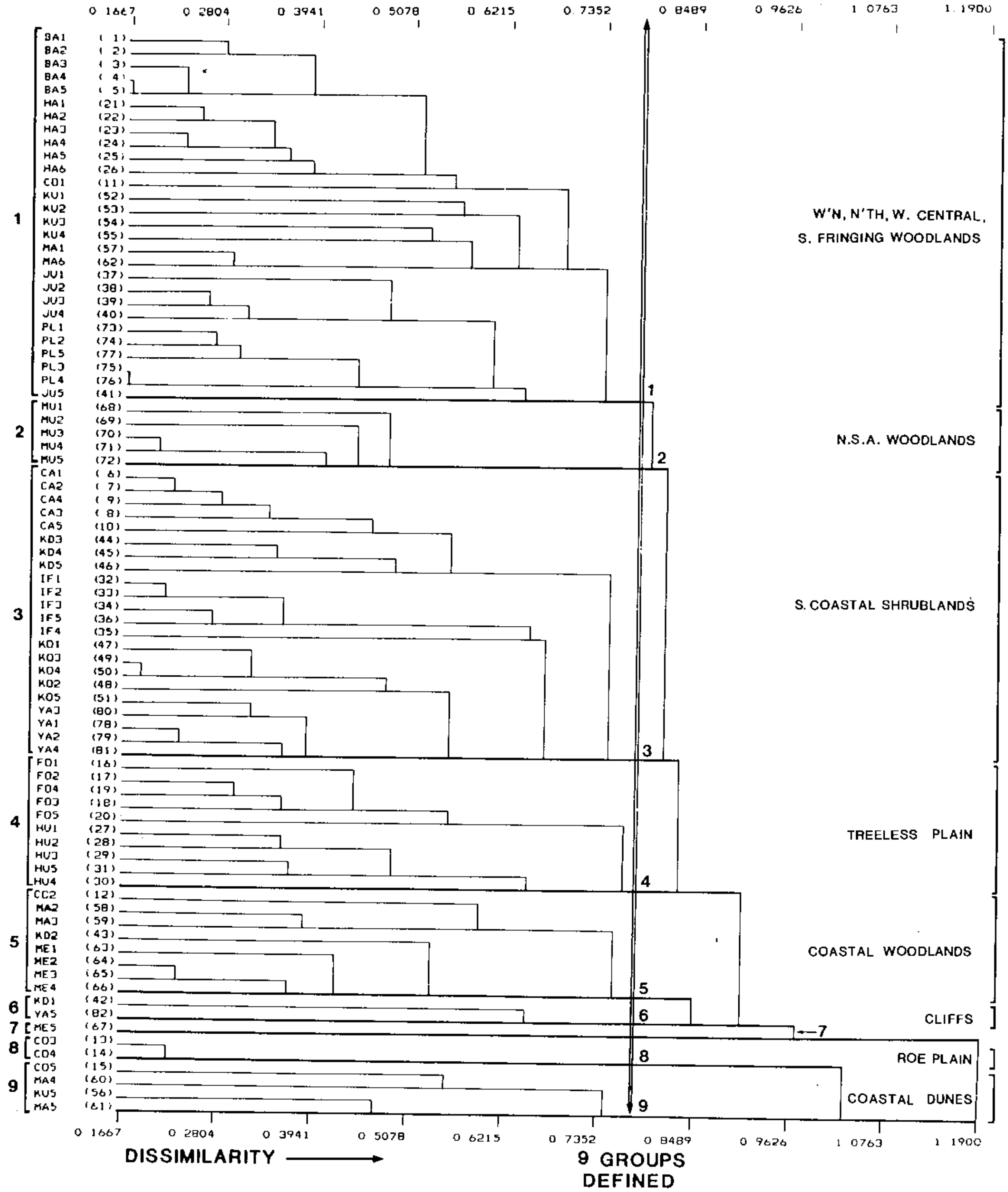


Figure 30

UPGMA QUADRAT CLASSIFICATION FOR TOTAL FLORA (CZEKANOWSKI)

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 82 POINTS
REGRESSIONS : Y = -0.1219E-05 + -0.1715 X
: X = -0.2873E-06 + -0.2362 Y
CORRELATION COEFICIENT (R) = -0.2012

LABEL	SEQ #	X-VALUE	Y-VALUE
BA1	1	0.1481	-0.2787
BA2	2	0.1233	-0.2857
BA3	3	0.1875	-0.1300
BA4	4	0.1968	-0.1380
BA5	5	0.1884	-0.1942
CA1	6	-0.3876	-0.1461
CA2	7	-0.3369	-0.9800E-01
CA3	8	-0.4564	-0.1762
CA4	9	-0.4129	-0.2590
CA5	10	-0.2901	-0.9820E-01
CO1	11	-0.1600E-01	-0.2722
CO2	12	-0.3466	0.1660
CO3	13	-1.249	-0.1332
CO4	14	-1.263	-0.6210E-01
CO5	15	-0.9525	0.4179
FO1	16	0.3028	-0.2575
FO2	17	0.3000	-0.2366
FO3	18	0.3912	-0.8600E-01
FO4	19	0.3378	-0.7780E-01
FO5	20	0.3395	-0.1690
HA1	21	0.4690E-01	-0.3903
HA2	22	0.5520E-01	-0.5052
HA3	23	0.1119	-0.2792
HA4	24	0.1364	-0.4346
HA5	25	0.1978	-0.3508
HA6	26	0.1085	-0.3319
HU1	27	0.2838	-0.1692
HU2	28	0.2485	-0.3979
HU3	29	0.3111	-0.1712
HU4	30	0.2601	-0.3728
HU5	31	0.3502	-0.1624
IF1	32	0.1418	-0.1626
IF2	33	0.2037	-0.1278
IF3	34	0.2453	-0.6990E-01
IF4	35	0.2299	0.1426
IF5	36	0.2000	-0.3020E-01
JU1	37	0.8920E-01	-0.1090E-01
JU2	38	0.1565	-0.1842
JU3	39	0.1520	-0.1661
JU4	40	0.2173	-0.2240
JU5	41	0.2540	-0.4140E-01
KD1	42	-0.1824	0.3031
KD2	43	0.8030E-01	0.4471
KD3	44	-0.2184	-0.8880E-01
KD4	45	-0.2660	-0.6330E-01
KD5	46	-0.4520E-01	0.3180E-01
KO1	47	0.7350E-01	0.2213
KO2	48	-0.3119	0.7440E-01
KO3	49	0.1074	0.3142
KO4	50	0.1361	0.3077
KO5	51	0.2255	0.3671
KU1	52	0.6300E-01	-0.5000E-03
KU2	53	-0.1980E-01	0.3730E-01
KU3	54	-0.2670	0.9200E-02
KU4	55	-0.1846	0.3300E-02
KU5	56	-0.2116	0.1044
MA1	57	-0.2980E-01	-0.3580E-01
MA2	58	-0.3160	0.1773
MA3	59	-0.3530	0.2832
MA4	60	-0.7677	0.2970
MA5	61	-0.3883	0.1476
MA6	62	-0.2330E-01	-0.5490E-01
ME1	63	-0.1593	0.7365
ME2	64	-0.2000E-02	0.6160
ME3	65	0.3170E-01	0.6343
ME4	66	0.6440E-01	0.3609
ME5	67	0.2062	0.2760E-01
MU1	68	0.1705	-0.1337
MU2	69	0.1517	-0.6380E-01
MU3	70	0.2557	-0.3640E-01
MU4	71	0.2847	-0.2500E-02
MU5	72	0.2403	0.9140E-01
PL1	73	0.1929	-0.1632
PL2	74	0.2016	-0.1651
PL3	75	0.7670E-01	-0.2090E-01
PL4	76	0.1062	-0.1069
PL5	77	0.1295	-0.2199
YA1	78	0.4120E-01	0.5687
YA2	79	0.4860E-01	0.5013
YA3	80	0.1585	0.5068
YA4	81	0.6360E-01	0.6448
YA5	82	-0.1677	0.2919

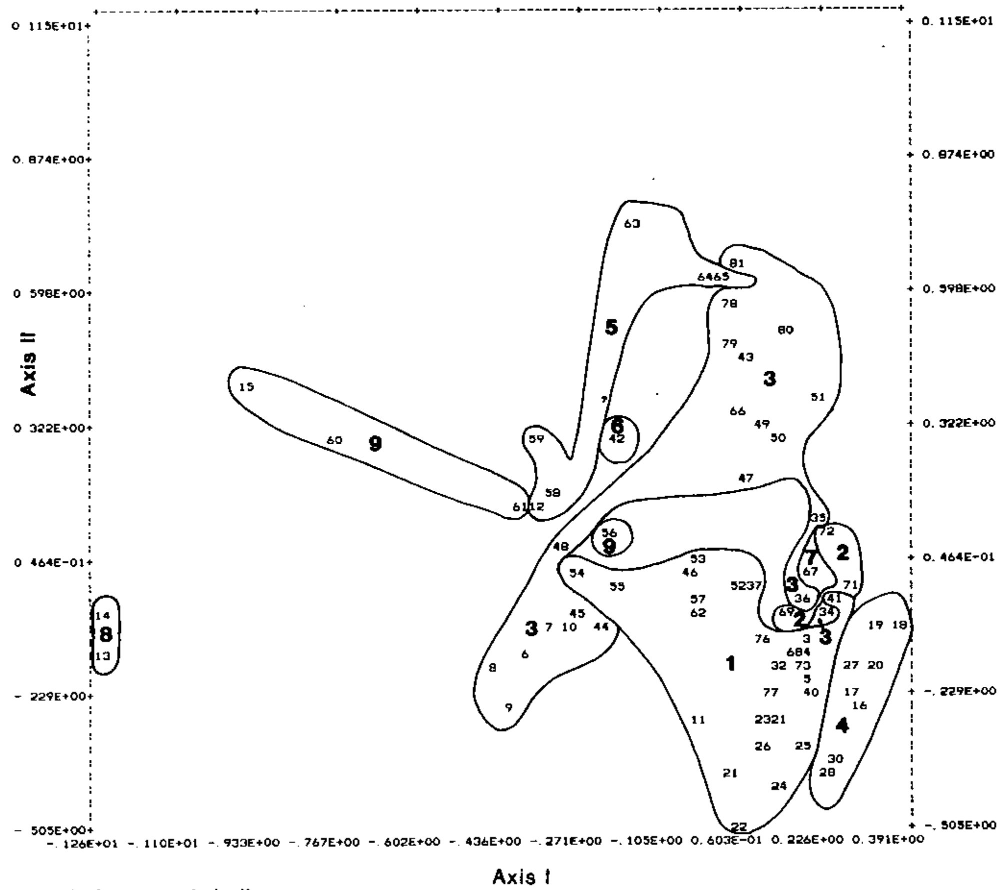
a.

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 82 POINTS
REGRESSIONS : Y = 0.2440E-05 + 0.1286 X
: X = -0.4373E-06 + 0.1794 Y
CORRELATION COEFICIENT (R) = 0.1519

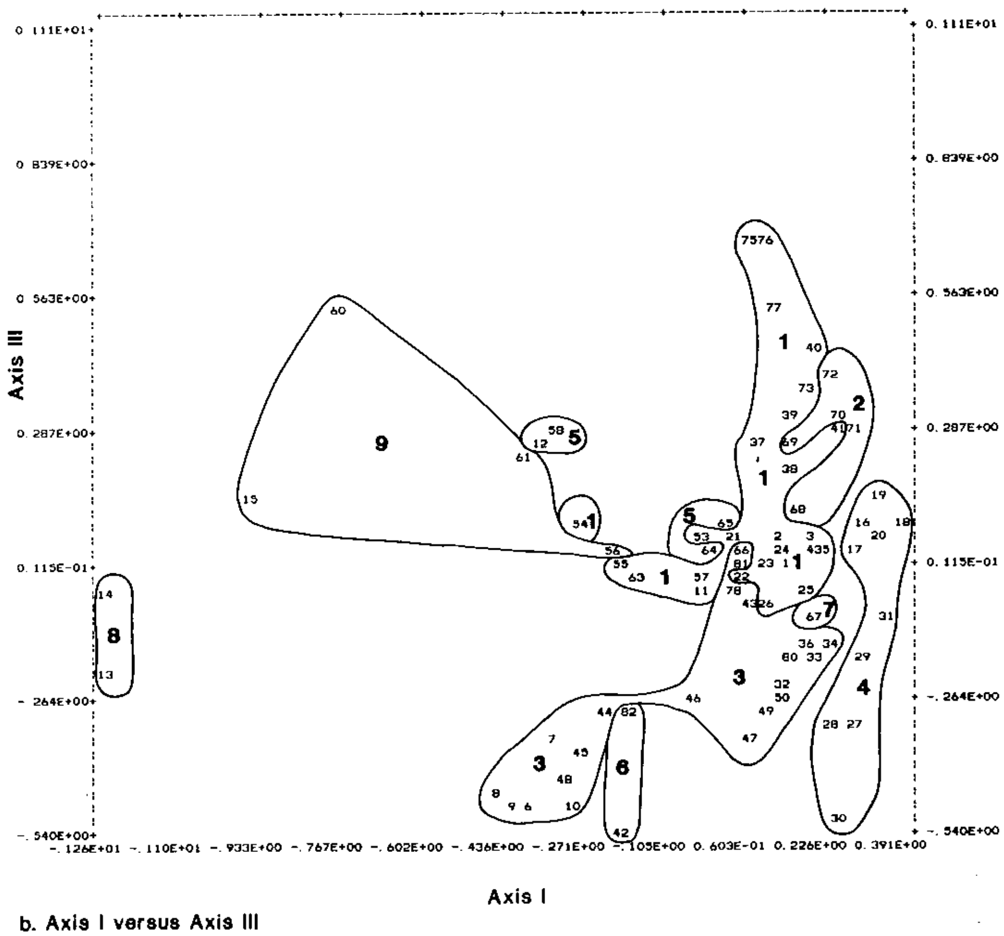
LABEL	SEQ #	X-VALUE	Y-VALUE
BA1	1	0.1481	-0.1600E-02
BA2	2	0.1233	0.6130E-01
BA3	3	0.1875	0.7700E-01
BA4	4	0.1968	0.4860E-01
BA5	5	0.1884	0.7740E-01
CA1	6	-0.3876	-0.4849
CA2	7	-0.3369	-0.3588
CA3	8	-0.4564	-0.4570
CA4	9	-0.4129	-0.4834
CA5	10	-0.2901	-0.4870
CO1	11	-0.1600E-01	-0.4830E-01
CO2	12	-0.3466	0.2557
CO3	13	-1.249	-0.2074
CO4	14	-1.263	-0.3840E-01
CO5	15	-0.9525	0.1613
FO1	16	0.3028	0.9570E-01
FO2	17	0.3000	0.2800E-01
FO3	18	0.3912	0.9900E-01
FO4	19	0.3378	0.1555
FO5	20	0.3395	0.6020E-01
HA1	21	0.4690E-01	0.7730E-01
HA2	22	0.5520E-01	-0.2920E-01
HA3	23	0.1119	0.2400E-01
HA4	24	0.1364	0.3100E-01
HA5	25	0.1978	-0.5550E-01
HA6	26	0.1085	-0.5960E-01
HU1	27	0.2838	-0.3169
HU2	28	0.2485	-0.3107
HU3	29	0.3111	-0.1883
HU4	30	0.2601	-0.5209
HU5	31	0.3502	-0.1037
IF1	32	0.1418	-0.2486
IF2	33	0.2037	-0.1945
IF3	34	0.2453	-0.1517
IF4	35	0.2299	0.4130E-01
IF5	36	0.2000	-0.1558
JU1	37	0.8920E-01	0.2488
JU2	38	0.1565	0.2122
JU3	39	0.1520	0.3148
JU4	40	0.2173	0.4564
JU5	41	0.2540	0.2975
KD1	42	-0.1824	-0.5401
KD2	43	0.8030E-01	-0.8470E-01
KD3	44	-0.2184	-0.2905
KD4	45	-0.2660	-0.3718
KD5	46	-0.4520E-01	-0.2625
KO1	47	0.7350E-01	-0.3467
KO2	48	-0.3119	-0.4412
KO3	49	0.1074	-0.2874
KO4	50	0.1361	-0.2546
KO5	51	0.2255	-0.1632
KU1	52	0.6300E-01	0.6800E-01
KU2	53	-0.1980E-01	0.7490E-01
KU3	54	-0.2670	0.1002
KU4	55	-0.1846	0.2180E-01
KU5	56	-0.2116	0.3400E-01
MA1	57	-0.2980E-01	-0.8900E-02
MA2	58	-0.3160	0.2804
MA3	59	-0.3530	0.2635
MA4	60	-0.7677	0.5301
MA5	61	-0.3883	0.2248
MA6	62	-0.2330E-01	-0.2800E-02
ME1	63	-0.1593	-0.1260E-01
ME2	64	-0.2000E-02	0.2580E-01
ME3	65	0.3170E-01	0.8130E-01
ME4	66	0.6440E-01	0.5170E-01
ME5	67	0.2062	-0.1021
MU1	68	0.1705	0.1284
MU2	69	0.1517	0.2526
MU3	70	0.2557	0.3159
MU4	71	0.2847	0.2969
MU5	72	0.2403	0.4088
PL1	73	0.1929	0.3651
PL2	74	0.2016	0.3578
PL3	75	0.7670E-01	0.6872
PL4	76	0.1062	0.6847
PL5	77	0.1295	0.5441
YA1	78	0.4120E-01	-0.4050E-01
YA2	79	0.4860E-01	-0.4350E-01
YA3	80	0.1585	-0.1719
YA4	81	0.6360E-01	0.1080E-01
YA5	82	-0.1677	-0.3004

b.

Figure 31



a. Axis I versus Axis II



b. Axis I versus Axis III

Figure 31

SCATTERGRAM RESULTING FROM THE ORDINATION OF 82 QUADRATS IN TERMS OF TOTAL FLORA

UPGMA group boundaries (bold face numbers) from Figure 30 are inserted

The MU sites separate from Group 4 to form a separate grouping; Group 2.

The remaining groupings are more complex:

Group 1 (Perennials)	Group 1 (Total)
BA 1, 3, 4, 5	BA 1-4
IF 1-5	HA 1-6
JU 1-5	CO 1
KO 1, 3, 4, 5	MA 1, 6
PL 1-5	KU 1-4
	JU 1-5
	PL 1-5

Group 3 (Perennials) (Treeless Plain)	Group 3 (Total)
BA 2	CA 1-5
HA 1-6	KO 3-5
HU 1, 2	IF 1-5
IF 1, 2	KO 1-5
CA 1, 3, 4	YA 1-4
CO 1	
KO 2	
CA 2, 5	
KO 4, 5, 3	

Group 4 (Perennials)	Group 5 (Total)
CO 2	CO 2
MA 2, 3, 5, 6	MA 2, 3
KU 1-4	KO 2
	ME 1-4

Group 6 of the perennial plant groupings is spread between Groups 5 (KO 2, ME 1-4) and Group 3 (YA 1-4).

The classification of quadrats on total species is, with the exception of the Roe Plain, coastal and cliff sites, essentially the same as that from the perennials. The north-eastern and north-western sites are separated, and the east-west divisions are accentuated (see Groups 3, 5). The woodland and treeless plain divisions are simplified (lumping BA, HA, PL, JU and some coastal sites).

Again there are strong substrate factors, east-west trends, and a climatic north-south axis apparent in the quadrat groupings.

The grouping of BA 2 and HU 4 with other quadrats of the HU campsite, and the enbloc groupings of most other quadrats, indicate that levels of disimilarity between quadrats of the same campsite have been lowered while that between UPGMA groupings has been raised, compared with the perennial plant data.

A principal co-ordinates analysis of the quadrats was then undertaken, and the results presented in Fig. 31.

Discrete clusters are not apparent, however the major groupings are again clearly apparent, especially the Roe Plain quadrats. The solitary group 7(ME5), usually clusters with the IF sites of Group 3. These quadrats (IF) are themselves intermediate in placement between the coastal quadrats of Group 1 and the woodland quadrats of Groups 1 and 2. KU5 the sole quadrat of the coastal dunes of Group 9 also groups closely with South Australian quadrats of Group 3. Group 5 the coastal plain sites also show distinct east-west groupings. This grouping is not surprising considering an analysis of the flora of south-eastern Nullarbor vs. the Roe Plains presented at the outset of Results (see Tables 2 and 4). Similarly the IF quadrats are placed near the Western Sandplains Environmental Region (GT in Table 4) which contains both mesic and desertic elements.

Axis I of the PCR has a distinct substrate factor, from structurally complex sites on the Roe Plain to structurally simple and species poor sites on the central treeless plain.

Axis II is also a species/structural axis running from the treeless plain to southern coastal regions.

Axis III is a latitudinal (north-south) gradient.

The 250 species of plants recorded from more than one quadrat were classified according to their presence or absence at 82 quadrats. Fifteen groups were distinguished using UPGMA (Fig. 32).

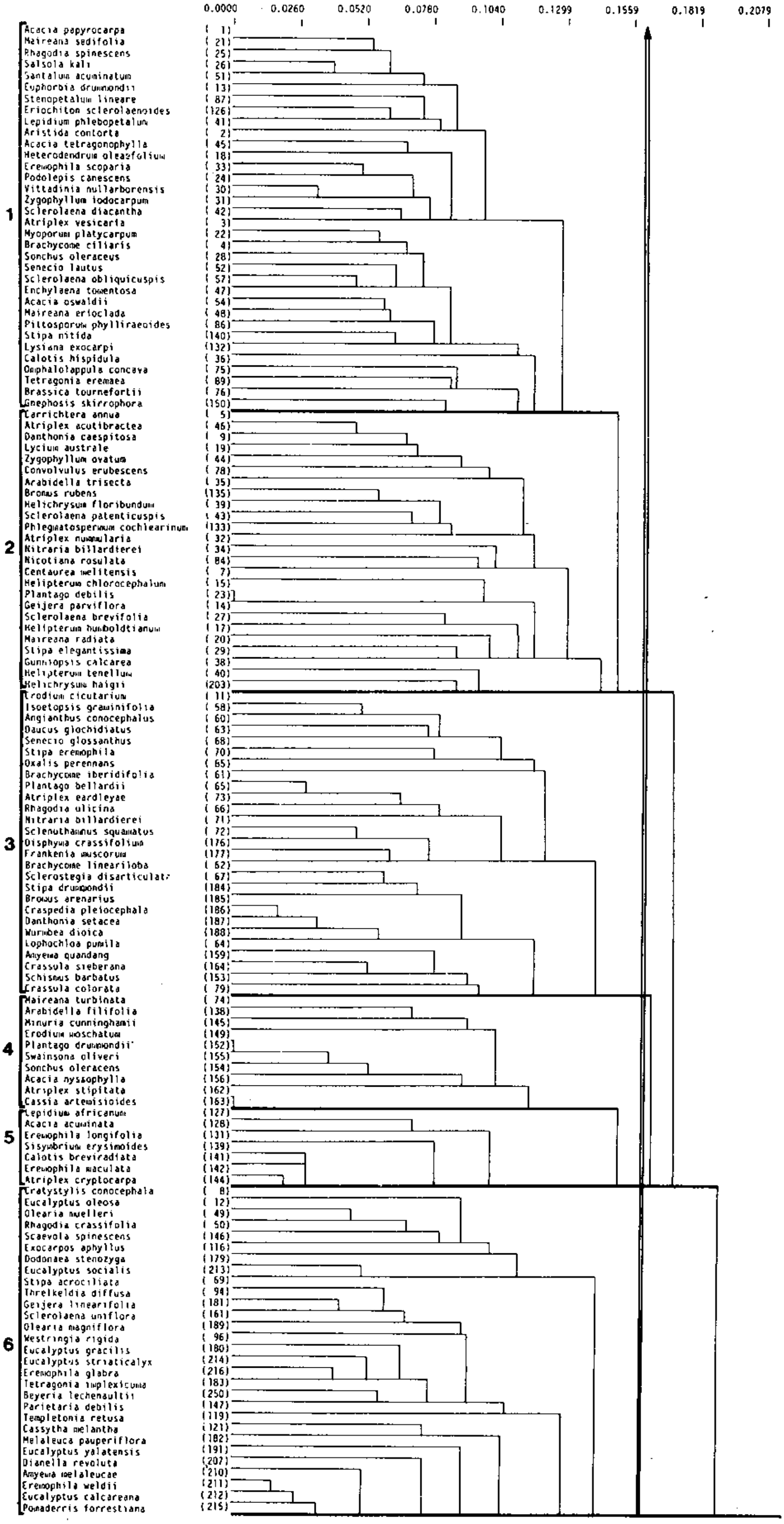
Group 1, with 34 members, of which 16 are annuals or grasses. Two are naturalized aliens (*Bassica tournefortii* and *Sonchus oleraceus*).

All members of this group are widespread in arid and semi-arid Australia, often extending into temperature regions. They are relatively catholic in soil types but can grow on calcareous loams.

Group 2, with 25 members, 14 of which are annuals or grasses. Three are naturalized aliens (*Bromus rubens*, *Carrichterra annua* and *Centaurea melitensis*). The distribution of this group is essentially similar to that of Group 1, but has a southern bias.

Group 3, with 27 members, 18 of which are annuals or grasses. Three are naturalized aliens (*Erodium cicutarium*, *Schismus barbatus* and *Lophochloa pumila*). Members of this group are widespread in southern Australia in temperate, semi-arid and arid Australia, and often occur on sandy soils.

Groups 4 (10 members; 6 annuals or grasses, 2 aliens) 5 (7; 3 and 2) (includes two Nullarbor endemics - *Atriplex cryptocarya* and *Calotis breviradiata*), and 6 (29; 2 annuals, no weeds) are southern temperate to arid species occurring on moderate to heavy soil.



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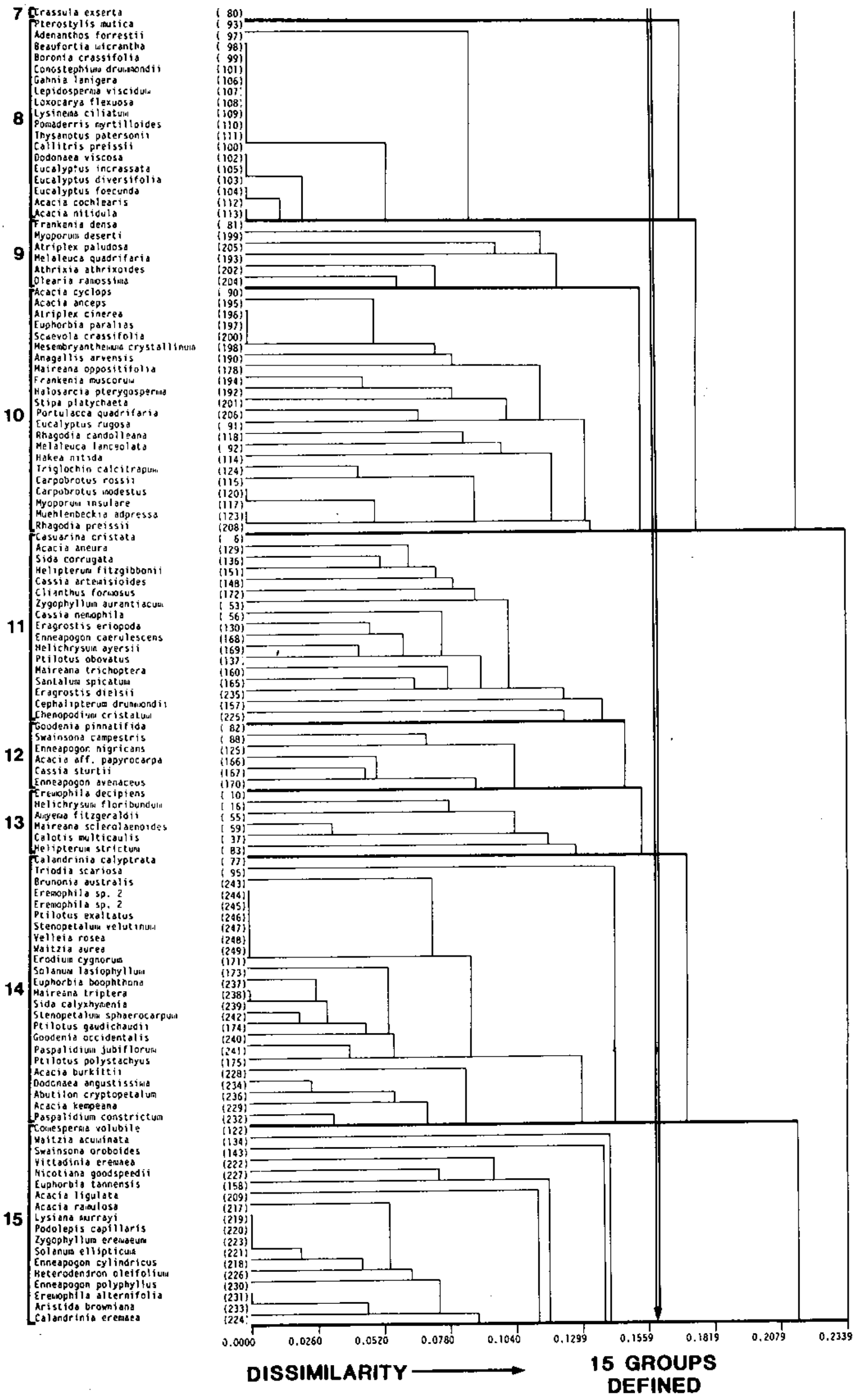


Figure 32

UPGMA CLASSIFICATION OF TOTAL FLORA SPECIES IN TERMS OF QUADRAT FIDELITY (TWO-STEP)

Group 7 contains only 1 species (Crassula exserta) and probably belongs in the above grouping.

Groups 8 (1 ephemeral - Pterostylis mutica) and 9 are southern temperate groupings of sandy or heavy soil species respectively.

Group 10 contains 22 species, including 6 annuals or grasses of which 3 (Anagallis arvensis, Euphorbia paralias and Mesembryanthemum crystallinum) are naturalized aliens. Members of this group are temperate, sandy soil species restricted to coastal or near coastal sites in the arid zone.

Group 11 contains 17 members; 8 are annuals or grasses, none are aliens. All are widespread arid to semi-arid species, usually occurring on sandy or loamy soils.

Group 12 (6; 4 and none) and 13 (6; 3 and none) are similar but occur on a wider range of soils.

Groups 14 (24 species; 13 annuals or grasses, no aliens) and 15 (18 species; 11 annuals or grasses, no aliens) have similar distributions to members of Group 11.

There are several major components of these groupings:

Group 1 and 2; widespread annuals or grasses of temperate to arid Australia, often extending into the tropics, able to tolerate calcareous loams.

Groups 3, 4 and 5 are widespread temperate, semi-arid to arid species, with a southern bias. Group 6 is the woodland component of this grouping (perhaps also 13, 5).

Groups 7, 8, 9, 10 are southern temperate species, which marginally penetrate the arid zone on sandy or near coastal sites.

Groups 11, 14 and 15 are the sandy soil desert groups of adjacent regions.

These groups can be related to the perennial plant species groupings as follows:

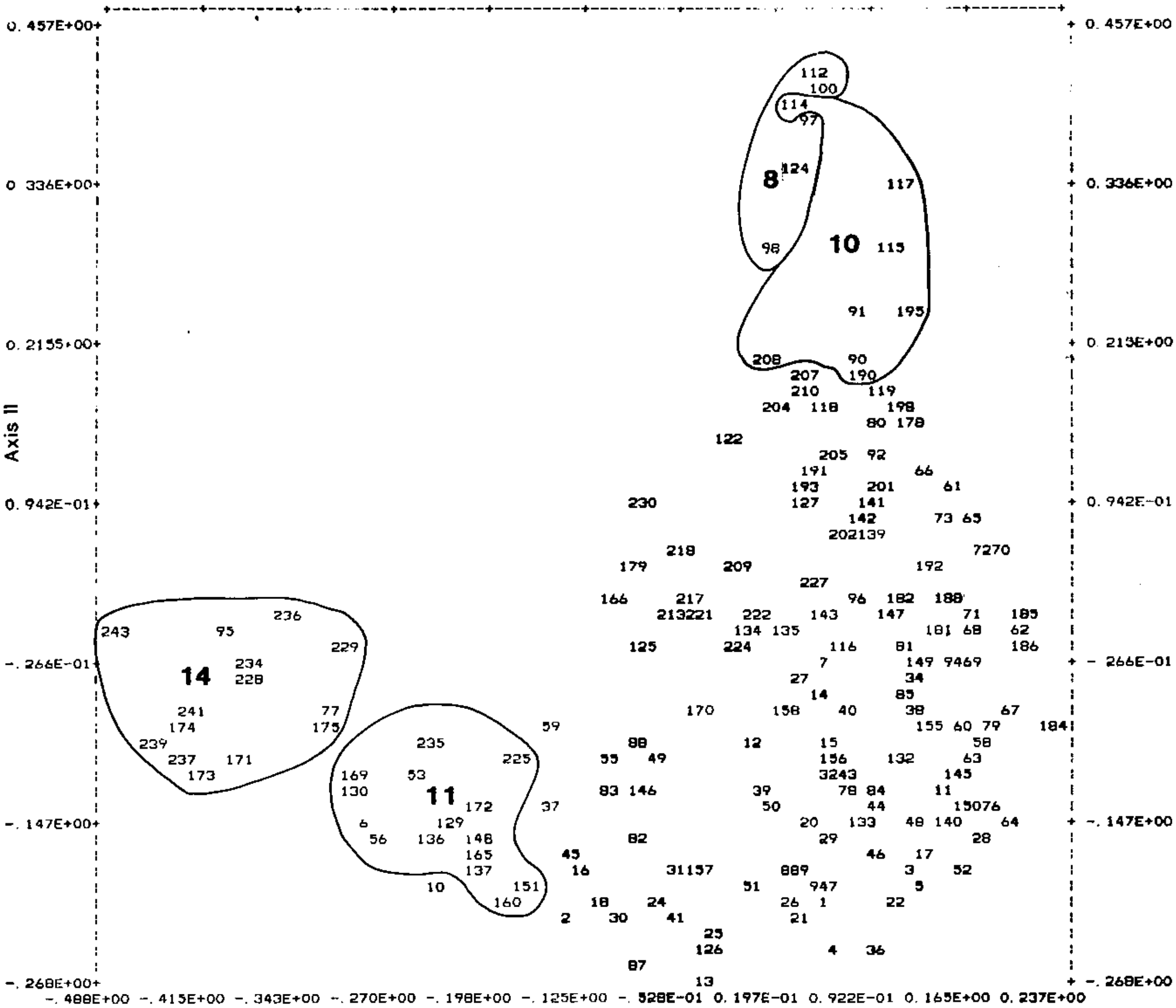
	Total	Perennials
Group	1	1
	2	1 (part), 4
	3	3
	4	2, 3
	5	3
	6	7, 10
	7	no equivalent group
	8	15
	9	12
	10	4, 11, 13
	11	5
	12	1
	13	5, 1
	14	5
	15	6
	(perennial groups 8, 9 no equivalent)	

A PCR analysis was carried out on the total flora presence and absence data to classify all species in terms of quadrats. The results are presented in Fig. 33. Discrete clusters are rarely apparent, and only a few of the UPGMA group boundaries were overlain. The 5 major groupings are still apparent, however and are defined by the three axes. Axis 1 is an east-west gradient along the coast and into the central treeless plain. Axis II is a gradient from the treeless plain to the coastal woodlands. Axis III is a gradient from the southern to the northern fringes of the study area.

A Two-Way table was then produced, (Table 8) using the UPGMA group boundaries for quadrats (columns) and species (rows).

Species classified in UPGMA Group 1 (Table 8) are widespread throughout the study area, except the Roe Plain or sandy coastal sites. Species Group 2 is similar but is more southern in its occurrence within the study area, and is especially well represented on the western fringing woodlands and treeless plain sites (HA and BA). Group 3 is a southern coastal calcium tolerant grouping which is primarily located in south-eastern parts of the study area, largely absent from the IF sites. Group 4 are southern species of the semi-arid which occur at the IF sites (along with parts of Group 3). Group 5 are the species found at FO and HU, containing species found in dongas (Eremophila longifolia), two Nullarbor endemics (Atriplex cryptocarya and Calotis breviradiata) and two weeds.

Group 6 are woodland and shrubland species of temperate affinities and are confined to the southern areas of the study site. Group 7 is an artifact. Group 8 are the species of the Roe Plain, confined to deep near coastal stable sandy sites. Group 8 are southern heavy soil groupings occurring on the near coastal Hampton Tableland in western and eastern regions. Group 10 are the near coastal sand species, often occurring on unstable sands. Group 11 are the wide-ranging loamy desert components found throughout the northern fringe, some of which extend to the



a. Axis I versus Axis II

Axis I

Figure 33a.

SCATTERGRAM FROM ORDINATION OF TOTAL PLANT SPECIES IN TERMS OF QUADRAT FIDELITY

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 250 POINTS
REGRESSIONS : Y = 0.1660E-05 + 0.2129 X
: X = 0.1154E-05 + 0.2229 Y
CORRELATION COEFICIENT (R) = 0.2178

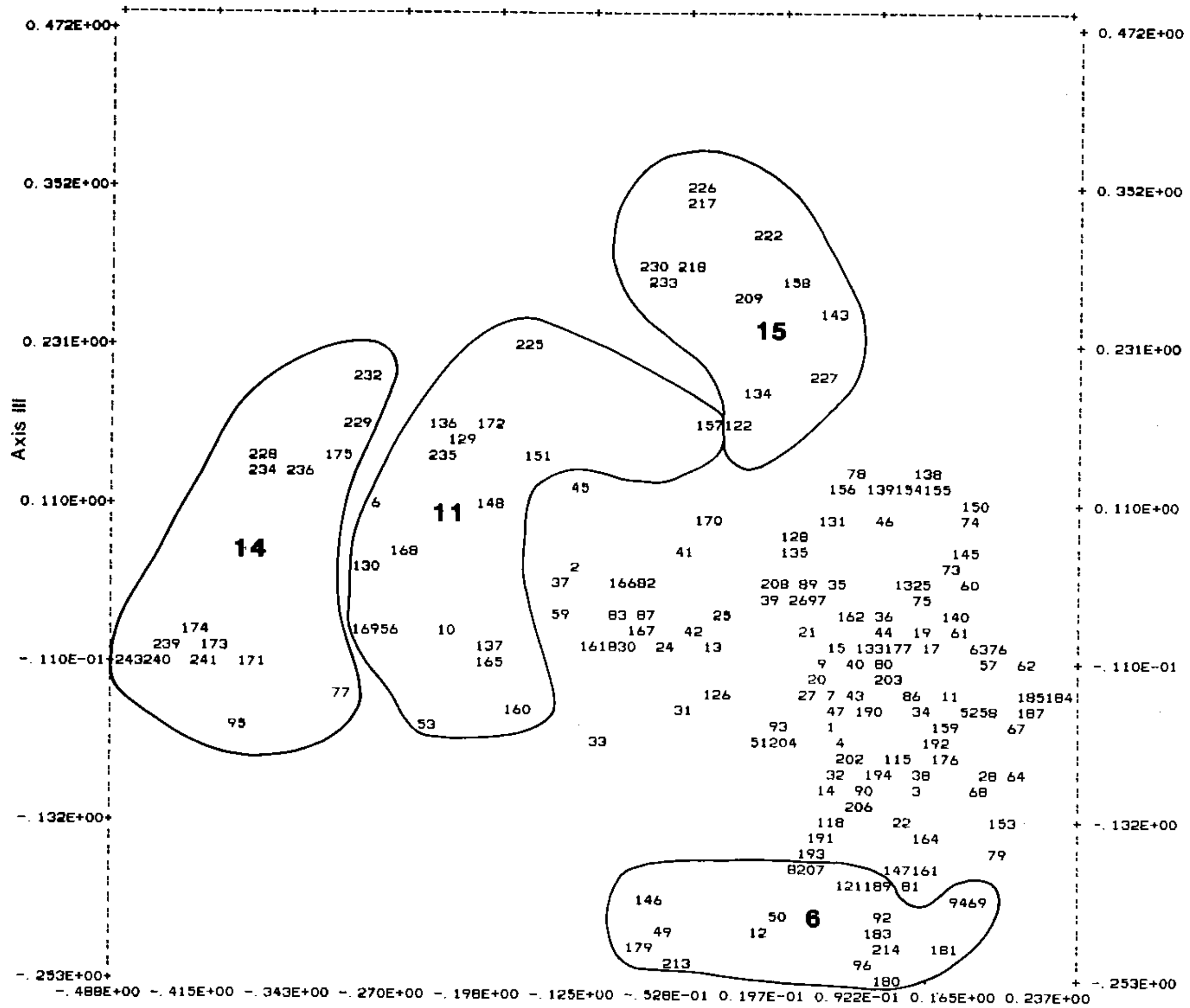
LABEL	SEQ #	X-VALUE	Y-VALUE
Acacpapy	1	0.5600E-01	-0.2116
Ariscont	2	-0.1405	-0.2196
Atrivesi	3	0.1245	-0.1806
Braccili	4	0.6280E-01	-0.2437
Carrannu	5	0.1268	-0.1980
Casucris	6	-0.2915	-0.1523
Centmeli	7	0.5900E-01	-0.2180E-01
Cratcono	8	0.2520E-01	-0.1887
Dantcaes	9	0.5100E-01	-0.1979
Eremdeci	10	-0.2347	-0.1972
Erodcicu	11	0.1514	-0.1231
Eucaoleo	12	0.1700E-02	-0.8870E-01
Euphdrum	13	-0.3270E-01	-0.2683
Geijparv	14	0.5830E-01	-0.4680E-01
Helichlo	15	0.6370E-01	-0.9110E-01
Heliflor	16	-0.1273	-0.1875
Helihumb	17	0.1321	-0.1698
Heteolea	18	-0.1107	-0.2116
Lyciaust	19	0.1253	-0.1785
Mairradi	20	0.5150E-01	-0.1464
Mairsedi	21	0.4230E-01	-0.2191
Myopplat	22	0.1127	-0.2069
Plandebi	23	0.6370E-01	-0.9110E-01
Podocane	24	-0.6460E-01	-0.2111
Rhagspin	25	-0.2230E-01	-0.2337
Salskali	26	0.3530E-01	-0.2123
Sclebrev	27	0.4260E-01	-0.4400E-01
Soncoler	28	0.1772	-0.1600
Stipeleg	29	0.6470E-01	-0.1546
Vittnull	30	-0.9490E-01	-0.2208
Zygoiodo	31	-0.5010E-01	-0.1802
Atrinumm	32	0.6640E-01	-0.1093
Eremscop	33	-0.1150	-0.2109
Nitrbill	34	0.1261	-0.3650E-01
Arabtris	35	0.6500E-01	-0.8730E-01
Calohisp	36	0.9890E-01	-0.2437
Calomult	37	-0.1504	-0.1404
Gunncalc	38	0.1320	-0.6300E-01
Heliflor	39	0.8800E-02	-0.1258
Helitene	40	0.8120E-01	-0.6690E-01
Lepiphle	41	-0.5270E-01	-0.2216
Sclediac	42	-0.4520E-01	-0.1865
Sclepate	43	0.7960E-01	-0.1158
Zygoovat	44	0.1012	-0.1318
Acactetr	45	-0.1353	-0.1722
Atriacut	46	0.9940E-01	-0.1769
Enchtome	47	0.6650E-01	-0.1948
Mairerio	48	0.1272	-0.1499
Oleamuel	49	-0.6960E-01	-0.9960E-01
Rhagcras	50	0.1620E-01	-0.1343
Santacum	51	0.2900E-02	-0.1949
Senelaut	52	0.1668	-0.1882
Zygoaura	53	-0.2470	-0.1109
Acacoswa	54	0.5520E-01	-0.1573
Amyefitz	55	-0.1032	-0.1009
Cassnemo	56	-0.2757	-0.1626
Scleobli	57	0.1773	-0.1654
Isoegram	58	0.1759	-0.8650E-01
Mairscle	59	-0.1505	-0.7340E-01
Angicono	60	0.1645	-0.7710E-01
Braciber	61	0.1552	0.1076
Bracline	62	0.2104	-0.7000E-03
Daucgloc	63	0.1750	-0.1028
Lophpumi	64	0.2009	-0.1444
Planbell	65	0.1698	0.8390E-01
Rhagulic	66	0.1363	0.1208
Scledisa	67	0.2017	-0.6360E-01
Seneglos	68	0.1738	0.4000E-03
Stipacro	69	0.1701	-0.2080E-01
Stiperem	70	0.1925	0.6400E-01
Nitrbill	71	0.1685	0.1280E-01
Sclesqua	72	0.1761	0.5540E-01
Atrieard	73	0.1489	0.8380E-01
Mairturb	74	0.1657	-0.9470E-01
Omphconc	75	0.1289	-0.2013
Brastour	76	0.1879	-0.1362
Calacaly	77	-0.3104	-0.6090E-01
Converub	78	0.8000E-01	-0.1214
Crascolo	79	0.1882	-0.6950E-01
Crasexse	80	0.1011	0.1541
Frandens	81	0.1242	-0.1570E-01
Goodpinn	82	-0.8160E-01	-0.1583
Helistri	83	-0.1045	-0.1173
Nicorosu	84	0.9890E-01	-0.1222
Oxalpere	85	0.1223	-0.4840E-01
Pittphyl	86	0.1186	-0.1487
Stenline	87	-0.8460E-01	-0.2601
Swaicamp	88	-0.7900E-01	-0.8520E-01
Tetrerem	89	0.3850E-01	-0.1780
Acaccycl	90	0.8290E-01	0.1977
Eucarugo	91	0.8570E-01	0.2386
Melalanc	92	0.9610E-01	0.1338
Ptermuti	93	0.2300E-01	0.2829
Thrediff	94	0.1559	-0.2860E-01
Trioscar	95	-0.3913	-0.8100E-02
Westrigi	96	0.8650E-01	0.2550E-01
Adenforr	97	0.4830E-01	0.3847
Beaumicr	98	0.4830E-01	0.3847
Borocras	99	0.4830E-01	0.3847
Callprei	100	0.6450E-01	0.4093
Conodrum	101	0.4830E-01	0.3847
Dodovisc	102	0.6450E-01	0.4093
Eucadive	103	0.5310E-01	0.4086
Eucafoec	104	0.5310E-01	0.4086
Eucaincr	105	0.6450E-01	0.4093
Gahnlani	106	0.4830E-01	0.3847
Lepivisc	107	0.4830E-01	0.3847
Loxoflex	108	0.4830E-01	0.3847
Lysicili	109	0.4830E-01	0.3847
Pomamyrt	110	0.4830E-01	0.3847
Thyspate	111	0.4830E-01	0.3847
Acaccoch	112	0.5670E-01	0.4174
Acacniti	113	0.5670E-01	0.4174
Hakeniti	114	0.4490E-01	0.3921
Carpross	115	0.1133	0.2930
Exocaphy	116	0.7530E-01	-0.1600E-01
Myopinsu	117	0.1205	0.3410
Rhagcand	118	0.6450E-01	0.1623
Tempretu	119	0.1083	0.1810
Carpmode	120	0.1133	0.2930
Cassmela	121	0.7850E-01	0.1978
Comevolu	122	-0.9300E-02	0.1430
Muehadpr	123	0.1205	0.3410
Trigcalc	124	0.3800E-01	0.3514
Ennenigr	125	-0.7130E-01	-0.1440E-01
Erioscle	126	-0.2350E-01	-0.2441
Lepiafri	127	0.4970E-01	0.8910E-01
Acacacum	128	0.3220E-01	0.9480E-01
Acacaneu	129	-0.2187	-0.1427
Eragerio	130	-0.2924	-0.1244
Eremlong	131	0.6300E-01	-0.2390E-01
Lysiexoc	132	0.1215	-0.9580E-01
Phlecoch	133	0.9530E-01	-0.1425
Waitacum	134	0.2300E-02	0.2900E-02
Bromrube	135	0.3520E-01	-0.4200E-02
Sidacorr	136	-0.2366	-0.1602
Ptilobov	137	-0.1966	-0.1859
Arabfili	138	0.1391	-0.1840E-01
Sisyerys	139	0.1011	0.7490E-01
Stipniti	140	0.1547	-0.1487
Calobrev	141	0.1005	0.9050E-01
Eremmacu	142	0.9240E-01	0.7750E-01
Swaiorob	143	0.6030E-01	0.4400E-02
Atricryp	144	0.8210E-01	0.8790E-01
Minucunn	145	0.1672	-0.1084
Scaespin	146	-0.7690E-01	-0.1219
Paridebi	147	0.1175	0.1540E-01
Cassarte	148	-0.1978	-0.1616
Erodmosc	149	0.1336	-0.2590E-01
Gnepskir	150	0.1699	-0.1373
Helifitz	151	-0.1588	-0.2006
Plandrum	152	0.1336	-0.2590E-01
Schibarb	153	0.1942	-0.8210E-01
Soncoler	154	0.1199	-0.5420E-01
Swaioliv	155	0.1402	-0.7570E-01
Acacnyss	156	0.7180E-01	-0.1002
Cephdrum	157	-0.3100E-01	-0.1881
Euphtann	158	0.3680E-01	-0.6820E-01
Amyequan	159	0.1524	-0.1139
Mairtric	160	-0.1751	-0.2100

Figure 33a

continued overleaf

Figure 33a (cont.)

LABEL	SEQ #	X-VALUE	Y-VALUE
Scleunif	161	0. 1338	-0. 5200E-01
Atristip	162	0. 8040E-01	-0. 6560E-01
Cassarte	163	0. 8040E-01	-0. 6560E-01
Crassieb	164	0. 1387	-0. 7830E-01
Santspic	165	-0. 1996	-0. 1709
Acacaff.	166	-0. 9450E-01	0. 1680E-01
Cassstur	167	-0. 8010E-01	0. 1700E-01
Ennecaer	168	-0. 2659	-0. 1535
Heliayer	169	-0. 2942	-0. 1114
Enneaven	170	-0. 3190E-01	-0. 6580E-01
Erodcygn	171	-0. 3821	-0. 1035
Cliaform	172	-0. 2011	-0. 1316
Solalasi	173	-0. 4054	-0. 1060
Ptilgaud	174	-0. 4200	-0. 7870E-01
Ptilpoly	175	-0. 3148	-0. 6940E-01
Dispcras	176	0. 1467	0. 1102
Franmusc	177	0. 1173	0. 1606
Mairoppo	178	0. 1285	0. 1498
Dodosten	179	-0. 8250E-01	0. 4080E-01
Eucagrac	180	0. 1101	0. 9000E-01
Geijline	181	0. 1477	-0. 5300E-02
Melapaup	182	0. 1187	0. 2420E-01
Tetrimpl	183	0. 9950E-01	0. 8560E-01
Stipdrum	184	0. 2372	-0. 7650E-01
Bromaren	185	0. 2132	0. 4200E-02
Craspl ei	186	0. 2127	-0. 1500E-01
Dantseta	187	0. 2144	-0. 6900E-02
Wurmdioi	188	0. 1605	0. 1590E-01
Oleamagn	189	0. 9660E-01	0. 1630E-01
Anagarve	190	0. 9470E-01	0. 1882
Eucayala	191	0. 5490E-01	0. 1240
Halopter	192	0. 1446	0. 4600E-01
Melaquad	193	0. 4580E-01	0. 1094
Franmusc	194	0. 9920E-01	0. 1507
Acacance	195	0. 1275	0. 2380
Atricine	196	0. 1275	0. 2380
Euphpara	197	0. 1275	0. 2380
Mesecrys	198	0. 1223	0. 1685
Myopdese	199	0. 1111	0. 1301
Scaecras	200	0. 1275	0. 2380
Stipplat	201	0. 1080	0. 1101
Athrathr	202	0. 7600E-01	0. 6500E-01
Helihaig	203	0. 1050	0. 1540E-01
Olearamo	204	0. 2390E-01	0. 1608
Atripalu	205	0. 7030E-01	0. 1325
Portquad	206	0. 8450E-01	0. 1276
Dianrevo	207	0. 4730E-01	0. 1879
Rhagprei	208	0. 2020E-01	0. 2047
Acacligu	209	-0. 1600E-02	0. 4210E-01
Amyemela	210	0. 4810E-01	0. 1792
Eremweld	211	0. 4990E-01	0. 1621
Eucacalc	212	0. 5370E-01	0. 1686
Eucasoci	213	-0. 5210E-01	0. 1200E-01
Eucastri	214	0. 1039	0. 7670E-01
Pomaforr	215	0. 4270E-01	0. 1802
Eremglab	216	0. 9830E-01	0. 8790E-01
Acacramu	217	-0. 4150E-01	0. 1980E-01
Ennecyli	218	-0. 4750E-01	0. 6150E-01
Lysimurr	219	-0. 4150E-01	0. 1980E-01
Podocapi	220	-0. 4150E-01	0. 1980E-01
Solaelli	221	-0. 3040E-01	0. 1330E-01
Vitterem	222	0. 1250E-01	0. 1460E-01
Zygoerem	223	-0. 4150E-01	0. 1980E-01
Calaerem	224	-0. 1100E-02	-0. 1520E-01
Chencris	225	-0. 1692	-0. 9840E-01
Heteolei	226	-0. 3820E-01	0. 2010E-01
Nicogood	227	0. 5360E-01	0. 3810E-01
Acacburk	228	-0. 3700	-0. 3890E-01
Acackemp	229	-0. 2972	-0. 1380E-01
Ennepoly	230	-0. 7500E-01	0. 9410E-01
Eremalte	231	-0. 7500E-01	0. 9410E-01
Paspcons	232	-0. 2894	-0. 1710E-01
Arisbrow	233	-0. 7050E-01	0. 9180E-01
Dodoangu	234	-0. 3691	-0. 3020E-01
Eragdiel	235	-0. 2335	-0. 8850E-01
Abutcryp	236	-0. 3441	0. 4600E-02
Euphboop	237	-0. 4232	-0. 9990E-01
Mairtrip	238	-0. 4232	-0. 9990E-01
Sidacaly	239	-0. 4444	-0. 8780E-01
Goodocci	240	-0. 4514	-0. 8370E-01
Paspjubi	241	-0. 4141	-0. 5970E-01
Stenspha	242	-0. 4397	-0. 1045
Brunaust	243	-0. 4879	-0. 3700E-02
Eremsp	244	-0. 4879	-0. 3700E-02
Eremsp	245	-0. 4879	-0. 3700E-02
Ptilexal	246	-0. 4879	-0. 3700E-02
Stenvelu	247	-0. 4879	-0. 3700E-02
Vellrose	248	-0. 4879	-0. 3700E-02
Waitaure	249	-0. 4879	-0. 3700E-02
Peyelech	250	0. 1079	0. 9780E-01



b. Axis I versus Axis III

Figure 33b.

SCATTERGRAM FROM ORDINATION OF TOTAL PLANT SPECIES IN TERMS OF QUADRAT FIDELITY

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 250 POINTS
REGRESSIONS : Y = -0.1086E-06 + -0.1821 X
: X = 0.1463E-05 + -0.3442 Y
CORRELATION COEFICIENT (R) = -0.2504

LABEL	SEQ #	X-VALUE	Y-VALUE
Acacpapy	1	0.5600E-01	-0.5420E-01
Ariscont	2	-0.1405	0.6540E-01
Atrivesi	3	0.1245	-0.1056
Braccili	4	0.6280E-01	-0.7160E-01
Carrannu	5	0.1268	0.4790E-01
Casucris	6	-0.2915	0.1079
Centmeli	7	0.5900E-01	-0.3680E-01
Cratcono	8	0.2520E-01	-0.1626
Dantcaes	9	0.5100E-01	-0.5500E-02
Eremdeci	10	-0.2347	0.1050E-01
Erodcicu	11	0.1514	-0.3830E-01
Eucaoleo	12	0.1700E-02	-0.2200
Euphdrum	13	-0.3270E-01	0.3900E-02
Geijparv	14	0.5830E-01	-0.1065
Helichlo	15	0.6370E-01	0.1000E-02
Heliflor	16	-0.1273	0.3300E-02
Helihumb	17	0.1321	-0.3800E-02
Heteolea	18	-0.1107	-0.9000E-03
Lyciaust	19	0.1253	0.1200E-01
Mairradi	20	0.5150E-01	-0.2340E-01
Mairsedi	21	0.4230E-01	0.7900E-02
Myopplat	22	0.1127	-0.1275
Plandebi	23	0.6370E-01	0.1000E-02
Podocane	24	-0.6460E-01	0.5400E-02
Rhagspin	25	-0.2230E-01	0.2410E-01
Salskali	26	0.3530E-01	0.3820E-01
Sclebrev	27	0.4260E-01	-0.3650E-01
Soncoler	28	0.1772	-0.9880E-01
Stipeleg	29	0.6470E-01	-0.6710E-01
Vittnull	30	-0.9490E-01	0.5600E-02
Zygoiodo	31	-0.5010E-01	-0.4680E-01
Atrinumm	32	0.6640E-01	-0.9300E-01
Eremscop	33	-0.1150	-0.7700E-01
Nitrbill	34	0.1261	-0.4660E-01
Arabtris	35	0.6500E-01	0.5440E-01
Calohisp	36	0.9890E-01	0.2050E-01
Calomult	37	-0.1504	0.5190E-01
Gunncalc	38	0.1320	-0.8960E-01
Heliflor	39	0.8800E-02	0.4250E-01
Helitene	40	0.8120E-01	-0.1100E-01
Lepiphle	41	-0.5270E-01	0.7350E-01
Sclediac	42	-0.4520E-01	0.7400E-02
Sclepate	43	0.7960E-01	-0.3060E-01
Zygoovat	44	0.1012	0.7400E-02
Acactetr	45	-0.1353	0.1193
Atriacut	46	0.9940E-01	0.9720E-01
Enchtome	47	0.6650E-01	-0.4310E-01
Mairerio	48	0.1272	-0.9710E-01
Oleamuel	49	-0.6960E-01	-0.2194
Rhagcras	50	0.1620E-01	-0.2022
Santacum	51	0.2900E-02	-0.6640E-01
Senelaut	52	0.1668	-0.5030E-01
Zygoaura	53	-0.2470	-0.5570E-01
Acacoswa	54	0.5520E-01	-0.5830E-01
Amyefitz	55	-0.1032	0.6500E-02
Cassnemo	56	-0.2757	0.1400E-01
Scleobli	57	0.1773	-0.1640E-01
Isoegram	58	0.1759	-0.4670E-01
Mairscle	59	-0.1505	0.2080E-01
Angicono	60	0.1645	0.5290E-01
Braciber	61	0.1552	0.1020E-01
Bracline	62	0.2104	-0.1080E-01
Daucgloc	63	0.1750	-0.3600E-02
Lophpumi	64	0.2009	-0.9580E-01
Planbell	65	0.1698	0.2300E-02
Rhagulic	66	0.1363	-0.1007
Scledisa	67	0.2017	-0.5950E-01
Seneglos	68	0.1738	-0.1131
Stipacro	69	0.1701	-0.1902
Stiperem	70	0.1925	-0.5920E-01
Nitrbill	71	0.1685	-0.1020E-01
Sclesqua	72	0.1761	-0.1220E-01
Atrieard	73	0.1489	0.6270E-01
Mairturb	74	0.1657	0.1021
Omphconc	75	0.1289	0.3570E-01
Brastour	76	0.1879	0.3600E-02
Calacaly	77	-0.3104	-0.3180E-01
Converub	78	0.8000E-01	0.1395
Crascolo	79	0.1882	-0.1565
Crasexse	80	0.1011	-0.1120E-01

LABEL	SEQ #	X-VALUE	Y-VALUE
Frandens	81	0.1242	-0.1855
Goodpinn	82	-0.8160E-01	0.5310E-01
Helistri	83	-0.1045	0.2570E-01
Nicorosu	84	0.9890E-01	-0.1300E-01
Oxalpere	85	0.1223	0.1850E-01
Pittphyl	86	0.1186	-0.3180E-01
Stenline	87	-0.8460E-01	0.1960E-01
Swaicamp	88	-0.7900E-01	0.4600E-01
Tetrerem	89	0.3850E-01	0.5500E-01
Acaccycl	90	0.8290E-01	-0.1111
Eucarugo	91	0.8570E-01	-0.1101
Melalanc	92	0.9610E-01	-0.2039
Ptermuti	93	0.2300E-01	-0.5510E-01
Thrediff	94	0.1559	-0.1968
Trioscar	95	-0.3913	-0.6390E-01
Westrigi	96	0.8650E-01	-0.2401
Adenforr	97	0.4830E-01	0.4200E-01
Beaumicr	98	0.4830E-01	0.4200E-01
Borocras	99	0.4830E-01	0.4200E-01
Callprei	100	0.6450E-01	0.6000E-02
Conodrum	101	0.4830E-01	0.4200E-01
Dodovisc	102	0.6450E-01	0.6000E-02
Eucadive	103	0.5310E-01	-0.3400E-02
Eucafoec	104	0.5310E-01	-0.3400E-02
Eucaincr	105	0.6450E-01	0.6000E-02
Gahnlani	106	0.4830E-01	0.4200E-01
Lepivisc	107	0.4830E-01	0.4200E-01
Loxoflex	108	0.4830E-01	0.4200E-01
Lysicili	109	0.4830E-01	0.4200E-01
Pomamyrt	110	0.4830E-01	0.4200E-01
Thyspate	111	0.4830E-01	0.4200E-01
Acaccoch	112	0.5670E-01	-0.3100E-02
Acacniti	113	0.5670E-01	-0.3100E-02
Hakeniti	114	0.4490E-01	-0.2950E-01
Carpross	115	0.1133	-0.7980E-01
Exocaphy	116	0.7530E-01	-0.2445
Myopinsu	117	0.1205	-0.3870E-01
Rhagcand	118	0.6450E-01	-0.1333
Tempretu	119	0.1083	-0.2088
Carpmode	120	0.1133	-0.7980E-01
Cassmela	121	0.7850E-01	-0.1814
Comevolu	122	-0.9300E-02	0.1699
Muehadpr	123	0.1205	-0.3870E-01
Trigcalc	124	0.3800E-01	-0.4090E-01
Ennenigr	125	-0.7130E-01	0.3040E-01
Erioscle	126	-0.2350E-01	-0.3800E-01
Lepiafri	127	0.4970E-01	0.4330E-01
Acacacum	128	0.3220E-01	0.8700E-01
Acacaneu	129	-0.2187	0.1535
Eragerio	130	-0.2924	0.5760E-01
Eremlong	131	0.6300E-01	0.9670E-01
Lysiexoc	132	0.1215	0.5190E-01
Phlecoch	133	0.9530E-01	-0.3900E-02
Waitacum	134	0.2300E-02	0.1940
Bromrube	135	0.3520E-01	0.7120E-01
Sidacorr	136	-0.2366	0.1672
Ptilobov	137	-0.1966	0.2500E-02
Arabfili	138	0.1391	0.1299
Sisyerys	139	0.1011	0.1173
Stipniti	140	0.1547	0.2010E-01
Calobrev	141	0.1005	0.1269
Eremmacu	142	0.9240E-01	0.1292
Swaiorob	143	0.6030E-01	0.2563
Atricryp	144	0.8210E-01	0.1261
Minucunn	145	0.1672	0.7570E-01
Scaespin	146	-0.7690E-01	-0.1929
Paridebi	147	0.1175	-0.1704
Cassarte	148	-0.1978	0.1142
Erodmosc	149	0.1336	0.1382
Gnepskir	150	0.1699	0.1148
Helifitz	151	-0.1588	0.1492
Plandrum	152	0.1336	0.1382
Schibarb	153	0.1942	-0.1341
Soncoler	154	0.1199	0.1180
Swaioliv	155	0.1402	0.1184
Acacnyss	156	0.7180E-01	0.1200
Cephdrum	157	-0.3100E-01	0.1704
Euphtann	158	0.3680E-01	0.2848
Amyequan	159	0.1524	-0.5720E-01
Mairtric	160	-0.1751	-0.4540E-01

Figure 33b

continued overleaf

Figure 33b.(cont.)

LABEL	SEQ #	X-VALUE	Y-VALUE
Scleunif	161	0. 1338	-0. 1639
Atristip	162	0. 8040E-01	0. 2730E-01
Cassarte	163	0. 8040E-01	0. 2730E-01
Crassieb	164	0. 1387	-0. 1411
Santspic	165	-0. 1996	-0. 1210E-01
Acacaff.	166	-0. 9450E-01	0. 4910E-01
Cassstur	167	-0. 8010E-01	0. 1700E-01
Ennecaer	168	-0. 2659	0. 7790E-01
Heliayer	169	-0. 2942	0. 7500E-02
Enneaven	170	-0. 3190E-01	0. 9390E-01
Erodcygn	171	-0. 3821	-0. 6400E-02
Cliaform	172	-0. 2011	0. 1755
Solalasi	173	-0. 4054	0. 5500E-02
Ptilgaud	174	-0. 4200	0. 1230E-01
Ptilpoly	175	-0 3148	0. 1488
Dispcras	176	0. 1467	-0. 8670E-01
Franmusc	177	0. 1173	-0. 3000E-02
Mairoppo	178	0. 1285	-0. 4140E-01
Dodosten	179	-0. 8250E-01	-0. 2270
Eucagrac	180	0. 1101	-0. 2527
Geijline	181	0. 1477	-0. 2256
Melapaup	182	0. 1187	-0. 1762
Tetrimpl	183	0. 9950E-01	-0. 2185
Stipdrum	184	0. 2372	-0. 4110E-01
Bromaren	185	0. 2132	-0. 3680E-01
Crasplei	186	0. 2127	-0. 4060E-01
Dantseta	187	0. 2144	-0. 5170E-01
Wurmdioi	188	0. 1605	-0. 4660E-01
Oleamagn	189	0. 9660E-01	-0. 1766
Anagarve	190	0. 9470E-01	-0. 5310E-01
Eucayala	191	0. 5490E-01	-0. 1438
Halopter	192	0. 1446	-0. 7580E-01
Melaquad	193	0. 4580E-01	-0. 1504
Franmusc	194	0. 9920E-01	-0. 9910E-01
Acacance	195	0. 1275	-0. 4960E-01
Atricine	196	0. 1275	-0. 4960E-01
Euphpara	197	0. 1275	-0. 4960E-01
Mesecrys	198	0. 1223	-0. 1715
Myopdese	199	0. 1111	-0. 2010
Scaecras	200	0. 1275	-0. 4960E-01
Stipplat	201	0. 1080	-0. 8570E-01
Athrathr	202	0. 7600E-01	-0. 8440E-01
Helihaig	203	0. 1050	-0. 2310E-01
Olearamo	204	0. 2390E-01	-0. 7540E-01
Atripalu	205	0. 7030E-01	-0. 1755

LABEL	SEQ #	X-VALUE	Y-VALUE
Portquad	206	0. 8450E-01	-0. 1182
Dianrevo	207	0. 4730E-01	-0. 1642
Rhagprei	208	0. 2020E-01	0. 5370E-01
Acacligu	209	-0. 1600E-02	0. 2651
Amyemela	210	0. 4810E-01	-0. 1594
Eremweld	211	0. 4990E-01	-0. 1527
Eucacalc	212	0. 5370E-01	-0. 1262
Eucasoci	213	-0. 5210E-01	-0. 2391
Eucastri	214	0. 1039	-0. 2306
Pomaforr	215	0. 4270E-01	-0. 1573
Eremglab	216	0. 9830E-01	-0. 2314
Acacramu	217	-0. 4150E-01	0. 3444
Ennecyli	218	-0. 4750E-01	0. 2863
Lysimurr	219	-0. 4150E-01	0. 3444
Podocapi	220	-0. 4150E-01	0. 3444
Solaelli	221	-0. 3040E-01	0. 3420
Vitterem	222	0. 1250E-01	0. 3136
Zygoerem	223	-0. 4150E-01	0. 3444
Calaerem	224	-0. 1100E-02	0. 1948
Chencris	225	-0. 1692	0. 2309
Heteolei	226	-0. 3820E-01	0. 3555
Nicogood	227	0. 5360E-01	0. 2065
Acacburk	228	-0. 3700	0. 1428
Acackemp	229	-0. 2972	0. 1704
Ennepoly	230	-0. 7500E-01	0. 2926
Eremalte	231	-0. 7500E-01	0. 2926
Paspcons	232	-0. 2894	0. 2042
Arisbrow	233	-0. 7050E-01	0. 2815
Dodoangu	234	-0. 3691	0. 1370
Eragdiel	235	-0. 2335	0. 1496
Abutcryp	236	-0. 3441	0. 1334
Euphboop	237	-0. 4232	-0. 3000E-03
Mairtrip	238	-0. 4232	-0. 3000E-03
Sidacaly	239	-0. 4444	-0. 3700E-02
Goodocci	240	-0. 4514	-0. 1280E-01
Paspjubi	241	-0. 4141	-0. 1390E-01
Stenspha	242	-0. 4397	0. 2900E-02
Brunaust	243	-0. 4879	-0. 1090E-01
Eremsp.	244	-0. 4879	-0. 1090E-01
Eremsp.	245	-0. 4879	-0. 1090E-01
Ptilexal	246	-0. 4879	-0. 1090E-01
Stenvelu	247	-0. 4879	-0. 1090E-01
Vellrose	248	-0. 4879	-0. 1090E-01
Waitaure	249	-0. 4879	-0. 1090E-01
Beyelech	250	0. 1079	-0. 1852

IF sites in South Australia. Groups 12 and 13 are subsets of Group 11 with a western bias, BA to PL and JU. Group 14 is the northern sandy soil element of the north-western margin (PL, JU) and only a minor leakage of species to MU can be seen. Group 15 is a similar group characterizing the MU sites.

(iii) Single Records - species recorded from only one quadrat
Nearly all single records (after deletion of the 16 spelling errors which were mainly common widespread species), were from peripheral sites on the coastal (35 species) and northern areas (39 species) Appendix II. The other major group of single records was from dongas on the central Nullarbor at FO and HU (Psoralea patens, Psoralea cinerea and Lavatera plebeia).

The largest grouping of "unique" species was on the sand dunes on MU4 or 5 (17 of the 20 unique species from MU were recorded from these sites), and these were basically Great Victoria Desert species (e.g. Dicrastylis beveridgei, Pomax umbellata, Enneapogon clelandii and Stackhousia muricata). In terms of their vegetation and superficial soil cover these quadrats were basically Great Victoria Desert rather than Eucla Basin quadrats.

The unique records (15) from PL are more scattered, as the change into the Great Victoria Desert is less abrupt, no sand dunes being found on any quadrats. The unique species (Alyxia buxifolia, Halgania viscida, Prostanthera baxteri, Helipterum maryonii, Triraphis mollis, Canthium lineare, Halorhagis trigonocarpa, Senecio gregorii, Swainsona kingii, Angianthus milnei, Euphorbia boophthona and Monochather paradoxa) are Great Victoria Desert species largely, but also there is a significant heavy soil component (Cratystylis subspinescens, Maireana pyramidata and Exocarpus sparteus) of the South-western Interzone.

The structurally simple community of the consolidated dune at CO5 contained many different species from the other sandy, near coastal quadrats (MA4, MA5 and KU5) of the Roe Plain (Adriana quadripartita, Myoporum capparioides, Pelargonium littorale, Calandrinia corrigioloides, Ehrharta longifolia and Trachymene pilosa). This was not able to be reflected in the analysis.

A future analysis should be undertaken which considers our flora data from patch types other than the primary patch type, as many had a radically different flora (e.g. CO3 III on the Hampton escarpment).

If it had been possible to include the single records in the analysis, they would cause greater east-west separation of the northern quadrats, and suggest some southern influences at PL. Interestingly, few unique records were found at JU which suggests that for plants it may be too far south of the boundary between the Great Victoria Desert and the Nullarbor Plain, whereas MU5 is the Great Victoria Desert.

Discussion
The absence of discrete clusters in the scattergrams (except for the Roe Plain and coastal sand sites) points to slow gradational changes in plant communities across the study area as has been noted in other chapters of this publication. This is not surprising given the regions low topographic relief, uniform soils and arid climate.

Oespite this, several major groups can be identified, and these relate closely with those noted in the introduction (the major geomorphological zones of Lowry (1970) and hence the vegetational zones of Beard (1975)). The geographic distribution of these vegetation communities across the Nullarbor Study Area is shown in Fig. 34.

(a) Coastal Communities
Most of the pleistocene sand flora of the western Roe Plain is placed within the south-western Interzone by Beard (1975) on the basis of vegetation structure and floristics; its flora has a significant component which also occurs within the south-western interzone (35.5%), yet shares only 18% with the treeless plain. However, the attenuation of the south-western flora across the Roe Plain is gradual so the boundaries shown by Beard (1975) need revision especially since some 33% of the flora is shared with the coastal sands of the South Australian side of the Nullarbor.

The communities of the sea-shore (MA5, YA5 and KU5) contain species also found nowhere else (Scaevola crassifolia, Atriplex cinerea and Euphorbia paralias), as do the cliff top sites KD1, YA5 (however, at least several species found at this site were also at patch III of CO3, the Hampton escarpment, not considered in the analysis).

Succulent shrublands develop on the bottom of the drainage lines, whereas in the central Nullarbor these form dongas and support quite a different vegetation. These succulent shrublands are often poor in perennials though they are rich in annuals during wet seasons (note CO1 with 10 perennials and 30 annuals).

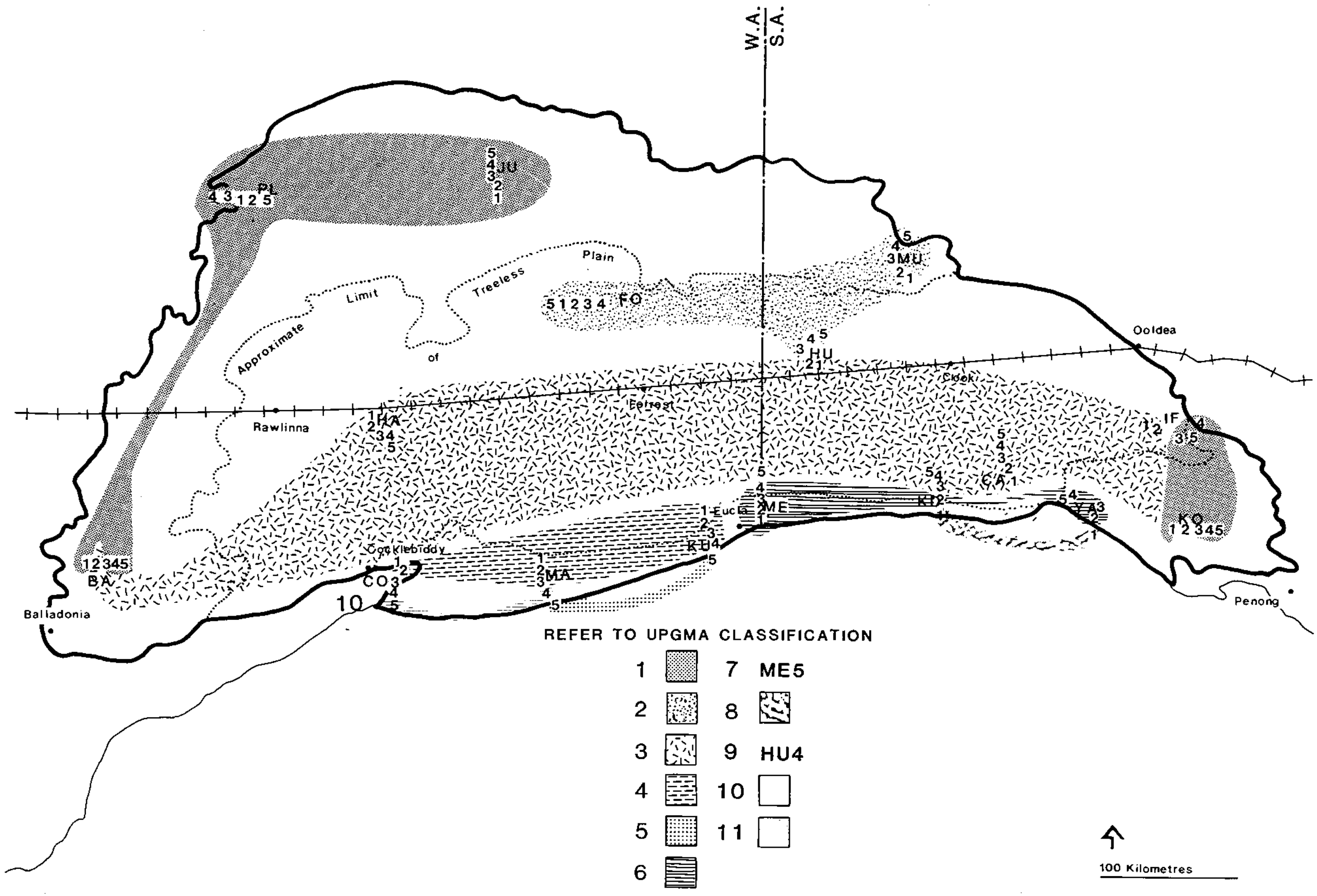
Immediately adjacent to these sites are the coastal woodlands (CO2, MA2, MA3, ME1, ME2, ME3, ME4, KD2, YA1, YA2, YA3, YA4), but these are always distinct from the succulent shrublands.

(b) Coastal Shrublands or Woodlands Above the Roe Plain, or on the South Australian Coastal Fringe
There is a distinct east-west split in these shrublands (CA, KD, KO, IF being one group and CO2, MA2, MA3, KD2, KEI-4 as the other). This split probably reflects the biogeographic affinities of the coastal flora as portrayed in the Two-Way tables and Table 2.

(c) Peripheral Woodlands
The two way tables also clearly show that the perennial flora separates the western, northern and eastern fringing woodlands, whereas the total flora separates the western and north-eastern woodlands. PL and JU are linked by common components, which are widespread along the northern fringes, but upon comparison of unique records the PL sites are very different from those of JU or BA with which they are linked.

(d) Treeless Plain
Two major sub groups are represented here, the western woodlands and treeless plain (BA, HA, CO1, KU, MA) and the degraded sites at FO and HU. The first grouping results from the treeless plain sites being a subset of the widespread shrub species found at BA, but having a more diverse annual component in selected areas (dongas, salt pans or drainage lines). The Eucalyptus oleosa woodlands are relatively species poor at BA due perhaps to extensive grazing and fires. Other sites on the Nyanga and Mardabilla Plains should be sampled for comparison.

Figure 34
GEOGRAPHICAL INTERPRETATION OF PERENNIAL PLANT SPECIES QUADRAT GROUPS (UPGMA) ACROSS THE NULLARBOR STUDY AREA



The species poor sites at FO and HU ravaged by fires and rabbits, demonstrated two features of the plain that may deserve further consideration. They had a high proportion of the Nullarbor endemics present on them which were not found at HA and they contained unique suites of species in the donga sites. Dongas were not adequately sampled during our survey, yet the deep soils and higher soil moistures generated at these sites allow species not normally present on the treeless plain to penetrate far into it. Ideally it would be desirable to sample a series of dongas peripheral to the central plain to ascertain the phytogeographic importance of these sites, and their conservation value.

TABLE 3: TOTAL KNOWN FLORA OF THE EUCLA BASIN, AND ITS MARGINS

Widgie-Zanthus list from Newbey and Hnatiuk (1985)
Great Victoria Desert from Jessop (1981)
Base data held at Woodvale

	WIDGIE/ZANTHUS	GRT.VIC DESERT	NYANGA	MARDABILLA	HAMPTON	ROE PLAIN	W. NULLARBOR	CARLISLE PLAIN	E. COASTAL	E. NULLARBOR	E. No.	S. EAST	ON
Pteridophyta	7	7	2	1	2	-	-	-	1	-	-	-	-
Gymnosperms	2	1	-	-	1	1	-	-	-	-	1	1	-
TOTAL	9	8	2	1	3	1	-	-	1	-	1	1	-
MONOCOTS													
Zannichelliaceae	-	-	-	-	-	1	-	-	1	-	-	-	-
Zosteraceae	-	-	-	-	-	-	-	-	1	-	-	1	-
Posidoniaceae	-	-	-	-	-	1	-	-	1	-	-	1	-
Juncaginaceae	3	-	2	2	-	1	-	-	1	-	1	1	1
Poaceae	18	31	14	1	17	8	20	3	8	12	22	15	13
Cyperaceae	10	4	1	-	4	7	-	-	1	-	-	-	-
Restionaceae	-	-	-	1	-	3	-	-	-	-	-	-	-
Centrolepidaceae	5	-	1	-	-	-	-	-	-	-	-	-	-
Juncaceae	2	-	1	-	-	-	-	-	-	-	-	-	-
Liliaceae	12	7	4	2	6	2	1	-	2	1	2	1	2
Hypoxidaceae	2	-	-	-	-	-	-	-	-	-	-	-	-
Orchidaceae	8	1	1	-	4	7	-	-	2	1	-	1	-
TOTAL	60	43	24	6	31	31	22	3	17	14	25	20	26
DICOTYLEDONS (TOTAL)	476	355	287	97	198	192	145	91	141	103	231	176	209
Casuarinaceae	6	1	2	1	2	-	-	1	-	-	-	-	-
Urticaceae	1	-	-	1	-	1	-	-	2	-	1	-	1
Proteaceae	16	10	1	2	11	6	1	1	1	-	1	2	5
Santalaceae	5	6	2	4	4	3	2	3	3	-	1	3	1
Loranthaceae	3	5	2	1	5	3	5	5	4	3	7	-	-
Viscaceae	-	-	-	-	-	-	-	-	-	-	-	-	1

Polygonaceae	2	-	3	-	-	2	2	-	-	1	1	1	-
Chenopodiaceae	54	31	31	3	24	28	22	16	28	16	35	24	28
Amaranthaceae	10	5	9	-	2	2	1	3	-	1	4	2	4
Nyctaginaceae	-	1	-	-	-	-	-	-	-	-	-	-	-
Gyrostemonaceae	-	1	-	-	-	-	-	1	-	-	-	-	-
Aizoaceae	7	2	5	2	3	6	1	-	3	-	2	-	2
Portulacaceae	6	3	3	2	2	2	-	2	-	-	4	3	3
Caryophyllaceae	3	1	1	-	1	-	-	-	-	-	1	-	-
Ranunculaeae	2	-	-	-	-	-	-	-	-	-	-	-	-
Lauraceae	1	-	-	-	-	2	-	-	-	-	1	-	-
Papaveraceae	-	-	-	-	-	-	?	-	-	-	-	-	1
Brassicaceae	17	9	9	-	7	8	10	4	9	4	9	13	8
Droseraceae	5	-	2	-	-	-	-	-	-	-	-	-	-
Crassulaceae	6	2	2	1	1	4	-	-	-	4	-	3	-
Pittosporaceae	1	1	1	-	3	2	1	-	1	1	1	1	1
Oleaceae	-	2	-	-	-	-	-	-	-	-	-	-	-
Mimosaceae	31	25	15	1	3	7	6	14	6	3	11	15	11
Caesalpiniaceae	4	3	2	-	TC	1	-	1	-	-	1	-	1
Fabaceae	14	25	8	2	7	5	11	2	3	1	15	6	7
Geraniaceae	4	1	6	-	1	2	6	-	1	1	4	-	5
Oxalidaceae	1	-	-	-	1	-	1	-	-	-	-	-	-
Zygophyllaceae	7	3	8	1	7	7	2	3	5	2	6	4	3
Rutaceae	6	1	6	6	5	4	1	-	3	-	2	3	1
Polygalaceae	2	-	-	-	1	1	-	-	-	-	-	-	-
Euphorbiaceae	7	4	4	-	3	4	1	-	1	1	4	2	4
Stackhousiaceae	2	2	-	-	-	1	-	-	-	-	1	-	-
Sapindaceae	8	5	6	3	4	1	1	1	3	-	3	5	4
Rhamnaceae	6	2	2	4	5	5	-	-	-	-	-	1?	-
Malvaceae	6	4	12	2	6	5	6	4	-	9	9	3	8
Sterculiaceae	5	2	5	-	-	-	-	2	-	-	-	-	-
Dilleniaceae	-	-	-	1	1	2	-	-	-	-	-	-	1
Clusiaceae	-	-	1	-	-	-	-	-	-	-	-	-	-
Elatinaceae	1	1	-	-	-	-	-	-	-	-	-	-	-
Frankeniaceae	4	3	6	2	4	5	2	-	6	5	3	4	4
Violaceae	2	-	1	-	-	-	-	-	-	-	-	-	-
Thymelaeaceae	2	2	2	1	2	2	1	1	-	-	2	2	2
Myrtaceae	57	43	20	14	13	25	2	3	9	2	13	14	9
Haloragaceae	2	4	-	-	-	-	-	-	1	-	1	-	-
Apiaceae	9	2	4	-	2	2	1	-	2	1	-	-	-

Epacridaceae	2	-	-	1	3	4	-	-	1	-	-	-	-
Primulaceae	1	-	1	-	1	1	-	-	1	-	-	1	-
Oleaceae	-	2	-	-	-	-	-	-	-	-	-	-	-
Loganiaceae	1	1	-	-	-	1	-	-	-	-	1	-	1
Gentianaceae	-	-	-	-	1	-	-	-	-	-	-	-	-
Apocynaceae	1	-	1	-	-	-	-	1	-	-	1	-	-
Asclepiadaceae	1	-	1	-	-	-	1	-	-	-	-	-	-
Convolvulaceae	1	1	2	1	-	-	1	1	2	-	1	-	2
Boraginaceae	11	-	4	-	3	2	3	-	1	1	2	2	4
Chloanthaceae	-	21	-	-	-	-	-	3	-	-	2	1	3
Lamiaceae	9	5	5	2	3	2	2	1	-	1	2	2	2
Solanaceae	8	15	11	2	3	3	7	-	4	5	10	8	9
Scrophulariaceae	2	3	2	2	-	-	-	-	-	-	-	1	-
Martyniaceae	-	-	1	-	-	-	-	-	-	-	-	-	-
Myoporaceae	22	30	14	2	11	7	7	8	7	4	14	12	15
Plantaginaceae	2	2	1	-	1	1	1	-	-	1	-	1	-
Rubiaceae	1	-	-	1	1	1	-	-	-	1	1	1	1
Dipsacaceae	-	-	-	-	1	-	-	-	-	-	-	-	-
Cucurbitaceae	-	-	-	-	-	-	1	-	-	-	-	-	-
Campanulaceae	3	-	1	-	1	1	-	-	-	-	-	1	-
Lobeliaceae	2	-	1	-	-	-	-	-	-	-	-	-	-
Goodeniaceae	16	21	5	10	4	4	2	-	3	3	10	4	7
Stylidiaceae	-	3	1	2	-	-	-	-	-	-	-	-	-
Asteraceae	68	39	53	16	23	17	31	10	29	31	39	30	48
TOTAL	545	406	313	104	232	224	167	94	159	117	257	197	225

TABLE 4: TOTAL KNOWN FLORA OF REGIONS ADJACENT TO THE EUCLA BASIN IN SOUTH AUSTRALIA (FROM JESSOP 1984)

Key: Introduced species in parenthesis
NW: Great Victoria Desert
GT: Gardiner-Torrens Region
EP: Eyre Peninsula
base data held at Woodvale

TAXON	NW	GT	EP
Pteridophyta	8	4	9
Gymnosperms	9	5	14(1)
TOTAL	17	9	23(1)
Casuarinaceae	3	3	4
Moraceae	1	-	-
Urticaceae	1	1	2(1)
Proteaceae	7	7	17
Olacaceae	-	-	1
Santalaceae	4	4	7
Loranthaceae	9	7	7
Polygonaceae	2(1)	7(3)	18(1)
Gyrostemonaceae	1	2	5
Nyctaginaceae	-	1	1
Aizoaceae	4	13(1)	18(7)
Portulacaceae	7	7	5
Caryophyllaceae	2(1)	4(3)	16(14)
Chenopodiaceae	79(2)	101(2)	104(3)
Amaranthaceae	19	12	13(1)
Lauraceae	-	1	4
Ranunculaceae	1	1	9(5)
Dilleniaceae	1	2	7
Hypericaceae	-	-	2(1)
Droseraceae	1	-	5
Papaveraceae	-	-	5(5)
Fumariaceae	-	-	7(7)
Capparaceae	1	-	1
Brassicaceae	18(4)	25(6)	49(24)

Resedaceae	-	-	2(2)
Crassulaceae	2	4	9(1)
Pittosporaceae	1	1	12
Rosaceae	-	-	10(4)
Mimosaceae	32	22(1)	55
Caesalpiniaceae	11	7	5
Fabaceae	42(1)	34(1)	80(22)
Oxalidaceae	2(1)	1	6(5)
Geraniaceae	6	7(3)	17(8)
Zygophyllaceae	13(1)	9	13(1)
Linaceae	-	-	2(1)
Euphorbiaceae	8	6	19(5)
Rutaceae	1	6	15
Polygalaceae	1	-	4(1)
Anacardiaceae	-	-	1(1)
Sapindaceae	5	6	12
Stackhousiaceae	2	1	5
Rhamnaceae	-	1	23(1)
Malvaceae	26(2)	23(2)	26(4)
Sterculiaceae	6	1	9
Thymelaeaceae	4	3	18
Violaceae	1	1	2
Tamaricaceae	-	-	1
Frankeniaceae	4	9	9
Elatinaceae	-	-	1
Cucurbitaceae	3(2)	3(2)	3(3)
Lythraceae	-	1	1
Myrtaceae	42	27	56
Onagraceae	-	-	3(1)
Haloragaceae	8	1	26
Umbelliferae	4	7	23(4)
Ericaceae	-	-	1(1)
Epacridaceae	-	1	10
Primulaceae	1	1	2(1)
Limoniaceae	-	-	3(3)
Oleaceae	1	1	2(1)
Loganiaceae	-	1	7
Gentianaceae	-	2	5(3)
Apocynaceae	-	-	1

Ascelpiadaceae	4	3	4(2)
Rubiaceae	5	3	8(3)
Convolvulaceae	5	2	8(2)
Boraginaceae	5(1)	6(2)	14(3)
Ehretiaceae	1	2	2
Verbenaceae	1(1)	1(1)	1(1)
Avicenniaceae	-	-	1
Chloanthaceae	10	4	2
Lamiaceae	10(1)	5	23(5)
Solanaceae	20	20(2)	34(13)
Scrophulariaceae	6	5	20(6)
Bignoniaceae	1	-	-
Acanthaceae	1	-	-
Pedaliaceae	1	-	-
Orobanchaceae	-	1	1
Myoporaceae	26	23	24
Plantaginaceae	2	2	9(4)
Valerianaceae	-	-	1(1)
Dipsacaceae	-	-	1(1)
Campanulaceae	6	5	7
Goodeniaceae	29	11	30
Stylidiaceae	-	-	4
Asteraceae	109(3)	117(4)	213(44)
TOTAL DICOTS	629(21)	599(32)	1213(236)
MONOCOTYLEDONS			
Hydrocharitaceae	-	-	2
Juncaginaceae	2	2	7
Potamogetonaceae	-	-	2
Posidoniaceae	-	-	1
Ruppiaceae	-	-	3
Zosteraceae	-	-	2
Zannichelliaceae	-	-	4
Liliaceae	5	7	35(7)
Amaryllidaceae	1	3	1
Hypoxidaceae	-	-	2
Iridaceae	-	-	13(12)
Juncaceae	1	1	8(2)
Restionaceae	-	-	3

Centrolepidaceae	1	-	4
Hydatellaceae	-	-	1
Poaceae	93(9)	63(4)	113(49)
Typhaceae	1	-	-
Cyperaceae	16	13(1)	46(3)
Orchidaceae	-	3	57
TOTAL MONOCOTS	120(9)	92(5)	304(73)
TOTAL FLORA	766(30)	700(37)	1540(310)

SUMMARY

Percentage of Total Flora

	NW	GT	EP	NW/GT	NW/EP	GT/EP	GT/EP/NW
Dicotyledons	6.5	3.9	20.4	6.7	4.9	16.5	41.1
Monocotyledons	4.8	3.2	24.2	19.4	4.8	14.5	29.0

TABLE 5: A COMPARISON OF QUADRAT GROUPS FROM PERENNIAL PLANT ANALYSIS, WITH PREVIOUS LAND SYSTEM AND VEGETATION MAPPING IN THE EUCLA BASIN

Perennial Plant Species Quadrat Groups (this study)	*Land Zone	+Structural Vegetation Type
1 Eucalypt, Mulga or Casuarina woodlands		Thickly wooded succulent steppe al, C_2, Li, k_2, Ci
2 Myall woodlands and treeless plain interface	Nullarbor	Lightly wooded succulent steppe al3, Lr, k, Ci
3 Treeless Plain	Hampton	Unwooded succulent steppe k_1, Ci, k_2, Ci
4 Southern low Myall, Mallee and Melaleuca	Roe	Shrubland e_{36}, Si
5 Unconsolidated dunes of the Roe Plain	Roe	Shrubland ea, Si
6 South Australian southern Myall, Mallee woodlands	-	-
7 Species poor site on central treeless plain	-	-
8 S.A. coastal cliff top sites	-	-
9 Disturbed species poor doline of central treeless plain	-	-
10 Consolidated sub-coastal dunes of the Roe Plain	Roe	Shrubland ea, Si
11 Near coastal dunes of the Roe Plain	Roe	Shrubland ea, Si

* classification of Mitchell et al. 1979
\+ classification of Beard 1970

Table 6

TWO-WAY TABLE OF PERENNIAL PLANT ANALYSIS

UPGMA Quadrat Groups

Quadrat groups: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

BBBBIIIKKKKJJJJJPPPPP FFFFFHHMMMMM BHHHHHHHHIICCCCCKKCKK CMMKKMMKK KM KYYYYMMMM M KY H CC CM
AAAAFFFOOOOUUUUULLLLL OOOOOUUUUUUU AAAAAAAUUFFAAAOADDAOD OAAUUAAUU UA DAAAAEEEE E DA U OO OA
134535413451234512534 124353512345 212465312121341245523 223311624 55 212431234 5 15 4 34 54

UPGMA Species Groups

Group	Species
1	Acacia papyrocarpa
	Santalum acuminatum
	Atriplex vesicaria
	Maireana erioclada
	Enchylaena tomentosa
	Acacia oswaldii
	Cratystylis conocephala
	Myoporum platycarpum
	Heterodendrum oleaefolium
	Eremophila scoparia
	Maireana sedifolia
	Rhagodia spinescens
	Salsola kali
	Sclerolaena diacantha
	Lycium australe
	Sclerolaena obliquicuspis
	Atriplex acutibractea
	Sclerostegia disarticulata
	Eriochiton sclerolaenoides
	Sclerolaena patenticuspis
	Atriplex nummularia
	Pittosporum phyllireaoides
	Lysiana exocarpi
	Maireana radiata
	Sclerolaena brevifolia
	Amyema fitzgeraldii
	Cassia sturtii
2	Acacia nyssophylla
	Minuria cunninghamii
	Amyema quandang
	Atriplex stipitata
	Cassia artemissioides
3	Maireana turbinata
	Atriplex eardleyae
	Acacia acuminata
	Eremophila longifolia
	Eremophila maculata
	Atriplex cryptocarpa
4	Gunniopsis calcarea
	Rhagodia ulicina
	Nitraria billardierei
	Sclenothamnus squamatus
	Frankenia muscosa
	Disphyma crassifolium
5	Casuarina cristata
	Acacia aneura
	Sida corrugata
	Acacia tetragonophylla
	Cassia artemissioides
	Ptilotus obovatus
	Acacia burkittii
	Dodonaea angustissima
	Acacia kempeana
	Eremophila decipiens
	Maireana sclerolaenoides
	Cassia nemophila
	Solanum lasiophyllum
	Maireana triptera
	Sida calyxhymenia
	Maireana trichophora
	Santalum spicatum
	Eremophila sp. 2
	Eremophila sp. 2
6	Comesperma volubile
	Acacia ligulata
	Acacia ramulosa
	Lysiana murrayi
	Solanum ellipticum
	Eremophila alternifolia
7	Eucalyptus oleosa
	Olearia muelleri
	Rhagodia crassifolia
	Scaevola spinescens
	Exocarpos aphyllus
	Dodonaea stenozyga
	Eucalyptus socialis
	Threlkeldia diffusa
	Sclerolaena uniflora
	Olearia magniflora
	Westringia rigida
	Geijera linearifolia
	Melaleuca pauperiflora
	Eucalyptus gracilis
	Eucalyptus striaticalyx
	Eremophila glabra
	Tetragonia implexicoma
8	Atriplex paludosa
	Beyeria lechenaultii
9	Templetonia retusa
10	Cassytha melantha
	Dianella revoluta
	Amyema melaleucae
	Eremophila weldii
	Eucalyptus calcareana
	Pomaderris forrestiana
	Eucalyptus yalatensis
11	Geijera parviflora
	Nitraria billardierei
	Maireana oppositifolia
	Frankenia muscosa
	Halosarcia pterygosperma
12	Frankenia densa
	Melaleuca lanceolata
	Myoporum deserti
	Melaleuca quadrifaria
	Olearia ramossima
13	Acacia cyclops
	Acacia anceps
	Atriplex cinerea
	Scaevola crassifolia
	Myoporum insulare
	Muehlenbeckia adpressa
	Rhagodia preissii
14	Eucalyptus rugosa
	Rhagodia candolleana
15	Adenanthos forrestii
	Beaufortia micrantha
	Boronia crassifolia
	Conostephium drummondii
	Gahnia lanigera
	Lepidosperma viscidum
	Loxocarya flexuosa
	Lysinema ciliatum
	Pomaderris myrtilloides
	Callitris preissii
	Dodonaea viscosa
	Eucalyptus incrassata
	Eucalyptus diversifolia
	Eucalyptus foecunda
	Acacia cochlearis
	Acacia nitidula
	Hakesa nitida

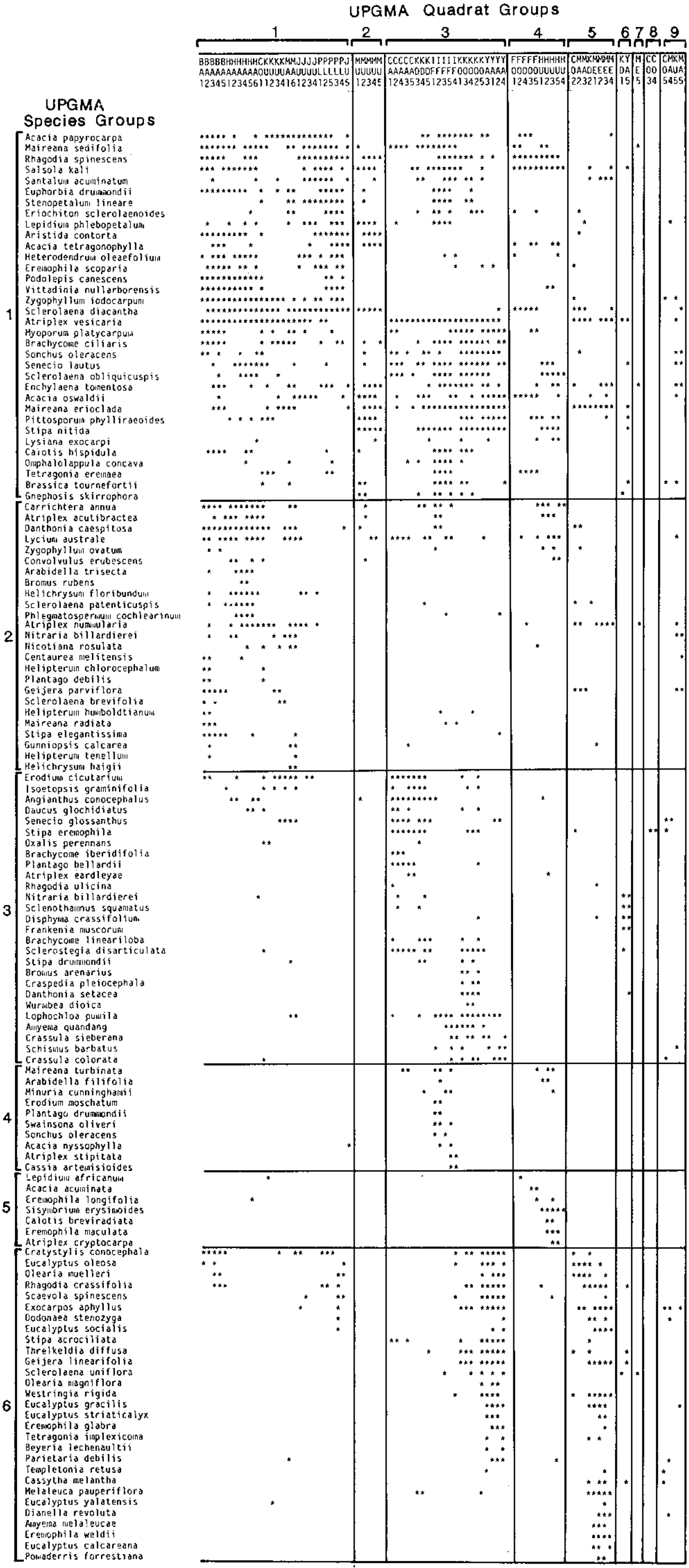
*** NODA TOTALS ***

TABLE 7: SPECIES RICHNESS OF PERENNIALS AND TOTAL FLORA PER QUADRAT

Quadrat	Perennials	Total
BA 1	16	34
2	9	38
3	21	34
4	22	34
5	24	34
HA 1	11	24
2	10	25
3	10	27
4	14	32
5	18	32
6	15	25
PL 1	24	38
2	23	46
3	31	57
4	30	61
5	22	46
JU 1	13	19
2	15	28
3	17	32
4	17	32
5	13	24
CO 1	10	30
2	16	24
3	17	19
4	18	21
5	23	36
CA 1	9	21
2	10	21
3	5	17
4	6	13
5	6	11
FO 1	8	9
2	7	9
3	9	10
4	6	8
5	18	25

MA 1	14	32
2	16	22
3	15	18
4	11	21
5	18	29
6	14	32
KU 1	11	17
2	9	16
3	15	22
4	11	19
5	18	30
ME 1	17	17
2	23	23
3	28	28
4	18	19
5	4	4
KD 1	10	12
2	20	21
3	7	24
4	13	24
5	12	16
YA 1	25	32
2	21	34
3	23	32
4	23	33
5	15	21
IF 1	8	31
2	12	36
3	15	31
4	23	25
5	22	41
MU 1	12	25
2	18	46
3	20	32
4	26	41
5	20	41
HU 1	7	14
2	9	17
3	14	24

	4	2	4
	5	13	19
KO	1	15	34
	2	5	-
	3	16	30
	4	19	36
	5	31	38


UPGMA Quadrat Groups
1 2 3 4 5 6 7 8 9
BBBBBHHHHHHCKKKKMMJJJJPPPPPJ MMMMM CCCCCKKKIIIIIKKKKKYYYY FFFFFHHHHH CMMKMMMM KY M CC CMKM
AAAAAAAAAAAOUUUUAAUUUULLLLLU UUUUU AAAAADDDFFFFFOOOOOAAAA OOOOOUUUUU OAADEEEE DA E OO OAUA
12345123456112341612341253 45 12345 12435345123541342531 24 1243512354 22321234 15 5 34 5455
UPGMA Species Groups
1
Acacia papyrocarpa
Maireana sedifolia
Rhagodia spinescens
Salsola kali
Santalum acuminatum
Euphorbia drummondii
Stenopetalum lineare
Eriochiton sclerolaenoides
Lepidium phlebopetalum
Aristida contorta
Acacia tetragonophylla
Heterodendrum oleaefolium
Eremophila scoparia
Podolepis canescens
Vittadinia nullarborensis
Zygophyllum iodocarpum
Sclerolaena diacantha
Atriplex vesicaria
Myoporum platycarpum
Brachycome ciliaris
Sonchus oleracens
Senecio lautus
Sclerolaena obliquicuspis
Enchylaena tomentosa
Acacia oswaldii
Maireana erioclada
Pittosporum phylliraeoides
Stipa nitida
Lysiana exocarpi
Calotis hispidula
Omphalolappula concava
Tetragonia eremaea
Brassica tournefortii
Gnephosis skirrophora
2
Carrichtera annua
Atriplex acutibractea
Danthonia caespitosa
Lycium australe
Zygophyllum ovatum
Convolvulus erubescens
Arabidella trisecta
Bromus rubens
Helichrysum floribundum
Sclerolaena patenticuspis
Phlegmatospermum cochlearinum
Atriplex nummularia
Nitraria billardierei
Nicotiana rosulata
Centaurea melitensis
Helipterum chlorocephalum
Plantago debilis
Geijera parviflora
Sclerolaena brevifolia
Helipterum humboldtianum
Maireana radiata
Stipa elegantissima
Gunniopsis calcarea
Helipterum tenellum
Helichrysum haigii
3
Erodium cicutarium
Isoetopsis graminifolia
Angianthus conocephalus
Daucus glochidiatus
Senecio glossanthus
Stipa eremophila
Oxalis perennans
Brachycome iberidifolia
Plantago bellardii
Atriplex eardleyae
Rhagodia ulicina
Nitraria billardierei
Sclerothamnus squamatus
Disphyma crassifolium
Frankenia muscorum
Brachycome lineariloba
Sclerostegia disarticulata
Stipa drummondii
Bromus arenarius
Craspedia pleiocephala
Danthonia setacea
Wurmbea dioica
Lophochloa pumila
Amyema quandang
Crassula sieberana
Schismus barbatus
Crassula colorata
4
Maireana turbinata
Arabidella filifolia
Minuria cunninghamii
Erodium moschatum
Plantago drummondii
Swainsona oliveri
Sonchus oleracens
Acacia nyssophylla
Atriplex stipitata
Cassia artemisioides
5
Lepidium africanum
Acacia acuminata
Eremophila longifolia
Sisymbrium erysimoides
Calotis breviradiata
Eremophila maculata
Atriplex cryptocarpa
6
Cratystylis conocephala
Eucalyptus oleosa
Olearia muelleri
Rhagodia crassifolia
Scaevola spinescens
Exocarpos aphyllus
Dodonaea stenozyga
Eucalyptus socialis
Stipa acrociliata
Threlkeldia diffusa
Geijera linearifolia
Sclerolaena uniflora
Olearia magniflora
Westringia rigida
Eucalyptus gracilis
Eucalyptus striaticalyx
Eremophila glabra
Tetragonia implexicoma
Beyeria lechenaultii
Parietaria debilis
Templetonia retusa
Cassytha melantha
Melaleuca pauperiflora
Eucalyptus yalatensis
Dianella revoluta
Amyema melaleucae
Eremophila weldii
Eucalyptus calcareana
Pomaderris forrestiana

CONTINUED FROM PREVIOUS PAGE

Noda	Species	A	B	C	D	E	F	G	H
7	Crassula exserta	*							*
8	Pterostylis mutica					*		*	
	Adenanthos forrestii							**	
	Beaufortia micrantha							**	
	Boronia crassifolia							**	
	Conostephium drummondii							**	
	Gahnia lanigera							**	
	Lepidosperma viscidum							**	
	Loxocarya flexuosa							**	
	Lysinema ciliatum							**	
	Pomaderris myrtilloides							**	
	Thysanotus patersonii							**	
	Callitris preissii							**	*
	Dodonaea viscosa							**	*
	Eucalyptus incrassata							**	*
	Eucalyptus diversifolia							*	*
	Eucalyptus foecunda							*	*
	Acacia cochlearis							*	*
	Acacia nitidula							*	*
9	Frankenia densa	* *		* *		**			*
	Myoporum deserti			*		*			*
	Atriplex paludosa			*		*			
	Melaleuca quadrifaria	*				** *			
	Athrixia athrixoides	*				**			
	Olearia ramosissima					**			
10	Acacia cyclops					*			**
	Acacia anceps								**
	Atriplex cinerea								**
	Euphorbia paralias								**
	Scaevola crassifolia								**
	Mesembryanthemum crystallinum			*					**
	Anagallis arvensis	*							*
	Maireana oppositifolia	*					*		*
	Frankenia muscorum	*				*			*
	Halosarcia pterygosperma	***					*		*
	Stipa platychaeta	*							**
	Portulacca quadrifaria	*				*			* *
	Eucalyptus rugosa	*				*		*	****
	Rhagodia candolleana			*		*			***
	Melaleuca lanceolata	*		***		***	*	*	** *
	Hakea nitida							*	**
	Triglochin calcitrapum								**
	Carpobrotus rossii								****
	Carpobrotus modestus								****
	Myoporum insulare								* *
	Muehlenbeckia adpressa								* *
	Rhagodia preissii		*						* *
11	Casuarina cristata	* ******	* **						
	Acacia aneura	* ********	*****		* *				
	Sida corrugata	** * ****	*****						
	Helipterum fitzgibbonii	*****	*****	*****					
	Cassia artemisioides	** **	***	* *					
	Clianthus formosus	** **	**						
	Zygophyllum aurantiacum	* ***** ***				**			*
	Cassia nemophila	** *********			*				
	Eragrostis eriopoda	* ** **			*				
	Enneapogon caerulescens	*** *** *	*						
	Helichrysum ayersii	********							
	Ptilotus obovatus	* ********	***	* ** *					
	Maireana trichoptera	* * *******		*** *		*			
	Santalum spicatum	* ***** **	*	* *					
	Eragrostis dielsii	**	*						
	Cephalipterum drummondii	** *	**	***					
	Chenopodium cristatum	*	*						
12	Goodenia pinnatifida	* ** * *** *							
	Swainsona campestris	* ***							
	Enneapogon nigricans	* **** *			* *				
	Acacia aff. papyrocarpa	* * *							
	Cassia sturtii	***							
	Enneapogon avenaceus	** ** *	*						
13	Eremophila decipiens	* ** ****							
	Helichrysum floribundum	* ** * ***							
	Amyema fitzgeraldii	** *							
	Maireana sclerolaenoides	* *							
	Calotis multicaulis	* *							
	Helipterum strictum	* *							
14	Calandrinia calyptrata	* ***							*
	Triodia scariosa	**				*			
	Brunonia australis	**							
	Eremophila sp. 2	**							
	Eremophila sp. 2	**							
	Ptilotus exaltatus	**							
	Stenopetalum velutinum	**							
	Velleia rosea	**							
	Waitzia aurea	**							
	Erodium cygnorum	* *** **							
	Solanum lasiophyllum	******							
	Euphorbia boophthona	*****							
	Maireana triptera	*****							
	Sida calyxhymenia	* ***							
	Stenopetalum sphaerocarpum	****							
	Ptilotus gaudichaudii	****							
	Goodenia occidentalis	* **			*				
	Paspalidium jubiflorum	* *							
	Ptilotus polystachyus	***	* *						
	Acacia burkittii	**	**						
	Dodonaea angustissima	**	**						
	Abutilon cryptopetalum	*	*						
	Acacia kempeana	*	**						
	Paspalidium constrictum	*	**						
15	Comesperma volubile		**						**
	Waitzia acuminata	*	*						
	Swainsona oroboides		*		* *				
	Vittadinia eremaea		**						
	Nicotiana goodspeedii		*				*		
	Euphorbia tannensis		*	*					
	Acacia ligulata		** **						*
	Acacia ramulosa		*****						
	Lysiana murrayi		*****						
	Podolepis capillaris		*****						
	Zygophyllum eremaeum		*****						
	Solanum ellipticum		** **						
	Enneapogon cylindricus		* * *						
	Heterodendrum oleaefolium		* *						
	Enneapogon polyphyllus		**						
	Eremophila alternifolia		**						
	Aristida browniana		**						
	Calandrinia eremaea		* **	*					

*** NODA TOTALS ***

COLUMN GROUPS

Table 8

TWO-WAY TABLE OF TOTAL FLORA ANALYSIS

MAMMALS

L.J. Boscacci,& N.L. McKenzie & C.M. Kemper

Background

This account comprises a review of the mammals known as extant from the Nullarbor Study Area (Fig. 1) since European settlement and presents the results of our surveys there from March 27 to April 20 and from September 10 to October 8, 1984. Voucher specimens from our 1984 surveys are lodged in the Western Australian and South Australian Museums.

There has been no previous attempt to comprehensively inventory this fauna; the annotated list derived from our review has been compiled from several sources:

(a) accounts of early explorers to the region;

(b) specimens collected from scattered localities and lodged in the collections of the South Australian, Western Australian and Australian Museums; and

(c) opportunistic observations on native and introduced mammals by several zoologists who spent varying periods on the Nullarbor.

Tate's (1879) account of his expedition along the coastal region of the Nullarbor, from the Head of the Bight in South Australia to the vicinity of Eucla, Western Australia, included brief observations on the abundance, habitat and habits of five native mammal species. The account however, was purely descriptive and no specimens were collected to substantiate sightings. As a result, the identity of one species observed - Bettongia campestris (sic) (synonymous with Caloprymnus campestris, Dixon 1973) cannot be confirmed.

Records of mammals from the Nullarbor in the South Australian Museum are scant, derived from few localities and in some cases can only be tentatively assigned to the Nullarbor. With few exceptions records pre-date 1930 and post-date 1960.

In South Australia the majority of records of ground mammals are from Ooldea, where zoologist F. Wood Jones and residents Daisy M. Bates (1863-1951) and A.G. Bolam procured specimens for the South Australian, Western Australian and Australian Museums during the 1920s and 1930s. The position of Ooldea, on a sharp interface between the Nullarbor Study Area and the Great Victoria Desert, presents difficulties in assigning records to the Study Area since specimens could have come from a vast area around Ooldea itself. In the collated species inventory presented later, Ooldea records are indicated and their reference to the Nullarbor Study area is qualified in the text where appropriate.

The earliest record that can be assigned to the Study Area, excluding Ooldea records, is of Lasiorhinus latifrons, the Southern Hairy-nosed Wombat. One specimen was collected at Yalata and registered in the South Australian Museum in 1914. In 1921, the Curator of Mammals at the Australian Museum, Ellis Troughton, worked along the transcontinental railway line from Ooldea to Fisher. He collected a series of specimens of Leporillus conditor, the Greater Stick-nest Rat, which subsequently provided the basis of his revision of the genus (Troughton 1923). His field observations produced comprehensive notes on the habits of the species and the first photograph of a Stick-nest Rat (Troughton 1924).

No records exist for the period 1932 to 1960. The few records available since 1960 are from Nullarbor Station and several caves in the south-western region of the Nullarbor Study Area in South Australia.

There are even fewer early records from Western Australia. The earliest was Notomys mitchellii (Mitchell's Hopping Mouse) collected at Balladonia in 1925.

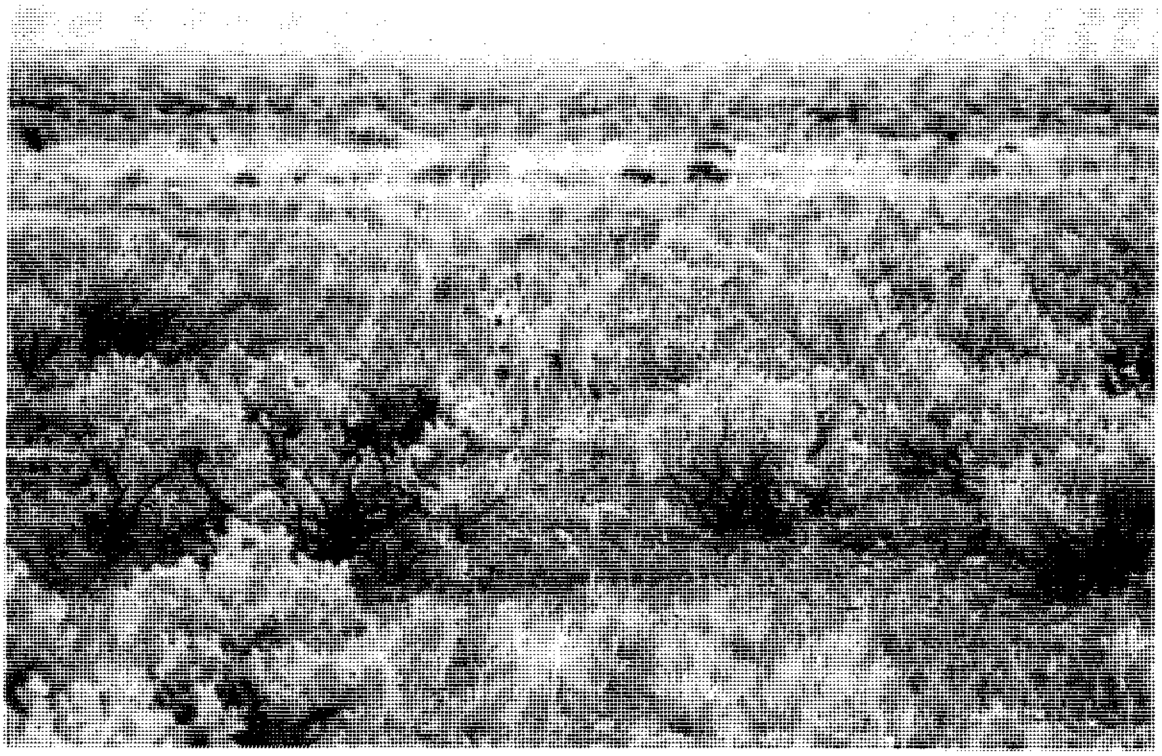
An important collection, comprising seven ground mammal species from near Rawlinna, was presented to the Australian Museum by A.S. Le Souef of Taronga Park Zoo, Sydney. The Museum acknowledged receipt of the specimens on August 2, 1928 (L. Gibson, Aust. Museum, pers. comm. 1985). Our further research since June 1984 has established that these specimens were collected by W.A. Wills in 1927 and/or 1928 while he was working as a dingo trapper north and south of Rawlinna (W.A. Wills, pers. comm. 1985). The original correspondence between the Australian Museum and J.G. Wills, a brother of W.A. Wills, who despatched the specimens from Rawlinna, is held in the archives of the Australian Museum.

Wills stated that all the animals he caught, shot or trapped came from the surrounds of Rawlinna; he also notes that he set his traps "40 miles north and 80 miles south of Rawlinna". We have not been able to more precisely define the area covered by Wills during his dingo trapping rounds, so we interpret the collection to be from the tract of country he trapped. Western and eastern limits cannot be applied but our correspondence indicates his trapping activities were confined to the Treeless Plain. Based on Beard's vegetation map of the Nullarbor (Beard 1975), the country around Rawlinna to more than 80 miles (128 km) south is Treeless (Nullarbor) Plain (succulent steppe of open Bluebush Maireana sedifolia plain with saltbush), and the point 40 miles (64 km) north is lightly wooded steppe of Myall (Acacia papyrocarpa) and Bluebush. The latter vegetation type is typical of the northern, western and eastern fringes of the Nullarbor. All points fall within the Nullarbor Study Area, although Wills' southern limit is close to areas lightly wooded with Eucalypt trees.

More recently, from 1967 to 1976, Brooker (1977) recorded opportunistic observations on the habitat distribution and abundance of eight native and seven introduced mammals in three areas within 150 km of Rawlinna. His analysis of the stomach contents of cats and foxes provided some indication of the ecological role of these feral species in the region.

There is reason to believe that major changes in the mammal fauna since European settlement observed throughout Australia in semi-arid and arid areas (Calaby 1971, Poole, Aitkin, Archer & Watts in Tyler 1978; Burbidge and Fuller 1979; McKenzie 1981), have also occurred on the Nullarbor. Significantly, six of the seven species collected by Wills have not since been recorded from the Nullarbor (see annotated list herein).

The small carnivorous marsupial Sminthopsis dolichura, only described as a distinct species in 1984. It was collected at a number of sites in the woodland fringes of the Nullarbor.
Photo D. Carter.



The Dingo, Canis familiaris dingo, a commonly encountered animal in all Nullarbor habitats. It is probably a major predator of rabbits in the area.
Photo A. Robinson.

The native rodent Pseudomys hermannsburgensis, a common and widespread small mammal in arid Australia, was collected from the northern woodland finges of the Nullarbor. Photo D. Carter.

The introduced House Mouse, Mus musculus, very common at most sites during this survey. It can be distinguished from the native mice by its smaller eyes and shorter ears together with its distinctive smell, different behaviour and, of course, on a number of characteristics of its skull. Photo D. Carter.

Figure 36
MAMMALS

Methods

Pit-trapping design and sampling procedure have been detailed elsewhere (Methods, this publication). Pit-trapping effort is quantified as the number of drift-fence nights. A total survey effort of 1432 drift-fence nights compares with an effort of 190 drift-fence nights in a recent survey of the Great Sandy Desert, Western Australia (Burbidge and McKenzie 1983) and 900 drift-fence nights in a recent survey of the South-west Interzone of the Eastern Goldfields (B.S.C.W.A. 1984).

Spotlighting effort averaged for the total survey was two hours per night. Spotlighting activities included traverses on existing tracks within study sites and a spotlight-shooting technique used to sample bat communities, cats and foxes.

Heart, liver and kidney samples were taken from small mammal and bat specimens within 20 minutes of death and frozen in liquid nitrogen for electrophoretic analyses. Analyses were run by the Evolutionary Biology Unit of the South Australian Musuem; electrophoretic determinations were used in conjunction with standard taxonomic procedures, based on morphology, to distinguish closely related species (see Appendix VII).

Our taxonomy follows Ride (1970), Archer (1975), Kitchener et al. (1983) - Ningaui spp., Kitchener et al. (1984a, 1984b) - Pseudomys and Sminthopsis spp. respectively and Kitchener & Caputi (1985) - Scotorepens sp..

Specimens from South Australian campsites are lodged in the South Australian Museum, accession numbers M11253-11326, M11524-11568, M11897-11900 and M11987-11991.

Western Australian specimens are to be accessed by the Western Australian Museum.

Results

Appraisal of Species Records Prior to the Survey

Previous mammal records from the Nullarbor are discussed in the following annotated list.

MACROPODIDAE

Macropus rufus (Desmarest) — Red Kangaroo

From the Nullarbor, a single Western Australian Museum (W.A.M.) specimen (M6741) was collected on the Eucla to Reid Road, Western Australia in January 1965. Habitat was described as "treeless plain". There are no South Australian Museum (S.A.M.) specimens.

The species actually occurs throughout the Nullarbor and it is often locally numerous. Kangaroo shooters were operating north of Eucla as early as 1896 (Mason and Young 1896 in Brooker 1977).

More recently, Brooker (1977) has recorded red kangaroos in a range of habitats north-west and north-east of Rawlinna including: Myall woodland, Bluebush and saltbush steppes, grasslands and dongas.

The species has also previously been reported on the Roe Plain in the vicinity of Eyre (R.A.O.U. 1982).

Macropus fuliginosus (Desmarest) — Western Grey Kangaroo

Grey kangaroos were observed by Tate (1879) in the coastal region from the Head of the Bight, South Australia to Eucla. He noted that the species was the "only kangaroo ... [it was] ... not abundant ... [and was] ... seen only in lightly timbered parts ...".

Western Australian Museum records exist from Naretha (M4963) and Rawlinna (M16638) on the treeless plain and from near Caiguna (M12221 to M12225) and Cocklebiddy (M16640) on the coastal strip. Specimens were collected from 1968 to 1972.

South Australian specimens, collected from 1965 to 1966 are from the vicinity of Nullarbor Station homestead (W.A.M. M6648) and from the Eyre Highway 20 kilometres south-west of Nullarbor Homestead (S.A.M. M8699).

Sightings have been reported from the central Nullarbor within 150 kilometres of Rawlinna in Myall woodland, "open country" and bluebush steppes (Brooker 1977), and from "sandhill and spinifex country along the northern edge of the Nullarbor Plain" (A.J. Carlisle pers. comm. in Brooker 1977). The species has also been recorded on the Roe Plain in the vicinity of Eyre (R.A.O.U. 1982).

Onychogalea lunata (Gould) — Crescent Nail-tail Wallaby

A single specimen (Aust. Mus. M4637) was collected by W.A. Wills (see Background, this chapter) in 1927 or 1928. No subsequent records exist and there is no evidence to suggest this species persists in the Study Area.

POTOROIDAE

(see Background to this paper for a discussion on Tate's (1879) observation of Bettongia campestris).

Bettongia lesueur (Quoy and Gaimard) — Burrowing Bettong

Although Brooker (1977) lists this species as being present on the western Nullarbor prior to 1940, we can find no records or substantiated accounts of B. lesueur on the Nullarbor since European settlement. There are no Western Australian Museum records from the Nullarbor district. The South Australian Museum's collection includes a specimen (M4140), dated 1936, from Malbooma Waterhole north-east of Ooldea; collector unknown. There are two records (M4141-2) from the period 1891 to 1897, with the locality given as "between Ooldea and Oolarinna". Both of these localities fall within the Great Victoria Desert Environmental Region.

Finlayson (1958 p. 60) discussed the distribution of this species. His account includes the only evidence we can find that it occurred on the Nullarbor: "The late Mrs Daisy Bates while at Ooldea collected considerable evidence from the aborigines to show that its numbers had diminished markedly in the coastal areas at the Head of the Bight before European influence had become appreciable there". Wood Jones (1924) contended that B. lesueur was "... still existing in some numbers in certain districts in the north-west [of South Australia]. Here it lives in company with the rabbits, sharing the larger warrens with them and preferring the warrens constructed amongst sandridges of the typical sandhill and claypan country ...".

Troughton, collecting in the Ooldea-Fisher region in 1921, did not encounter this species (Troughton 1967).

There is no evidence to suggest the species persists in the Study Area.

Bettongia pencillata (Gray) — Brush-tailed Bettong

A.J. Carlisle (pers. comm. cited in Brooker 1977) observed "Grass-nest Rats" on the north-western Nullarbor in 1938. The name given by Carlisle may describe B. pencillata. The species characteristically constructs nests of grass or shredded bark in shallow hollows, usually scratched out at the base of an overhanging tussock or bush (Troughton 1967).

There are no specimens of B. pencillata from the Nullarbor in the collections of the South Australian and Western Australian Museums. Finlayson (1958) could find no evidence to suggest its presence on the Nullarbor at European settlement. Wood Jones (1924) wrote that B. penicillata "was once extremely common over the greater part of South Australia ... about 1904, dealers in Adelaide did a great trade selling them by the dozen at about ninepence a head ..." [but that] "... as far as can be ascertained ... this animal seems to have disappeared from South Australia ...".

BURRAMYIDAE

Cercartetus concinnus (Gould) — Western Pygmy Possum

There is no museum record of this species from the Nullarbor. However, it has previously been observed on the Roe Plain in the vicinity of Eyre (R.A.O.U. 1982).

PERAMELIDAE

Isoodon auratus (Ramsay) — Golden Bandicoot

The South Australian Museum holds a single specimen (M4641) collected near Ooldea in 1922; however, without precise locality and/or habitat information the specimen cannot be assigned to the Nullarbor (see Background).

Perameles bougainville (Quoy and Gaimard) — Western Barred Bandicoot

The two geographical races of Perameles myosura Wagner 1841 (P. myosura from south-western Western Australia and P. myosura notina, from south-eastern Western Australia and South Australia) (see Troughton 1969), are now considered to be subspecies of Perameles bougainville (see Burbidge, in Strahan 1983).

There is good evidence to suggest that Perameles bougainville notina was extant on the Nullarbor prior to about 1940.

The South Australian Musuem holds four specimens from Ooldea (M846, M1397, M4639, M4640), collected by D.M. Bates and F. Wood Jones in 1921 and 1922. A further eight specimens from Ooldea, collected by D.M. Bates in 1922 (M570 to M577) are held in the collection of the Western Australian Museum. (The latter are the last museum specimens of the species collected from the Australian mainland).

Wood Jones (1924) assessed the status of the species in South Australia in 1923 and contended that it was restricted to the sub desert western portion of the state, ... "its present habitat is the open plains, the level stretches of which are broken only by sandhills and outcrops of limestone, and for vegetation, the blue bush ..., the saltbush ..., and the various stunted desert acacias ... on the plains it makes a nest under a saltbush [and is] given to excavating hollows in which to accumulate its nesting material ...".

The Australian Museum holds four specimens of immature Perameles bougainville, (M4368-4371), collected by W.A. Wills prior to August 1928 (see Background, this chapter). Note was made of the purchase of these from J. Wills by the Australian Museum in the interchange of correspondence between the two parties.

Other possible accounts of P. bougainville on the western Nullarbor in Western Australia include A.J. Carlisle's observation that "zebra rats" were plentiful from 1928 to 1936 (A.J. Carlisle pers. comm. in Brooker 1977). In conjunction with a research program on desert mammals (Burbidge and Fuller, unpublished data), we visited A.J. Carlisle at Kalgoorlie in August 1984 and by presenting a museum skin of P. bougainville were able to confirm that this was the species referred to as "zebra rats". Carlisle added that "zebra rats" were common around Ooldea, Nullarbor Station and Koonalda Station from about 1927 to 1930.

Barrett (1930) mentioned a "striped bandicoot".

THYLACOMYIDAE

Macrotis lagotis (Reid) — Bilby

Macrotis lagotis appears to have been extant on the Nullarbor prior to 1940.

Two specimens held by the Australian Museum (M4639-40), were collected by W.A. Wills in the vicinity of Rawlinna in 1927 and/or 1928 (see Background). Troughton (1967) assigned these Rawlinna specimens to Macrotis lagotis interjecta.

Sightings of "rabbit-eared bandicoots" on the north-western Nullarbor in 1938 have also been reported by A.J. Carlisle (pers. comm. in Brooker 1977).

There are two South Australian Museum specimens from Ooldea (M2459, M3922); collection dates unknown. A black-footed race M. lagotis nigripes was originally described as a full species by Wood Jones (1923) from specimens obtained around Ooldea. Bilbies "were by no means uncommon" in the vicinity of Ooldea in 1923 (Wood Jones 1923), however specimens recorded from the vicinity of Ooldea cannot be assigned to the Nullarbor since no habitat information accompanies records.

There are no subsequent records or more recent evidence of M. lagotis from the Nullarbor.

DASYURIDAE

Dasyurus geoffroii Gould — Western Quoll

Carlisle (pers. comm. in Brooker 1977) reported seeing a "native cat" in 1938 on the north-western Nullarbor. No subsequent records are available.

Dasycercus cristicauda (Krefft) Mulgara

Five specimens of D. cristicauda, M4862-66, held by the Australian Museum, were collected by Ellis Troughton at Fisher between 22 and 24 October 1921 (L. Gibson, Australian Museum, pers. comm. February 1985). Troughton (1967) cites these specimens as having been collected "between Ooldea and Fisher"; it is possible that he nominated Fisher on the specimen labels because it was closest to the actual collection point(s). Habitat description is provided by Troughton (1967, p. 313): "... Out on the plain some 12 miles from Ooldea, the dongas gradually disappear. At Fisher siding about 40 miles along ... the limestone landscape is flat and covered with knee-deep bushes ...".

Two specimens (M455-6) in the Australian Museum were collected by W.A. Wills near Rawlinna prior to August 1928 (see Background). No information is available to establish whether these specimens were collected in habitat similar to the treeless-plain source of the Fisher specimens.

Although no subsequent records exist and D. cristicauda was not recorded during the 1984 surveys, available records, above, suggest that the species was extant on the Nullarbor at least prior to 1929.

Sminthopsis dolichura Kitchener

Sminthopsis dolichura (Fig. 35) was formerly included in Sminthopsis murina (Kitchener et al. 1984b). A single previous specimen (S.A.M. M12251) is known from the Study Area. It was collected at Yalata in 1980.

Antechinomys laniger (Gould) Kultarr

One specimen, (M4641), held by the Australian Museum, was collected from the Rawlinna region by W.A. Wills in 1927 or 1928 (see Background).

Troughton (1967) possibly based his distribution note "Central Australia, between the James and MacDonnell Ranges, ranging to Rawlinna" on this record.

Sminthopsis crassicaudata (Gould) Fat-tailed Dunnart

There is one previous record of this species from the Nullarbor in South Australia (S.A.M. M9265). It was collected at Watson in 1974. An additional specimen (S.A.M. M7694) collected at Ooldea in 1969 cannot be assigned to the Nullarbor on available information (see Background). Western Australian specimens have been collected from the vicinity of Naretha siding (W.A.M. - M7746, M7747) in 1969, at Forrest (W.A.M., M10131) on the central Nullarbor in 1969 and from Mundrabilla Station (W.A.M., M14608) on the southern Nullarbor in 1976. The species was observed by Brooker (1977) in two areas approximately 100 kilometres north and north-east of Rawlinna during the period May 1969 to September 1976.

MURIDAE

Leporillus conditor (Sturt) Greater Stick-nest Rat

The Nullarbor appears to have been the last mainland stronghold of Leporillus conditor. It persisted there until about 1940.

The earliest account of this species is by Tate (1879). He recorded "Hapalotis conditor or walka, the building hapalotis" on the coastal region west of the Head of the Bight, South Australia. There are four specimens (M2280, M2464, M9152 , M9153) in the South Australian Museum, and one specimen (M830) in the Western Australian Museum, collected from around Ooldea between 1926 and 1928. The 1928 specimens were the last to be collected from the Australian mainland (Watts and Aslin 1981).

In 1921 Troughton (1923, 1924) found numerous active nests in dongas and on the open chenopod shrubland from Ooldea to Fisher. Occasionally animals were observed sunning themselves on the tops of nests. Specimens that were lodged at the Australian Museum were obtained by digging out burrows and firing nests.

The only possible account of the species on the Nullarbor in Western Australia is by A.J. Carlisle of Rawlinna (pers. comm. in Brooker 1977) who last saw "stick nest rats" in 1938. These were likely to be L. conditor. There are no specimens of the Lesser Stick-nest Rat, Leporillus apicalis from the Nullarbor. Available records (reviewed by Watts and Aslin 1981, Read 1984) suggest that by European settlement L. apicalis had a more northerly distribution than L. conditor; the former was predominantly an inhabitant of rocky ranges and mulga woodlands in central Australia.

There is no evidence to suggest the species persists on the Nullarbor. Remaining populations are known only from the Franklin Islands of the Nuyts Archipelago in South Australia.

Notomys mitchellii (Ogilby) Mitchells' Hopping Mouse

From South Australia, there are nine museum specimens of N. mitchellii collected at Ooldea on the north-eastern edge of the Nullarbor over the period 1922 to 1939. Two specimens (S.A.M., M8056, M9025) were collected at Yalata in 1970.

There is one museum specimen from the Nullarbor in Western Australia. It was collected at Balladonia on the western edge of the Nullarbor in 1925.

Notomys fuscus (Jones) Dusky Hopping Mouse

Wood Jones (1925) noted that numerous specimens were collected by A.G. Bolam from "about Ooldea". There, the species was "not uncommon" and "lived in company with Notomys mitchellii" (Wood Jones ibid). No habitat data was given.

The species can be assigned to the Nullarbor fauna only on the basis of one record from Rawlinna (Watts and Aslin 1981). However we can find no evidence to substantiate this record or to indicate the species was ever on the plain. All recent records have come from north-eastern South Australia and south-western Queensland (Watts and Aslin ibid) where the species probably persists.

Pseudomys hermannsburgensis (Waite) Sandy Inland Mouse

Recent work suggests P. hermannsburgensis includes two species; herein these are listed as P. hermannsburgensis (Fig. 36) and Pseudomys bolami (Kitchener et al. 1984a).

Three modern specimens of P. hermannsburgensis, M13363-M13365 were collected from low open woodland of Myall (Acacia papyrocarpa) and Sheoak (Casuarina cristata) in the Plumridge Lakes area in 1975 (Burbidge et al. 1976).

Pseudomys bolami (Troughton)
There are two Australian Museum specimens, M4644 and M4645, which are listed as Pseudomys hermannsburgensis bolami (L. Gibson, Aust. Museum, pers. comm. 1985). Specimen M4644 was confirmed as P. bolami by Kitchener et al. (1984a). M4645 was placed in the subspecies bolami with M4644 by Troughton and is almost certainly P. bolami. Both specimens were collected in the vicinity of Rawlinna by W.A. Wills in 1927 and/or 1928 (discussed in Background, this paper).

Kitchener et al. (1984a) lists three specimens of P. bolami (A.M. M4938, M4931-2) which were collected at Ooldea by Troughton and Wright in 1921. A further specimen from Ooldea (A.M. M2991) was collected in 1921 by Le Souef (Kitchener et al. ibid).

One modern specimen, W.A.M. 13366, was collected in 1975 from low open woodland of Myall and Sheoak in the Plumridge Lakes area (Burbidge et al. 1976).

Pseudomys australis Gray — Plains Rat
One specimen (A.M. M4636) was collected near Rawlinna by W.A. Wills in 1927 or 1928 (see Background, this chapter).

A synonymous species, Pseudomys rawlinnae, was described by Troughton in 1932 (Troughton 1967) from two additional Australian Museum specimens (M4642-3, the holotype and paratype respectively), collected by W.A. Wills, in the same area.

P. australis was apparently also collected from Ooldea (by H.H. Finlayson) prior to 1940 (Watts and Aslin 1981).

A more recent specimen (M8111) in the Western Australian Museum was collected in May 1969 near Mundrabilla Homestead. Although this specimen is listed as P. gouldii, it has recently been re-examined and is P. australis (A. Baynes, pers. comm.). No subsequent records exist.

Recent colonies are known from the vicinity of Charlotte Waters in the southern Northern Territory and Marla Bore in northern South Australia (Watts and Aslin 1981). The species appears to be restricted to gibber and soft earth surfaces in that region.

Mus musculus Linnaeus — House Mouse
Mus musculus (Fig. 36) has been known from the Nullarbor since 1931 when a specimen (S.A.M. M3002) was collected at Cook on the transcontinental railway in South Australia. Two other specimens (S.A.M. M3001, M3086) were collected at Ooldea in the same year.

The first museum specimens (S.A.M. M7669-M7672) from the Nullarbor in Western Australia were collected at Rawlinna in 1968. It is likely, however, that the species was present well before this. The history of introduction of house mice into Western Australia is unrecorded; Shortridge (1936) in Chapman (1981) stated that "it now vastly outnumbers the native rodents and has spread everywhere even into the Spinifex deserts of the far interior ...". Shortridge collected over the period 1904-07 and it is likely he refers to this period; one of his collecting localities was Kalgoorlie (Chapman 1981). It is probable that the spread of house mice onto central and northern portions of the Nullarbor was effected or hastened via the transcontinental railway (see Land Use History, this publication).

Fifteen specimens (W.A.M.) were collected from 1968 to 1972 from other Western Australian localities: Madura, Nurina siding, Widdingbillia Hill (Roe Plain), Yellowtail Bore and Seemore Downs. A plague of house mice was reported on the Nullarbor in Autumn 1968 (Brooker 1977), coinciding with mouse plagues in a number of habitats in Central Australia (Newsome and Corbett 1975 in Brooker 1977). Subsequently, large numbers of Mus musculus were present on the Nullarbor in the summer of 1974-75 ("West Australian", June 1975 in Chapman 1981).

MOLOSSIDAE

Tadarida australis (Gray) — White-striped Mastiff Bat
One specimen (S.A.M. M474) with a source locality given as "Nullarbor Plains" is held by the South Australian Museum. The collection date is unknown. A specimen (S.A.M. M9566) was collected at Ooldea in 1973 and another (W.A.M. M10988) was collected at Forrest in 1972.

T. australis was collected by Brooker (1977) over the period 1967 to 1976, in an area approximately 50 km north-west of Naretha siding on the western periphery and at "Lake Brown" on the northern edge of the Nullarbor.

VESPERTILIONIDAE

Nyctophilus timoriensis (Geoffrey) — Greater Long-eared Bat
Apart from one Ooldea record (S.A.M. M9140) collected by Wood Jones (no collection date), the species was only known in the Nullarbor Study Area on the basis of a single specimen (W.A.M. M8735) collected on Widdingbillia Hill on the Roe Plain in 1969.

Nyctophilus geoffroyi Leach — Lesser Long-eared Bat
South Australian Museum records include 4 specimens (M2200-001, M2200-002, M3693, M9114) from Ooldea, collected over the period 1926 to 1933.

The species has previously been recorded on the Roe Plain (W.A.M. M8378, 10332 and S.A.M. M10977-M10979) in 1966 and 1973, and at Kanandah Homestead (M10344) north-west of Rawlinna, in 1972.

Chalinolobus gouldii (Gray) — Gould's Wattled Bat
Two specimens were collected over a water tank on the Hampton Escarpment above Madura in Western Australia in March 1984, during reconnaissance for the present survey (W.A. Department of Fisheries and Wildlife field numbers FW2036, FW2037). There are no other previous records of this species from the Nullarbor.

Chalinolobus morio (Gray) Chocolate Wattled Bat

The species has previously been collected from Warbla Cave on the south-western Nullarbor in South Australia (S.A.M. M10416, M10550-M10562).

In Western Australia, specimens have been collected from several localities on the southern Nullarbor over the period 1964 to 1968. These are: Madura (W.A.M. M8452-M8454), Cocklebiddy Cave (W.A.M. M8550) and Murra el Elevyn Cave (W.A.M. M9667). It has also been recorded from the Roe Plain: at Eyre in 1935 (W.A.M. M1920/001, M1920/002) and from Mundrabilla homestead in 1967 (W.A.M. M8555).

TACHYGLOSSIDAE

Tachyglossus aculeatus (Shaw) Echidna

There is no museum record of this species from the Nullarbor but Brooker (1977) observed one individual in Myall woodland north-west of Rawlinna in Western Australia during the period 1967 to 1976.

VOMBATIDAE

Lasiorhinus latifrons (Owen) Southern Hairy-nosed Wombat

The first museum specimen (S.A.M. M395) of this species from the Nullarbor in South Australia was collected at Yalata and registered in 1914. Subsequently a series of specimens lodged in the South Australian Museum (M8771-M8836, M8914-M8949, M8983, M9217, M9592, M9593, M9595-9598) were collected from Nullarbor Station in 1963 and 1964.

Aitken (1971) mapped populations of L. latifrons on the Nullarbor in South Australia.

Reports of L. latifrons in Western Australia to 1962 are summarized by Jenkins (1962): Mason (1896) in Jenkins (1962) referred to wombats in the area 100 miles north-west of Twilight Cove. Crawford (1900) in Jenkins (1962) came across large wombat holes and managed to capture an individual on the north-western Nullarbor. Mrs A.E. Crocker of Balladonia, recalled in 1952, that two wombats "reached Balladonia" about 1903-1904.

Brooker (1977) noted other reports: A rabbitter claimed to have shot a wombat near Rawlinna in the 1960s, and in 1976, warrens and footprints that are consistent with wombats, were described from an area 100 kilometres south of Naretha siding.

There is one museum specimen from Western Australia (W.A.M. M4236). It was collected on the Western Australian-South Australian border, south of Deakin siding, in 1959.

CANIDAE

Canis familiaris Meyer Dingo

Twenty-four specimens of Canis familiaris (Fig. 35) were collected on the Nullarbor in the 1960s and are held in the Western Australian Museum. Collecting localities include: the vicinity of Rawlinna, Haig and Forrest on the Trans-Australia railway line; Iltoon and Boorabie Rock Holes, Cocklebiddy and Mundrabilla Station on the southern Nullarbor.

Dingoes are shot, trapped and/or baited by pastoralists and professional doggers throughout pastoral areas of the Nullarbor in Western and South Australia. In Western Australia, doggers operate as far north as Lake Gidgi on the northern periphery of the Nullarbor. There has been government involvement in dingo control on the Nullarbor in Western Australia for about thirty years, mediated by the Department of Agriculture which subsidises stations or groups of stations contracting professional doggers. Prior to this, dingo numbers in pastoral areas were largely controlled by pastoralists who usually had a full-time dogger in employ (J. Stevens, Department of Agriculture, Kalgoorlie, pers. comm. June 1984).

Vulpes vulpes Linnaeus European Fox

Foxes were first reported at Eucla on the southern edge of the Nullarbor in 1911 (Long 1974).

Wills (pers. comm. 1985) described foxes as being non-existant or rare in the vicinity of Rawlinna prior to about 1930, and dates the advent of the fox on this part of the Nullarbor at around 1930.

There is one specimen (W.A.M. M4241) collected in 1960 from Boo-Yoo-Noo Rockhole on the southern Nullarbor in Western Australia.

Foxes were seen in all years from 1967 to 1976 on the north-western Nullarbor (Brooker 1977). Foxes were reported in plague numbers on Rawlinna Station in 1975 (Bonnin 1978).

Professional fox-shooters operate on an intinerant basis on the Nullarbor in South and Western Australia.

LEPORIDAE

Oryctolagus cuniculus Lilljeborg European Rabbit

Rabbits were first reported at Eucla in Western Australia in 1894 (Long 1974) and at Eyre on the Roe Plain in 1896 (Mason 1897 in Brooker 1977).

Fuller (1970) describes the series of rabbit invasions which passed through Eucla, and the environmental destruction which resulted. Belated attempts to control the westward movement of rabbits in the goldfields and other parts of Western Australia were ineffective. Cats (Felis catus) released at Eucla in 1899, were observed to be more effective at reducing the numbers of native species (Fuller 1970).

The rabbit plague was reduced by Myxomatosis in 1954 and in 1966 no rabbits were seen during traverses of the Nullarbor (Beard 1975). During 1984 however rabbits were recorded at virtually every sample site and in some areas, particularly the northern part of the treeless plain they were so abundant that they supported a significant commercial rabbit shooting operation.

FELIDAE

Felis catus Linnaeus — Feral Cat

Two hundred cats were released between Eyre on the Roe Plain and near Israelite Bay, Western Australia in 1899 to control rabbits (Department Agriculture, pers. comm. June 1984). Feral cats were present at Eyre on the Roe Plain in 1896 (Mason 1897 in Brooker 1977).

Specimens were collected in 1960 from Boorabie and Boo-Yoo-Noo Rockholes (W.A.M. M4239, M4240) on the southern Nullarbor in Western Australia.

Cats were present but not numerous on the north-western Nullarbor in all years over the period 1968 to 1975. They were considered numerous in 1967 and again in 1976 (Brooker 1977).

Cat shooters operate on an intinerant basis on the Nullarbor in Western and South Australia.

CAMELIDAE

Camelus dromedarius Linnaeus — Camel

One (W.A.M. M7001) was collected at Eucla on the southern Nullarbor in Western Australia in 1966. Camels have been reported as common along the south-western edge of the Nullarbor (Long 1974). Brooker (1977) observed camels on the northern periphery of the Nullarbor in Western Australia in all years from 1967 to 1976.

BOVIDAE

Ovis aries Linnaeus — Sheep

Bos taurus Linnaeus — Cattle

Equus equus Linnaeus — Horses

The introduction of sheep, cattle and horses onto the Nullarbor accompanied the establishment of pastoral stations, the earliest being Mundrabilla Station in 1871 (see Land Use History, this publication).

Patterns of Mammals in the Nullarbor Study Area During 1984

Appendix III is a list of quadrats in the Study Area at which each mammal species was detected. In order to view patterning of mammal species within the Study Area, small mammals, other ground mammals, bats and introduced species are dealt with separately in the following account.

(a) Small Ground Mammal Abundance and Species Richness.

Ten native and one introduced species of small mammals were recorded in the Nullarbor Study Area.

Table 9 lists the number of live captures of these species at each of the 16 campsites. Results from the March-April and September-October surveys are pooled. Pitfall and Elliott metal trap captures are listed separately. (Elliott traps were used on the South Australian campsites only). No native small ground mammals were recorded opportunistically (outside quadrats) during the surveys.

Mammal numbers during both surveys were relatively few compared with those achieved using similar techniques during recent surveys in the Eastern Goldfields (B.S.C.W.A. 1984) and the Great Sandy Desert (Burbidge and McKenzie 1983). Small mammal returns from pitfall trapping in the Nullarbor Study Area, were proportionally fewer than returns from the Kurnalpie-Kalgoorlie cell (B.S.C.W.A. 1984) of the Eastern Goldfields (p¡0.001) and from the Great Sandy Desert (p¡0.001) (see Table 10).

It is worth noting that the autumn Nullarbor survey was carried out at the end of a long, hot, dry summer. Furthermore the vegetation at most sites bore evidence of a prolonged drought; few perennial species were flowering, seeding or had new shoots and few ephemeral plants were noted.

The spring survey was rain-affected to some extent; however all pitlines with the exception of four on the first and second quadrats at Kuthala campsite (KU1 and 2) were functional over four nights of sampling. Waterlogging caused early closure of these lines, reducing sampling to three nights.

The most abundant native small ground mammal was Sminthopsis crassicaudata; however it is apparent that populations of native small mammals exist at low levels throughout the Study Area, in contrast with Mus musculus which was ubiquitous and numerous at most sites during both sampling sessions.

Of the 81 quadrats sampled in the Study Area, 11 quadrats (13.9%) had no small ground mammals, 31 quadrats (38.3%) had 1 species only and the remaining 39 quadrats (48%) had 2 or more species (Fig. 37). Of these, twenty-seven quadrats (33.3%) had 2 species and only 12 quadrats (14.8%) had 3 or more sympatric small ground mammals.

Plumridge (PL) quadrats showed the highest levels of sympatry with 5 species at PL5 and 4 species at PL1 and PL3. BA4, another quadrat of the western fringe, also had 4 coexisting species.

Quadrats of the central northern fringes at Jubilee (JU) and Muckera (MU), which supported Myall and Mulga woodlands, had a maximum of 3 coexisting small mammals, as did quadrats of the eastern and south-eastern fringes (at Ifould and Yalata).

A maximum of 2 species was detected on quadrats of the northern, central, southern and eastern treeless plain at FO, HA, KU, KO, CA, KU1, KU2, ME5 and IF.

On the Roe Plain, a maximum of 3 sympatric species was detected in Eucalypt woodland at MA3 and on foredunes at KU5.

Clearly, the basic pattern of mammal species richness in the Study Area is one of species-poor assemblages (zero, one or 2 species) throughout most of the Study Area, with richer assemblages occurring on parts of the periphery and on the Roe Plain.

(b) Patterns in the Assemblage Composition of Small Ground Mammals.

The presence-absence data on small ground mammals formed a separate subset of the quantitative pattern analyses that were carried out on each of the taxonomic groups comprising the total assemblage sampled in the Study Area.

The analysis pathways are described in Methods (this publication) and were based on the small ground mammals that were systematically captured in pitfall and Elliott traps. Quadrats from which fewer than two species were recorded during the total survey period could not be included in the pattern analyses.Thus, 42 of the 81 quadrats were excluded (see Fig. 37). Nor could species that were recorded in only one quadrat be included: Notomys alexis (recorded only at PL4) and Ningaui ridei (only captured at PL6 in the Great Victoria Desert outside the Study Area - see Appendix III and Vegetation, this publication).

To identify groups of small mammals that consistently coexisted in quadrats in the Study Area, the 9 mammal species (N. alexis excluded) were classified according to their presence and absence in the 38 quadrats that were retained in the analysis data set.

The dendrogram of the UPGMA classification is shown in Fig. 38. Four species groups were derived. Each of species groups 1, 2 and 4 hold together as separate ecological units, respectively comprising species which, Australia-wide, inhabit or prefer similar microhabitats (defined in terms of vegetation and surface types).

Group 1 comprises Mus musculus and Sminthopsis crassicaudata. Both occupy a variety of open vegetation formations with a particular preference for open grasslands and low shrublands. Both are wide-ranging through semi-arid/arid to more mesic regions in Australia: S. crassicaudata is confined to central and southern Australia; Mus musculus is feral throughout Australia except in the mesic tropics.

Group 2 comprises 1 species, Sminthopsis dolichura. The species appears to be a habitat generalist in semi-arid southern Western and South Australia, occurring in open woodlands of Eucalyptus spp. and Acacia spp. (Mulga, Myall), Mallee-Triodia formations, open to closed shrublands and heath (Kitchener, et al. 1984b).

Group 4 comprises Cercartetus concinnus, Notomys mitchellii and Sminthopsis gilberti; all inhabit open Eucalyptus woodlands and/or Mallee in southern and Western Australia. C. concinnus and N. mitchellii are predominantly associated with open Eucalyptus woodland and mallee formations in semi-arid and mesic districts to the south-west and the south-east of the Study Area. S. gilberti is known from open Eucalyptus woodlands, Mallees and heathland in semi-arid districts of south-western Western Australia.

Two of Group 3 species, Pseudomys hermannsburgensis and Sminthopsis ooldea show similar habitat associations; both are closely associated with open vegetation formations on sandy surfaces (Mulga woodlands, Mallee) in semi-arid and arid districts throughout their ranges in Central, Southern and Western Australia. Pseudomys bolami, however, shows broader habitat associations across its range in semi-arid and arid parts of southern and Western Australia; in the Eastern Goldfields of Western Australia it occurs in the lower levels of the landscape (valley floors and lower slopes including saltpans) on alkaline and calcareous soils which are usually vegetated with a ground cover of chenopods, often under open woodlands. Where the sandy surfaces derived from saltpans are adjacent to "high level" sandy situations such as lateritic sands and derived spillway deposits down slope (including the red dune-forming sands of the Great Victoria Desert), both Pseudomys species may occur (McKenzie et al. in prep.).

In South Australia, P. bolami has been captured in Mallee north of Renmark in the Danggali Conservation Park. On a survey of the Gawler Ranges, P. bolami was the most common of the two Pseudomys species; only one P. hermannsburgensis was recorded (C. Kemper, pers. comm.).

For comparison with the UPGMA analyses, a principal co-ordinate analysis (PCR) (Methods, this publication) was also carried out on the presence and absence data to classify small mammals in terms of quadrats. The scattergrams are shown in Fig. 39, with the UPGMA group boundaries superimposed.

Fig. 39a shows species arrayed on Axes I and II. Three discrete clusters are clear, corresponding with UPGMA groups 1, 4 and a combination of groups 2 and 3.

Axis I clearly distinguishes UPGMA species groups 1, 2 and 3 from group 4.

Axis II clearly separates group 1 from groups 2, 3 and 4.

Fig. 39b diagrams Axis I versus Axis III. Axis III separates UPGMA species group 2 from group 3.

Fig. 40 presents the dendrogram produced from the U.P.G.M.A. group classification of the 38 quadrats retained in the analysis data set in terms of the presence or absence of the 9 mammal species.

Three major quadrat groups were apparent as delineated.

Group 1 is a group of quadrats which are peripheral to the central treeless plain in the south-west, north-west, south-east and south. Within this grouping, the north-western (PL) quadrats are distinguishable as a distinct group, separating out at the fourth classificatory step in the dendrogram. Group 2 comprises mainly treeless plain and central northern fringe quadrats and Group 3 comprises all the Roe Plain quadrats that were left in the data set (with the exception of MA5). This group split off at a very high level from the other groups on the dendrogram.

A principle co-ordinate analysis was carried out on the small mammal data to cluster the 38 quadrats according to species. This analysis provides a comparison with the UPGMA classification.

The resultant scattergrams are presented in Fig. 41. Fig. 41a arrays quadrats along Axis I versus Axis II and the boundaries of the 3 quadrat groups distinguished by UPGMA are superimposed.

Figure 37
QUADRATS AT WHICH SMALL GROUND MAMMALS WERE DETECTED.

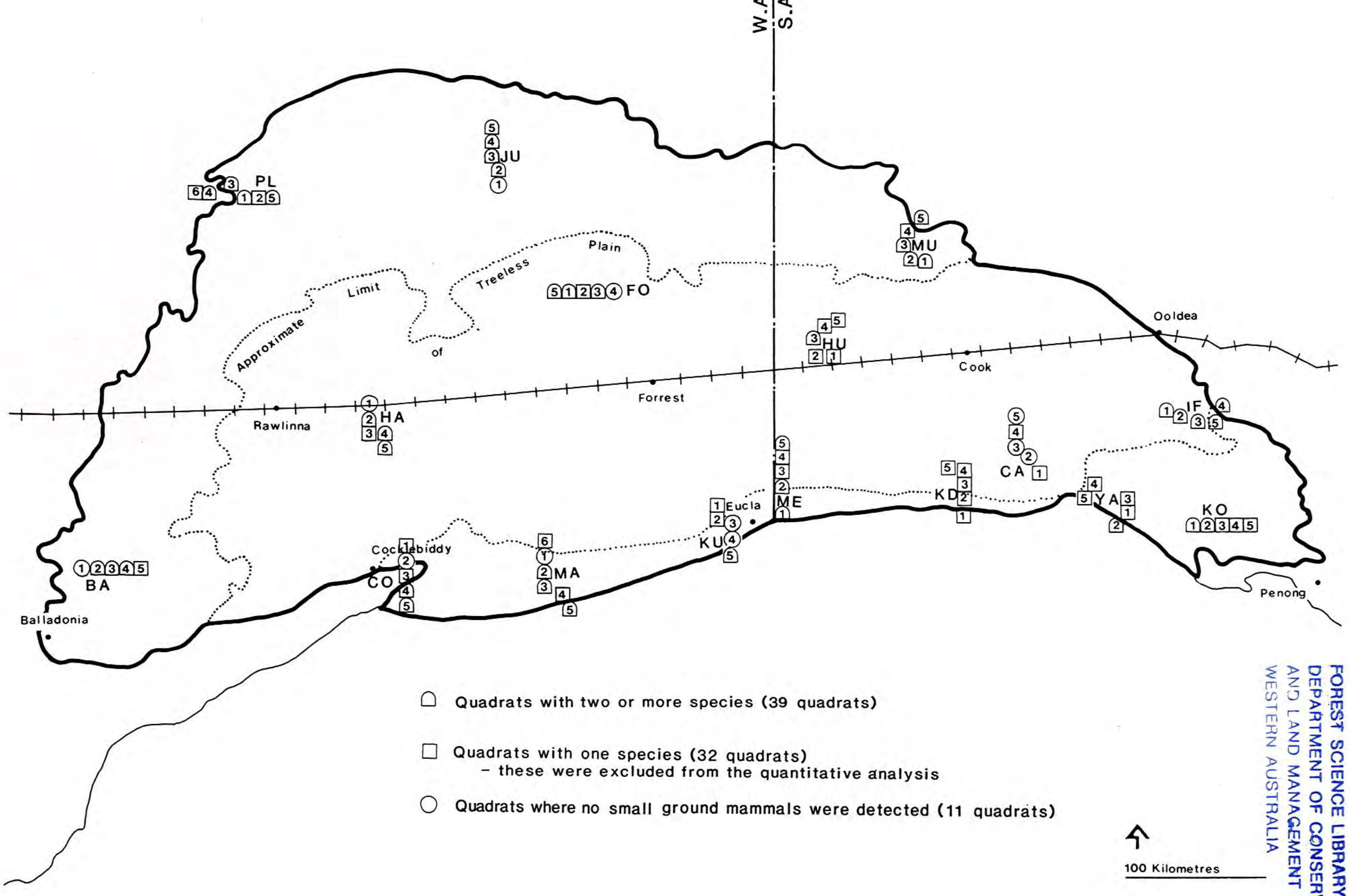
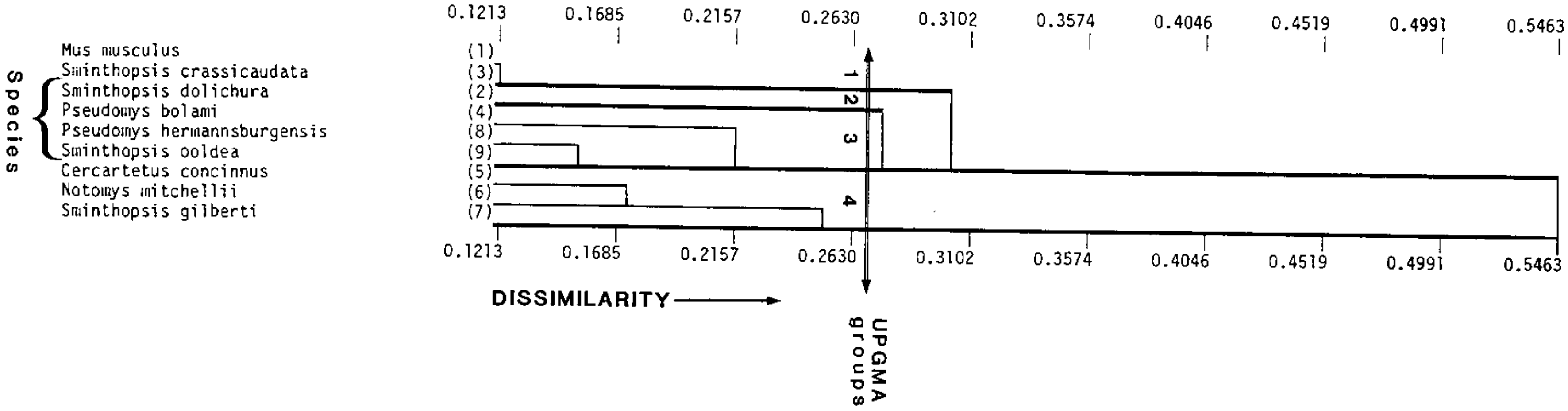


Figure 38
DENDROGRAM PRODUCED BY UPGMA CLASSIFICATION OF THE NINE SMALL MAMMAL SPECIES ACCORDING TO QUADRAT SIMILARITIES (TWO STEP).
(The four species groups that were distinguished are indicated)



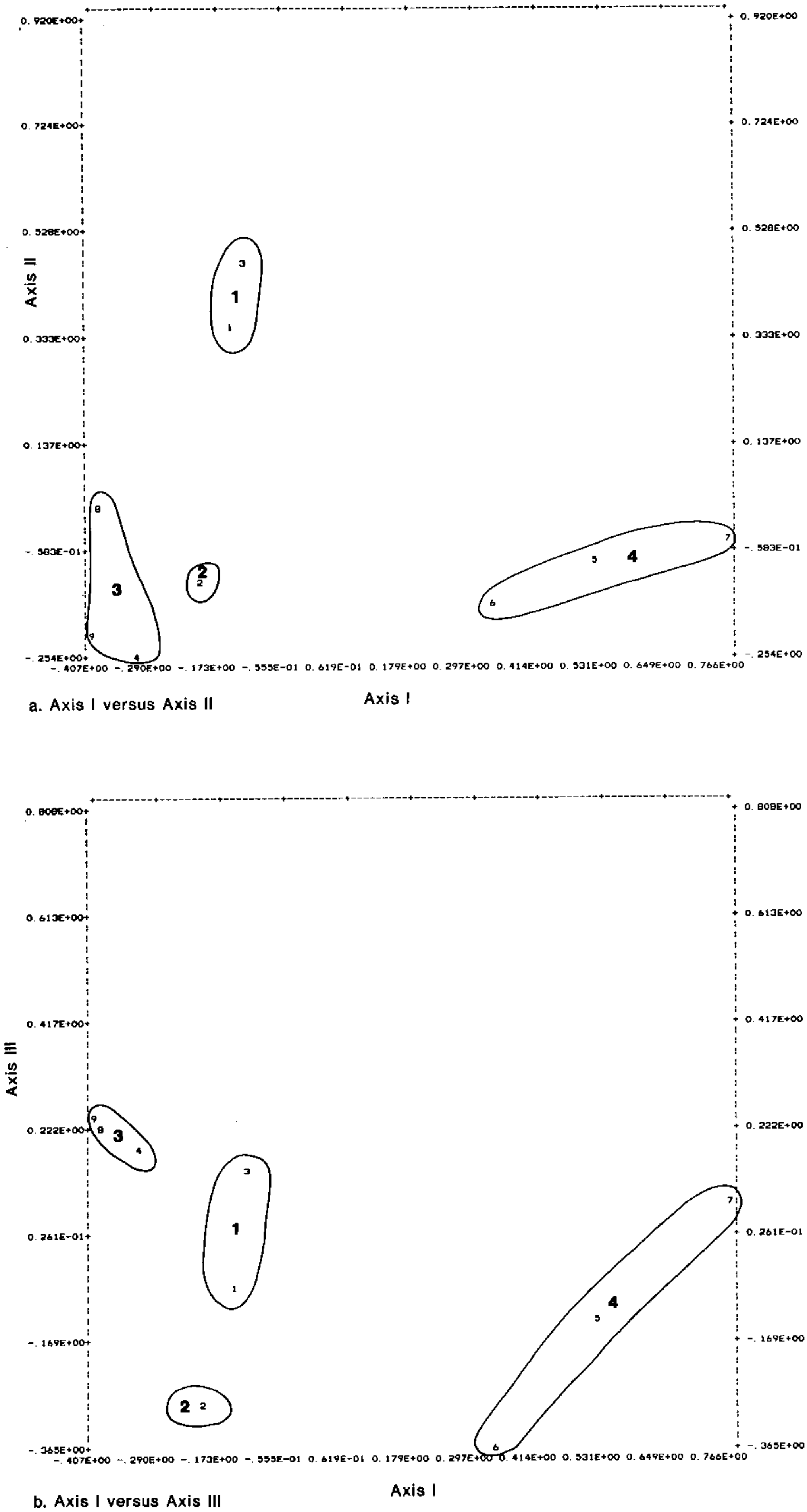


Figure 39

SCATTERGRAM RESULTING FROM THE ORDINATION OF 9 MAMMAL SPECIES IN TERMS OF QUADRAT FIDELITIES
The UPGMA species groups are delineated

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 9 POINTS
REGRESSIONS : Y = -0.1230E-04 + -0.3571E-01 X
: X = -0.3450E-04 + -0.1054 Y
CORRELATION COEFICIENT (R) = -0.6134E-01

a.

LABEL	SEQ #	X-VALUE	Y-VALUE
Mus musc	1	-0.1530	0.3590
Smindoli	2	-0.2077	-0.1177
Smincras	3	-0.1258	0.4700
Pseubola	4	-0.3293	-0.2539
Cercconc	5	0.5201	-0.8560E-01
Notomitc	6	0.3372	-0.1554
Smingilb	7	0.7659	-0.3290E-01
Pseuherm	8	-0.4002	0.2380E-01
Sminoold	9	-0.4075	-0.2074

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 9 POINTS
REGRESSIONS : Y = 0.1533E-04 + -0.2066 X
: X = -0.1629E-04 + -0.7667 Y
CORRELATION COEFICIENT (R) = -0.3980

b.

LABEL	SEQ #	X-VALUE	Y-VALUE
Mus musc	1	-0.1530	-0.8080E-01
Smindoli	2	-0.2077	-0.2843
Smincras	3	-0.1258	0.1356
Pseubola	4	-0.3293	0.1736
Cercconc	5	0.5201	-0.1317
Notomitc	6	0.3372	-0.3650
Smingilb	7	0.7659	0.9430E-01
Pseuherm	8	-0.4002	0.2123
Sminoold	9	-0.4075	0.2462

Figure 39

Axes I and II are not readily interpretable in terms of vegetation or surface type characteristics. However, quadrats belonging to the same UPGMA group are neighbours in the PCR scattergrams, e.g. Roe Plain Mallee and Eucalyptus woodland quadrats (MA2, MA3, CO4, CO5) are well separated on the left end of Axis I, away from treeless plain quadrats and quadrats peripheral to the treeless plain on the right.

In contrast with the UPGMA classification, it is noteworthy that MA5 is positioned close to the other Roe Plain quadrats (Group 3).

Group 1 quadrats do not cluster into a single discrete group; this accords with the ecological heterogeneity of the group as discussed in relation to the UPGMA classification. However, it is notable that the PL quadrats tend to be clustered off to the right on Axis I (Fig. 41a, b), approximating the tight subgrouping of these quadrats in the UPGMA dendrogram (Fig. 4D).

Additionally, treeless plain quadrats of UPGMA group 2 cluster together into a tight group on the far right of Axis I, in accord with the close grouping of these quadrats produced by the UPGMA classification (Fig. 40).

As the final step in the analysis, the 4 species groups and the 3 quadrat groups distinguished by UPGMA, were arrayed in the form of a Two-Way table (Table 11). The geographic distribution of these mammal communities over the Nullarbor Study Area is shown in Fig. 42. Our interpretation is as follows:

Quadrat group 2, predominantly treeless plain and northern fringing quadrats supporting low shrublands and grassland was mainly characterized by Mus musculus and Sminthopsis crassicaudata, the two species that comprised species group 1. This is consistent with the known habitat distributions of the two species in open vegetation formations, particularly open grasslands and low shrublands, throughout their respective geographic ranges. Within the Study Area, both species were almost ubiquitous although S. crassicaudata was not detected on the Roe Plain.

Group 2 quadrats on the northern fringe of the Study Area (JU3-5, MU3-5) had an additional two species, Pseudomys hermannsburgensis and Sminthopsis ooldea. This is consistent with the close association of these two species with open vegetation formations on sandy surfaces (Mulga woodlands, Mallee) in semi-arid and arid districts of their ranges, including the adjacent Great Victoria Desert and parts of the Eastern Goldfields.

The separation of all the north-western fringe quadrats at which small ground mammals were recorded (PL1, 3, 5-UPGMA quadrat group 1) from the central northern fringe quadrats of group 2 (JU and MU) is noteworthy and is attributed to the occurrence of S. dolichura and P. bolami. Separate clustering of the PL quadrats from JU and MU was also evident in the PCR analysis (Fig. 41).

Quadrat group 1, an ecologically heterogeneous group of quadrats which are, however, all peripheral to the central treeless plain in the south-west, central south, south-east and east of the Study Area were characterized mainly by S. dolichura and M. musculus. N. mitchellii was present only in Eucalyptus woodland quadrats in the central south (ME1, 2) and the south-east (YA2) and at the eastern Mallee quadrat, IF4.

The Roe Plain quadrats, comprising UPGMA quadrat group 3, were clearly characterised by group 4 species Cercartetus concinnus, Notomys mitchellii and Sminthopsis gilberti. This is consistent with the characteristics of these quadrats, which include Mallee, woodlands of Eucalyptus spp. and foredune Acacia shrubland established on sandy loam soils and subcoastal marine sands, and the known habitat associations of the 3 species (see the earlier discussion on the UPGMA species classification). This "species group 4 - quadrat group 3" association indicates that the general patterns of distribution that characterise these species elsewhere also hold for the Study Area.

(c) Bats

Since a large proportion of bat records were opportunistic, being recorded at sites where bats congregate (caves, dongas, over dams and pools, dense flyways) rather than on quadrats, data on bat distributions within the Study Area are presented in the form of species versus campsite.

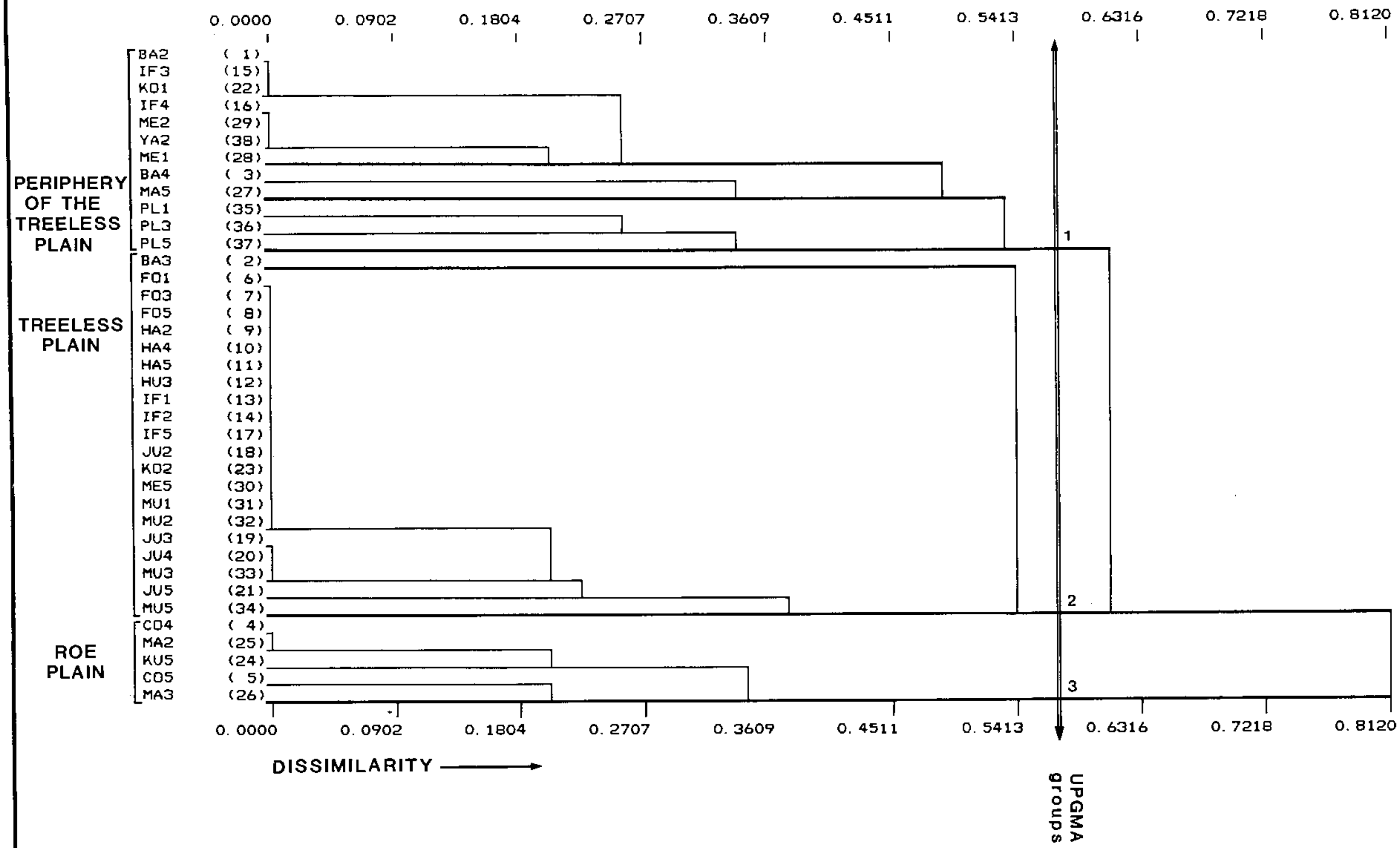
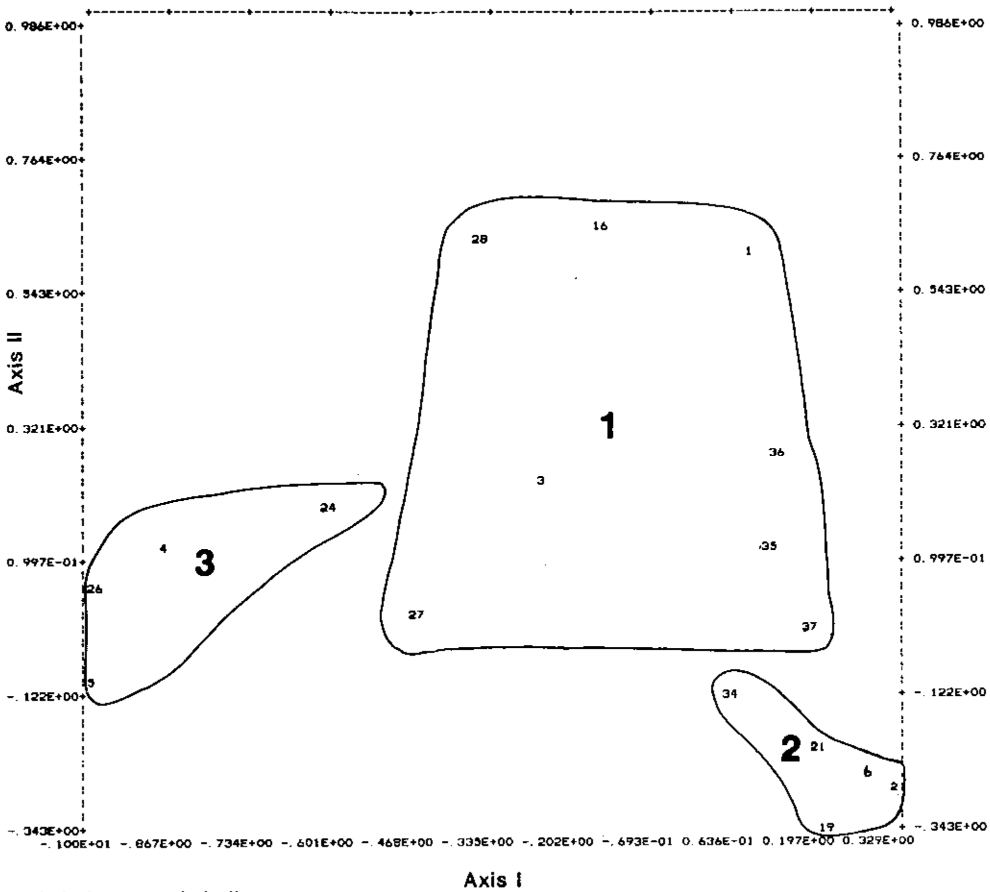
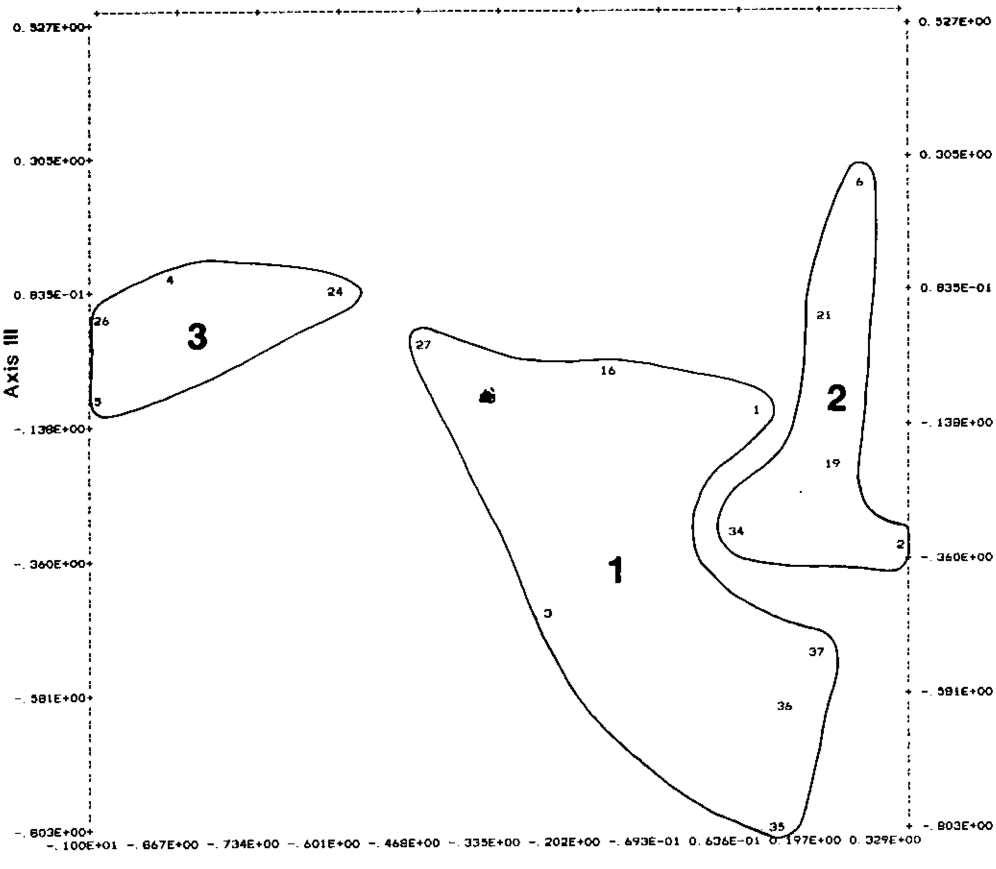


Figure 40
DENDROGRAM OF UPGMA QUADRAT CLASSIFICATION BASED ON SMALL MAMMAL SPECIES SIMILARITIES (CZEKANOWSKI ASSOCIATION MEASURE).



a. Axis I versus Axis II



b. Axis I versus Axis III

Figure 41.

SCATTERGRAM PRODUCED BY THE ORDINATION OF 38 QUADRATS IN TERMS OF THE PRESENCE AND ABSENCE OF SMALL MAMMAL SPECIES The UPGMA quadrat groups are indicated (see figure40)

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 38 POINTS
REGRESSIONS : Y = 0.9617E-05 + -0.3442 X
: X = 0.2044E-05 + -0.4445 Y
CORRELATION COEFICIENT (R) = -0.3912

LABEL	SEQ #	X-VALUE	Y-VALUE
BA2	1	0.8700E-01	0.6028
BA3	2	0.3295	-0.2695
BA4	3	-0.2596	0.2240
CO4	4	-0.8813	0.1220
CO5	5	-0.9998	-0.1104
FO1	6	0.2577	-0.2522
FO3	7	0.2577	-0.2522
FO5	8	0.2577	-0.2522
HA2	9	0.2577	-0.2522
HA4	10	0.2577	-0.2522
HA5	11	0.2577	-0.2522
HU3	12	0.2577	-0.2522
IF1	13	0.2577	-0.2522
IF2	14	0.2577	-0.2522
IF3	15	0.8700E-01	0.6028
IF4	16	-0.1550	0.6638
IF5	17	0.2577	-0.2522
JU2	18	0.2577	-0.2522
JU3	19	0.2226	-0.3434
JU4	20	0.2226	-0.3434
JU5	21	0.2159	-0.2061
KO1	22	0.8700E-01	0.6028
KO2	23	0.2577	-0.2522
KU5	24	-0.6068	0.1855
MA2	25	-0.8813	0.1220
MA3	26	-0.9951	0.5180E-01
MA5	27	-0.4542	0.2100E-02
ME1	28	-0.3418	0.6404
ME2	29	-0.1550	0.6638
ME5	30	0.2577	-0.2522
MU1	31	0.2577	-0.2522
MU2	32	0.2577	-0.2522
MU3	33	0.2226	-0.3434
MU5	34	0.6220E-01	-0.1247
PL1	35	0.1362	0.1185
PL3	36	0.1471	0.2690
PL5	37	0.1996	-0.1080E-01
YA2	38	-0.1550	0.6638

a.

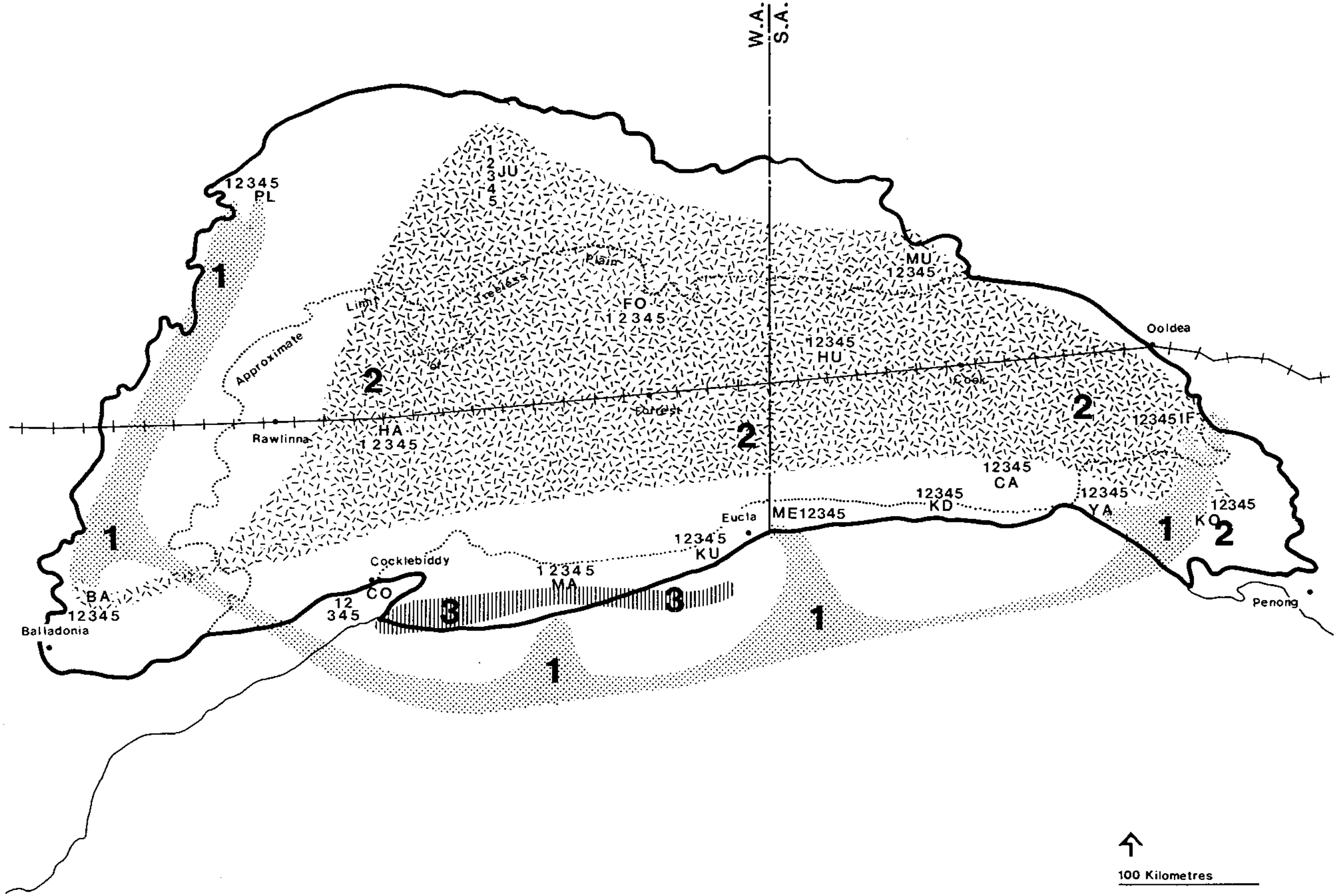
VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 38 POINTS
REGRESSIONS : Y = -0.2441E-05 + 0.7300E-01 X
: X = -0.2261E-05 + 0.1419 Y
CORRELATION COEFICIENT (R) = 0.1018

LABEL	SEQ #	X-VALUE	Y-VALUE
BA2	1	0.8700E-01	-0.1079
BA3	2	0.3295	-0.3299
BA4	3	-0.2596	-0.4579
CO4	4	-0.8813	0.1042
CO5	5	-0.9998	-0.9430E-01
FO1	6	0.2577	0.2638
FO3	7	0.2577	0.2638
FO5	8	0.2577	0.2638
HA2	9	0.2577	0.2638
HA4	10	0.2577	0.2638
HA5	11	0.2577	0.2638
HU3	12	0.2577	0.2638
IF1	13	0.2577	0.2638
IF2	14	0.2577	0.2638
IF3	15	0.8700E-01	-0.1079
IF4	16	-0.1550	-0.5240E-01
IF5	17	0.2577	0.2638
JU2	18	0.2577	0.2638
JU3	19	0.2226	-0.2138
JU4	20	0.2226	-0.2138
JU5	21	0.2159	0.5020E-01
KO1	22	0.8700E-01	-0.1079
KO2	23	0.2577	0.2638
KU5	24	-0.6068	0.7810E-01
MA2	25	-0.8813	0.1042
MA3	26	-0.9951	0.4610E-01
MA5	27	-0.4542	-0.1300E-02
ME1	28	-0.3418	-0.9430E-01
ME2	29	-0.1550	-0.5240E-01
ME5	30	0.2577	0.2638
MU1	31	0.2577	0.2638
MU2	32	0.2577	0.2638
MU3	33	0.2226	-0.2138
MU5	34	0.6220E-01	-0.3058
PL1	35	0.1362	-0.8027
PL3	36	0.1471	-0.6061
PL5	37	0.1996	-0.5253
YA2	38	-0.1550	-0.5240E-01

b.

Figure 41

Figure 42
GEOGRAPHIC INTERPRETATION OF THE SMALL GROUND MAMMAL QUADRAT GROUPS (UPGMA) ACROSS THE STUDY AREA.



Eight bat species were recorded from the Nullarbor Study Area (Table 12). Four species (Chalinolobus morio, Nyctophilus timoriensis, N. cf. gouldi and Eptesicus regulus) were detected only on southern (south-western, southern and south-eastern) sites - BA, CO, MA, YA and KO. Three species, Tadarida australis, Chalinolobus gouldii and Nyctophilus geoffroyi, were geographically wide-ranging throughout the Study Area. Scotorepens balstoni was recorded only in the north-west fringe of the Study Area - at PL2 in an open Myall woodland and at PL6 in a Mallee-Triodia community of the Great Victoria Desert.

(d) Other Ground Mammals and Marine Mammals

The distributions of five mammals, Macropus rufus, Macropus fuliginosus, Tachyglossus aculeatus, Lasiorhinus latifrons and Canis familiaris dingo according to campsite, are shown in Table 13. Records from the two survey periods are listed separately, and quadrat and opportunistic records have been pooled to denote presence.

M. rufus was not detected on the Roe Plain. Elsewhere in the Study Area it was widespread and at times locally common. Numbers were fewer at northern fringing sites within the Myall and Mulga woodlands of the Carlisle Plain (PL, JU) and MU. Macropus fuliginosus was common on the Roe Plain and widespread throughout the rest of the Study Area, including northern fringing sites in Western Australia, PL and JU. However, the species was only detected at these sites during the spring survey.

Reasons for the vagaries in the distribution and abundances of the two macropods, particularly M. rufus, aren't clearcut; the effects of population control in pastoral areas by the shooting industry and patchiness of local rainfall (and therefore, areas of green pick) are probably both implicated.

Our failure to detect C. f. dingo over most of the western Australian side of the Study Area apart from northern fringing sites (PL, JU and FO), probably largely reflects the ongoing eradication of the species from pastoral holdings across the central and southern Nullarbor (see Land Use History, this publication and the annotated species list herein).

In addition to the campsite records of Tachyglossus aculeatus in (Table 13), an individual was observed 56 kilometres north-east of Rawlinna on the Connie Sue Highway in November 1984. Surrounding vegetation consisted of open grassy steppe with sparse Myall and Bluebush.

We have several records of Lasiorhinus latifrons from places outside the campsites; these and the campsite records (Table 13) are summarised as a distribution map (Fig. 44). This is not intended as a comprehensive map of the current distribution of the species in the district; see Aitken (1971) and Loffler and Margules (1980) for supplementary records.

Three marine mammals, Neophoca cinerea, the Australian Sea Lion, Peponocephala electra, the Melon-headed Whale (skull only), and Balaena australis, the Southern Right Whale were recorded on the Nullarbor coast (Table 13). The record of P. electra is the first for the species in Western Australia. Balaena australis, the Southern Right Whale, appears to have its major Australian calving area off the Nullarbor coast, particularly at the Head of the Bight and the Merdayerrah Sandpatch (A. Robinson, pers. comm.). A population of Australian Sea Lions was reported to occupy a site at the base of cliffs east of the Merdayerrah Sandpatch but we were unable to check this locality during the survey.

(e) Introduced Species

Introduced species, Vulpes vulpes, Felis catus and Oryctolagus cuniculus, were ubiquitous and varyingly abundant in the Study Area.

Extremely high densities of rabbits were observed on coastal (KU), central treeless plain (HA, HU), and certain northern (FO) sites. Most severe habitat degradation by rabbits was observed at FO and HU. Densities of foxes and cats were high on both coastal and central treeless plain sites.

The stomach contents of six foxes and eight cats were examined during the autumn and spring surveys. Fox stomachs examined in autumn contained whole and fragmented centipedes (one stomach contained 21 entire centipedes), insect (grasshopper, coleopteran) remains, ants (possibly ingested incidentally), whole fruit of Nitraria billardieri, Mus musculus and rabbit fur and bone fragments.

The fresh carcass of a gecko Diplodactylus granariensis was found in a fox stomach in spring. Cat stomachs examined in autumn contained seven species of reptiles, insect fragments, centipedes, some rabbit fur and bone fragments, Mus musculus and bird remains.

No new reptile species were detected in stomachs of cats shot in spring, although one contained fledglings, possibly plovers. The following reptile species were retrieved from cat stomachs: Tiliqua occipitalis, Egernia multiscutata, Morethia adelaidensis, Ctenotus uber, Amphibolurus nullarbor, Tympanocryptis lineata, Phyllurus millii and a small elapid snake.

Although the samples were too small to view seasonal dietary differences, the combined autumn and spring samples demonstrate there was a marked difference in the diets of feral cats and foxes at the time of the surveys. Reptiles comprised the bulk of items ingested by cats while foxes appeared to be more omnivorous, ingesting plants and insects/arachnids to a greater extent. Rabbits and Mus musculus constituted common food items.

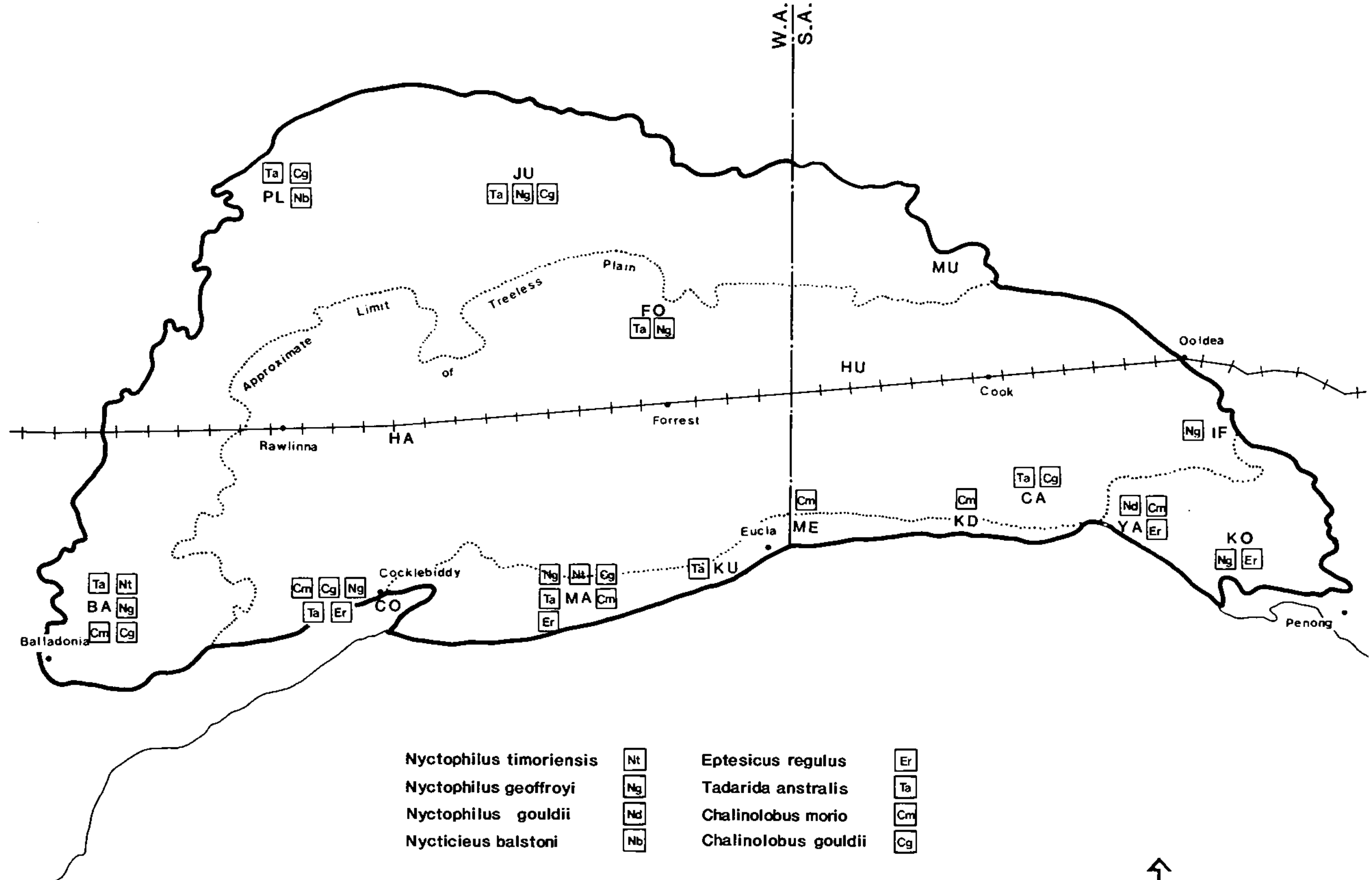
Records of Camelus dromedarius in the district included sightings at BA and YA, fresh signs (tracks, dung) at JU and MU, and old signs at FO5, IF and CA. The majority of sightings were at YA.

Discussion

Species Composition

Twenty-one native and seven introduced mammal species were recorded living in the Nullarbor Study Area during the March-April 1984 survey. The September-October survey recorded 19 native and eight introduced species, with an additional native, Sminthopsis gilberti, being added to the April list. The 1984 combined surveys inventory for the Nullarbor Study Area stands at 22 native and 8 introduced mammal species.

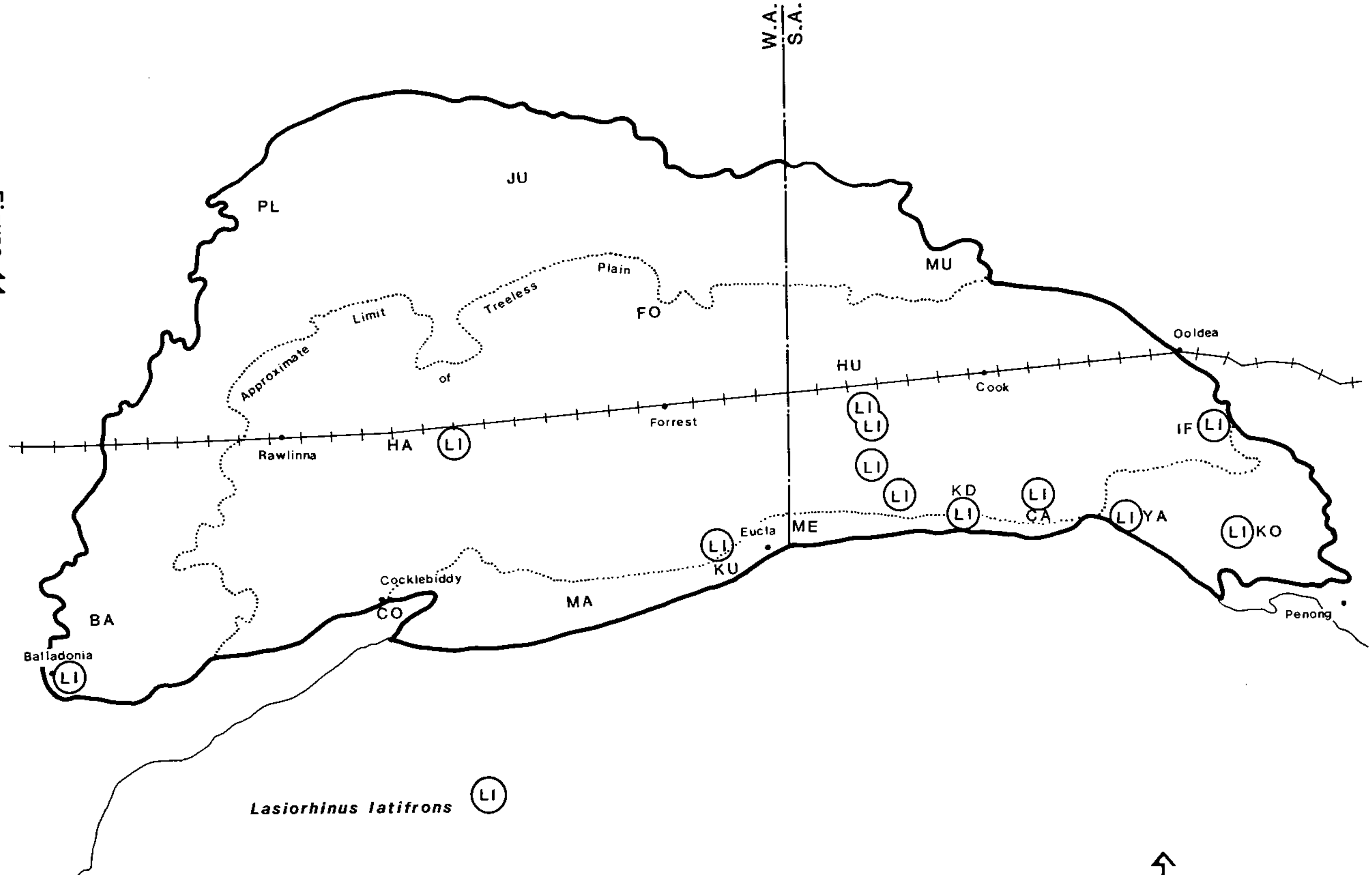
Figure 43
DISTRIBUTION OF BAT SPECIES RECORDED DURING THE SURVEY



DISTRIBUTIONS OF BAT SPECIES IN THE NULLARBOR STUDY AREA ACCORDING TO CAMPSITE.

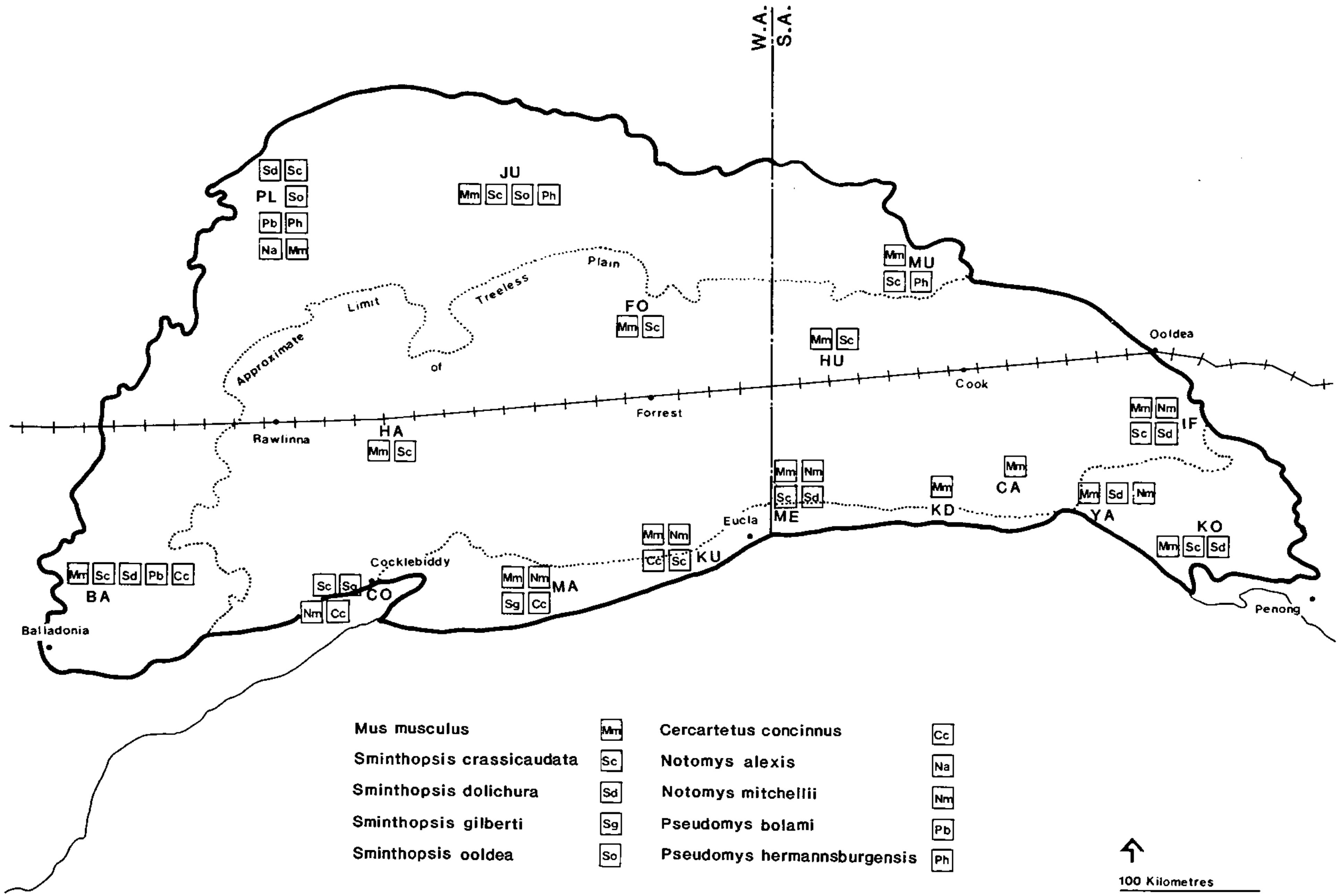
N.B. Quadrat and opportunistic records from both the March-April and September-October sampling sessions are pooled.

Figure 44
RECORDS OF *Lasiorhinus latifrons*
IN THE NULLARBOR STUDY AREA IN 1984



Presence at a campsite is indicated by a single point
irrespective of the number of individual records

Figure 45
THE DISTRIBUTIONS OF 10 SMALL MAMMAL SPECIES
IN THE NULLARBOR STUDY AREA ACCORDING TO CAMPSITE



These are listed in Table 15 along with previous extant mammal records, to provide a total list of species known to have been extant on the Nullarbor at the time of European settlement. When a species was not detected during the 1984 surveys, the date of its most recent record from the Nullarbor was indicated in the annotated list.

The 1984 field work added 4 species, comprising 2 small ground mammals and 4 bats, to the previously known list: Sminthopsis gilberti, Sminthopsis ooldea, Chalinolobus gouldii, Scotorepens balstoni, Eptesicus regulus and Nyctophilus cf. gouldi (see Appendix VII).

Specimens identified as Pseudomys bolami were formerly included in Pseudomys hermannsburgensis (Kitchener 1984a). Re-examination of an Australian Museum specimen from the Rawlinna region yielded a previous early record of P. bolami (see the annotated list).

Sminthopsis gilberti was formerly included in S. murina (Kitchener et al. 1984b). Prior to the present survey work, populations were known only from the near coastal Darling Ranges and in the central and southern wheatbelt of the South-Western Botanical Province of Western Australia; the easternmost locality record was Lake Cronin on the eastern edge of the Southern Wheatbelt (Kitchener ibid). Our records of S. gilberti from quadrats on the Roe Plain at the Cocklebiddy and Madura campsites, either represent a dramatic eastward extension of range for the species or indicate a population which is geographically disjunct from the south-western populations. Electrophoretic analysis indicated that the specimens belong with south-western populations (P. Baverstock, pers. comm. 1984) although morphological differences were apparent from specimens listed in Kitchener et al. (1984b); measures of specimens from CO and MA are presented in Table 14. Future survey of geographically intermediate localities is needed to resolve the status of the Roe Plain population.

Records of Cercartetus concinnus from MA and KU extend the species' known eastward limit in Western Australia (from the region of Eyre) by 150 kilometres. Our record of C. concinnus at the 8A camp (in Myall/Bluebush woodland) is probably near the inland limit of the species' range in the Study Area.

Previously, Sminthopsis dolichura was known in the Nullarbor Study Area from a single specimen collected at Yalata (see annotated list). Our further records from the Study Area suggest that populations in south-western Western Australia (northernmost records come from the semi-arid Austin District) are continuous with those in south-eastern Australia which range to the west of the Flinders Ranges, South Australia; see Kitchener et al. (1984b).

Available records (Table 15) indicate dramatic changes in the mammal fauna of the Nullarbor. There were at least eleven native species extant on the Nullarbor at the time of European settlement that were not recorded in 1984 (a 34% decline). Ten of these have only been recorded pre-1940 (Antechinomys laniger, Bettongia lesueur, Bettongia penicillata, Dasycercus cristicauda, Dasyurus geoffroii, Macrotis lagotis, Leporillus conditor, Notomys fuscus, Onychogalea lunata and Perameles bougainville). The eleventh species Pseudomys australis may be extant in the Study Area; although we did not detect the species, it was recorded as recently as 1969 from the southern part of the Study Area in Western Australia (see the annotated species list). Since then, colonies of this species have been discovered only in the south-eastern Northern Territory and north-eastern South Australia (Watts and Aslin 1981).

Species not detected during our surveys have body weights ranging from about 20 g to 3-4 kg. Our failure to detect medium sized bettong, bandicoot and a small wallaby species is consistent with the observed decline of these species elsewhere throughout semi-arid to arid areas of Australia (McKenzie 1981).

In fact, evidence from superficial cave deposits suggests an even more dramatic decline has occurred in the Study Area during the late Holocene. Data presented in Baynes (this publication) suggest a 60% (32 of 53 species) decline in the mammal fauna of the Study Area, nearly all confined to the middle weight ranges. Only six small native mammals (less than 35g.) were recorded in the superficial cave deposits which were not detected by the trapping survey: Pseudomys fieldi, P. desertor, P. albocinereus, P. occidentalis, Tarsipes rostratus and Antechinomys laniger. The last four of these are currently known as living animals in nearby districts; however on current knowledge the Study Area appears to be too dry for several of these species.

Possible causes of the observed decline of this suite of small to medium-sized mammals throughout arid and semi-arid mainland regions have been discussed by several authors (see Background, this paper). In addition, Watts and Aslin (1981) consider possible reasons why rodents such as Pseudomys australis and Leporillus conditor may have declined in post-European times. Read's (1984) comments on the rapid demise of Leporillus spp. from the mainland are also relevant since the Nullarbor appears to have been a last mainland stronghold for L. conditor.

Our 1984 surveys detected few species extant in the Study Area that were not reported by Baynes (this publication) in superficial bone deposits: Notomys alexis, Pseudomys hermannsburgensis, Sminthopsis ooldea, S. dolichura, S. gilberti and five species of bats. The first three of these are desert species that would only occur in northern parts of the Study Area from which little cave material is available. Baynes reported "Sminthopsis sp. murina gp." from many Nullarbor deposits; these could have been either (or both) S. dolichura or S. gilberti. None of the five bats are cave dwellers; they are less likely to be represented in these deposits than are cave bats or cave dwelling mammals.

Species Richness

Table 15 compares a list of extant native mammals recorded on the Nullarbor Study Area since the time of European settlement (32 species) with equivalent lists from adjacent natural districts. These are:

(i) the Great Victoria Desert, specifically the Helms Botanical District in Western Australia (Beard 1980), the Western Sandplains Environmental Region and the Great Victoria Desert Environmental Region in South Australia (Laut et al. 1977); and

(ii) the South-western Interzone of the Eastern Goldfields, specifically the Coolgardie Botanical District (Beard 1980).

Museum records and a corresponding historical inventory are not available for the region mapped as the Central Plains and Dunes Environmental Region, in particular, the Bookabie Environmental Association (Laut et al. 1977) which adjoins the south-eastern boundary of the Nullarbor in South Australia.

Overall the Nullarbor Study Area was not poor in native species compared with adjacent districts. There can be no doubt that there were at least 32 species of native mammals in the Study Area ca 1800 A.D.

The Great Victoria Desert supported 34 (perhaps 35) species and, to the west of the Nullarbor, the South-western Interzone of the Eastern Goldfields had 38 or more.

The apparent richness of the South-western Interzone can be explained by the diversity of its patchy environment, reflecting its intermediate climate, its geographical location between and its geomorphic continuity with the arid Great Victoria Desert, the semi-arid Roe and Avon Botanical Districts that comprise the Western Australian wheatbelt, and the arid Nullarbor Plain. The Nullarbor's richness derives from biogeographic sources.

Patterns of Small Ground Mammals

The distributions of the ten small ground mammal species in the Nullarbor Study Area according to campsite presence are plotted in Fig. 45. From this plot and the two-way table (Table 11), four components of the mammal fauna of the Study Area can be distinguished:

1. a ubiquitous component, comprising Mus musculus and Sminthopsis crassicaudata. Both species were wide-ranging throughout the geographical extant of the Study Area although the latter species was not detected on the Roe Plain except in superficial bone deposits (Baynes, this publication).

2. a "western fringe" component, comprising Pseudomys bolami. The species probably ranges throughout the Plain and in salt lake systems around its periphery (see Table 18 in Baynes, this publication).

3. a peripheral woodlands component in the north-west, south-west, south, south-east and east of the Study Area, comprising Sminthopsis dolichura.

4. a mesic/semi-arid component restricted to the southern portion of the Study Area: Cercartetus concinnus, S. gilberti and Notomys mitchellii. N. mitchellii was also detected further inland on the eastern fringe (at IF).

The occurrence of P. bolami on the western periphery (at PL and BA), but not in the central north (JU and MU), reflects the proximity of the Eastern Goldfields district (B.S.C.W.A. 1984) in which the species appears to be widespread and common (see Kitchener et al. 1984a). The Eastern Goldfields is continuous with the Carlisle Plain (Sensu Beard 1975) on which BA and PL are positioned.

The peripheral occurrence of S. dolichura within the district (at PL, BA, ME, KO and IF) and its association with the open treed formations of these sites (open woodlands of Eucalyptus spp., Myall, Mulga and Casuarina cristata), is consistent with the species' known habitat associations in districts to the east and west of the Study Area.

S. gilberti was detected at only two quadrats in the Study Area: CO5 and MA3 on the Roe Plain. Our records of N. mitchellii within the Study Area were southern coastal (ME, CO, MA, KU), coastal south-eastern (YA2) and eastern fringing (IF4). South-western and south-eastern populations appear to be separated on the southern portion of the Study Area in South Australia by the southerly incursion of the Treeless Plain between KO and YA. The CA campsite was centred on this tract. In contrast, data in Baynes (this publication) indicates a species of Notomys occurred throughout the Study Area during the late Holocene.

A similar discontinuity is predicted for south-western and south-eastern populations of Cercartetus concinnus, although the break may be wider in this case since the species was not detected in the Mallee quadrats at ME or in the Eucalyptus woodlands at YA (there are specimens from Mallee just east of YA, P. Bird, pers comm.) and data in Baynes provides no evidence that it formerly occurred on the Treeless Plain.

In overview, the patterning of small ground mammal distribution and overall species richness in the Study Area is produced by the peripheral intrusion of species from adjacent natural districts and the presence of a ubiquitous component, M. musculus and S. crassicaudata. P. bolami, a rodent of heavy poorly drained soils supporting chenopod shrublands (Kitchener et al. 1984a), and which we only recorded in the western end of the Study Area, is probably also ubiquitous in the Nullarbor in some years. It was known from the vicinity of Rawlinna and Ooldea earlier this century.

Biogeography of Extant Mammal Fauna of the Study Area in 1984

No species are endemic or currently confined to the Study Area. In fact, with the exception of Sminthopsis gilberti (discussed earlier), no species were recorded on the Nullarbor during our survey that are not also known from at least one of the immediately adjacent natural districts (see Table 15).

The contemporary distribution of Lasiorhinus latifrons is centred on the southern portion of the Nullarbor in South Australia, where the species is most abundant. Although the southern Nullarbor in South Australia has historically comprised a large portion of the species' range, a contraction from agricultural and settled areas from the Murray River in north-western Victoria and South Australia since European settlement, as documented by Aitken (1971), has left the bulk of the population west from Penong South Australia. A westernmost record of the species, near Balladonia, was confirmed during the 1984 survey. Even in the recent past, only Leporillus conditor appears to have had a range centered on the Nullarbor.

Several biogeographical components of the total extant native mammal fauna of the Study Area are recognisable:

1. Species that occupy a variety of habitats and show a wide geographic spread on the continent from high rainfall to arid and semi-arid regions; Nyctophilus geoffroyi, Tadarida australis, Scotorepens balstoni, Chalinolobus gouldii, Canis familiaris dingo and Tachyglossus aculeatus.

2. Eyrean species confined to semi-arid and arid areas of central, western and parts of southern Australia: Macropus rufus, Notomys alexis, Pseudomys hermannsburgensis and Sminthopsis ooldea.

3. Species confined to the southern half of the continent. These include species which are widespread and occupy a range of habitats from semi-arid and arid regions excluding the sandy deserts - Macropus fuliginosus, Sminthopsis dolichura, S. crassicaudata, Cercartetus concinnus, Notomys mitchellii, Pseudomys

bolami, *Eptesicus regulus*, *Nyctophilus timoriensis*, *N.* cf. *gouldi* and *Chalinolobus morio*, although several are also found in more mesic areas in south-western and south-eastern Australia. Two species show relatively restricted distributions in southern Australia: *Sminthopsis gilberti* and *Lasiorhinus latifrons* (discussed earlier).

It is apparent that the dominant component of the list of extant mammals comprises species of semi-arid and arid southern Australia (excluding the sandy deserts) - 12 species, including two species with restricted southern distributions. More wide-ranging species (6 species) and strictly Eyrean species (4 species) form lesser components.

Overview

Thus, the overall species richness of the Nullarbor Study Area derives (or derived) from biogeographic influences. There has been a considerable decline in its richness in the last few hundred years. In addition, small ground mammals, the group of mammals least affected by this decline, have assemblages on the Nullarbor Study Area which are poorer in species (or population densities are very much lower) than sites in other arid and semi-arid districts of Western Australia surveyed using similar techniques - the South-western Interzone and the Great Sandy Desert. Assemblages over most of the Nullarbor Study Area were found to support one or two species. Of 5 quadrats in the portion of the Kurnalpi-Kalgoorlie cell that is placed within the South-western Interzone (B.S.C.W.A. 1984), the maximum level of small ground mammal sympatry detected on a single quadrat was 5 species (four native species and *M. musculus*). Four species were detected at another three quadrats and three species at one quadrat (McKenzie 1984).

In the Great Sandy Desert, the maximum number of co-existing small ground mammals at sample sites in sandplain and sand dune areas well within the Desert was three native species (McKenzie and Youngson 1983) even though sampling effort at individual quadrats was confined to one visit (in one season) and totalled only 20 to 25% of the effort at quadrats on the Nullarbor Study Area.

TABLE 9:

TABLE 9: LIVE CAPTURES OF SMALL GROUND MAMMALS IN THE NULLARBOR STUDY AREA IN 1984. Results of the March-April and September-October Surveys are combined.

Species	Campsite																Total Number of Live Captures
	BA	PL	JU	FO	HA	KU	MA	CO	HU	MU	IF	KO	YA	CA	KD	ME	
Sminthopsis dolichura	2	4									4	1	8			2	21
																(1)	(1)
S. gilberti							2	1									3
S. ooldea		4	2														6
S. crassicaudata	2	4	10	6	4	1		1	1	6	3	1				1	40
*Ningaui ridei**		1															1
Cercartetus concinnus	1					1	16	6									24
Pseudomys bolami	4	4															8
P. hermannsburgensis		5	4							1							10
										(1)							(1)
Notomys mitchellii						1	2	6					2			7	18
											(1)		(1)			(7)	(9)
N. alexis		1															1
Mus musculus	6	5	7	8	4	4	13	–	3	18	5	22	17	4	9		125
									(11)	(41)	(5)	(42)	(28)	(3)	(26)	(4)	(160)
No. of native species	4	7	3	1	1	3	3	4	1	2	3	1	2	–	–	3	
Pit-fence nights	92	104	92	92	92	84	104	92	80	88	104	80	88	80	80	80	

x Number of individuals captured in pitfall traps
(x) Number of individuals captured in Elliott traps (South Australian campsites only)
* Captured at PL6 outside the Study Area

TABLE 10: COMPARISON OF PIT TRAPPING SUCCESS IN THE NULLARBOR STUDY AREA, THE SOUTH-WESTERN INTERZONE OF THE EASTERN GOLDFIELDS AND THE GREAT SANDY DESERT, WESTERN AUSTRALIA. Trapping effort is quantified in terms of pitfence nights; one pitfence comprises 6 pit traps at 10 metre intervals.

	Nullarbor Study Area	South-western Interzone (Kurnalpi-Kalgoorlie Cell, Western Australia (1)	Great Sandy Desert, Western Australia (2)
Total Small Mammal Species	11	7	11
Total Number of Mammal captures*	257(125)	81(21)	109(1)
Pitfence Nights	1432	124	157

(1)Kurnalpi-Kalgoorlie Cell of the Biological Survey of the Eastern Goldfields (B.S.C.W.A. 1984). Data from McKenzie (in prep).

(2)McKenzie and Youngson 1983 (in Burbidge and McKenzie 1983).

* Figures in parentheses are numbers of *Mus musculus*.

Table 11

TWO – WAY TABLE OF QUADRATS VERSUS SMALL MAMMAL SPECIES.

UPGMA QUADRAT GROUP

UPGMA SPECIES GROUP	Species	1	2	3	
		BIKIMYM BM PPP AFOFEAE AA LLL 2314221 45 135	B FFFHHHHIIIJKMMMJJMJM A OOOAAAUFFFUOEUUUUUUU 3 13524531252251234355	CMKCM OAUOA 42553	KKKBCCCCKKKFMPHHKMHHYHYKMYKYMMKP DDDAAAOOOOUOELUADAUUAUAOUAUAAEDL 12351413451232535612345341244444
1	Mus musculus	****** ** **	*******************	*	****** ******* ********* * **
	Sminthopsis crassicaudata	*	* ******************		** * *
2	Sminthopsis dolichura	******* * ***			* *
3	Pseudomys bolami	* * *	*		
	Pseudomys hermannsburgensis	***	*** *		
	Sminthopsis ooldea	**	*		
4	Cercartetus concinnus	**		*****	*
	Notomys mitchellii	****		*** *	
	Sminthopsis gilberti			**	
	Notomys alexis				*

UPGMA group boundaries are indicated. Quadrats and species which were recorded only once were excluded from the analysis and are those outside UPGMA groups

TABLE 12: DISTRIBUTION OF BAT SPECIES IN THE NULLARBOR STUDY AREA ACCORDING TO CAMPSITE. MARCH-APRIL AND SEPTEMBER-OCTOBER SURVEY DATA ARE POOLED.

Species	Campsite															
	BA	PL	JU	FO	HA	KU	MA	CO	HU	MU	IF	KO	YA	CA	KD	ME
*Tadarida australis**	x	x	x	x		x	x	x						x		
Chalinolobus gouldii	x	x	x				x	x						x		
C. morio	x						x	x					x		x	x+
Nyctophilus timoriensis	x						x									
N. geoffroyi	x		x	x			x	x			x	x				
N. cf. *gouldi*													x			
Scotorepens balstoni		x														
Eptesicus regulus							x	x				x	x			

x Quadrat or opportunistic record

* Specimen or heard overhead

\+ Wombat Cave, east of ME campsite

TABLE 13: DISTRIBUTION OF FIVE SPECIES OF GROUND MAMMALS AND TWO MARINE MAMMALS IN THE NULLARBOR STUDY AREA. Presence at campsites is indicated.

Mammal Species	Campsite BA	PL	JU	FO	HA	KU a	KU b	MA	CO a	CO b	HU	MU	IF	KO	YA	CA	KD	ME	Survey Period
Macropus rufus	X	X	X	X		X					X	X	X	X			X		M
		X	X	X	X						X	X	X	X		X			S
M. fuliginosus	X				X	X	X	X	X				X				X	X	M
	X	X	X		X	X	X	X	X	X			X	X	X	X	X	X	S
Tachyglossus aculeatus*	X							X	X	X									M
													X						S
Lasiorhinus latifrons*						X							X	X		X	X		M
						X							X	X		X	X		S
Canis familiaris dingo		X	X	X							X	X	X	X			X		M
		X	X	X								X				X	X		S
Neophoca cinerea																			M
								+											S
Peponocephala electra (skull)								X											M
																			S

M March-April survey
S September-October survey
X Quadrat and/or opportunistic (outside quadrat) record
a Above Hampton Escarpment
b Below Hampton Escarpment on Roe Plain
* Sighting and/or fresh signs (diggings, active warrens, fresh tracks and dung)
\+ On beach, 15 km east of MA5

TABLE 14: MEASUREMENTS OF ADULT *SMINTHOPSIS GILBERTI* FROM THE ROE PLAIN. ALL MEASUREMENTS ARE IN MILLIMETRES. CRANIAL AND EXTERNAL MEASURES FOLLOW ARCHER (1981). ABBREVIATIONS OF CRANIAL MEASURES ARE EXPLAINED IN KITCHENER *ET AL.* (1984b).

Specimen Number	FW 5468	FW 2267	FW 5484
Sex	M	M	F
Live Weight (g)	25.0	24.5	19.5
Nose - Vent	90.80	91.90	87.20
Tail - Vent	85.0 (damaged)	92.35	78.60
(damaged)			
Hindfoot	18.95	18.95	18.10
Ear Length (from Notch)	23.10	23.15	23.05
BL	27.28		
ZW	15.72		
OBW	11.03		
IBW	3.56		
C^1-M^4	11.25		
M^{1-4}	5.65		
M^{1-3}	4.90		
R-LM^3	8.91		
IO	5.85		
IPVD	4.32 (LHS)		
	4.85 (RHS)		
DL	21.80		
I_1-M_4	12.81		
M_{1-4}	6.49		
M_{1-3}	4.70		
C-AP	5.90		
C-AR	4.95		
C-AR/M^{1-4}	0.76		
M^3 Metacristid	1.44		
M^3 Length	1.60		
C^1-P^4	5.37		
C^1-P^4/M^{1-3}	1.10		

TABLE 15: THE MAMMAL FAUNA KNOWN TO BE EXTANT AT EUROPEAN SETTLEMENT IN THE NULLARBOR STUDY AREA AND ADJACENT NATURAL DISTRICTS.

Species	Nullarbor Study Area	Great Victoria Desert (South Australia and Western Australia)	South-west Interzone of Eastern Goldfields (Western Australia)
Tachyglossus aculeatus	X	X[1]	X
Dasyurus geoffroii	D[1]	?	D[1]
Dasycercus cristicauda	D[1]	D[4]	-
Phascogale calura	-	-	D
Sminthopsis dolichura	X	X	X
S. gilberti	X	-	-
S. ooldea	X	X	-
S. crassicaudata	X	X	X
S. hirtipes	-	X	X
Ningaui ridei	-	X	X
N. yvonneae	-	X	X
Antechinomys laniger	D[1]	?	X
Myrmecobius fasciatus	-	-	D[1927]
Notoryctes typhlops	-	X[2]	-
Chaeropus ecaudatus	-	D[4]	D
Perameles bougainville	D[1]	D[2]	D[2]
Macrotis lagotis	D[1]	D[2]	D[1973]
Lasiorhinus latifrons	X	-	-
Trichosurus vulpecula	-	-	D
Cercartetus concinnus	X	-	X
Bettongia penicillata	D[1]	D[2]	D
B. lesueur	D[1]	D	D
Lagorchestes hirsutus	-	?	D
Onychogalea lunata	D[1]	D	D
Macropus fuliginosus	X	X[1,3c]	X
M. robustus	-	-	X
M. rufus	X	X	X
Pseudomys australis	D[1]	X[2]	-
P. bolami	X	-	X
P. hermannsburgensis	X	X	X
Leporillus conditor	D[1]	-	-

L. apicalis	-	D[3b]	D
Notomys mitchellii	X	X[3a]	X
N. alexis	X	X	-
N. cervinus	-	D	-
Tadarida australis	X	X	X
Mormopterus planiceps	-	X	X
Nyctophilus timoriensis	X	X	X
N. cf. gouldi	X	-	X
N. geoffoyi	X	X	X
Chalinolobus gouldii	X	X	X
C. morio	X	-	X
Scotorepens balstoni	X	X	X
Eptesicus pumilus	-	X	-
E. regulus	X	-	X
E. vulturnus	-	X[5]	X
Canis familiaris dingo	X	X	X
Mus musculus	X	X	X
Vulpes vulpes	X	X	X
Felis catus	X	X	X
Oryctolagus cuniculus	X	X	X
Camelus dromedarius	X	X	X
Bos taurus	X	-	X
Ovis aries	X	-	X
Equus equus	X	-	X
Capra hircus	X	-	-

Legend: X Extant in 1984
D Declined or Extinct

Source: Nullarbor Study Area - Records of the Australian, Western Australian and South Australian Museums
1: See annotated species list herein.
Great Victoria Desert - South Australian or Western Australian Museum records unless qualified otherwise:
1. McKenzie and Burbidge (1979)
2. Museum record from Ooldea
3. Greenslade et al. (ed.) (1986): a. capture; b. old nests, species uncertain; c. observation
4. Wood Jones (1969)
5. In South Australia (P. Bird, pers. comm.).

South-western Interzone - McKenzie (in prep.); dates included where known.
1. Photograph, no museum record.
2. Either Perameles bougainville or P. eremiana

THE ORIGINAL MAMMAL FAUNA OF THE NULLARBOR AND SOUTHERN PERIPHERAL REGIONS: EVIDENCE FROM SKELETAL REMAINS IN SUPERFICIAL CAVE DEPOSITS

Alexander Baynes[1]

Introduction

The original (i.e. immediately pre-European) mammal fauna of the Hampton Tableland part of the Nullarbor Region was largely established by Lundelius (1957, 1963), as a result of field work carried out three decades ago. Further collecting of material now lodged in the Western Australian Museum, by J.W.J. Lowry, M. Archer et al. and others, has added to the species list for this area: Merrilees (1968a) and Archer (1974a). Lowry's very extensive collections include material from the plain to the north of the Hampton Tableland, but her publications on the vertebrates of the region (Lowry and Lowry 1967, Lowry and Merrilees 1968 and Lowry 1972) have been solely concerned with Thylacines, which are substantially older than the material considered in this study (Partridge 1967, Merrilees 1970, Milham and Thompson 1976). P.J. Thompson investigated the distribution patterns and ecology of the mammals of the southern Nullarbor Region in the course of an archaeological study in Madura Six Mile South Cave (N62) (Thompson in Marun 1969, Thompson pers. comm.). Unfortunately this work has not been published.

Beard's (1975) vegetation study was the first to describe biogeographic patterns for the region.

In this paper mammal faunas from the surfaces of deposits in sites of the western and central Nullarbor, and peripheral areas to the south-west and south-east, are summarized and compared with the vegetation patterns revealed by Beard's survey. New data from the southern peripheral areas are included because they provide context for species occurring in the original faunas of the southern Nullarbor.

Materials and Methods

(a) Sites

The geographic positions of the sites which have provided material for this study, numbered 1 to 53, are shown on Fig. 46. The sites are numbered in order from the north by physiographic/vegetational unit recognized by Beard (1975). These units are listed in Table 16, which also provides a key to Fig. 46.

Full details of the sites are given in Appendix VI, near the back of this publication.

(b) Materials

This study is restricted to material in the collections of the Western Australian Museum, except for the Eyre Peninsula material which is in the collections of the South Australian Museum or G.C. Medlin. Data from the Eyre Peninsula, (Watts and Ling 1985 with some reidentifications), have kindly been made available by C.H.S. Watts and G.C. Medlin.

The Western Australian material consists of extensive older collections made in the 1960s and 1970s from many caves in the Nullarbor Plain and Hampton Tableland, plus new collections made by the author in 1984 from an area south-west of the Nullarbor, ranging from the southern Nyanga Plain and western Hampton Tableland to the eastern south coast of W.A. and Peak Charles. Other collectors are listed, under site, in Appendix VI. Those who have made particularly significant contributions include J.W.J. Lowry, whose collections remain the most geographically comprehensive, A.J. Carlisle who has collected from the most remote sites, and members of the Western Australian Speleological Group who have made continual contributions over the last 25 years. All this material has been or is being accessed into the vertebrate palaeontological collection of the W.A. Museum. The accession numbers of the specimens used are listed for each site in Appendix VI.

(c) Samples

Only surface samples were considered for inclusion in this study. For many, however, the provenance of samples is not recorded. In such cases the age of the material has been assessed by examination. Only material which appears to have originated from the surface of deposits was used. Even so, the antiquity of the well-preserved Thylacine from the surface in Thylacine Hole cave (Lowry and Merrilees 1968, Merrilees 1970) shows that this does not guarantee a recent date. The age of the material is discussed further in the Taphonomy section below.

Wherever possible the samples I collected in 1984 were randomly scooped in bulk from the surface of the deposit, with no more preparation in the field than screening by a fine sieve to remove dust and sand to reduce sample weight. Such samples are suitable for quantitative treatment. Although none of the Western Australian samples has yet been fully quantified into minimum numbers of individuals, semi-quantitative data have been generated from them by estimating for each species in the sample which of three categories (rare, common and very abundant) it falls into. In the case of a site from which there are both qualitative surface and bulk quantitative samples, a species recorded in the qualitative but not the quantitative sample is included in the fauna reported in the Results section but is distinguished by a different symbol.

It was assumed that all samples which are not stated to be randomly collected bulk, are composed of material selected from the surface and are not suitable for quantitative treatment. Such selection also introduces a bias in the species represented in the sample, increasing the large to medium-sized species component at the expense of the smaller ones.

Both samples from the Eyre Peninsula are bulk samples and have been fully quantified, although they also are presented in a semi-quantitative manner here.

(d) Data Generation

For the older collections, faunas were extracted from the catalogues of the vertebrate palaeontological collection of the W.A. Museum. Specimens' identifications were checked where the catalogue entries were in pencil, indicating that they were tentative, or were only at generic or higher level; also, where the record was at the limit of a species' range. Doubtful records have been omitted.

Identification was made by comparison with named material in the modern mammal and vertebrate palaeontological collections of the Western Australian Museum. In the case of the material from the Eyre Peninsula, the initial identifications were made by G.C. Medlin, and then the material sent to me for checking.

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Figure 46
PHYSIOGRAPHIC/VEGETATIONAL UNITS AND COLLECTION SITES
– See table 16 and appendix VI

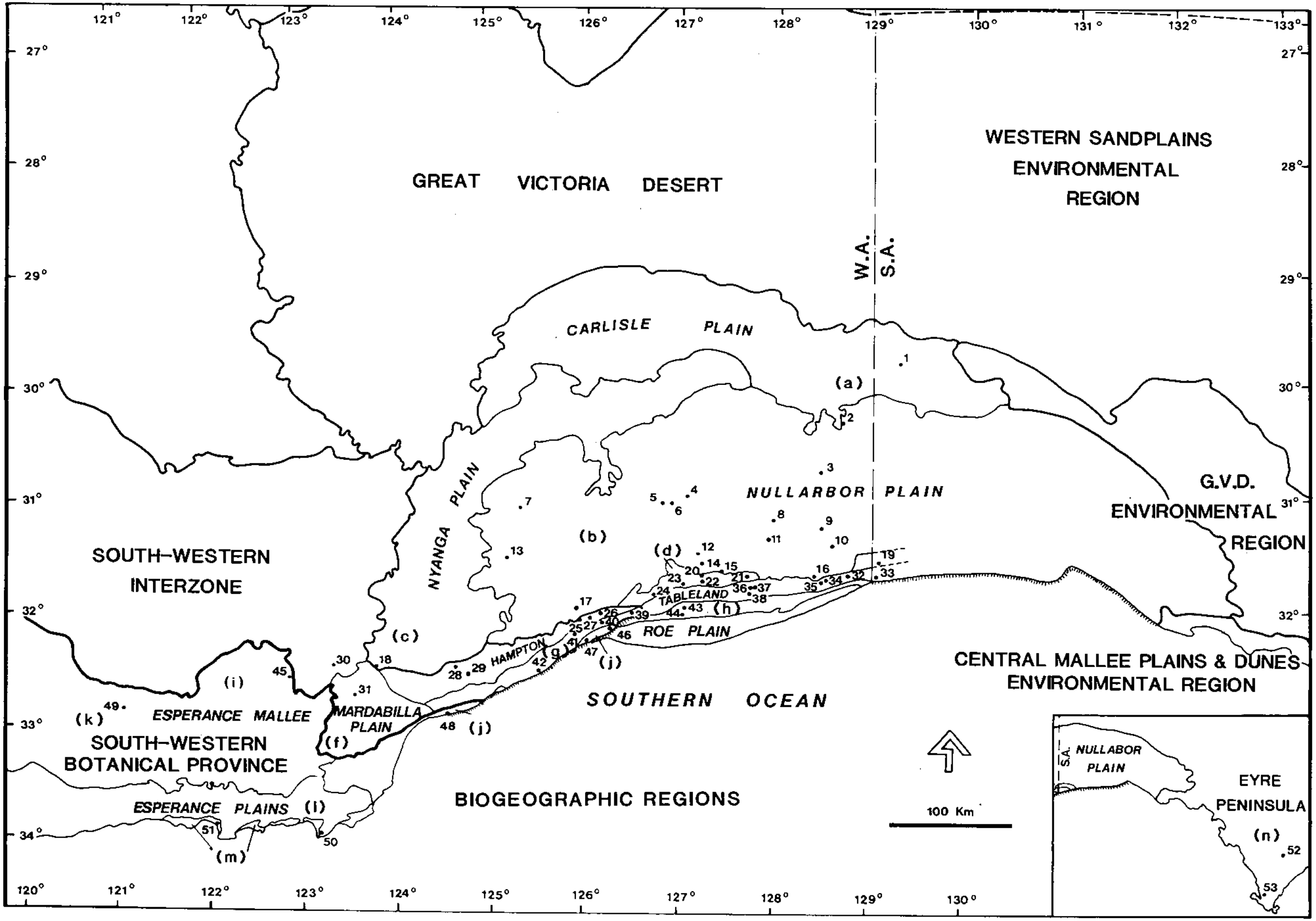

TABLE 16: THE PHYSIOGRAPHIC/VEGETATIONAL UNITS USED IN THIS STUDY (AFTER BEARD 1975)

(a)	Carlisle Plain with lightly wooded succulent steppe.
(b)	Nullarbor Plain with unwooded succulent steppe.
(c)	Nyanga Plain with Myoporum and saltbush with patches of eucalypt woodland.
(d)	Hampton Tableland with lightly wooded succulent steppe.
(e)	Hampton Tableland with eucalypt woodland.
(f)	Mardabilla Plain with eucalypt woodland.
(g)	Hampton Tableland with mallee and boree over saltbush.
(h)	Roe Plains with lightly wooded succulent steppe.
(i)	Esperance Mallee with mallee with patches of woodland.
(j)	Hampton Tableland with mallee heath.
(k)	Lake Hope Uplands with mallee with patches of woodland.
(l)	Esperance Plains with mallee heath.
(m)	Esperance Plains with coastal dune scrub.
(n)	Eyre Peninsula (vegetation not known).

Concepts implied by the names are considered in the Systematics section below.

Systematics
The nomenclature used throughout this paper follows that in Strahan (1983) for all species except Pseudomys bolami and Pseudomys fieldi. Thus, for example, the ringtail possum specimens are referred to the species Pseudocheirus peregrinus because that is the currently accepted name for populations to both east and west of the Nullarbor. If the south-western Australian populations are again raised to specific status (P. occidentalis), the Nullarbor material will need re-examination to determine its affinities. A similar situation exists for Perameles bougainville.

Pseudomys bolami populations were previously referred to P. hermannsburgensis, but have been shown by Kitchener et al. (1984) to represent a separate species. The upper first molar cusp characters permit dentate maxillae from Nullarbor caves to be easily identifified as P. bolami rather than P. hermannsburgensis. No P. hermannsburgensis (s.s.) specimens have been found in these deposits.

The case of Pseudomys fieldi is rather more complicated. It is now clear that the remains of medium-sized Pseudomys in the Nullarbor cave deposits include two species. The more widespread and abundant in surface material is a member of the P. australis group, characterized by hypsodont molars, which have relatively vertical cusps and lack an anterior accessory cusp on M^1 and central lingual root on M_1. The interorbital region of the skull is relatively long and narrow and has bevelled interorbital ridges; and each anterior palatine foramen pinches to a point at the posterior end. The less common species is a member of the P. gouldii group, characterized by brachydont molars, which have relatively sloping cusps; an accessory cusp is present on the anterior lingual side of M^1 and a central lingual root is well developed on M_1. The interorbital region of the skull is short and broad with interorbital ridges forming sharp right angles; the posterior ends of the anterior palatine foramina are wide and evenly rounded.

Lundelius (1964) was the first to study this very difficult material from cave deposits. He recognized that there was substantial variation in skull morphology within his Nullarbor cave sample, particularly in interorbital width and shape, but concluded that this represented intraspecific variation and referred all the specimens to P. rawlinnae, now regarded (e.g. Watts and Aslin 1981) as a member of the P. australis group. Now that the distinguishing characters have been established, it is possible to see from Lundelius' skull figures that his sample included species from both groups.

Since I have made no morphological study of Pseudomys of the P. australis group, I follow current practice and place P. rawlinnae in synonymy with P. australis. However, I have observed considerable morphological difference between the P. australis material from the Nullarbor deposits compared with that from Medlin's and Watts' samples from Eyre Peninsula, respectively from sites 52 and 53. The Nullarbor P. australis are substantially smaller, having shorter and proportionally deeper dentaries. These differences suggest that the specific status of P. rawlinnae should eventually be re-examined.

I have, on the other hand, been engaged in an, as yet mainly unpublished, study aimed at elucidating the systematics of the Pseudomys gouldii group (P. gouldii, P. fieldi and P. praeconis) since 1970 (Archer and Baynes 1973, Baynes 1979, 1980). Since all populations except the P. praeconis on Bernier Island, Shark Bay, now appear to be extinct, and very few modern specimens were collected (three in N.S.W., one in the N.T., and about 10 along the west coast of W.A.), the study has depended largely upon fragmentary remains from cave deposits. It has therefore been constrained by discovery of new samples of such material, but has recently been advanced by the collection of a large sample of P. fieldi remains from a cave at Simpsons Gap near Alice Springs (Johnson and Baynes 1982). Results to date show the group to consist of P. gouldii which occurred in N.S.W., on the western slopes of the eastern highlands and the western plains; populations which occurred in the middle longitudes of Australia, around Alice Springs (the type locality of P. fieldi), in the Flinders Ranges (Smith 1977), on the Eyre Peninsula (Watts and Ling 1985), and on the Nullarbor; and a form which originally occurred along the west coast from the extreme south-west (Archer and Baynes 1973) at least as far north as Shark Bay (the type locality of P. praeconis), and inland to the western margin of the Gibson Desert (Baynes 1984, unpublished data). At present material from the intermediate areas is lacking. Therefore, at this stage of the investigation, and although I suspect that there are fewer than three species involved, I am maintaining the separate names P. gouldii, P. fieldi and P. praeconis for the eastern, central and western populations respectively.

Use of the name Pseudomys fieldi for the Nullarbor member of the P. gouldii group is also consistent with the very close morphological similarity of the Nullarbor material to that in the Simpsons Gap sample. In this match it also differs from the P. australis situation.

The mammal listed as an unnamed potoroid in Results is the species called Caloprymnus campestris by Lundelius (1957, 1963) and subsequent authors, e.g. Archer (1974a). This point is established by Lundelius' reference specimens (No. 63.6.4) lodged in the Western Australian Museum. The misidentification was discovered by Peter Thompson who considered that the animal may differ from all other potoroids at generic level (in litt. P.J.T. to O. Merrilees 31 January 1973).

Finally, it may be noted that the specimens of Nyctophilus geoffroyi from the Nullarbor cave deposits show some morphological differences from those of adjacent regions. In particular they have larger teeth, especially the premolars.

Results
The mammals identified from the 53 sites (Fig. 46) are presented here in Tables 17-20, in which the sites are grouped by physiographic/vegetational unit (see Table 16 above).

A key to the symbols used is provided with Table 17.

Taphonomy and Age of Material
The principal agents of accumulation of the Nullarbor mammal remains are owls. The majority of the material fulfils Lundelius' (1966) three owl accumulation criteria. On the basis of zoogeography, the likely species are the Barn Owl Tyto alba (Storr and Johnstone 1979) and the Masked Owl (Tyto novaehollandiae). Mummified bodies of Masked Owls and addled eggs (Fig. 48) from a nest were collected from Ivy Cave during the present survey but the abundant bone deposits in the cave have yet to be sampled. Another bird of prey which may have contributed mammal

remains to the deposits is the Australian Kestrel Falco cenchroides which is closely associated with the Nullarbor caves. Because Kestrels are smaller and hunt by day, mammals are not as important a component of their diet as insects and lizards, but they do take some small mammals.

Caves with suitable structures also contain a component of mammal remains accumulated by mammalian predators. Such specimens are typically much more damaged than bird prey (Lundelius 1966). The final way in which mammals' remains are introduced into caves is when living animals are pit-fall trapped by vertical walls at the entrance.

Accumulation by both avian and mammalian predators introduces uncertainty into the locality of origin of prey individuals, because the predators range out from the cave for variable distances. Pit fall accumulated individuals lived in the immediate vicinity of the cave entrance.

Ages of specimens in samples can be judged on the basis of four criteria: stratigraphy, associated fauna, radiometric dates and appearance of the material.

This study has been based only on specified surface material or, in the case of collections made by non-biologists, specimens which are not stated to have been excavated. One of the strongest arguments that the specimens at the surfaces of cave deposits truly represent the original local faunas, is that the mammal faunas change only very slowly through time in the few Holocene cave deposits which have been excavated and dated (e.g. Baynes 1979). Although Archer's (1974a) excavation in Horseshoe Cave has not been fully published, examination of the records in the catalogues of the Department of Palaeontology of the W.A. Museum shows that many of the species occur throughout the depth of the deposit. As a result, there is only a low probability that an old specimen on the surface will introduce a spurious datum to a fauna. The cave surface mammal fauna from the cave at Simpsons Gap (Johnson and Baynes 1982) shows a very close match with the local modern mammal fauna collected by the Horn Expedition before extinctions began. However, the Nullarbor surface material does include Thylacinus cynocephalus which is known to have been extinct for at least 3000 years (Milham and Thompson 1976), and Sarcophilus harrisii which was probably extinct on mainland Australia before European man arrived (Archer and Baynes 1973). Where these have been found on the surface the records are included in Results to indicate that some older material has come from the surface in those sites.

There are very few relevant radiocarbon dates for the Nullarbor surface material. Merrilees (1970) recorded a date of 180 + 76 years B.P. on flesh from a mummified rabbit from the surface in Thylacine Hole. A new radiocarbon date was obtained on wood and charcoal from the surface sample from site 28 after both Phascogale tapoatafa and Pseudocheirus peregrinus were identified in the fauna. The result was a date of 390 + 210 years B.P. (W.A.I.T. 98). Both these dates are consistent with surface material representing the original mammal fauna.

The age of the furred Thylacine mummy from Thylacine Hole (Lowry and Merrilees 1968) shows how misleading appearance can be in judging age. However, bone darkens in colour as it ages, even on the surface in highly protected environments, and colour has been used as a cross check in assessing age of surface specimens.

Discussion

(a) The Significance of Presence and Absence

Whether or not a species is present in a sample depends upon a number of factors: the presence of the species in the local biotic communities at some point in the time spanned by the sample; biasses in the sampling; and the interaction of chance with the size of the sample and the structure of the local biotic communities.

The biasses in the Nullarbor cave deposit samples mainly stem from the accumulating agents, which in turn are partly constrained by the structure of the cave. Thus a large cave with a deep entrance doline with walls which are all vertical (though typical in having limestone shelves) would have provided a safe roost for a number of individual birds of prey and also operated as a trap, but would not have provided a suitable den for a carnivore such as a Dingo. Compared with the surrounding communities, the mammal remains accumulated in such a cave would therefore be biassed by the birds of prey towards species of small size, limited by the birds' lifting capabilities, and perhaps towards over-representation of the commoner species, by their search images. It is difficult to predict any bias introduced by the pit fall, but it appears from the material to be towards an increased proportion of medium-sized species and carnivores. Apart from possums (Trichosurus), and stick-nest rats (Leporillus) which almost certainly lived in the caves, the animals most frequently represented in the W.A. Museum collection by mummified whole animals, indicating pit fall rather than predator accumulation, are species of Bettongia, and Onychogalea. There are also the Thylacines (Lowry and Lowry 1967) and a number of Dingoes. The lack of kangaroo mummies may reflect the fact that they are regarded as 'common' when collections are made, and not worth the trouble to carry out of caves. Kangaroo mummies were noted but not collected in Ivy Cave (a pitfall trap) during the present survey. Alternatively, the specimen count may truly represent a low proportion of pit trapped kangaroos, perhaps because they travel along paths which avoid the cave entrances, or because their eyes are sufficiently high above the ground to enable them to avoid the holes.

Caves with structures which make them suitable for use as lairs by mammalian carnivores accumulate the remains of their prey which are most frequently of medium-sized species (Lundelius 1966). Thus a cave which has provided all three means of accumulation of mammal remains is most likely to have the full size range of the local fauna represented.

Superimposed upon these natural biasses are others imposed by the people who collect, select and sort the bone material. Only the samples treated semi-quantitatively above are bulk random collections. All others appear to be selections of material made either at the collecting stage or in the laboratory. In such selections specimens of the smallest species tend to be overlooked in favour of larger forms and those whose skulls remain intact after predation and digestion by owls.

The effects of chance are rather more complex, forming an important aspect of the study of ecological diversity. In my (unpublished) study of the mammal samples from Hastings Cave near the western coast of Australia at 30°S. (Baynes 1979), I analysed this point in depth. Making use of the ecological principles reviewed by May (1975), among others, I plotted rank abundance diagrams from the quantified Hastings Cave mammal samples. Those suggested that the Hastings Cave samples are lognormally distributed, which is to be expected in a sample composed of species drawn from more than one community. In order for such a sample to contain specimens of all the species in the local fauna, i.e. for the number of species to be fully 'unveiled', theoretical relationships (May 1975) require enormous sample sizes of several thousands to tens of thousands of individuals. Although no Nullarbor sample is yet fully quantified, and so rank abundance distributions cannot yet be plotted (which would, anyway, be beyond the scope of the present study), it is likely that they also will prove to be lognormally distributed. It is difficult, when working with selected identified material, to assess the size of the sample from which it is drawn. But none of the Nullarbor samples appears to be in the right order of magnitude to provide a comprehensive fauna.

For all the reasons outlined above, only presence has any meaning within samples in the present study. Absence may begin to have some significance at the scale of a group of samples from one physiographic/vegetational unit.

(b) Patterns in Original Occurrence of Species
Beard's (1975) biogeographic units were used as the basis of the order of presentation of site results, in the expectation that any patterns in the occurrence of the mammal species would reflect the effects of the same ecological factors. The data largely fulfil that expectation. At present there are no data for the desert at the northern edge of the area under consideration, but from the known sites it is possible to derive three original mammal faunas: a Plain fauna which occurred on both the Nullarbor Plain and the Hampton Tableland, a Hampton Tableland fauna which occurred on the Hampton Tableland but not the Plain, and a south coast fauna. The component species are listed in the Conclusions, below, in Tables 21, 22 and 23 respectively. First, it is necessary to discuss allocation of some of the species to these faunas.

Problems with placement of species in the faunas arise mainly from two causes, inadequate numbers and sizes of samples, particularly on the Plain; and remains of species being found in a site within a zone in which the species could not have maintained a viable population either because it dispersed into that zone as a living animal or its bones were carried there by a predator which consumed it. Another source of error in allocation is where material thousands of years old has been inadvertently included in a surface sample. In particular site 12 stands out as a cause of suspicion in this regard, even though its fauna contains neither Thylacinus nor Sarcophilus. Although it is located some distance from the southern edge of the Nullarbor Plain, its fauna includes the most northerly local record of Phascogale calura, which is absent from the surface of site 15 (with good stratigraphic control), and of the murina group Sminthopsis, and Leporillus apicalis which are both rare in site 15. More information is needed on the stratigraphy in site 12 and the vegetation surrounding it before the significance of the records can be assessed. In the meantime these three species have been placed in the Hampton Tableland fauna rather than the Plain fauna. In the cases of Phascogale calura and Leporillus apicalis their restriction to an area with trees is consistent with what is known of their natural history. P. calura is an arboreal species, and L. apicalis probably used hollow tree trunks for nest sites. It is also difficult to decide the allocation of Thompson's unnamed potoroid between these two faunas, because there are so few records and nothing at all is known about its natural history.

As it is at present not possible to specifically identify dissociated skull material of small species of Notomys, I cannot be confident that the Notomys sp. which occurred in all three areas is the same animal. However, I think it likely to be Notomys mitchellii throughout, on the basis of its occurrence as a living animal as far north as Queen Victoria Spring (McKenzie and Burbidge 1979).

Potorous platyops is here placed in the south coast fauna. In this study it has only been found in the coastal faunas. Lundelius (1963) reported P. platyops from Webbs Cave (site 37). However, the age of his specimen is not known, and until the record is supported by further material it does not seem to be justified to include P. platyops in the Hampton Tableland fauna.

Pseudomys desertor is included in the Hampton Tableland as much on the basis of its absence from Nullarbor Plain faunas as the single specimen in the one Nyanga Plain fauna, and because it is recorded from the deeper levels in Archer's (1974a) excavation in Horseshoe Cave (site 15) where the mammal fauna is generally more mesic.

Conclusions
With the reservations discussed above, it has been possible to generate lists of the mammal species which made up the original Plain fauna (Table 21), the Hampton Tableland fauna (Table 22) and those originally restricted to the south coast in the Nullarbor region (Table 23). Using data from Baynes (1973, 1979, 1984) and Morton and Baynes (1985) the biogeographic affinities of the species can be determined.

It can be seen from the tables that these faunas show very clear biogeographic patterns. With the exceptions of only Perameles bougainville, Macropus fuliginosus and Pseudomys bolami the original mammal fauna of the Plain is composed of species with extensive arid zone ranges. Many also had southern ranges and some, such as Dasyurus geoffroii, originally occurred throughout southern central and south-western Australia. Except for Leporillus apicalis and the unnamed potoroid, the species locally restricted to the Hampton Tableland all had southern ranges. The most striking pattern is in the coastal fauna, which is composed entirely of species with southern distributions, except Petrogale lateralis. P. lateralis is probably a member of this fauna only because suitable habitat in the region is restricted to the coastal cliffs.

For mammals the Hampton Tableland represents an ecotone with arid zone, southern and arboreal elements all present in the fauna. The most abrupt change of fauna occurs, however, as might be expected, at the boundary of the South Western Botanical Province with the South Western Interzone (see Fig. 46). This boundary represents the range limit of the south-western Australian sand plain mammals such as Parantechinus apicalis, Tarsipes rostratus, Pseudomys albocinereus and P. shortridgei. The south-western sand plain suite of mammals is not only found in sites 50 and 51 as well as 48 in this study, but also in Hastings Cave and as far north as Shark Bay (Baynes 1979). There are at least 11 species in common between the faunas of site 48 and the surface of the deposit in Hastings Cave (Baynes 1982). This would be raised to 14 if the murina group Sminthopsis, and Pseudomys praeconis and P. fieldi are the same species in each deposit; and if Tarsipes rostratus had been detected in the Hastings Cave material.

The recently discovered Eyre Peninsula material (sites 52 and 53) shows that originally several species in the south-western suite also occurred on the eastern side of the Great Australian Bight. The notable absence from the east of Pseudomys albocinereus is consistent with the recent re-establishment of this and its eastern sibling P. apodemoides, as separate species (e.g. Watts and Aslin 1981). Eyre Peninsula is the only area considered in this study which includes sand desert species in the original fauna - Sminthopsis psammophila and Pseudomys hermannsburgensis (s.s.); the Notomys sp. is probably N. alexis, another desert form.

Finally, it must be admitted that this study has only scratched the surface of the potential of the mammal remains available from the caves of the Nullarbor region. Much more material, particularly in quantifiable samples, is needed from the northern margins of the Plain and the Plain itself.

This material resource represents the only possible means of elucidating the ecology of the original mammal communities of this area.

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This paper could not have been written without using the products of the time of many other people, some of whom have spent much longer working on the material than I have. In particular I thank Jackie Lowry, who collected so many of the specimens; and Duncan Merrilees who not only curated most of them but did the baseline research necessary to set up a large reference collection from nothing. His collection has formed the basis of all my work on original mammal faunas, and the data in this paper are to a large extent plunder from his storehouse of information. The contributions of many other collectors are acknowledged in the listings for the sites in Appendix VI. The work owes a debt of inspiration to Ernie Lundelius, and ultimately to Bert Main who was instrumental in interesting Lundelius in Western Australian caves sites.

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TABLE 17 FAUNAS FROM NULLARBOR SITES Nos 1 - 17

Units	(a)	(b)															
Site Nos	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Thylacinus cynocephalus	✓	•	•	•	•	•	•	•	•	•	•	•	•	✓	•	•	•
Dasycercus cristicauda	✓	✓	•	✓	✓	•	✓	✓	✓	✓	✓	✓	•	•	XXX	✓	✓
Dasyurus geoffroii	•	✓	•	✓	•	•	•	✓	•	•	•	✓	•	•	X	✓	✓
Phascogale calura	•	•	•	•	•	•	•	•	•	•	•	✓	•	•	•	•	•
Sarcophilus harrisii	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	✓
Antechinomys laniger	✓	✓	•	✓	✓	•	•	✓	✓	✓	✓	✓	•	✓	XX	✓	✓
Sminthopsis crassicaudata	•	•	•	✓	•	•	•	✓	•	•	✓	•	•	•	✓	✓	✓
Sminthopsis sp. *murina* gp	•	•	•	•	•	•	•	•	•	•	•	✓	•	•	X	✓	•
Perameles bougainville	✓	✓	•	✓	✓	•	•	✓	✓	✓	✓	✓	•	✓	XXX	✓	✓
Chaeropus ecaudatus	✓	•	•	•	•	•	•	✓	•	✓	•	•	•	•	X	•	•
Macrotis lagotis	✓	•	•	•	•	•	•	✓	✓	✓	✓	✓	•	✓	X	✓	✓
Trichosurus vulpecula	✓	•	✓	•	•	•	•	•	•	•	•	✓	•	•	✓	✓	✓
Bettongia lesueur	✓	•	✓	•	•	•	•	✓	•	•	•	✓	•	✓	X	✓	✓
Bettongia penicillata	•	•	•	•	•	•	•	•	•	•	•	✓	✓	✓	✓	✓	✓
Unnamed potoroid	•	•	•	•	•	•	•	•	•	•	✓	•	•	✓	X	•	✓
Lagorchestes hirsutus	•	•	•	•	•	•	•	•	•	•	•	✓	•	✓	X	•	✓
Lagostrophus fasciatus	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	✓	✓
Onychogalea lunata	✓	•	✓	•	•	✓	•	•	✓	•	✓	✓	•	✓	X	✓	✓
Macropus fuliginosus	•	•	✓	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Macropus rufus	✓	•	•	•	•	•	•	•	•	•	•	•	•	•	✓	•	✓
Lasiorhinus latifrons	•	•	✓	•	•	•	•	•	•	•	•	•	•	•	•	•	✓
Felis catus	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	✓	•
Canis familiaris	✓	•	✓	•	✓	•	•	•	•	•	•	✓	•	•	•	•	✓
Vulpes vulpes	•	•	•	•	•	•	•	•	•	•	✓	•	•	•	•	•	✓
Pseudomys australis	✓	✓	•	✓	✓	•	✓	✓	✓	✓	✓	✓	•	•	XXX	✓	✓
Pseudomys bolami	✓	•	•	✓	✓	•	cf	✓	✓	cf	✓	✓	•	✓	XXX	✓	✓
Pseudomys fieldi	•	•	•	✓	✓	•	•	•	•	•	•	•	•	•	X	•	✓
Leporillus apicalis	•	•	•	•	•	•	•	•	•	•	•	✓	•	•	X	✓	✓
Leporillus conditor	✓	•	•	✓	✓	•	✓	✓	✓	✓	✓	✓	•	✓	XXX	✓	✓
Notomys sp. indet.	✓	✓	•	✓	•	•	•	✓	✓	•	✓	✓	•	•	XXX	✓	✓
Rattus villosissimus	•	✓	•	•	•	•	•	•	•	•	✓	•	•	•	X	•	•
Mus musculus	•	•	•	•	•	•	•	✓	•	•	•	•	•	•	X	•	✓
Oryctolagus cuniculus	•	•	✓	•	•	•	•	•	✓	•	•	•	•	•	X	•	✓
Chalinolobus morio	•	•	•	•	•	•	•	•	•	•	•	✓	•	•	•	✓	✓
Nyctophilus geoffroyi	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	✓	•
Species totals	15	7	7	10	8	1	4	13	10	8	13	19	1	11	24	20	27

Key to symbols:

✓ = Recorded.

• = Not recorded.

X = Rare in semi-quantitative sample.

XX = Common in semi-quantitative sample.

XXX = Very abundant in semi-quantitative sample.

cf = Comparable with.

TABLE 18 FAUNAS FROM NULLARBOR SITES Nos 18 - 31

Units	(c)	(d)						(e)					(f)	
Site Nos	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Tachyglossus aculeatus	•	•	•	•	•	•	•	•	•	•	•	•	✓	•
Thylacinus cynocephalus	•	•	•	✓	•	•	•	✓	•	✓	•	•	•	•
Dasycercus cristicauda	XX	✓	✓	✓	✓	✓	✓	✓	•	✓	•	✓	•	•
Dasyurus geoffroii	X	✓	✓	✓	✓	✓	✓	•	•	•	X	✓	✓	•
Phascogale calura	X	✓	✓	✓	•	•	•	•	•	✓	X	✓	cf	•
Phascogale tapoatafa	X	•	•	•	•	•	•	•	•	•	X	•	•	•
Sarcophilus harrisii	•	•	•	✓	•	•	•	•	•	•	•	•	•	•
Antechinomys laniger	XX	✓	✓	✓	✓	✓	✓	✓	•	✓	XX	•	•	•
Sminthopsis crassicaudata	X	•	✓	✓	•	✓	•	•	•	✓	X	✓	•	•
Sminthopsis sp. *murina* gp	XX	•	✓	✓	•	✓	•	•	•	•	X	✓	cf	•
Perameles bougainville	XXX	✓	✓	✓	✓	✓	✓	✓	✓	✓	XX	✓	✓	•
Isoodon obesulus	•	•	✓	•	•	•	•	✓	•	•	•	•	•	•
Chaeropus ecaudatus	X	✓	✓	✓	✓	✓	✓	•	•	•	•	•	•	•
Macrotis lagotis	XX	✓	✓	✓	•	✓	✓	✓	✓	✓	•	•	•	✓
Trichosurus vulpecula	✓	✓	•	✓	•	✓	•	•	•	•	•	•	•	•
Cercartetus concinnus	X	•	✓	•	•	•	•	•	•	✓	X	✓	•	•
Pseudocheirus peregrinus	•	•	•	•	•	•	•	•	•	•	X	✓	•	•
Bettongia lesueur	X	✓	•	✓	✓	✓	✓	✓	✓	✓	X	•	•	•
Bettongia penicillata	•	✓	•	•	•	✓	•	•	✓	•	X	•	•	✓
Unnamed potoroid	•	•	✓	✓	•	•	•	•	•	•	•	•	•	•
Lagorchestes hirsutus	•	✓	•	✓	•	•	•	•	•	•	X	•	•	•
Onychogalea lunata	X	✓	✓	✓	✓	✓	✓	✓	•	•	X	•	✓	✓
Macropus fuliginosus	•	•	•	•	✓	•	•	•	•	✓	•	✓	•	•
Macropus rufus	•	•	•	✓	•	•	•	•	•	•	•	•	•	•
Lasiorhinus latifrons	•	•	•	✓	•	•	•	•	•	•	•	•	•	•
Felis catus	•	•	•	✓	•	•	•	•	•	•	•	•	•	•
Canis familiaris	✓	•	•	•	✓	•	✓	•	•	•	•	•	✓	•
Vulpes vulpes	•	•	•	•	•	✓	•	•	•	•	•	•	•	•
Pseudomys albocinereus	•	•	•	•	•	•	•	•	•	•	•	✓	•	•
Pseudomys australis	XX	•	✓	✓	✓	✓	✓	✓	•	✓	XX	✓	•	•
Pseudomys bolami	XXX	•	✓	✓	✓	✓	✓	✓	•	✓	XXX	✓	•	•
Pseudomys fieldi	XX	•	✓	✓	•	•	✓	•	•	✓	XX	✓	•	•
Pseudomys desertor	X	•	•	•	•	•	•	•	•	•	•	•	•	•
Pseudomys occidentalis	•	•	•	•	•	•	•	•	•	✓	•	•	•	•
Leporillus apicalis	XX	✓	•	✓	•	✓	✓	•	•	✓	XXX	✓	cf	•
Leporillus conditor	XX	✓	✓	✓	✓	✓	✓	•	✓	✓	XX	•	✓	•
Notomys sp. indet.	XXX	✓	✓	✓	✓	✓	✓	✓	✓	✓	XXX	•	cf	•
Rattus villosissimus	•	•	•	cf	•	✓	•	•	•	✓	•	•	•	•
Mus musculus	X	•	•	•	•	✓	✓	•	•	✓	XX	•	•	•
Oryctolagus cuniculus	X	✓	•	✓	✓	✓	✓	✓	•	✓	X	•	✓	•
Ovis aries	X	•	•	•	•	•	•	•	•	•	•	•	•	•
Chalinolobus morio	•	•	✓	•	•	•	•	•	✓	✓	•	•	•	•
Chalinolobus gouldii	•	•	✓	•	•	•	•	•	•	•	•	•	•	•
Nyctophilus geoffroyi	X	•	✓	✓	✓	•	•	✓	•	✓	X	•	•	•
Species totals	26	16	21	28	15	21	17	13	7	22	22	14	11	3

See Table 17 for key to symbols

TABLE 19 FAUNAS FROM NULLARBOR SITES Nos 32 - 45

Units	(g)											(h)	
Site Nos	32	33	34	35	36	37	38	39	40	41	42	43	44
Thylacinus cynocephalus	•	•	•	•	√	•	•	•	•	•	•	•	•
Dasycercus cristicauda	√	•	√	√	•	√	•	•	•	√	•	√	•
Dasyurus geoffroii	√	•	√	√	•	•	√	•	√	•	•	•	•
Phascogale calura	•	√	√	√	•	√	•	•	•	•	•	√	•
Phascogale tapoatafa	•	•	•	•	•	•	•	•	•	•	•	•	•
Sarcophilus harrisii	•	•	•	•	•	•	•	√	•	•	•	•	•
Antechinomys laniger	√	•	•	√	•	√	•	•	•	•	•	√	•
Sminthopsis crassicaudata	•	√	•	√	•	•	•	•	•	•	•	√	•
Sminthopsis sp. *murina* gp	√	√	•	•	•	•	•	•	•	•	•	•	•
Perameles bougainville	√	√	√	√	•	√	√	√	√	√	√	√	√
Isoodon obesulus	•	•	•	•	•	•	•	•	•	•	√	√	•
Chaeropus ecaudatus	•	•	√	√	•	•	√	•	•	•	•	√	•
Macrotis lagotis	√	•	√	√	•	√	√	•	•	•	•	√	•
Trichosurus vulpecula	√	•	•	√	√	•	√	√	√	√	•	√	√
Pseudocheirus peregrinus	•	•	√	•	•	•	•	•	•	•	•	•	•
Bettongia lesueur	√	•	•	√	√	√	√	√	√	√	•	√	•
Bettongia penicillata	√	•	•	√	•	•	•	•	√	√	√	√	•
Unnamed potoroid	•	√	•	•	•	•	•	√	•	•	•	•	•
Petrogale lateralis	•	√	•	•	•	•	•	•	•	•	•	•	•
Lagorchestes hirsutus	•	•	•	•	•	•	•	•	•	√	•	•	•
Onychogalea lunata	•	•	•	√	√	√	√	√	•	√	•	√	√
Macropus fuliginosus	•	•	•	•	•	√	•	•	•	•	•	•	•
Lasiorhinus latifrons	•	•	•	•	•	•	•	•	•	√	•	•	•
Canis familiaris	•	•	•	√	•	•	•	•	•	•	•	•	•
Pseudomys australis	√	√	√	•	•	√	•	•	√	•	•	√	•
Pseudomys bolami	•	√	•	√	•	√	•	•	•	•	•	√	•
Pseudomys fieldi	•	√	•	•	•	√	√	•	•	•	•	•	•
Pseudomys occidentalis	•	√	•	√	•	•	•	•	•	•	•	•	•
Leporillus apicalis	√	√	√	√	•	√	√	•	√	√	•	√	•
Leporillus conditor	√	√	√	√	•	√	√	√	•	√	•	√	•
Notomys sp. indet.	√	√	√	√	•	√	√	√	√	•	•	√	√
Rattus fuscipes	•	√	•	•	•	•	•	•	•	•	•	•	•
Mus musculus	•	•	•	√	•	•	•	•	•	•	•	√	•
Oryctolagus cuniculus	•	√	•	•	•	√	•	•	√	•	•	√	√
Chalinolobus morio	√	•	•	•	•	√	•	•	•	•	•	√	√
Species totals	14	15	11	19	4	16	11	8	9	10	3	20	6

See Table 17 for key to symbols

TABLE 20 FAUNAS FROM PERIPHERAL SITES, Nos 45 - 53

Units	(i)	(j)			(k)	(l)	(m)	(n)	
Site Nos	45	46	47	48	49	50	51	52	53
Tachyglossus aculeatus	•	•	•	•	✓	•	•	•	•
Dasycercus cristicauda	•	•	•	X	•	•	•	•	X
Dasyurus geoffroii	•	•	•	X	•	•	X	•	X
Phascogale calura	✓	•	•	X	✓	•	•	X	•
Phascogale tapoatafa	✓	•	•	•	•	•	•	•	•
Sarcophilus harrisii	•	•	•	•	•	•	X	•	•
Ningaui yvonnae	✓	•	•	•	•	•	•	X	•
Parantechinus apicalis	✓	•	•	X	✓	X	X	•	X
Antechinomys laniger	•	•	•	•	•	•	•	X	•
Sminthopsis crassicaudata	•	•	•	•	•	•	•	X	•
Sminthopsis granulipes	•	•	•	•	•	X	XX	•	•
Sminthopsis sp. *murina* gp	✓	•	•	XX	✓	XX	XX	X	XX
Sminthopsis psammophila	•	•	•	•	•	•	•	XX	•
Perameles bougainville	✓	•	•	XXX	✓	•	•	XXX	X
Isoodon obesulus	•	•	✓	XX	✓	X	X	•	X
Tarsipes rostratus	•	•	•	X	•	XX	X	•	•
Trichosurus vulpecula	•	•	•	•	✓	•	•	•	•
Cercartetus concinnus	✓	•	•	X	✓	X	X	X	X
Pseudocheirus peregrinus	•	•	•	•	•	X	•	•	•
Potorous platyops	✓	•	•	XX	•	X	X	X	X
Bettongia lesueur	•	•	•	•	•	•	•	X	•
Bettongia penicillata	✓	•	•	XX	✓	X	X	•	•
Petrogale lateralis	•	•	✓	X	✓	•	✓	•	•
Lagostrophus fasciatus	✓	✓	•	X	•	•	•	•	•
Macropus eugenii	•	•	•	•	•	•	X	•	•
Macropus fuliginosus	•	•	•	•	✓	•	X	•	•
Canis familiaris	•	•	•	•	•	•	X	•	•
Vulpes vulpes	•	•	✓	•	•	•	•	•	•
Pseudomys albocinereus	•	•	•	XX	•	XX	XXX	•	•
Pseudomys australis	•	•	•	X	•	•	•	XX	XXX
Pseudomys bolami	✓	•	•	X	•	•	•	•	•
Pseudomys fieldi	•	•	•	X	•	•	•	X	•
Pseudomys hermannsburgensis	•	•	•	•	•	•	•	X	X
Pseudomys occidentalis	•	•	•	XXX	•	XX	XX	X	X
Pseudomys shortridgei	•	•	•	XX	✓	XX	XXX	X	X
Leporillus apicalis	✓	•	•	X	✓	•	•	X	•
Notomys mitchellii	•	•	•	•	•	•	•	XX	X
Notomys sp. indet.	✓	•	✓	XX	✓	X	XX	X	•
Rattus fuscipes	•	•	•	XXX	✓	XXX	XXX	XX	XXX
Rattus tunneyi	•	•	•	•	•	•	•	•	X
Mus musculus	•	•	•	X	✓	•	•	XXX	•
Oryctolagus cuniculus	✓	•	✓	X	✓	•	✓	•	•
Chalinlobus morio	✓	•	•	•	•	•	•	•	•
Eptesicus sp.	✓	•	•	•	•	•	•	•	•
Nyctophilus geoffroyi	•	•	•	•	✓	•	•	•	•
Nyctophilus major	✓	•	•	•	•	•	•	•	•
Species totals	17	1	5	24	18	14	20	20	15

See Table 17 for key to symbols

TABLE 21: ORIGINAL MAMMAL FAUNA OF THE NULLARBOR PLAIN IN W.A.

	Biogeography		
	Extensive Original Arid Zone Distribution	Original Southern Range	Distribution Centred on Nullarbor
Dasycercus cristicauda	X		
Dasyurus geoffroii	X	X	
Antechinomys laniger	X		
Sminthopsis crassicaudata	X		
Perameles bougainville		X	
Chaeropus ecaudatus	X		
Macrotis lagotis	X	X	
Trichosurus vulpecula	X	X	
Bettongia lesueur	X	X	
Onychogalea lunata	X	X	
Macropus fuliginosus		X	
Macropus rufus	X		
Lasiorhinus latifrons	X		
Canis familiaris	X	X	
Pseudomys australis	X	X	
Pseudomys bolami			X
Pseudomys fieldi	X		
Leporillus conditor	X		
Notomys sp. indet.	?	?	
Rattus villosissimus	X		

Total 20 species

TABLE 22: ORIGINAL MAMMAL FAUNA OF THE HAMPTON TABLELAND IN W.A.

	Biogeography		
	Extensive Original Arid Zone Distribution	Original Southern Range	Distribution Centred on Nullarbor
Dasycercus cristicauda*	X		
Dasyurus geoffroii*	X	X	
Phascogale calura	X	X	
Phascogale tapoatafa		X	
Antechinomys laniger*	X		
Sminthopsis crassicaudata*	X		
Perameles bougainville*		X	
Isoodon obesulus		X	
Chaeropus ecaudatus*	X		
Macrotis lagotis*	X	X	
Trichosurus vulpecula*	X	X	
Cercartetus concinnus		X	
Pseudocheirus peregrinus		X	
Bettongia lesueur*	X	X	
Bettongia penicillata	X	X	
Unnamed potoroid			X
Lagorchestes hirsutus	X	X	
Lagostrophus fasciatus		X	
Onychogalea lunata*	X	X	
Macropus fuliginosus*		X	
Macropus rufus*	X		
Lasiorhinus latifrons*	X		
Canis familiaris*	X	X	
Pseudomys australis*	X	X	
Pseudomys bolami*			X
Pseudomys fieldi*	X		
Pseudomys desertor	X		
Pseudomys occidentalis		X	
Leporillus apicalis	X		
Leporillus conditor*	X		
Notomys sp. indet.*	?	?	
Rattus villosissimus*	X		
Chalinolobus morio		X	
Chalinolobus gouldii	X	X	
Nyctophilus geoffroyi	X	X	

Total 36 species

*Also a member of the Plain fauna

TABLE 23: SPECIES RESTRICTED TO THE (SOUTH) COAST IN THE NULLARBOR REGION

	Biogeography		
	Extensive Original Arid Zone Distribution	Original Southern Range	Distribution Centred on Nullarbor
Parantechinus apicalis		X	
Tarsipes rostratus		X	
Potorous platyops		X	
Petrogale lateralis	X	X	
Pseudomys albocinereus		X	
Pseudomys shortridgei		X	
Rattus fuscipes		X	

Total 7 species

BIRDS

Andrew A. Burbidge, K.D. Casperson and P.J. Fuller

Introduction

This chapter describes the patterning of bird species within the Study Area (Fig. 1) and examines the relationships of Nullarbor birds with those of adjacent natural districts. An analysis of these patterns and an examination of the requirements of endemic or rare species will provide an objective basis for assessing the representativeness of the region's conservation reserves system and management requirements.

The biogeographic affinities of the bird fauna of the Nullarbor Study Area have previously been discussed by Brooker et al. 1979 and Ford and Sedgwick 1967. In brief, the Nullarbor lies within the Eyrean Sub-region and its bird fauna reflects the extremely arid, unpredictable climate (Curry, this publication) it shares with the rest of the Eyrean. The more predictable, mesic influence of the Southern Ocean on the coastal margin of the Nullarbor is recognisable in the presence there of Bassian species (e.g. Eyre Bird Observatory Annual Reports).

The calcium-rich soils of the limestone plains surfaces of the Nullarbor Study Area are geologically quite different from the rest of the Eyrean. This difference should be reflected in the fauna and flora of the Study Area because high levels of calcium restrict the availability of soil nutrients so that the Nullarbor flora and fauna might be expected to occur in assemblages with low biomass and low species richness. The almost total absence of topographic relief across inland parts of the Study Area, combined with the uniform nature of its surface chemistry, would be expected to result in relatively high species similarities between even geographically distant assemblages on the Nullarbor Plain. The mobility of bird species was expected to heighten similarities in bird assemblages compared with other organisms sampled in the Study Area although such factors as the relatively short sample period, the locally unpredictable weather and the vagrant nature of many of the birds could, at least partly, offset this effect. Also the very different vegetation structure of the treeless plain compared with the better vegetated fringes provides an opportunity to examine the effect of various structural components on bird distribution.

The bird fauna of the area surveyed is not well documented. Visits to the area have generally been of short duration and bird lists have usually been compiled by people in transit without regard for habitat description. This survey constitutes the first attempt to document the patterning of the area's fauna and, although as systematic as possible, it still retains the shortcomings of a relatively brief survey of an area almost as large as the state of Victoria.

Eighty-three quadrats were sampled for birds on the Nullarbor Study Area during our 1984 surveys. As was pointed out in detail (see Methods, this publication), these quadrats were positioned across the Study Area to provide data on: (1) the bird communities associated with the array of surface-types present and, (2) the species composition of passerine bird assemblages associated with each bird community. At the same time, such data would allow an assessment of any influence on bird assemblages of climatic gradients across the district (within each surface-type), and (3) the avifaunal influence of adjacent natural districts: the Great Victoria Desert to the north, the South West Interzone (Coolgardie Botanical District) to the west and the Eyre Peninsula mallee to the east.

By analysing the bird data from quadrats sampled both in autumn and spring it was hoped to gain a better overview of habitat requirements for these mobile organisms throughout the whole year than could be achieved with data from a single season; our experience in the Eastern Goldfields indicated marked seasonality in habitat usage by many passerines (McKenzie 1984).

Results

Previous bird surveys in the Nullarbor Study Area (Fig. 1) are discussed by Higginbottom (this publication). To document the total bird fauna recorded in the Study Area in the past we obtained special printouts of the data collected for the Royal Australasian Ornithologists Union Atlas of Australian Birds (Blakers et al. 1984). The list of pre-1984 birds for the Study Area includes 236 species (Table 24). We recorded an additional six species: Sooty Albatross, Short-tailed Shearwater, Sulphur-crested Cockatoo, Bourke's Parrot, Thick-billed Grass-wren and White-winged Chough.

The results of the quadrat sampling are summarised in Appendix IV. Other data recorded on the bird data sheets are stored in computer files. One hundred and forty species were recorded on quadrats, 57.8% of the known avifauna. A further 21 species were recorded outside quadrats (Table 27) bringing the total proportion of the known avifauna recorded by us to 66.5%. Of the total avifauna, 89 species are water, shore or sea birds and the remaining 153 species are land birds.

Pattern analyses were undertaken of the bird data from the quadrats. The analysis pathways followed are described in Methods (this publication) along with an explanation of the philosophy behind the separate analyses of taxonomic groupings (birds, mammals, reptiles, perennial plants) as sub-sets of the total species lists from the quadrats (the assemblage data).

Surveys restricted to relatively small quadrats that are sampled over only a few, relatively brief, intervals of time are more likely to provide meaningful comparisons between quadrats if stochastic influences on the samples are minimised. This was attempted through restriction of the analysis to passerine species recorded more than once from the quadrats; species considered to be sedentary during the period of the survey. The 242 species of bird recorded since European settlement in the Study Area comprise 150 non-passerines and 92 passerines. The more mobile birds, the non-passerines, were poorly represented in our samples; overall 54% of known non-passerine species were recorded by us, but only 41% were recorded on quadrats. Of the non-passerine land birds only 58% were recorded on quadrats. By comparison, 85% (78 species) of passerines were recorded during our field work and all but one (the exotic House Sparrow) were on quadrats. Thus, to reduce the influence of chance on our sampling we restricted the analysis to passerine birds. Seven species were recorded on only one quadrat and were excluded from the analysis: Western Gerygone (PL4), Rufous Tree-creeper (YA1), White-winged Chough (YA2), Splendid Fairy-wren (MU5), Brown Honeyeater (MA5), New Holland Honeyeater (MA5) and Rufous Songlark (MA1). Corvids were also excluded from the analysis because they are difficult to identify in the field. The Magpie-lark was omitted from the analysis in error.

The Wedge-tailed Eagle Aquila audax a very common bird on the Nullarbor where, judging from bones found beneath its nests, it is a significant predator of rabbits. Photo A. Robinson.

The Owlet Nightjar Aegotheles cristatus a delicate nocturnal bird captured at a number of sites in the woodland areas in mist-nets set specifically to catch bats. Photo A. Robinson.

Figure 47
BIRDS

The Inland Dotterel Peltohyas australis a common bird of the northern treeless plain. Photo P. Copley.

An old nest and eggs of the extinct Masked Owl Tyto novaehollandiae in Ivy Cave. Photo D. Carter.

(a) Passerine Analysis

In terms of passerine species richness, the quadrats on the Treeless Plain were by far the poorest (mean = 6.6 ± 2.8 (SD), n = 22). Quadrats with structurally more complex vegetations had more species irrespective of whether they had Myall (Acacia papyrocarpa) and/or Eucalyptus spp. and/or Mulga (A. aneura) upper-stories (17.7 ± 4.8 (SD) 53). Samphire sites were also rich in species (15.5 ± 2.4 (SD) 4), the richest being those with trees (KO2 and BA2; quadrat No. 2 at both the Colona and Balladonia campsites).

The UPGMA classification of the 83 quadrats according to the presence and absence of 69 passerine species resulted in the dendrogram presented in Fig. 49. Two main groups of quadrats were immediately distinguished: bird assemblages of the Treeless Plain (except those at KD5 and ME5) versus all other sites. KD5 and ME5 were positioned in areas of low shrubland and grassland, ca 1 km wide, that occurred in a mosaic pattern with mixed stands of Myall and eucalypts along the southern margin of the Treeless Plain. For organisms as mobile as passerine birds, some influence from birds of these adjacent vegetations would be predicted even though the tree stands themselves were not sampled because they were considered to be distinct patches within the quadrats. However, geographic proximity was not the prime influence on the species composition of passerine bird assemblages; KD4, which was within 3 km of KD5, but in more open country (with no stands of trees actually in the quadrat), was classified with the "Treeless Plain" quadrats in Fig. 49. There are many other examples where dissimilar quadrats, within only a few kilometres of one another, were well-separated in this dendogram while "replicate" quadrats from opposite ends of the Study Area were clustered together, sometimes as closely as neighbouring replicate pairs (e.g. JU1, JU2 and PL2; IF5, BA4 and IF3).

To examine some of its internal structure, nine main groups were distinguished in the dendrogram. These groups could be interpreted ecologically in terms of vegetation and topography, although Group 2 (four quadrats) and Group 3 (one quadrat) seemed only subtly different from Group 1. The groups are listed and interpreted in Table 25.

It is clear from Table 25 that the species composition of passerine bird assemblages is also strongly influenced by the levels of disturbance. Disturbance (thought to be due to rabbit grazing) has resulted in the loss of most vegetation from the IF1 and HU1-S quadrats. These were grouped together at a very high level in Fig. 49. HU4, almost totally stripped of vegetation (see Appendix 1), formed a very distinct group on its own (Fig. 49). Although vegetation loss also was dramatic at FO quadrats, this was not evidenced by any separate clustering, probably because small patches of Myall trees persisted there. Although mapped by Beard (1975) in the treeless plain, FO should probably be placed in the northern fringe; its treeless nature is an artifact of overgrazing by rabbits.

A principal co-ordinate analysis (PCR, see Methods, this publication) was carried out on the passerine data to cluster the quadrats in terms of species. This was done primarily as a cross-check of the groupings distinguished from UPGMA. The results are presented in Fig. 50 with the UPGMA group boundaries from Figure 49 overlaid. The strong influence of vegetation structural complexity on bird species richness is well documented (e.g. Kikkawa 1982). Vegetation structural complexity is consistent with the patterning of quadrats observed along Axis I of Fig. 50(a). It also explains patterning within the UPGMA Groups superimposed on Fig. 50(a); quadrats with lower and/or more open vegetation are on the left-hand side of the indicated clusters. For instance, the quadrats to the left of the Group 1 cluster are either (1) very badly disturbed open-Myall-woodland sites in which many perennial plants are dead or gone (FO1-4, MA1), or (2) sites in quadrats adjacent to extensive woodland stands (ME5, KD5, KU2, CO1 and KU4). Axis II in Fig. 50(a) can be explained by changes in floristic composition of the upper storey (at least) of the woodland community-types - from Eucalyptus spp. in the south to Acacia spp. further north.

In Fig. 50(b), Axis I versus III is diagrammed. Axis III arrays UPGMA Group 1 assemblages along a gradient that can be interpreted in terms of vegetation density: positive loadings for quadrats with sparse formations of the perennials found in Myall and/or Mulga woodlands (low biomass) and negative loadings for those quadrats with a high biomass of these perennial plants (including those quadrats with an overstorey of Casuarina cristata). An example was discussed in the previous paragraph.

It is also clear from the scattergrams that the geographical distance between quadrats does not have a major influence on the species composition of passerine assemblages. Neighbouring quadrats in the field, even those considered "proximate replicates", were not necessarily clustered together more closely than quadrats on opposite sides of the Study Area (Fig. 49). For example, BA5, BA4, IF3 and IF5 were all clustered together in Fig. 50 even though IF is at the opposite end of the Nullarbor to BA (Fig. 1). The UPGMA analysis discussed earlier yielded a similar conclusion. The absence of discrete clusters in the scattergrams (Fig. 50) points to gradual changes in passerine bird assemblages across the Study Area - a conclusion consistent with the district's low topographic relief, uniform geology and hence soils (two main soil types: coastal sands and limestone-derived earths), aridity and largely unpredictable climate. In addition, the mobility of birds would contribute to such gradational patterning. Nevertheless, the four main UPGMA groupings can be readily distinguished even on the first scattergram (Fig. 50a), indicating that passerine birds do perceive habitat patterns within the Study Area. These coincide with the pattern of change in vegetation structure and upper-stratum floristics across the Study Area. The geographic distribution of these nine groups across the Nullarbor Study Area is shown in Fig. 51.

To search for groups of passerine bird species that consistently co-exist in assemblages, the 69 passerine species (excluding corvids) recorded from more than one quadrat were classified according to their presence or absence at the 83 quadrats sampled. Eight groups of species were distinguished using UPGMA (Fig. 52 and Table 26).

The single species that formed Group 7 was not a passerine at all; a single record of the Budgerigar and two other non-passerine species (Black-eared Cuckoo and Horsfield's Bronze Cuckoo) were overlooked during the editing operation (see Methods, this publication). An examination of Table 28 suggests that removal of these few records would make little or no difference to the overall groupings.

Three of the remaining seven groups are ecologically distinct; each comprises a group of species whose climatic and microhabitat needs throughout their range in Australia are similar. Group 1 comprises species that occur in the open woodlands of the semi-arid and arid interior of Australia e.g. Grey Butcher-bird, Pied Butcher-bird, Spiny-cheeked Honeyeater, Red-capped Robin, Hooded Robin, Ground Cuckoo-shrike, as well as species of widespread arid and semi-arid occurrence e.g. Richard's Pipit, Brown Songlark, Chestnut-rumped Thornbill, Crimson Chat, Black-faced Woodswallow. Most species in Group 2 belong to the more mesic districts to the south-east and/or

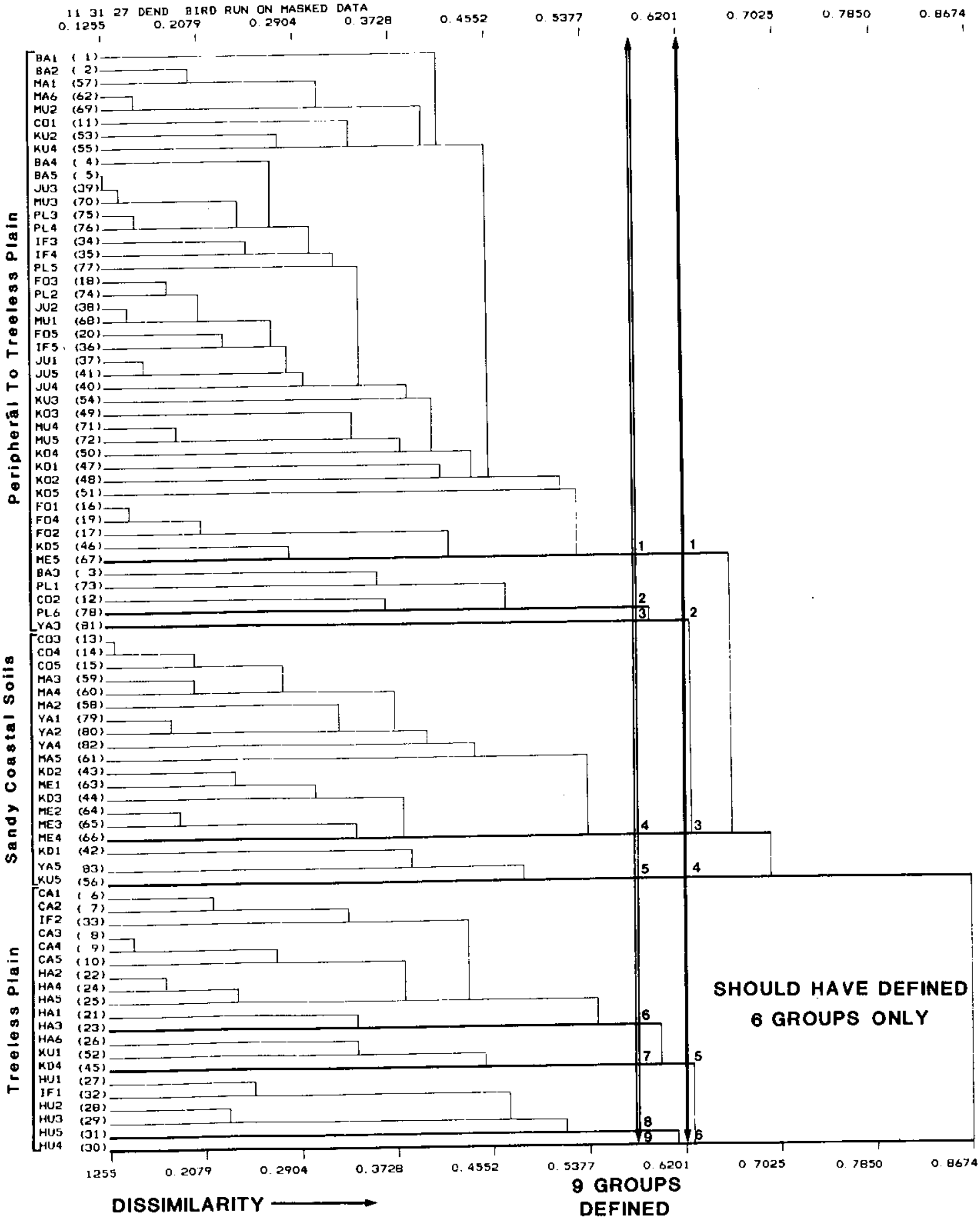
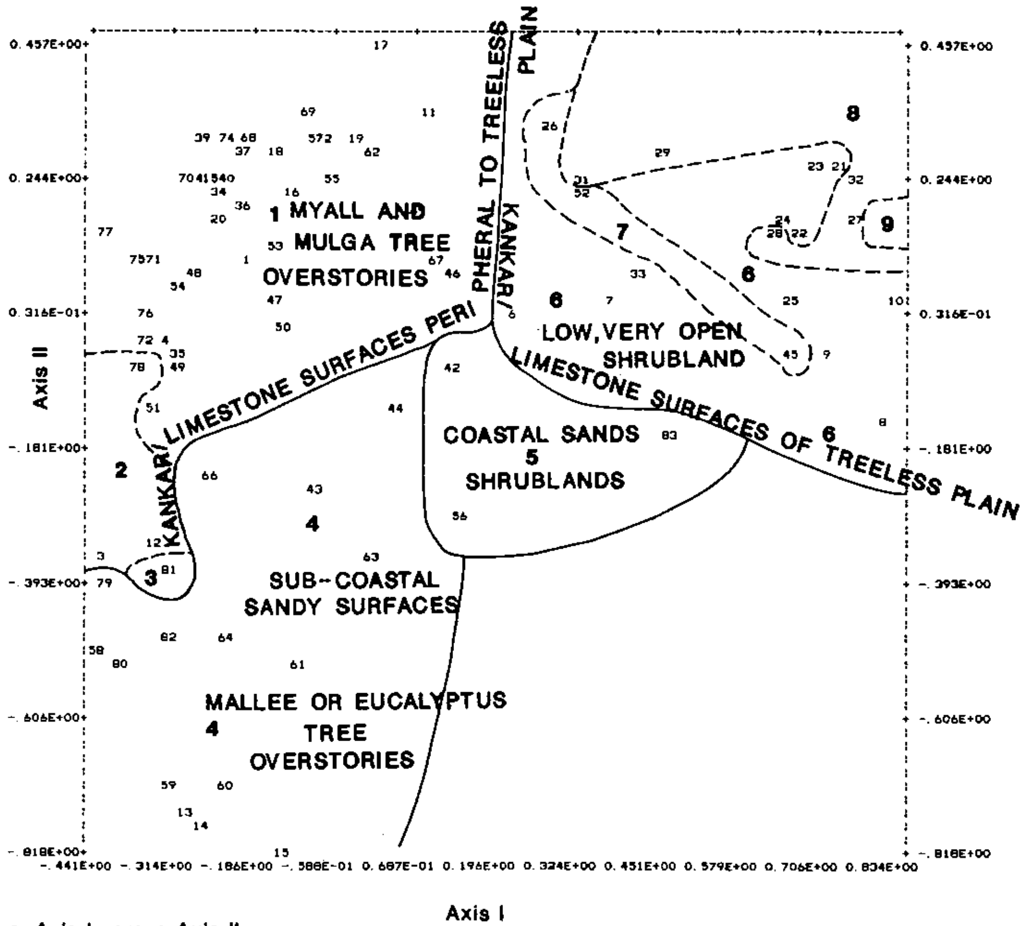
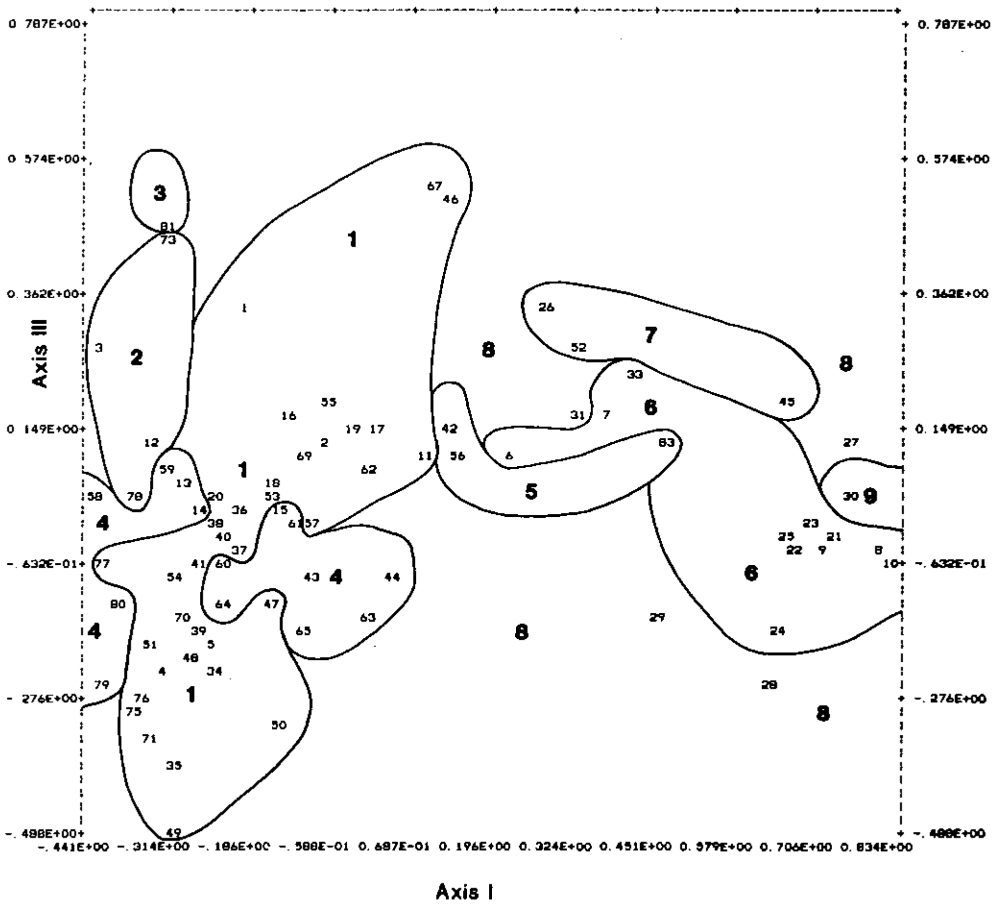


Figure 49
UPGMA QUADRAT CLASSIFICATION IN TERMS OF PASSERINE SPECIES SIMILARITIES (CZEKANOWSKI).



a. Axis I versus Axis II



b. Axis I versus Axis III

Figure 50

SCATTERGRAM RESULTING FROM THE ORDINATION OF 83 QUADRATS IN TERMS OF PASSERINE BIRDS

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 83 POINTS
REGRESSIONS : Y = 0.6168E-05 + 0.1197 X
: X = -0.2116E-05 + 0.1513 Y
CORRELATION COEFICIENT (R) = 0.1346

LABEL	SEQ #	X-VALUE	Y-VALUE
BA1	1	-0.2453	0.1172
BA2	2	-0.6440E-01	0.3401
BA3	3	-0.1911	-0.3868
BA4	4	-0.3072	-0.5160E-01
BA5	5	-0.2624	0.2360
CA1	6	0.1944	0.1562
CA2	7	0.3761	0.1946
CA3	8	0.7759	-0.2820E-01
CA4	9	0.7179	0.6110E-01
CA5	10	0.8053	0.2200E-01
CO1	11	0.7170E-01	0.3890
CO2	12	-0.2878	-0.3619
CO3	13	-0.7410E-01	-0.7440
CO4	14	-0.5570E-01	-0.7468
CO5	15	0.8000E-03	-0.7607
FO1	16	-0.2154	0.2372
FO2	17	-0.2410E-01	0.4451
FO3	18	-0.2203	0.3101
FO4	19,	-0.8360E-01	0.3455
FO5	20	-0.3178	0.1728
HA1	21	0.6772	0.6580E-01
HA2	22	0.6830	0.1454
HA3	23	0.6592	0.8950E-01
HA4	24	0.6451	0.1862
HA5	25	0.6588	0.1487
HA6	26	0.2707	0.3223
HU1	27	0.6471	-0.8900E-02
HU2	28	0.5909	0.1047
HU3	29	0.4389	0.2363
HU4	30	0.6456	-0.1980E-01
HU5	31	0.2677	0.1864
IF1	32	0.6889	0.8420E-01
IF2	33	0.4372	0.2400
IF3	34	-0.2607	0.2072
IF4	35	-0.2414	-0.6030E-01
IF5	36	-0.2703	0.2076
JU1	37	-0.2460	0.2846
JU2	38	-0.2974	0.2480
JU3	39	-0.2851	0.2879
JU4	40	-0.2762	0.2360
JU5	41	-0.3250	0.2209
KD1	42	0.9600E-02	0.2580E-01
KD2	43	-0.1986	-0.2314
KD3	44	-0.6600E-01	-0.7600E-01
KD4	45	0.5650	0.2270E-01
KD5	46	0.4260E-01	0.1758
KO1	47	-0.2115	0.4630E-01
KO2	48	-0.2138	0.7470E-01
KO3	49	-0.1921	-0.7620E-01
KO4	50	-0.1601	0.1290E-01
KO5	51	-0.2362	-0.1401
KU1	52	0.2819	0.2889
KU2	53	-0.1973	0.1540
KU3	54	-0.3245	0.6840E-01
KU4	55	-0.1033	0.2907
KU5	56	0.5730E-01	-0.2084
MA1	57	-0.1015	0.3358
MA2	58	-0.1785	-0.5522
MA3	59	-0.9650E-01	-0.6996
MA4	60	-0.8000E-01	-0.6831
MA5	61	-0.1093	-0.4903
MA6	62	-0.3750E-01	0.3485
ME1	63	-0.1093	-0.3080
ME2	64	-0.1742	-0.4782
ME3	65	-0.1597	-0.4948
ME4	66	-0.2534	-0.2249
ME5	67	0.4520E-01	0.1890
MU1	68	-0.2667	0.2800
MU2	69	-0.1537	0.3759
MU3	70	-0.3144	0.2279
MU4	71	-0.3040	0.7690E-01
MU5	72	-0.2796	-0.5470E-01
PL1	73	-0.2266	-0.5620E-01
PL2	74	-0.2750	0.3052
PL3	75	-0.3407	0.7070E-01
PL4	76	-0.3136	-0.3500E-01
PL5	77	-0.3805	0.9230E-01
PL6	78	-0.2633	-0.9250E-01
YA1	79	-0.2308	-0.4425
YA2	80	-0.2162	-0.5535
YA3	81	-0.1459	-0.3835
YA4	82	-0.1864	-0.5177
YA5	83	0.3979	-0.2270E-01

a.

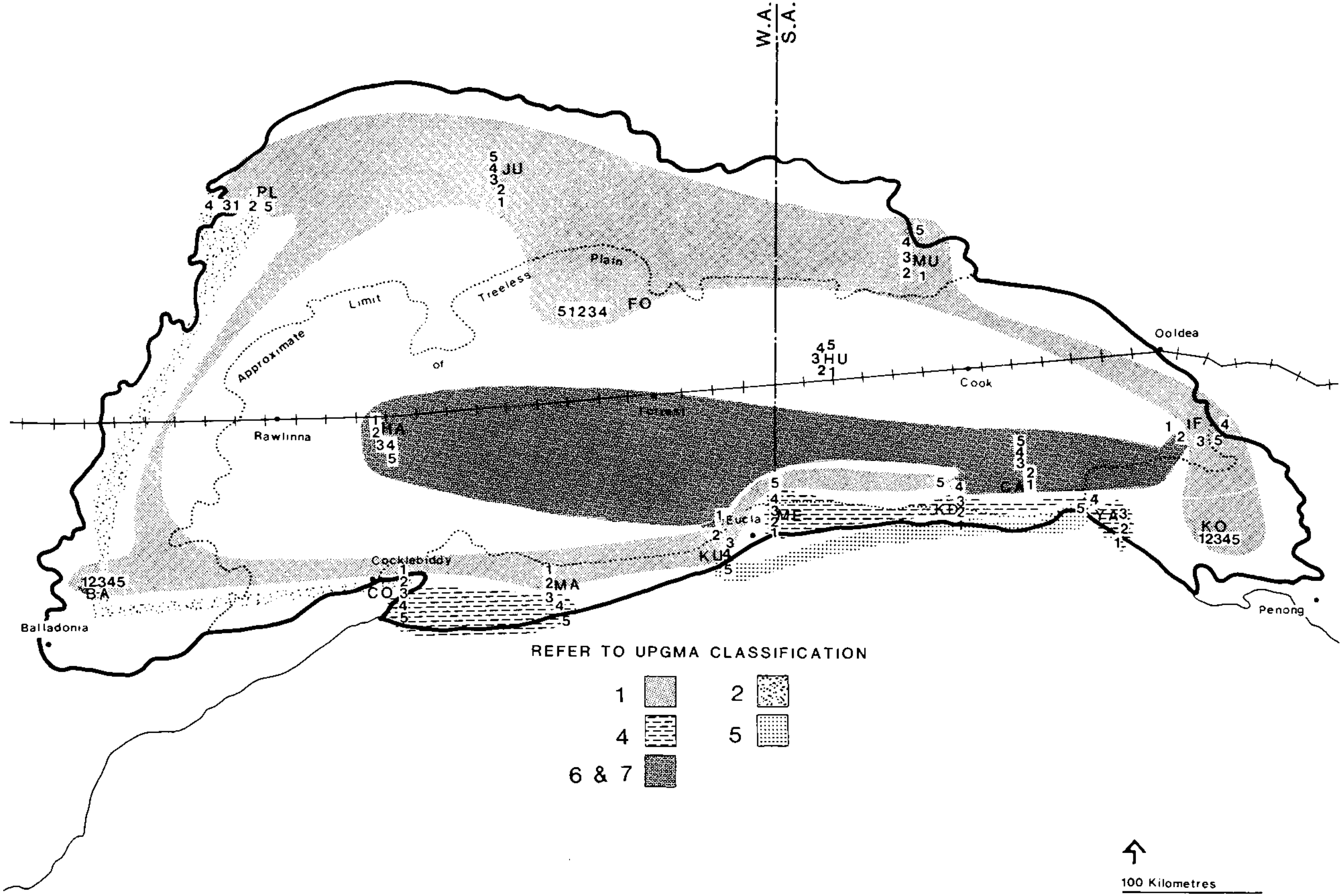
VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 83 POINTS
REGRESSIONS : Y = -0.3382E-05 + 0.1929 X
: X = 0.7487E-06 + 0.5404 Y
CORRELATION COEFICIENT (R) = 0.3229

LABEL	SEQ #	X-VALUE	Y-VALUE
BA1	1	-0.2453	0.1888
BA2	2	-0.6440E-01	-0.4900E-01
BA3	3	-0.1911	0.2330E-01
BA4	4	-0.3072	-0.3160
BA5	5	-0.2624	-0.2939
CA1	6	0.1944	0.5960E-01
CA2	7	0.3761	0.8360E-01
CA3	8	0.7759	-0.1300E-01
CA4	9	0.7179	-0.2420E-01
CA5	10	0.8053	-0.8790E-01
CO1	11	0.7170E-01	0.7990E-01
CO2	12	-0.2878	0.1950E-01
CO3	13	-0.7410E-01	0.2630E-01
CO4	14	-0.5570E-01	0.5520E-01
CO5	15	0.8000E-03	0.4910E-01
FO1	16	-0.2154	0.2482
FO2	17	-0.2410E-01	0.1661
FO3	18	-0.2203	0.1025
FO4	19	-0.8360E-01	0.2102
FO5	20	-0.3178	0.9480E-01
HA1	21	0.6772	-0.9800E-02
HA2	22	0.6830	-0.1980E-01
HA3	23	0.6592	-0.1740E-01
HA4	24	0.6451	-0.7740E-01
HA5	25	0.6588	0.1310E-01
HA6	26	0.2707	0.2594
HU1	27	0.6471	0.1067
HU2	28	0.5909	-0.6700E-02
HU3	29	0.4389	0.1430E-01
HU4	30	0.6456	0.6250E-01
HU5	31	0.2677	0.3046
IF1	32	0.6889	0.1297
IF2	33	0.4372	0.1495
IF3	34	-0.2607	-0.2800
IF4	35	-0.2414	-0.4481
IF5	36	-0.2703	0.4230E-01
JU1	37	-0.2460	-0.7070E-01
JU2	38	-0.2974	-0.6700E-02
JU3	39	-0.2851	-0.2287
JU4	40	-0.2762	-0.2710E-01
JU5	41	-0.3250	-0.6030E-01
KD1	42	0.9600E-02	0.3626
KD2	43	-0.1986	0.1364
KD3	44	-0.6600E-01	0.1290
KD4	45	0.5650	0.2499
KD5	46	0.4260E-01	0.5251
KO1	47	-0.2115	-0.4420E-01
KO2	48	-0.2138	-0.2515
KO3	49	-0.1921	-0.4876
KO4	50	-0.1601	-0.2995
KO5	51	-0.2362	-0.2304
KU1	52	0.2819	0.3118
KU2	53	-0.1973	-0.6000E-03
KU3	54	-0.3245	-0.5460E-01
KU4	55	-0.1033	0.1300
KU5	56	0.5730E-01	0.2564
MA1	57	-0.1015	-0.9080E-01
MA2	58	-0.1785	-0.1334
MA3	59	-0.9650E-01	-0.1820E-01
MA4	60	-0.8000E-01	-0.9780E-01
MA5	61	-0.1093	0.1404
MA6	62	-0.3750E-01	0.8490E-01
ME1	63	-0.1093	0.1182
ME2	64	-0.1742	-0.2980E-01
ME3	65	-0.1597	0.7760E-01
ME4	66	-0.2534	-0.1058
ME5	67	0.4520E-01	0.4808
MU1	68	-0.2667	-0.2800E-02
MU2	69	-0.1537	0.9060E-01
MU3	70	-0.3144	-0.2051
MU4	71	-0.3040	-0.3520
MU5	72	-0.2796	-0.3363
PL1	73	-0.2266	0.2136
PL2	74	-0.2750	-0.4700E-01
PL3	75	-0.3407	-0.3941
PL4	76	-0.3136	-0.3890
PL5	77	-0.3805	-0.1776
PL6	78	-0.2633	-0.1231
YA1	79	-0.2308	-0.3130
YA2	80	-0.2162	-0.2041
YA3	81	-0.1459	0.3565
YA4	82	-0.1864	-0.4050E-01
YA5	83	0.3979	0.3122

b.

Figure 50

Figure 51
GEOGRAPHIC DISTRIBUTION OF QUADRAT GROUPS FROM PASSERINE BIRD ANALYSES



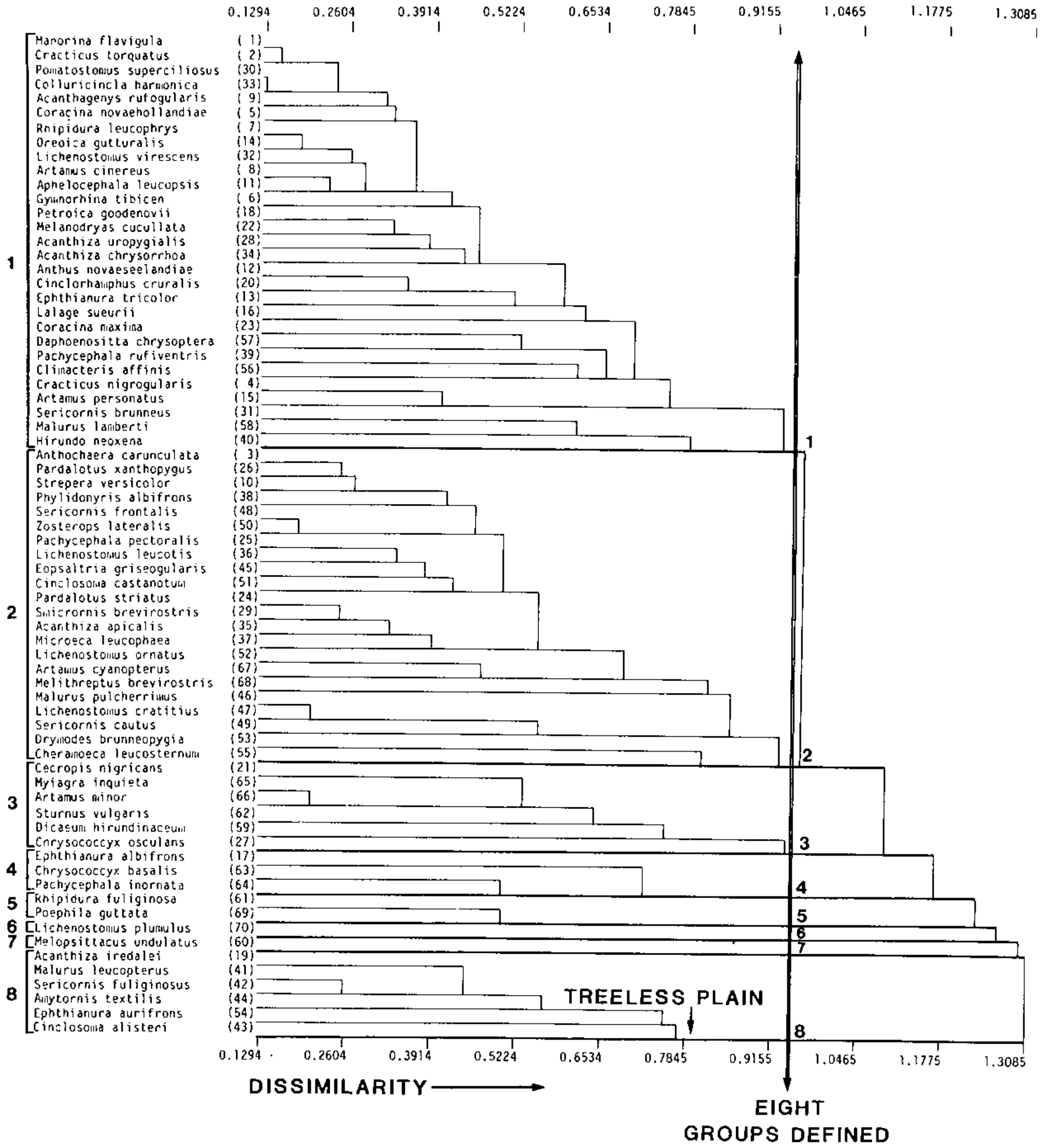
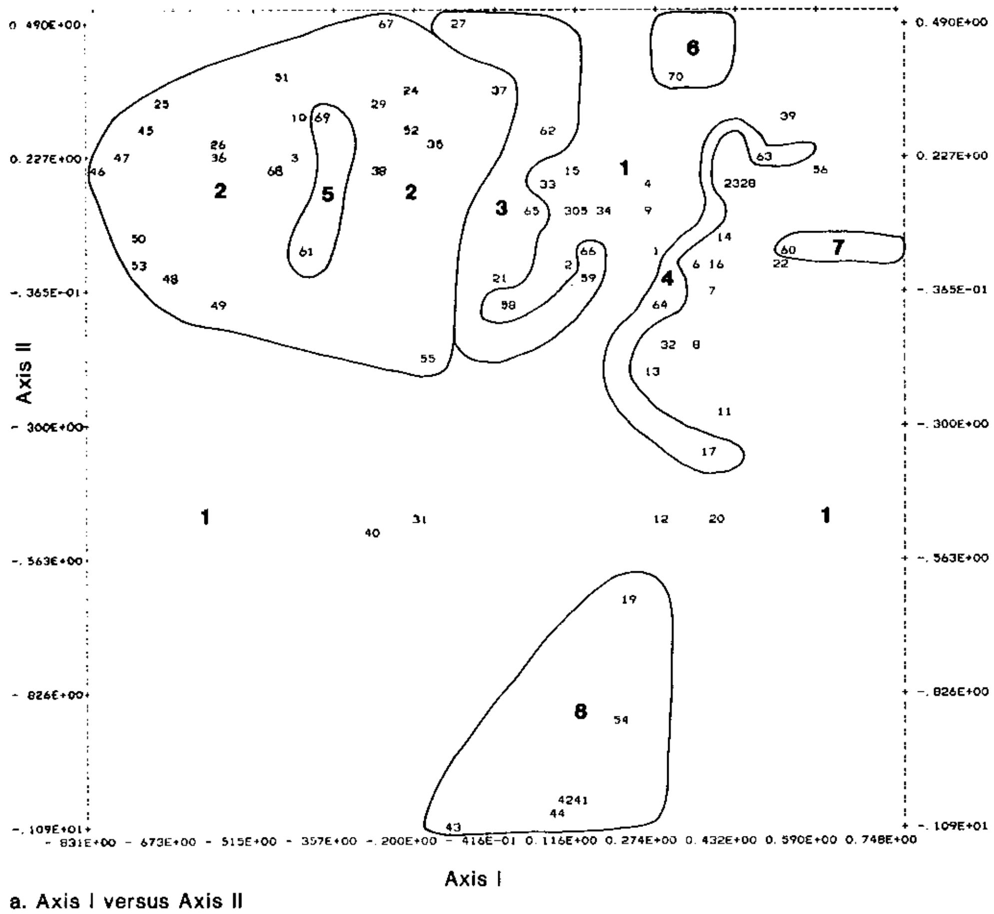
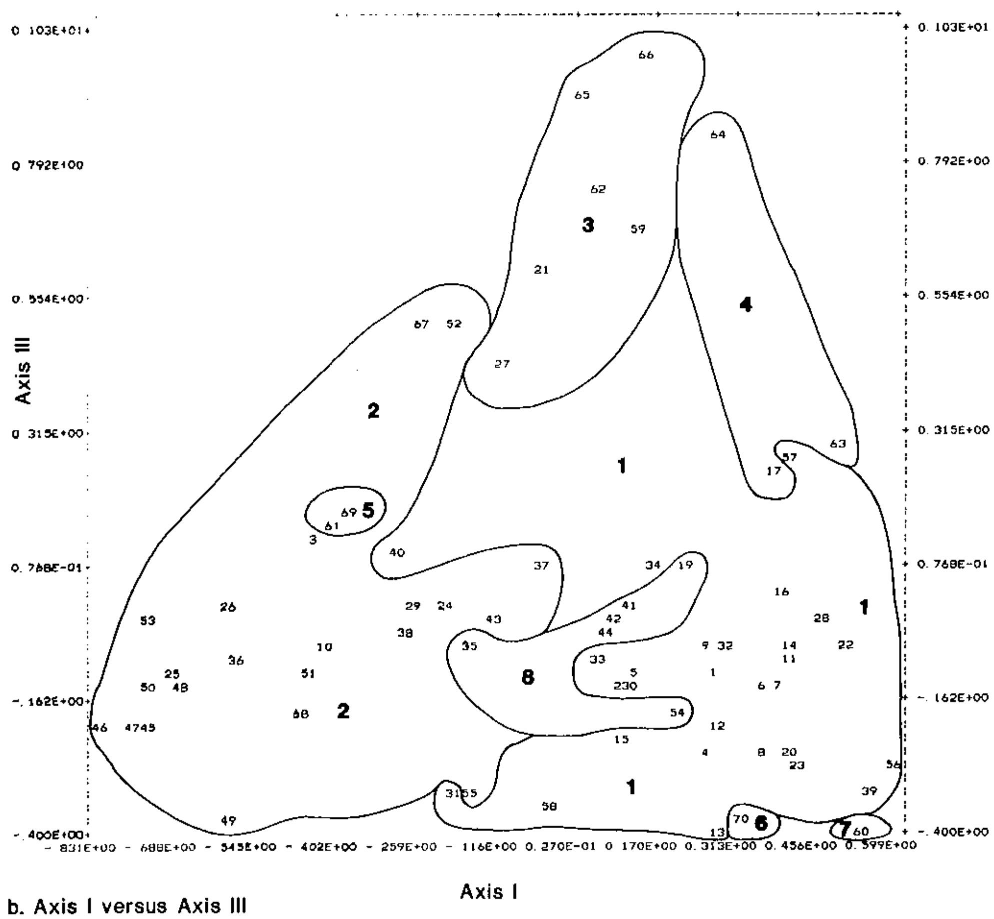


Figure 52

UPGMA SPECIES CLASSIFICATION IN TERMS OF QUADRAT SIMILARITIES(TWO-STEP).



a. Axis I versus Axis II



b. Axis I versus Axis III

Figure 53

SCATTERGRAM FROM THE ORDINATION OF PASSERINE BIRD SPECIES IN TERMS OF QUADRAT FIDELITY

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 70 POINTS
REGRESSIONS : Y = 0.2005E-05 + -0.2018 X
: X = 0.3184E-05 + -0.2294 Y
CORRELATION COEFICIENT (R) = -0.2151

LABEL	SEQ #	X-VALUE	Y-VALUE
Manoflav	1	0.2683	0.4970E-01
Cractorq	2	0.9690E-01	0.5500E-02
Anthcaru	3	-0.4413	0.2182
Cracnigr	4	0.2604	0.1772
Coranova	5	0.1281	0.1196
Gymntibi	6	0.3556	0.1270E-01
Rhipleuc	7	0.3917	-0.4640E-01
Artacine	8	0.3611	-0.1501
Acanrufo	9	0.2553	0.1230
Strevers	10	-0.4153	0.3042
Apheleuc	11	0.4172	-0.2670
Anthnova	12	0.2843	-0.4894
Ephttric	13	0.2815	-0.2060
Oreogutt	14	0.4174	0.6870E-01
Artapers	15	0.1143	0.1942
Lalasueu	16	0.4021	0.2810E-01
Ephtalbi	17	0.3902	-0.3481
Petrgood	18	0.3984	0.6570E-01
Acanired	19	0.2342	-0.6315
Cinccrur	20	0.4082	-0.4938
Cecrnigr	21	-0.2810E-01	-0.9900E-02
Melacucu	22	0.5199	0.8800E-02
Coramaxi	23	0.4340	0.1825
Pardstri	24	-0.1952	0.3655
Pachpect	25	-0.6933	0.3238
Pardxant	26	-0.5835	0.2530
Chryoscu	27	-0.1085	0.4900
Acanurop	28	0.4645	0.1704
Smicbrev	29	-0.2635	0.3348
Pomasupe	30	0.1240	0.1251
Seribrun	31	-0.1858	-0.4961
Lichvire	32	0.3015	-0.1292
Collharm	33	0.6860E-01	0.1764
Acanchry	34	0.1728	0.1304
Acanapic	35	-0.1582	0.2433
Lichleuc	36	-0.5795	0.2381
Micrleuc	37	-0.3090E-01	0.3630
Phylalbi	38	-0.2686	0.1879
Pachrufi	39	0.5505	0.2937
Hiruneox	40	-0.2860	-0.5126
Maluleuc	41	0.1301	-1.026
Serifuli	42	0.1013	-1.028
Cincalis	43	-0.1142	-1.089
Amyttext	44	0.7760E-01	-1.064
Eopsgris	45	-0.7266	0.2841
Malupulc	46	-0.8313	0.1980
Lichcrat	47	-0.7668	0.2371
Serifron	48	-0.6678	-0.1110E-01
Sericaut	49	-0.5861	-0.6320E-01
Zostlate	50	-0.7291	0.7660E-01
Cinccast	51	-0.4515	0.3907
Lichorna	52	-0.1945	0.2690
Drymbrun	53	-0.7376	0.1680E-01
Ephtauri	54	0.2130	-0.8797
Cherleuc	55	-0.1608	-0.1749
Climaffi	56	0.5992	0.2107
Daphchry	57	0.4106	0.1713
Malulamb	58	-0.1270E-01	-0.6670E-01
Dicahiru	59	0.1447	-0.2200E-02
Meloundu	60	0.5479	0.4100E-01
Rhipfuli	61	-0.4029	0.4740E-01
Sturvulg	62	0.7110E-01	0.2795
Chrybasa	63	0.4973	0.2352
Pachinor	64	0.2899	-0.6160E-01
Myiainqu	65	0.4090E-01	0.1253
Artamino	66	0.1513	0.4180E-01
Artacyan	67	-0.2439	0.4829
Melibrev	68	-0.4616	0.2100
Poepgutt	69	-0.3715	0.2958
Lichplum	70	0.3209	0.3799

a.

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 70 POINTS
REGRESSIONS : Y = 0.5665E-05 + 0.1695E-01 X
: X = 0.2703E-05 + 0.2679E-01 Y
CORRELATION COEFICIENT (R) = 0.2131E-01

LABEL	SEQ #	X-VALUE	Y-VALUE
Manoflav	1	0.2683	-0.1219
Cractorq	2	0.9690E-01	-0.1272
Anthcaru	3	-0.4413	0.1130
Cracnigr	4	0.2604	-0.2582
Coranova	5	0.1281	-0.1191
Gymntibi	6	0.3556	-0.1455
Rhipleuc	7	0.3917	-0.1305
Artacine	8	0.3611	-0.2627
Acanrufo	9	0.2553	-0.6160E-01
Strevers	10	-0.4153	-0.7350E-01
Apheleuc	11	0.4172	-0.7870E-01
Anthnova	12	0.2843	-0.2119
Ephttric	13	0.2815	-0.3936
Oreogutt	14	0.4174	-0.7720E-01
Artapers	15	0.1143	-0.2300
Lalasueu	16	0.4021	0.1910E-01
Ephtalbi	17	0.3902	0.2351
Petrgood	18	0.3984	0.2350E-01
Acanired	19	0.2342	0.8520E-01
Cinccrur	20	0.4082	-0.2604
Cecrnigr	21	-0.2810E-01	0.5955
Melacucu	22	0.5199	-0.6910E-01
Coramaxi	23	0.4340	-0.2804
Pardstri	24	-0.1952	0.2600E-02
Pachpect	25	-0.6933	-0.1060
Pardxant	26	-0.5835	0.1290E-01
Chryoscu	27	-0.1085	0.4312
Acanurop	28	0.4645	-0.2290E-01
Smicbrev	29	-0.2635	-0.3300E-02
Pomasupe	30	0.1240	-0.1432
Seribrun	31	-0.1858	-0.3261
Lichvire	32	0.3015	-0.5970E-01
Collharm	33	0.6860E-01	-0.1011
Acanchry	34	0.1728	0.7200E-01
Acanapic	35	-0.1582	-0.7520E-01
Lichleuc	36	-0.5795	-0.8620E-01
Micrleuc	37	-0.3090E-01	0.8420E-01
Phylalbi	38	-0.2686	-0.4100E-01
Pachrufi	39	0.5505	-0.3251
Hiruneox	40	-0.2860	0.9610E-01
Maluleuc	41	0.1301	0.5800E-02
Serifuli	42	0.1013	-0.1520E-01
Cincalis	43	-0.1142	-0.2850E-01
Amyttext	44	0.7760E-01	-0.3700E-01
Eopsgris	45	-0.7266	-0.2117
Malupulc	46	-0.8313	-0.2143
Lichcrat	47	-0.7668	-0.2198
Serifron	48	-0.6678	-0.1412
Sericaut	49	-0.5861	-0.3777
Zostlate	50	-0.7291	-0.1328
Cinccast	51	-0.4515	-0.1184
Lichorna	52	-0.1945	0.5034
Drymbrun	53	-0.7376	-0.1090E-01
Ephtauri	54	0.2130	-0.1741
Cherleuc	55	-0.1608	-0.3341
Climaffi	56	0.5992	-0.2753
Daphchry	57	0.4106	0.2586
Malulamb	58	-0.1270E-01	-0.3631
Dicahiru	59	0.1447	0.6625
Meloundu	60	0.5479	-0.4000
Rhipfuli	61	-0.4029	0.1588
Sturvulg	62	0.7110E-01	0.7373
Chrybasa	63	0.4973	0.2850
Pachinor	64	0.2899	0.8408
Myiainqu	65	0.4090E-01	0.9208
Artamino	66	0.1513	0.9930
Artacyan	67	-0.2439	0.4945
Melibrev	68	-0.4616	-0.1796
Poepgutt	69	-0.3715	0.1730
Lichplum	70	0.3209	-0.3785

b.

Figure 53

south-west of the Study Area: Yellow-rumped Pardalote, Silvereye, Golden Whistler, White-eared Honeyeater, Western Yellow Robin, Purple-gaped Honeyeater and Southern Scrub-robin. Group 8 includes six species all of which are virtually confined to low shrubland and/or grassland communities in Australia: Slender-billed Thornbill, White-winged Fairy-wren, Thick-billed Grass-wren, Orange Chat, Nullarbor Quail-thrush and Calamanthus. Only White-winged Fairy-wren and Calamanthus extend their range outside of the arid zone. Groups 3, 4, 5 and 6 are small and include species with few records on quadrats, thus stochastic effects may be influencing the groupings. Group 3 includes species of the semi-arid and more heavily wooded districts to the east and west of the Study Area. Group 4 contains some unedited records of the non-passerine Horsfield's Bronze-cuckoo; the other two species do not appear to be ecologically similar, nor do the two species in Group 5. Group 6 includes a single species, the Grey-fronted Honeyeater, that is restricted to the arid zone.

BA5, PL4, PL3, JU3, IF3, MU3 and BA4 had 66% or more of the 29 bird species included in Group 1 (Table 28) and are probably the most "typical" Group 1 quadrats. CO3, MA3, CO5 and CO4 had 64% or more of the 22 passerines listed in Group 2. Finally, CA4, HA5, HA2, CA3, IF2 and HA4 had 67% or more of the species comprising Group 8.

A principal co-ordinate analysis was carried out on the presence and absence quadrat data to classify passerine species in terms of quadrats. The results are presented in Fig. 53 with UPGMA species-group boundaries superimposed. The clusters distinguished are poorly defined although, from a knowledge of the ecology of individual species (elsewhere in Australia), both Axis I and Axis II of Fig. 53(a) can be related to environmental gradients in the Study Area. Axis I is consistent with a north-south climatic gradient from dependable winter rainfall along the coastal strip (negative loadings) to the irregular, undependable non-seasonal rainfall of the Treeless Plain and its periphery (positive loadings). Axis II separates passerine birds of mallee and woodland quadrats from passerines of the Treeless Plain (negative loadings).

The absence of discrete clustering in the scattergrams (Fig. 53) points to a relationship between bird mobility and the gentle gradients of change in the vegetation and climate across the Study Area and is reflected in the complexity of the dendogram (Fig. 52) at high dissimilarity levels.

The final stage in the quantitative analysis was the production of a Two-Way table using the UPGMA Group boundaries for quadrats (columns) and species (rows). This is presented in Table 28. Certain specific features are worth special note. The Orange Chat is distinctly more common in the de-vegetated quadrats on the Treeless Plain (HU1-3, HU5, IF1) than on HA1-5, CA1-5 and IF2. The latter quadrats are still covered with perennial plants and grasses. Away from the Treeless Plain this species was only recorded at FO4, FO2, and KD5; the FO sites were the only other largely de-vegetated sites in the Study Area.

Table 28 clearly shows the close correlation of Group 1 species with Group 1 quadrats (periphery of the treeless plain), Group 2 species with Group 4 quadrats (coastal woodlands and mallee) and Group 8 species with Group 6 quadrats (treeless plain). Quadrat Groups 8 and 9 (highly disturbed treeless plain) possess a depauperate selection of species Group 8 as well as some of the widespread ubiquitous birds from species Group 1. Thus three basic passerine bird community-types could be discerned as ecologically distinct.

(b) Non-Passerine Patterns
For the reasons stated earlier, we believe that the non-passerine data would not sustain the same detailed analyses as our data on passerines. It is possible, however, to look at some frequently recorded species to see if their distribution follows the same patterns as passerines (Table 29).

Some species were ubiquitous: Australian Kestrel, Brown Falcon, Little Button-quail and Horsfield's Bronze-cuckoo. Several were closely correlated with Group 1 quadrats (periphery of the treeless plain, see Table 26): Spotted Harrier, Red-backed Kingfisher, Galah, Banded Lapwing, Budgerigar and Naretha Blue Bonnet; while others were associated with both Group 1 and Group 4 (coastal woodlands and mallee) and/or Group 2 (peripheral woodlands, W.A.) and Group 3 (peripheral woodland, S.A.): Mulga Parrot, Port Lincoln Ringneck, Owlet Nightjar (Fig. 47), Tawny Frogmouth, Emu and Pallid Cuckoo. A few species were recorded only in woodlands - the Mallee Fowl in Group 4 quadrats and the Boobook Owl in both Groups 2 and 4.

The Inland Dotterel (Fig. 48) occurred on the typical treeless plain quadrats of Group 6, but was more plentiful on the highly disturbed quadrats of Group 8 and the similarly disturbed FO quadrats in Group 1. The Pink Cockatoo was recorded only at quadrats near the coast from Groups 1, 3, 4 and 5. It was seen feeding on seeds and pods of *Acacia saligna* in coastal dunes at Kuthala. The Australian Bustard occurred in Group 1 and Group 6 quadrats where the chenopod shrub layer was in good condition.

One unusual set of records is worth mention. At the MA campsite on 7 October 1984 numerous small flocks of Budgerigars and Crimson Chats appeared, all flying eastward. The Budgerigar flocks of about 20-30 birds were scattered all through the Study area below the old cliff line but the Crimson Chats were concentrated near the ocean. In a period of 15 minutes from 1500 hrs 6 flocks of about 100 birds each were seen flying eastwards within 100 m of the beach. On the same day a flock of over 1000 Masked Woodswallows arrived at the campsite and moved slowly towards the beach. The day was the second of two with unseasonally high temperatures. Unfortunately we had to leave the area the next day and cannot record how much longer this phenomenum continued. Similar observations were made at Eyre Bird Observatory, 75km to the west, on the same day (Dymond 1984).

Discussion
The avifauna of the Nullarbor Study Area is predominantly Eyrean with 47 of the 88 species autochthonous to the Eyrean (Schodde 1982a) being recorded. Bassian species are present in the Study Area (e.g. Southern Scrub-robin, Western Yellow Robin, Golden Whistler, Blue-breasted Fairy-wren, White-browed Scrub-wren, Red Wattlebird, Purple-gaped Honeyeater, New Holland Honeyeater) but they are restricted to the coastal fringe and do not occur on the treeless plain. Other species represented include cosmopolitan (e.g. Peregrine Falcon), migrant (e.g. Bronze-Cuckoos) or vagrant (e.g. Australasian Shoveler) species-groups.

The avifauna of the Study Area (242 species including 153 species of land birds) is comparatively rich for such an arid, uniform area. However, birds which occur in areas peripheral to the treeless plain account for most of the species richness; few are widespread and abundant on the treeless plain itself. Table 30 lists only 18 species which were frequently recorded on treeless plain quadrats during our survey, the low number presumably being due to the lack of structural and species diversity in the vegetation. All these, except the Nullarbor Quail-thrush, have widespread arid zone distributions and Ford (1983) has recently suggested that the Nullarbor Quail-thrush be considered a subspecies of the widespread Cinnamon Quail-thrush (*Cinclosoma cinnamomeum*).

If the Nullarbor has a distinctive assemblage of birds it is the species of the treeless plain. The analyses of our bird data showed clearly that there are three distinct assemblages of birds in the Study Area - that of the western, northern and eastern periphery, where there are open woodlands of myall, mulga, casuarina, and eucalypts, that of the southern fringe where there are mallee and eucalypt woodlands on coastal dunes and sandplains, and that of the true treeless plain.

Few species that are widespread in the arid zone have not been recorded in the Nullarbor Study Area. However, several have been recorded only rarely around the edges e.g. Chiming Wedgebill, Fairy Martin, Splendid Fairy-wren, Western Gerygone, Varied Sitella, White-browed and Rufous Treecreepers and Grey-fronted and Brown Honeyeaters.

The Nullarbor is an effective barrier to the distribution of a number of mainly Bassian birds. Species which have populations in south-western and south-eastern Australia that are separated by the Nullarbor include Crested Shrike-tit, Scarlet Robin, Western Yellow Robin, Restless Flycatcher, Western Whipbird, Southern Emu-wren, Little Wattlebird, Purple-gaped Honeyeater, Brown-headed Honeyeater, White-naped Honeyeater, New Holland Honeyeater, Tawny-crowned Honeyeater, Spotted Pardalote and Dusky Woodswallow. The Nullarbor seems to have prevented the westward spread of species such as Laughing Kookaburra (until it was spread by man), Superb Fairy-wren, Red-browed Firetail (also spread by man), Diamond Firetail, White-winged Chough and Little Raven. It has also acted as a barrier to the westward spread of several exotics from the south-east, viz Skylark, House Sparrow, Blackbird and, until recently, Common Starling; the spread of the last is now being actively controlled. Other species have been able to utilise corridors along the southern edge of the plain and through the better vegetated northern fringe and southern Great Victoria Desert (Ford and Sedgwick 1967).

The birds of surrounding natural districts are listed in Table 24. While such lists are difficult to analyse because they include many rare and vagrant records (e.g. the Nullarbor list includes several birds which could not be considered to be regular visitors: Peaceful Dove, White-throated Needletail, Chiming Wedgebill, Cinnamon Quail-thrush) it does appear that the Nullarbor Study Area shares most species with adjacent regions, suggesting that the mapped boundary used in this study is not recognised by most birds. Only one land bird found in the South-west Interzone of Western Australia has not been rcorded in the Study Area: the Western Rosella, which only just extends into the Eastern Goldfields from the south-west. Two Great Victoria Desert land birds have not been recorded further south, Grey Honeyeater and Striated Grasswren. Both are sandy desert specialists which are unlikely to be found on the Nullarbor. The Central Mallee Plains and Dunes Environmental Region of South Australia (Laut et al. 1977) is known to support populations of only one species not recorded on the Nullarbor - the Striated Grasswren.

Two taxa are restricted to the Nullarbor Study Area. The Nullarbor Quail-thrush is an inhabitant of the chenopod shrub-steppe and stony plains. It is patchily distributed and not particularly common, being recorded on only four quadrats during the Survey. However, it is wary and can easily avoid observation because of the excellent visibility provided by the low vegetation of its habitat. Little is known of its status or of trends in population numbers and the species should be examined more intensively to see if it requires conservation action.

The Naretha Blue Bonnet, a distinctive subspecies of a more widespread eastern species, occupies much of the Nullarbor Study Area, being recorded on 13 quadrats during the Survey. Its stronghold is the northern fringe but it is also found on the Treeless Plain, where it is usually associated with dongas (dolines) and is occasionally observed at the southern edge of the Plain. An attractive species, it has been the subjected to illegal poaching for the cage-bird trade, an activity which often destroys its nest hollows. However, our observations suggest that it is holding its own and that special conservation action is not required at present.

The Study Area contains good populations of several species which are either uncommon or declining elsewhere: Mallee Fowl, Pink Cockatoo, Ground Cuckoo-strike and Australian Dotterel. The Australian Bustard, a species which currently seems to be on the increase (Blakers et al. 1984), was also comparatively common for an area so far south.

The existing conservation reserve system does not include significant areas of the Treeless Plain. It is clear from this study that the Forrest campsite area, which is within the inappropriately named Great Victoria Desert Nature Reserve and which was mapped by Beard (1975) in the Treeless Plain, is actually in the northern fringe - its 'treeless' nature being due to overgrazing by rabbits. Also the eucalypt woodlands in the south-western part of the Study Area, as represented by the Balladonia campsite, and in the south-eastern part, as represented by the YA3 quadrat, are not protected.

The major conservation management problem is the continuing damage by rabbits, especially to areas of the Treeless Plain. An extreme case was the bird fauna at HU4 quadrat; this was so depauperate that the UPGMA classification placed it in a group of its own. Group 8, comprising 5 quadrats (HU1, HU2, HU3, HU5 and IF1) that were also extensively damaged, formed another distinctive group. While a few birds seem to do well in the damaged areas e.g. Inland Dotterel and Orange Chat, most are unable to persist e.g. Slender-billed Thornbill, Calamanthus and Thick-billed Grass-wren.

Of special concern in the latter group is the Thick-billed Grass-wren *Amytornis textilis textilis*. Once widespread in the southern arid zone of Western Australia it has suffered such a major decline in range and abundance that it has been placed on the Australian official list of endangered vertebrates (Burbidge and Jenkins 1984). It was common on all Haig quadrats during the Autumn 1984 visit but was absent during the spring trip. Previously the species, although known to be associated with chenopod shrublands, was thought to be absent from the Nullarbor Plain (Schodde 1982b). Our data suggest that it is present, but subject to local or seasonal movement. A better understanding of this species on the Nullarbor is urgently required. The closest known populations at present are at Shark Bay, several hundred kilometres to the west.

Acknowledgements
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TABLE 24: THE BIRDS OF THE NULLARBOR STUDY AREA AND ADJACENT REGIONS

	pre-1984[1]	Nullarbor Survey 1984	South-west Inter-zone[2] W.A.	Great Victoria Desert[3]	Central Mallee Plains and Dunes Environmental Region Eyre Peninsula S.A.[3]
Emu	X	X	X	X	X
Great Crested Grebe	X				X
Hoary-headed Grebe	X	X	X		X
Australasian Grebe	X	X	X		X
Little Penguin	X		X		X
Black-browed Albatross	X	X			X
Yellow-nosed Albatross	X	X	X		X
Sooty Albatross		X			
Great-winged Petrel	X				
White-headed Petrel	X	X			X
Flesh-footed Shearwater	X		X		X
Short-tailed Shearwater		X	X		X
Fluttering Shearwater	X				X
Wilson's Storm-petrel	X				X
Australian Pelican	X		X		X
Australasian Gannet	X	X	X		X
Black-faced Shag	X				X
Great Cormorant	X	X	X		X
Pied Cormorant	X	X	X		X
Little Pied Cormorant	X				X
Little Black Cormorant	X		X		X
Pacific Heron	X	X	X		X
White-faced Heron	X	X	X		X
Cattle Egret		X	X		
Great Egret	X				X
Eastern Reef Egret	X		X		X
Rufous Night Heron	X				X
Glossy Ibis	X				X
Straw-necked Ibis	X				X
Royal Spoonbill	X				X
Yellow-billed Spoonbill	X				X
Black Swan	X		X		X
Freckled Duck			X		
Australian Shelduck	X	X	X		X
Pacific Black Duck	X		X		X
Grey Teal	X	X	X		X
Chestnut Teal			X		
Australasian Shoveller	X				X
Pink-eared Duck	X				X
Hardhead	X		X		X
Maned Duck	X	X	X		X
Musk Duck	X		X		X
Osprey	X		X		X
Black-shouldered Kite	X	X			X
Black Kite	X				X
Square-tailed Kite	X	X	X		
Black-breasted Buzzard	X	X	X	X	
Whistling Kite	X	X	X	X	X

Brown Goshawk	X	X	X		X
Collared Sparrowhawk	X	X			X
White-bellied Sea-eagle	X		X	X	X
Wedge-tailed Eagle	X	X	X		X
Little Eagle	X	X	X	X	X
Spotted Harrier	X	X	X		X
Black Falcon	X				X
Peregrine Falcon	X	X	X	X	X
Australian Hobby	X	X	X		X
Grey Falcon	X			X	X
Brown Falcon	X	X	X	X	X
Australian Kestrel	X	X	X		X
Malleefowl	X	X	X		X
Stubble Quail	X	X	X		X
Brown Quail	X			X	
Little Button-quail	X	X	X		X
Buff-banded Rail	X				X
Baillon's Crake	X				X
Black-tailed Native-hen	X				X
Eurasian Coot	X			X	X
Australian Bustard	X	X	X		X
Pied Oystercatcher	X	X	X		X
Sooty Oystercatcher	X	X	X		X
Banded Lapwing	X	X	X		X
Masked Lapwing	X				X
Grey Plover	X	X	X		X
Lesser Golden Plover	X		X		X
Hooded Plover	X	X	X	X	X
Mongolian Plover	X				X
Double-banded Plover	X		X		X
Large Sand Plover	X		X		X
Oriental Plover	X				X
Red-capped Plover	X	X	X		X
Black-fronted Plover	X	X	X		X
Inland Dotterel	X	X	X		X
Red-kneed Dotterel	X				X
Black-winged Stilt	X		X		X
Banded Stilt	X	X	X		X
Red-necked Avocet	X		X		X
Ruddy Turnstone	X	X	X		X
Eastern Curlew	X		X		X
Wimbrel	X				X
Wood Sandpiper	X		X		X
Grey-tailed Tattler	X		X		X
Common Sandpiper	X	X	X		X
Greenshank	X		X		X
Marsh Sandpiper	X				X
Terek Sandpiper	X				
Black-tailed Godwit	X				
Bar-tailed Godwit	X	X	X		X
Red Knot	X	X	X		X
Great Knot	X		X		X
Sharp-tailed Sandpiper	X	X	X		X
Pectoral Sandpiper	X				
Baird's Sandpiper	X				
Curlew Sandpiper	X	X	X		X
Red-necked Stint	X	X	X		X
Long-toed Stint	X				X
Sanderling	X	X	X		X

Red-necked Phalarope	X				
Australian Pratincole	X	X			X
Silver Gull	X	X	X		X
Pacific Gull	X	X	X		X
Whiskered Tern	X				X
White-winged Tern	X				
Gull-billed Tern	X				X
Caspian Tern	X	X	X		X
Fairy Tern	X				X
Crested Tern	X	X	X		X
Feral Pigeon	X	X	X	X	X
Crested Pigeon	X		X		X
Peaceful Dove	X				X
Diamond Dove	X				X
Common Bronzewing	X	X	X	X	X
Brush Bronzewing	X	X	X	X	X
Spinifex Pigeon				X	
Galah	X	X	X	X	X
Pink Cockatoo	X	X	X		X
Sulphur-crested Cockatoo		X			X
Purple-crowned Lorikeet	X		X		X
Regent Parrot	X	X	X	X	
Alexandra's Parrot	X			X	
Cockatiel	X	X	X	X	X
Budgerigar	X	X			X
Western Rosella			X	X	
Port Lincoln Ringneck	X	X	X	X	X
Mulga Parrot	X	X	X		X
Blue Bonnet	X	X			X
Bourke's Parrot		X	X		X
Rock Parrot	X	X			X
Scarlet-chested Parrot	X			X	X
Pallid Cuckoo	X	X	X		X
Fan-tailed Cuckoo	X	X	X	X	X
Black-eared Cuckoo	X	X	X	X	X
Horsfield's Bronze-cuckoo	X	X	X		X
Shining Bronze-cuckoo	X	X	X	X	X
Southern Boobook	X	X	X		X
Barn Owl	X				X
Masked Owl	X	X		X	
Tawny Frogmouth	X	X	X	X	X
Australian Owlet-Nightjar	X	X	X	X	X
Spotted Nightjar	X	X	X		X
White-throated Needletail	X			X	
Fork-tailed Swift	X		X	X	X
Red-backed Kingfisher	X	X	X		X
Sacred Kingfisher	X	X	X		X
Rainbow Bee-eater	X		X	X	X
White-backed Swallow	X	X	X		X
Welcome Swallow	X	X	X	X	X
Tree Martin	X	X	X	X	X
Fairy Martin	X		X	X	X
Richard's Pipit	X	X	X	X	X
Black-faced Cuckoo-shrike	X	X	X	X	X
Ground Cuckoo-shrike	X	X	X	X	X
White-winged Triller	X	X	X		X
Southern Scrub-robin	X	X	X	X	X
Red-capped Robin	X	X	X	X	X
Hooded Robin	X	X	X		X

Western Yellow Robin	X	X	X	X	X
Jacky Winter	X	X	X		X
Crested Shrike-tit	X		X	X	X
Gilbert's Whistler	X	X	X		X
Golden Whistler	X	X	X	X	X
Rufous Whistler	X	X	X	X	X
Grey Shrike-thrush	X	X	X	X	X
Crested Bellbird	X	X	X		X
Restless Flycatcher	X	X	X		X
Grey Fantail	X	X	X	X	X
Willie Wagtail	X	X	X		X
Chiming Wedgebill	X			X	
Chestnut Quail-thrush	X	X	X		X
Cinnamon Quail-thrush	X				X
Nullarbor Quail-thrush	X	X		X	
White-browed Babbler	X	X	X		X
Rufous Songlark	X	X		X	X
Brown Songlark	X	X	X	X	X
Splendid Fairy-wren	X	X	X	X	X
Variegated Fairy-wren	X	X			X
Blue-breasted Fairy-wren	X	X	X	X	X
White-winged Fairy-wren	X	X	X		X
White-browed Scrub-wren	X		X	X	X
Striated Grasswren					X
Thick-billed Grasswren		X			X
Shy Hylacola	X	X	X	X	X
Redthroat	X	X	X		X
Calamanthus	X	X	X	X	X
Weebill	X	X	X	X	X
Western Gerygone	X	X	X	X	X
Inland Thornbill	X	X	X	X	X
Chestnut-rumped Thornbill	X	X	X	X	X
Slaty-backed Thornbill	X				
Slender-billed Thornbill	X	X			X
Yellow-rumped Thornbill	X	X	X	X	X
Southern Whiteface	X	X	X		X
Varied Sittella	X	X	X	X	X
White-browed Treecreeper	X	X	X	X	X
Rufous Treecreeper	X	X	X	X	X
Red Wattlebird	X	X	X		X
Little Wattlebird	X			X	
Spiny-cheeked Honeyeater	X	X	X	X	X
Yellow-throated Miner	X	X	X	X	X
Singing Honeyeater	X	X	X		X
White-eared Honeyeater	X	X	X		X
Purple-gaped Honeyeater	X	X	X		X
Yellow-plumed Honeyeater	X	X	X	X	X
Grey-fronted Honeyeater	X	X	X	X	X
White-plumed Honeyeater	X		X		X
Brown-headed Honeyeater	X	X	X		X
Brown Honeyeater	X	X	X		X
New Holland Honeyeater	X	X	X		X
White-cheeked Honeyeater	X			X	
White-fronted Honeyeater	X	X	X		X
Tawny-crowned Honeyeater	X		X	X	X
Grey Honeyeater				X	
Black Honeyeater	X		X	X	
Pied Honeyeater	X		X	X	
Crimson Chat	X	X	X	X	X

Orange Chat	X	X	X		X
White-fronted Chat	X	X	X	X	X
Mistletoe Bird	X	X	X		X
Yellow-rumped Pardalote	X	X	X	X	X
Red-browed Pardalote	X	X	X	X	
Striated Pardalote	X	X	X		X
Silvereye	X	X	X		X
House Sparrow	X	X		X	X
Zebra Finch	X	X	X		X
Common Starling	X	X			X
White-winged Chough		X		X	X
Australian Magpie-lark	X	X	X	X	X
Masked Woodswallow	X	X	X		X
White-browed Woodswallow	X		X	X	X
Black-faced Woodswallow	X	X	X		X
Dusky Woodswallow	X	X	X	X	X
Little Woodswallow	X	X		X	X
Grey Butcherbird	X	X	X	X	X
Pied Butcherbird	X	X	X	X	
Australian Magpie	X	X	X		X
Grey Currawong	X	X	X		X
Australian Raven	X	X	X	X	X
Little Crow	X	X	X	X	X
Torresian Crow	X		X	X	

1 Data from Nullarbor are based upon printouts supplied by the RAOU Bird Atlas project and on a variety of literature sources including Brooker et al. (1979), RAOU (1982), Ford and Sedgwick (1967), Reilly et al. (1975) and Ashton and Ashton (1983). English names listed above follow RAOU (1978).

2 Data for the South-west Interzone are compiled from the RAOU Atlas data base, records collected during the biological survey of the Eastern Goldfields of W.A. (B.S.C.W.A. 1984) and unpublished records of the Western Australian Wildlife Research Centre, W.A. Department of Conservation and Land Management.

3 Blakers, et al. (1984).

TABLE 25: INTERPRETATION OF THE NINE GROUPS DEFINED FORM THE UPPGMA CLASSIFICATIONS OF QUADRATS IN TERMS OF PASSERINE BIRD SPECIES SIMILARITIES

GROUP: 1 39 MEMBERS

Open woodlands of *Casuarina cristata* to low open woodlands of Myall and/or Mulga. Tree-mallees of *Eucalyptus*. KD5 and ME5 are clearings in Myall/Mallee. KO2, CO1 AND KU4 are samphire associations. All sites are peripheral to the Treeless plain.

BA1	BA2	MA1	MA6
MU2	CO1	KU2	KU4
BA4	BA5	JU3	MU3
PL3	PL4	IF3	IF4
PL5	FO3	PL2	JU2
MU1	FO5	IF5	JU1
JU5	JU4	KU3	KO3
MU4	MU5	KO4	KO1
KO2	KO5	FO1	FO4
FO2	KD5	ME5	

GROUP: 2 4 MEMBERS

Open woodlands of large *Eucalyptus* spp. or of *Casuarina* with Myall/Mulga, peripheral to the Treeless Plain in Western Australia. PL6 is a Triodia-mallee association of the Great Victorian Desert.

BA3	PL1	CO2	PL6

GROUP: 3 1 MEMBER

Open woodland of large *Eucalyptus* spp. over Greybush understorey, S.A.

YA3

GROUP: 4 16 MEMBERS

Mallee and *Eucalyptus* woodland communities over shrublands on consolidated sub-coastal sand dunes and sandplains (CO3,YA4) or sandy loam plains (KD2,ME4). MA5 is a shrubby herbfield on a sandy coastal strip between a beach and an extensive stand of mallee.

CO3	CO4	CO5	MA3
MA4	MA2	YA1	YA2
YA4	MA5	KD2	ME1
KD3	ME2	ME3	ME4

GROUP: 5 3 MEMBERS

Coastal shrublands in hollows behind beach dune or coastal cliffs.

KD1	YA5	KU5

GROUP: 6 11 MEMBERS

Treeless Plain; perennials and grass cover showed little sign of recent damage.

CA1	CA2	IF2	CA3
CA4	CA5	HA2	HA4
HA5	HA1	HA3	

GROUP: 7 3 MEMBERS

Treeless Plain with small scattered stands of Myall and/or low eucalypts.

HA6	KU1	KD4

GROUP: 8 5 MEMBERS

Treeless Plain with most perennials lost or dying.

HU1	IF1	HU2	HU3
HU5			

GROUP: 9 1 MEMBER

Treeless Plain with all perennials lost; some dead herb cover.

HU4

TABLE 26: THE EIGHT GROUPS OF PASSERINE* SPECIES DEFINED FROM THE UPGMA CLASSIFICATION OF SPECIES IN TERMS OF QUADRATS

GROUP: 1	29 MEMBERS	
Yellow-throated Miner		Grey Butcherbird
White-browed Babbler		Grey Shrike-thrush
Spiny-cheeked Honeyeater		Black-faced Cuckoo-shrike
Willie Wagtail		Crested Bellbird
Singing Honeyeater	Black-faced Woodswallow	
Southern Whiteface	Australian Magpie	
Red-capped Robin		Hooded Robin
Chestnut-rumped Thornbill		Yellow-rumped Thornbill
Richard's Pipit		Brown Songlark
Crimson Chat		White-winged Triller
Ground Cuckoo-shrike		Varied Sittella
Rufous Whistler		White-browed Treecreeper
Pied Butcherbird		Masked Woodswallow
Redthroat		Variegated Fairy-wren
Welcome Swallow		

GROUP: 2	22 MEMBERS	
Red Wattlebird		Yellow-rumped Pardalote
Grey Currawong		White-fronted Honeyeater
White-browed Scrubwren		Silvereye
Golden Whistler		White-eared Honeyeater
Western Yellow Robin		Chestnut Quail-thrush
Striated Pardalote	Weebill	
Inland Thornbill		Jacky Winter
Yellow-plumed Honeyeater		Dusky Woodswallow
Brown-headed Honeyeater		Blue-breasted Fairy-wren
Purple-gaped Honeyeater		Shy Hylacola
Southern Scrub-robin		White-backed Swallow

GROUP: 3	6 MEMBERS	
Tree Martin	Restless Flycatcher	
Little Woodswallow	Common Starling	
Mistletoebird		Black-eared Cuckoo*

GROUP: 4	3 MEMBERS	
White-fronted Chat	Horsfield's Bronze-cuckoo*	
Gilbert's Whistler		

GROUP: 5	2 MEMBERS	
Grey Fantail		Zebra Finch

GROUP: 6	1 MEMBERS	
Grey-fronted Honeyeater		

GROUP: 7	1 MEMBERS	
Budgerigar*		

GROUP: 8	6 MEMBERS	
Slender-billed Thornbill		White-winged Fairy-wren
Calamanthus	Thick-billed Grasswren	
Orange Chat	Nullarbor Quail-thrush	

* non-passerine species records overlooked during screening of data

TABLE 27: BIRD SPECIES RECORDED OPPORTUNISTICALY OUTSIDE THE SURVEY QUADRATS DURING THE NULLARBOR SURVEY

Poliocephalus poliocephalus Hoary-headed Grebe
28.3.84, "Balladonia", in dam

Tachybaptus novaehollandiae Australasian Grebe
11.4.84, Cook, in water tank

Diomedea chlororhynchos Yellow-nosed Albatross
19.9.84, "Koonalda", ocean
1.10.84, "Kuthala", dead on beach

Diomedia melanophrys Black-browed Albatross
18.9.84, "Koonalda", ocean

Phoebetria fusca Sooty Albatross
4.10.84, "Cocklebiddy", dead on beach

Pterodroma lessonii White-headed Petrel
4.10.84, "Cocklebiddy", dead on beach

Phalacrocorax varius Pied Cormorant
12.9.84, "Merdayerrah", over sea
1.10.84, "Kuthala", on beach
4.10.84, "Madura", on beach

Tadorna tadornoides Australian Shelduck
29.3.84, "Balladonia", on dam

Anas gibberfrons Grey Teal
1.10.84, "Kuthala", on beach
2.10.84, "Kuthala", in pool in road

Chenonetta jubata Maned Duck
7.10.84, "Balladonia", on dam

Haematopus longirostris Pied Oystercatcher
1.10.84, "Kuthala", in pool in road

Pluvialis squatarola Grey Plover
1.10.84, "Kuthala", on beach

Cladorhynchus leucocephalus Banded Stilt
27.2.84, Nullarbor Motel, carpark

Arenaria interpres Ruddy Turnstone
1.10.84, "Kuthala", on beach

Calidris canutus Red Knot
1.10.84, "Kuthala", on beach

Calidris acuminata Sharp-tailed Sandpiper
1.10.84, "Kuthala", on beach
4.10.84, "Madura", on beach

Columba livia Feral Pigeon
2.4.84, Hughes, settlement

Phaps elegans Brush Bronzewing
1.10.84, "Cocklebiddy", similar to C03

Neophema petrophila Rock Parrot
1.10.84, "Kuthala", on beach

Tyto novaehollandiae Masked Owl
20.9.84, Ivy Cave (old eggs, date laid unknown)

Passer domesticus House Sparrow
11.4.84, Cook, settlement
12.4.84, Nullarbor Roadhouse, settlement
19.9.84, Nullarbor Roadhouse, settlement

UPGMA Quadrat Groups

UPGMA Species Groups	Species	1	2	3	4	5	6	7	8	9
		BBMMMCKKBBJMPPIIPFPJMFIJJJKKMMKKKKFFFKM	BPCP	Y	CCCMMMYYYMKMKMMM	KYK	CCICCCHHHHH	HKK	HIHHH	H
		AAAAUOUUAAUULLFFLOLUUOFUUUUOUUOOOOOOODE	ALOL	A	OOOAAAAAAADEDEEE	DAU	AAFAAAAAAAA	AUD	UFUUU	U
		121621244533343453221551543345412514255	3126	3	3453421245213234	155	12234524513	614	11235	4
1	Manorina flavigula	* *** ******************** **********	****	*	**** ******		*			
1	Cracticus torquatus	***** ******************** ***** **	****	*	***************	***	***			
1	Pomatostomus superciliosus	** *************** ******** ***			** ***** *******	*				
1	Colluricincla harmonica	***************** ********	*		***************					
1	Acanthagenys rufogularis	*** ****** ******** * ******	* **		*** ******	*				
1	Coracina novaehollandiae	* ******** ** * **** *** * *	****		* ***** * * *	*	**			
1	Rhipidura leucophrys	*** ************************** ****	*		** * * *		*	*	*	
1	Oreoica gutturalis	******* ********* ************* * *	**		** *	*				
1	Lichenostomus virescens	************** ******************			***** *	***	*		***	
1	Artamus cinereus	*************** ********** ** ** *****	***		** *	*	*** *	**	*	
1	Aphelocephala leucopsis	************* ** **** ********* *******					*** * **	**		
1	Gymnorhina tibicen	** ******* ** ******* *** ******	***	*	*					
1	Petroica goodenovii	* *********** *** ** *** ***			* * *				**	
1	Melanodryas cucullata	**** ******* * *** *** ******					*			
1	Acanthiza uropygialis	******** * * **** *	* *							
1	Acanthiza chrysorrhoa	* * ******** * ***** **			* * *** *		*			
1	Anthus novaeseelandiae	******** *** * ********* ** *****			***	***	***********	***	*****	*
1	Cinclorhamphus cruralis	******* ** * **** *			*		** *****	***	* *	
1	Ephthianura tricolor	***** **** * **** *			*		* *	*		
1	Lalage sueurii	** *** ***** * **			*	*		*	*	
1	Coracina maxima	** * ****** * * **	***							
1	Daphoenositta chrysoptera	***** ** *			*					
1	Pachycephala rufiventris	***** * **	*							
1	Climacteris affinis	* *** * *								
1	Cracticus nigrogularis	** * * *	**							
1	Artamus personatus	*** ** ** *	**		***					
1	Sericornis brunneus	* *			** ***		***			
1	Malurus lamberti	* *			* **					
1	Hirundo neoxena	* * * *	*		* * **** **	***	** ** *	**		
2	Anthochaera carunculata	* * **	* *	*	***********	*				
2	Pardalotus xanthopygus		*	*	***** ***** *					
2	Strepera versicolor	* *	* *	*	********* ***					
2	Phylidonyris albifrons	* * ** *** *	*	*	**** ** **** **					
2	Sericornis frontalis				***** ***** *	* *				
2	Zosterops lateralis				**** ****	*				
2	Pachycephala pectoralis		*		**** * **					
2	Lichenostomus leucotis	* *			****** * *					
2	Eopsaltria griseogularis				* ** *					
2	Cinclosoma castanotum	* *			******** *					
2	Pardalotus striatus	* *** * *	****		* *******					
2	Smicrornis brevirostris	* * * * * *	* **		********** ***					
2	Acanthiza apicalis	* ** ** ** * * *	*		********* ******					
2	Microeca leucophaea	* ** * *	**		*****					
2	Lichenostomus ornatus	* * ***			* * ***					
2	Artamus cyanopterus	*			****					
2	Melithreptus brevirostris				**					
2	Malurus pulcherrimus				***					
2	Lichenostomus cratitius				**					
2	Sericornis cautus	*			*					
2	Drymodes brunneopygia				* *					
2	Cheramoeca leucosternum	* * **			* **		*			
3	Cecropis nigricans	** * * *			* *	*				
3	Myiagra inquieta	* *			*					
3	Artamus minor	* *								
3	Sturnus vulgaris	* *								
3	Dicaeum hirundinaceum	* * *								
3	Chrysococcyx osculans		*		*					
4	Ephthianura albifrons	* ** *					*			
4	Chrysococcyx basalis	* *								
4	Pachycephala inornata	* *								
5	Rhipidura fuliginosa				* *					
5	Poephila guttata	*			*					
6	Lichenostomus plumulus	*	*							
7	Melopsittacus undulatus	* * *								
8	Acanthiza iredalei	*** *** ** *					********* *			
8	Malurus leucopterus						**********		**	*
8	Sericornis fuliginosus	*				*	*********		***	
8	Amytornis textilis						* *****			
8	Ephthianura aurifrons	***					* *		*****	
8	Cinclosoma alisteri						**		*	

Table 28
TWO-WAY TABLE FOR PASSERINE BIRD ANALYSIS

TABLE 29

TWO-WAY TABLE OF QUADRATS VERSUS SOME COMMONLY RECORDED NON-PASSERINE SPECIES

	BBM AAA 121	MMC AUO 621	KKB UVA 244	BJMP AUJL 5333	PII LFF 434	PFP LOL 532	JMF UUO 215	IJJ FUU 515	JKK UUO 433	MMK UUO 454	KKK 000 125	FFF 000 142	KM DE 55	BPCP ALOL 3126	Y A 3	CCC 000 345	MMM AAA 342	YYM AAA 124	MKM ADE 521	KMMM OEEE 3234	KYK DAU 155	CCI AAF 122	CCC AAA 345	HHH AAA 245	HH AA 13	HKK AUD 614	HIHHH UFUUU 11235	H U 4
Mulga Parrot		*	**	*	***	* *	*	***	***	***	***			*				**	*	*	*							
Wedge-Tailed Eagle	*	*	*	* *		* *	*	*	*					*														
Spotted Harrier	*	*										*																
Owlet Nightjar				**		*								* *	*		*										*	
Red-Backed Kingfisher		*		*		*	*			*	* *		*															
Pink Cockatoo									**	*	**				*	**	*		*		*							
Galah	**				**	*	*	*	*	*	***			*														
Inland Dotterel						*						***									*			*	*		* **	
Banded Lapwing						*	*	* *				*		*														
Hosefield Bronze Cuckoo**	*	**	* **	*	*					*	*			**		*		*				**		*	*			
Pallid Cuckoo		**	***	* *	***	***	***	**	**	***	**	**		* **	*			*			*	*						
Emu		*							*	*	*								*									
Brown Falcon	***	***	***	***	* *	**	**	* *	* *	**	**	***	**				* *			*		***	*	**				
Australian Kestrel	***	* *	***	* *		*	***	**	**	**		***	*	***	*				* *	*	**	*	**	***	**	*	****	
Mallee Fowl																*	* *											
Aust. Bustard	* *							*																**	*			
Port Lincoln Parrot		*	*	* *	***	*			*	*	***			* *	*	*	* *	**	*	*								
Budgerigar	**	**	*	****			*	*	*	**				*					*			*						
Naretha Parrot				*		***	*	***	*		*	**														*		
Tawny Frogmouth			*				*	*	*	*				*	*		*	* *		*		*						
Boobook Owl														* *			* *	**										
Little Button-Quail	**	***	*	* *	*	*		* *		*	*				*							*			*	*		

Two way table of quadrats versus some commonly recorded non-passerine species using quadrat groups defined by the UPFMA analysis of passerine data.

TABLE 30 SPECIES COMMONLY RECORDED ON THE TREELESS PLAIN

Inland Dotterel
Brown Falcon
Australian Kestrel
Wedge-tailed Eagle
Australian Bustard
Little Button-quail
Black-faced Woodswallow
Southern Whiteface
Richard's Pipit
Brown Songlark
Redthroat
Welcome Swallow
Singing Honeyeater
Slender-billed Thornbill
White-winged Fairy-wren
Calomanthus
Orange Chat
Nullarbor Quail-thrush

REPTILES

N.L. McKenzie, J.K. Rolfe and D. Carter

Background

The aims of this chapter are to describe the patterning of amphibian and reptile species within the study area (Fig. 1) and examine the relationship between the herpetofauna of the Study Area and those of adjacent natural districts. Its purpose is to provide an objective basis for selecting areas of land to be recommended as conservation reserves that, together, will include representative populations of all species comprising the Nullarbor District's herpetofauna.

The history of herpetological investigation of the Study Area is reviewed in Introduction (this publication). The herpetofauna known from the Nullarbor prior to our surveys has been briefly discussed by Brooker and Wombey (1977) and Storr, Hanlon and Harold (1981). Storr et al. (ibid) discusses the biogeographical affinities of the coastal fringe of our Study Area; they recognised several biogeographical components:

(i) a south-western Australian component restricted to coastal areas;

(ii) a component of species typical of the semi-arid interior of south-western Australia that reach their eastern limit in western parts of the Study Area;

(iii) a Nullarbor component which also includes species characteristic of eastern Australian succulent steppe habitats.

(iv) an endemic component in the vicinity of the Great Australian Bight.

Although the taxonomic terminology used in the survey data base (Appendix V) and in the pattern analyses follows Cogger et al. (1983), in interpreting our results we have followed finer levels of taxonomic discrimination (e.g. trinomials) where these have biogeographic significance. These are referenced where used.

A number of physical factors were expected to influence species patterning within the Study Area. In particular, climatic gradients and changes in soil-type were expected to be important. For instance, the high levels of Calcium (associated with the limestone surfaces) ubiquitous in central and northern areas of the Study Area were expected to restrict the availability of soil nutrients, limit vegetation productivity and structural diversity and, because of the absence of suitable microhabitats, act as a biogeographic barrier to the dispersal of many species resulting in:

(i) amphibian and reptile assemblages with low biomass and species richness;

(ii) a tendency towards mozaic patterning in the amphibia and reptiles round the periphery of the Study Area, caused by their relatively low mobility and the biogeographical influences from adjacent districts. This was expected to be off-set in its central areas by the low gradients of change in physical factors such as climate, the almost total absence of topographic relief, and the low species richness (a species-poor pool of potential colonizers for assemblages); few endemic reptiles are known.

Eighty-two quadrats were sampled for reptiles and amphibians on the Nullarbor Study Area (Fig. 1) during our 1984 surveys. In total, 1540 drift-fence nights (9240 pit-trap nights) were undertaken along with more than 160 man-days of foraging by the primary herpetologists (40 days x 4 people) plus additional records made by other field personnel (such as the ornithologists and mammologists) during their own program of field sampling on the quadrats. Reptiles encountered while travelling between camps and between quadrats were also recorded as opportunistic data.

As was pointed out in detail in Methods (this publication), these quadrats were positioned across the Study Area to provide representation of (i) the reptile and amphibian communities associated with each of the surface-types represented there, and (ii) the alternative species compositions of reptile and amphibian assemblages assigned to each community. At the same time, such data would allow us to assess (i) the effect of climatic gradients across the district and/or (ii) the influence of adjacent natural districts (such as the Great Victoria Desert and the South-Western Interzone), on the species structure of these assemblages.

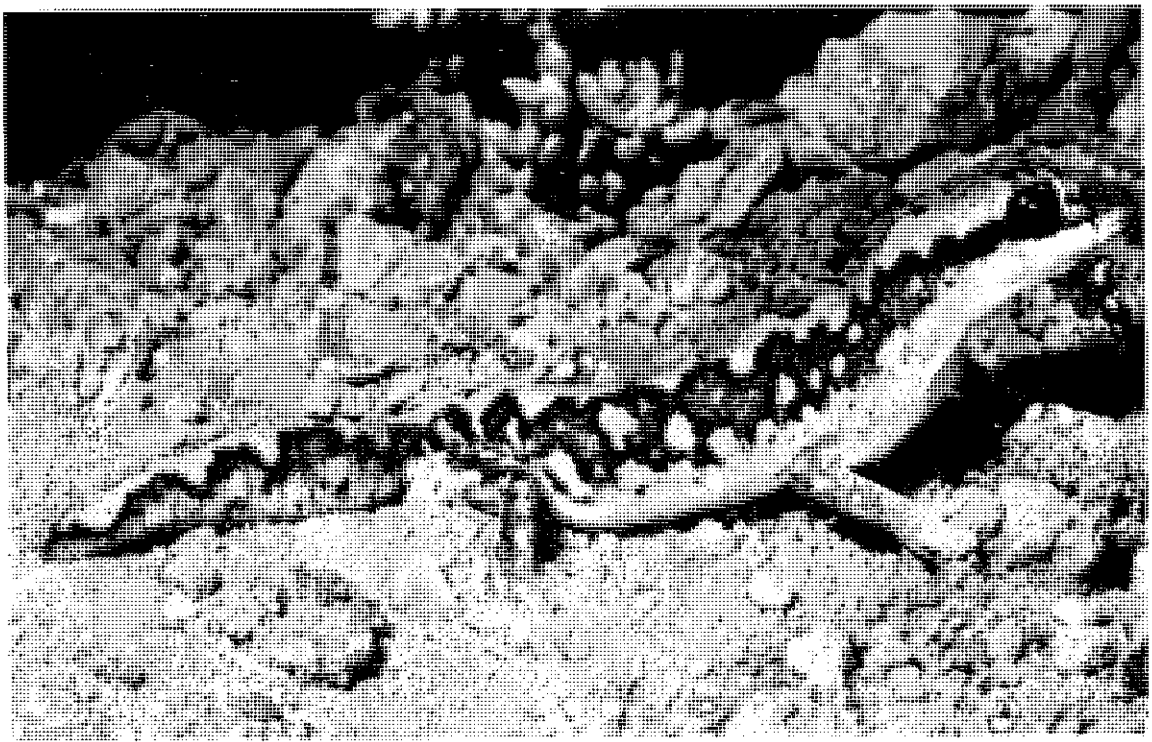
A knowledge of these patterns allow a quantitative appraisal of the conservation-reserve needs of reptiles and amphibia in the Study Area. By analysing the combined April and September herpetological data from quadrats, it was hoped to gain a better overview of species' habitat requirements because analyses based on presence-absence data can be biased by the strong influence that seasonal patterns of temperature and rainfall have on the activity of most heterothermic species; in addition syntopic reptiles are known to partition resources by temporal as well as spatial means (Pianka 1969, pp. 1023). In this context it should also be noted that our data was insufficient to assess the influence of population density on species' habitat selectivity (see Rosenzweig and Abramsky 1986).

Results

To document the total list of reptiles and amphibians recorded in the Nullarbor Study Area since the time of European settlement, we reviewed the collection of the South and Western Australian Museums and records in available literature. This list of pre-1984 records comprises 72 species and is included in Table 31.

The 75 amphibian and reptile species recorded during our March and September 1984 surveys have also been listed in Table 31. Representatives of all species are lodged in the collection of the relevant State museum. Other data recorded in the data sheets are stored on computer file.

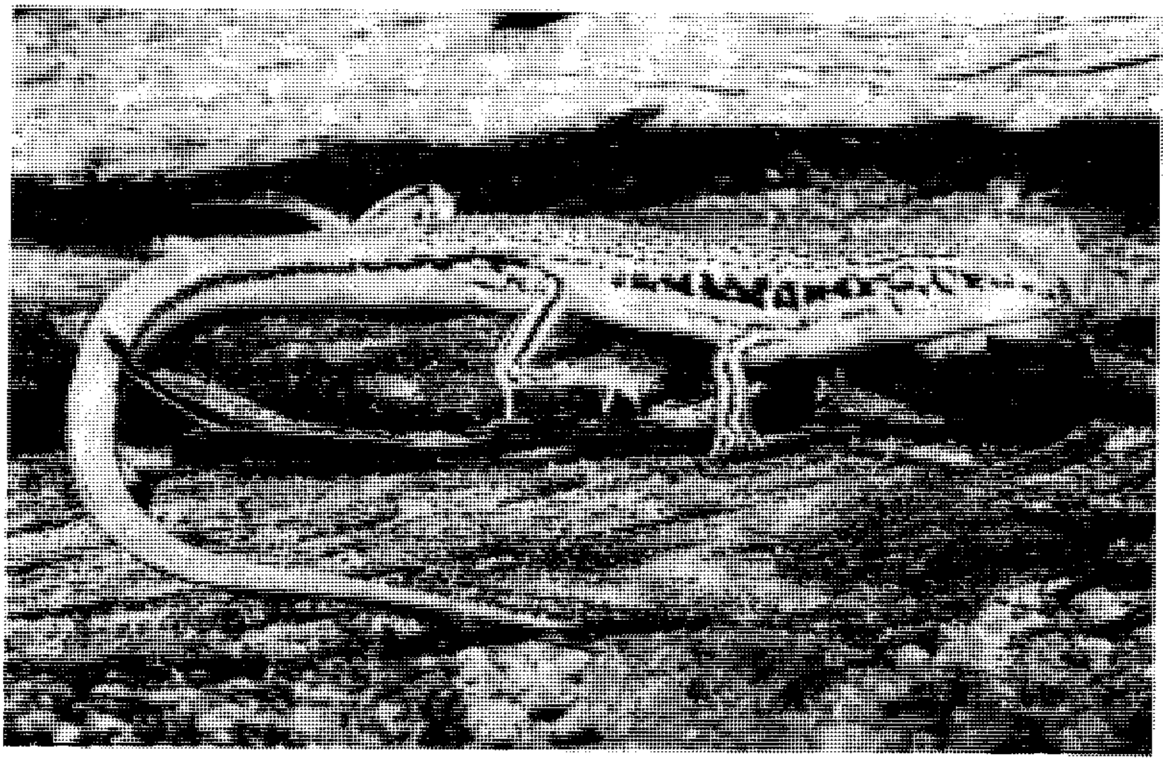
Seventy-one species were recorded on quadrats during our survey; 84% of the total herpetofauna now known from the Study Area. These are listed, by quadrat, in Appendix V. Two of the four species that we only recorded opportunistically (not on quadrats) are detailed in Table 32. Eleven of the pre-1984 records were not encountered during our survey - Loggerhead Turtle (Caretta caretta), Lialis burtonis, Diporiphora linga, Varanus eremius, V. rosenbergi, Ctenotus atlas, Ramphotyphlops australis, Aspidites ramsayi, Acanthophis antarcticus, Demansia psammophis and Unechis nigriceps. Diporiphora linga, Varanus eremius and Ctenotus atlas are species of sandy



The Gecko Diplodactylus granariensis recently described as a species separate from the much more widespread D. vittatus was found at several sites during the survey. Photo A. Wells.

The spectacular gecko Diplodactylus pulcher, the capture of this species is a significant range extension eastwards and the first record for South Australia. Photo D. Carter.

The Pigmy Mulga Goanna Varanus gilleni an attractive small animal found under the bark of mulga trees killed by fire. A relatively poorly known species it was collected form the Muckera site during the survey. Photo D. Carter.



The Skink Ctenotus brooksi euclae an endemic sub-species of this widespread species which is confined to the coastal areas of the Nullarbor from Twilight Cove to Point Sinclair. Photo A. Wells.

surfaces with porcupine grass, habitats atypical of the Study Area but widespread around its northern periphery. For instance, the sole Ctenotus atlas record came from a patch of "mallee and porcupine grass" (Brooker and Wombey 1977).

Both Bassian and Eyrean components are present though the latter sort of species are more numerous overall and more widespread in the Study Area. The known herpetofaunas of adjacent districts are presented in Tables 33 and 34.

Only one species of amphibian has been recorded from the Study Area. Neobatrachus centralis has been recorded from Plumridge Lakes (Burbidge et al. 1976), and from a flooded claypan south-east of Lake Brown (29°22' 126°07') and a flooded donga on Kanandah Pastoral Lease (Brooker and Wombey 1977). The Neobatrachus recorded from BA1 (i.e. Quadrat No. 1 from the Balladonia campsite), PL and FO are either N. sutor or N. centralis; the two specimens from BA (snout-vent lengths of 54mm and 59mm) are probably N. centralis (Tyler, Smith and Johnstone 1984). Other species of frogs may occur in the Study Area, although we checked many dams and other sites with permanent and ephemeral water. We also encountered heavy rain at many sites during September. A review of geographic ranges of Australian frogs suggests that Neobatrachus wilsmorei and Pseudophryne occidentalis may also occur in the Study Area.

Pattern analyses were undertaken of the reptile data from the quadrats. The analysis pathways followed are described in Methods (this publication) along with an explanation of the philosophy behind the separate analyses of taxmonomic groups (birds, reptiles and plants) as sub-sets of the total species lists from the quadrats.

Surveys restricted to relatively small quadrats that are sampled over only a few, relatively brief, intervals of time are more likely to provide meaningful comparisons between quadrats if the influence of stochasm on the samples is minimised (see Wiens 1981). This can be done by restricting the analysis to sedentary species with relatively small territories, and therefore greater abundance in suitable habitat. The 84 species of non-marine reptiles known in the Study Area comprises 14 geckos, 5 legless lizards, 14 dragons, 4 monitors, 31 skinks, and 16 snakes (including one python and 2 blind snakes). The larger and more mobile reptiles were poorly represented in our samples; we recorded only 50% (2 species) of the known monitors and 56% (9 species) of known snakes. In comparison, the smaller and less mobile groups were much better represented by our quadrat sampling: 100% (14 species) of the known geckos, 80% (4 species) of the legless lizards, 93% (13 species) of the dragons and 90% (28 species) of the skinks. Thus, to reduce the influence of chance on our sampling we excluded snakes and monitors from the assemblage analysis. Records in these two groups, along with a few pre-1984 records of other lizards, are presented in Fig. 56.

Reptile Analysis

In terms of reptile species richness, the quadrats on the Treeless Plain (HU1-5, IF1, 2, CA1-5, HA1-5, KD4 and KU1) were the poorest (mean = 3.7 ± 1.7 (SD), n = 19). Quadrats in clearings (grassed and/or low shrub) between tree or mallee stands on the south edge of the Treeless Plain (KD3, KD5, ME5, KU2, BA2 and MA1) had greater species richness (6.3 ± 0.8 (SD) n = 6) while quadrats with structurally more complex vegetations (and greater floristic richness) were usually the richest in reptile species (7.5 ± 3.0 (SD) n = 50). The result of a regression analysis between lizard species richness and the floristic richness of quadrats (from Table 7 in Keighery et al., this publication) is presented in the discussion. The species richness of quadrats in Myall, Mulga, Casuarina and Eucalyptus woodlands, and of mallee quadrats, were not appreciablly different; nor did a quadrat's position to the north, south, east or west of the Treeless Plain make any consistent difference to species richness (see Table 36).

Only a single reptile species was recorded at five of the 82 quadrats sampled (KU4, ME4, HU2, 4 and 5) and 12 of the 59 species were recorded at only one quadrat (see Table 35). These quadrats and species could not be analysed. The UPGMA classification of the remaining 77 quadrats according to the presence and absence of the remaining 47 reptile species, resulted in the dendrogram presented in Fig. 57.

Seven groupings were initially distinguished in the dendrogram (Fig. 57). These groups can be interpreted ecologically in terms of the vegetation and geographical location of their component quadrats.

Group 1 comprised 34 quadrats all belonging to the Treeless Plain, to low-shrub or to relatively open Eucalypt and Myall vegetations south, south-east and south-west of the Plain.

Group 6 (2 quadrats) comprised Treeless Plain quadrats with very low species richness (IF1, 2 species; CA5, 2 species).

Group 5 (3 quadrats) included the most species-poor coastal (beach-front) quadrat (KU5, 3 species), a species poor quadrat in an isolated patch of Myall on the Treeless Plain (HA6, 4 species) and a species poor quadrat on the Treeless Plain (HU3, 2 species).

Because of their very low reptile species richness, the classification of the quadrats included in Groups 5 and 6 is likely to have been strongly influenced by chance; in all cases the species present on these quadrats were also present on Group 1 quadrats.

Group 2 comprised the 14 quadrats that represented the dense woodlands and thickets of mallee, tree-Eucalyptus and Melaleuca found along the southern (coastal) margin of the Study Area. The influence of the coast is evident in the sandy texture of the soils of these quadrats.

Group 3 comprised a single quadrat (YA1); it was similar to quadrats of both Groups 1 and 2 in its vegetation, soils and location.

Group 4 comprised 22 quadrats. With the exception of IF5 (Group 1), these included all quadrats located between the Treeless Plain and the Great Victoria Desert. For our purposes, the Great Victoria Desert includes the Western Sandplains Province of South Australia. The only odd quadrat in Group 4 is YA3; in terms of its geographic location and vegetation, we would have expected it in Group 1. Despite its rich reptile assemblage (10 species), YA3 is only weakly classified into Group 4.

Group 7 comprised a single quadrat (IF4). It was on a red sand dune of the Great Victoria Desert, just outside the eastern extremity of the Study Area.

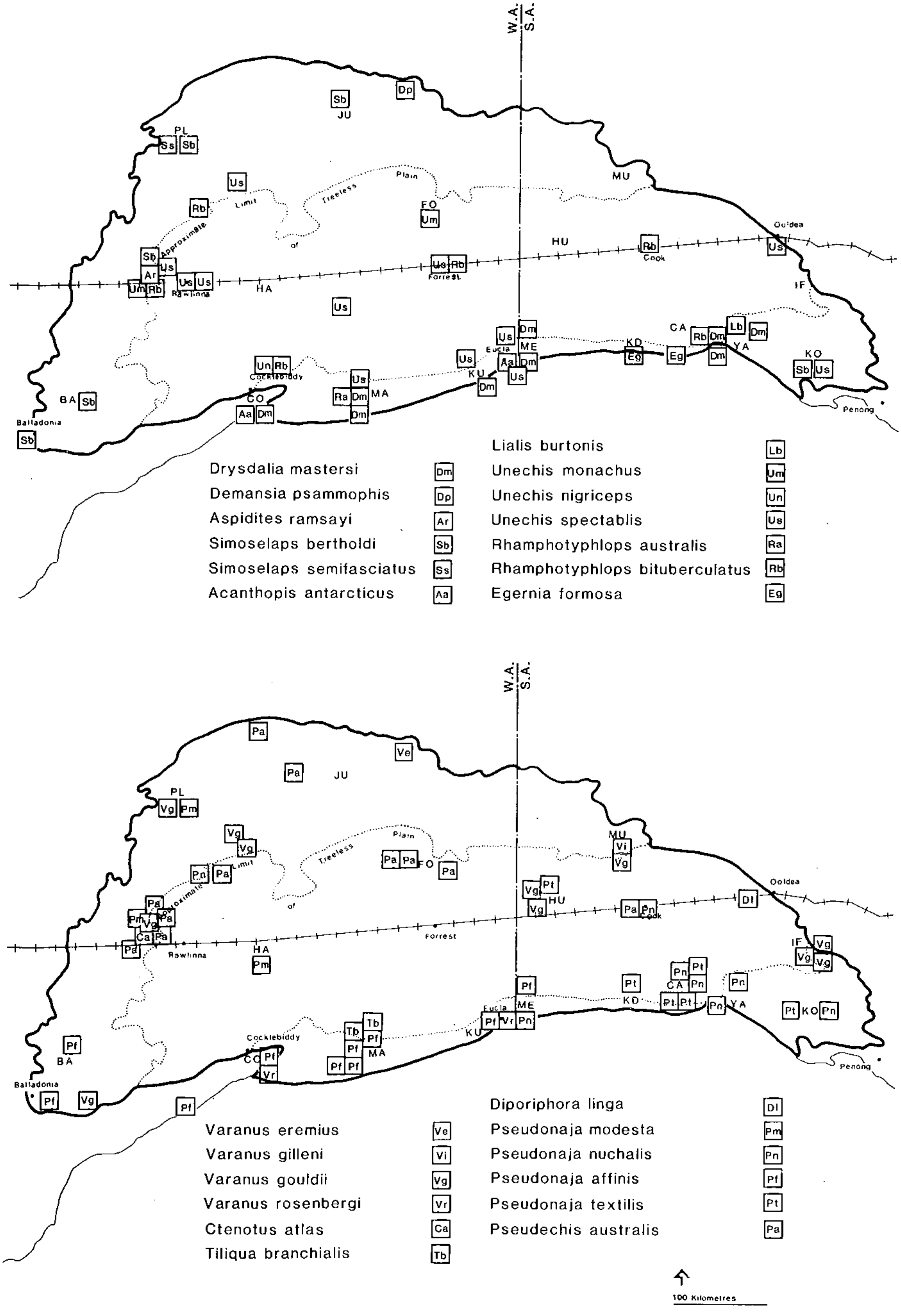


Figure 56

SNAKE AND MONITOR RECORDS FROM THE STUDY AREA

-A few additional lizard records are included

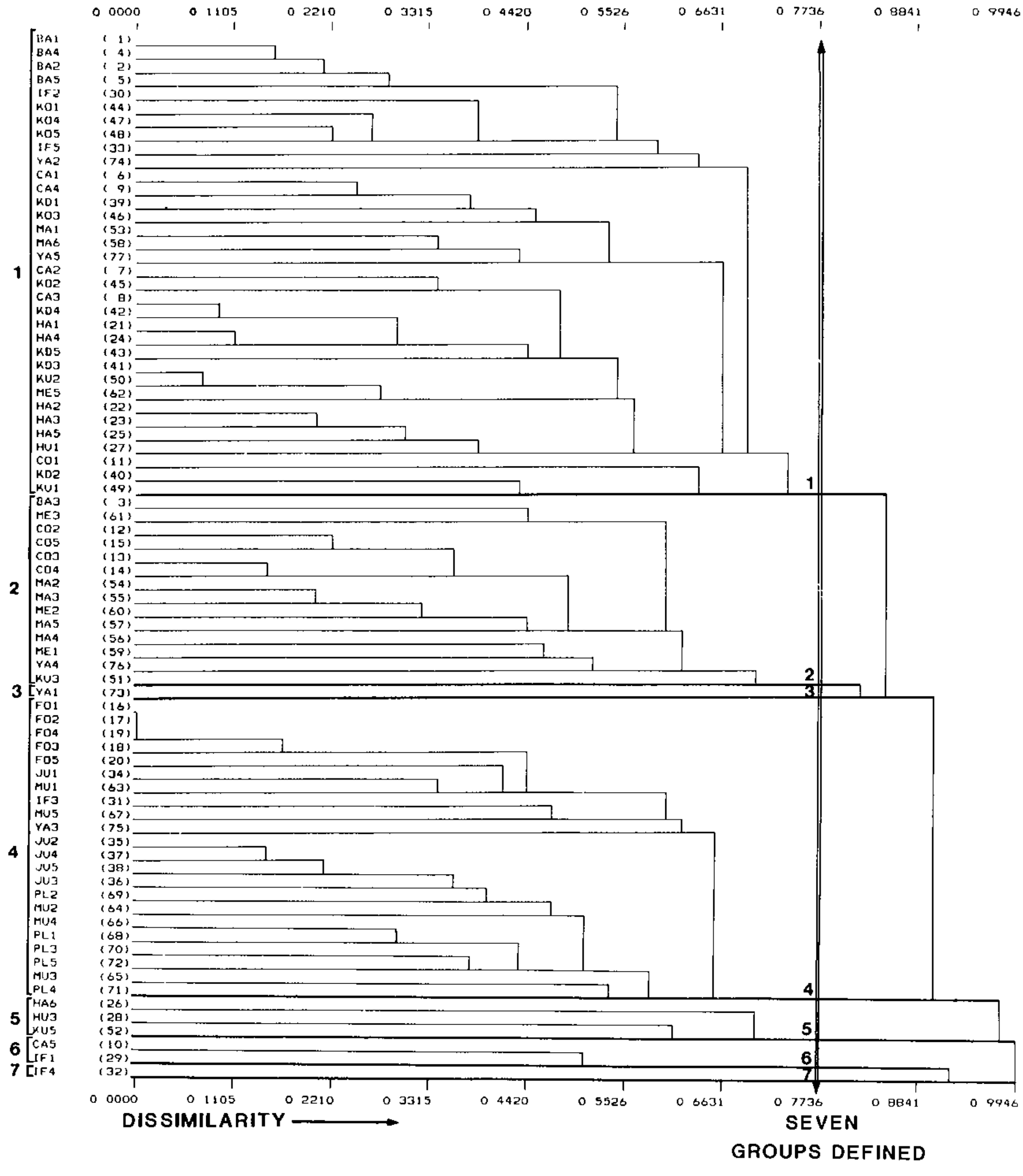
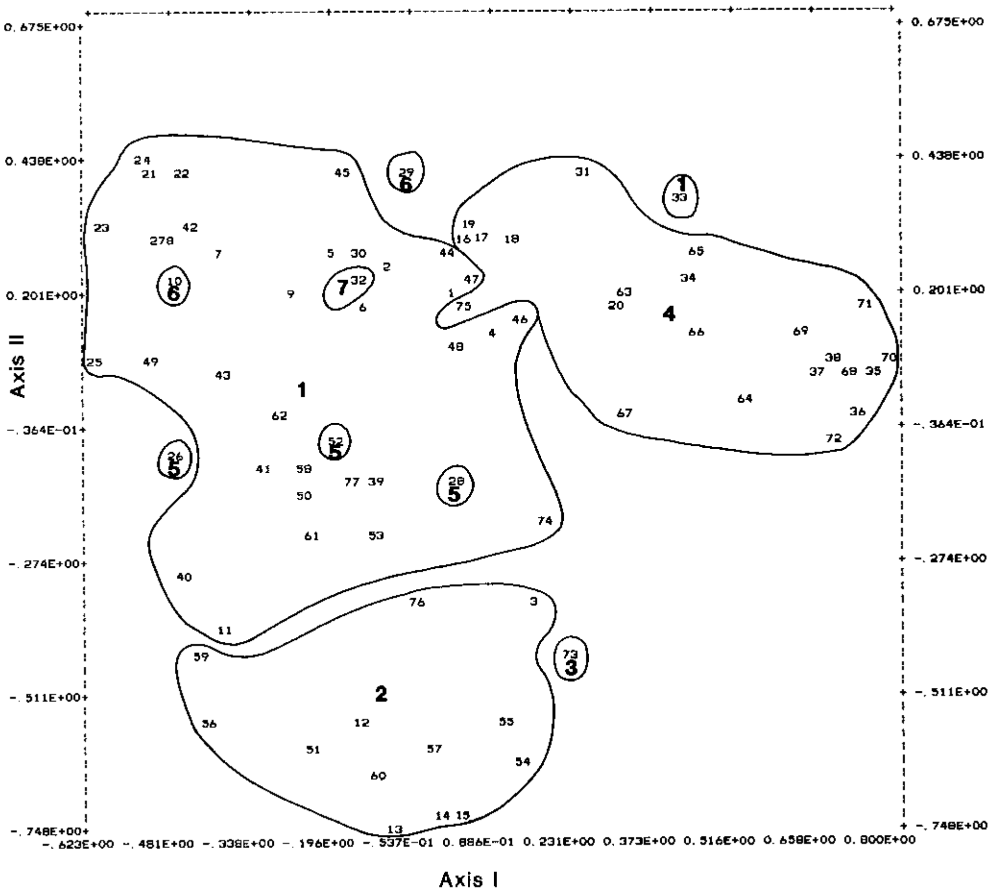
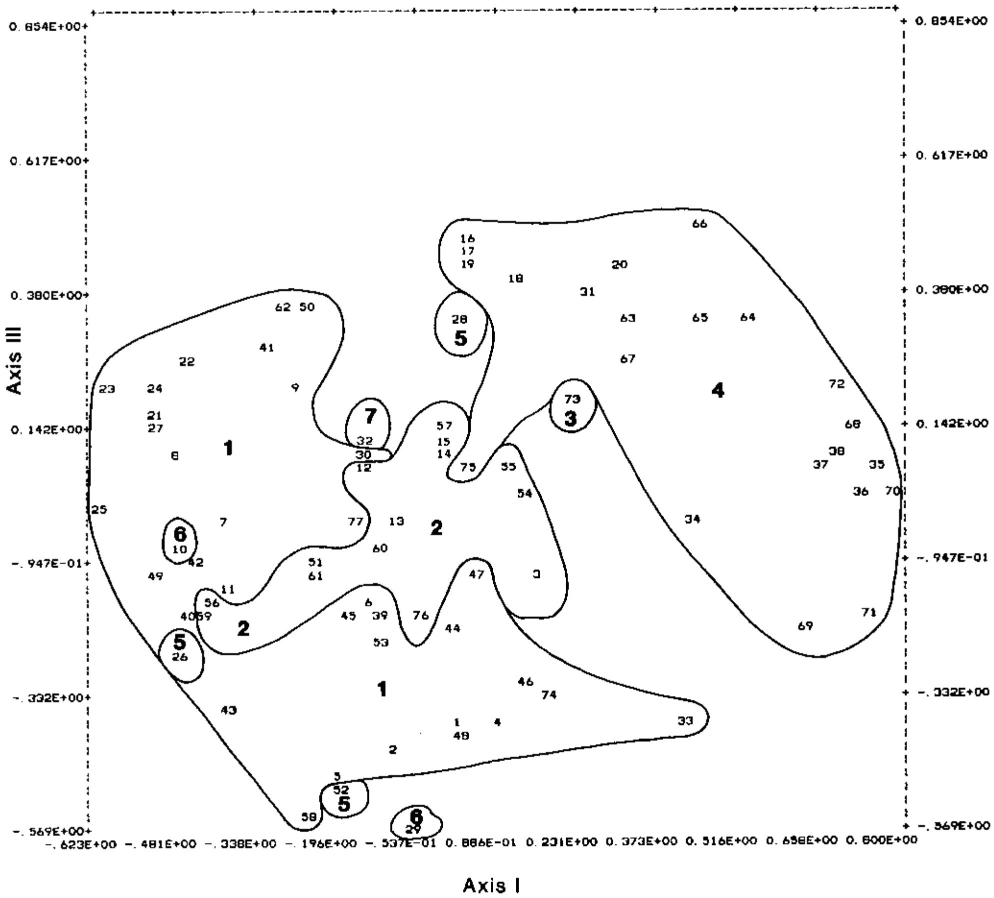


Figure 57

UPGMA QUADRAT CLASSIFICATION - REPTILE SPECIES SIMILARITIES
(Czekanowski similarity measure on presence/absence data)



a. Axis I versus Axis II



b. Axis I versus Axis III

Figure 58

SCATTERGRAM RESULTING FROM THE ORDINATION OF 77 QUADRATS IN TERMS OF REPTILES

UPGMA group boundaries from figure 57 are inserted and identified by group numbers

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 77 POINTS
REGRESSIONS : Y = -0.5499E-05 + 0.1172 X
: X = 0.3826E-05 + 0.2366 Y
CORRELATION COEFICIENT (R) = 0.1666

LABEL	SEQ #	X-VALUE	Y-VALUE
BA1	1	0.1430E-01	-0.3822
BA2	2	-0.9650E-01	-0.4154
BA3	3	0.1662	-0.1299
BA4	4	0.8670E-01	-0.3794
BA5	5	-0.2005	-0.4735
CA1	6	-0.1400	-0.1714
CA2	7	-0.3971	-0.3030E-01
CA3	8	-0.4782	0.8460E-01
CA4	9	-0.2617	0.2125
CA5	10	-0.4603	-0.6410E-01
CO1	11	-0.3876	-0.1413
CO2	12	-0.1451	0.6400E-01
CO3	13	-0.8450E-01	-0.2990E-01
CO4	14	-0.6000E-03	0.8790E-01
CO5	15	0.3900E-02	0.8610E-01
FO1	16	0.4400E-01	0.4707
FO2	17	0.4400E-01	0.4707
FO3	18	0.1384	0.3915
FO4	19	0.4400E-01	0.4707
FO5	20	0.3099	0.4277
HA1	21	-0.5029	0.1678
HA2	22	-0.4580	0.2593
HA3	23	-0.5987	0.2051
HA4	24	-0.5133	0.2148
HA5	25	-0.6229	0.4100E-02
HA6	26	-0.4613	-0.2711
HU1	27	-0.4974	0.1711
HU3	28	0.3380E-01	0.3245
IF1	29	-0.4970E-01	-0.5691
IF2	30	-0.1396	0.1064
IF3	31	0.2623	0.3828
IF4	32	-0.1340	0.6860E-01
IF5	33	0.4318	-0.3732
JU1	34	0.4504	-0.3140E-01
JU2	35	0.7725	0.7250E-01
JU3	36	0.7374	0.2530E-01
JU4	37	0.6751	0.6000E-01
JU5	38	0.6990	0.9860E-01
KD1	39	-0.1057	-0.1943
KD2	40	-0.4551	-0.1781
KD3	41	-0.3048	0.2964
KD4	42	-0.4395	-0.9190E-01
KD5	43	-0.3790	-0.3628
KO1	44	0.1940E-01	-0.2154
KO2	45	-0.1704	-0.1977
KO3	46	0.1430	-0.3002
KO4	47	0.5670E-01	-0.1111
KO5	48	0.3040E-01	-0.3989
KU1	49	-0.5121	-0.1167
KU2	50	-0.2450	0.3538
KU3	51	-0.2235	-0.1062
KU5	52	-0.1859	-0.4986
MA1	53	-0.1055	-0.2373
MA2	54	0.1398	0.1920E-01
MA3	55	0.1173	0.6150E-01
MA4	56	-0.4025	-0.1605
MA5	57	-0.7100E-02	0.9210E-01
MA6	58	-0.2442	-0.5377
ME1	59	-0.4189	-0.1836
ME2	60	-0.1166	-0.6690E-01
ME3	61	-0.2289	-0.1070
ME5	62	-0.2757	0.3634
MU1	63	0.3352	0.3225
MU2	64	0.5503	0.3230
MU3	65	0.4525	0.3303
MU4	66	0.4590	0.4869
MU5	67	0.3353	0.2695
PL1	68	0.7238	0.1404
PL2	69	0.6403	-0.2226
PL3	70	0.8002	0.2470E-01
PL4	71	0.7520	-0.1820
PL5	72	0.6979	0.2096
YA1	73	0.2339	0.1856
YA2	74	0.1902	-0.3283
YA3	75	0.4470E-01	0.6730E-01
YA4	76	-0.3350E-01	-0.1823
YA5	77	-0.1516	-0.3160E-01

a.

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 77 POINTS
REGRESSIONS : Y = -0.7868E-05 + 0.2909E-01 X
: X = 0.2900E-05 + 0.3889E-01 Y
CORRELATION COEFICIENT (R) = 0.3363E-01

LABEL	SEQ #	X-VALUE	Y-VALUE
BA1	1	0.1430E-01	0.1974
BA2	2	-0.9650E-01	0.2563
BA3	3	0.1662	-0.3485
BA4	4	0.8670E-01	0.1344
BA5	5	-0.2005	0.2829
CA1	6	-0.1400	0.1683
CA2	7	-0.3971	0.2697
CA3	8	-0.4782	0.2951
CA4	9	-0.2617	0.1916
CA5	10	-0.4603	0.2153
CO1	11	-0.3876	-0.3876
CO2	12	-0.1451	-0.5620
CO3	13	-0.8450E-01	-0.7479
CO4	14	-0.6000E-03	-0.7305
CO5	15	0.3900E-02	-0.7301
FO1	16	0.4400E-01	0.2855
FO2	17	0.4400E-01	0.2855
FO3	18	0.1384	0.2882
FO4	19	0.4400E-01	0.2855
FO5	20	0.3099	0.1823
HA1	21	-0.5029	0.4200
HA2	22	-0.4580	0.4199
HA3	23	-0.5987	0.3306
HA4	24	-0.5133	0.4202
HA5	25	-0.6229	0.7900E-01
HA6	26	-0.4613	-0.8070E-01
HU1	27	-0.4974	0.3017
HU3	28	0.3380E-01	-0.1360
IF1	29	-0.4970E-01	0.4225
IF2	30	-0.1396	0.2631
IF3	31	0.2623	0.4056
IF4	32	-0.1340	0.2238
IF5	33	0.4318	0.3675
JU1	34	0.4504	0.2309
JU2	35	0.7725	0.5270E-01
JU3	36	0.7374	-0.1300E-02
JU4	37	0.6751	0.5810E-01
JU5	38	0.6990	0.8240E-01
KD1	39	-0.1057	-0.1295
KD2	40	-0.4551	-0.2868
KD3	41	-0.3048	-0.1132
KD4	42	-0.4395	0.3246
KD5	43	-0.3790	0.6070E-01
KO1	44	0.1940E-01	0.2650
KO2	45	-0.1704	0.4204
KO3	46	0.1430	0.1427
KO4	47	0.5670E-01	0.2293
KO5	48	0.3040E-01	0.1172
KU1	49	-0.5121	0.7240E-01
KU2	50	-0.2450	-0.1575
KU3	51	-0.2235	-0.6136
KU5	52	-0.1859	-0.5140E-01
MA1	53	-0.1055	-0.2369
MA2	54	0.1398	-0.6313
MA3	55	0.1173	-0.5635
MA4	56	-0.4025	-0.5678
MA5	57	-0.7100E-02	-0.6126
MA6	58	-0.2442	-0.9950E-01
ME1	59	-0.4189	-0.4390
ME2	60	-0.1166	-0.6603
ME3	61	-0.2289	-0.2144
ME5	62	-0.2757	-0.7200E-02
MU1	63	0.3352	0.2047
MU2	64	0.5503	0.7400E-02
MU3	65	0.4525	0.2801
MU4	66	0.4590	0.1407
MU5	67	0.3353	-0.1610E-01
PL1	68	0.7238	0.5920E-01
PL2	69	0.6403	0.1275
PL3	70	0.8002	0.8130E-01
PL4	71	0.7520	0.1731
PL5	72	0.6979	-0.5900E-01
YA1	73	0.2339	-0.4500
YA2	74	0.1902	-0.1974
YA3	75	0.4470E-01	0.1815
YA4	76	-0.3350E-01	-0.3512
YA5	77	-0.1516	-0.1216

b.

Figure 58

From the arrangement of quadrats in the above groups (and see Fig. 61) it is clear that the strongest gradient of change in the reptile assemblages was along a north-south axis.

Populations of small reptiles are not very mobile so the distance separating quadrats was expected to be an important source of variation in reptile assemblages. Geographically proximate quadrats (2 to 40 kilometres apart - see Fig. 1) that were considered "replicates" in terms of their soils, vegetation and flora (HA2, 3, 4 and 5; MA2 and 3; JU2 and 4; BA1, 4 and 5; PL3 and 4) almost always showed lower dissimilarity values (mean = 0.31 ± 0.17 (SD), n = 12) in their reptile assemblages than did geographically well-separated "replicates" such as those at opposite ends of the Study Area (BA3 and KO3, BA1 and KO1, PL1 and MA6, BA2 and PL1, BA4 and KO4, BA4 and KO1, HA4 and KD4, BA1 and IF5, IF3 and PL1, HA3 and IF2); the mean value was 0.65 ± 0.20 (SD) n = 10 for these pairs of quadrats that were similar, but 350 to 800 kilometres apart.

The dissimilarity values of ecologically dissimilar, but proximate, pairs of quadrats were also relatively high. The mean value was 0.68 ± 0.20 (SD) n = 17 for pairs of dissimilar quadrats less than 30 kilometres apart (BA3 and BA4, IF3 and IF4, PL2 and PL4, PL1 and PL3, IF1 and IF5, BA2 and BA3, MU1 and MU5, IF2 and IF3, KO2 and KO3, KU2 and KU3, JU1 and JU5, CO2 and CO5, CO2 and CO4, YA5 and YA2, KD1 and KD4, ME1 and ME5, MA6 and MA2).

A principal co-ordinate analysis (PCR - see Methods, this publication) was carried out on the reptile data to cluster the quadrats in terms of species. This was done primarily as a cross-check of the groups distinguished from UPGMA. The results are presented in Fig. 58 with the UPGMA group boundaries overlaid.

Discrete clusters are not apparent in the scattergrams (Fig. 58). Nevertheless, the first three axes clearly discriminate the three largest groups distinguished by UPGMA (Groups 1, 2 and 4). In addition, the PCR clustered:

(i) YA1 (the solitary quadrat comprising UPGMA Group 3) with UPGMA Group 2;

(ii) CA5 and IF1 (which together comprised UPGMA Group 6) with UPGMA Group 1;

(iii)HA6, KU5 and HU3 (which together comprised UPGMA Group 5) with UPGMA Group 1).

We speculated on the possibility of these re-arrangements in our discussion of Fig. 57. Once again, YA3 is intermediate between the three main clusters but marginally closer to Group 4.

A gradient of change in the species composition of reptile assemblages, running from quadrats in central parts of the Study Area (HA, HU, KD, ME and KU) to the quadrats on its northern margin (PL, JU, MU), is consistent with the patterning of quadrats along Axis I of the Scattergrams (Fig. 58).

Axis II is consistent with a similar gradient from the central parts of the Study Area to its southern (coastal) margin; from quadrats on the Treeless Plain to the most heavily vegetated quadrats near the coast.

Axis III arrays quadrats along a gradient from central parts of the Study Area (HA, CA, HU; FO, MU) to its eastern and western extremes (IF, YA, KO; BA, PL, JU). The eastern end of the Study Area is not distinguished from its western end in the reptile PCR.

To search for groups of reptiles that consistently co-exist in assemblages, the 47 species (excluding varanids and snakes) recorded from more than one quadrat were classified according to their presence and absence at 77 of the quadrats. Six groups of species were distinguished using UPGMA (Fig. 59). Four groups are ecologically distinct in terms of the geographic ranges of their component species Australia-wide. In Western Australian areas we have followed the species' distribution maps in Storr, Smith and Johnstone (1981, 1983); elsewhere we follow Cogger (1983). A detailed review of the species composition of adjacent districts was also made (summarized in Tables 33 and 34).

Group 1 comprise five species. Four are widely spread throughout arid and semi-arid areas of southern Australia, including the study Area (Menetia greyi, Gehyra variegata, Amphibolurus minor and Ctenotus schomburgkii). The fifth species (Diplodactylus maini) occurs only in Western Australia; its range is centred on the Study Area. All 5 species occur in both the Great Victoria Desert to the north and the South-western Interzone to the west of the Study Area.

Group 2 comprises 12 species. Nine of the 12 species do not penetrate the Great Victoria Desert. Tympanocryptis lineata houstoni and Amphibolurus nullarbor are limited to the Study Area. The others occur across the Study Area and range eastwards and westwards through semi-arid to arid woodlands and scrubs such as those of the South-west Interzone. Most extend to the coast in these arid and semi-arid areas. A tenth species (Amphibolurus pictus) penetrates this desert to the east of the Study Area but only in patches of samphire and saltbush; it does not occur in the red sandridge and sandplain surfaces that characterize the Desert. The two remaining species in UPGMA Group 2 (Ctenotus uber and Diplodactylus stenodactylus) occur in inland parts of the Study Area and are widespread in the Great Victoria Desert. C. uber also occurs in the semi-arid and arid woodlands and scrubs described above. Like A. pictus, both C. uber and D. stenodactylus generally avoid sand surfaces, favouring areas of clay or loam, although D. stenodactylus is also found on loamy sands of interdune swales and can be found on sand.

Group 5 comprises 11 species. All are species or sub-species of sub-humid to semi-arid districts that are restricted to near-coastal environments in arid areas. Some (Amphibolurus maculatus dualis, A. adelaidensis chapmani, Ctenotus brooksi euclae, Leilopisma baudini, Lerista picturata baynesi and L. microtis arenicola) favour sandy surfaces. The last four are confined to the Study Area.

Group 6 comprises 13 species. All are true arid-zone species widespread in the Great Victoria Desert, and/or the arid woodlands and scrubs such as those of the South-west Interzone, but barely penetrating semi-arid areas and not occurring in cool coastal areas of southern Australia.

Groups 3 and 4 each comprise 3 species but are more difficult to interpret. Dr R.A. How has suggested that Group 3 species are typical of semi-arid sandplain environments, and Group 4 of semi-arid woodland-leaf litter environments, in south-western Australia. They comprise species recorded on relatively few quadrats so chance may have influenced their classifications.

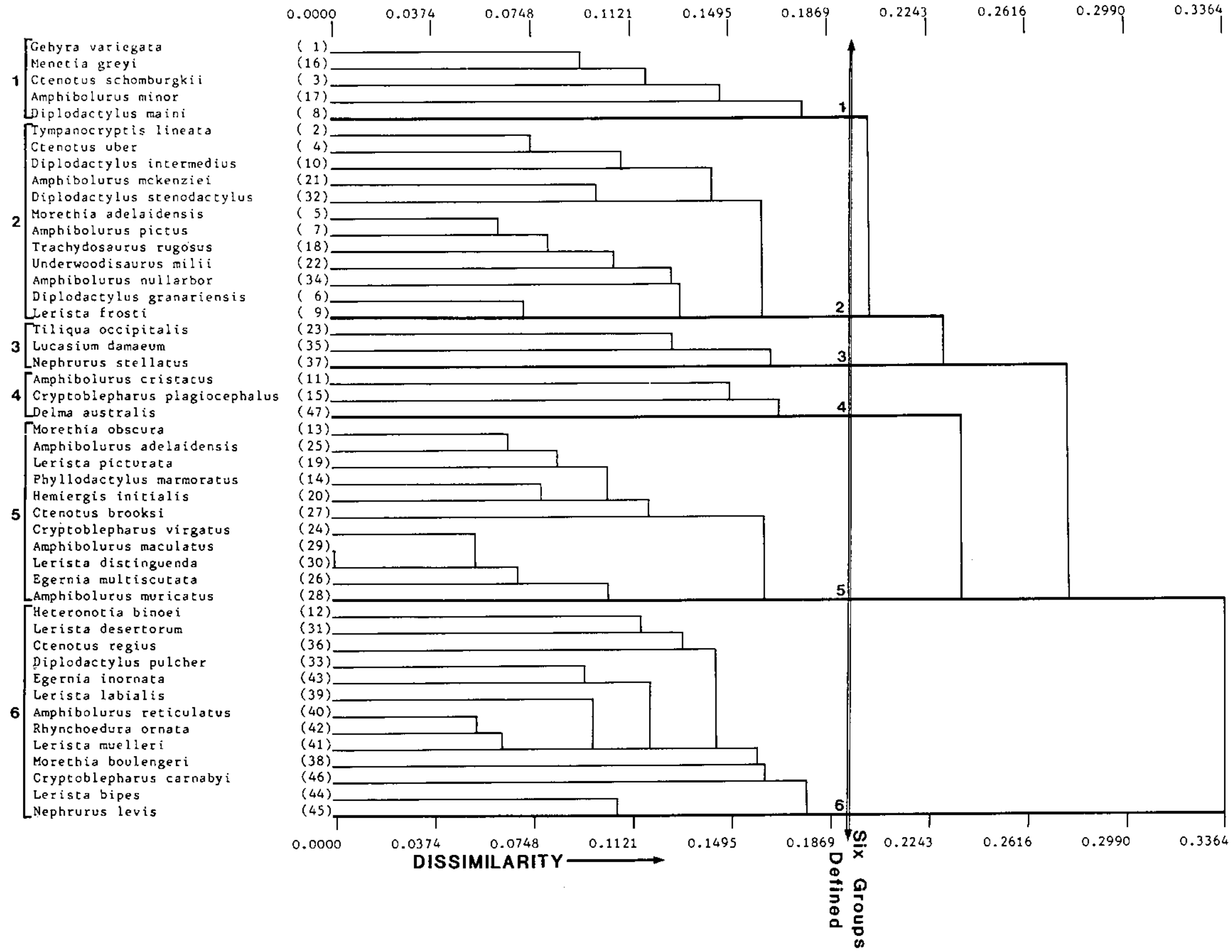
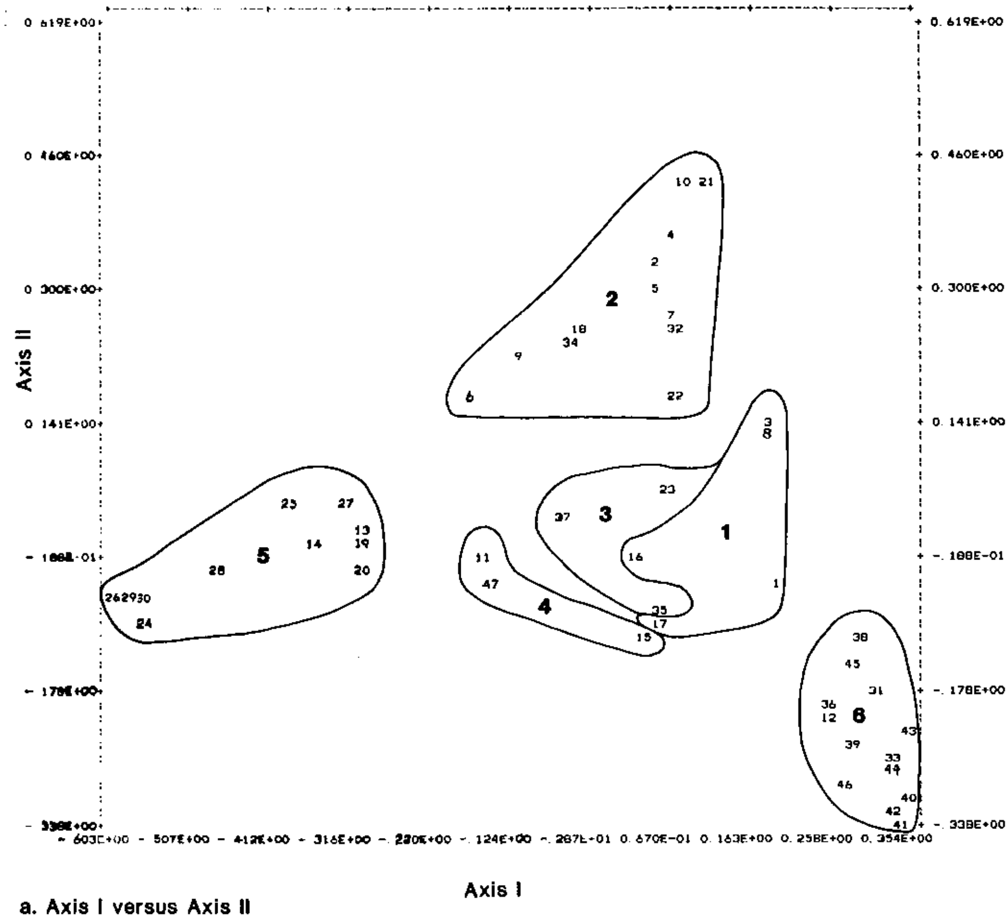
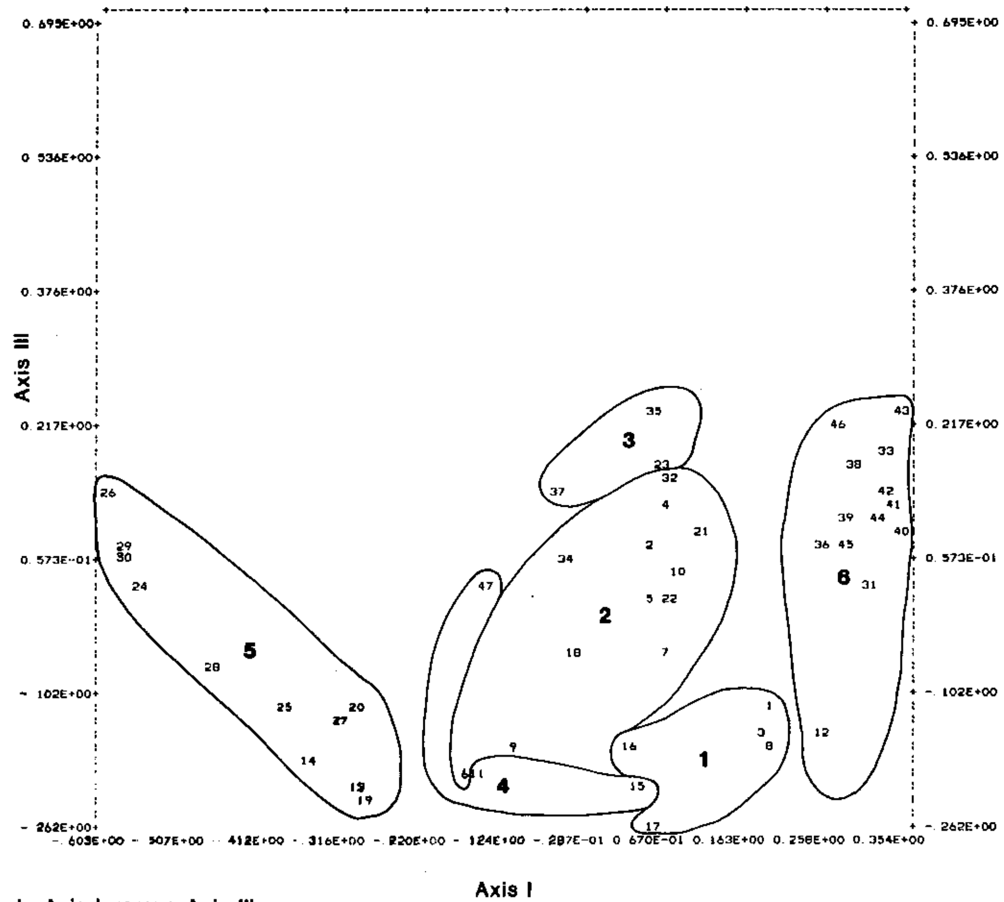


Figure 59
UPGMA SPECIES CLASSIFICATION IN TERMS OF QUADRAT SIMILARITIES
(Two-Step similarity measure on presence/absence data)



a. Axis I versus Axis II



b. Axis I versus Axis III

Figure 60

SCATTERGRAM RESULTING FROM THE ORDINATION OF 47 REPTILE SPECIES IN TERMS OF QUADRAT FIDELITIES.

UPGMA Groups from figure 59 are overlaid. Full species names are provided in Figure 59.

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 47 POINTS
REGRESSIONS : Y = -0.2128E-05 + -0.1808 X
: X = -0.7273E-06 + -0.3426 Y
CORRELATION COEFICIENT (R) = -0.2489

LABEL	SEQ #	X-VALUE	Y-VALUE
Gehyvari	1	0.1936	-0.4500E-01
Tympline	2	0.4930E-01	0.3251
Ctenscho	3	0.1836	0.1340
Ctenuber	4	0.6830E-01	0.3654
Moreadel	5	0.4510E-01	0.2978
Diplgran	6	-0.1723	0.1726
Amphpict	7	0.6330E-01	0.2658
Diplmain	8	0.1944	0.1395
Lerifros	9	-0.1172	0.2264
Diplinte	10	0.9060E-01	0.4251
Amphcris	11	-0.1503	-0.1220E-01
Hetebino	12	0.2550	-0.2141
Moreobsc	13	-0.2943	0.6900E-02
Phylmarm	14	-0.3512	-0.1900E-02
Crypplag	15	0.3740E-01	-0.1198
Menegrey	16	0.3090E-01	-0.2020E-01
Amphmino	17	0.5970E-01	-0.9530E-01
Tracrugo	18	-0.3650E-01	0.2464
Leripict	19	-0.2887	0.2070E-01
Hemiinit	20	-0.2934	-0.3890E-01
Amphmcke	21	0.1137	0.4233
Undemili	22	0.7970E-01	0.1771
Tiliocci	23	0.6900E-01	0.5470E-01
Crypvirg	24	-0.5511	-0.9330E-01

LABEL	SEQ #	X-VALUE	Y-VALUE
Amphadel	25	-0.3788	0.3840E-01
Egermult	26	-0.6030	-0.6450E-01
Ctenbroo	27	-0.3182	0.4410E-01
Amphmuri	28	-0.4730	-0.3580E-01
Amphmacu	29	-0.5764	-0.5990E-01
Leridist	30	-0.5764	-0.5990E-01
Leridese	31	0.3202	-0.1708
Diplsten	32	0.7580E-01	0.2507
Diplpulc	33	0.3337	-0.2559
Amphnull	34	-0.5170E-01	0.2415
Lucadama	35	0.5500E-01	-0.8990E-01
Ctenregi	36	0.2540	-0.1975
Nephstel	37	-0.5620E-01	0.3190E-01
Moreboul	38	0.3014	-0.1154
Lerilabi	39	0.2895	-0.2466
Amphreti	40	0.3504	-0.3100
Lerimuel	41	0.3406	-0.3379
Rhynorna	42	0.3348	-0.3233
Egerinor	43	0.3542	-0.2307
Leribipe	44	0.3230	-0.2560
Nephlevi	45	0.2838	-0.1490
Crypcarn	46	0.2816	-0.2936
Delmaust	47	-0.1429	-0.5010E-01

a.

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 47 POINTS
REGRESSIONS : Y = 0.1478E-09 + 0.1691 X
: X = 0.1415E-08 + 0.6636 Y
CORRELATION COEFICIENT (R) = 0.3350

LABEL	SEQ #	X-VALUE	Y-VALUE
Gehyvari	1	0.1936	-0.1209
Tympline	2	0.4930E-01	0.7180E-01
Ctenscho	3	0.1836	-0.1507
Ctenuber	4	0.6830E-01	0.1256
Moreadel	5	0.4510E-01	0.1650E-01
Diplgran	6	-0.1723	-0.1911
Amphpict	7	0.6330E-01	-0.5690E-01
Diplmain	8	0.1944	-0.1657
Lerifros	9	-0.1172	-0.1690
Diplinte	10	0.9060E-01	0.4430E-01
Amphcris	11	-0.1503	-0.2031
Hetebino	12	0.2550	-0.1469
Moreobsc	13	-0.2943	-0.2077
Phylmarm	14	-0.3512	-0.1884
Crypplag	15	0.3740E-01	-0.2156
Menegrey	16	0.3090E-01	-0.1689
Amphmino	17	0.5970E-01	-0.2618
Tracrugo	18	-0.3650E-01	-0.5320E-01
Leripict	19	-0.2887	-0.2272
Hemiinit	20	-0.2934	-0.1119
Amphmcke	21	0.1137	0.9000E-01
Undemili	22	0.7970E-01	0.8600E-02
Tiliocci	23	0.6900E-01	0.1636
Crypvirg	24	-0.5511	0.3090E-01

LABEL	SEQ #	X-VALUE	Y-VALUE
Amphadel	25	-0.3788	-0.1231
Egermult	26	-0.6030	0.1313
Ctenbroo	27	-0.3182	-0.1286
Amphmuri	28	-0.4730	-0.6670E-01
Amphmacu	29	-0.5764	0.7880E-01
Leridist	30	-0.5764	0.7880E-01
Leridese	31	0.3202	0.2720E-01
Diplsten	32	0.7580E-01	0.1537
Diplpulc	33	0.3337	0.1886
Amphnull	34	-0.5170E-01	0.5090E-01
Lucadama	35	0.5500E-01	0.2257
Ctenregi	36	0.2540	0.7770E-01
Nephstel	37	-0.5620E-01	0.1349
Moreboul	38	0.3014	0.1628
Lerilabi	39	0.2895	0.1012
Amphreti	40	0.3504	0.8890E-01
Lerimuel	41	0.3406	0.1174
Rhynorna	42	0.3348	0.1369
Egerinor	43	0.3542	0.2300
Leribipe	44	0.3230	0.1035
Nephlevi	45	0.2838	0.8000E-01
Crypcarn	46	0.2816	0.2185
Delmaust	47	-0.1429	0.1930E-01

b.

Figure 60

A principal co-ordinate analysis was carried out on the presence and absence quadrat data to classify reptiles in terms of quadrats. The results are presented in Fig. 60, with UPGMA Group boundaries superimposed. The four main UPGMA groups (1, 2, 5 and 6) were clearly defined as clusters by Axis I and Axis II; Axis I representing a north-south change in the composition of reptile assemblages - from those comprising "sub-humid to semi-arid" species (negative loadings) to assemblages of species that are more widespread in the arid zone (positive loadings). Axis II separates the arid zone species into two sorts, those that can occur in sandy environments of the Great Victorian Desert from those that do not. Axis III clusters Amphibolurus cristatus and Cryptoblepherus plagiocephalus of UPGMA Group 4 with species of UPGMA Group 1 (negative loadings), but distinguishes UPGMA Group 3 (Tiliqua occipitalis, Nephrurus stellatus and Lucasium damaeum) as a separate cluster (positive loadings).

The final stage of the quantitative analysis was the production of a "Two-Way table" (Table 36) using the UPGMA Group boundaries for quadrats (columns) and species (rows). However, some re-ordering was carried out following the detailed examination of the UPGMA Groups, and their comparison with clusters from the PCR's, discussed earlier in this paper.

The species classified into UPGMA Species-Group 1 occur in a variety of arid and semi-arid situations in southern Australia; they occur throughout the Study Area except the blue-bush/saltbush/grassland environments of the Treeless Plain.

Species-Group 2 comprises semi-arid to arid zone species that occur in an east-west band across the Study Area. They generally do not penetrate the Great Victoria Desert and barely penetrate either the northern fringe or the wetter (semi-arid) coastal environments of the Study Area. Most of the species in this group extend onto the Treeless Plain (to a variable extent); noting that Amphibolurus nullarbor and Tympanocryptis lineata houstoni are endemic, the Treeless Plain fauna is a species-poor selection of UPGMA Group 2 species.

An appraisal of the geographical distributions of the species comprising Groups 3 and 4, in conjunction with the (relatively few) available records from the Study Area, suggests they belong to UPGMA Species Groups 2 and 1 respectively.

The species of UPGMA Species-Group 5, the mesic fauna, are more or less confined to the southern margin of the Study Area. In contrast, species of the desert fauna (Group 6) dominate the assemblages of quadrats to the north and east of the Treeless Plain that are adjacent to the Great Victoria Desert.

Discussion

(a) Patterning of Reptiles in the Study Area
The absence of discrete clusters in the scattergrams of quadrats (Fig. 58) points to gradational changes in the reptile assemblages across the Study Area. This conclusion is consistent with the district's low topograhic relief, uniform geology and hence soils (limestone derived earths with a variable component of coastal sand in southern areas and of red desert sand in northern areas), and consistently arid, unpredictable climate. Nevertheless, four groups are consistently distinguished by both the UPGMA and PCR analyses (Figs. 57 and 58) so reptiles do perceive habitat patterns within the Study Area. These are mapped in Fig. 61.

Ecologically distinct groups of reptiles can also be distinguished in the fauna of the Study Area (Figs. 59 and 60); the species within each group are similar in terms of the surface-types and/or climatic regimes that characterize their geographic distribution.

When considered together with the quadrat groupings (Table 36), these species clusters point to the source of patterning in the reptile fauna of the Study Area - influence from the faunas of adjacent natural districts. On this basis we distinguish four main reptile community-types in the Study Area.

A. The Northern Community
There are no locally endemic species included in the Northern Community. The assemblages on the far northern fringe of the Study Area (PL1-5, JU1-5 and MU3-4) tend to have greater lizard species richness (mean = 8.2 ± 1.4(SD)n = 12) than those closer to the Treeless Plain (FO1-5, IF3, YA3, MU1 and 2 : 5.3 ± 1.4(SD)n = 9).

Table 36 clearly shows that assemblages of the northern quadrats are strongly influenced by the fauna of the Great Victoria Desert although other "arid to semi-arid" species are also important, especially at quadrats more remote from the Desert (FO). MU5, though the only reptile quadrat on a dune typical of the Great Victoria Desert, seems to have relatively few desert species. This was an artefact of the analysis; a variety of other arid-zone species belonging to sandy surfaces were recorded on MU5 (Amphibolurus isolepis, A. fordi, Eremiascincus richardsonii, Moloch horridus and Nephrurus laevissimus) but because these species were not recorded on any other quadrat in the Study Area, they had to be eliminated from the quantitative analyses. Pygopus nigriceps (from MU3) is another species, widespread in the arid and semi-arid zone in southern Australia, that was recorded from only one quadrat.

For comparison, other sites just inside the Great Victoria Desert (outside the Study Area) were sampled opportunistically. These were on red sandplains in Eucalyptus gongylocarpa/Mallee/Porcupine grass formations typical of this desert. The reptiles recorded from such a site, 7.2km west-north-west of PL4, were Amphibolurus isolepis, A. cristatus, Gehyra purpurascens, Cryptoblepharus sp., Ctenotus atlas, C. quattuordecimlineatus, C. schomburgki, Egernia inornata, Lerista bipes, L. desertorum and Morethia butleri. In addition Amphibolurus minor and Lerista sp. affin. distinguenda were recorded in similar habitat 15.4km north of JU5. The above species are a mixture of desert species and (a few) of the more widely spread arid-zone species belonging to the circum-Treeless Plain Groups (UPGMA Species Groups 1 and 4: A. cristatus, A. minor and C. schomburgki). The sudden appearance of all these desert species, as well as those from MU5 discussed above, evidences an abrupt faunal interchange between the Northern Community of the Nullarbor and the reptile fauna of the Great Victoria Desert.

B. The Coastal Community
The more heavily vegetated coastal quadrats have a strong component of exclusively mesic reptile species with affinities to the faunas of districts to the south-west and south-east, via coastal corridors. The reptile assemblages on consolidated coastal and sub-coastal dunes of the Roe Plains (CO3-5, MA2-5), are especially rich in this mesic component. Once more, the "arid to semi-arid" reptile component is also present.

Additional mesic species were recorded on these near-coastal quadrats but were excluded from the quantitative analysis because they were recorded from only one quadrat: Leiolopisma baudini (MA5), Lerista microtis arenicola (KO1), Aprasia inaurita (MA4), Egernia carinata (MA3) and Pygopus lepidopodus (YA5). One species and three sub-species are endemic to this coastal community, but lizard assemblages are no richer than those of other well-vegetated quadrats elsewhere in the Study Area (see Table 36).

C. The Peripheral Woodlands Community
Table 36 also distinguishes a strong component of non-desert species (UPGMA Species Group 2) typical of woodland, scrub and saltbush vegetations found in arid and semi-arid districts to the west and south-east of the Study Area. The lizards in this group have permeated the entire Study Area, but contribute most to the species richness of lizard assemblages occupying the Eucalyptus and Myall woodlands that surround the western, south-eastern and southern margins of the Treeless Plain (UPGMA Quadrat Group 1 in Table 36). In these areas, peripheral to the Treeless Plain, a smaller group of more wide-ranging arid and semi-arid zone species (UPGMA Species Group 1) is also included in assemblages, along with two of the Nullarbor endemics (discussed below). The average lizard species richness of these assemblages is 6.9 ± 2.5 (SD), n = 21.

D. The Treeless Plain Community
UPGMA Species-Group 2 includes the only species to colonize habitats of the Treeless Plain; reptile assemblages there comprise a species-poor sub-set of this group and, as well, two endemics (Amphibolurus nullarbor and Tympanocryptis lineata houstoni). The average species richness of lizard assemblages on the Treeless Plain is 3.4 ± 1.7 (SD), n = 23).

The Peripheral Woodlands and Treeless Plain Communities grade into one another so it is not surprising that they are merged in Table 36. The soils and vegetations of the two are also very similar; the vegetation of the Treeless Plain is dominated by species common in the understorey of the Peripheral Woodlands. The interface between the two, in which many Peripheral Woodland quadrats were placed, is a mosaic of habitat patches; KD3, KD5, KU2, ME5 and KD2 were Treeless patches in otheriwse wooded quadrats while IF2, CA1 and CA4 were sited in mosaics of Treeless Plain large enough to accommodate entire quadrats. On the basis of vegetation and geography we treated HA1-6, HU1-5, IF1 and 2, CA1-5, KD1 and 4, CO1 and KU1 as Treeless Plain quadrats.

This attenuation of the reptile species richness in the central parts of the Study Area is an important biological gradient. At the outset of this paper we predicted that Calcium levels were likely to lead to such an effect. However, a regression of the reptile species richness of assemblages against soil-Calcium concentrations gave a non-significant result (d.f. = 74, Correlation Coefficient (r) = -0.1188), even when the log of Calcium values was tried (r = -0.2172). However, a highly significant positive correlation between reptile and plant assemblage-species-richness was found (r = 0.36, n = 82, p.¡0.01), especially perennial plant species richness (r = 0.48, n = 82, p.¡0.001). This last observation suggests that the extra microhabitats provided by complex vegetation-structure are important in determining species richness. Nutrient availability may influence biomass of lizards, but its effect on lizard richness, if any, is indirect (via vegetation) and unlikely to be as significant. Our data-base includes data on relative species abundance that could be used to gain a relative estimate of biomass and test this hypothesis.

(b) The Richness of the Nullarbor Fauna
The relative richness of the South-west Interzone (Table 39) can be explained by the diversity of its patchy environment, reflecting its intermediate climate, its geographical location between, and its geomorphic continuity with the arid Great Victoria Desert, the semi-arid Roe and Avon Botanical Districts that comprise the Western Australian wheatbelt, and the arid Nullarbor Plain (see Beard 1980).

Overall, the Study Area is not poor in reptile species (Table 39). While some of the Nullarbor's species richness, like that of the Great Victoria Desert, comes from the diversity of arid-adapted Genera (see Table 37) - Diplodactylus (5 spp. Fig. 54), Amphibolurus (11 spp) and Lerista (8 spp) - most comes from the blending of three biogeographic sources (mesic, desert, and "arid to semi-arid non-desert") discussed earlier, and is a direct result of the diversity of woodlands environments present in the Study Area. Kitchener et al. (1980) identified woodlands of the Western Australian wheatbelt as being particularly rich in lizards (and snakes, Chapman and Dell 1985).

This beta-diversity (Pianka 1981) probably accounts for the great richness of Amphibolurus in the Nullarbor. Many agamids are quite specific in their vegetation and soil preference and few occur in ecological sympatry (Chapman and Dell 1985). From Table 36 it can be seen that the maximum number of co-existing agamids in Nullarbor assemblages was three (at CO3, MA2, MA6, KO2, BA4 and BA5); all were in tree-mallee or woodland environments. The richness of Ctenotus in the Study Area was also the result of beta-diversity from biogeographic influences rather than ecologic sympatry. Unlike the Great Victoria Desert, where Pianka (1969b) recorded as many as 7 Ctenotus species in ecologic sympatry, the assemblages on the Nullarbor never included more than two such species.

Individual assemblages in the Nullarbor are generally much poorer (see Table 36) than those reported by Pianka (1969a) for the Great Victoria Desert. In a square kilometre of sandridge habitat he found 39 species of lizard co-existing in sympatry; at several sandplain sites he reported up to 30 different species. Even in a pure spinifex flat, and on a lake bed with chenopod shrubland, he recorded 15 to 20 sympatric species.

South-western Interzone assemblages were also richer in lizard species than those of the Nullarbor. McKenzie (1984) reported lizard assemblages near Kalgoorlie in the South-west Interzone with an average species richness of 12 + 3.9(SD),n = 7 in woodlands and 7.5 + 2.5(4) in shrub communities. Dell and How (in Newbey et al. 1984), near Widgiemooltha in the South-west Interzone, adjacent to the western end of the Nullarbor Study Area, report woodland lizard assemblages averaging 14.8 ± 1.7(6) and shrub communities averaging 15.0 ± 3.4(5) species.

The above observations again support a biogeographic beta-diversity explanation for the richness of the Nullarbor reptile fauna.

(c) Biogeographic Boundaries and Endemism
From the low species richness of its assemblages, and the strong north-south pattern in the Study Area's biogeographic components (Fig. 61), the Treeless Plain is clearly a major barrier to the dispersal of many lizard species, especially those of arid, sandy substrates and those species with mesic affinities.

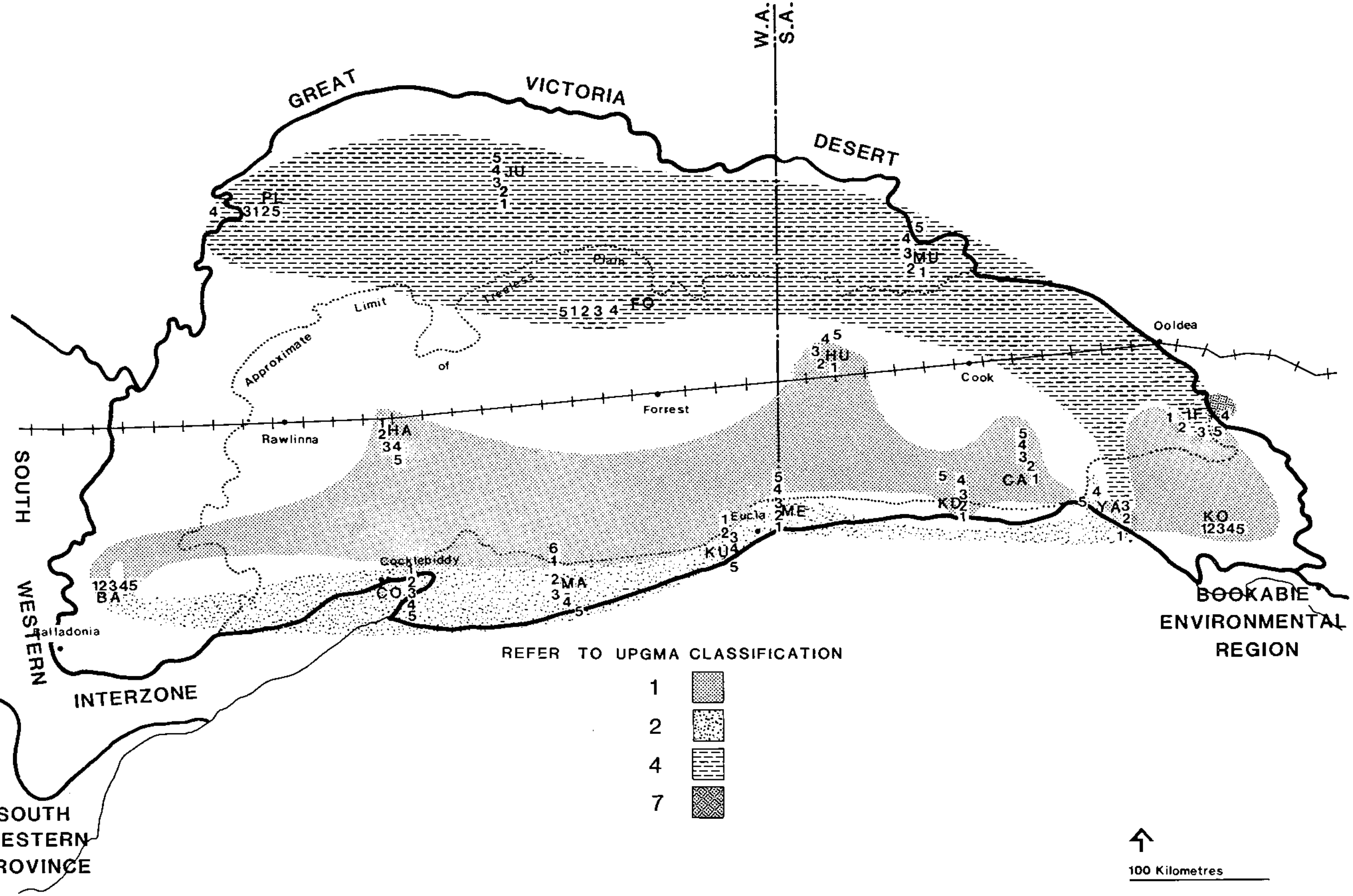


Figure 61
GEOGRAPHICAL INTERPRETATION OF REPTILE SPECIES QUADRAT GROUPS (UPGMA) ACROSS THE NULLARBOR STUDY AREA

From Tables 33 and 34, species similarity values were calculated to compare the lizard faunas of each of the four community-types recognised in the Study Area with the faunas of the adjacent districts (Fig. 61). The results of the calculations are presented in Tables 38 and 39.

While there is an abrupt faunal interchange in lizard species at the northern margin of the Study Area, the attenuation of the desert component intrudes quite a long way into the Study Area. Tables 38 and 39 show that, overall, the Northern Community is just as closely related to the Great Victoria Desert (34.9%) and South-western Interzone (32.9%) lizard faunas as it is to the lizard fauna of the rest of the Study Area (29.0%).

The Peripheral Woodlands community is more distinct from the Desert, sharing 27 of its 30 species (J = 54%) with the remainder of the Study Area (Table 39), 29.2% (26 of 30) similarities with the Interzone but only 16.9% with the Desert (Table 38). Being a sub-set of the Peripheral Woodlands species, the Treeless Plain community has similar relationships. It shares all 16 of its species (J = 23.5%) with the rest of the Study Area, has 17.9% similarities (15 of 16 species) with the Interzone, but only 7.1% with the Desert. Unlike the north-south gradient (that involves a turnover in species composition), this biogeographic pattern is a gradual attenuation of species along a gradient extending from the Interzone (and probably from equivalent districts to the south-east in South Australia where distribution data on reptiles is still incomplete) into the centre of the Study Area. It corresponds to a decrease in ecological sympatry, expressed as assemblage richness, along the gradient. The overall species richness of the Interzone is promoted even further by the district's greater beta-diversity from habitat patchiness; as well as chenopod shrublands and Nullarbor-like woodlands, the Interzone includes lateritic gravel and sandplains, greenstone and granite-derived surfaces, saltlake systems etc. Neither the Nullarbor nor the Great Victoria Desert show this strong geochemical source of patchiness. One of the five Peripheral Woodland species not in the Interzone is Amphibolurus nullarbor, a Treeless Plain endemic that penetrates the Peripheral Woodlands; two others are endemic to the Coastal Community and only penetrate the southern margin of the Peripheral Woodlands (Lerista microtis arenicola and Ctenotus brooksi euclae Fig. 55). The distribution of Tympanocryptis lineata houstoni is centered on the Treeless Plain but penetrates the Peripheral Woodlands and the south-eastern part of the Interzone.

In species composition, the Coastal Community is as similar to the South-western Interzone (30.2%) as it is to the rest of the Study Area (28.6%). Most of the endemism in the Study Area is found in the Coastal Community; the Roe Plains, and the narrow sandy strip running eastwards along the top of the Bunda cliffs to YA, include four endemics (Ctenotus brooksi euclae, Leiolopisma baudini, Lerista microtis arenicola and L. picturata baynesi). All are associated with sandy surfaces of coastal origin. It is likely that the habitats of the Treeless Plain, being an almost complete barrier to the dispersal of reptiles favouring sandy surfaces, provided opportunities for speciation among the lizards that colonized, from the east and west, this 600 kilometres corridor of coastal sand. At present the corridor is interrupted west of the Roe Plain and near CA; it would have been continuous, and much wider, during pre-Holocene eras of low sea level.

TABLE 31: REPTILES AND AMPHIBIANS KNOWN[1] FROM THE NULLARBOR OF WESTERN AUSTRALIA (W.A.) AND SOUTH AUSTRALIA (S.A.)

Species	Pre-1984		1984	
	W.A.	S.A.	W.A.	S.A.
Neobatrachus centralis	X		X	
Caretta caretta*	B			
Diplodactylus granariensis	X		X	X
Diplodactylus intermedius	B	X	X	X
Diplodactylus maini	X		X	
Diplodactylus pulcher	X		X	X
Diplodactylus stenodactylus		X	X	X
Gehyra variegata	X	X	X	X
Heteronotia binoei	X	K	X	X
Lucasium damaeum	A		X	X
Nephrurus laevissimus	C			X
Nephrurus levis	C		X	X
Nephrurus stellatus				X
Phyllodactylus marmoratus	X	X	X	X
Rhynchoedura ornata			X	X
Underwoodisaurus milii	X	X	X	X
Aprasia inaurita	X		X	
Delma australis	B		X	X
Lialis burtonis*		X		
Pygopus lepidopodus	B	X		X
Pygopus nigriceps				X
Amphibolurus adelaidensis chapmani	B	X	X	X
Amphibolurus cristatus	X	X	X	X
Amphibolurus fordi		X		X
Amphibolurus isolepis gularis	X			X
Amphibolurus maculatus dualis	B	X	X	X
Amphibolurus mckenziei			X	X
Amphibolurus minor	D	X	X	X
Amphibolurus muricatus	B		X	X

Amphibolurus nullarbor	X	X	X	X
Amphibolurus pictus pictus	X	X	X	X
Amphibolurus reticulatus	X		X	X
Diporiphora linga*		X		
Moloch horridus	X	J	X	X
Tympanocryptis lineata houstoni	X	X	X	X
Varanus eremius*	E			
Varanus gilleni				X
Varanus gouldii	X		X	X
Varanus rosenbergi*	B			
Cryptoblepharus carnabyi			X	
Cryptoblepharus plagiocephalus	B		X	X
Cryptoblepharus virgatus clarus	X		X	X
Ctenotus atlas*	X			
Ctenotus brooksi euclae	B	X	X	X
Ctenotus regius			X	X
Ctenotus schomburgkii	X		X	X
Ctenotus uber	X	X	X	X
Egernia carinata		X	X	
Egernia inornata			X	X
Egernia ? formosa*				X
Egernia multiscutata bos	X		X	
Eremiascincus richardsonii	X			X
Hemiergis initialis brookeri	B	X	X	X
Leiolopisma baudini			X	
Lerista bipes	F		X	X
Lerista desertorum			X	
Lerista distinguenda	B		X	
Lerista frosti	X	X	X	X
Lerista labialis	X		X	X
Lerista microtis arenicola	B	X	X	X
Lerista muelleri	X		X	
Lerista picturata baynesi	B	X	X	X
Menetia greyii	X	X	X	X
Morethia adelaidensis	X	X	X	X
Morethia boulengeri	X		X	
Morethia butleri	X		X	X

Morethia obscura	X	X	X	X
*Tiliqua branchialis**	B			X
Tiliqua occipitalis	X		X	X
Trachydosaurus rugosus	X	X	X	X
*Ramphotyphlops australis**	B			
*Ramphotyphlops bituberculatus**	X	X		X
*Aspidites ramsayi**	X			
*Acanthophis antarcticus**	B			
*Demansia psammophis**	H			
Drysdalia mastersi	B		X	X
Pseudechis australis	X	X	X	X
Pseudonaja affinis	B		X	
Pseudonaja modesta	X		X	
Pseudonaja nuchalis	X	X		X
Pseudonaja textilis		X		X
Simoselaps bertholdi	X		X	X
Simoselaps semifasciatus			X	
*Unechis monachus**	I		X	
*Unechis nigriceps**	B			
Unechis spectabilis	B	X	X	X

[1] Pre-1984 records from W.A. are from Brooker and Wombey (1978) or A: Burbidge *et al*. (1976), B: Storr *et al*. (1981), C: Storr (1963), D: Storr (1982), E: Storr (1980), F: Storr (1972), G: Smith (1981), H: Storr (1978), I: Storr (1981) and K: the collection of the Western Australian Museum if not already listed in the literature. Pre-1984 records from S.A. were drawn from the collection of the South Australian Museum or J: Houston (1978).

Three specimens of *Egernia* ? *formosa* (R26314-6, S.A. Museum) were recorded in September 1984 from South Australian end of the Study Area. These possibly represent a new species. The W.A. Museum has a single specimen of *Egernia formosa* (R29172) from Loongana Siding in Western Australia (Storr 1978); the possibility remains that the specimen may have been transported by a railway train.

* Not recorded on quadrats.

TABLE 32: SPECIES ONLY RECORDED OPPORTUNISTICALLY DURING THE 1984 SURVEY

Ramphotyphlops bituberculatus	31°27' 130°54', Nullarbor Hotel Collection
Unechis monachus	FO camp (Fig. 56)

TABLE 33: LIST OF REPTILES AND AMPHIBIANS OF THE SOUTH-WESTERN INTERZONE, CITING SOURCE OF INFORMATION

Limnodynastes dorsalis (Coragina Rock)	D*
Neobatrachus centralis	A
Neobatrachus pelobatoides	Z
Neobatrachus sutor	A
Neobatrachus wilsmorei	C
Pseudophryne occidentalis	A
Ranidella pseudinsignifera (Nanambinia)	Y
Litoria cyclorhynchus (Coragina Rock)	D
Crenadactylus ocellatus	B
Diplodactylus conspicillatus (Kalgoorlie AM R7240-1)	F
Diplodactylus elderi	A
Diplodactylus granariensis	A
Diplodactylus intermedius	A
Diplodactylus maini	A
Diplodactylus pulcher	A
Diplodactylus spinigerus	D
Gehyra purpurascens	E
Gehyra variegata	A
Heteronotia binoei	A
Lucasium damaeum (19m W of Randalls Station R12231)	F
Nephrurus laevissimus (19m W of Randalls)	G
Nephrurus stellatus	B
Nephrurus vertebralis	C
Oedura reticulata	A
Phyllodactylus marmoratus (Deralinya Ruins)	W
Rynchoedura ornata	C
Underwoodisaurus milii	A

Delma australis	A
Delma fraseri	A
Delma nasuta	A
Lialis burtonis	A
Pygopus lepidopodus	A
Pygopus nigriceps (Karonie W.A.M. R2783)	H
Amphibolurus adelaidensis chapmani (Fraser Range R44526)	I
Amphibolurus cristatus	A
Amphibolurus fordi	C
Amphibolurus isolepis gularis	A
Amphibolurus maculatus griseus and A. M. dualis	B
Amphibolurus mckenziei (R59754 8km SW of Ponier Rock)	J
Amphibolurus minor	A
Amphibolurus muricatus (21km S of Caiguna)	D
Amphibolurus nuchalis ("inermis")	A
Amphibolurus ornatus	E
Amphibolurus pictus salinarum	A
Amphibolurus reticulatus	A
Amphibolurus scutulatus	A
Diporiphora reginae	A
Moloch horridus	A
Tympanocryptis cephalus (Kalgoorlie R4329)	K
Tympanocryptis lineata houstoni (16km NE Fraser Range R14184)	L
Varanus caudolineatus	C
Varanus gouldii	A
Varanus rosenbergi	M
Varanus tristis (R10417 Kalgoorlie)	N
Chryptoblepharus carnabyi	D
Chryptoblepharus plagiocephalis	A
Chryptoblepharus virgatus clarus	D
Ctenotus atlas	A
Ctenotus gemmula (7km NE of Toolina RH)	D
Ctenotus impar	O
Ctenotus leonhardii	A
Ctenotus pantherinus	A
Ctenotus schomburgkii	A

Ctenotus severus	O
Ctenotus uber	B
Ctenotus xenopleura	B
Egernia carinata	A
Egernia depressa	A
Egernia formosa	A
Egernia inornata	A
Egernia multiscutata bos	A
Egernia napoleonis (confined to Baxter Cliffs)	D
Eremiascincus richardsonii	A
Hemiergis initialis brookeri and H. i. initialis	A
Hemiergis millewae	A
Hemiergis peronii (33km N of Mount Ragged)	D
Lerista desertorum (Randalls)	O
Lerista distinguenda	Z
Lerista frosti	D
Lerista gerrardii	B
Lerista macropisthopus	E
Lerista muelleri	A
Lerista picturata picturata	A
Lerista terdigitata	A
Menetia greyii	A
Morethia adelaidensis	C
Morethia butleri	A
Morethia obscura	A
Tiliqua branchialis ("Omolepida")	A
Tiliqua occipitalis	B
Trachydosaurus rugosus	A
Ramphotyphlops australis	B
Ramphotyphlops bituberculatus	A
Ramphotyphlops hamatus (R7025 - Boulder)	Q
Ramphotyphlops waitii	Z
Aspidites ramsayi (Zanthus - R31152)	S
Liasis stimsoni stimsoni	Z
Morelia spilota (Yellowdine - R6550)	S

Acanthopis antarcticus (Toolinna R.H. & other)	D
Acanthopis pyrrhus (R70699 Kalgoorlie)	S
Demansia psammophis ("reticulata")	A
Denisonia fasciata	B
Echiopsis curta	T
Furina ornata (Cundeelee - R58714)	U
Neelaps bimaculatus (R4722 8m SW of Kalgoorlie)	V
Pseudechis australis	A
Pseudonaja affinis	B
Pseudonaja modesta	A
Pseudonaja nuchalis	X
Simoselaps bertholdi	A
Simoselaps fasciolatus (R26643 - Widgiemooltha)	V
Simoselaps semifasciatus	A
Unechis gouldii	A
Unechis monachus	A
Unechis nigriceps (Mullendunya Tank & Cocklebiddy)	D

*A: Newbey et al. (1984); B: author's unpublished data, Southern Cross-Boorabbin; C: author's unpublished data, Kurnalpi-Kalgoorlie; D: Storr et al. (1981); E: A.A. Burbidge (pers. comm.), Barlee-Menzies; F: Kluge (1967); G: Storr (1963); H: Kluge (1974); I: Storr (1977b); J: Storr (1981b); K: Storr (1964); L: Storr (1982b); M: Storr et al. (1983); N: Storr (1980b); O: Storr et al. (1981b); P: Storr (1978a); Q: Storr (1981b); R: Smith, L.A. (1981); S: Storr (1981c); T: Storr (1982a); U: Storr (1981d); V: Storr (1967); W: author's unpublished data, Balladonia-Norseman; X: Bush (1981); Y: Tyler et al. (1984); Z: collection of the Western Australian Museum.

TABLE 34: REPTILES AND AMPHIBIANS KNOWN[1] FROM THE GREAT VICTORIA DESERT OF WESTERN AUSTRALIA AND SOUTH AUSTRALIA, INCLUDING THE WESTERN SANDPLAINS ENVIRONMENTAL REGION OF SOUTH AUSTRALIA

Cyclorana maini (E)	*Varanus gilleni* (G, C)
Pseudophryne occidentalis (E)	*Varanus gouldii*
Neobatrachus centralis (D, E)	*Varanus tristis*
Neobatrachus sutor (E)	*Cryptoblepharus plagiocephalus*
Diplodactylus ciliaris	*Ctenotus ariadne*
Diplodactylus conspicillatus	*Ctenotus atlas* (J)
Diplodactylus elderi	*Ctenotus brooksi brooksi*
Diplodactylus maini (F)	*Ctenotus calurus*
Diplodactylus stenodactylus	*Ctenotus colletti*
Diplodactylus strophurus	*Ctenotus dux*
Gehyra purpurascens (L)	*Ctenotus grandis*
Gehyra variegata	*Ctenotus greeri* (I)
Heteronotia binoei	*Ctenotus hanloni* (B)
Lucasium damaeum	*Ctenotus helenae*
Nephrurus laevissimus	*Ctenotus leae*
Nephrurus levis	*Ctenotus leonhardii*
Nephrurus stellatus (G)	*Ctenotus pantherinus*
Nephrurus vertebralis	*Ctenotus piankai*
Rhynchoedura ornata	*Ctenotus quattuordecimlineatus*
Delma australis (H)	*Ctenotus regius* (G)
Delma fraseri (P)	*Ctenotus schomburgkii*
Delma nasuta (G)	*Ctenotus uber* (J)
Lialis burtonis	*Egernia inornata*
Pygopus nigriceps	*Egernia kintorei*
Amphibolurus clayi	*Egernia striata*
Amphibolurus fordi	*Eremiascincus richardsonii*
Amphibolurus isolepis gularis	*Lerista bipes*
Amphibolurus minor	*Lerista desertorum*
Amphibolurus nuchalis	*Lerista labialis* (P)
Amphibolurus pictus (G)	*Lerista macropisthopus*
Amphibolurus reticulatus	*Lerista muelleri* (J)
Amphibolurus scutulatus	*Menetia greyii*
Caimanops amphiboluroides (N)	*Morethia boulengeri* (J)
Diporiphora linga (G)	*Morethia butleri*
Diporiphora winneckei	*Proablepharus reginae* (B)
Lophognathus longirostris	*Tiliqua branchialis*
Moloch horridus	*Tiliqua multifasciata*
Tympanocryptis lineata (G, C)	*Demansia psammophis* (O)
Varanus caudolineatus (M)	*Pseudechis australis* (D)
Varanus eremius	*Pseudonaja modesta* (G)

[1] Source from Pianka (1969) or B: Storr (1980a); C: Houston (1978); D: Burbidge *et al.* (1976); E: Tyler *et al.* (1984); F: Burbidge *et al.* (1983); G: South Australian Museum reptile collection; H: Cogger (1983);

I: Storr (1979); J: Storr, Smith and Johnstone (1981); K: Smith and Johnson (1979); L: Storr (1982); M: Storr (1980b); N: Storr (1974); O: Storr (1978b); P: Western Australian Museum Register.

TABLE 35: THE TWELVE LIZARD SPECIES EXCLUDED FROM THE ANALYSES BECAUSE THEY WERE RECORDED FROM ONLY ONE QUADRAT; THE FIVE QUADRATS EXCLUDED BECAUSE ONLY A SINGLE SPECIES OF LIZARD WAS RECORDED

Nephrurus laevissimus, MU5	*Moloch horridus*, MU5
Aprasia inaurita, MA4	*Egernia carinata*, MA3
Pygopus lepidopodus, YA5	*Eremiascincus richardsonii*, MU5
Pygopus nigriceps, MU3	*Leiolopisma baudini*, MA5
Amphibolurus fordi, MU5	*Lerista microtis*, KD1
Amphibolurus isolepis gularis, MU5	*Morethia butleri*, BA3
ME4, *Amphibolurus nullarbor*	HU4, *Underwoodisaurus milii*
KU4, *Lerista frosti*	HU5, *Underwoodisaurus milii*
HU2, *Trachydosaurus rugosus*	

UPGMA QUADRAT GROUP

	1 · 5 · 6	2 · 3	4	7
	BBBBIKKKIYCCKKMMYCKCKHHKKKMHHHHCKKHHKCI	BMCCCCMMMMMMYKY	FFFFFJMIMYJJJJPMMPPPMP	I
	AAAAFOOOFAAADOAAAAOAOAADDUEAAAUODUAUUAF	AEOOOOAAEAAEAUA	OOOOOUUFUAUUUULUULLLUL	F
	142521455214131652234145325235112163551	332534232541431	1243511353245322413534	4

UPGMA SPECIES GROUP	Species	Quadrat groups 1, 5, 6	Quadrat groups 2, 3	Quadrat group 4	Quadrat group 7
1	Gehyra variegata	** ******	* **	***********************	
	Menetia greyi	* ***** * *** *	* ** *** * *	******* * ******** *	
	Ctenotus schomburgkii	**** **** * * *	**	** ***** *	
	Amphibolurus minor	* *	* * *	** * *	
	Diplodactylus maini	****	*	* *	
2	Tympanocryptis lineata	**** * **** * ******		****	
	Ctenotus uber	* ** ** *** *			
	Diplodactylus intermedius	* * *		*	
	Amphibolurus mckenziei	* * *			
	Diplodactylus stenodactylus	** *		*	
	Morethia adelaidensis	***** ** ** **** ***** *		**** *	
	Amphibolurus pictus	**** ****** ******* * * * *		* *	
	Trachydosaurus rugosus	***** **** ********** * *** ** *	*** ***	*	*
	Underwoodisaurus milii	*** ******* ***** *	*	********** * *	
	Amphibolurus nullarbor	** **** ****	*		
	Diplodactylus granariensis	*** **** * *** * ***	*********		
	Lerista frosti	** * ** ** *** * *	** ***** *		
3	Tiliqua occipitalis	* * **		* *	
	Lucasium damaeum			* **	*
	Nephrurus stellatus	*		*	*
4	Amphibolurus cristatus	*	** *		
	Cryptoblepharus plagiocephalus	*	* *	*	
	Delma australis	*	* *		
5	Morethia obscura	* * *** *	*************	*	
	Amphibolurus adelaidensis	* **	******* ***		
	Lerista picturata	* * *	* * ** * **	*	
	Phyllodactylus marmoratus	*	**** ** *		
	Hemiergis initialis	**	* ** ***** *		
	Ctenotus brooksi	* * *	** * * *		
	Cryptoblepharus virgatus		*****		
	Amphibolurus maculatus		*** *		
	Lerista distinguenda		*** *		
	Egernia multiscutata		**		
	Amphibolurus muricatus		* ****		
6	Heteronotia binoei	*	* *	* **** ** *** *	
	Lerista desertorum			*** *** * **	
	Ctenotus regius	*		** * * *** *	*
	Diplodactylus pulcher			* ***	
	Egernia inornata			**	
	Lerista labialis			** * * *	
	Amphibolurus reticulatus			* *** ******	
	Rhynchoedura ornata			* *** *	
	Lerista muelleri			* *** *	
	Morethia boulengeri			* *	
	Cryptoblepharus carnabyi			**	
	Lerista bipes			* * ** *	
	Nephrurus levis			* *	
Species Richness*		**4.8±(2.6)44** Woodland: 6.9±(2.5)21 Treeless Plain: 3.4±(1.7)22	**8.3±(3.3)15**	**7.4±(2.7)22**	**4**

*Species and Quadrats in Table 35 are included: mean ±(Standard Deviation) number of quadrats sampled.

Table 36

TWO – WAY TABLE OF QUADRATS VERSUS REPTILES. QUADRAT GROUP BOUNDARIES ARE A MODIFICATION (SEE TEXT) OF THOSE DISTINGUISHED FROM UPGMA

TABLE 37: NUMBER OF REPTILE AND AMPHIBIAN SPECIES KNOWN FROM THE STUDY AREA AND ADJACENT DISTRICTS (FROM TABLES 31, 33 AND 34)

	Great Victoria Desert	Nullarbor	South-western Interzone
GEKKONIDAE			
Crenadactylus	-	-	1
Diplodactylus	6	5	7
Gehyra	2	1	2
Heteronotia	1	1	1
Lucasium	1	1	1
Nephrurus	4	3	3
Oedura	-	-	1
Phyllodactylus	-	1	1
Rhynchoedura	1	1	1
Underwoodisaurus	-	1	1
PYGOPODIDAE			
Aprasia	-	1	-
Delma	3	1	3
Lialis	1	1	1
Pygopus	1	2	2
AGAMIDAE			
Amphibolurus	8	11	13
Caimanops	1	-	-
Diporiphora	2	1	1
Lophognathus	1	-	-
Moloch	1	1	1
Tympanocryptis	1	1	2
SCINCIDAE			
Cryptoblepharus	1	3	3
Ctenotus	18	5	9
Egernia	3	4	6
Eremiascincus	1	1	1
Hemiergis	-	1	3
Leiolopisma	-	1	-
Lerista	5	8	8
Menetia	1	1	1
Morethia	2	4	3
Proablepharus	1	-	-
Tiliqua	2	2	2
Trachydosaurus	-	1	1
VARANIDAE			
Varanus	6	4	4
TYPLOPIDAE			
Rhamphotyphlops	-	2	4

Snakes	3	14	20
Frogs	4	1	8
TOTAL	81	85	115

TABLE 38: COMPARISON OF LIZARD SPECIES COMPRISING EACH OF THE FOUR COMMUNITY-TYPES DISTINGUISHED IN THE NULLARBOR STUDY AREA WITH THE POOLED FAUNA OF THE REST OF THE STUDY AREA

Community-type	Richness	Similarities* (Number of Species in Common)			
Northern Community (NC)	38	29.0 (18)			
Peripheral Woodlands (PW)	30		54.0 (27)		
Treeless Plain (TP)	16			23.5 (16)	
Coastal Community (CC)	29				28.6 (18)
Remainder of Study Area (Species Richness)	(PW (TP (CC (42)	(NC (TP (CC (47)	(NC (PW (CC (68)	(NC (PW (TP (52)	

*Jaccard Coefficients (%)

TABLE 39: PAIRED COMPARISONS OF THE LIZARD FAUNAS KNOWN FROM DISTRICTS ADJACENT TO, AND THE FOUR COMMUNITY-TYPES WITHIN, THE NULLARBOR PLAIN

Faunas	Richness	Similarities (Jaccard Coeff.)						
		GVD	SWI	NC	PW	TP	CC	N
GREAT VICTORIA DESERT (GVD)	74		35.3	34.9	16.9	7.1	8.4	37.9
SOUTH-WESTERN INTERZONE (SWI)	83	41		32.9	29.2	17.9	30.2	49.5
Northern Community (NC)	38	29	30		41.5	22.7	17.5	
Peripheral Woodlands (PW)	30	15	26	17		48.4	40.5	
Treeless Plain (TP)	16	6	15	10	15		25.0	
Coastal Community (CC)	29	8	26	10	17	9		
NULLARBOR STUDY AREA (N)	68	39	50					
		Number of Species in Common						

BIOLOGICAL PATTERNS IN THE NULLARBOR STUDY AREA

N.L. McKenzie, D.L. Belbin, A. Gunjko and A.C. Robinson

Background

In the previous sections of this publication, the taxonomic groups we sampled (birds, reptiles, mammals and perennial and ephemeral plants) were analysed as individual sub-sets. These groups were expected to respond to different attributes of the environment (soils, climatic factors, other biotic attributes etc.) and perceive quite different geographical and temporal scales because of differences in their mobilities, dispersal strategies, longevities, physiological characteristics (e.g. activity patterns of heterotherms in relation to ambient temperature) and sensitivity to disturbances (e.g. post-European extinctions in mammals).

This section reports the outcome of subjecting the entire data base to pattern analysis in which species were given equal weight by coding species presence and absence data per quadrat. The alternative strategy, of assigning equal weighting to the sub-sets, was rejected because it would have over-weighted the species-poor sub-sets (mammals and reptiles). The aim of our analysis was to:

(a) document geographic patterns in assemblage species richness and composition using more complete ecolgoical systems that involve a greater array of life history strategies than any particular sub-set.

(b) determine the extent that the ecological and biogeographic patterns perceived from this analysis encompassed the patterns from the individual sub-sets and provided a basis for designing a more representative reserve system.

(c) seek correlates between the observed patterns in the biota and attributes or scalars of the physical environment (e.g. climate). Gradients in a number of physical attributes were expected to influence biological patterns in the Study Area. These were measured or calculated for each quadrat and superimposed as extrinsic attributes on the output of the pattern analyses (see Analysis Pathways, in Methods, this publication). Could these physical attributes be used to predict (interpolate) the assemblage composition of other sites in the Study Area?

Our work documented the species present at 83 quadrats during March/April 1984, and again during September/October 1984. At each quadrat, birds, reptiles, mammals, perennial plants and ephemeral plants were recorded along with accessory data.

To obtain a better overview of species' habitat requirements we combined the March/April and September/October data from quadrats (but see Wiens 1981). We minimised the effects of stochasm in the sampling by excluding:

1. species for which our quadrat-based sampling techniques, involving sessions of only four days and nights during each of the two seasonal visits, were inappropriate (non-passerine birds, bats and large mammals, snakes and goannas); and

2. species difficult to identify (corvids, sterile grasses).

These procedures left 524 species eligible for the pattern analysis. Another 151 of these species were not included because they were recorded on only one quadrat and their inclusion would only have added "noise" to the numerical taxonomic techniques. The analysis ultimately involved 373 species: 248 (perennial and ephemeral) plants, 69 passerine birds, 47 lizards and 9 small ground-dwelling mammals.

The elimination of "rare" species, such as the 151 above, was expected to minimize the influence of sampling bias due to chance occurrences but, at the same time, to reduce the predictive ability of the data base and ignore the group of species most likely to require special conservation attention (management and/or reservation) unless the apparent "rarity" was the result of edge effects (e.g. at the boundary of the Study Area) and the species were widespread in more suitable habitats of adjacent districts. Of the 151 species eliminated from the analysis because they were recorded on only one quadrat, more than 90 percent were from quadrats on the boundary of the Study Area and are widespread in adjacent districts. Examples were discussed in the previous sections of this publication.

Of the 83 quadrats at which we sampled, two (PL6: quadrat No. 6 at the Plumridge camp, and HA6) were eliminated from analysis because they were not sampled using the systematic drift-fence and bird census techniques employed on the others; MA6 was eliminated by mistake but did not represent a unique situation and will provide an opportunity to test the predictive capability of the data base. Thus, the pattern analysis involved 80 quadrats. The pathways followed in the pattern analyses are discussed in 'Methods', this publication.

Species Analysis

To search for groups of species that consistently co-existed in assemblages, the 373 species recorded on more than one quadrat were classified according to their presence and absence at the 80 quadrats. The three main species groups that separated at high level in the UPGMA (Sneath and Sokal 1973) dendogram (Fig. 62) were ecologically distinct in terms of the geographic ranges and the preferred substrates of their component species elsewhere in Australia. In these terms, sub-groups forming internal structure in the dendogram could also be interpreted. At this point a few small errors were found in the data base but were not expected to affect the classification groupings. For instance, three records of the Budgerigar (a non-passerine) were not masked out and *Nitraria billardieri* was split into two groups because of a spelling error.

Group A comprises mesic and semi-arid species largely restricted to coastal and near-coastal areas in arid southern Australia (e.g. sub-groups 14 and, especially, 19; the latter includes many plants restricted to sandy surfaces). Some (sub-group 17) are restricted to saline environments such as unconsolidated beach dunes and samphire flats. Others (sub-groups 15 and 16) are more widely distributed semi-arid species penetrating the arid zone on heavier soils with woodlands. This group includes the Zebra Finch and *Crassula exserta* which are probably random assignments; each was based on only two records. Some species are endemic to the Study Area.

Group B comprises true arid zone species most of which are normally associated with sandy surfaces. These are mostly desert species that penetrate adjacent arid and semi-arid districts in sandy situations (sub-groups 10 and 11) or where there are deeper, well drained, friable soils (e.g. loams). For instance, sub-group 8 includes many species in this category. Sub-group 12 comprises sandplain species of south-eastern Australia.

Group C is the largest group. It comprises generally widespread arid to semi-arid, mainly temperate species that prefer the heavy, less well-drained soils supporting woodlands (especially) and scrubs to shrublands and grasslands. They do not occur on sandy surfaces so most do not occur through the sandy deserts of the interior such as the Great Victoria Desert; those that do are confined to areas with heavy soil. A few are almost confined to grassland and low shrubland environments (sub-group 5).

To investigate the internal structure of these main groups, the dendogram (Fig. 62) was cut at the 19 group level for production of the 2-way table (discussed later).

A principal co-ordinate analysis was also carried out on the presence and absence quadrat data to classify the 373 species in terms of quadrats. The results are presented in Fig. 63, with UPGMA boundaries superimposed. Because of the very large number of species involved, each species code was replaced by the sub-group number into which it was classified by the UPGMA (from Fig. 62).

Again, discrete clustering was not found although there was clear separation of the three main UPGMA groups, and many of the sub-groups. These are marked on the scattergrams (Fig. 63). Using species' "geographic range" and "preferred substrate" characteristics that we used earlier to interpret the UPGMA groupings (see text concerning Fig. 62) it was possible to derive gradients from Fig. 63:

Axis I - the patterning of species along Axis I of Fig. 63a is consistent with a gradient of change from "mesic to semi-arid" species (with negative loadings) to arid zone species (positive loadings).

Axis II - can be interpreted as a gradient of change from desert species that favour well-drained, sandy surfaces (positive loadings) to:

(i) "arid to semi-arid" species found on heavier, poorly drained soils (calcareous earths and clayey soils) - negative loadings on the right side of Fig. 63a; and

(ii) "mesic to semi-arid zone" species of better watered coastal areas, especially coastal sandhills of marine origin - negative loadings on the left side of Fig. 63a.

Axis III - a strong gradient from species of Eucalyptus woodland habitats (negative loadings in Fig. 63b), via Mallee and Myall open low woodlands and scrubs, to species of low shrub and grassland environments (positive loadings).

Quadrat Analysis

To search for groups of assemblages with similar species composition, the 80 quadrats were classified in terms of the presence and absence of 373 species.

The dendrogram resulting from the UPGMA classification is presented in Fig. 64. Eleven groups were distinguished at high level; these were discriminated in terms of the geographical location and vegetation of their component quadrats. The internal structure in most of these groups could also be interpreted using these criteria. Fig. 65 is a geographical representation of the quadrat groupings. Photographs of the quadrats are presented in Appendix 1.

Group 1 comprised 10 quadrats round the south-west periphery of the Treeless Plain. Most are open woodlands of Myall and or Eucalyptus although quadrats of samphire shrublands (KU4, C01 and, to a lesser extent, 8A2) are also included.

Group 2 - all 20 quadrats on the Carlisle Plain, to the north of the Nullarbor (Treeless) Plain (see Fig. 14 in the Introduction, this publication).

Group 3 - the 12 woodland quadrats to the east and south-east of the Treeless Plain.

Group 4 - the 5 mallee and mixed-low-woodland sites along the near-coastal southern edge of the Treeless Plain, east of the Roe Plain.

Group 5 - (8 quadrats) comprises low-shrubland and grassed quadrats in the only area where the Treeless (Nullarbor) Plain is actually adjacent to the coast. The KD quadrats in this group are mozaics of Treeless Plain between stands of mallee.

Group 6 - the two coastal-shrubland quadrats in the south-east of the Study Area.

Group 7 - the two shrub and grassland quadrats immediately inland of the Hampton Range, near Eucla.

Group 8 - (7 quadrats) all the mid-latitude Treeless Plain quadrats retaining reasonable vegetation cover.

Group 9 - the five Treeless Plain quadrats sampled near Hughes (HU); all are severely disturbed and include many introduced herbs.

Group 10 - the seven heavily wooded Eucalyptus and mallee quadrats of consolidated marine-sand surfaces on, or immediately adjacent to, the Roe Plain.

Group 11 - the two beach-dune quadrats on the Roe Plain.

From the arrangements of the quadrat groups in Fig. 65, a strong north-south gradient of change in the biota was apparent. East-west changes in the species composition of assemblages were also apparent along the southern margin of the Study Area, especially at the eastern end of the Roe Plains and in the vicinity of CA.

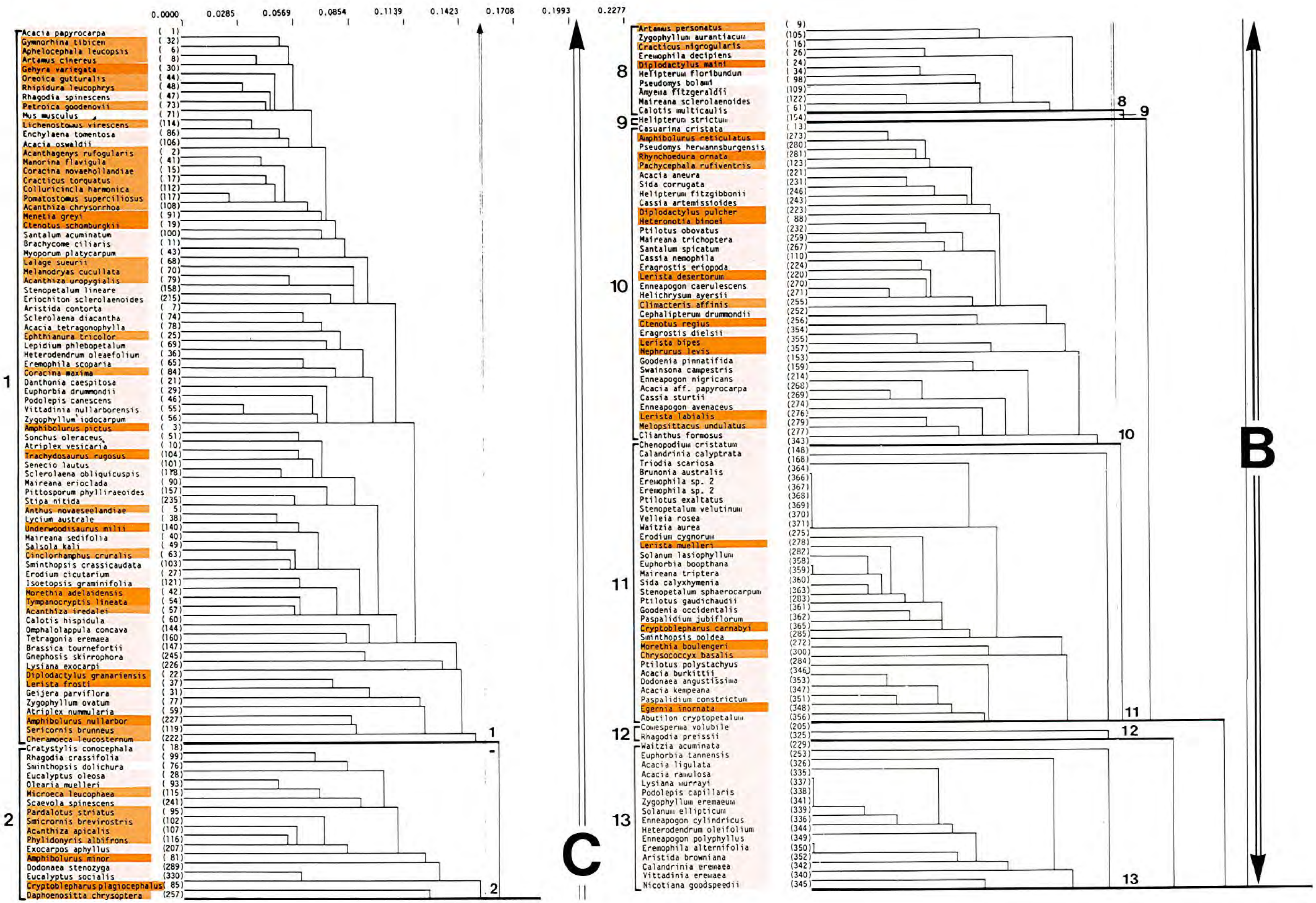
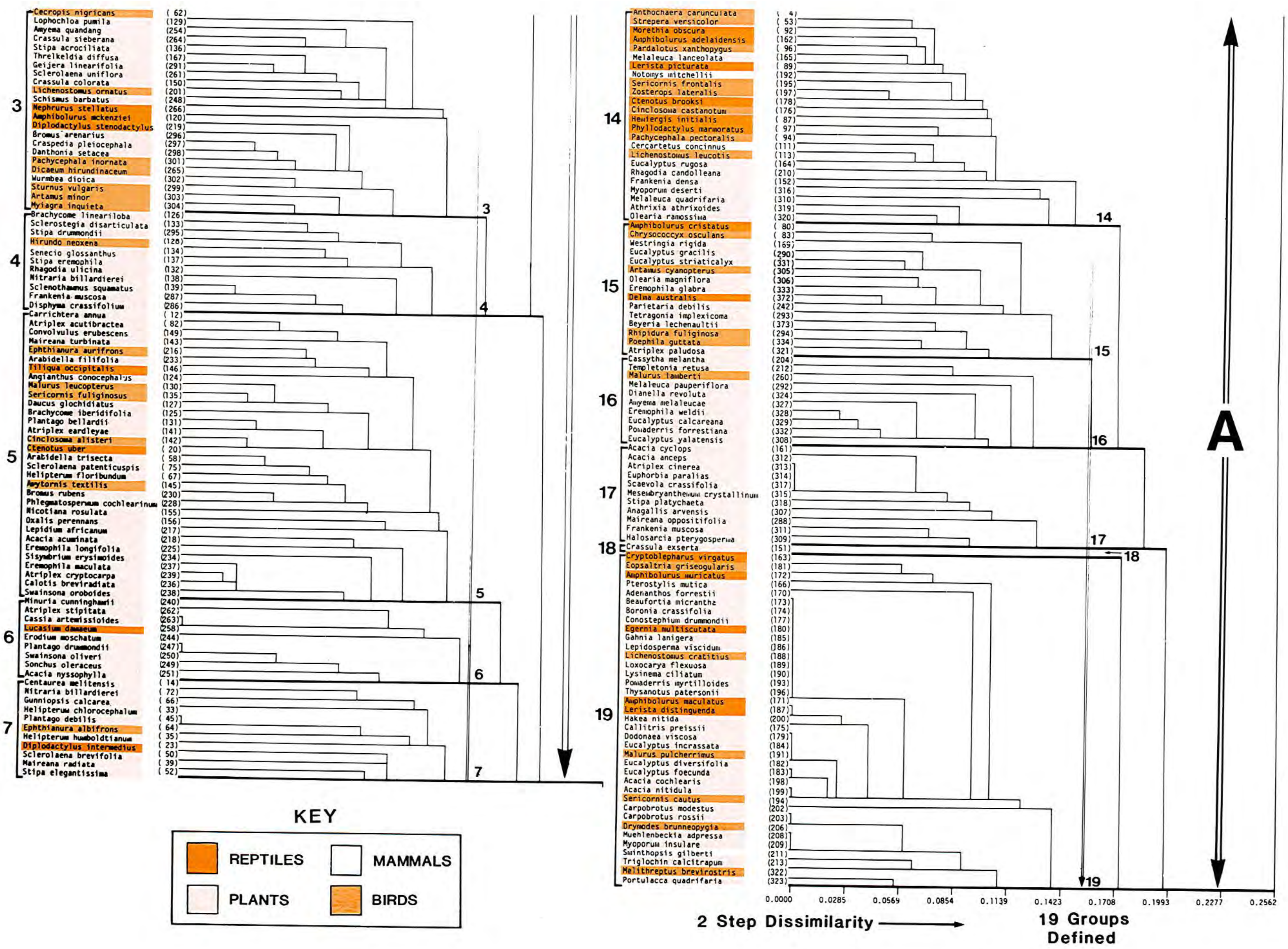
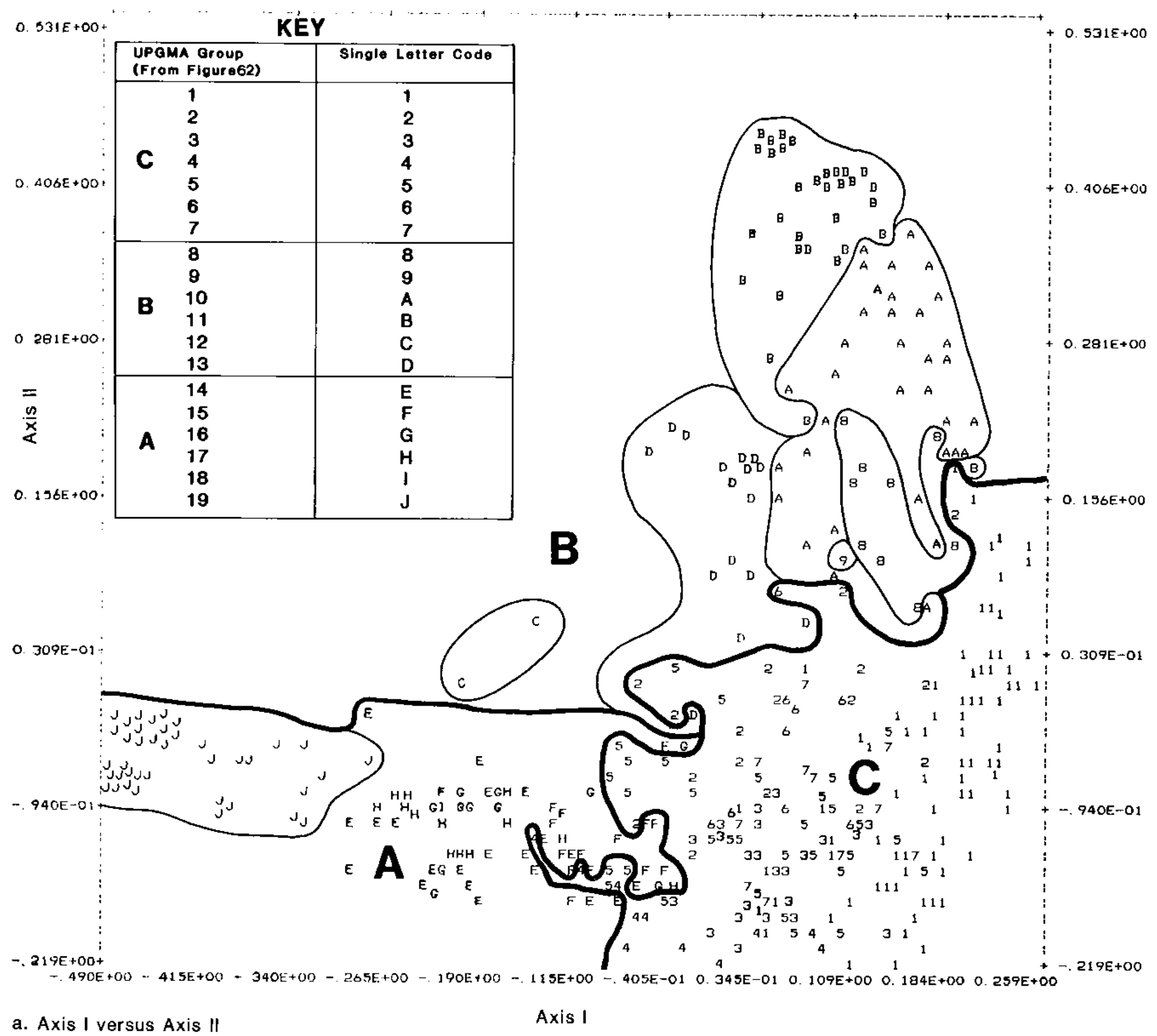


Figure 62

UPGMA SPECIES CLASSIFICATION IN TERMS OF QUADRAT FIDELITY (TWO-STEP SIMILARITY MEASURE ON PRESENCE/ABSENCE DATA.)



Cecropis nigricans (62)
Lophochloa pumila (129)
Amyema quandang (254)
Crassula sieberana (264)
Stipa acrociliata (136)
Threlkeldia diffusa (167)
Geijera linearifolia (291)
Sclerolaena uniflora (261)
Crassula colorata (150)
Lichenostomus ornatus (201)
Schismus barbatus (248)
Nephrurus stellatus (266)
Amphibolurus mckenziei (120)
Diplodactylus stenodactylus (219)
Bromus arenarius (296)
Craspedia pleiocephala (297)
Danthonia setacea (298)
Pachycephala inornata (301)
Dicaeum hirundinaceum (265)
Wurmbea dioica (302)
Sturnus vulgaris (299)
Artamus minor (303)
Myiagra inquieta (304)
Brachycome lineariloba (126)
Sclerostegia disarticulata (133)
Stipa drummondii (295)
Hirundo neoxena (128)
Senecio glossanthus (134)
Stipa eremophila (137)
Rhagodia ulicina (132)
Nitraria billardierei (138)
Sclerothamnus squamatus (139)
Frankenia muscosa (287)
Disphyma crassifolium (286)
Carrichtera annua (12)
Atriplex acutibractea (82)
Convolvulus erubescens (149)
Maireana turbinata (143)
Ephthianura aurifrons (216)
Arabidella filifolia (233)
Tiliqua occipitalis (146)
Angianthus conocephalus (124)
Malurus leucopterus (130)
Sericornis fuliginosus (135)
Daucus glochidiatus (127)
Brachycome iberidifolia (125)
Plantago bellardii (131)
Atriplex eardleyae (141)
Cinclosoma alisteri (142)
Ctenotus uber (20)
Arabidella trisecta (58)
Sclerolaena patenticuspis (75)
Helipterum floribundum (67)
Amytornis textilis (145)
Bromus rubens (230)
Phlegmatospermum cochlearinum (228)
Nicotiana rosulata (155)
Oxalis perennans (156)
Lepidium africanum (217)
Acacia acuminata (218)
Eremophila longifolia (225)
Sisymbrium erysimoides (234)
Eremophila maculata (237)
Atriplex cryptocarpa (239)
Calotis breviradiata (236)
Swainsona oroboides (238)
Minuria cunninghamii (240)
Atriplex stipitata (262)
Cassia artemisioides (263)
Lucasium damaeum (258)
Erodium moschatum (244)
Plantago drummondii (247)
Swainsona oliveri (250)
Sonchus oleraceus (249)
Acacia nyssophylla (251)
Centaurea melitensis (14)
Nitraria billardierei (72)
Gunniopsis calcarea (66)
Helipterum chlorocephalum (33)
Plantago debilis (45)
Ephthianura albifrons (64)
Helipterum humboldtianum (35)
Diplodactylus intermedius (23)
Sclerolaena brevifolia (50)
Maireana radiata (39)
Stipa elegantissima (52)
3
4
5
6
7
Anthochaera carunculata (4)
Strepera versicolor (53)
Morethia obscura (92)
Amphibolurus adelaidensis (162)
Pardalotus xanthopygus (96)
Melaleuca lanceolata (165)
Lerista picturata (89)
Notomys mitchellii (192)
Sericornis frontalis (195)
Zosterops lateralis (197)
Ctenotus brooksi (178)
Cinclosoma castanotum (176)
Hemiergis initialis (87)
Phyllodactylus marmoratus (97)
Pachycephala pectoralis (94)
Cercartetus concinnus (111)
Lichenostomus leucotis (113)
Eucalyptus rugosa (164)
Rhagodia candolleana (210)
Frankenia densa (152)
Myoporum deserti (316)
Melaleuca quadrifaria (310)
Athrixia athrixoides (319)
Olearia ramosissima (320)
Amphibolurus cristatus (80)
Chrysococcyx osculans (83)
Westringia rigida (169)
Eucalyptus gracilis (290)
Eucalyptus striaticalyx (331)
Artamus cyanopterus (305)
Olearia magniflora (306)
Eremophila glabra (333)
Delma australis (372)
Parietaria debilis (242)
Tetragonia implexicoma (293)
Beyeria lechenaultii (373)
Rhipidura fuliginosa (294)
Poephila guttata (334)
Atriplex paludosa (321)
Cassytha melantha (204)
Templetonia retusa (212)
Malurus lamberti (260)
Melaleuca pauperiflora (292)
Dianella revoluta (324)
Amyema melaleucae (327)
Eremophila weldii (328)
Eucalyptus calcareana (329)
Pomaderris forrestiana (332)
Eucalyptus yalatensis (308)
Acacia cyclops (161)
Acacia anceps (312)
Atriplex cinerea (313)
Euphorbia paralias (314)
Scaevola crassifolia (317)
Mesembryanthemum crystallinum (315)
Stipa platychaeta (318)
Anagallis arvensis (307)
Maireana oppositifolia (288)
Frankenia muscosa (311)
Halosarcia pterygosperma (309)
Crassula exserta (151)
Cryptoblepharus virgatus (163)
Eopsaltria griseogularis (181)
Amphibolurus muricatus (172)
Pterostylis mutica (166)
Adenanthos forrestii (170)
Beaufortia micrantha (173)
Boronia crassifolia (174)
Conostephium drummondii (177)
Egernia multiscutata (180)
Gahnia lanigera (185)
Lepidosperma viscidum (186)
Lichenostomus cratitius (188)
Loxocarya flexuosa (189)
Lysinema ciliatum (190)
Pomaderris myrtilloides (193)
Thysanotus patersonii (196)
Amphibolurus maculatus (171)
Lerista distinguenda (187)
Hakea nitida (200)
Callitris preissii (175)
Dodonaea viscosa (179)
Eucalyptus incrassata (184)
Malurus pulcherrimus (191)
Eucalyptus diversifolia (182)
Eucalyptus foecunda (183)
Acacia cochlearis (198)
Acacia nitidula (199)
Sericornis cautus (194)
Carpobrotus modestus (202)
Carpobrotus rossii (203)
Drymodes brunneopygia (206)
Muehlenbeckia adpressa (208)
Myoporum insulare (209)
Swainsona gilberti (211)
Triglochin calcitrapum (213)
Melithreptus brevirostris (322)
Portulacca quadrifaria (323)
14
15
16
17
18
19
A
0.0000
0.0285
0.0569
0.0854
0.1139
0.1423
0.1708
0.1993
0.2277
0.2562
2 Step Dissimilarity
19 Groups Defined
KEY
REPTILES
MAMMALS
PLANTS
BIRDS



KEY

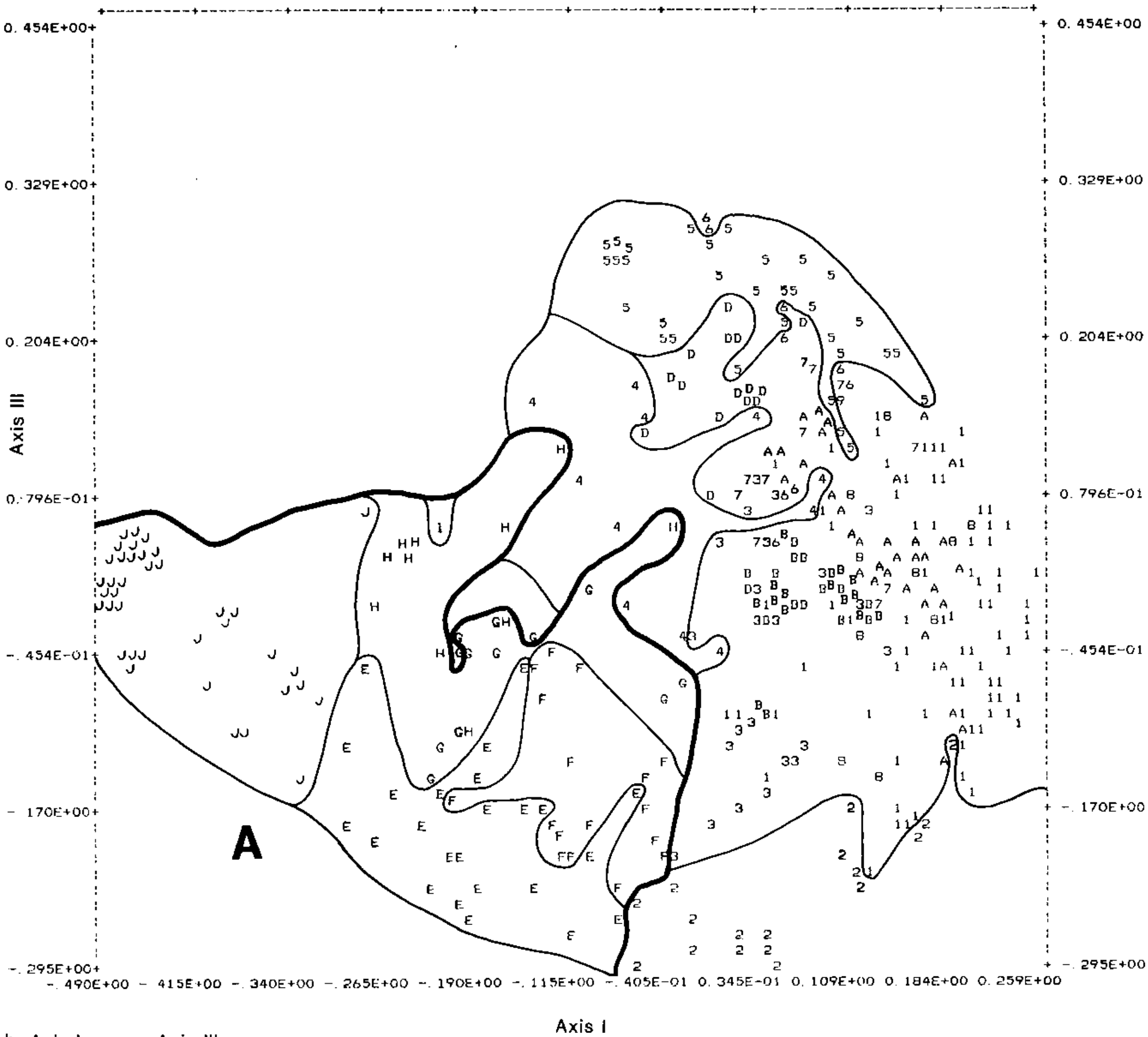
UPGMA Group (From Figure62)		Single Letter Code
C	1	1
	2	2
	3	3
	4	4
	5	5
	6	6
	7	7
B	8	8
	9	9
	10	A
	11	B
	12	C
	13	D
A	14	E
	15	F
	16	G
	17	H
	18	I
	19	J

a. Axis I versus Axis II

Figure 63a

SCATTERGRAM RESULTING FROM THE ORDINATION OF 373 SPECIES (OF PLANTS AND VERTEBRATES) IN TERMS OF QUADRAT FIDELITIES

UPGMA species groups from figure 62 are superimposed and each species code is replaced by the sub-group number into which it was classified (from Figure 62)



b. Axis I versus Axis III

Figure 63b

SCATTERGRAM RESULTING FROM THE ORDINATION OF 373 SPECIES (OF PLANTS AND VERTEBRATES) IN TERMS OF QUADRAT FIDELITIES.

UPGMA species groups and sub-groups from figure 62 are superimposed as in figure 63a

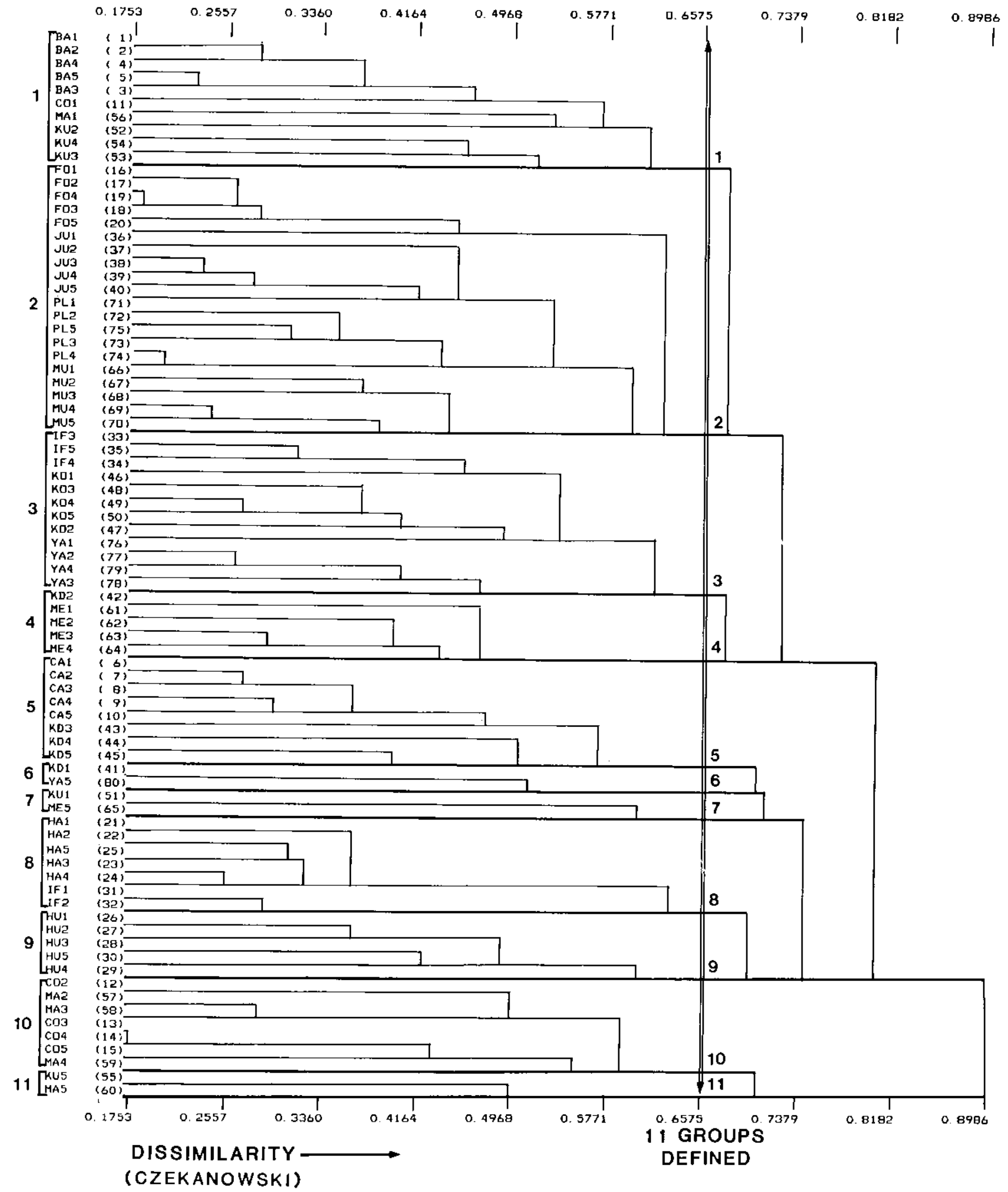
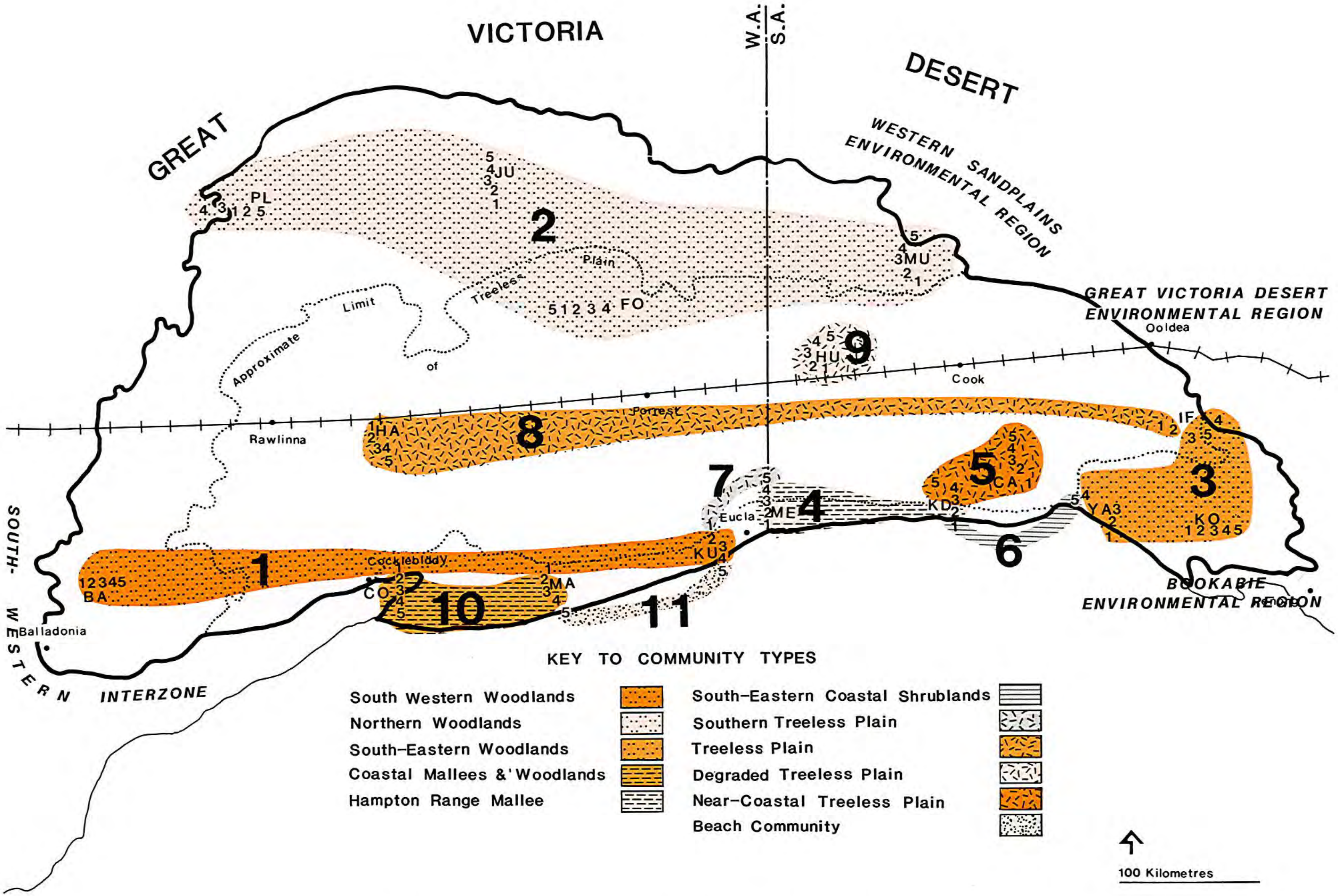


Figure 64
UPGMA QUADRAT CLASSIFICATION BASED ON THE PRESENCE AND ABSENCE ON QUADRATS OF THE 373 SPECIES SUBJECTED TO ANALYSIS.

Figure 65
GEOGRAPHICAL DISTRIBUTION OF QUADRAT GROUPS FROM TOTAL ANALYSIS



Geographical interpretation of the total species quadrat groups(UPGMA)across the Nullarbor study area (UPGMA group numbers are superimposed in bold)

Also consistent, though less important, as a source of variation in the species composition of quadrats was their degree of geographic separation. This was shown in Fig. 64; quadrats belonging to the same campsite were tightly clustered within UPGMA groups unless they reflected very different soil conditions. Instances include the separate grouping of beach-dune quadrats (MA5, KU5) and the separation of IF1-2 from IF3-5.

A principal co-ordinate analysis (P.C.R. - see Methods, this publication) was carried out to ordinate the quadrats in terms of species as a cross-check of the groups distinguished from UPGMA. The results are presented in Fig. 66 with the UPGMA group boundaries overlaid.

Only one cluster (Group 9) is discrete in the scattergrams (Fig. 66). Nevertheless, the three axes were sufficient to discriminate the main UPGMA groups:

Axis I and II separate UPGMA Groups 2, 5, 8, 9 and 10. Axis I exhibits a gradient of change in the overall density of vegetation from the sparse centre of the Treeless Plain to the heavily vegetated Roe Plain quadrats near the coast (also see Fig. 65). The five quadrats near the Hughes campsite (HU1-5), FO1-4, IF1 and CA4-5 have been stripped of much of their vegetative cover (see Vegetation, this publication).

Axis II separates the near-coastal Treeless Plain quadrats (CA1-5, KD3-5) that comprise UPGMA Group 5, from quadrats on the northern margin of the Study Area (the Carlisle Plain). Initially, we could recognise no obvious climatic or soil-type pattern that was consistent with the arrangement of quadrats along this axis. (Explained by Total Rainfall in BIOCLIM).

Axis III distinguishes UPGMA Groups 1 and 3 as distinct clusters and shows the separation between Groups 10 and 11. A comparison with Fig. 65 suggests that this axis corresponds to the strong west to east changes in the UPGMA groupings across non-coastal parts of the Study Area. This view is evidenced in Fig. 66 by the separation of UPGMA Group 8 and the separation of the western end of Group 8 (the HA quadrats) from Group 9, the separation of the PL end from the MU end of Group 2, and finally, the arrangements of quadrats in Groups 5 and 7.

This data set was also analysed using the multi-dimensional scaling package, KYST (Kruskal et al. 1973). A three dimensional representation of the KYST scatterplot is presented in Fig. 67. The colours represent the eleven UPGMA groups and each of the 80 quadrats is represented. The size of the circles provides a perspective of the third axis; large circles represent quadrats in the foreground of the constellation, smaller circles are more distant quadrats. Unlike the PCR and ALSCAL (Young and Lewysckyj, 1979), KYST does not use squared distances so does not tend to over-emphasise greater separations and under-emphasise differences between similar quadrats. As a result, the tightly grouped central cluster visible in Fig. 66 appears exploded in the KYST scatterplot (Fig. 67). Otherwise, the scatterplots (Figs. 67 and 66) and the UPGMA classification can virtually be superimposed, suggesting robustness.

Three gradients were detected in the KYST ordination; they are indicated on Fig. 67. The first two are somewhat rotated and suggest slightly different interpretations from those perceived in the PCR scatterplots (Fig. 66) discussed above.

Analysis of Biophysical Attributes

From the outset we expected a number of physical factors to influence, if not determine, broad patterns in the biota of the Study Area. Climatic factors and soil attributes (such as Calcium values) were considered likely to have a more prominent influence on the total composition of assemblages than other sources of variation such as ongoing community processes, the recent history of localised climatic events such as thunderstorms, the effects of disturbances such as grazing and mammal extinctions and, hopefully, sampling bias.

Values for a variety of biophysical attributes were recorded (Appendix 1), assayed (Appendix IX) or calculated (BIOCLIM attributes - Nix, Busby and Hutchinson in prep., Nix and Gillison 1985) for each quadrat. (Note that the quadrat size we selected was the same as the level of resolution for semi-arid and arid regions available through a preliminary version of the Australian Environmental Geographic Information System (AEGIS) - 2km x 2km - see Nix and Gillison 1985, p. 47).

To search for correspondence between the biophysical attributes and the assemblage (quadrat) groupings, values for each of the above attributes were, in turn, calculated for the eleven quadrat groups defined by UPGMA (see Fig. 64) using the GSTA package from NTP described in Methods (this publication). The results are presented in Table 40.

There was no pattern of change in measured soil attributes that could be related to biotic patterns across the Study Area. Of the eleven soil attributes analyses, only Calcium and Magnesium values showed a significant contribution to the pattern of assemblages distinguished by UPGMA (see Table 40); the quadrats comprising UPGMA Groups 2 and 9 (see Fig. 64) had significantly lower Calcium levels than quadrats elsewhere in the Study Area (Fig. 68). Even in the KYST scatterplot (Fig. 67), no clear patterning of quadrats corresponding to a gradient in Calcium or Magnesium values could be recognised.

Of the six species richness attributes analysed, only passerine bird species richness showed any clear separation of the UPGMA Quadrat-Groups (Table 40 and Fig. 68). Assemblages of central parts of the Study Area (Groups 5, 6, 7, 8 and 9) were significantly poorer than assemblages around its periphery. This pattern of change corresponded to the gradient in vegetation biomass and structural diversity identified with Axis 1 in the KYST scatterplot (Fig. 67).

Many of the climatic attributes showed clear separation of UPGMA Quadrat-Groups (Fig. 69). Of the solar radiation attributes, Mean Annual Radiation (0.95), Radiation Range (0.96) and Radiation Seasonality (0.97) had the highest Cramer ratios; they consistently distinguished UPGMA Quadrat-Groups 10 and 11 from Groups 1, 3, 4, 5, 6 and 7 from Groups 8 and 9 from Group 2 (see Fig. 69) which correspond to a south to north gradient of change in the species composition of assemblages (Fig. 65) and could be related to the high Cramer ratio (0.98) found for Latitude (Fig. 69).

Distance from the coast corresponded closely to the arrangement of quadrats along KYST Axis 2 (see Fig. 67) and could be related to the separation of UPGMA Quadrat Groups provided by temperature attributes, particularly "Mean Annual Temperature" in Fig. 70.

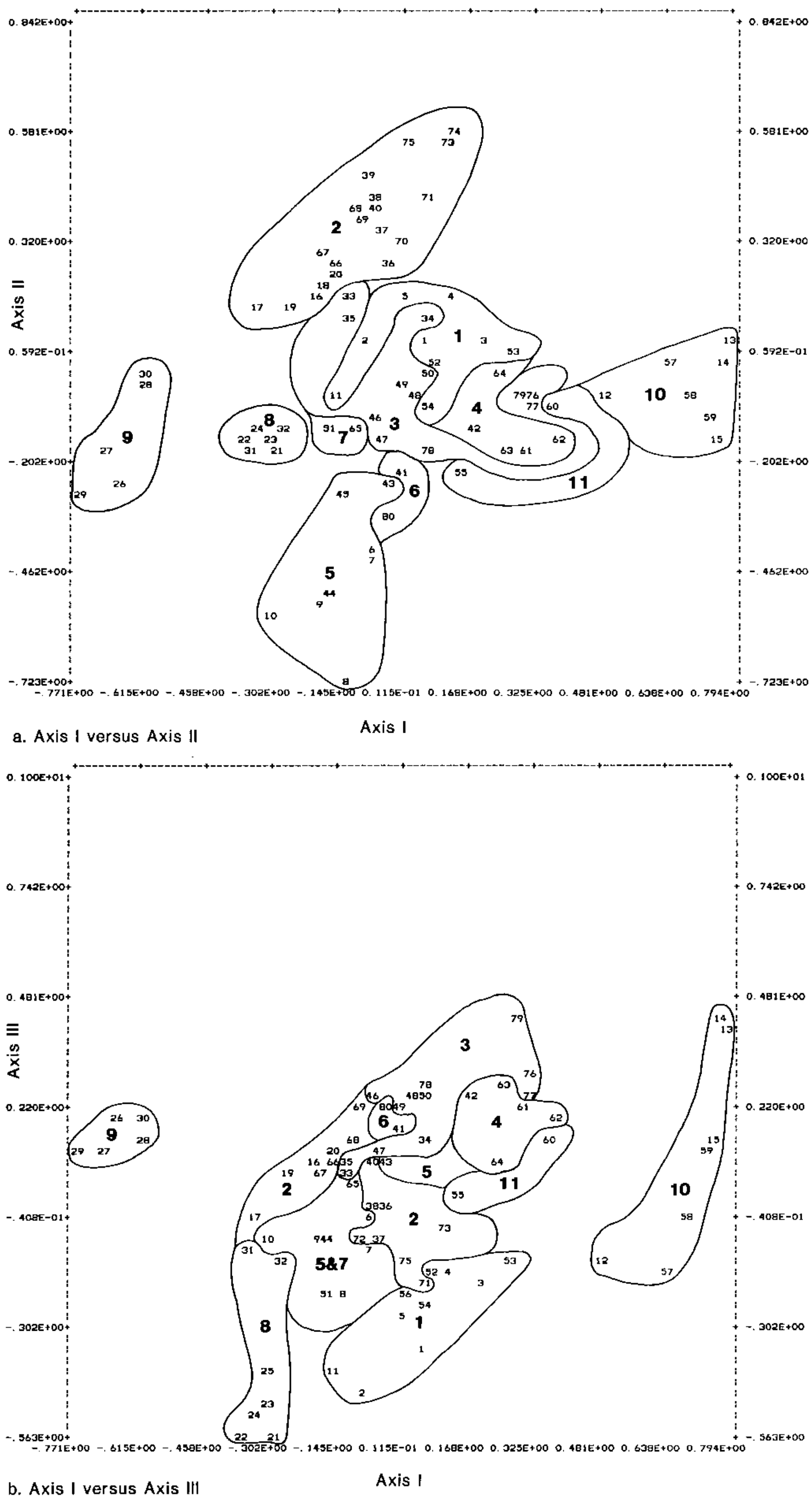


Figure 66

SCATTERGRAM RESULTING FROM THE ORDINATION OF 80 QUADRATS IN TERMS OF THE PRESENCE AND ABSENCE ON QUADRATS OF 373 SPECIES (VERTEBRATE AND PLANT)

The UPGMA group boundaries from figure 64 are superimposed and can be identified by their group number

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 80 POINTS
REGRESSIONS : Y = 0.4999E-05 + 0.8441E-01 X
: X = -0.6108E-06 + 0.1221 Y
CORRELATION COEFFICIENT (R) = 0.1015

LABEL	SEQ #	X-VALUE	Y-VALUE
BA1	1	0.6120E-01	0.7900E-01
BA2	2	-0.8440E-01	0.7950E-01
BA3	3	0.1916	0.9150E-01
BA4	4	0.1162	0.1842
BA5	5	0.7300E-02	0.1797
CA1	6	-0.7070E-01	-0.4056
CA2	7	-0.7230E-01	-0.4287
CA3	8	-0.1271	-0.7233
CA4	9	-0.1930	-0.5358
CA5	10	-0.2942	-0.5700
CO1	11	-0.1411	-0.3720E-01
CO2	12	0.4964	-0.3960E-01
CO3	13	0.7940	0.7330E-01
CO4	14	0.7815	0.3120E-01
CO5	15	0.7610	-0.1459
FO1	16	-0.1941	0.1877
FO2	17	-0.3289	0.1696
FO3	18	-0.1728	0.2200
FO4	19	-0.2487	0.1733
FO5	20	-0.1497	0.2439
HA1	21	-0.2786	-0.1662
HA2	22	-0.3635	-0.1580
HA3	23	-0.2939	-0.1402
HA4	24	-0.3339	-0.1131
HA5	25	-0.3047	-0.1706
HU1	26	-0.6629	-0.2532
HU2	27	-0.6850	-0.1791
HU3	28	-0.6048	-0.2030E-01
HU4	29	-0.7710	-0.2725
HU5	30	-0.5933	0.1120E-01
IF1	31	-0.3432	-0.1649
IF2	32	-0.2769	-0.1110
IF3	33	-0.1115	0.1879
IF4	34	0.7300E-01	0.1451
IF5	35	-0.1158	0.1400
JU1	36	-0.1770E-01	0.2556
JU2	37	-0.3430E-01	0.3478
JU3	38	-0.4740E-01	0.4280
JU4	39	-0.6410E-01	0.4646
JU5	40	-0.4880E-01	0.3886

LABEL	SEQ #	X-VALUE	Y-VALUE
KD1	41	0.1640E-01	-0.2326
KD2	42	0.1872	-0.1336
KD3	43	-0.1310E-01	-0.2415
KD4	44	-0.1629	-0.5069
KD5	45	-0.1284	-0.2745
KO1	46	-0.5190E-01	-0.9780E-01
KO2	47	-0.2800E-01	-0.1587
KO3	48	0.4440E-01	-0.3220E-01
KO4	49	0.1190E-01	-0.2360E-01
KO5	50	0.7510E-01	-0.4900E-02
KU1	51	-0.1530	-0.1364
KU2	52	0.9080E-01	0.2010E-01
KU3	53	0.2706	0.5960E-01
KU4	54	0.6890E-01	-0.6110E-01
KU5	55	0.1453	-0.2224
MA1	56	0.2710E-01	-0.2560E-01
MA2	57	0.6537	0.2060E-01
MA3	58	0.7069	-0.5400E-01
MA4	59	0.7505	-0.9190E-01
MA5	60	0.3732	-0.7510E-01
ME1	61	0.3114	-0.1841
ME2	62	0.3926	-0.1556
ME3	63	0.2552	-0.1880
ME4	64	0.2440	0.3200E-02
ME5	65	-0.1024	-0.1334
MU1	66	-0.1377	0.2595
MU2	67	-0.1777	0.2979
MU3	68	-0.1058	0.3866
MU4	69	-0.8300E-01	0.3806
MU5	70	0.1520E-01	0.3298
PL1	71	0.6850E-01	0.4213
PL2	72	-0.8650E-01	0.4084
PL3	73	0.1190	0.5512
PL4	74	0.1299	0.5798
PL5	75	0.2990E-01	0.5481
YA1	76	0.3246	-0.3510E-01
YA2	77	0.3195	-0.8120E-01
YA3	78	0.7700E-01	-0.1666
YA4	79	0.2914	-0.5360E-01
YA5	80	-0.2370E-01	-0.3424

a.

VALUES ON SCATTER PLOT REPRESENT SEQUENCE NUMBERS
X-Y AXES SCALED DEPENDENTLY
REGRESSIONS AND PLOT BASED ON 80 POINTS
REGRESSIONS : Y = -0.1249E-05 + 0.1972 X
: X = 0.4936E-06 + 0.3953 Y
CORRELATION COEFFICIENT (R) = 0.2792

LABEL	SEQ #	X-VALUE	Y-VALUE
BA1	1	0.6120E-01	-0.3596
BA2	2	-0.8440E-01	-0.4628
BA3	3	0.1916	-0.2091
BA4	4	0.1162	-0.1720
BA5	5	0.7300E-02	-0.2649
CA1	6	-0.7070E-01	-0.4620E-01
CA2	7	-0.7230E-01	-0.1065
CA3	8	-0.1271	-0.2155
CA4	9	-0.1930	-0.9670E-01
CA5	10	-0.2942	-0.8670E-01
CO1	11	-0.1411	-0.4017
CO2	12	0.4964	-0.1342
CO3	13	0.7940	0.4094
CO4	14	0.7815	0.4160
CO5	15	0.7610	0.1420
FO1	16	-0.1941	0.9230E-01
FO2	17	-0.3289	-0.4790E-01
FO3	18	-0.1728	0.9920E-01
FO4	19	-0.2487	0.5800E-01
FO5	20	-0.1497	0.1234
HA1	21	-0.2786	-0.5607
HA2	22	-0.3635	-0.5625
HA3	23	-0.2939	-0.4845
HA4	24	-0.3339	-0.5004
HA5	25	-0.3047	-0.4033
HU1	26	-0.6629	0.1884
HU2	27	-0.6850	0.1054
HU3	28	-0.6048	0.1365
HU4	29	-0.7710	0.1094
HU5	30	-0.5933	0.2044
IF1	31	-0.3432	-0.1239
IF2	32	-0.2769	-0.1342
IF3	33	-0.1115	0.6660E-01
IF4	34	0.7300E-01	0.1367
IF5	35	-0.1158	0.8050E-01
JU1	36	-0.1770E-01	-0.2380E-01
JU2	37	-0.3430E-01	-0.8760E-01
JU3	38	-0.4740E-01	-0.1790E-01
JU4	39	-0.6410E-01	-0.4570E-01
JU5	40	-0.4880E-01	0.7690E-01

LABEL	SEQ #	X-VALUE	Y-VALUE
KD1	41	0.1640E-01	0.1630
KD2	42	0.1872	0.2552
KD3	43	-0.1310E-01	0.7690E-01
KD4	44	-0.1629	-0.8230E-01
KD5	45	-0.1284	0.5840E-01
KO1	46	-0.5190E-01	0.2397
KO2	47	-0.2800E-01	0.1196
KO3	48	0.4440E-01	0.2415
KO4	49	0.1190E-01	0.2183
KO5	50	0.7510E-01	0.2386
KU1	51	-0.1530	-0.2137
KU2	52	0.9080E-01	-0.1706
KU3	53	0.2706	-0.1419
KU4	54	0.6890E-01	-0.2455
KU5	55	0.1453	0.8100E-02
MA1	56	0.2710E-01	-0.2163
MA2	57	0.6537	-0.1689
MA3	58	0.7069	-0.4880E-01
MA4	59	0.7505	0.1159
MA5	60	0.3732	0.1469
ME1	61	0.3114	0.2135
ME2	62	0.3926	0.1902
ME3	63	0.2552	0.2734
ME4	64	0.2440	0.9720E-01
ME5	65	-0.1024	0.3330E-01
MU1	66	-0.1377	0.8760E-01
MU2	67	-0.1777	0.7600E-01
MU3	68	-0.1058	0.1450
MU4	69	-0.8300E-01	0.2241
MU5	70	0.1520E-01	0.2238
PL1	71	0.6850E-01	-0.1851
PL2	72	-0.8650E-01	-0.9230E-01
PL3	73	0.1190	-0.5680E-01
PL4	74	0.1299	-0.7770E-01
PL5	75	0.2990E-01	-0.1327
YA1	76	0.3246	0.3011
YA2	77	0.3195	0.2416
YA3	78	0.7700E-01	0.2817
YA4	79	0.2914	0.4329
YA5	80	-0.2370E-01	0.2322

b.

Figure 66

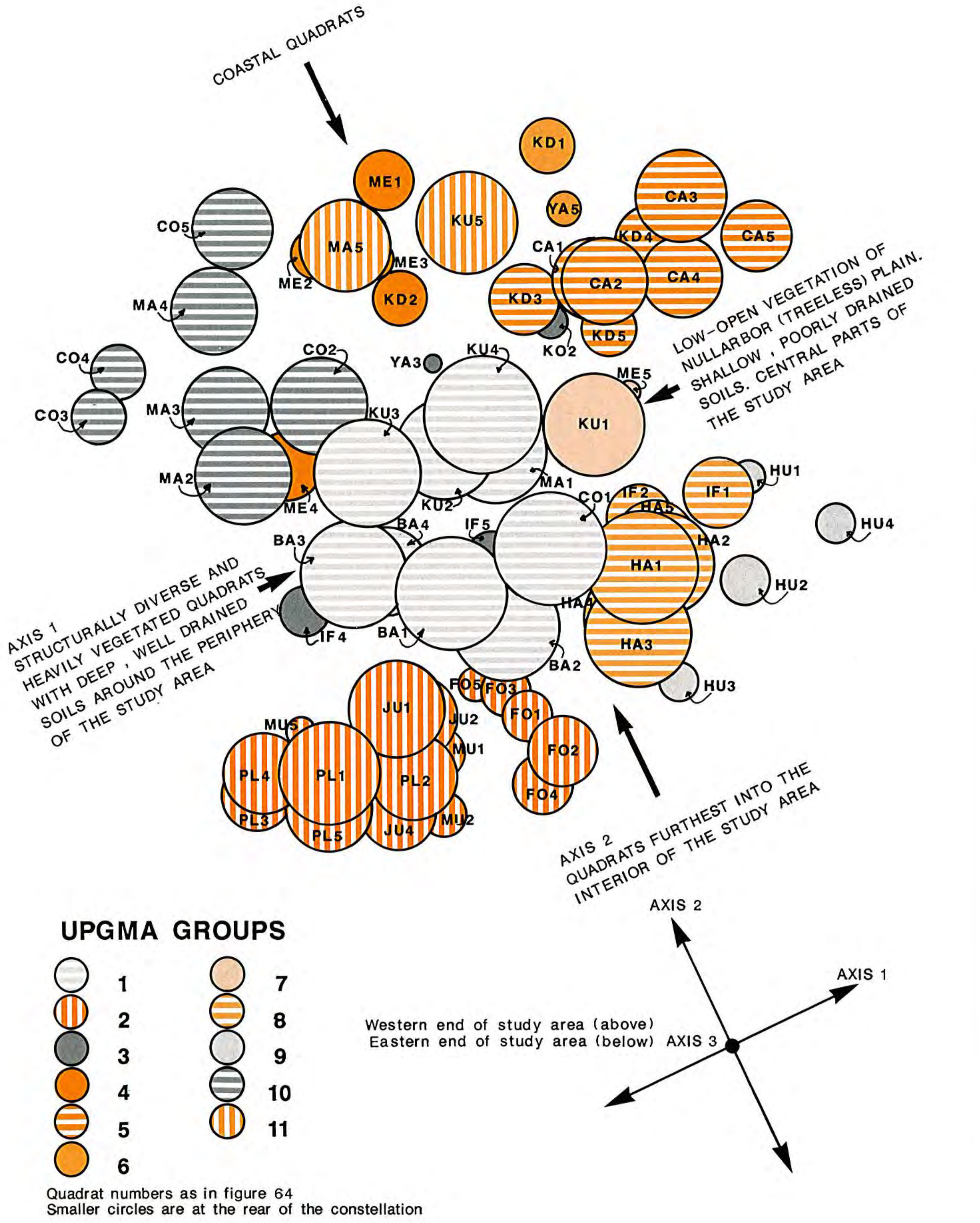


Figure 67

THREE DIMENSIONAL SCATTERGRAM FROM MULTIDIMENSIONAL SCALING (KYST) OF THE 80 QUADRATS IN TERMS OF THE PRESENCE AND ABSENCE (ON QUADRATS) OF 373 SPECIES (VERTEBRATES AND PLANTS)

A similar south to north gradient could be perceived in "Mean Annual Rainfall" (Fig. 70). In addition, this rainfall attribute had a geographically orthogonal gradient across the near-coastal parts of the Study Area, from west (drier) to east (wetter), that corresponded closely to the (west to east) pattern of change in assemblage composition identified in near-coastal areas by UPGMA (Fig. 65). The "Highest Mean Monthly Rainfall" attribute showed this west to east gradient across near-coastal areas even more clearly (Fig. 70). A similar east-west separation in assemblage composition was consistent with KYST Axis 3 (Fig. 67).

Integration of Quadrat Groups with Species Groups
The next stage in the taxonomic analysis of the binary data-base was the production of a Two-way Table (Table 41) using the UPGMA group boundaries for quadrats (columns) and species (rows). This allowed us to interpret the 19 Species Sub-groups (defined in Fig. 62) in terms of the 11 Quadrat Groupings (from Fig. 64).

UPGMA Species Group C
Semi-arid to arid zone species that favour heavy soils rather than desert sands - includes the most widespread species in the Study Area as well as those confined to woodlands, scrubs, and shrubland situations peripheral to the Treeless Plain, and a group of species confined to the shrubland situations of the Treeless Plain.

Sub-group 1 comprises species that are ubiquitous across the temperate and semi-arid zones of Australia where they favour heavy soils in association with a variety of vegetation structures (woodlands, scrubs, shrublands and grasslands). These are the most ubiquitous species; they occur in all parts of the Study Area including, to a variable extent, the Treeless (Nullarbor) Plain and the near-coastal sandy surfaces of the Roe Plain.

Sub-group 2 are woodland species widespread across Australia (as in Sub-group 1) but not penetrating the Treeless Plain.

Sub-group 3 are mainly species of semi-arid woodland environments to the east and west of the Study Area. These penetrate the Study Area in its wettest areas, the vicinity of IF, KO and YA (see Fig. 65). For some reason, few were recorded at the Balladonia (BA) quadrats even though all (except the Common Starling) occur in the heavier woodlands of the Dundas Nature Reserve, less than 100km to the south-east of BA (author's unpubl. data). Some occur in the mallee scrubs and other near-coastal parts of the Study Area. They do not penetrate the areas north of the Treeless Plain.

Sub-group 4 are species found in woodlands, mallee-scrubs and shrublands to the south and east of the Treeless Plain. As with Sub-group 3, they do not penetrate the areas north of the Treeless Plain.

Sub-group 5 are mostly species of shrubland situations that occasionally occur in very open woodlands. In the Study Area these species appeared to be almost confined to the Treeless Plain although they were occasionally found in the peripheral woodland quadrats (either in the clearings or in very open Myall and Mulga formations).

Sub-group 6 are species that only penetrate the Study Area in the vicinity of the Ifould (IF) quadrats although a few scattered records were made round the northern periphery.

Sub-group 7 comprises species widespread in shrublands and open low woodlands, to the south-east and south-west of the Treeless Plain. Some penetrate better vegetated parts of the Treeless Plain (HA).

UPGMA Species Group B
This group comprises arid zone species of well drained soils such as desert sands and deep loams - in the Study Area its species are confined to the northern periphery. Sub-grouping is apparent that can be related to:

(i) distance from the deserts; and

(ii) proximity to the South-west Interzone, the western end of the Great Victoria Desert, or the more eastern parts of the desert (known as the Western Sandplains Province).

Sub-group 8 reflects the proximity of the South-western Interzone and is a component of widespread arid zone woodland and shrubland species of heavier loamy soils that occur in the relatively dense Myall and Mulga woodlands round the western and north-western periphery of the Study Area.

Sub-group 10 comprises species widespread in the arid zone that favour the well drained sandy surfaces of the deserts and South-west Interzone, but many penetrate southwards into the Study Area as far as the northern edge of the Treeless Plain (FO5 and MU1). Some species also occur as far south as quadrats at Haig (HA), others follow the western and eastern perphery further southwards to BA and IF.

Sub-group 11 comprises sandy-surface desert species with little penetration of the Study Area. Many of the plants are confined to the western end of the Great Victoria Desert.

Sub-group 13 - arid desert species, of the Western Plains Province of the Great Victoria Desert, that distinguish the Muchera (MU) quadrats from others in the northern periphery of the Study Area. A strong eastern component is included (see Vegetation, this publication) but not all are sandy surface species.

UPGMA Species Group A
In the Study Area these mesic to semi-arid species of temperate Australia are confined to the sub-coastal and coastal areas. Sub-grouping is strong and can be related to the extent that species colonize, or are confined to:

(i) sandy sub-coastal environments of the Roe Plain;

Soil Calcium (Cramer = 0.7763)

```
         1.000            5.500             10.00             14.50             19.00
GP  NO   +-----------------+-----------------+-----------------+-----------------+

 1  10                           L---*======M=========3----------------------U
 2  15    *=======DM==3--------------U
 3  11                    L---------------1===========M====D=====3---------U
 4   5                    L-------1===D=========M=====================*
 5   8                        L-----------1=====MD=3--------------U
 6   2                                                     *=========*=========*
 7   2                              *===*====*
 8   7                        L-------------1===========M======D=====3-----U
 9   5        *===D==M3---------------U
10   4    L-------------1=================M=====D=============3---U
11   2                                                                 *===*==*
```

Soil Magnesium (Cramer = 0.7696)

```
          .000            7.000             13.00             19.00             25.00
GP  NO    +-----------------+-----------------+-----------------+-----------------+

 1  10                         L--1========DM========3--------U
 2  15    L--1=====DM====3--------U
 3  11          L-------------1=MD==3---------U
 4   5                         L--*==M==3------U
 5   8                                  L----1==M=*--U
 6   2                                            **=*
 7   2                      *==========*==========*
 8   7                      L--1==DM3-------------U
 9   5                            *-M------U
10   4    L--------------1=======================M==D===================3-------U
11   2                                                 *=====*=====*
```

Passerine Bird Species Richness (Cramer = 0.7519)

```
          0.00             2.25              4.50              6.75              9.00
GP  NO    +-----------------+-----------------+-----------------+-----------------+

 1  10                                    L---1====D==M====3--------------U
 2  20                            L-------1========D=M=====3----------------------U
 3  12                    L--------------------1=======MD===========3-------U
 4   5                                    L---1===M*-------U
 5   8            L---1===D==M========3---U
 6   2            *===*===*
 7   2                    *
 8   7            *=======*=======*
 9   5    L-------*=====M=3------------------U
10   7                                             L-------*M==3---U
11   2                                    *============*===========*
```

KEY

*	UPGMA Group Numbers from Figure 64
NO	Number of Quadrats in Group
1 & 3	1st & 3rd Quartiles
M	Mean
D	Median
U	Maximum Value
L	Minimum Value

Figure 68
INTERPRETATION OF UPGMA QUADRAT GROUPS IN TERMS OF SOIL CALCIUM, SOIL MAGNESIUM AND PASSERINE BIRD SPECIES RICHNESS VALUES.

Mean Annual Radiation (Cramer = 0.9531)

```
         19.15            19.47            19.80            20.12            20.44
GP  NO    +----------------+----------------+----------------+----------------+

 1  10          *=*==*
 2  20                                             L---1======D==M=========3---U
 3  12           *=D====M=====3--------U
 4   5          L*U
 5   8            L1DM==3U
 6   2          *=*=*
 7   2            ***
 8   7                                 L--1=*=3U
 9   5                                       L1M*U
10   7    L-1*3U
11   2    *=*=*
```

Radiation Seasonality (Cramer = 0.9672)

```
        Ø.83ØØ           Ø.87ØØ           Ø.91ØØ           Ø.95ØØ           Ø.99ØØ
GP  NO    +----------------+----------------+----------------+----------------+

 1  1Ø                                                        *=D==M=======*
 2  2Ø    L----1===DM=====3------U
 3  12                                          L------1=====M====*
 4   5                                                            *
 5   8                                                        *==M*
 6   2                                                            *
 7   2                                                        *=*=*
 8   7                                      L-1==DM==3----U
 9   5                                      L---M*
1Ø   7                                                                    L------**
11   2                                                                        *==**
```

Latitude (°South) (Cramer = 0.9812)

```
         29.38            3Ø.Ø9            3Ø.8Ø            31.52            32.23
GP  NO    +----------------+----------------+----------------+----------------+

 1  1Ø                                                                L---1=MD*
 2  2Ø    L------1==DM====3-U
 3  12                                          L--------1====M==D=*
 4   5                                                             ***
 5   8                                                     L-1=MD3U
 6   2                                                           ***
 7   2                                                           *==*=*
 8   7                                               L-*M3U
 9   5                                     L*3U
1Ø   7                                                                         L-**
11   2                                                                       *==*=*
```

KEY

*	UPGMA Group Numbers from Figure 64
NO	Number of Quadrats in Group
1 & 3	1st & 3rd Quartiles
M	Mean
D	Median
U	Maximum Value
L	Minimum Value

Figure 69

INTERPRETATION OF UPGMA QUADRAT GROUPS IN TERMS OF SOLAR RADIATION AND LATITUDE ATTRIBUTES.

Mean Annual Temperature (Cramer = 0.9340)

```
          16.97             17.71             18.45             19.19             19.93
GP  NO   +-----------------+-----------------+-----------------+-----------------+
 1  10         L-------1==M=D3---U
 2  20                                           L----L=========DM============3-U
 3  12              L-1D===M===3--------U
 4   5    *3MD---U
 5   8            L1=*=3U
 6   2          *===*===*
 7   2       *=**
 8   7                            L------1==M==*U
 9   5                             L1=M*U
10   7                L--1==MD=3U
11   2              *=**
```

Mean Annual Rainfall (Cramer = 0.9340)

```
          158.2             180.9             203.5             226.2             248.9
GP  NO   +-----------------+-----------------+-----------------+-----------------+
 1  10                                  L--1=======M=D=3---U
 2  20   L-----1========MD=========3---U
 3  12                                          L------1===========M=====D===3-U
 4   5                                                  L**-----U
 5   8                                                     L1*=*
 6   2                                                          ***
 7   2                                            *=*==*
 8   7                             L*====M==3----------U
 9   5                             *==*=3U
10   7                                    L--1DM=3--U
11   2                                       *
```

Highest Mean Monthly Rainfall (Cramer = 0.9186)

```
          18.90             22.60             26.30             30.01             33.71
GP  NO   +-----------------+-----------------+-----------------+-----------------+
 1  10              L-1====D=M==========3U
 2  20   L1DM==3--U
 3  12                                 L--------------1=============M=====D=======*
 4   5                                          L-1*-M-------------U
 5   8                                                   L-1=MD=3U
 6   2                                                             *=*=*
 7   2                                 *===*===*
 8   7        *D=======M======3-----------------U
 9   5               **=*
10   7                       L-1D=M=3---U
11   2                                   *=*=*
```

KEY

- * UPGMA Group Numbers from Figure 64
- NO Number of Quadrats in Group
- 1 & 3 1st & 3rd Quartiles
- M Mean
- Median
- U Maximum Value
- L Minimum Value

Figure 70
INTERPRETATION OF UPGMA QUADRAT GROUPS IN TERMS OF TEMPERATURE AND RAINFALL ATTRIBUTES.

(ii) beach situations; or

(iii)southern Eucalyptus woodlands and/or mallees.

Sub-group 14 species are widespread in quadrats of the near-coastal situations with more predictable rainfall, including southern mallee-scrubs and Eucalyptus woodlands as far north as the quadrats at the Balladonia camp (BA). This group comprises mostly vertebrates. It may reflect their mobility or distinguish species with less specialised resource requirements.

Sub-group 15 comprises species that favour the near-coastal Eucalyptus woodlands and mallee scrubs found along the most mesic parts of the southern periphery of the Treeless Plain (ME, KD, KU2, YA).

Sub-group 16 species favour the mallee-scrubs of the Hampton Range (ME, KD, KU2), but not the woodlands. The Variegated Fairy-Wren is more widespread.

Sub-group 17 - species favouring unconsolidated beach dunes and adjacent vegetations. The last three are salt marsh (samphire) species.

Sub-group 19 - species of the consolidated marine sand dunes of the Roe Plain some of which were also recorded on adjacent unconsolidated beach dunes.

Discussion

Structure and Geographic Patterning of Assemblages in the Study Area

The main physical and biological gradients that correspond to patterns of change in assemblage composition (binary data) recognised across the Study Area are indicated on Fig. 67.

Axis 1 was interpreted as a gradient, from peripheral to central parts of the Study Area, involving decreasing soil depth and porosity. Such gestalt characters have previously been found to provide a better correspondence with patterning of species than is provided by the individual soil attributes we measured (Webb et al. 1980, Beeston and Webb 1977). Unfortunately, the soil depth and porosity attributes were not quantified during the 1984 field program.

In general, our approach to soil sampling proved unsatisfactory, with just one grab sample per 4km^2 quadrat. The axis separating species of sandy, well-drained substrates from those of poorly drained soils in Fig. 67 suggests that careful soil descriptions may help to identify the causal factors underlying Axis 1 of Fig. 67.

Axis 1 also corresponds to a gradient of change in the structural diversity and biomass of the vegetation and in passerine bird species richness.

Axis 2 in Fig. 67 corresponds to a gradient from quadrats in coastal areas (with lowest mean annual solar radiation and temperature, the highest mean annual rainfall and with a strongly seasonal rainfall pattern) to those furthest inland. These climatic attributes are likely to be influenced by the anti-clockwise direction of airflow associated with the anticyclones that move across the Study Area in a west to east direction. These bring cool, moist air masses from the southern ocean, northwards, into the Study Area. This probably accounts for the strong south-north (rather than west-east) pattern of change noted in the species composition of heterotherm (lizard) assemblages and the similarity of their assemblages east to west (described in Reptiles and Amphibians, this publication).

North-south patterns of change in assemblage composition were also noted in the other sub-sets analysed (see the appropriate bird and vegetation sections of this publication). The above climatic gradients provide a physical explanation why "distance from the ocean" corresponded to a major axis in the KYST scatterplot (Fig. 67) derived from biological attributes.

However, east-west patterns of change were at least as important as north-south patterns in the plant and bird assemblages (especially the patterns of annual plants) (see relevant papers here-in) as well as in the combined assemblages (Fig. 65). These east-west patterns were shown to correspond very closely to a gradient in rainfall attributes that is most obvious across the near-coastal parts of the Study Area and recognisable as KYST Axis 3. The far eastern end of the Study Area has the highest, strongly seasonal rainfall, the western near-coastal end has a significantly lower, but equally seasonal rainfall.

It seems that there are differences in the environmental scalars (see Austin, Cunningham and Fleming 1984) that are important in specifying the biotic gradients perceived in the different sorts of organisms. Thus, a more thorough appraisal of the physical attributes is needed in which the sub-sets of birds, reptiles, mammals and plants are examined separately. In this context, the seasonal mobility of many birds also needs to be taken into account.

The absence of discrete clusters in the scattergrams of quadrats in Figs. 66 and 67, and the step-wise structure of the dendogram of quadrats (Fig. 64), point to gradational changes in the assemblages of species across the Study Area, rather than abrupt biotic boundaries.

This conclusion is consistent with the district's low topographic relief, uniform geology, (hence gradational rather than mozaic patterns of change in soils) and consistently arid, but locally unpredictable climate. Soils are limestone derived earths with a variable component of ferruginous desert sands in the north and marine sands in near-coastal areas. Climatic patterns range from:

(i) predictable, almost semi-arid, strongly seasonal (winter) rainfall in near-coastal areas - associated with proximity to the Southern Ocean and the topographic influence of the Hampton Range and Bunda Cliffs (see Fig. 14), to

(ii) the unpredictable, more extreme, arid climate of the Nullarbor (Treeless) Plain, and especially the northern periphery of the Study Area.

Communities Recognised

The eleven ecologically distinct groups of quadrats distinguished by the pattern analyses are mapped in Fig. 65. Ecologically distinct groups of species could also be distinguished; the species within each group are similar in terms of the surface-types and/or climatic regimes that characterize their geographic distributions across the continent. Because of a deadline for this (initial) publication, no quantitative attempt is made here-in to interpret these species-groups in terms of physical attributes, though, as has been pointed out by De Graaf, Tilghman and Anderson (1985), such species-groups may provide a basis for ecosystem management.

By considering the intersection of quadrat-groups and species-groups in the Two-way Table (Table 41) we could distinguish eleven community-types in the Study Area that have general relevance to wildlife management decisions such as reserve system design. The internal structures of these community-types are compared below.

(1) The South-western Woodlands and Shrublands Assemblages.
These assemblages were a mixture of Species Sub-groups 1, 2, 4 and 7 (ubiquitous semi-arid to arid species of heavy soils), including some of the shrubland specialists (Sub-group 5), along with a selection of exclusively arid zone species from Sub-groups 8 and 10, and the semi-arid vertebrates of Sub-group 14 (see Figs. 65 and Table 41).

They included an average of 56 $\pm$ 13.9 (SD), (n=10) species (excluding non-passerine birds, corvids, snakes and goannas) and comprised a selection of the species found in equivalent situations in the South-western Interzone. The quadrats further into the Study Area (KU2-4, MA1 and CO1) were considerably poorer in species (45 $\pm$ 10.3(5)) than those at the Balladonia (BA) camp (67 $\pm$ 5.4 (5)), reflecting a continuation of a gradient of attenuation in species richness extending eastwards from the heavier woodlands of the South-western Interzone. The three semi-arid samphire species of Sub-group 17 (found at KU3-4 and MA1) were not recorded on the BA quadrats or CO1.

(2) The Northern Woodlands Assemblages.
These comprised a selection of the more mobile species of Sub-groups 1 and 2 (semi-arid to arid species ubiquitous on heavy soils, especially the birds), as well as a rich component of arid zone plant and vertebrate species most of which favour the well-drained soils of desert areas to the north. This community-type included the richest assemblages in the Study Area, those adjacent to the Great Victoria Desert (herein this includes the Western Sandplain and Great Victoria Desert Environmental Region of South Australia) - the Plumridge (PL) and Muckera (MU) quadrats (mean = 73 $\pm$ 14.9(10)). The PL quadrats included Species Sub-groups 8 and 11, whereas the MU quadrats included Species Sub-group 13; this is mainly a vegetational difference thought to reflect differences between the floras of Western Australia's Great Victoria Desert (adjacent to PL) and the Western Sandplain Environmental Region of South Australia (adjacent to MU). The vertebrate faunas of MU, JU and PL were more similar than their floras (see Table 41).

The quadrats near the Forrest (FO) campsite were further from these desert areas and poorer in species (mean = 32 $\pm$ 9.7(5)); they included a reduced selection of desert plant and vertebrate species (Species Group B), many of the vertebrates, but not the plants, of Sub-group 1 (woodland and thicket on heavy soils), and only one species (a bird) from Sub-group 2. Unlike other Northern Woodlands assemblages, a proportion of chenopod shrubland species typical of the Treeless Plain (Sub-group 5) was present at FO.

In terms of their distance from the desert, their species composition, and their richness, the quadrats near the Jubilee (JU) campsite were intermediate between PL and FO assemblages.

(3) The South-eastern Woodlands Assemblages.
These were very similar in species richness (60 $\pm$ 7.6 (12)) and composition to those of the "South-western Woodlands and Shrublands". The main difference was the presence in the South-east of fewer "Sub-group 1" species but a much greater variety of the species found in heavier woodlands and scrubs of the semi-arid districts to the east and west of the Study Area. In particular, the South-eastern Woodlands included the "arid to semi-arid" Sub-groups 2 and 3 (Table 41) of Species-Group C and the vertebrates (mainly) of the "mesic to semi-arid" Sub-groups 14 and 15 of Group A. This "mesic" component was part of the assemblages sampled at the Yalata (YA) campsite but few were recorded further inland at KO or IF quadrats (see Fig. 65). The arid-zone vertebrates and plants of Sub-group 8 were absent although some of the species favouring arid sandy surfaces (Sub-group 10) were recorded in the IF quadrats.

(4) Hampton-Range Mallee-Scrub Assemblages.
These comprised: (a) the components of species Group A (mesic to semi-arid species) that were found in semi-arid areas (Sub-groups 14, 15 and especially 16) and (b) the vertebrates (mainly) of Sub-groups 1 and 2 of the semi-arid zone species that favoured heavy soils, except those from Sub-group 1 that favoured open-woodland and shrublands of the arid zone (such as the Ground Cuckoo-Shrike, Crimson Chat, Slender-billed Thornbill, *Tympanocryptus lineata* and a variety of herbs and grasses). Mobility seemed to be an important factor governing the colonization of these assemblages by Group C species.

These assemblages had similar species richness (43 $\pm$ 7.0 (5)) to mallee-scrub quadrats further west on the Hampton Range near Cocklebiddy and Kuthala (CO3 : 49 species, KU2 : 42 species) but were poorer than mallee quadrats sampled on the Roe Plain : CO4 (53 species), CO5 (68), MA4 (49).

(5) Near-coastal Treeless Plain Assemblages.
These comprised a selection of the "semi-arid to arid zone" species of heavy soils (Sub-group 1), especially those of open vegetations such as chenopod shrublands and grasslands (Sub-groups 4 and 5). A few of the semi-arid birds from Group A were also present. Assemblage species richness averaged 32 $\pm$ 8.6 (8).

(6) South-eastern Coastal Shrubland Assemblages.
These comprised a selection of "arid to semi-arid" plant and vertebrate species of heavy soils from Sub-group 1, Sub-group 4 and several of the semi-arid tolerant vertebrates from the "mesic to semi-arid" Group A (Sub-group 14). Species richness of the two quadrats (KD1 and YA5) comprising this community-type was 26 and 38 respectively.

(7) Southern Treeless Plain Assemblages.
These (KU1 and ME5 see Fig. 65) were dominated by a selection of heavy soil species ubiquitous in arid to semi-arid woodlands, chenopod shrublands and grasslands (Sub-group 1). These two quadrats were as poor in species (28 and 18 species respectively) as the Treeless Plain quadrats north of Hughes (HU1-5) in the driest part of the Study Area. Essentially, the KU1 and ME5 sites supported a very poor sub-set of the more ubiquitous species recorded in the "Near-coastal Treeless Plain assemblages".

(8) Treeless Plain.
The less disturbed assemblages of the Treeless Plain comprised a selection of the ubiquitous Sub-group 1 species as well as the chenopod shrubland/grassland specialists of Sub-group 5 and a few desertic species (Group B) at their southern limits. The "semi-arid to mesic" component found on the "Near-coastal Treeless Plain assemblages" was absent. Species richness averaged 43 $\pm$ 7.9 (7).

(9) Degraded Treeless Plain Assemblages.
These were a species-poor (23 + 9.8, (5)) selection of the species components comprising the "Treeless Plain assemblages", though three native plants of Sub-group 5 were only recorded at these quadrats.

(10) Coastal Mallee and Woodland Assemblages.
These included a selection of the more ubiquitous birds and reptiles belonging to the "arid to semi-arid species" of Sub-group 1, and a dozen of the non-desert arid to semi-arid woodland species of Sub-group 2 (again these were mainly birds and reptiles). But the richest component of species in these assemblages, including nearly all the plants, belonged to Species Group A - the "mesic to semi-arid" species of Sub-groups 14 and 19. The mean species richness of the assemblages was (54 $\pm$ 7.4 (7)), similar to that of the south-western and south-eastern woodlands assemblages.

(11) Beach Assemblages.
These were most similar in composition to those of the "Coastal Mallee and Woodland". However, few of the Sub-group 19 species were included and eight of the plants in Sub-group 17 were confined to these unconsolidated marine sands. Quadrat richness was similar to other sandy sites on the Roe Plain; 58 species (MA5) and 48 species (KU5).

Overview

The above descriptions of intersections between Quadrat-groups and Species-groups, point to the sources of patterning in the biota of the Study Area - influence from the biotas of adjacent natural districts, combined with attenuation in the species richness of assemblages in the Study Area related to increasing distance inside its boundaries. Quadrats towards the centre of the Study Area have lower species richness; they support a species-poor subset of the species present in more peripheral assemblages.

The composition of assemblages depends on their proximity to adjacent natural districts but is influenced by soil-type, climatic gradients and differences in the mobility of vertebrates compared with plants.

The correspondence shown between patterns in the biota and gradients in physical attributes (discussed earlier) is further evidence of the influence of soil-types and climatic attributes. These interpretive analyses indicate that differences in the patterning of the bird, reptile, mammal and plant sub-sets were not due to stochasm (see Wiens 1981); they could be interpreted in terms of different responses to various gradients in the physical environment. The patterns derived from our analyses of the combined assemblage data were shown to encompass at least the principal biotic gradients noted in all sub-sets (see Fig. 67).

The mobility of the vertebrate species compared with the plants also explains some of the differences in quadrat classifications noted when the pattern of community-types described above (and mapped in Fig. 65) was compared with its equivalents in the sub-set chapters. These were discussed individually in the preceding descriptions. For instance, the intrusion of a small group of "mesic to semi-arid" vertebrates from Sub-group 14, northward as far as the Balladonia (8A) quadrats, was identified in the description of the "South-western Woodland Assemblages".

In distinguishing the eleven community-types described above, equal weighting was given to every species irrespective of whether it was a honeyeater, a cryptic little herb or a gum tree. These groupings can be used as an almost objective basis for assessing the representativeness (sensu. Austin and Margules 1984) of the existing reserve system on the Nullarbor Study Area because:

(1) they encompassed pattering by organisms of very different sorts with divergent mobilities, longevities, dispersal mechanisms etc.; and

(2) biotic gradients were recognised between and within these 'community-types' that could be related to certain topographic and climatic attributes of the physical environment.

Such a reserve system assessment is made in the next chapter where recommendations for additional major reserves are derived using a tabular approach. However, as pointed out by Margules and Scott (1984), such an approach is only a first approximation to designing a representative reserve system.

Further refinement of reserve system design involves the modelling of biotic variation. For the Nullarbor this will be the subject of a subsequent project in which logistic regression analysis (and extra field-sampling if necessary) will be used to specify the relationships between the biotic gradients and gradients in the physical environment. These should allow us to predict the species composition of unsampled sites elsewhere in the Study Area in terms of a set of already-mapped environmental attributes. For instance, using the computer package GLIM (Baker and Nelder 1978), Austin, Cunningham and Fleming (1984), and Margules and Nicholls (in press) have successfully applied this analysis to sets of floristic data from Australia.

Some modification of the above patterns should be expected, year to year, because the habitat selectivity of many vertebrate species is known to change with population density (Rosenzweig and Abramsky 1985).

TABLE 40: ANALYSIS OF BIOPHYSICAL ATTRIBUTES: AN INTERPRETATION OF UPGMA QUADRAT GROUPINGS IN TERMS OF BIOPHYSICAL ATTRIBUTE VALUES

Attribute Name	Cramer Ratio*	Attribute Name	Cramer Ratio
SOIL		Seasonality	0.97
Total Nitrogen	0.51	Wettest Quarter	0.87
Phosphorus	0.55	Driest Quarter	0.37
Potassium	0.60	TEMPERATURE	
Calcium	0.78	Mean Annual	0.93
Magnesium	0.77	Highest Mean Monthly	0.91
¿2mm Gravel	0.43	Lowest Mean Monthly	0.83
% Sand	0.70	Range	0.93
% Silt	0.70	Seasonality	0.85
% Clay	0.64	Wettest Quarter	0.89
Ph	0.51	Driest Quarter	0.33
Conductivity	0.61	RAINFALL	
SPECIES RICHNESS		Mean Annual	0.90
Passerine Bird	0.75	Highest Mean Monthly	0.92
Lizard	0.62	Lowest Mean Monthly	0.71
Small Ground Mammal	0.52	Range	0.85
Perennial Plant	0.57	Seasonality	0.76
Total Plant	0.51	Wettest Quarter	0.91
Total	0.64	Driest Quarter	0.41
SOLAR RADIATION		GEOGRAPHICAL	
Mean Annual	0.95	Latitude (^{o}S)	0.98
Highest Mean Monthly	0.76	Longitude (^{o}E)	0.82
Lowest Mean Monthly	0.94	Altitude	0.88
Range	0.96		

Cramer Ratio (Between Sample Variance/Total Variance) is a measure of "goodness of fit". A perfect fit has a value of 1.0.

REPTILES

PLANTS

MAMMALS

BIRDS

● ERRORS IN DATA BASE

Table 41

TWO-WAY TABLE FROM TOTAL DATA ANALYSIS

QUADRAT GROUPS

SPECIES GROUPS / Species Sub-Groups	Species	1	2	3	4	5	6	7	8	9	10	11
		BBBBBCMKKK AAAAAOAUUU 1245311243	FFFFFJJJJJPPPPPMMMMM OOOOOUUUUULLLLUUUUU 12435123451253412345	IIIKKKKKYYYY FFFOOOOOAAAA 354134521243	KMMMM DEEEE 21234	CCCCCKKK AAAAADDD 12345345	KY DA 15	KM UE 15	HHHHHII AAAAAFF 1253412	HHHHH UUUUU 12354	CMMCCCM OAAOOOA 2233454	KM UA 55
A	Acacia papyrocarpa	***** ****	*** ********	******* *	*	**		*	* *			
	Gymnorhina tibicen	****** ***	***** ******* ** *	** * **		*		*			*	
	Aphelocephala leucopsis	**** *****	**** ***** * * *****	*** ****		** * *		**	* * *			
	Artamus cinereus	**** ****	********************	** * *	* *	** *	*	**	* *	*	*	*
	Gehyra variegata	* * *	********************	** * ** * *					*		**	
	Oreoica gutturalis	**** *** *	* ****** *********	******* *	*		*				**	
	Rhipidura leucophrys	**** *****	********** *********	*** *** **	* *	* *		*		*		
	Rhagodia spinescens	*****	************** ****	******* *					* * *	****		
	Petroica goodenovii	***	**** * *** **** **	* **** ** *	*					**		
	Mus musculus	***	* ** **** *********	******** ***	* **	* * ***	**	**	** ***	*****		**
	Lichenostomus virescens	** *****	********** * *******	******** *	** *	*	**		*	***		**
	Enchylaena tomentosa	*** *	* **** ****	******* * *	***	*		**	* *	**	*	**
	Acacia oswaldii	* *	********* *****	** ** ****	* *	* ***				*		*
	Acanthagenys rufogularis	*********	** ** **** **	* **** ****	*****	*					*	*
	Manorina flavigula	* *** ****	********************	**** *******	*****	* * *					**	
	Coracina novaehollandiae	* *** ***	**** ** *** **	** ** ***	* *	**					**** *	**
	Cracticus torquatus	***** ****	* **************	**** *******	*****	** * *	**	*	*		*******	**
	Colluricincla harmonica	** *	***** * ***** ***	***********	*****	*					*******	*
	Pomatostomus superciliosus	** *	* *** **** *********	******* **	*****	*	*				**** *	*
	Acanthiza chrysorrhoa	** ** *	* ** ***	*** *******	*	*					**	
	Menetia greyi	* **	************* ** **	** *		* * *	**	*		*	*** **	*
	Ctenotus schomburgkii	*****	***** * **	* *****	*							
	Santalum acuminatum	* *	******* *	*** ***	* ***	**						
	Brachycome ciliaris	**********	* ** * *	** ***** ***		*			**			
	Myoporum platycarpum	********	** * *	****** ****		**						
	Lalage sueurii	* * ***	* ** **	* **						*	*	*
	Melanodryas cucullata	*** *	***** *********	* *** *		*						
	Acanthiza uropygialis	***	** *** ***	* * ** *								
	Stenopetalum lineare	**	*** ***** *	** **					**			
	Eriochiton sclerolaenoides	*	* * ****	* ***		*			* **		*	
	Aristida contorta	******	******* ****						** **		*	
	Sclerolaena diacantha	******* *	*******************	*	*			*	*****		***	*
	Acacia tetragonophylla	***	* ** * * *** ****						*	**		
	Ephthianura tricolor	**** *	** *** ***	*					* *		*	
	Lepidium phlebopetalum	* *	*** *******	**		*			* ***		* *	
	Heterodendrum oleaefolium	* ***	* *** * ***	* *					****	*		
	Eremophila scoparia	****	* * ** *	* * *					* **		*	
				* *							*	
								*	*******		**	
			*	** *					** ****			
									*****			
									*****	**		
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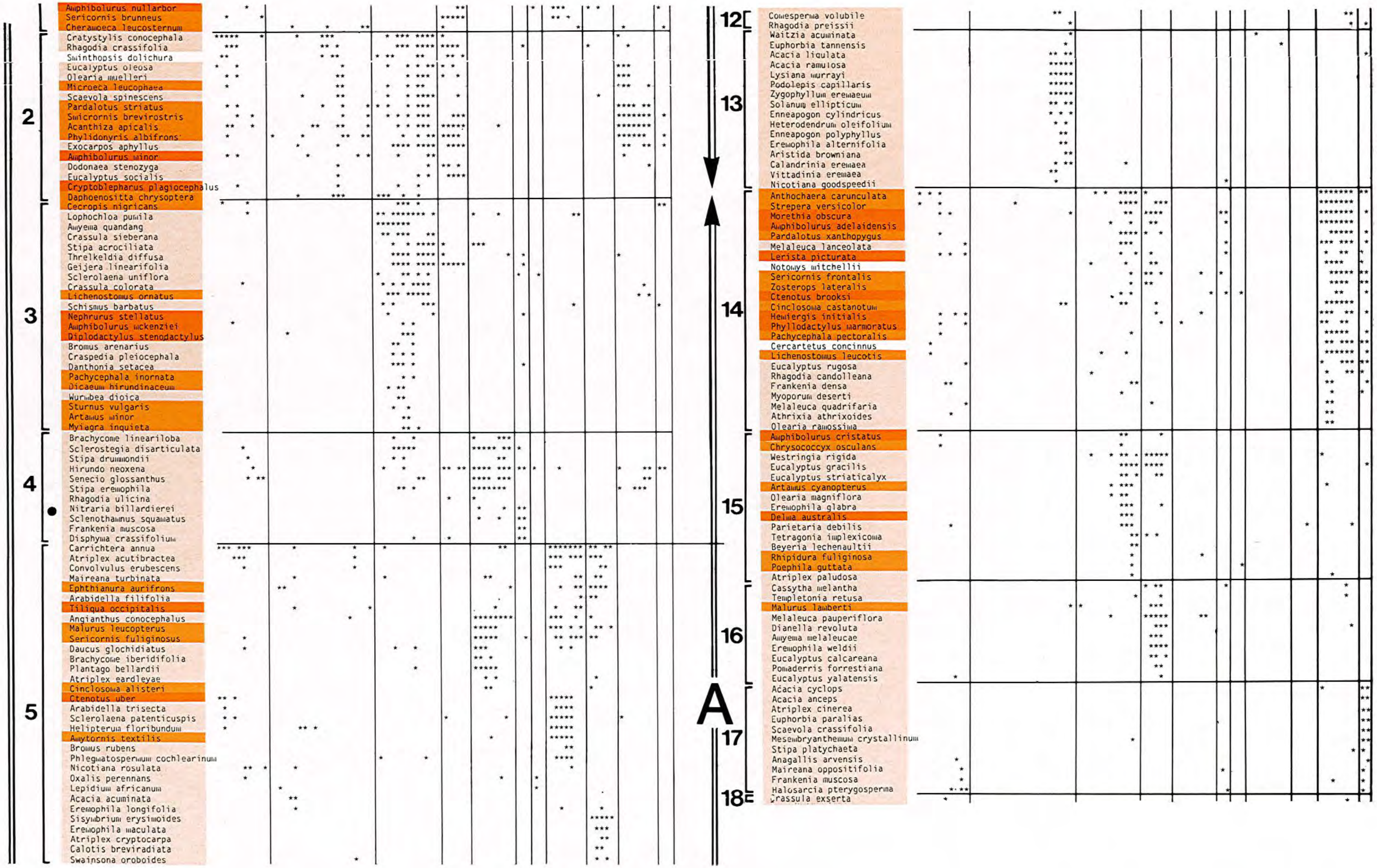
				* ***** *		** **	**		*			*
			*	******* *		*** **			* *		*	**
				********** *	* ***	********	**	*	*******		***	*
				****** **	** *	********	**	**	* *** *	**	* *	
			* *	** ***** ***		** * **	*	*	******	***		**
C	Sclerolaena obliquicuspis			** ***** *		** **			*****	*****		
	Maireana eriocłada	*** * **	* ****	***********	*****	* * **	*	*	**		***	
	Pittosporum phylliraeoides	* *	** ****	**** ****	*		*	*	* **	* **		
	Stipa nitida		*****	** *********		***	*		**	****		
	Anthus novaeseelandiae	** * ****	********** * ***	** * *	**	********	**	**	*******	*****		*
	Lycium australe	**** ** *	* ** **	** *		**** **			*** *	***		*
	Underwoodisaurus milii	*	****** * ***	* * * * *	*	** **	*	*	** ** *	* **		
	Maireana sedifolia	*******	** ******** *	***		**** ***		**	*** ***	**		
	Salsola kali	** **	***** * * *** *****	**** *	* *	** *	*		*******	*****		
	Cinclorhamphus cruralis	* * ****	* * ** * ***			* **		*	*******	*		
	Sminthopsis crassicaudata	** *	** ** **** * ***	* *				*	******	*		
	Erodium cicutarium	** *****	**	* *		*******			*			
	Isoetopsis graminifolia	* * **		* *		* * ***						
	Morethia adelaidensis	**** *	****	*** *		* ** **	*	*	* * *			
	Tympanocryptis lineata	**** *	****	*		*** **		*	****			
	Acanthiza iredalei	*** * *		* * *		*****			**** *			
	Calotis hispidula	****	* *	** ***					* ***			
	Omphalolappula concava	*	*	** *		* *			***			
	Tetragonia eremaea	* *	**** **	**				*	**			
	Brassica tournefortii	**	**	** ** *			*		**		*	*
	Gnephosis skirrophora		**	* * *		*	*		**			
	Lysiana exocarpi		* *	* *			*			**		
	Diplodactylus granariensis	*** ** *		* ** *	* **	*		**	* *		******	
	Lerista frosti	* ********			**	* ***					** *	*
	Geijera parviflora	***** * *									***	**
	Zygophyllum ovatum	**							*	* *	*	
	Atriplex nummularia	* ***	* ** *		****			*	* ***		**	*

QUADRAT GROUPS

SPECIES GROUPS / Species Sub-Groups	Species	1	2	3	4	5	6	7	8	9	10	11
		BBBBBCMKKK AAAAAOAUUU 1245311243	FFFFFJJJJJPPPPPMMMMM OOOOOUUUUULLLLUUUUU 12435123451253412345	IIIKKKKKYYYY FFFOOOOOAAAA 354134521243	KMMMM DEEEE 21234	CCCCCKKK AAAAADDD 12345345	KY DA 15	KM UE 15	HHHHHII AAAAAFF 1253412	HHHHH UUUUU 12354	CMMCCCM OAAOOOA 2233454	KM UA 55
8	Artamus personatus	***** *	* ***								** *	
	Zygophyllum aurantiacum	*	**** * ***								** *	
	Cracticus nigrogularis	** *	****									
	Eremophila decipiens	*	****						* *			
	Diplodactylus maini	*****	**									
	Helipterum floribundum	* ** *	***									
	Pseudomys bolami	* *	* *									
	Amyema fitzgeraldii	**	*									
	Maireana sclerolaenoides	*	*									
	Calotis multicaulis	*	*									
9	Helipterum strictum	*	*									
10	Casuarina cristata	*	******* **									
	Amphibolurus reticulatus		** ****** **									
	Pseudomys hermannsburgensis		** * ** * *									
	Rhynchoedura ornata		* * * **									
	Pachycephala rufiventris	*	* *** ***									
	Acacia aneura		* *************					*		*		
	Sida corrugata		* *********						**			
	Helipterum fitzgibbonii		**********	***					**			
	● Cassia artemissioides		** ** ***	*					*			
	Diplodactylus pulcher		* * * *									
	Heteronotia binoei	*	**** ***** *	* **								
	Ptilotus obovatus		******** ***	* * **					*			
	Maireana trichoptera		** *****	*** *				*			*	
	Santalum spicatum	*	**** * ** *	* *								
	Cassia nemophila	**	* *********									
	Eragrostis eriopoda		* ** ** *									
	Lerista desertorum		**** **** *									
	Enneapogon caerulescens		*** *** * *									
	Helichrysum ayersii		**** ****									
	Climacteris affinis		*** **	*								
	Cephalipterum drummondii		** * **	**					*			
	Ctenotus regius		* ** ****	***								
	Eragrostis dielsii		** *									
	Lerista bipes		*** **									
	Nephrurus levis		* *									
	Goodenia pinnatifida	*	*** *						* **			
	Swainsona campestris	*	***									
	Enneapogon nigricans	*	* * *****									
	Acacia aff. papyrocarpa		* * *									
	Cassia sturtii		***									
	Enneapogon avenaceus	* *	** * *									
	Lerista labialis		*** **									
	● Melopsittacus undulatus		* * *									
	Clianthus formosus		** ** **									
B	Chenopodium cristatum		* *									
11	Calandrinia calyptrata		***								*	
	Triodia scariosa		**								*	
	Brunonia australis		**									
	Eremophila sp. 2		**									
	Eremophila sp. 2		**									
	Ptilotus exaltatus		**									
	Stenopetalum velutinum		**									
	Velleia rosea		**									
	Waitzia aurea		**									
	Erodium cygnorum		* * ** **									
	Lerista muelleri		* * ***									
	Solanum lasiophyllum		* *****									
	Euphorbia boopthana		*****									
	Maireana triptera		*****									
	Sida calyxhymenia		* ***									
	Stenopetalum sphaerocarpum		****									
	Ptilotus gaudichaudii		* ***									
	Goodenia occidentalis		* **									
	Paspalidium jubiflorum		* *									
	Cryptoblepharus carnabyi		**									
	Sminthopsis ooldea		** *									
	Morethia boulengeri		* *									
	Chrysococcyx basalis		*	*								
	Ptilotus polystachyus		* ** * *									
	Acacia burkittii		** **									
	Dodonaea angustissima		** **									
	Acacia kempeana		* **									
	Paspalidium constrictum		* **									
	Egernia inornata		* *									
	Abutilon cryptopetalum		* *									



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Group		Species											
6		Minuria cunninghamii			**		*				*		
6		Atriplex stipitata			**								
6	●	Cassia artemissioides			**								
6		Lucasium damaeum		*	* *								
6		Erodium moschatum								**			
6		Plantago drummondii								**			
6		Swainsona oliveri			*					**			
6	●	Sonchus oleraceus			*					*			
6		Acacia nyssophylla		*	*					*			
7		Centaurea melitensis	**							*			*
7	●	Nitraria billardierei	* ***							**			**
7		Gunniopsis calcarea	* *			*	*						
7		Helipterum chlorocephalum	** *										
7		Plantago debilis	** *										
7		Ephthianura albifrons	* * *		*					*			
7		Helipterum humboldtianum	**		*					*			
7		Diplodactylus intermedius	* *										
7		Sclerolaena brevifolia	* * **										
7		Maireana radiata	** *		* *								
7		Stipa elegantissima	*****		*					*			

Group	Species											
19	Cryptoblepharus virgatus										** ***	
19	Eopsaltria griseogularis										*** *	
19	Amphibolurus muricatus				*						****	
19	Pterostylis mutica										* *	
19	Adenanthos forrestii										**	
19	Beaufortia micrantha										**	
19	Boronia crassifolia										**	
19	Conostephium drummondii										**	
19	Egernia multiscutata										**	
19	Gahnia lanigera										**	
19	Lepidosperma viscidum										**	
19	Lichenostomus cratitius										**	
19	Loxocarya flexuosa										**	
19	Lysinema ciliatum										**	
19	Pomaderris myrtilloides										**	
19	Thysanotus patersonii										**	
19	Amphibolurus maculatus										****	
19	Lerista distinguenda										****	
19	Hakea nitida										***	
19	Callitris preissii										***	
19	Dodonaea viscosa										***	
19	Eucalyptus incrassata										***	
19	Malurus pulcherrimus										***	
19	Eucalyptus diversifolia										* *	
19	Eucalyptus foecunda										* *	
19	Acacia cochlearis										**	
19	Acacia nitidula										**	
19	Sericornis cautus	*									*	
19	Carpobrotus modestus										**	**
19	Carpobrotus rossii										**	**
19	Drymodes brunneopygia										*	*
19	Muehlenbeckia adpressa										*	*
19	Myoporum insulare										*	*
19	Sminthopsis gilberti										* *	
19	Triglochin calcitrapum										**	
19	Melithreptus brevirostris										* *	
19	Portulacca quadrifaria										* *	*

CONCLUSIONS AND CONSERVATION RECOMMENDATIONS

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Overview

The development of a national system of representative conservation reserves has become part of conservation management strategy throughout Australia. This concept was examined by Fenner (1975). Specht, Roe & Boughton (1975) assessed the reserve networks of Australia in terms of their representation of the range of vegetation structural-types. Since then, State conservation agencies have acquired more of their reserves to represent the variety of indigenous vegetation-types, or land systems, than to conserve known populations of any particular species of plant or animal.

There has since been debate on what constitutes a "representative" conservation reserve system (see Austin & Margules 1984) and on how to optimise the design of such a reserve system so that it will include and maintain as much as possible of the biotic richness and variation of its region. Many aspects of this subject remain unresolved; the percentage (by area) of the vegetation or land systems of a region that can be reserved usually depends on the availability of land and political factors; the optimum patterning of reserves across a region depends on effects such as the influence of patch size and community truncation/population fragmentation on species richness (see Simberloff & Abele 1982; Shaffer & Samson 1985; Wilcox & Murphy 1985; Fahrig & Merriam 1985; Kitchener, Chapman, Muir & Palmer 1980; Kitchener, Chapman, Dell & Muir 1981; Kitchener 1982). A reserve system that is effective for supporting populations of a mobile species with a short lifespan may not suit a sedentary, long-lived species.

Beside ad hoc decisions to create reserves (see Burbidge 1984), the usual approach to selecting "designed" systems of reserves has involved a mapping process, based either on land units (Christian & Stewart 1953) or vegetation units (e.g. Specht et al. 1974). Bolton and Specht (1983) have attempted to quantify this approach using a computer-based method involving 20 distinct steps. This has allowed them to objectively select nature conservation areas in south-west Queensland using, as raw data, existing vegetation or land-system maps. Purdie (1985) has recently modified the Bolton-Specht method and applied it to the Mulga Lands Biogeographic Region in western Queensland. The revised method aims to allow the selection of a number of large, general reserves containing a high diversity of representative samples of the variety of ecosystems in the region, and additional, smaller, special purpose reserves to conserve the rare ecosystem components.

The theoretical basis and effectiveness of such reserve selection methods have been questioned (see McKenzie 1984, Austin & Margules 1984, Game & Peterken 1984). Typically, such mapping units are assumed to be internally homogeneous yet this is seldom true even for the few, structurally dominant species used to characterise them. For the multitude of other species comprising the assemblages of the region, the levels of internal heterogeneity of the mapped units are not measured and the unit boundaries are unlikely to be meaningful.

To design a reserve system representative of the Nullarbor District, we set out to reveal the patterning of the biota across this Study Area using an explicit, quantitative method that gave equal weighting to a wide array of the different sorts of lifeform found there. This strategy of survey (McKenzie in press) aimed to provide an objective appraisal of the existing reserve system yet, at the same time, to be relevant to other aspects of wildlife management. We needed a data base that was suitable for monitoring future changes in the District's biota. Thus, we chose to exhaustively sample a relatively small number of quadrats (82), carefully positioned to represent the District's geographical extent and diversity, for as wide an array of its biotic components as possible - organisms with differing longevities, mobilities, foecundities, trophic roles, etc. To allow measurement of change through time, we sampled fixed, permanently marked quadrats, many of which were replicated. As an acknowledgement to seasonal variation in species composition, we sampled these quadrats in two different seasons. To distinguish local events from regional trends and as a cross-check of the effectiveness of our sampling, we replicated a selection of quadrats; some replicates were adjacent and others were geographically remote from one another. The rationale determining the size and acceptable patchiness of the quadrats was discussed in Methods (this publication).

A total of 367 vascular plant species, 85 reptiles, 1 amphibian, 32 native and 8 introduced mammals, and 239 native and 3 introduced birds have now been recorded extant in the Nullarbor District during the period of European settlement. Even so, the District as a whole is not as rich in species as its neighbours. For instance, there are 68 lizard species known for the Nullarbor Study Area but 74 species known from the Great Victoria Desert and 81 from the South-western Interzone. The 367 species of vascular plant known from the Nullarbor compares with 406 from the Great Victoria Desert, 1873 from the South-western Interzone and 1540 from the "Eyre and Yorke Peninsula Environmental Province". The relatively great richness of the South-western Interzone derives from three sources: medium levels of sympatry in assemblages, patchiness in habitat associated with the geochemical diversity of surface-types present, and biogeographic influences from adjacent districts to the north, south and west. Species endemic to the Nullarbor, or having their distributions centred upon it, mostly belong to the less mobile groups among the organisms we sampled - the reptiles and plants rather than birds or mammals; most of the endemism within the district is found on the (currently isolated) sandy surfaces of the coastal community-types. This has been discussed in the preceding chapters.

Many species were first recorded in the Nullarbor Study Area during our 1984 surveys (circa 15% of plants, 2.5% of birds, 13% of reptiles and 19% of native mammals). On the other hand, we did not record a variety of previously known species though most (except certain mammals) are still believed to persist in the district. We could not expect our sampling to be exhaustive for the district as a whole; we sampled at only 82 quadrats in an area of more than 250 000 square kilometres, and on only two occasions during a single year (1984). In fact, quite a few of the species we recorded on quadrats could not actually be used in the quantitative analysis because our quadrats were too small and too briefly sampled to indicate the species presence or absence with sufficient certainty. This problem was severe for snakes and goannas (see McKenzie, Rolfe & Carter, this publication) and non-passerine birds (see Burbidge et al. this publication), but was also noted for herbs (see Keighery et al. this publication). Such reptiles and birds generally occur at relatively low densities; herb assemblages have a rapid turnover in species composition (see Grubb, Kelly & Mitchley 1982). For instance, we recorded 85% of known Nullarbor passerine bird species on our quadrats but only 55% of the non-passerines known from the Nullarbor; only 61% of snakes and goannas but 94% of the other sorts of lizards (skinks, dragons, legless lizards and geckoes); more than 95% of the perennial plants but only circa. 65% of the herbs. It is clear that additional scales of sampling are needed to provide data on the more mobile and the more ephemeral species of even our target groups.

There was another source of chaos in the patterning of the Nullarbor biota that was not an artefact of our sampling; recent disturbances have resulted in the extinction or decline of many mammal species (see Boscacci, McKenzie & Kemper and Baynes, this publication). These disturbances include the introduction of a variety of exotic species and superimposed pastoral management practices. As far as possible we have identified the species that have disappeared from, declined in, or colonized the District.

An appraisal of our quadrat data showed that central Nullarbor assemblages are much poorer in species of plants and vertebrates (20-40 species) than are peripheral assemblages (40-90 species) or those of adjacent districts such as the South-western Interzone and Great Victoria Desert. In their composition, the assemblages of the Treeless Plain are a sub-set of the species comprising assemblages around its periphery. Peripheral assemblages, in turn, share high species similarities with the closest adjacent natural district, so the periphery of the Treeless Plain can be regarded as a series of distinctive community-types, each having strong biogeographic affinities with its adjacent natural district. The species with least penetration of the Nullarbor are those that favour sandy and/or other well-drained substrates. It seems that the habitats of the Treeless Plain are an almost complete barrier to the dispersal of many species, especially those favouring sandy surfaces, and that most of the species richness of the district is contributed by the areas peripheral to the Treeless Plain.

When the quadrat data were classified and ordinated in terms of the species composition of their individual assemblages, a set of community-types could be defined. All species were equally weighted during this analysis, irrespective of their relative biomass or abundance, by accessing only the binary (presence/absence) data.

There were two main areas of subjectivity in this process of defining community-types:

(1) Our sampling design. Because of the size of the Study Area and manpower/time/access constraints, we had to position our quadrats using a "stratified random" instead of a "grid-based" strategy. There was a danger that the stratification criteria would influence, or even determine, the biological patterns indicated by the analysis of the quadrat data (see Taylor & Friend 1984). To overcome this, and some of the other drawbacks inherent in our choice (see also Margules & Scott 1984), the stratification was determined by available geological maps and the quadrats positioned to give geographic coverage of the Study Area.

(2) The community boundaries - the level at which we cut the classification dendrograms. The dendrograms were cut to create as many groups as could be interpreted ecologically in terms of the vegetation, surface-type and geographical location of their component quadrats and, for species groupings, the preferred habitat-types of their component species throughout their geographic ranges Australia-wide. Inspection of the Two-way Tables and the corresponding ordination scattergrams allowed the validity of these inter-group discontinuities to be assessed (in terms of gradational patterns) then related to gradients in biophysical parameters across the district (distance from the coast, climate, vegetation structural diversity, substrate patterns).

When the various taxonomic groups that we sampled on each quadrat were analysed separately they yielded community-types with different geographic patterns (compare Figs. 34, 42, 51, 61, 65). Thus, reptiles, birds, small ground-dwelling mammals and plants respond differently to environmental parameters. However, to objectively assess reserve needs on the Nullarbor Study Area, a single pattern of community-types was needed that encompassed the variety of its indigenous species. Therefore, the binary data from each assemblage was re-analysed with equal weighting being given to every species, irrespective of taxonomic affiliations. That is, the vertebrate and plant species were combined for each assemblage. The community-types discerned from this classification analysis, and the gradients perceived in the assemblage scattergrams, were then related to patterns earlier recognised for the individual taxmonomic groups (see Fig. 67) and correlated with geographic and climatic attributes using BIOCLIM, or related to soil drainage characteristics, as a first approximation to modelling the District's biotic variation.

Eleven biologically recognisable community-types were distinguished from the "combined" analysis. Most of these were near the coast (see Fig. 65); changes in the biota further inland were gradual, occurring over great distances. The particularly species-poor assemblages that characterize the spectacular karst landscape of the Nullarbor also give the District its distinctive character. We have as much obligation to conserve these areas as the richer, more "attractive", assemblages elsewhere in Australia. Yet conservation of a sample of the Treeless Plain will not represent the District's biological diversity. Contrary to existing vegetation maps (Beard 1970), the Great Victoria Desert Nature Reserve (Fig. 71) does not include communities of the Treeless Plain; quadrats sampled in its southern areas (quadrats F01-F05) classify as "Northern Woodlands" assemblages (see the previous chapter in this publication) that have been degraded by grazing and/or drought (see Keighery et al. this publication).

The karst landscape of the Nullarbor District has conservation value in its own right. It includes a multitude of small blowholes, rockholes and caves, and is the only arid or semi-arid karst area of any significance in the world. Its caves are of international interest; they contain rare halite speleothems, new mineral species, large lakes and underwater passages, important fossil deposits, significant Aboriginal sites and troglobitic fauna. The underwater passages of caves such as Cocklebiddy and Weebubbie are among the largest known and are unequalled for recreation anywhere in Australia or overseas. These caves, which occur in both South and Western Australia, are in urgent need of management. Erosion at cave entrances caused by people and stock goes on unchecked while, in many caves, careless or thoughtless visitors have contributed to a general deterioration by walking on sand dunes, damaging crystal deposits at lake edges, walking on rare mineral crusts, disturbing bats and breaking speleothems. These aspects of the Nullarbor have been considered in detail by Davey (1978 and 1984a) and his recommendations have been included below.

For the moment we have used a tabular approach, based on the eleven community-types distinguished from the combined analysis, to appraise reserve needs for the Nullarbor (this is done later in this chapter). The drawbacks of the tabular strategy have been discussed by Margules and Scott (1984). We can further improve the representativeness of our reserve-system recommendations by modelling the biotic variation of the District. The methodology, and the current status of our Nullarbor model, have been described at the end of the chapter "Biological Patterns in the Nullarbor Study Area" (this publication); the ground-truthing process and data-base amendments are currently being implemented.

The approach and methods used for this survey also need further development. One aspect requiring study for future surveys of areas with unpredictable climate is the resilience of assemblages (in species composition) year-to-year. To assess the influence that such climatic variation might have on our monitoring, we are beginning an annual program of re-sampling at certain Nullarbor quadrats to measure variation through time in between-assemblage similarities (in species composition). Research programs on this data-base are also needed to design techniques that consistently sample organisms that perceive very different scales in the environment (see Dale 1984, McKenzie 1984), so that an even wider array of organisms can be incorporated in the analyses. The logical extension of our work is to test how well community patterns identified using the existing data base actually represent the richness and patterning of the organisms indigenous to the District (see discussion at the end of the previous paper). For instance, what influence does the density dependent habitat selectivity of many species have on the patterns described herein. If we had established more sampling sites through the Study Area, would the community-patterns described earlier have changed? At present we believe that they would not because:

(a) The patterns we generated made sense in terms of the sort of physical gradients that other, more intensive, studies have shown to influence the biotic groups we sampled (e.g. Kikkawa 1982; Margules & Nicols, in press).

(b) Even in an area such as the Nullarbor, where we expected changes in assemblage composition to be gradual and occur over long distances, the positions where, and directions in which, such changes actually occurred could be readily related to changes in the patterning of the physical environment.

Interpretation of Biophysical Patterns for Reserve System Design

(1) Community Patterns
In terms of community boundaries derived from the classification of assemblages, each of the biotic groups sampled showed a different pattern across the District.

The perennial plants, the least mobile of the groups, showed the greatest array of distinct community-types. Five geographically widespread, and six more restricted, communities were distinguished from the Two-way Table (Table 6); steep gradients of change in species composition occurred along coastal and north-south axes, with a very pronounced difference between eastern and western extremities of the Study Area. Herb assemblages (Table 8) distinguished the north-eastern from the north-western periphery of the Study Area and emphasised overall east to west differences.

Lizards (Table 36) showed a distinct north-south gradient in assemblage composition with weaker, but still clear, differences between the south-eastern and south-western ends of the Study Area. The four main community-types distinguished from the relevant Two-way Table (Table 36) are mapped in Fig. 61.

The terrestrial native mammals (Table 11) are now poor in species; only three community-types could be recognised. Individual mammal assemblages at the time of European settlement were much richer, comprising 10 to 20 species (see Baynes, this publication) compared with today's four to five species, if kangaroos and dingoes are included (see Boscacci et al. this publication). This implies that patterning derived from today's mammal communities is likely to be largely irrelevant in choosing a representative reserve network provided populations of the few persisting species are included.

Being the most mobile group analysed, the passerine bird assemblages formed community-types that were the least discrete and that occupied substantial portions of the Study Area. Community patterns along the coastal strip showed some complexity. Three community-types were well defined in the relevant Two-way Table (Table 28). The south-eastern and south-western differences were largely an artefact of the district (Study Area) boundaries we chose; if sites with a carbonate substrate even 30 kilometres further west were included, nearly all differences would have disappeared.

The combined analysis indicated a general east-west change in the species composition of assemblages, with the most abrupt changes in composition and the maximum biotic complexity near the coast (Axis 3 in Fig. 67). Assemblage composition also changes dramatically from the coast northwards (Axis 2). The third important axis of change in the composition of Nullarbor assemblages is a gradient from the relatively complex woodlands around the periphery of the Study Area towards the central, and vegetationally simple, Treeless Plain (Axis 1). Eleven community-types were distinguishable from the relevant Two-way Table (Table 41).

Individually, the biotic groups weight the above three axes of community patterning differently. However, the principal gradients of all groups were identifiable in Fig. 67; therefore they were encompassed by the combined analysis. In Table 42 (and see Table 41) the Nullarbor's conservation reserve system is appraised in terms of the 11 community-types distinguished from the combined analysis. Although the Un-named Conservation Park and Eucla National Park were not sampled during the survey, their communities have been inferred from the nearest sampling points on the basis of substrate characteristics and the biotic gradients described herein. The 11 community-types were described and compared in the previous chapter; those that do not, or barely, occur in the existing reserves are:

South-western Woodlands assemblages (Group 1 in the previous chapter) - there is some coverage by the northern extension of the Nuytsland Nature Reserve near Cocklebiddy, but this community-type includes an east-west gradient of change in its biota. The tiny Eucla National Park (3342 ha) does not include assemblages typical of the eastern extreme of this community-type.

South-eastern Woodlands assemblages (Group 3).

Southern Treeless Plain (Group 7).

Treeless Plain (Group 8), including the degraded areas north of Hughes that were distinguished as Group 9.

Hampton Range Mallee Scrub (Group 4), Coastal Mallee and Woodlands (Group 10) and Beach assemblages (Group 11) - the Nuytsland Nature Reserve, and Nullarbor and Eucla National Parks conserve only small areas of the biotic variation in these near-coastal parts of the Study Area.

(2) Species
The persistence of a variety of taxa will depend almost entirely on conservation measures taken in the Nullarbor Study Area. In this context it is worth noting that our study only considered plants and vertebrate animals. Although these are the larger and taxonomically better known organisms, they comprise less than 20% of the total richness of organisms that form the building-blocks of Nullarbor communities. For instance, invertebrate animals such as insects were completely ignored in this study.

Plant and vertebrates endemic to this District, or with distributions centred on it, include:

Plants
Gunniopsis calcaraea
Calotis breviradiata
Atriplex cryptocarya
Wurmbaea sp. nov.

Birds
Nullarbor Quail Thrush
Naretha Blue Bonnet

Reptiles
Amphibolurus nullarbor
A. maculatus dualis
A. mckenziei
Tympanocryptis lineata houstoni
Ctenotus brooksi euclae
Leiolopisma baudini
Lerista picturata baynesi
L. microtis arenicola

The Nullarbor supports important populations of a number of other species. Some of these are discussed below to indicate the sorts of criteria involved:

Plants
Santalum accuminatum ssp. nov. - on Roe Plain and near Toolina Cove.

Mammals
Sminthopsis gilberti - the Nullarbor population is anatomically different.
Chalinolobus morio - Nullarbor caves shelter large breeding colonies.
Southern Right Whale - According to J.L. Bannister (pers. comm.), Southern Right Whales come close to the Nullarbor coast to calve in late winter, spring and early summer. They appear to favour particular sheltered bays, such as "Head of the Bight", where females with calves and instances of mating have been observed. Cows with calves are also regularly observed off Eucla, the Eyre Bird Observatory and Twilight Cove at this time of year.
Southern Hairy-nosed Wombat - major populations occur on the Nullarbor.

Birds
Pink Cockatoo - an uncommon species; breeding population near Cocklebiddy.
Thick-billed Grass Wren - a rare and endangered species.
Slender-billed (Samphire) Thornbill - largest area of favourable habitat.

(3) Landforms
The most widespread of the karst landscape features of the Nullarbor Plain are the dongas and the ridge and corridor terrain. The vast area of these two solutional terrain-types is the reason for recognising so large an area on the Nullarbor Plain as karst (over 200,000 km2 - Lowry & Jennings 1974), even though caves, collapse dolines and the other, more familiar, specific karst landforms are relatively scarce. These two landform types, rather than caves and collapse dolines, are the principal characteristic of the world's largest karst area.

Dongas
These depressions are characteristic of the Nullarbor karst, especially of the northern Nullarbor. They are mostly circular in plan, typically a few metres to a few hundred metres in diameter, and little more than a metre deep. They acquire a relatively silty floor and often support distinctive vegetation because of the local concentration of runoff. This habitat permits some birds (such as Singing Honeyeaters) to penetrate the otherwise inhospitable treeless plain. No measure of donga number or density has ever been attempted, but there must be many hundreds of thousands of them.

The dongas which are characteristic of the northern treeless plain are rare in existing reserves; those present in the Great Victoria Desert Nature Reserve are very badly degraded (by rabbits).

Ridge and Corridor Terrain
This terrain is most evident in the southern parts of the Nullarbor region, where rainfall is slightly higher than in the north and where rectilinear jointing of the bedrock limestone is relatively intense. The depressions here are elongate (up to several kilometres long, usually a few hundred metres wide, and up to several metres deep). They are also much more closely packed than the dongas of the north, occurring in parallel fields separated by narrow rocky ridges which have been stripped of residual soil cover. Like dongas, depressions of the ridge-and-corridor country are extremely numerous and are distributed over a very large area. They are quite characteristic of the region and, like dongas, are a feature peculiar to the semi-arid Nullarbor karst.

Very little of the ridge and corridor country is included in existing reserves; some small areas occur in the Nuytsland Nature Reserve, south of Cocklebiddy. However, the best examples of the terrain are further east on the southern Bunda Plateau (Fig. 14) adjacent to the Hampton Range between Madura and Eucla. [An important example is included in the proposed reserve (see Fig. 71) centred on the Abrakurrie complex of caves and dolines].

Collapse Dolines, Caves and Other Karst Features

The more familiar landforms of karst terrain are sparsely scattered across the Nullarbor. Many of these sites are important because they provide examples of the arid-environment processes that have modified landforms initially produced by karst processes.

With some important exceptions, the caves, collapse dolines and other karst landforms are concentrated in the slightly wetter, coastal third of the Study Area. It is important that all such features be protected from disturbance, but the following individual sites and areas are identified as warranting specific recognition and protection in the reserve system (updated from Davey 1978, 1984):

Western Australia

- Weebubbie Cave N2 (water reserve) - one of the largest and most spectacular lakes of the Nullarbor caves, in a very large collapse cave reached from an impressive collapse doline; already heavily used by visitors; of outstanding aesthetic, archaeological, geomorphological and biospeleological significance.

- Abrakurrie Cave complex (vacant Crown land between Eucla and Mundrabilla) - including Abrakurrie Cave N3 [probably the largest underground space in all of Australia], Chowilla Landslip N17 [a collapse doline], Kutowalla Doline N44, Winbirra Cave N45, numerous related dolines along an interesting structural lineament, excellent examples of ridge and corridor terrain, and an extensive example of the geomorphologically and biologically important former sea cliff of the Hampton Range, together with a progression of vegetation structure from the relatively dense mallee and myall shrub steppe near the old sea cliff northward onto the treeless plain. The complex includes many sites of outstanding aesthetic, geomorphological and archaeological significance.

- Mullamullang Cave N37 (pastoral lease) - by far the most extensive of the Nullarbor Caves, with many kilometres of passages; it contains numerous small lakes and deposits of very rare and vulnerable mineral speleothems; it is of outstanding aesthetic, geomorphological and biospeleological significance. A few kilometres north of this site, out on the treeless plain, are the most spectacular collapse dolines of the Nullarbor - Kestrel Cavern No. 1 N40, Spider Sink N41 and Kestrel Cavern No. 2 N42.

- Cocklebiddy Cave N48 (Nuytsland Nature Reserve) - already heavily used by visitors; the "Mount Everest" of cave diving, with over 6km of water-filled passages explored so far, and with cave diving now at the very limits of technology and human endurance; of geomorphological, biospeleological and palaeontological significance.

- Madura Cave N62 (pastoral lease) - a very important geomorphological, archaeological and palaeontological site.

- Old Homestead Cave N83 (vacant Crown land) - one of the most northern of the relatively deep and extensive caves, with several kilometres of passage; of geomorphological significance.

South Australia

- Warbla Cave N1 (pastoral lease) - a very large and spectacular collapse doline and cave, containing a small lake; of outstanding aesthetic, geomorphological, archaeological and biospeleological significance.

- Koonalda Cave N4 (pastoral lease) - another large and complex cave, containing a series of lakes; of outstanding archaeological, geomorphological and biospeleological significance.

- Koomooloobooka Cave N6 (pastoral lease) - a small cave of geomorphological and archaeological significance.

- Murrawijinie Caves N7, 8 and 9 (Nullarbor National Park) - shallow dolines and caves of geomorphological and archaeological interest.

- Ivy [Graveyard] Cave N13 (Nullarbor National park) - a small but complex cave of geomorphological and and palaeoenvironmental interest.

- Weekes Cave N15 (pastoral lease) - a small cave of geomorphological and palaeontological interest.

- Clay Dam Cave N16 (pastoral lease) - a spectacular and unstable collapse doline, of geomorphological interest.

- Jimmie Cave N23 (Aboriginal land) - a shallow cave of geomorphological and archaeological interest.

- Mottled Cave N27 (pastoral lease) - a small complex cave of geomorphological interest.

- Disappointment Cave N85 (vacant Crown land) - a cave of geomorphological and archaeological significance.

- Diprose Caves N96-99 (vacant Crown land) - caves and dolines of outstanding geomorphological and archaeological significance.

- Allens Cave N145 (pastoral lease) - a shallow doline cave of archaeological interest.

- Wigunda Cave N147 (Nullarbor National Park) - a large two-stage collapse doline and small cave, of geomorphological interest.

- Creek Tanks Cave N151 (pastoral lease) - a complex large and unstable collapse doline and cave of geomorphological interest.

- Wombat Cave N264 (pastoral lease) - a complex cave of geomorphological, biospeleological, palaeontological, archaeological and cave mineral significance.

Complex of rockholes, caves and dolines between Kudna Rockhole and the Diprose Caves (vacant Crown land north and north-east of Nullarbor National Park) - including many sites of geomorphological and archaeological significance.

Palaeochannels
At present the main palaeochannels of the northern Nullarbor are conserved only in the Great Victoria Desert Nature Reserve and the Unnamed Conservation Park, where they are in terrain marginal to the karst of the plain. The old river channels out on the treeless karst plain are not conserved at all. The most outstanding example is The Dip (Jones 1880, Jennings 1967c), which extends east-south-east from the Great Victoria Desert to the transcontinental railway near Cook.

Cliffs
Since the account of Flinders voyage appeared in 1814, the Nullarbor coastline has been recognised for its scenery. The appeal of the great cliffs is recognised today in the deliberate location of the Eyre Highway close to the edge of the Bunda Cliffs and the provision of access roads to special vantage points. West of Eucla, the highway runs for many hundreds of kilometres at the foot of a relictual sea cliff - the Hampton Range.

Most of the Baxter Cliffs (Fig. 14), and a substantial part of the Bunda Cliffs, are within the Nuytsland Nature Reserve and the Nullarbor National Park respectively. The Wilson Bluff - Merdayerrah area (at the western end of the Bunda Cliffs) includes a complex series of cliff levels, Pleistocene aeolianites and sand dunes of geomorphological, biological and archaeological interest. The area needs to be reserved.

The former sea cliff of the Hampton Range is very poorly represented within existing reserves; a relatively short section of the far western end in included in the Nuytsland Nature Reserve. A substantial part of the range could be included in the proposed reservation of the Abrakurrie complex.

Coastal Sand Dunes
The coastal dune complexes are relatively well conserved within the Nuytsland Nature Reserve. The main exceptions are the transitional coastlines at Wilson Bluff and Head of Bight, where a series of dunes have ramped up the adjacent cliffs to form cliff-top dunes (Jennings 1967B).

Reserve Recommendations
In Fig. 71, extensions to the existing reserve system are recommended that will improve its coverage of the plant and vertebrate communities recognised in this study, populations of the species that depend on the Nullarbor environments, and the diversity of caves and landforms that characterize this District.

(1) Treeless Plain
Areas of the vacant Crown land in the Treeless Plain should be proclaimed as a two-State National Park as soon as possible. Western Australian land to the north and east of the Kybo Pastoral Lease, and another tract between Eucla and the Great Victoria Desert Nature Reserve, should be included. Equivalent South Australian land adjacent to the State border should also be included in the proposed Park and, as a subsequent step in this process, negotiations might begin to transfer the part of the Maralinga Tjaruta Lands along the State border, north of the Railway line, to the proposed Park. This would result in the inclusion of a large portion of The Dip (palaeochannel) in a reserve.

Small areas of not greater than 30 hectares need to be excised from several pastoral leases to provide protection for caves that are not otherwise included in the proposed reserve network. These small areas should encompass all cave entrances and associated structures. The nine relevant areas on the Madura and Mundrabilla Pastoral Leases were listed earlier and are indicated in Fig. 71.

(2) Coastal Fringe
In Western Australia, the Nuytsland Nature Reserve should be extended northwards to at least the Eyre Highway in two areas; the Eucla National Park should be included in the proposed two-State national park, and enlarged so that it takes in tracts of the Roe Plains and Hampton Range between Kuthala Pass and the State border. These extensions will involve excision of approximately 15% of the currently vacant Virginia Pastoral Lease area, and exclusion of land for existing roads and appropriate tourist complexes (especially near Eucla) from the proposed Park.

In South Australia, effort should be made to acquire Koonalda Pastoral Station (but not by resumption) for inclusion in the proposed Park, and arrangements made to exclude land required by the Border Village tourist complex. The mallee and Myall woodlands in the south-eastern part of the Study Area comprise the largest area of relatively undisturbed semi-arid woodland remaining in South Australia. Most of it is included in Yalata Aboriginal Reserve so the conservation significance of this area of Aboriginal land cannot be over-emphasised. The area of woodlands to the north of the dog fence should be proclaimed for conservation as soon as possible.

Consideration should be given to the proclaimation of marine reserves for Southern Right Whales at the Head of the Bight, and between Eyre and Twilight Cove.

Management Recommendations
Neither the Western Australian Department of Conservation and Land Management nor the South Australian National Parks and Wildlife Service have resident ranger staff in their existing reserves in the Nullarbor District. These reserves are occasionally visited by mobile rangers based at Kalgoorlie (in W.A.) and Streaky Bay (in S.A.). The more extensive reserve system, and in particular the proposed national park, will be of international significance and will require closer supervision, preferably by a staff of resident rangers. A ranger should probably be based at Eucla first, then additional rangers later positioned at Cook, Nullarbor and Cocklebiddy.

Major management problems that became apparent during this study were the continuing degradation of the District by rabbits and invasive weeds, and the destruction of caves by visitors. To measure the effect of grazing by rabbits, and the success of invasive weeds in the absence of such grazing, we suggest that a series of exclosures be placed in some of our quadrats so that their floristic composition can be monitored under a variety of treatments. Unfortunately, appropriate methods of controlling rabbit and weed populations in areas as large as the Nullarbor remain to be developed. To identify long-term changes in the species composition of the District, we have accurately mapped and permanently marked (Appendix I) the quadrats sampled during this survey so that they can be re-sampled in 10 to 15 years time. Such data should help to guide future management programs.

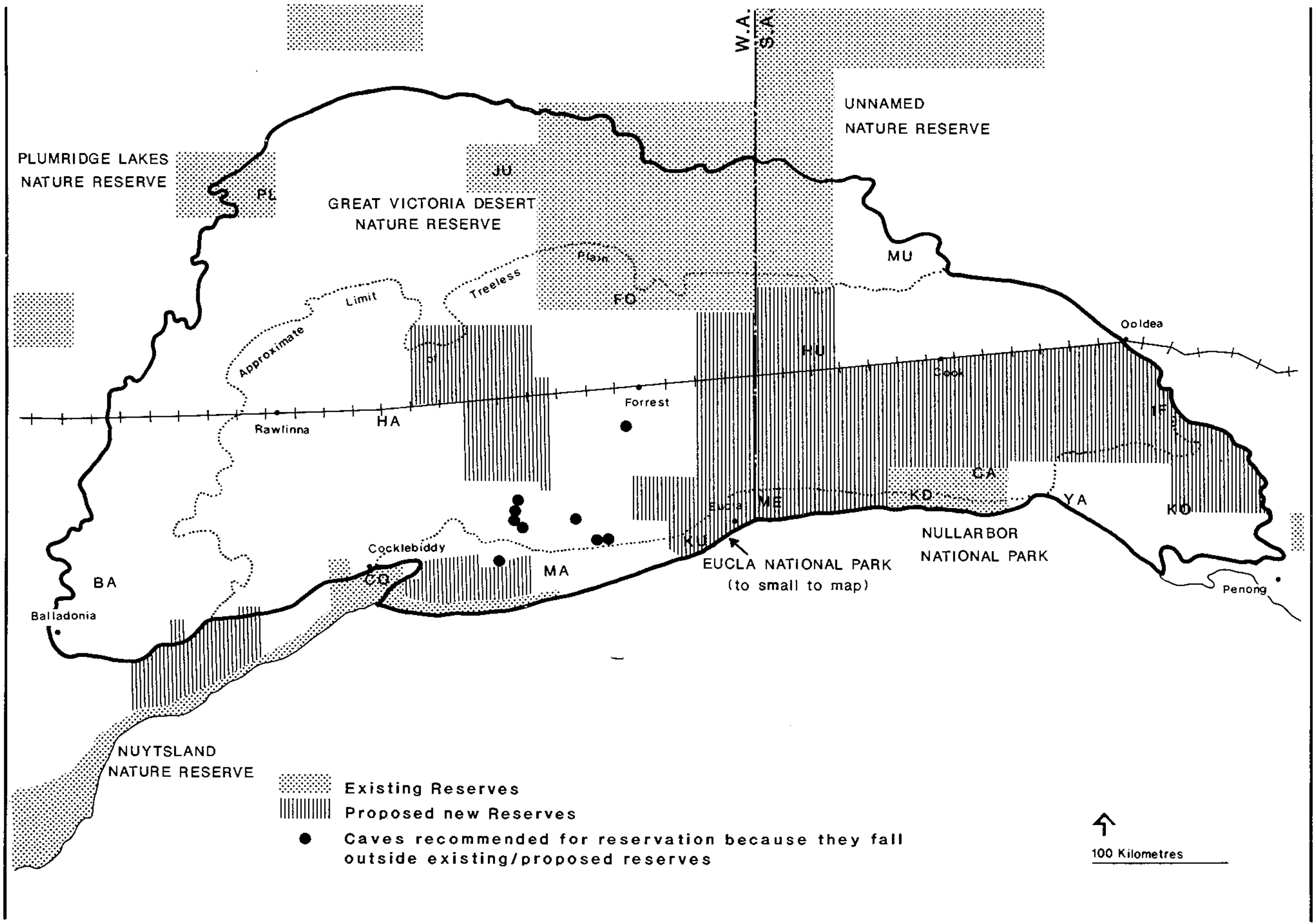

Figure 71
PROPOSED CONSERVATION AREAS

Details of the active management required by Nullarbor Caves are given in Davey (1978) and Davey (1984a). These include a recommendation for the development of at least one cave for tourists; a proposal that is only feasible with resident rangers.

The opportunity exists to establish a national park of world standing on the Nullarbor Plain and, because of the two-State nature of the management commitment necessary, an on-going involvement of the Commonwealth Government would seem to be appropriate to enable it to be managed as one of Australia's premier conservation areas.

TABLE 42: CONSERVATION STATUS OF THE COMMUNITIES RECOGNISED ON THE NULLARBOR STUDY AREA IN THE SIX EXISTING CONSERVATION RESERVES

Reserve Name	Community-type (from previous chapter)										
	1	2	3	4	5	6	7	8	9	10	11
Plumridge Lakes		x									
Nuytsland	x									x	x
Great Victoria Desert		x									
Un-named		x									
Nullarbor				x	x	x					
Eucla				x							x
Unconserved			*				*	*	*		

RESOURCE MATERIAL AND BIBLIOGRAPHY

MAPS

1:250 000 Topographic

Plumridge	SH 51-8	1964,	Jubilee	SH 52-5	1964
Mason	SH 52-6	1964,	Wyola	SH 52-7	1966
Cundalee	SH 51-11	1964,	Seemore	SH 51-12	1964
Loongana	SH 52-9	1964,	Forrest	SH 52-10	1964
Cook	SH 52-11	1976,	Ooldea	SH 52-12	1966
Barton	SH 53-9	1964,	Zanthus	SH 51-15	1981
Nareetha	SH 51-16	1981,	Madura	SH 52-13	1981
Eucla	SH 52-14	1981,	Coompana	SH 52-15	1981
Nullarbor	SH 52-16	1981,	Fowler	SH 53-13	1981
Burnabbie	SI 52-1	1981,	Noonaera	SI 52-2	1964
Baladonia	SI 51-3	1981,	Culver	SI 51-4	1981

Division of National Mapping, Canberra.

1:250 000 Geological

Vernon	SH 52-1	1977,	Culver	SI 51-4	1970
Plumridge	SH 51-8	1977,	Jubilee	SH 52-5	1970
Mason	SH 52-6	1974,	Cundalee	SH 51-11	1977
Seemore	SH 51-12	1975,	Loongana	SH 52-9	1970
Forrest	SH 52-10	1970,	Zanthus	SH 51-15	1970
Madura-Burnabbie	SH 52-13 & PT SI 52-1	1972,			
Eucla-Noonaera	SH 52-14 & PT SI 52-2	1971,			
Baladonia	SI 51-3	1970,			

Geological Survey, Western Australia

Wyola	70-1170 Preliminary Edition 1970,
Cook	Preliminary Edition 1970,
Ooldea	69-1984/6 Preliminary Edition 1969,
Barton	74-651 Preliminary Edition 1974,
Coompana	72-204 Provisional Edition 1969,
Nullarbor	72-205 Provisional Edition 1969,
Fowler	SH 53-13 1975,

Department of Mines and Energy, South Australia

1:100 000 Photomaps (South Australia only)

Wilson	4734	March 1978,	Merdeyerrah	4735	March 1978
Bunburra	4736	Mar,Apr 1978,	Karana	4737	Mar,Apr 1978
Tadlanya	4738	March 1978,	Purlanna	Pt 4739	March 1978
Albalakaroo	4834	March 1978,	Coompana	4835	March 1978
Bundulla	4836	Mar,Apr 1978,	Coorara	4837	Mar,Apr 1978
Tallara	4838	March 1978,	Yangoonabie	4934	March 1978
Knarda	4935	March 1978,	Cook	4936	March 1978
Saleh	4937	Mar,Apr 1978,	Chilbinga	Pt 4938	Mar,Apr 1978
Wigunda	5034	Feb 1977,	Nullarbor	5035	Feb 1977
Fisher	5036	Jan,Feb 1979,	Fisk	5037	Jan,Feb 1979
Coymbra	5134	Feb 1977,	Illcumba	5135	Feb 1977
Reid	5136	Jan, Feb 1979,	Yarle	Pt 5137	Jan,Feb 1979
Pilpuppie	5234	Feb 1977,	Yalata	5235	Feb,Mar 1977
Moondrah	5236	Jan,Feb 1979,	Maralinga	Pt 5237	Jan,Feb 1979
Tallacootra	5335	May 1978,	Pidinga	Pt 5336	Aug 1981
Midgerie	Pt 5435	May 1978,			

Department of Lands, South Australia

AERIAL PHOTOGRAPHS

Western Australia - The map numbers refer to master sheets held by the Department of Lands. Only photographs which link the quadrant sites to the nearest clearly defined reference point are given. Photos cited from left to right in geographical orientation west to east.

Balladonia Site Map Balladonia SI/51/51-3
Date photos = T.11.61
Run 1, Photos 5702-5705

Haig Site Map Madura SH/52-13
Date photos = October 1961
Run 1 of CAF 4005, Photos 5891-5890
Run 2 of CAF 4008, Photos 5443-5444

Madura Site A. Map Madura SH/52-13
Date photos = October 1961
Run 8 of CAF 4011, Photos 5099-5098
B. Map Burnabbie SI/52-1
Job No. 830478, date photos 2.4.84
Run 1, Photos 5076-5075
Run 2, Photos 5121-5123
Run 3, Photos 5133-5131

Eyre Site Map Burnabbie SI/52-1
Job No. 830478, Date photos 2.4.84
Run 1, Photos 5094-5093
Run 2, Photos 5104-5106
Run 3, Photos 5151-5149

Kuthala Site Map Eucla SH/52-14
Date photos = October 1961
Run 6 of CAF 4006, Photos 5176-5178
Run 7 of CAF 4011, Photos 5072-5074
Run 8 of CAF 4011, Photos 5087-5086

Plumridge Site Map Plumridge SH/51-8
Date photos = Nov/Dec 1970
Run 6/0049 of CAF 4116, Photos 0065-0073
Run 7/0141 of CAF 4116, Photos 0112-0108

Forrest Site Map Forrest SH/52-10
Date photos = 1961
Run 2 of CAF 4006, Photos 5070-5077

Seemore Site Map Seemore SH/51-12
Date photos = October 1961
Run 6/5621, Photos 28-29 (Peter Well)
Run 7/5740, Photos 34-32 (Dallas Well)
Run 8/5596, Photos 2-4 (Snake Gulley)

Jubillee Site A. Map Jubillee CAF 109, Chain Photos
Run 3/0229 of CAF 4118, Photos 0260-0261. Date = 28.12.70
Run 4/0057 of CAF 4119, Photos 0027-0025. Date = 6.12.70
Run 5/0071 of CAF 4118, Photos 0042-0040. Date = 28.12.70
Run 6/0095 of CAF 4121. Photos 0065-0063. Date = 8.12.70
Run 7/0095 of CAF 4120. Photos 0065-0063. Date = 7.12.70
Run 8/0089 of CAF 4117, Photos 0017-0019. Date = 20.11.70
B. Map Loongana H52-9
Run 1/5125 of CAF 4006, Photos 13-12. Date = October 1961
Run 2/5052 of CAF 4001, Photos 63-64. Date = October 1961

South Australia - The surveys referred to below give complete coverage of all of the Nullarbor study area in South Australia. All are available in colour from the South Australian Department of Lands.

Coompana	1:87 700	Surveys 2216,2217 (March 1978)
Nullarbor	1:89 000	Surveys 2080,2081,2082,2083 (Feb, Mar 1977)
Fowler	1:88 300	Surveys 2250,2251,2252,2263,2264 (Apr,May 1978)
Cook	1:87 700	Surveys 2217,2218 (March 1978), 2247,2248 (April 1978)
Ooldea	1:87 000	Surveys 2352,2353,2360,2537 (Jan 1979), 2369 (Feb 1979)
Barton	1:87 000	Surveys 2735,2736,2727,2738,2739,2740 (Aug 1981)
Wyola	1:86 500	Surveys 2219,2220 (March 1978) 2245,2246 (April 1978)
Maurice	1:87 000	Surveys (August 1983)

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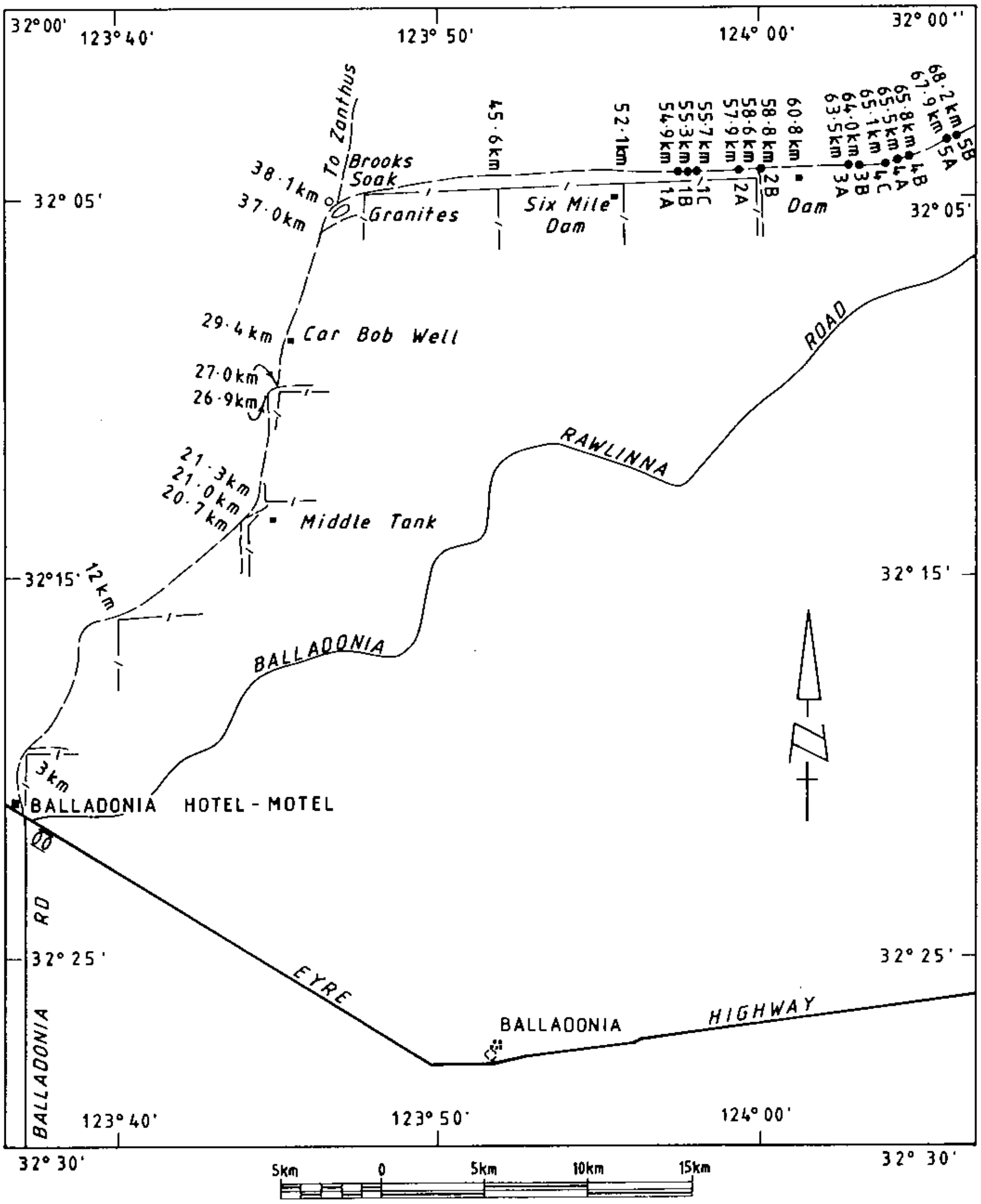
APPENDIX I

QUADRATS AND TRAPSITE LOCATIONS



BALLADONIA (BA)

TRAP LINE	GEOGRAPHICAL		A.M.G. ZONE 51		DESCRIPTION
	SOUTH LAT.	EAST LONG.	EAST	NORTH	
1 A	32° 4' 27". 01	123° 57' 44". 60	590 832	6 450 926	St. pkt. & Indicator
1 B	32° 4' 26". 78	123° 58' 0". 58	591 251	6 450 929	" "
1 C	32° 4' 26". 55	123° 58' 15". 81	591 650	6 450 933	" "
2 A	32° 4' 25". 33	123° 59' 38". 48	593 818	6 450 951	" "
2 B	32° 4' 27"" 23	124° 0' 11". 53	594 684	6 450 884	" "
3 A	32° 4' 22". 15	124° 3' 2". 04	599 156	6 450 998	" "
3 B	32° 4' 22". 51	124° 3' 19". 82	599 622	6 450 982	" "
4 A	32° 4' 9". 76	124° 4' 12". 13	600 997	6 451 361	" "
4 B	32° 4' 5". 41	124° 4' 25". 39	601 346	6 451 492	" "
4 C	32° 4' 11". 86	124° 4' 2". 38	600 741	6 451 299	" "
5 A	32° 3' 46". 58	124° 5' 38". 04	603 257	6 452 052	" "
5 B	32° 3' 41". 44	124° 5' 49". 14	603 550	6 452 208	" "

HORIZONTAL RELIABILITY ± 5m OR BETTER

MAR REFERENCE : SI 51-3 BALLADONIA 1 : 250000

AUSTRALIAN SURVEY OFFICE W.A. PLAN No, A4-6042 S.I.F. 84120 1985

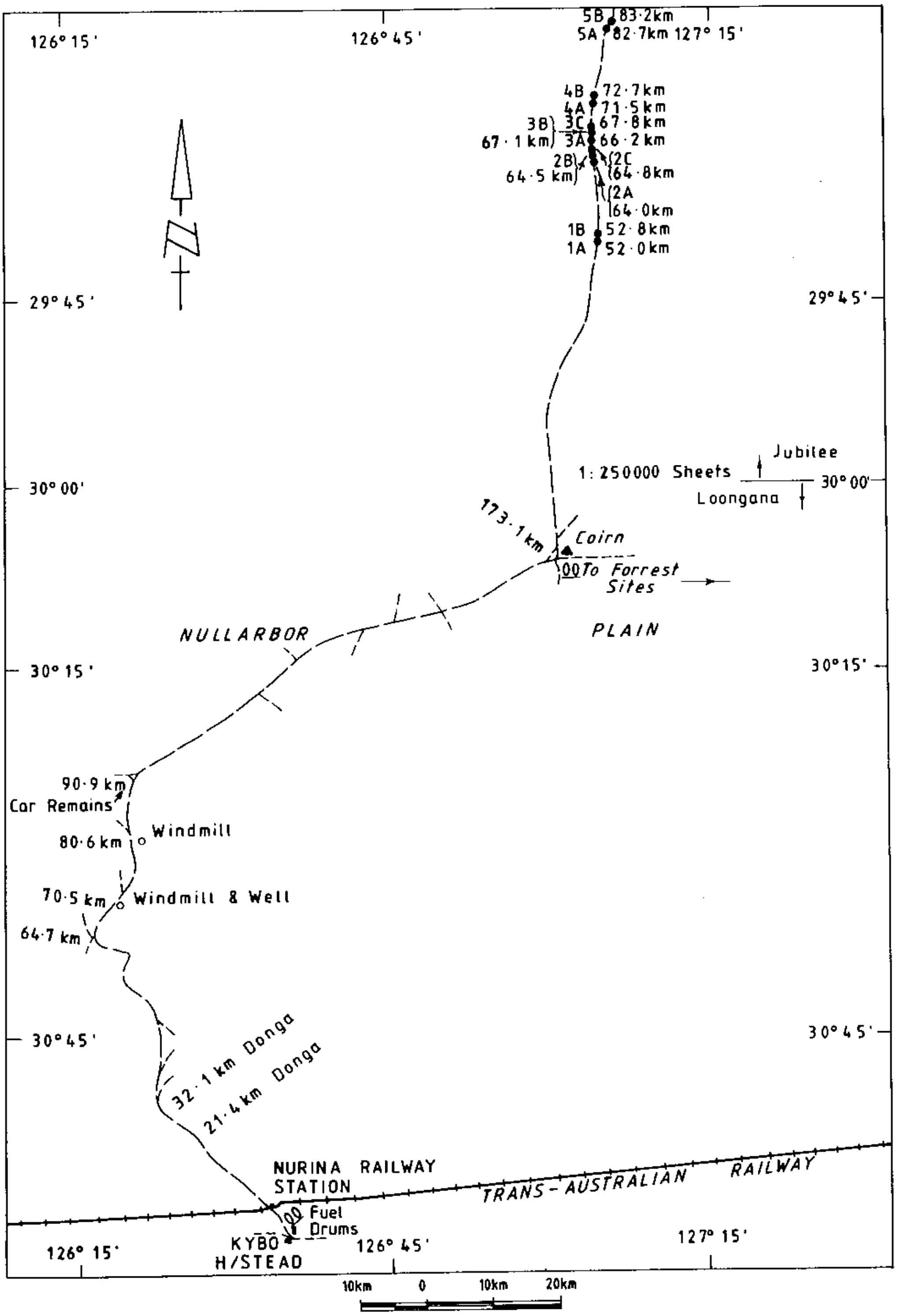
QUADRAT BA 1 DATE 29/03/84
LATITUDE 32,41,26 LONGITUDE 123,58,00
ALTITUDE 150 metres
LOCATION 44 km N Balladonia Rock, Western Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE grazing

QUADRAT BA 2 II DATE 29/03/84
LATITUDE 32,04,27 LONGITUDE 124,00,11
ALTITUDE 135 metres
LOCATION 44 km N Balladonia Rock, Western Australia
LANDFORM depression SOIL TEXTURE sandy clay loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE light grazing

QUADRAT BA 3 DATE 28/03/84
LATITUDE 32,04,22 LONGITUDE 124,03,00
ALTITUDE 150 metres
LOCATION 46 km NE Balladonia Rock, Western Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE grazing

QUADRAT BA 4 DATE 30/03/84
LATITUDE 32,04,05 LONGITUDE 124,04,25
ALTITUDE 155 metres
LOCATION 47 km N Balladonia Rock, Western Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE light grazing

QUADRAT BA 5 DATE 31/03/84
LATITUDE 32,03,46 LONGITUDE 124,05,38
ALTITUDE 155 metres
LOCATION 48 km NE Balladonia Rock, Western Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE light grazing



MAP REFERENCE : SH 52-5
JUBILEE 1 : 250000

JUBILEE (JU)

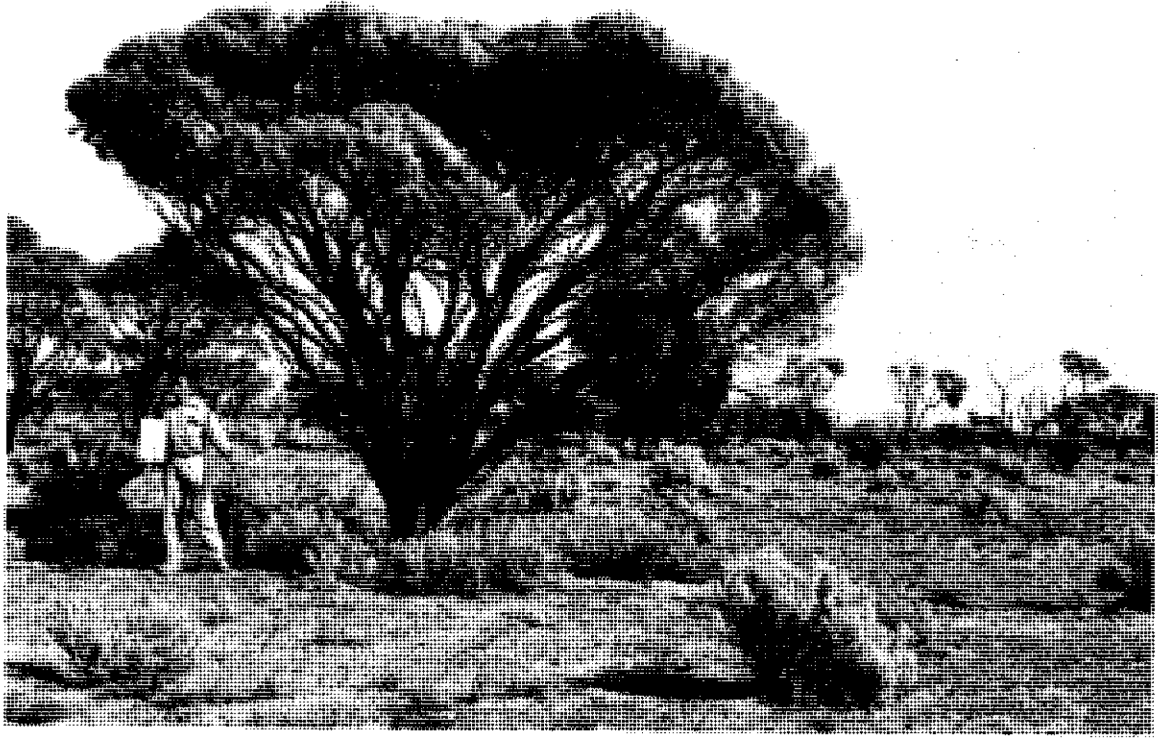
TRAP LINE	GEOGRAPHICAL SOUTH LAT.	GEOGRAPHICAL EAST LONG.	A.M.G. ZONE 52 EAST	A.M.G. ZONE 52 NORTH	DESCRIPTION
1 A	29° 39' 25". 94	127° 4' 9". 27	313 127	6 717 628	St Pkt. & Indicator
1 B	29° 39' 11". 01	127° 4' 10". 23	313 145	6 718 088	" "
2 A	29° 33' 3". 87	127° 3' 47". 29	312 340	6 729 381	" "
2 B	29° 32' 46". 73	127° 3' 49". 54	312 391	6 729 910	" "
2 C	29° 32' 37". 41	127° 3' 50". 15	312 403	6 730 197	" "
3 A	29° 31' 51". 60	127° 3' 52". 54	312 444	6 731 609	" "
3 B	29° 31' 23". 14	127° 3' 52". 21	312 421	6 732 485	" "
3 C	29° 30' 58". 04	127° 3' 50". 84	312 371	6 733 257	" "
4 A	29° 29' 3". 18	127° 4' 11". 18	312 860	6 736 802	" "
4 B	29° 28' 25". 78	127° 4' 19". 30	313 060	6 737 957	" "
5 A	29 23 10". 80	127 5 17". 51	314 469	6 747 680	" "
5 B	29° 22' 53". 33	127° 5' 23". 99	314 634	6 748 221	" "

HORIZONTAL RELIABILITY ± 5m OR BETTER

AUSTRALIAN SURVEY OFFICE W.A. PLAN No. A4-6076

S.I.F. 84114 1985

QUADRAT JU 1 OATE 08/04/84
LATITUOE 29,39,25 LONGITUDE 127,04,09
ALTITUOE 210 metres
LOCATION 143.7 km N Loongana, Western Australia
LANOFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE conservation

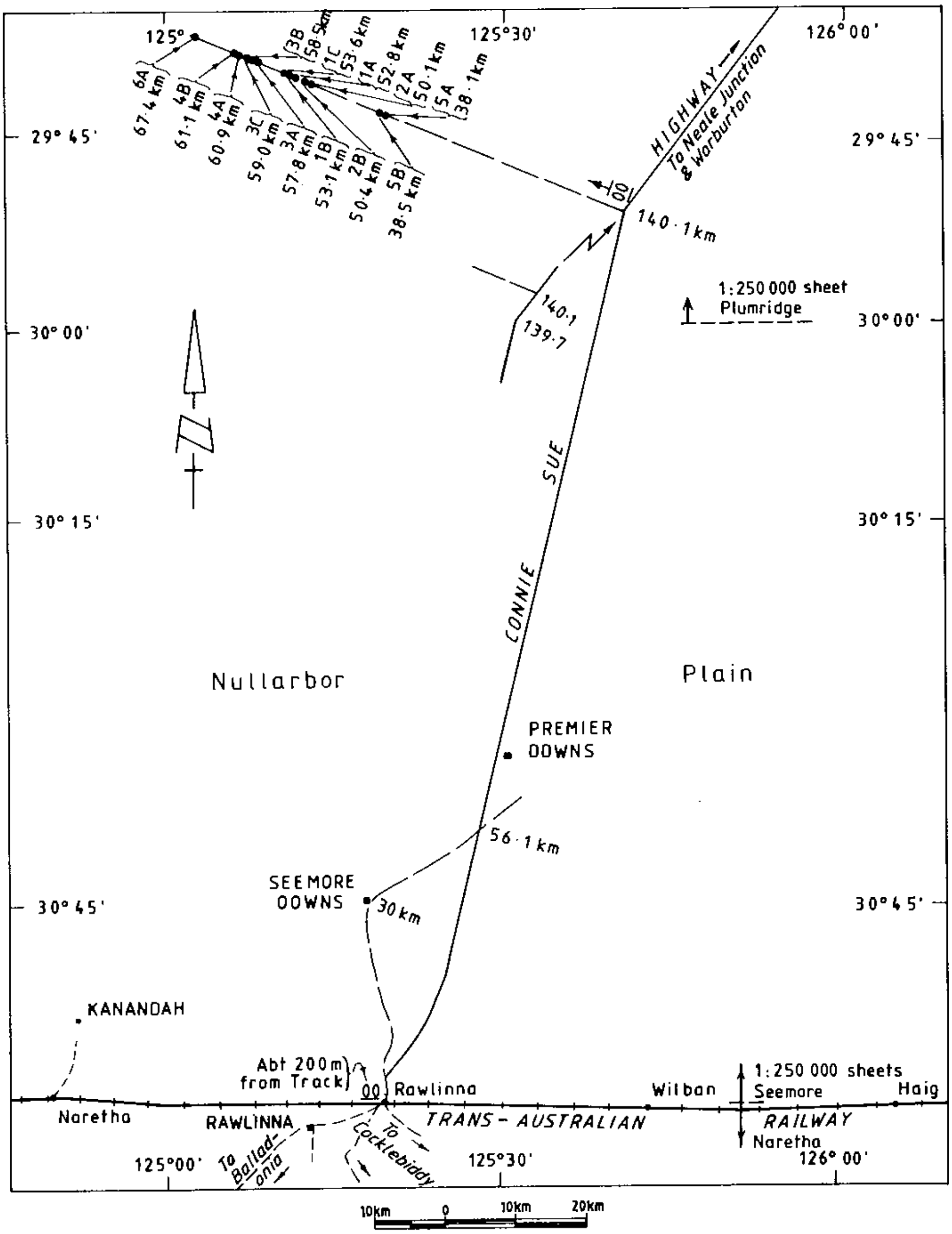


QUAORAT JU 2 OATE 08/04/84
LATITUDE 29,32,46 LONGITUOE 127,03,49
ALTITUOE 225 metres
LOCATION 155 km N Loongana, Western Australia
LANOFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE sheet eroded
LAND USE grazing

QUADRAT JU 3 DATE 08/04/84
LATITUDE 29,31,23 LONGITUDE 127,03,52
ALTITUDE 230 metres
LOCATION 166 km N Loongana, Western Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE conservation

QUADRAT JU 4 DATE 09/04/84
LATITUDE 29,28,25 LONGITUDE 127,04,19
ALTITUDE 230 metres
LOCATION 164 km N Loongana, Western Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE sheet eroded
LAND USE conservation

QUADRAT JU 5 I DATE 09/04/84
LATITUDE 29,22,53 LONGITUDE 127,05,23
ALTITUDE 214 metres
LOCATION 175 km N Loongana, Western Australia
LANDFORM depression SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE conservation



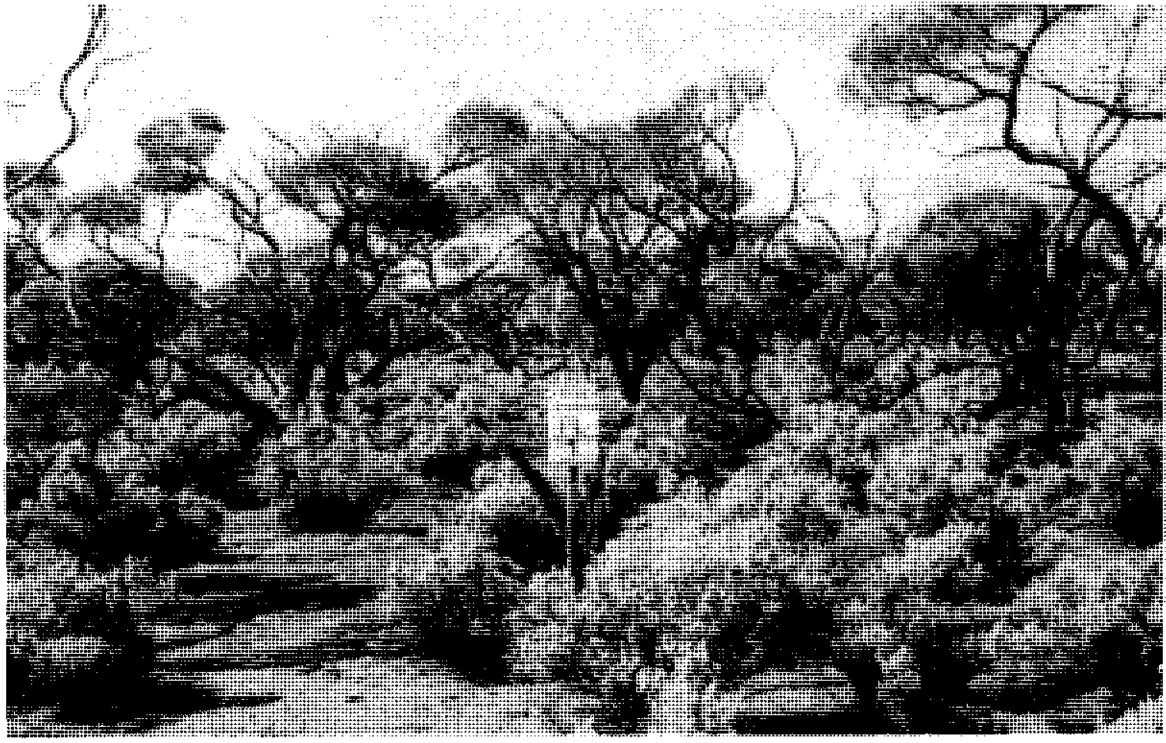
PLUMRIDGE (PL)

TRAP LINE	GEOGRAPHICAL SOUTH LAT.	GEOGRAPHICAL EAST LONG.	A.M.G. ZONE 51 EAST	A.M.G. ZONE 51 NORTH	DESCRIPTION
1 A	29° 41' 11". 24	125° 10' 32". 84	710 533	6 713 965	St. Pkt. & Indicator
1 B	29° 41' 8". 44	125° 10' 21". 90	710 240	6 714 057	" "
1 C	29° 41' 5". 14	125° 10' 3". 88	709 758	6 714 168	" "
2 A	29° 41' 31". 97	125° 12' 7". 61	713 069	6 713 279	" "
2 B	29° 41' 26". 90	125° 11' 49". 97	712 598	6 713 444	" "
3 A	29° 40' 14". 38	125° 7' 43". 95	706 025	6 715 801	" "
3 B	29° 40' 5". 21	125° 7' 22". 73	705 459	6 716 094	" "
3 C	29° 39' 58". 00	125° 7' 5". 18	704 992	6 716 324	" "
4 A	29° 39' 30". 51	125° 6' 2". 12	703 311	6 717 201	" "
4 B	29° 39' 27". 42	125° 5' 54". 34	703 104	6 717 300	" "
5 A	29° 43' 17". 18	125° 19' 10". 41	724 370	6 709 817	" "
5 B	29° 43' 12". 60	125° 18' 52". 10	723 881	6 709 968	" "
6 A	29° 37' 55". 83	125° 2' 21". 17	697 421	6 720 223	" "

HORIZONTAL RELIABILITY ± 5m OR BETTER

MAP REFERENCE : SH 51-8 PLUMRIDGE 1 : 250000

AUSTRALIAN SURVEY OFFICE W.A. PLAN No. A4-6071 S.I.F. 84113 1985

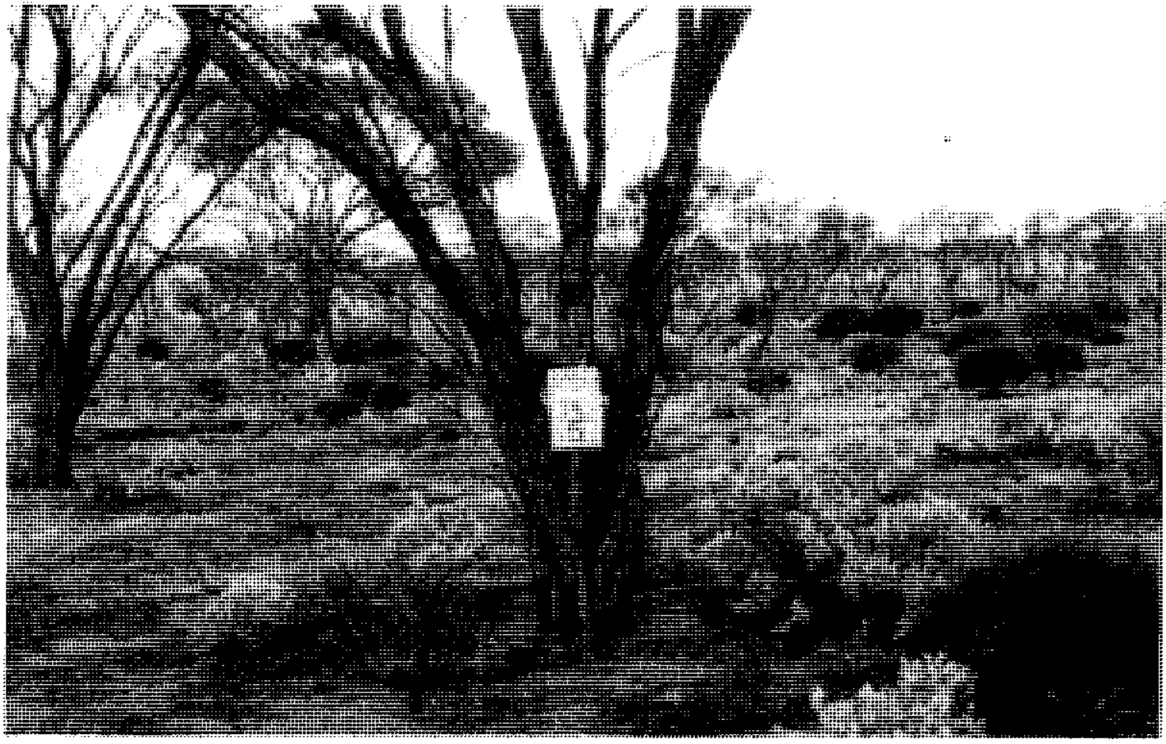


QUADRAT PL 1 DATE 15/04/84
LATITUDE 29,41,08 LONGITUDE 125,10,21
ALTITUDE 200 metres
LOCATION 53.0 km NW Connie-Sue Highway, Western Australia
LANDFORM rise SOIL TEXTURE loam
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE conservation

QUADRAT PL 2 DATE 15/04/84
LATITUDE 29,41,26 LONGITUDE 125,11,49
ALTITUDE 200 metres
LOCATION 50.0 km NW Connie-Sue Highway, Western Australia
LANDFORM rise SOIL TEXTURE loam
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE conservation

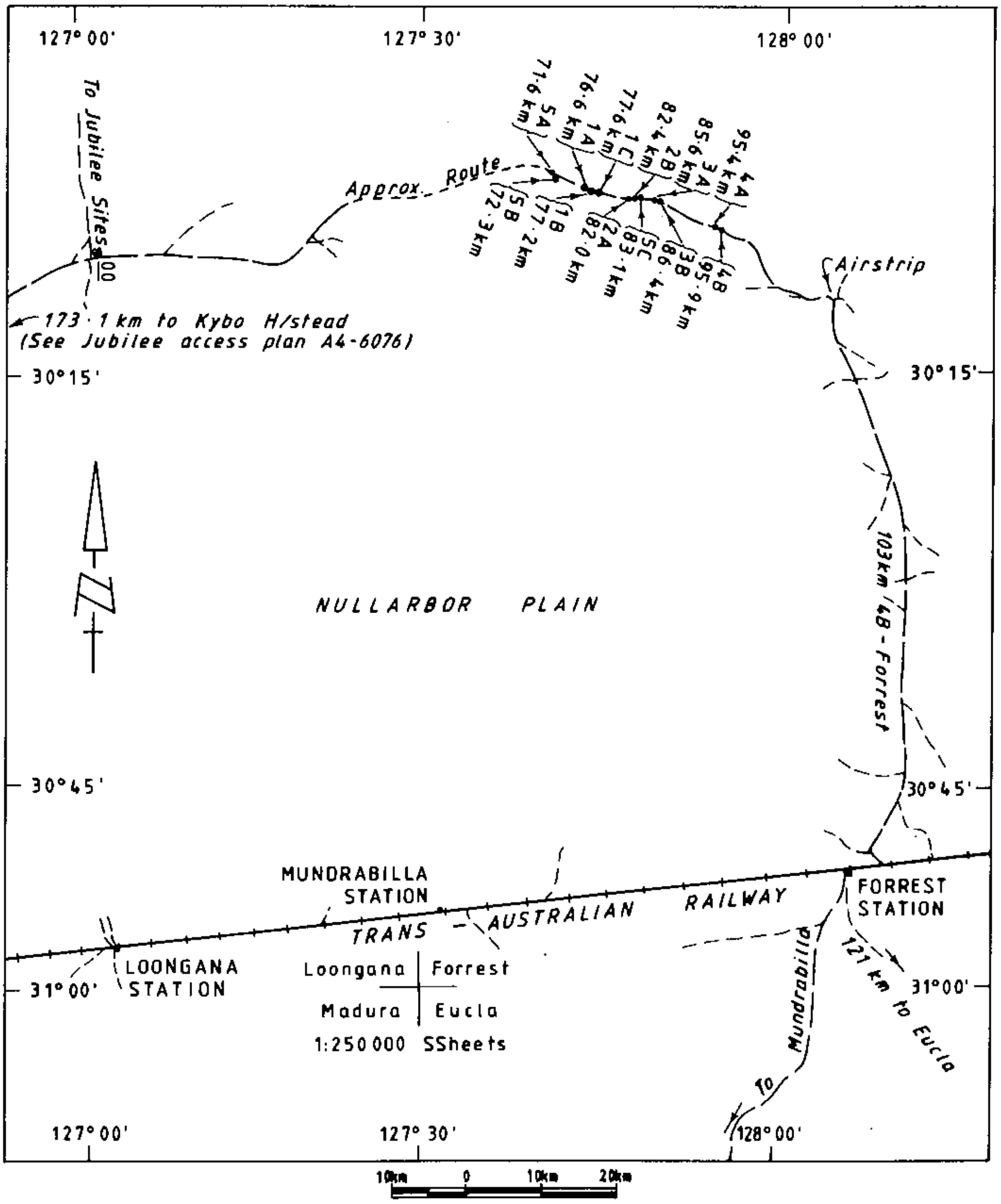
QUADRAT PL 3 DATE 15/04/84
LATITUDE 29,40,05 LONGITUDE 125,07,22
ALTITUDE 200 metres
LOCATION 58.5 km NW Connie-Sue Highway, Western Australia
LANDFORM rise SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE conservation

QUADRAT PL 4 DATE 14/04/84
LATITUDE 29,39,27 LONGITUDE 125,05,54
ALTITUDE 210 metres
LOCATION 60.8 km NW Connie-Sue Highway, Western Australia
LANDFORM rise SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE conservation



QUADRAT PL 5 DATE 13/04/84
LATITUDE 29,43,12 LONGITUDE 125,18,52
ALTITUDE 205 metres
LOCATION 38.3 km NW Connie-Sue Highway, Western Australia
LANDFORM rise SOIL TEXTURE loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE conservation

QUADRAT PL 6 DATE 13/04/84
LATITUDE 29,37,55 LONGITUDE 125,02,21
ALTITUDE 210 metres
LOCATION 68 km NW Connie-Sue Hignway, Western Australia
LANDFORM other SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE conservation



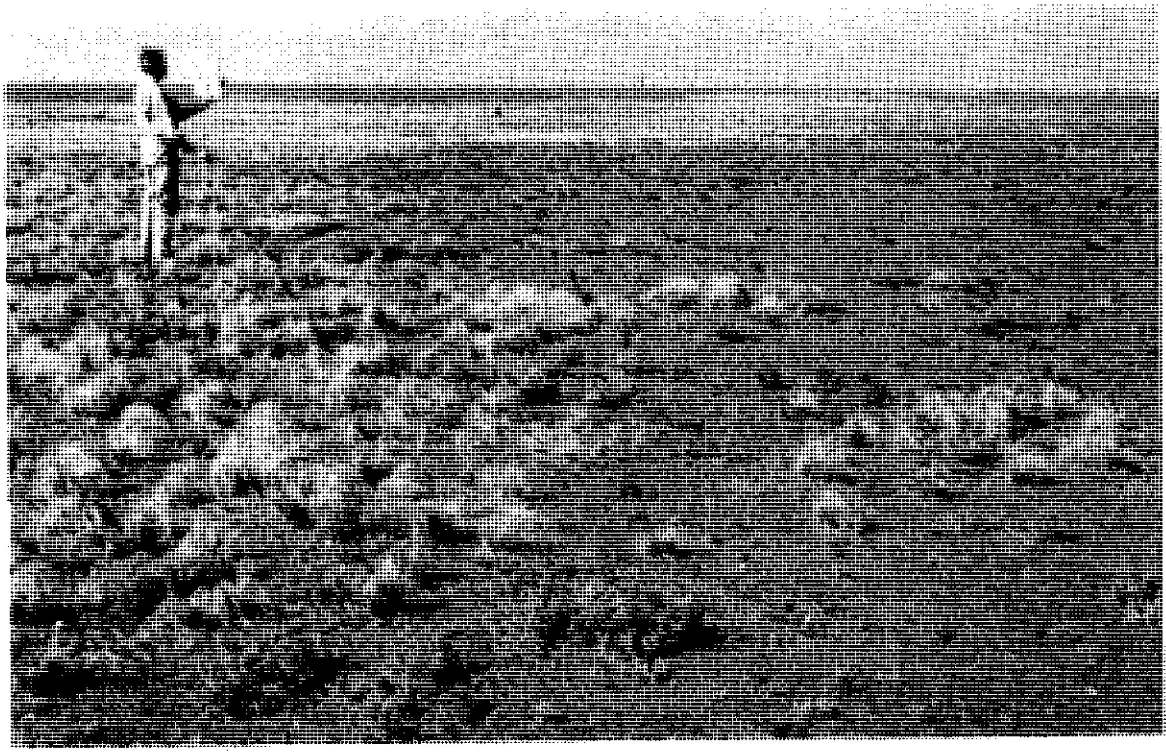
FORREST (FO)

TRAP LINE	GEOGRAPHICAL		A.M.G. ZONE 52		DESCRIPTION
	SOUTH LAT.	EAST LONG.	EAST	NORTH	
1 A	30° 1' 33". 46	127° 43' 50". 12	377 595	6 677 648	St. Pkt. & Indicator
1 B	30° 1' 41". 93	127° 44' 12". 19	378 189	6 677 394	" "
1 C	30° 1' 47". 44	127° 44' 23". 97	378 506	6 677 227	" "
2 A	30° 2' 10". 75	127° 47' 7". 00	382 881	6 676 557	" "
2 B	30° 2' 8". 63	127° 47' 20". 84	383 251	6 676 626	" "
5 C	30° 2' 3". 35	127° 47' 47". 03	383 951	6 676 796	" "
3 A	30° 2' 11". 46	127° 49' 15". 71	386 328	6 676 571	" "
3 B	30° 2' 4". 74	127° 49' 43". 85	387 080	6 676 786	" "
4 A	30° 4' 15". 80	127° 54' 37". 79	394 991	6 672 829	" "
4 B	30° 4' 25". 63	127° 54' 53". 54	395 416	6 672 531	" "
5 A	30° 0' 34". 65	127° 41' 12". 76	373 359	6 679 411	" "
5 B	30° 0' 49". 11	127° 41' 19". 61	373 547	6 678 968	" "

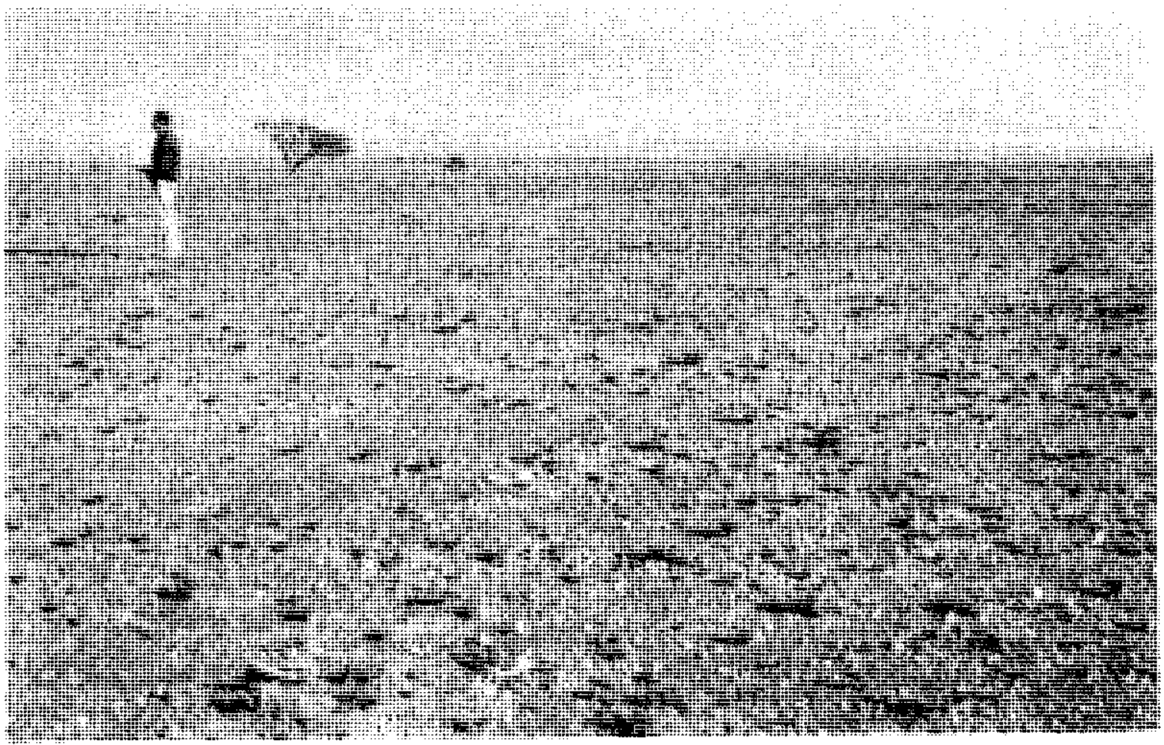
HORIZONTAL RELIABILITY ± 5m OR BETTER

MAP REFERENCE : SH 52-10 FORREST 1 : 250000

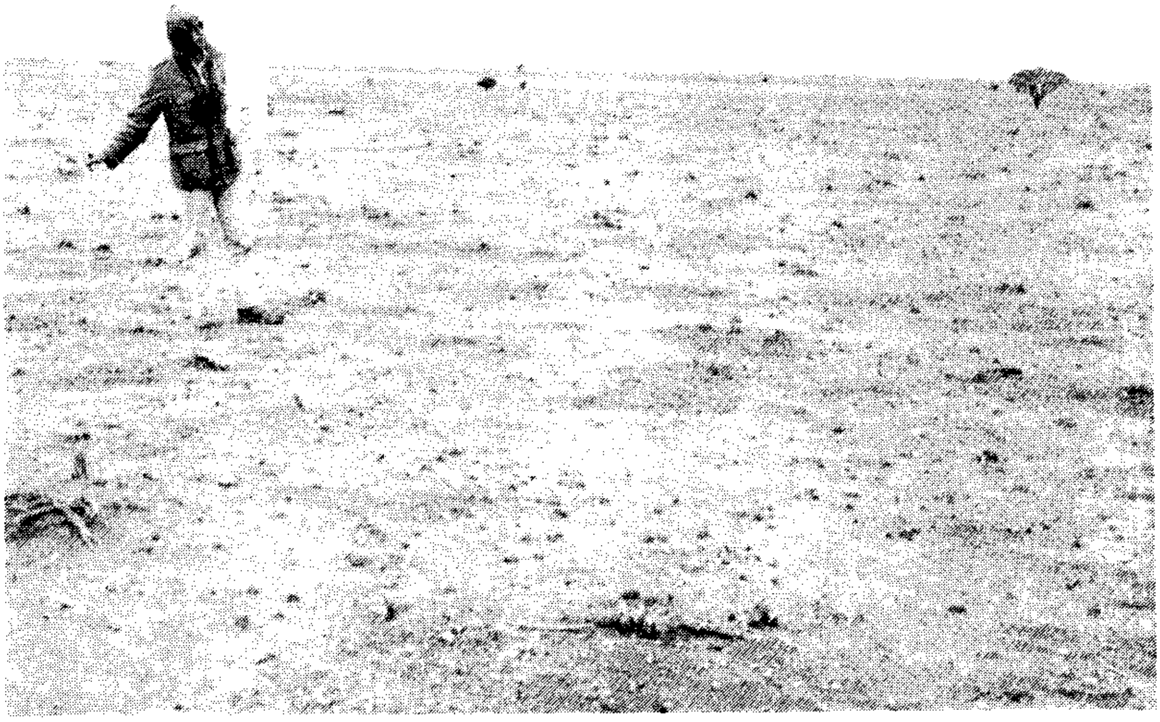
AUSTRALIAN SURVEY OFFICE W.A. PLAN No. A4-6084 S.I.P. 84116 1985



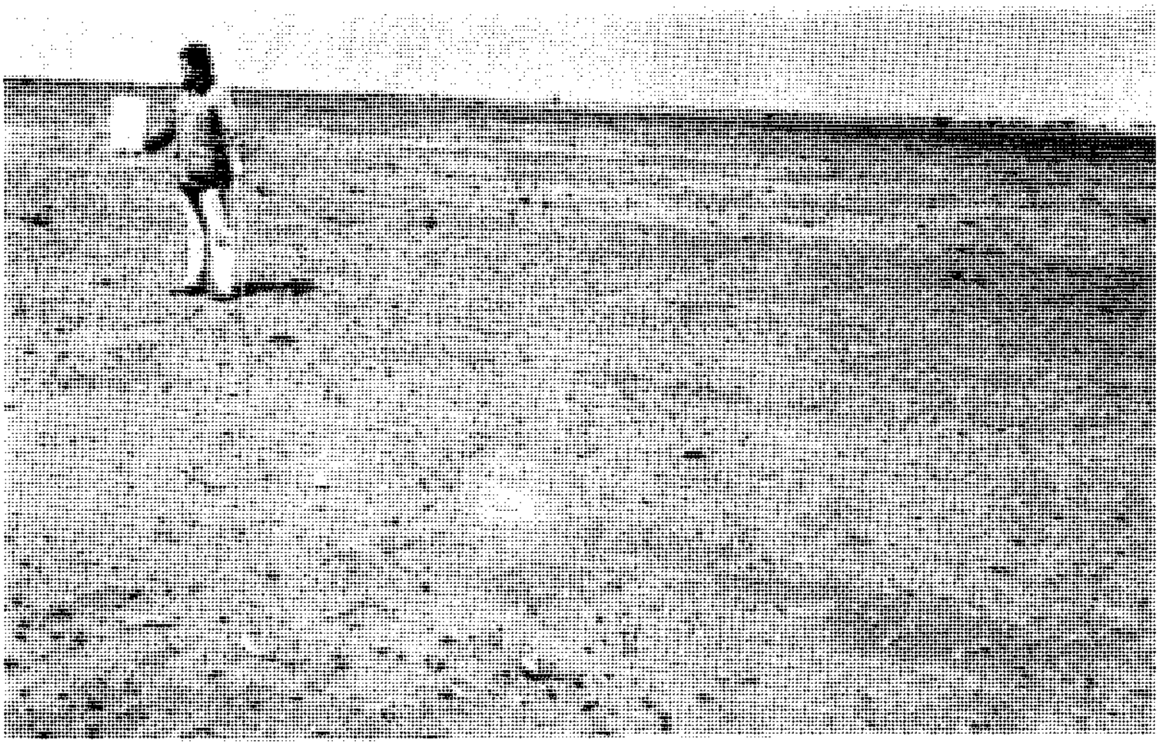
QUADRAT FO 1 DATE 14/04/84
LATITUDE 30,01,41 LONGITUDE 127,44,12
ALTITUDE 210 metres
LOCATION 98 km NW Forrest, Western Australia
LANDFORM plain SOIL TEXTURE loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE conservation



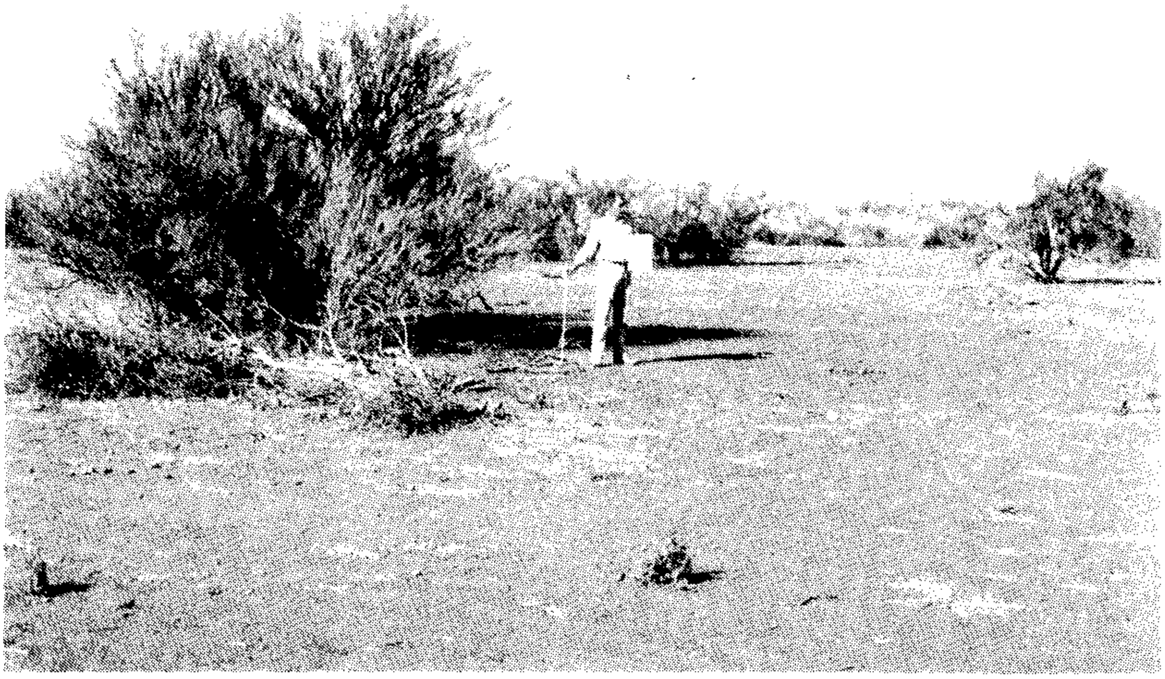
QUADRAT FO 2 DATE 15/04/84
LATITUDE 30,02,08 LONGITUDE 127,47,20
ALTITUDE 210 metres
LOCATION 92 km NW Forrest, Western Australia
LANDFORM rise SOIL TEXTURE loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE sheet eroded
LAND USE conservation



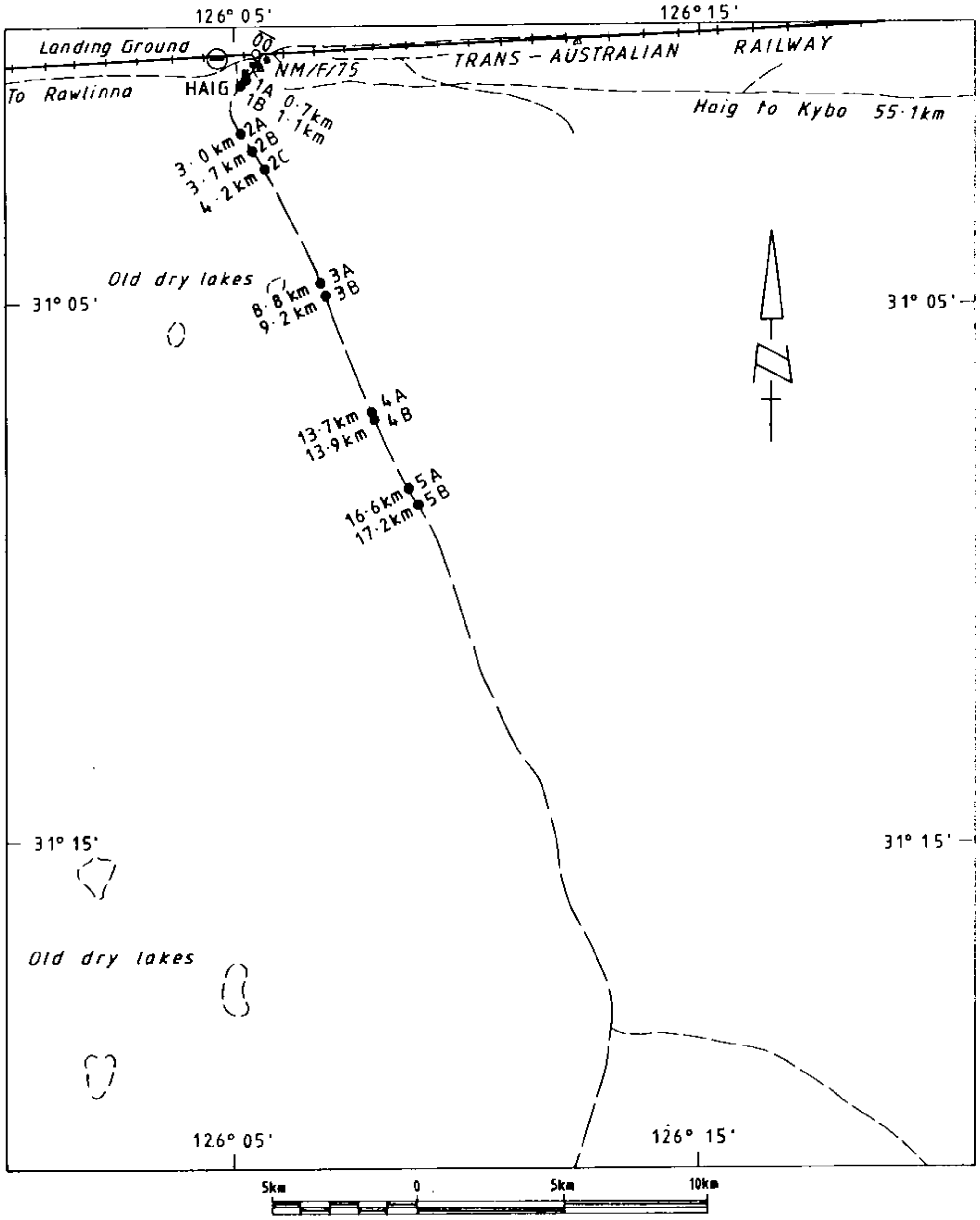
QUADRAT FO 3 DATE 13/04/84
LATITUDE 30,02,04 LONGITUDE 127,49,43
ALTITUDE 210 metres
LOCATION 87.5 km NW Forrest, Western Australia
LANDFORM rise SOIL TEXTURE sandy clay loam
SURFACE STREW cobble (64-256mm)
SURFACE CONDITION loose DISTURBANCE sheet eroded
LAND USE conservation



QUADRAT FO 4 DATE 13/04/84
LATITUDE 30,04,25 LONGITUDE 127,54,53
ALTITUDE 210 metres
LOCATION 81.0 km NW Forrest, Western Australia
LANDFORM rise SOIL TEXTURE sandy clay loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE sheet eroded
LAND USE conservation



QUADRAT FO 5 DATE 14/04/84
LATITUDE 30,00,49 LONGITUDE 127,41,19
ALTITUDE 200 metres
LOCATION 97 km NW Forrest, Western Australia
LANDFORM doline SOIL TEXTURE clay
SURFACE STREW none apparent
SURFACE CONDITION hard setting DISTURBANCE none visible
LAND USE conservation

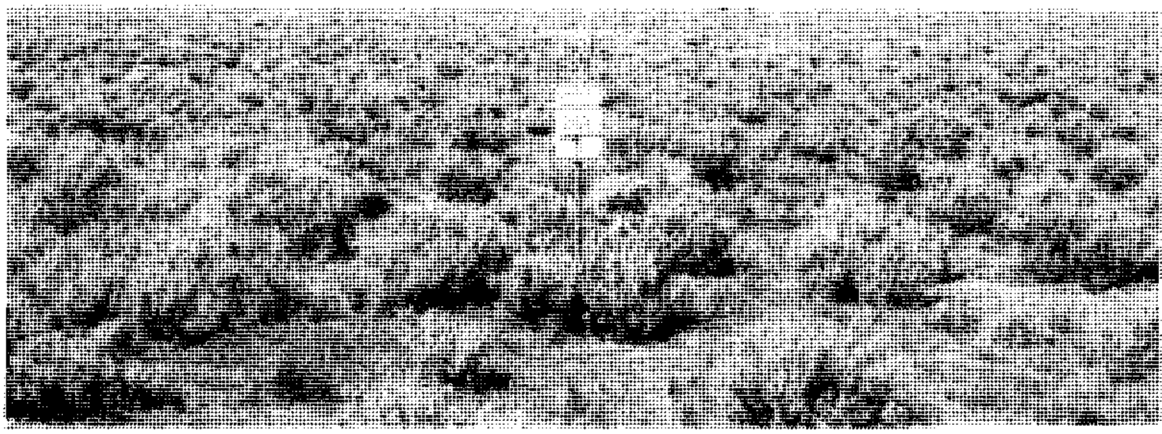


HAIG (HA)

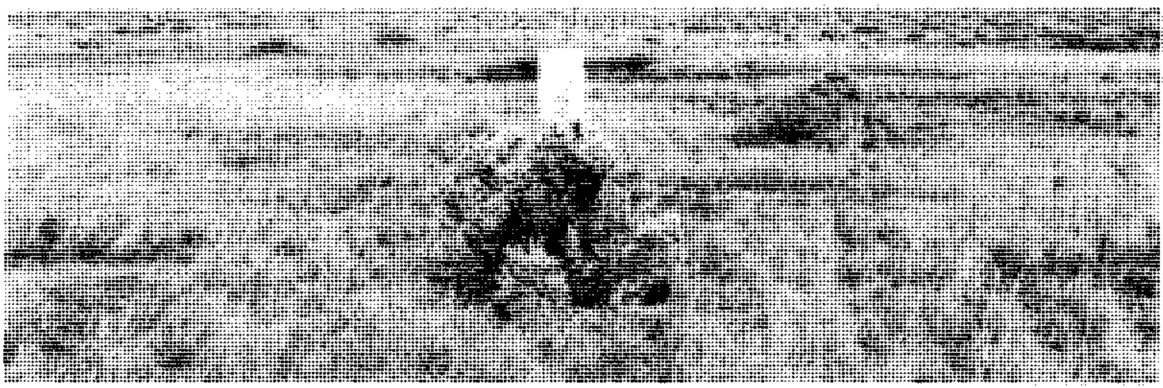
TRAP LINE	GEOGRAPHICAL SOUTH LAT.	EAST LONG.	A.M.G. ZONE 52 EAST	NORTH	DESCRIPTION
1 A	31° 0' 46". 63	126° 5' 12". 81	221 877	6 565 306	St Pkt, & Indicator
1 B	31° 0' 53". 97	126° 5' 5". 90	221 700	6 565 075	" "
2 A	31° 1' 48". 37	126° 5' 0". 86	221 610	6 563 396	" "
2 B	31° 2' 8". 16	126° 5' 13". 37	221 958	6 562 795	" "
2 C	31° 2' 22". 78	126° 5' 23". 00	222 225	6 562 351	" "
3 A	31° 4' 34". 44	126° 6' 40". 82	224 395	6 558 350	" "
3 B	31° 4' 47". 59	126° 6' 47". 86	224 592	6 557 949	" "
4 A	31° 6' 59". 90	126° 7' 52". 03	226 399	6 553 918	" "
4 B	31° 7' 7". 97	126° 7' 56". 45	226 522	6 553 672	" "
5 A	31° 8' 25". 25	126° 8' 42". 44	227 802	6 551 323	" "
5 B	31° 8' 41". 86	126° 8' 53". 74	228 115	6 550 819	

HORIZONTAL RELIABILITY ± 5m OR BETTER

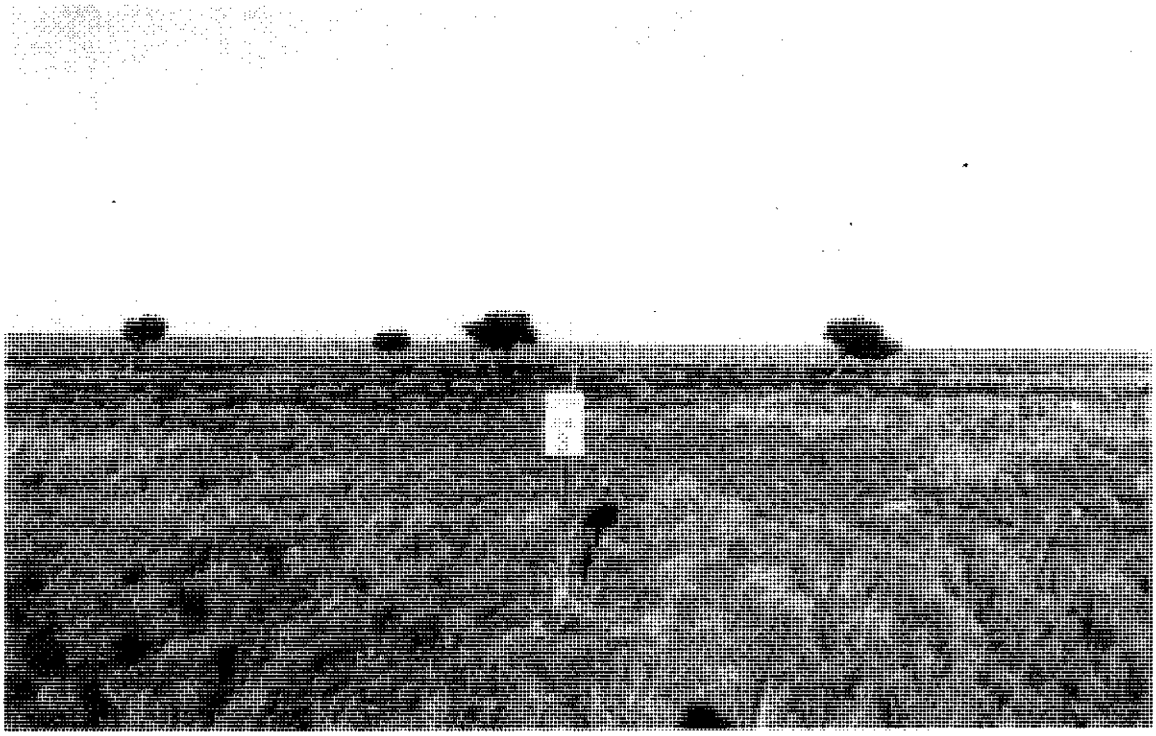
MAP REFERENCE : SH 52-13 MADURA 1 : 250000



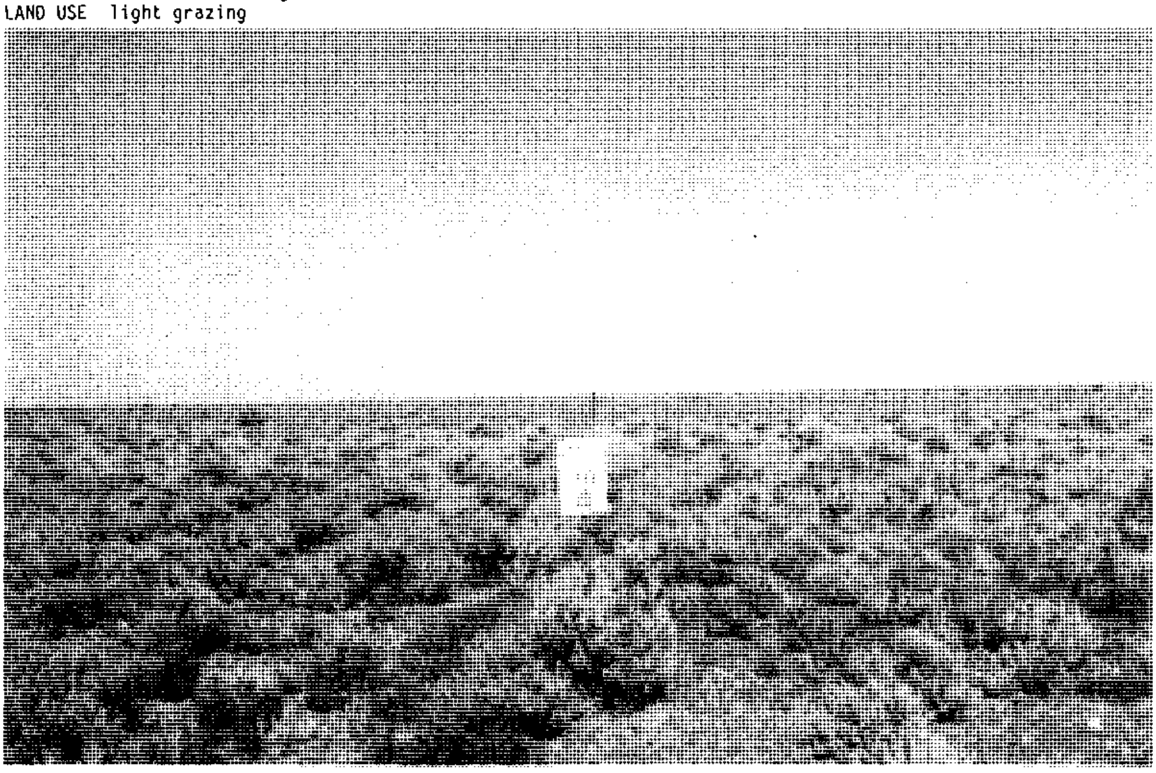
QUADRAT HA 1 DATE 08/04/81
LATITUDE 31,00,53 LONGITUDE 126,05,05
ALTITUDE 174 metres
LOCATION 0.5 km SE Haig, Western Australia
LANDFORM plain SOIL TEXTURE loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE light grazing



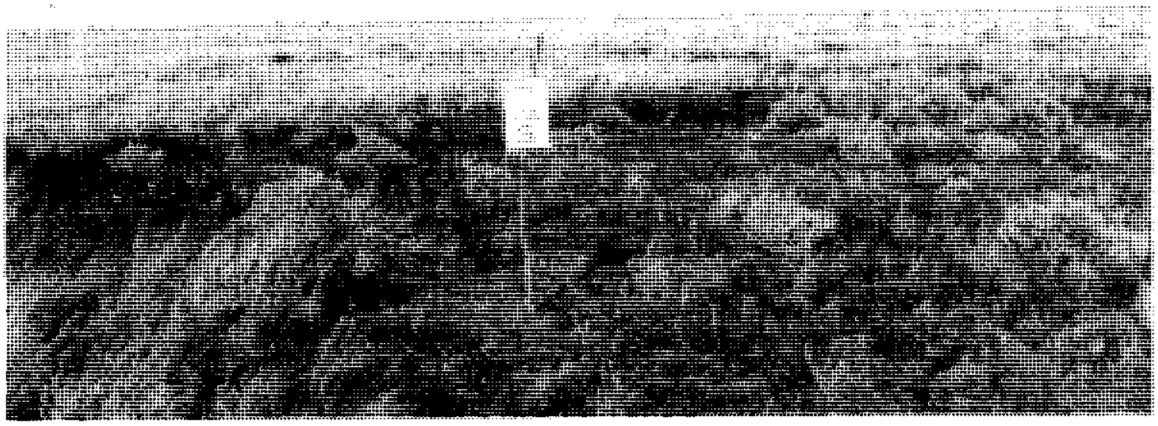
QUADRAT HA 2 DATE 08/04/84
LATITUDE 31,02,08 LONGITUDE 126,05,13
ALTITUDE 165 metres
LOCATION 3.2 km SE Haig, Western Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE light grazing



QUADRAT HA 3 DATE 09/04/84
LATITUDE 31,04,47 LONGITUDE 126,06,47
ALTITUDE 167 metres
LOCATION 8.7 km SE Haig, Western Australia
LANDFORM plain SOIL TEXTURE loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE light grazing

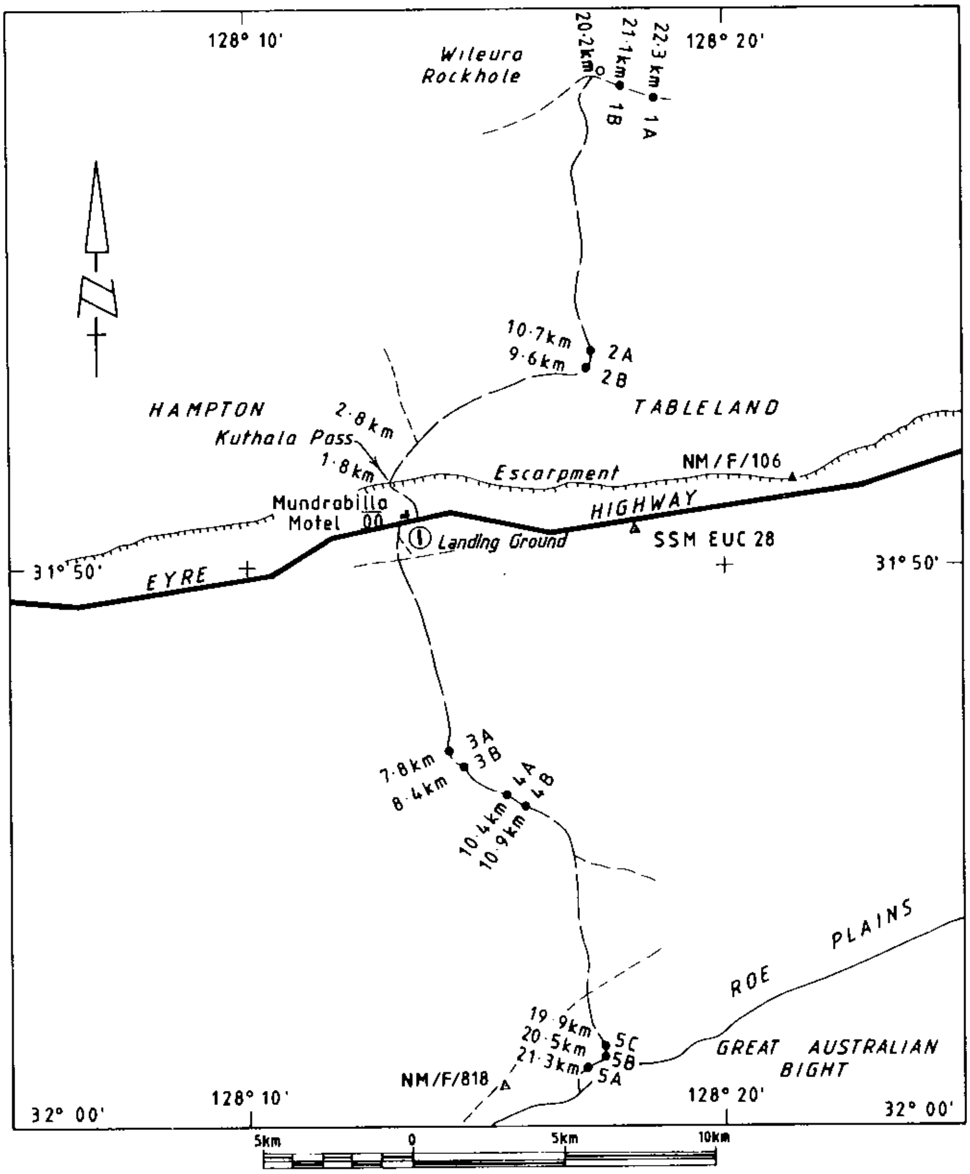


QUADRAT HA 4 DATE 09/04/84
LATITUDE 31,07,07 LONGITUDE 126,07,56
ALTITUDE 159 metres
LOCATION 13.5 km SE Haig, Western Australia
LANDFORM depression SOIL TEXTURE loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE light grazing



QUADRAT HA 5 DATE 08/04/84
LATITUDE 31,08,41 LONGITUDE 126,08,53
ALTITUDE 158 metres
LOCATION 17.5 km SE Haig, Western Australia
LANDFORM depression SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE light grazing

QUADRAT HA 6 DATE 08/04/84
LATITUDE 31,01,46 LONGITUDE 126,04,00
ALTITUDE
LOCATION 3.5 km SW Haig, Western Australia
LANDFORM plain SOIL TEXTURE loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE light grazing

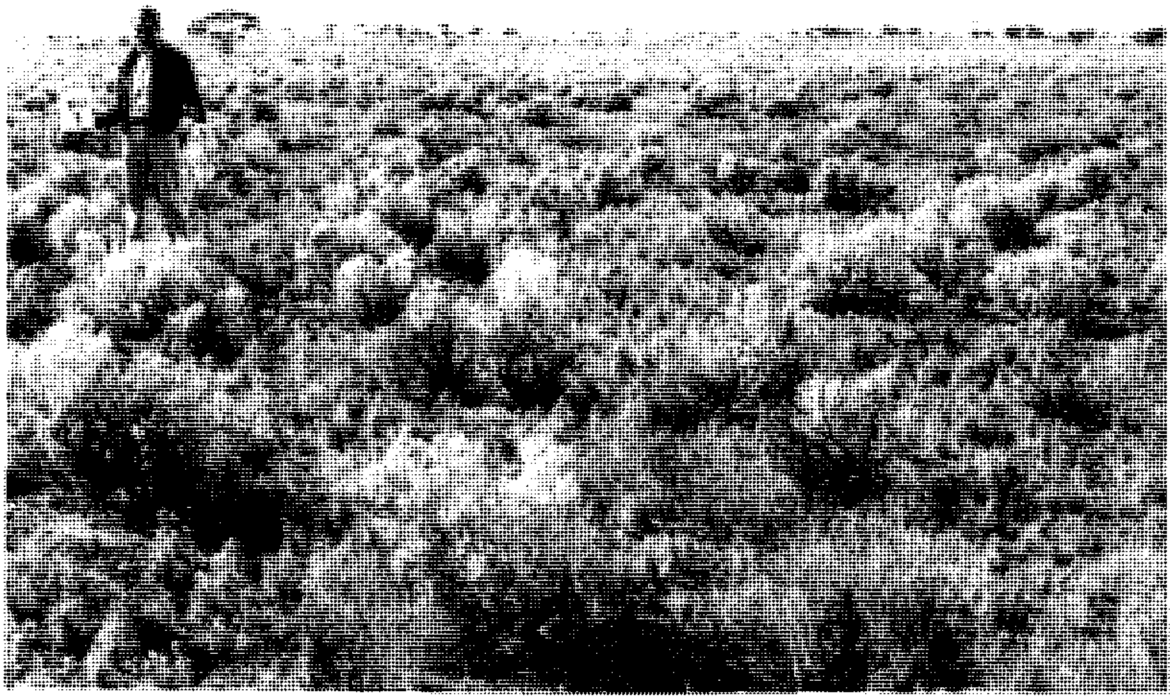


KUTHALA (KU)

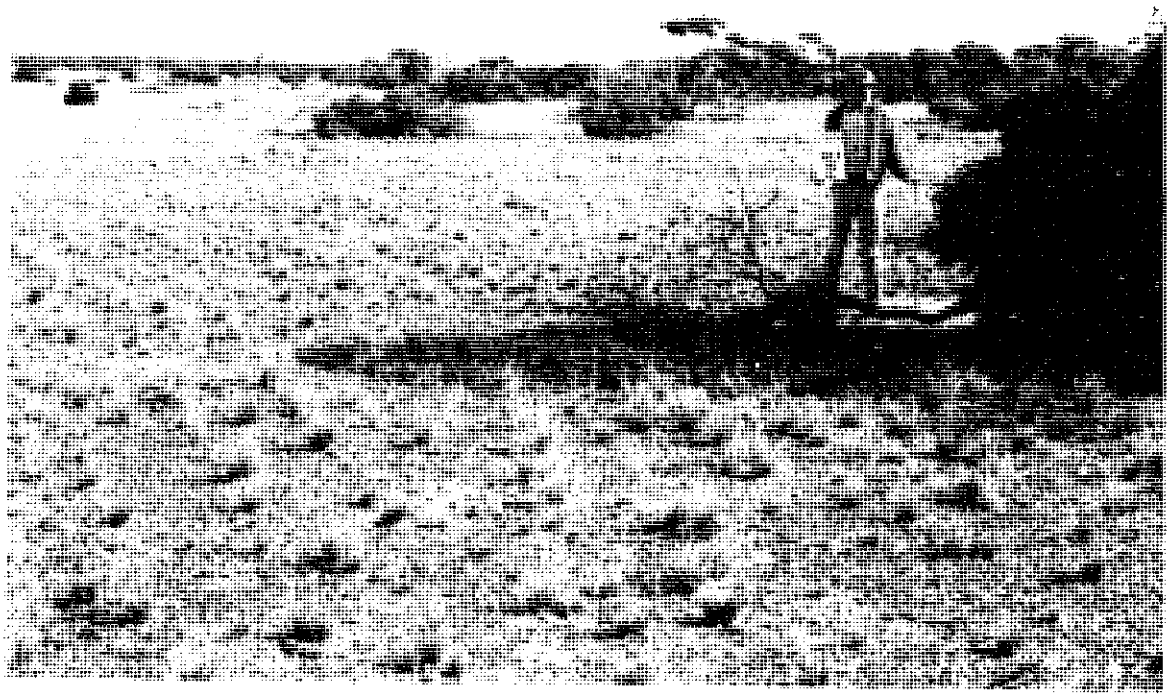
TRAP LINE	GEOGRAPHICAL		A.M.G. ZONE 52		DESCRIPTION
	SOUTH LAT.	EAST LONG.	EAST	NORTH	
1 A	32° 41' 33". 57	128° 18' 31". 62	434 493	6 493 410	St Pkt, & Indicator
1 B	31° 41' 22". 24	128° 17' 49". 94	433 394	6 493 752	" "
2 A	31° 46' 10". 46	128° 17' 16". 21	432 564	6 484 872	" "
2 B	31° 46' 32". 90	128° 16' 58". 68	432 107	6 484 178	" "
3 A	31° 53' 19". 31	128° 14' 13". 20	427 842	6 471 635	" "
3 B	31° 53' 35". 11	128° 14' 28". 45	428 246	6 471 151	" "
4 A	31° 54' 7". 84	128° 15' 32". 69	429 [illegible]41	6 470 155	" "
4 B	31° 54' 15". 46	128° 15' 48". 20	430 350	6 469 924	" "
5 A	31° 59' 3". 40	128° 17' 8". 86	432 527	6 461 072	" "
5 B	31° 58' 53". 11	128° 17' 35". 43	433 222	6 461 393	" "
5 C	31° 58' 37". 85	128° 17' 31". 29	433 110	6 461 963	" "

HORIZONTAL RELIABILITY ± 5m OR BETTER

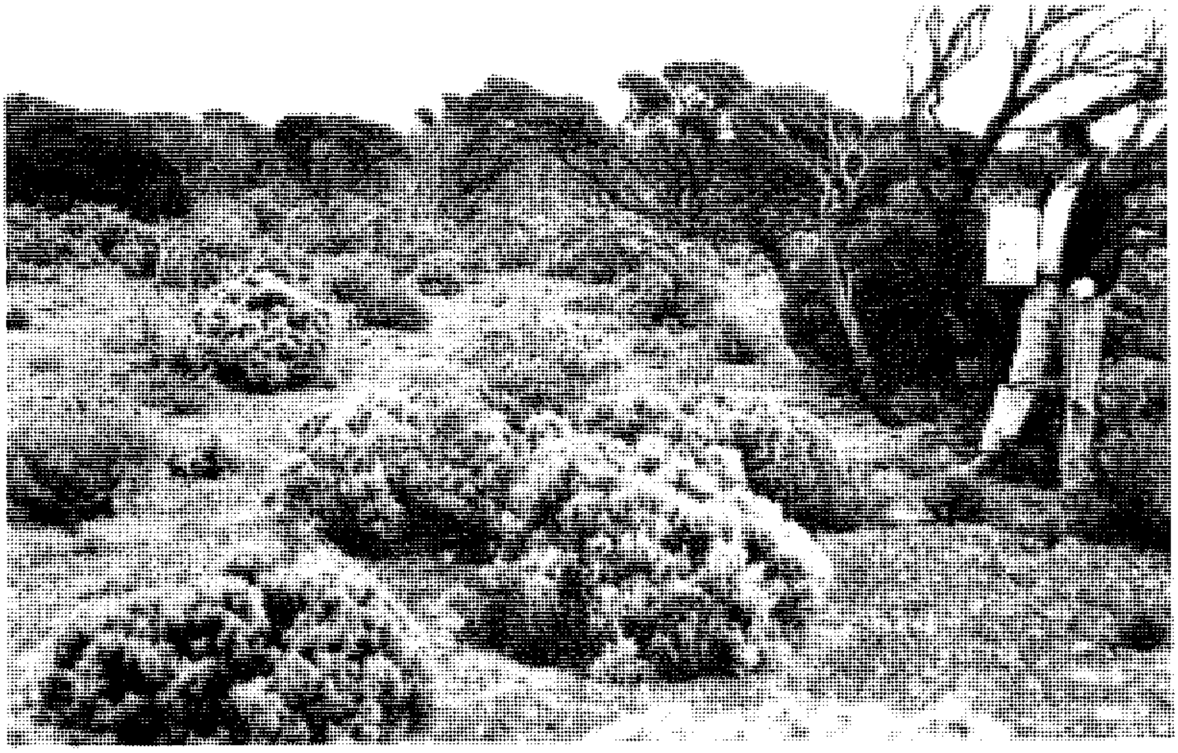
MAP REFERENCE : SH 52-14 EUCLA 1 : 250000



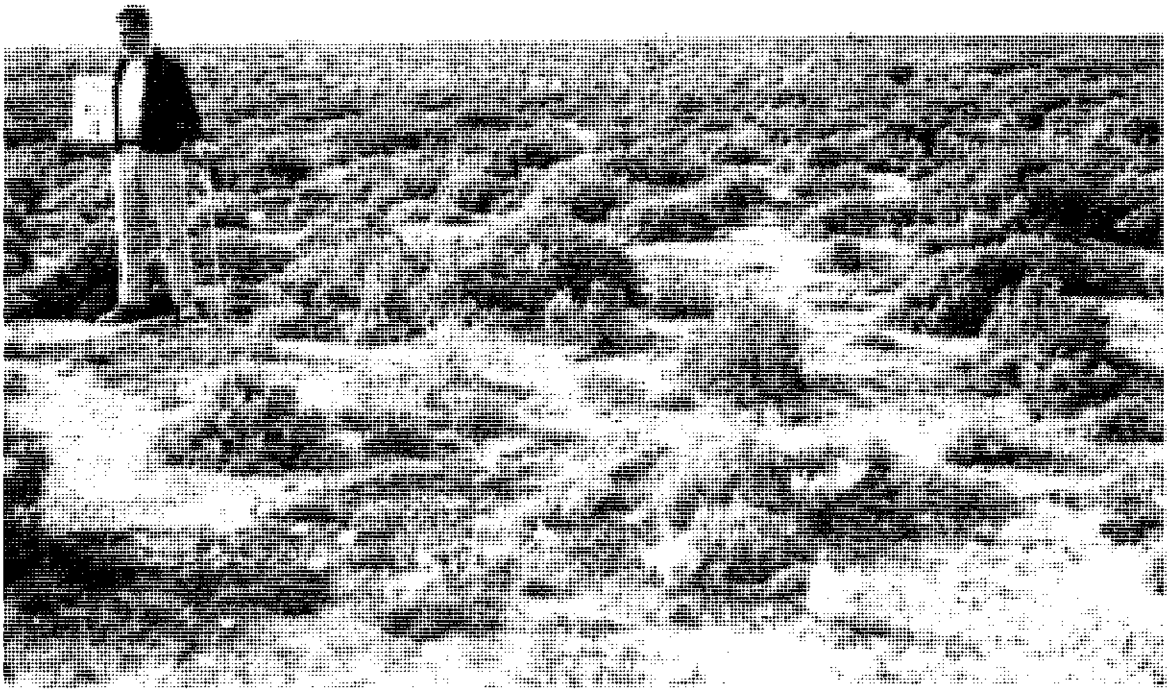
QUADRAT KU 1 DATE 02/04/84
LATITUDE 31,41,22 LONGITUDE 128,17,49
ALTITUDE 100 metres
LOCATION 16 km NE Mundrabilla, Western Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE sheet eroded
LAND USE grazing



QUADRAT KU 2 I DATE 02/04/84
LATITUDE 31,46,32 LONGITUDE 128,16,58
ALTITUDE 93 metres
LOCATION 8 km NE Mundrabilla Hotel, Western Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE grazing

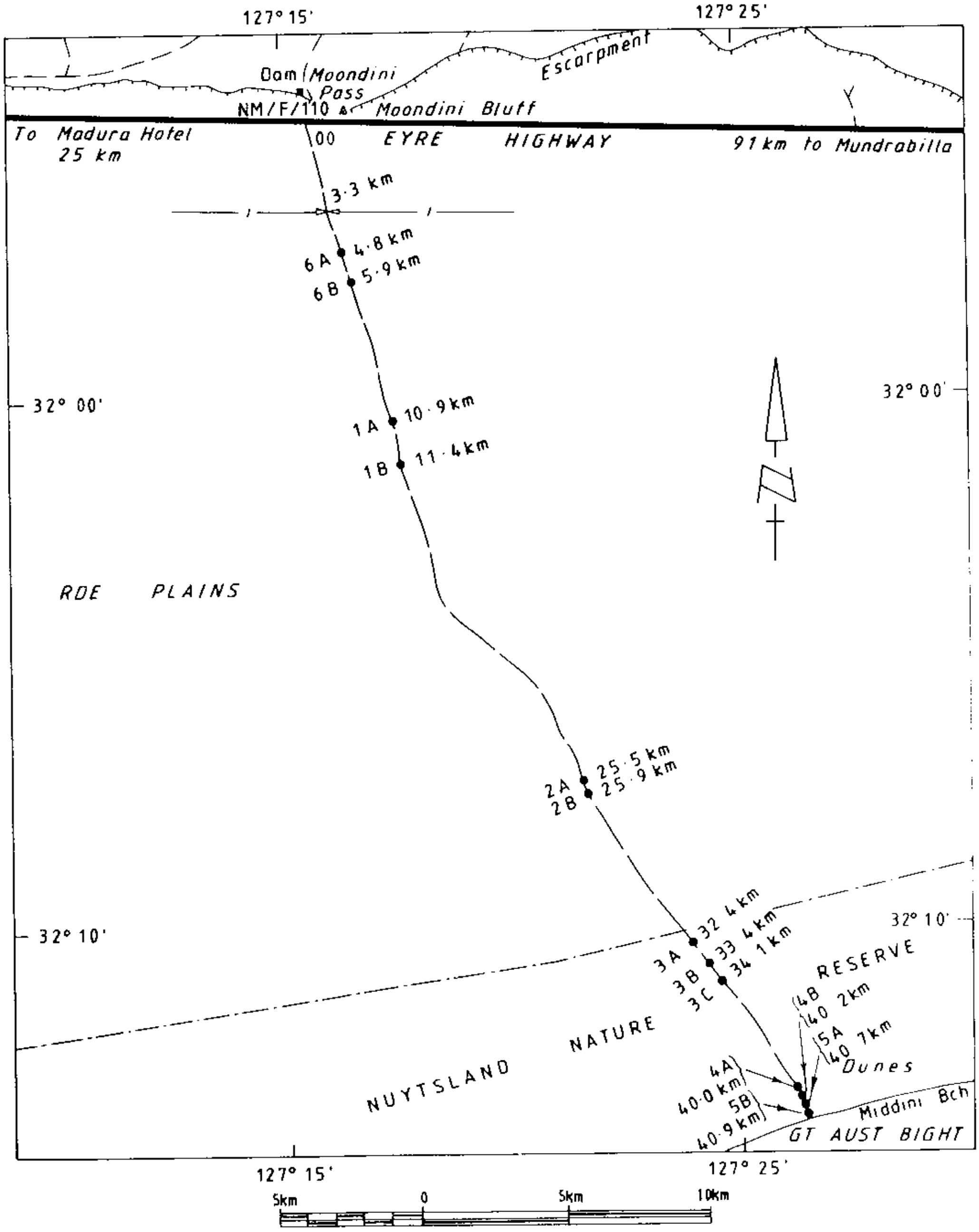


QUADRAT KU 3 DATE 04/04/84
LATITUDE 31,53,35 LONGITUDE 128,14,28
ALTITUDE 10 metres
LOCATION 6.0 km S Mundrabilla Hotel, Western Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE grazing



QUADRAT KU 4 DATE 03/04/84
LATITUDE 31,54,15 LONGITUDE 128,15,48
ALTITUDE 4 metres
LOCATION 9 km S Mundrabilla Hotel, Western Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE sheet eroded
LAND USE grazing

QUADRAT KU 5 I DATE 03/04/84
LATITUDE 31,58,53 LONGITUDE 128,17,35
ALTITUDE 6 metres
LOCATION 19.5 km SE Mundrabilla Hotel, Western Australia
LANDFORM dune SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE grazing



MADURA (MA)

TRAP LINE	GEOGRAPHICAL		A.M.G. ZONE 52		DESCRIPTION
	SOUTH LAT.	EAST LONG.	EAST	NORTH	
1 A	32° 0' 21". 69	127° 17' 29". 49	338 625	6 457 609	St. Pkt. & Indicator
1 B	32° 0' 38". 39	127° 17' 33". 95	338 750	6 457 096	" "
2 A	32° 6' 59". 30	127° 21' 32". 78	345 195	6 445 463	" "
2 B	32° 7' 11". 16	127° 21' 34". 23	345 239	6 445 099	" "
3 A	32° 10' 23". 58	127° 23' 56". 65	349 059	6 439 229	" "
3 B	32° 10' 32". 13	127° 24' 5". 77	349 302	6 438 969	" "
3 C	32° 10' 41". 45	127° 24' 12". 34	349 479	6 438 685	" "
4 A	32° 13' 8". 50	127° 26' 19". 89	352 885	6 434 205	" "
4 B	32° 13' 16". 79	127° 26' 20". 49	352 904	6 433 950	" "
5 A	32° 13' 31". 29	127° 26' 23". 96	353 002	6 433 505	" "
5 B	32° 13' 36". 35	127° 26' 24". 53	353 019	6 433 349	" "
6 A	31° 57' 13". 77	127° 16' 22". 27	336 769	6 463 368	" "
6 B	31° 57' 48". 21	127° 16' 34". 00	337 093	6 462 312	" "

HORIZONTAL RELIABILITY ± 5m OR BETTER

MAP REFERENCE : SI 52-1 BURNABBIE 1 : 250000
SH 52-13 MADURA 1 : 250000

AUSTRALIAN SURVEY OFFICE W.A. PLAN No. A4-6088

S.I.F. 84118 1985

QUADRAT MA 1 DATE 28/03/84
LATITUDE 32,00,38 LONGITUDE 127,17,33
ALTITUDE 15 metres
LOCATION 27.0 km SE Madura, Western Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE sheet eroded
LAND USE grazing

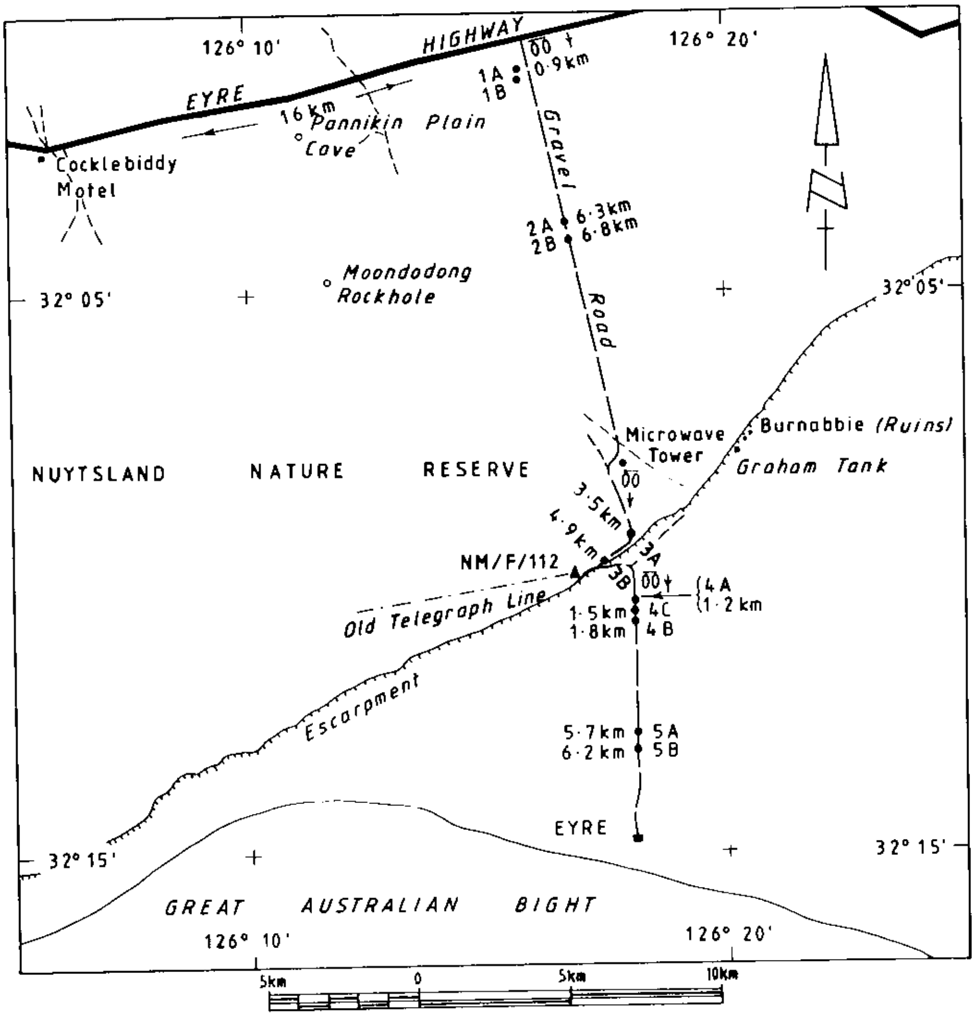
QUADRAT MA 2 DATE 29/03/84
LATITUDE 32,07,11 LONGITUDE 127,21,34
ALTITUDE 14 metres
LOCATION 39.5 km SE Madura, Western Australia
LANDFORM plain SOIL TEXTURE loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE
LAND USE light grazing

QUADRAT MA 3 DATE 30/03/84
LATITUDE 32,10,32 LONGITUDE 127,24,05
ALTITUDE 13 metres
LOCATION 49 km SE Madura, Western Australia
LANDFORM plain SOIL TEXTURE loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE grazing

QUADRAT MA 4 DATE 29/03/84
LATITUDE 32,13,16 LONGITUDE 127,26,20
ALTITUDE 25 metres
LOCATION 52.5 km SE Madura, Western Australia
LANDFORM dune SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE conservation

QUADRAT MA 5 i DATE 30/03/84
LATITUDE 32,13,36 LONGITUDE 127,26,24
ALTITUDE 9 metres
LOCATION 53 km SE Madura, Western Australia
LANDFORM dune SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE
LAND USE conservation

QUADRAT MA 6 DATE 28/03/84
LATITUDE 31,57,48 LONGITUDE 127,16,34
ALTITUDE 18 metres
LOCATION 23.5 km E Madura, Western Australia
LANDFORM plain SOIL TEXTURE loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE sheet eroded
LAND USE grazing



COCKLEBIDDY (CO)

TRAP LINE	GEOGRAPHICAL SOUTH LAT.	GEOGRAPHICAL EAST LONG.	A.M.G. ZONE 52 EAST	A.M.G. ZONE 52 NORTH	DESCRIPTION
1 A	32° 0" 48". 73	126° 15' 46". 84	241 471	6 454 777	St Pkt, & Indicator
1 B	32 0' 56". 70	126° 15' 31". 72	241 080	6 454 521	" "
2 A	32° 3' 44". 30	126° 16' 42". 47	243 067	6 449 405	" "
2 B	32° 3' 59". 13	126° 16' 48". 11	243 226	6 448 952	" "
3 A	32° 9' 30". 26	126° 18' 4". 94	245 497	6 438 802	" "
3 B	32° 9' 51". 96	126° 17' 25". 02	244 468	6 438 107	" "
4 A	32° 10' 33". 04	126° 18' 1". 07	245 445	6 436 866	" "
4 B	32° 10' 50". 90	126° 18' 1". 65	245 474	6 436 316	" "
4 C	32° 10' 40". 71	126° 18' 1". 72	245 467	6 436 630	" "
5 A	32° 12' 52". 83	126° 18' 6". 00	245 682	6 432 563	" "
5 B	32° 13' 10". 07	126° 18' 6". 55	245 710	6 432 032	" "

HORIZONTAL RELIABILITY ± 5m OR BETTER

MAP REFERENCE : SI 52-1 BURNABBIE 1 : 250000

AUSTRALIAN SURVEY OFFICE W.A. OFFICE PLAN No, A4-6067

S.I.F. 84119 1985

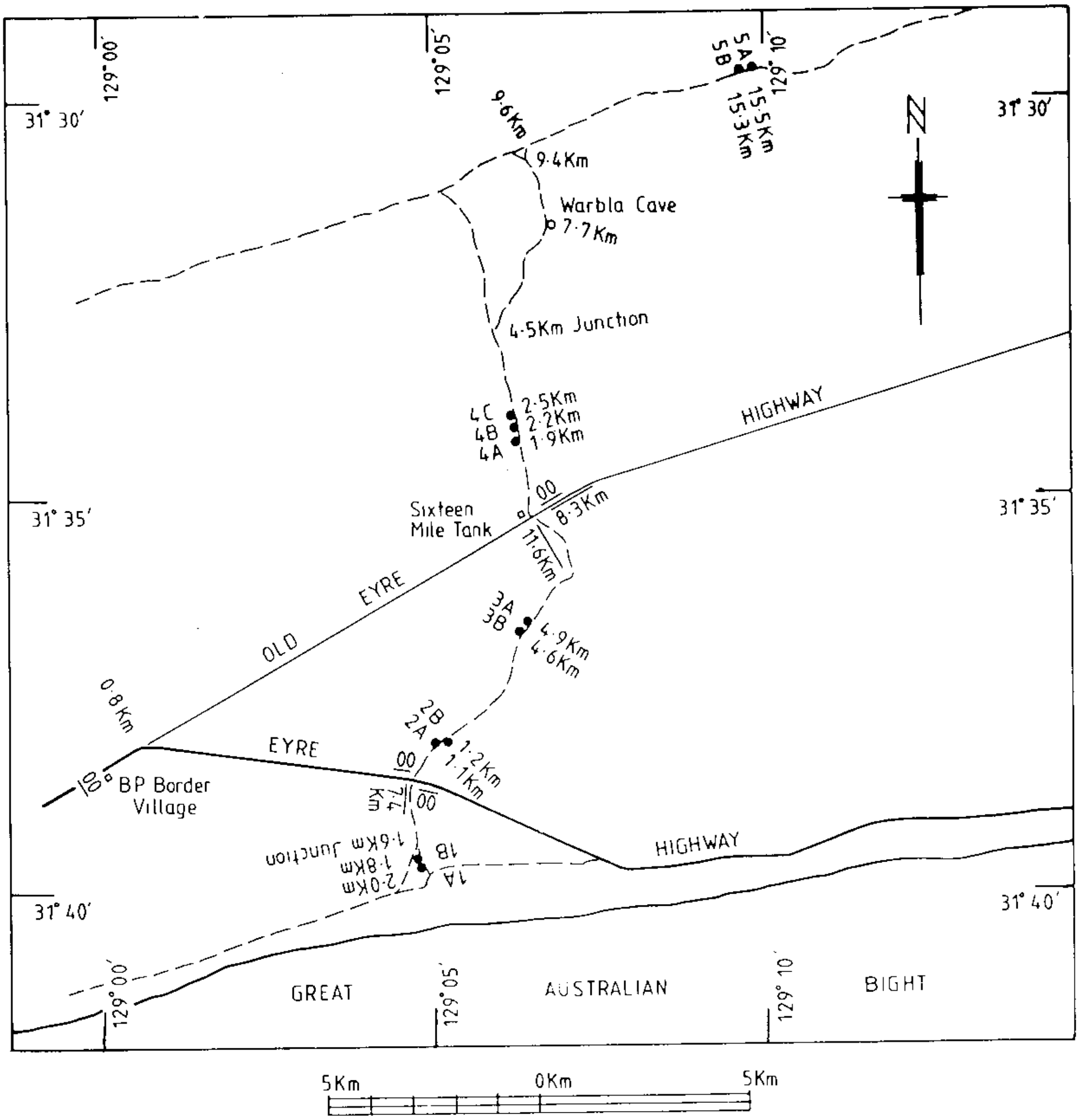
QUADRAT CO 1 I DATE 02/04/84
LATITUDE 32,00,56 LONGITUDE 126,15,31
ALTITUDE 85 metres
LOCATION 16 km E Cocklebiddy, Western Australia
LANDFORM depression SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE sheet eroded
LAND USE grazing

QUADRAT CO 2 II DATE 05/04/84
LATITUDE 32,03,59 LONGITUDE 126,16,48
ALTITUDE 95 metres
LOCATION 17.5 km E Cocklebiddy, Western Australia
LANDFORM rise SOIL TEXTURE loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE light grazing

QUADRAT CO 3 1 DATE 03/04/84
LATITUDE 32,09,51 LONGITUDE 126,17,25
ALTITUDE 82 metres
LOCATION 10 km N Eyre, Western Australia
LANDFORM dune SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE conservation

QUADRAT CO 4 I DATE 03/04/84
LATITUDE 32,10,50 LONGITUDE 126,18,01
ALTITUDE 30 metres
LOCATION 25 km SE Cocklebiddy, Western Australia
LANDFORM dune SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE conservation

QUADRAT CO 5 DATE 04/04/84
LATITUDE 32,13,10 LONGITUDE 126,18,06
ALTITUDE 20 metres
LOCATION 4 km N Eyre, Western Australia
LANDFORM dune SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE conservation



MERDAYERRAH (ME)

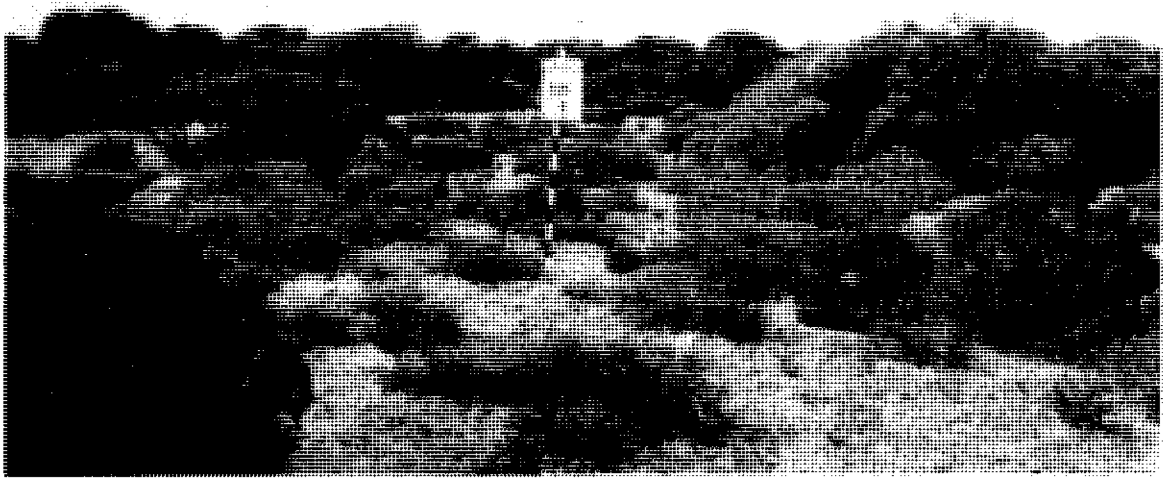
TRAP LINE	GEOGRAPHICAL SOUTH LAT.	GEOGRAPHICAL EAST LONG.	AMG (84) ZONE 52 EAST	AMG (84) ZONE 52 NORTH	SA PSM REF. NO	DESCRIPTION
1 A	31 39 35.59	129 04 52.14	507 693	6 497 247	4734/1034	PM & INDICATOR
1 B	31 39 29.70	129 04 49.43	507 622	6 497 429	4734/1035	"
2 A	31 38 04.89	129 05 05.31	508 042	6 500 040	4734/1036	"
2 B	31 38 02.05	129 05 10.27	508 173	6 500 127	4734/1037	"
3 A	31 36 34.31	129 06 28.61	510 239	6 502 827	4734/1039	"
3 B	31 36 41.28	129 06 21.72	510 057	6 502 612	4734/1038	"
4 A	31 34 16.41	129 06 18.71	509 982	6 507 072	4734/1040	"
4 B	31 34 05.25	129 06 18.54	509 978	6 507 416	4734/1041	"
4 C	31 33 56.94	129 06 16.72	509 931	6 507 672	4734/1042	"
5 A	31 29 36.34	129 09 52.68	515 635	6 515 688	4735/1022	"
5 B	31 29 37.35	129 09 46.45	515 471	6 515 657	4735/1021	"

HORIZONTAL RELIABILITY ± 5m OR BETTER

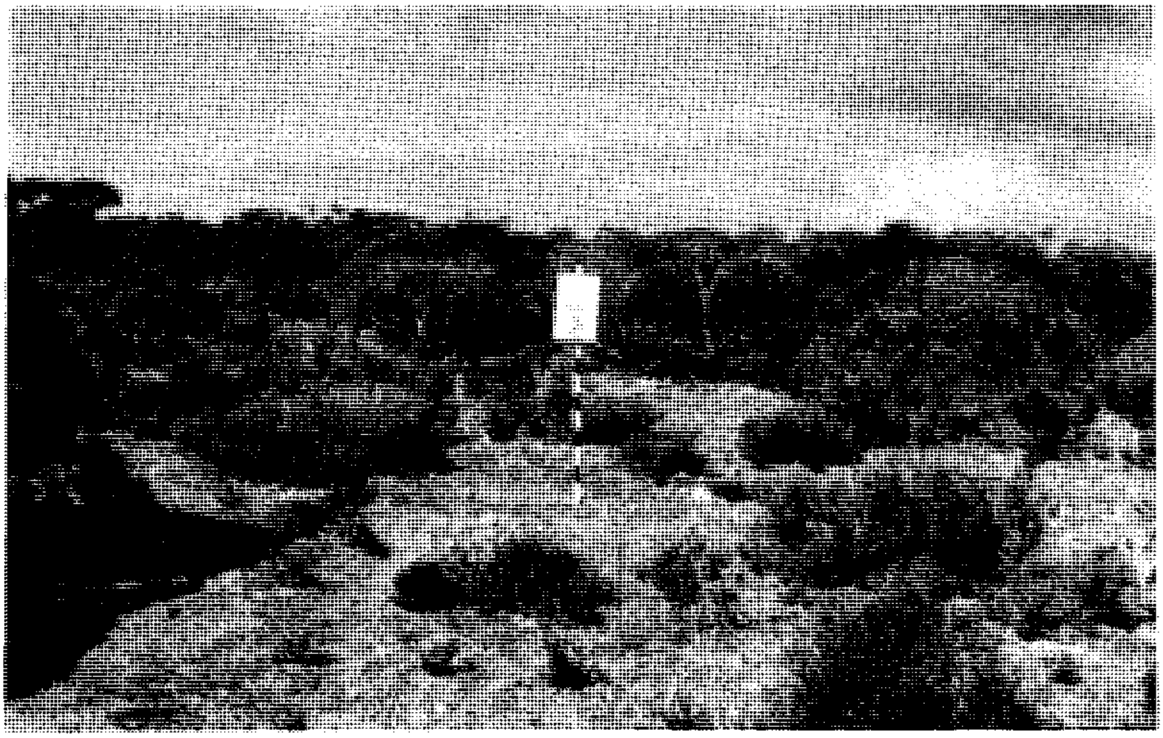
MAP REFERENCE
MERDAYERRAH 4735
WILSON 4734
1: 100,000

SURVEY: T.S.F; D.C.W

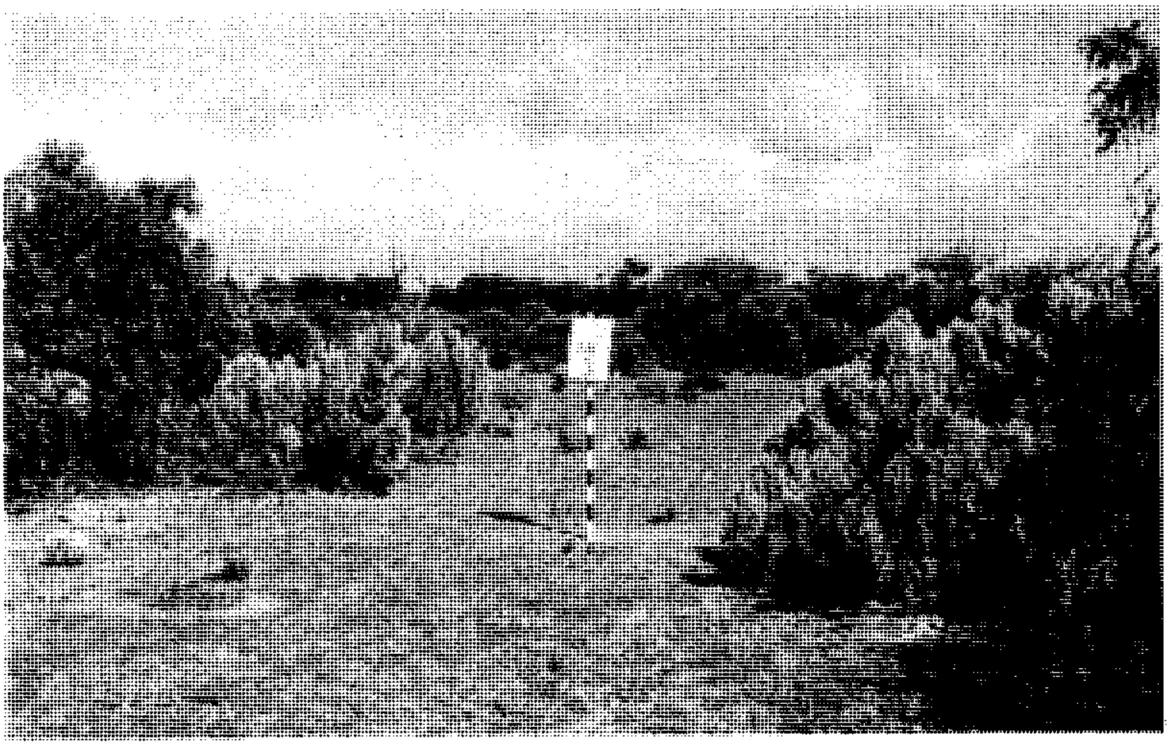
AUST. SURVEY OFFICE S.A. | A4/2562



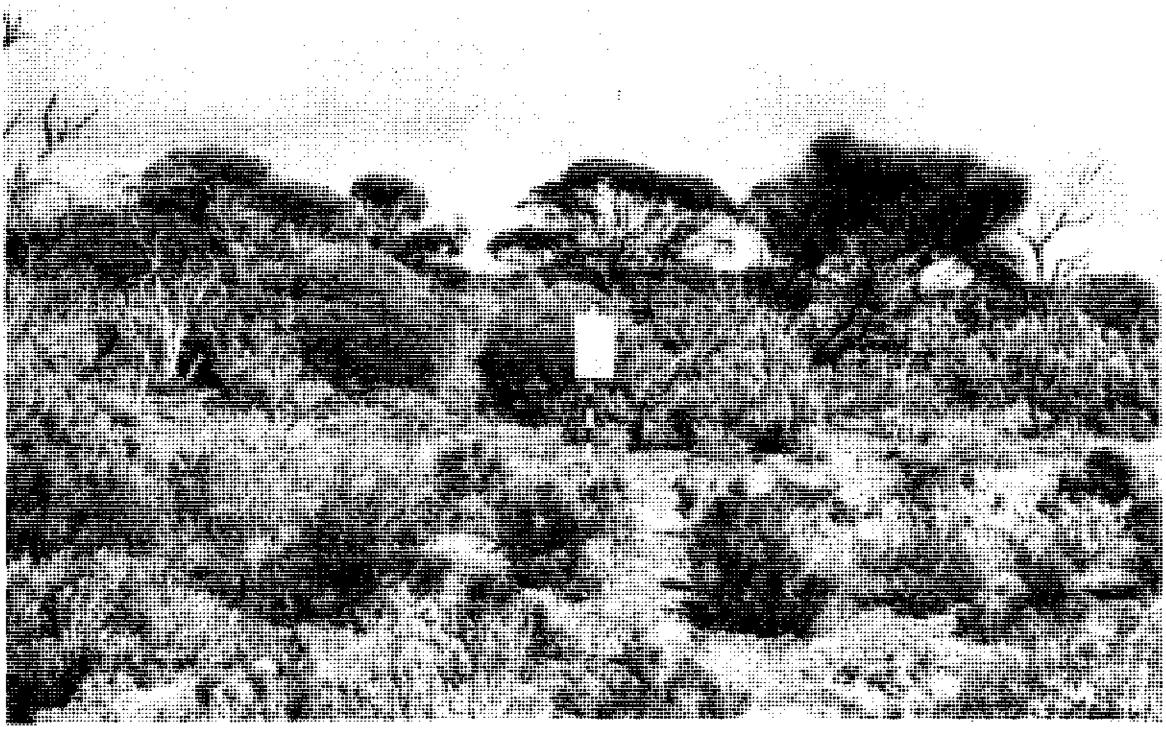
QUADRAT ME 1 I DATE 05/04/84
LATITUDE 31,39,36 LONGITUDE 129,04,52
ALTITUDE 100 metres
LOCATION 8 km SE Border Village, South Australia
LANDFORM rise SOIL TEXTURE loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE light grazing



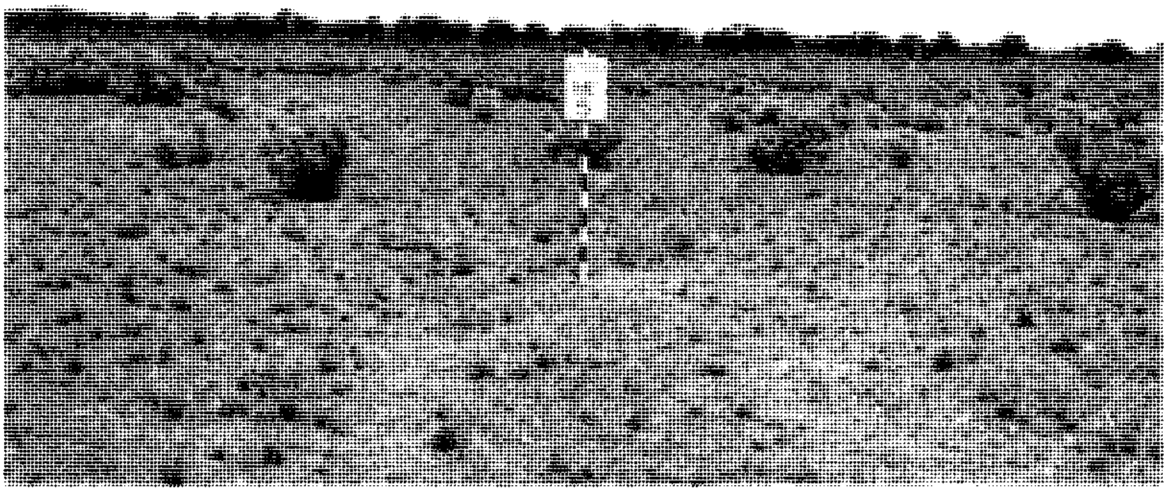
QUADRAT ME 2 I DATE 05/04/84
LATITUDE 31,38,05 LONGITUDE 129,05,05
ALTITUDE 100 metres
LOCATION 8 km E Border Village, South Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW cobble (64-256mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use



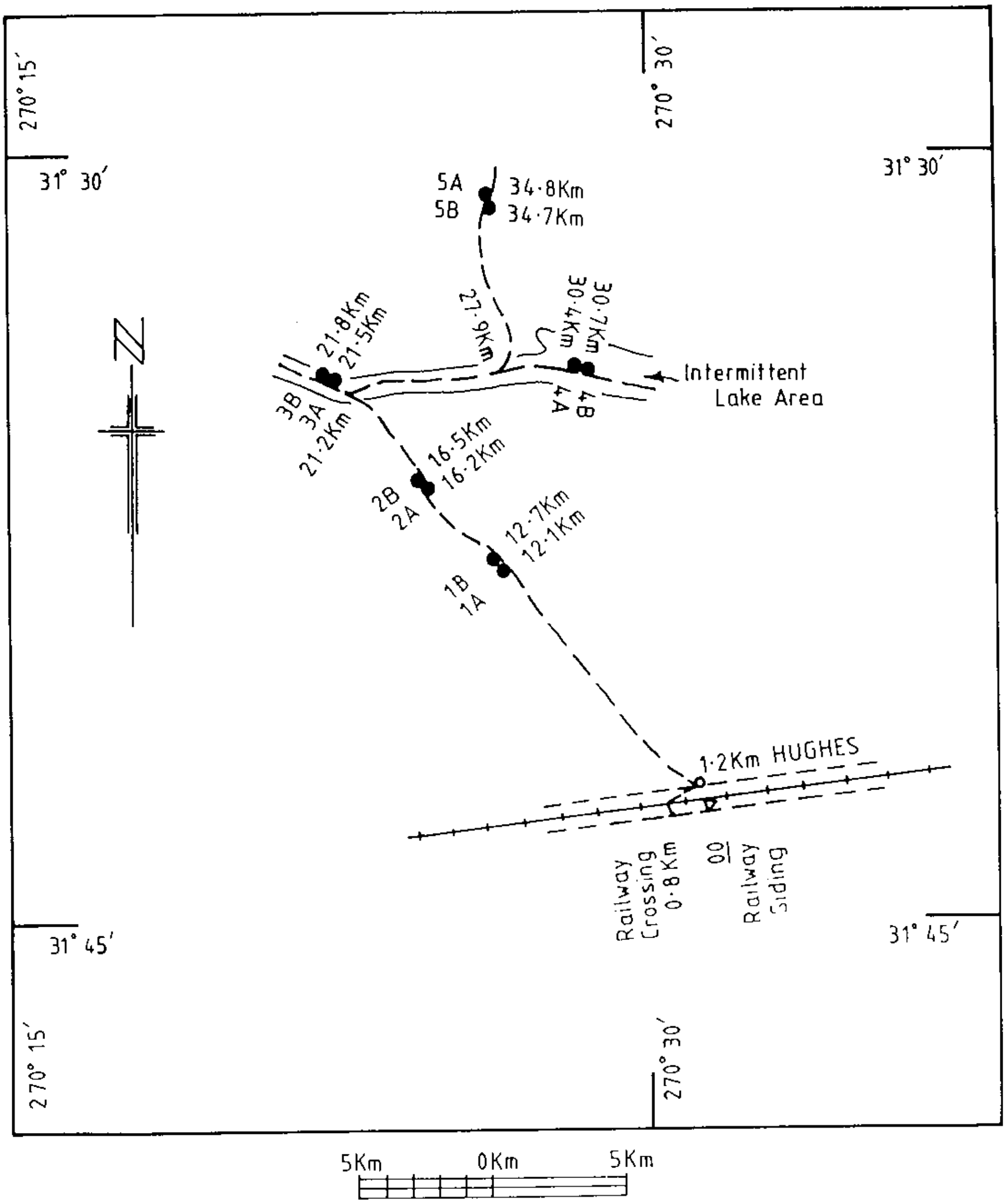
QUADRAT ME 3 I DATE 05/04/84
LATITUDE 31,36,34 LONGITUDE 129,06,29
ALTITUDE 100 metres
LOCATION 10 km NE Border Village, South Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use



QUADRAT ME 4 II DATE 05/04/84
LATITUDE 31,34,16 LONGITUDE 129,06,19
ALTITUDE 100 metres
LOCATION 13 km NE Border Village, South Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use



QUADRAT ME 5 III   OATE 04/04/84
LATITUDE 31,29,36   LONGITUDE 129,09,53
ALTITUOE 100 metres
LOCATION 21 km NE Border Village, South Australia
LANDFORM rise   SOIL TEXTURE sandy clay loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION hard setting   DISTURBANCE none visible
LAND USE no defined use



HUGHES (HU)

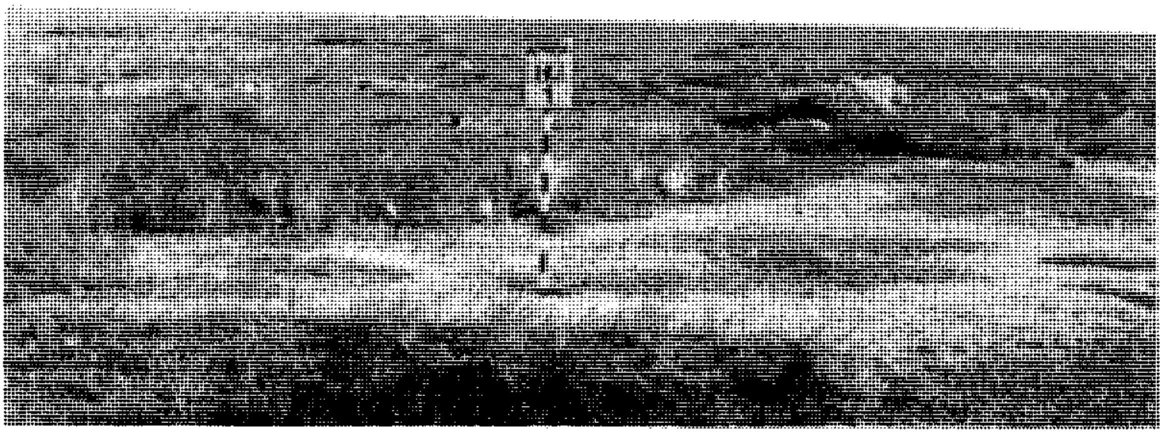
TRAP LINE	GEOGRAPHICAL		AMG (84) ZONE 52		SA PSM	DESCRIPTION
	SOUTH LAT.	EAST LONG.	EAST	NORTH	REF. NO	
1 A	30 38 17.72	129 26 32.63	542 393	6 610 392	4736/1031	PM & INDICATOR
1 B	30 38 04.50	129 26 13.29	541 880	6 610 801	4736/1032	"
2 A	30 36 40.50	129 24 47.09	539 595	6 613 395	4736/1033	"
2 B	30 36 35.00	129 24 35.83	539 295	6 613 566	4736/1034	"
3 A	30 34 35.67	129 22 38.70	536 189	6 617 250	4736/1035	"
3 B	30 34 30.96	129 22 28.23	535 911	6 617 396	4736/1036	"
4 A	30 34 14.90	129 28 19.59	545 271	6 617 856	4736/1037	"
4 B	30 34 17.52	129 28 32.86	545 624	6 617 773	4736/1038	"
5 A	30 30 58.34	129 26 11.50	541 883	6 623 920	4736/1039	"
5 B	30 31 01.36	129 26 14.63	541 966	6 623 827	4736/1040	"

HORIZONTAL RELIABILITY ± 5m OR BETTER

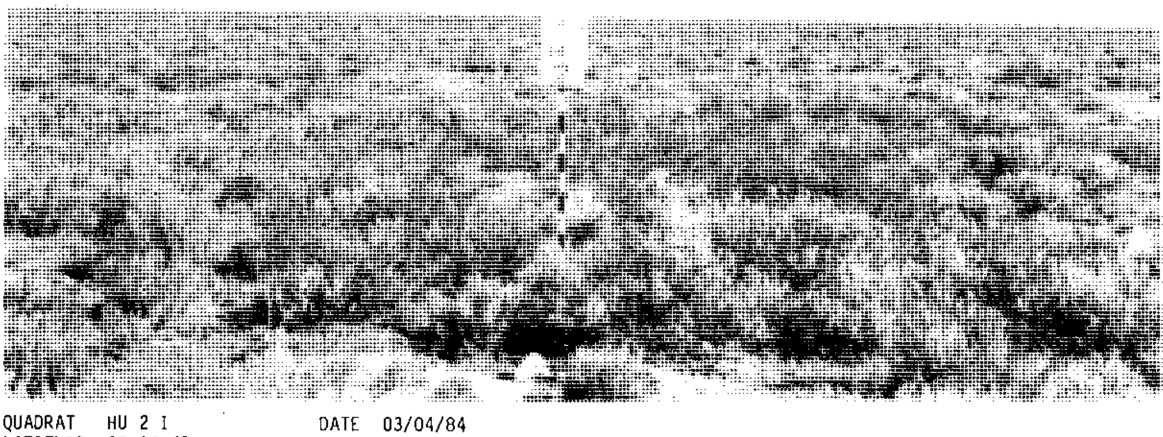
MAP REFERENCE
COOK SH 52-11
1:250,000

SURVEY: T.S.F; D.C.W

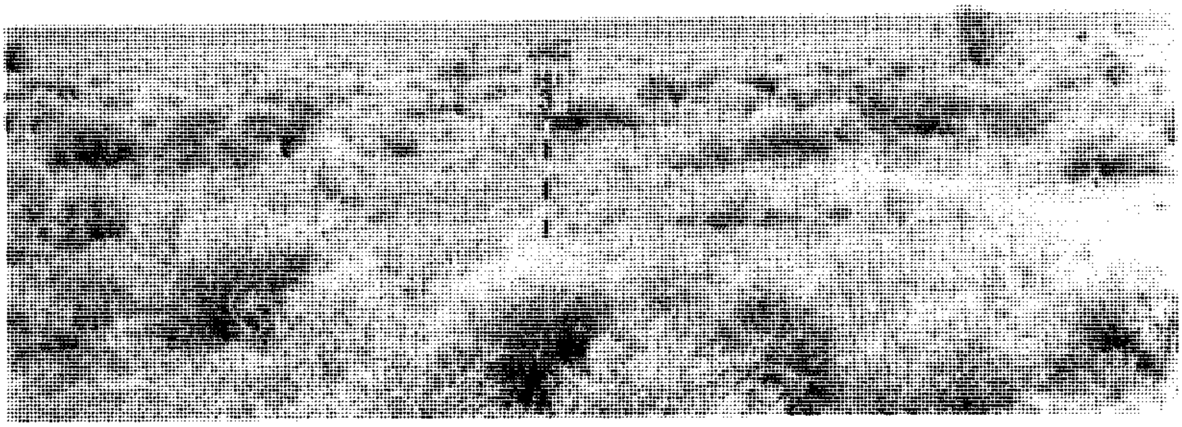
AUST. SURVEY OFFICE S.A. | A4/2563



QUADRAT HU 1 I DATE 03/04/84
LATITUDE 30,38,18 LONGITUDE 129,26,33
ALTITUDE 130 metres
LOCATION 12 km NW Hughes, South Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW cobble (64-256mm)
SURFACE CONDITION crusting DISTURBANCE scalded
LAND USE no defined use

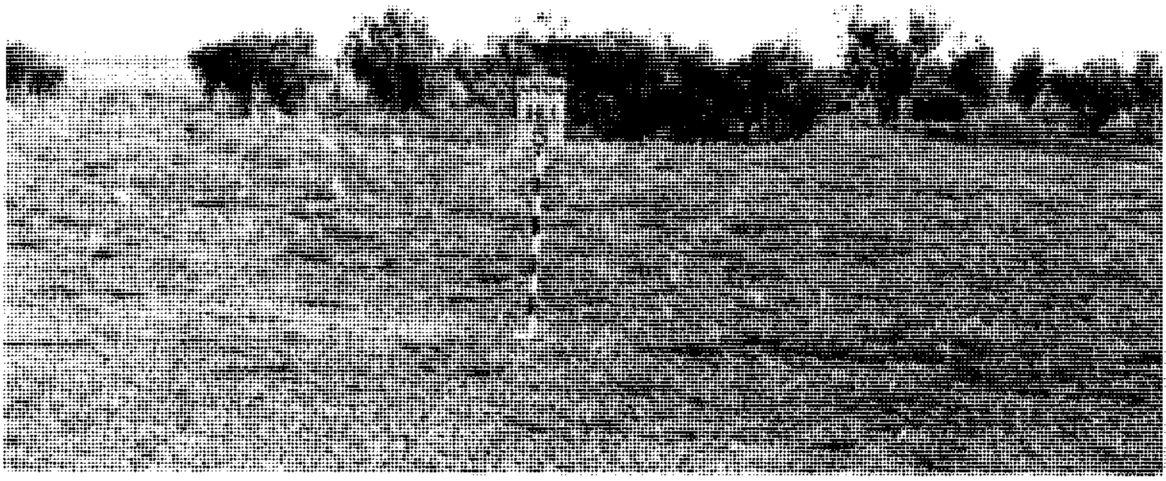


QUADRAT HU 2 I DATE 03/04/84
LATITUDE 30,36,41 LONGITUDE 129,24,47
ALTITUDE 125 metres
LOCATION 15.9 km NW Hughes, South Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW cobble (64-256mm) boulder (gt 256mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use

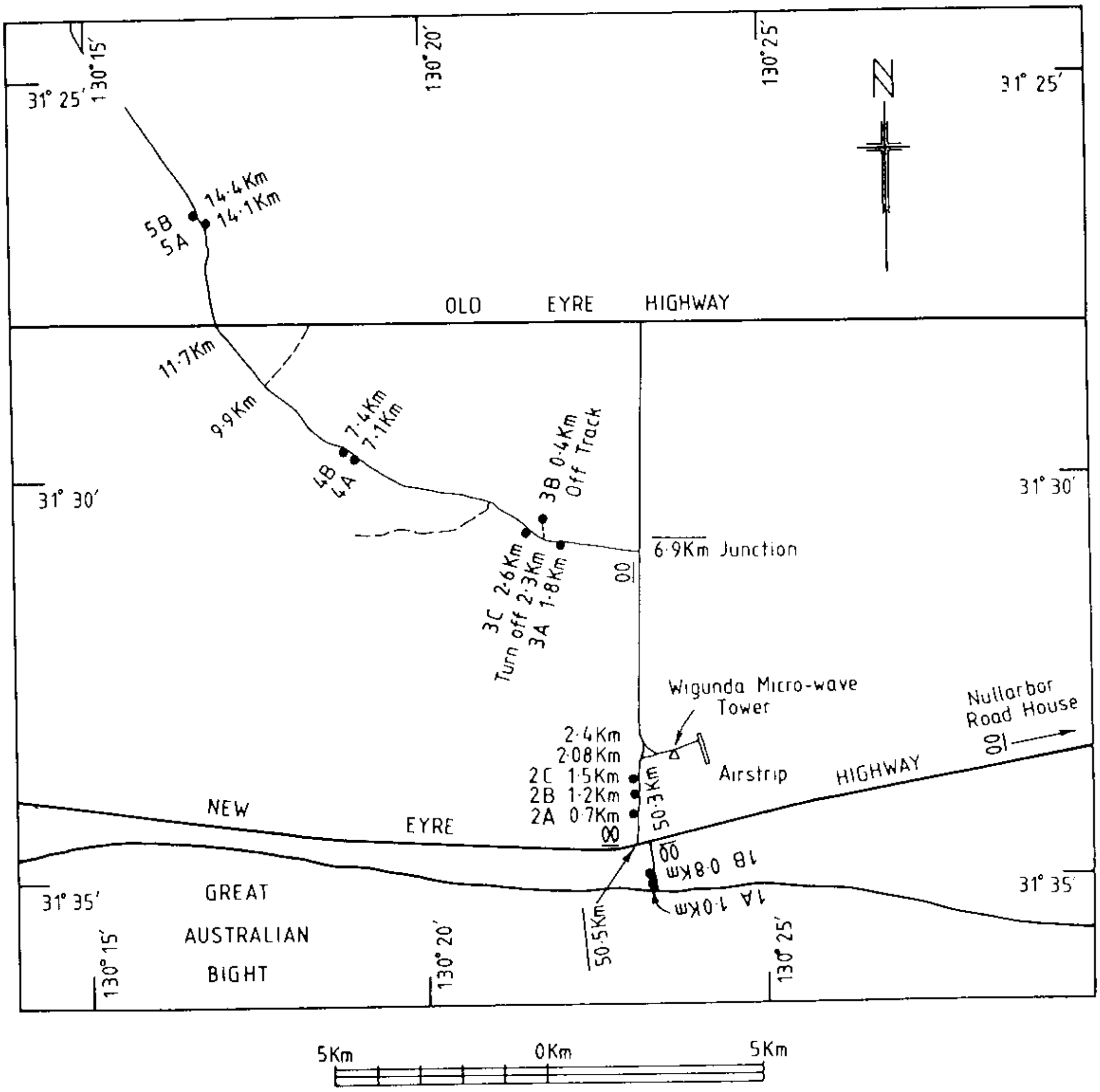


QUADRAT HU 3 I DATE 03/04/84
LATITUDE 30,34,36 LONGITUDE 129,22,39
ALTITUDE 90 metres
LOCATION 21.2 km NW Hughes, South Australia
LANDFORM channel SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use

QUADRAT HU 4 I DATE 03/04/84
LATITUDE 30,34,15 LONGITUDE 129,28,20
ALTITUDE 90 metres
LOCATION 17 km N Hughes, South Australia
LANDFORM channel SOIL TEXTURE sandy clay loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE scalded
LAND USE no defined use



QUADRAT HU 5 I DATE 02/03/84
LATITUDE 30,30,58 LONGITUDE 129,26,12
ALTITUDE 120 metres
LOCATION 24 km N Hughes, South Australia
LANDFORM depression SOIL TEXTURE sandy clay loam
SURFACE STREW boulder (gt 256mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use



KOONALDA (KD)

TRAP LINE	GEOGRAPHICAL SOUTH LAT.	GEOGRAPHICAL EAST LONG.	AMG (84) ZONE 52 EAST	AMG (84) ZONE 52 NORTH	SA PSM REF. NO	DESCRIPTION
1 A	31 35 05.80	130 23 18.79	631 750	6 504 720	4934/1004	PM & INDICATOR
1 B	31 34 59.65	130 23 17.49	631 718	6 504 910	4934/1005	"
2 A	31 34 12.55	130 23 01.86	631 324	6 506 365	4934/1006	"
2 B	31 33 57.76	130 23 03.35	631 370	6 506 821	4934/1007	"
2 C	31 33 47.75	130 23 02.40	631 348	6 507 129	4934/1008	"
3 A	31 30 48.17	130 22 01.24	629 805	6 512 679	4934/1009	"
3 B	31 30 32.26	130 21 44.96	629 382	6 513 174	4934/1010	"
3 C	31 30 41.68	130 21 31.01	629 010	6 512 889	4934/1011	"
4 A	31 29 44.76	130 18 59.90	625 045	6 514 690	4935/1031	"
4 B	31 29 38.69	130 18 50.94	624 811	6 514 879	4935/1032	"
5 A	31 26 48.10	130 16 47.67	621 620	6 520 170	4935/1033	"
5 B	31 26 39.84	130 16 38.89	621 391	6 520 428	4935/1034	"

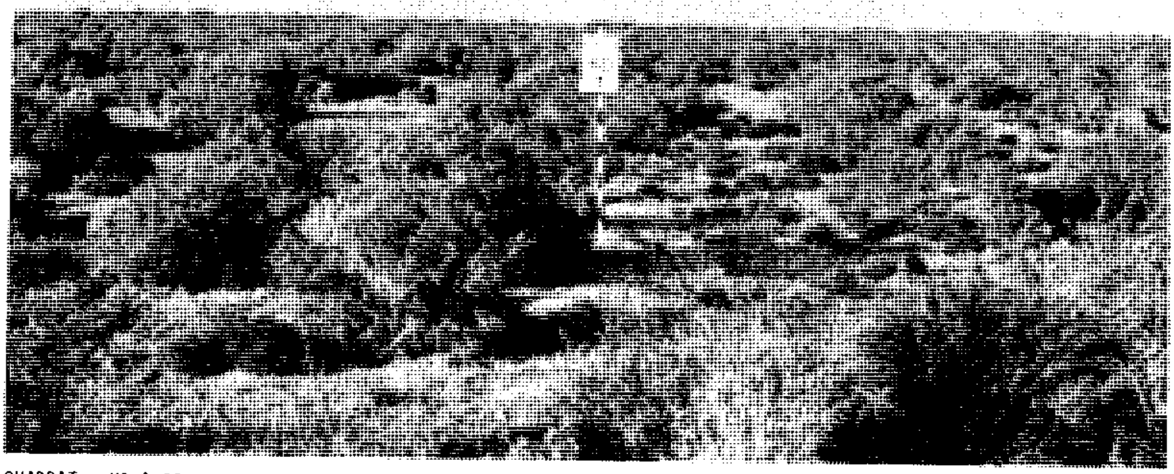
HORIZONTAL RELIABILITY ± 5m OR BETTER

MAP REFERENCE

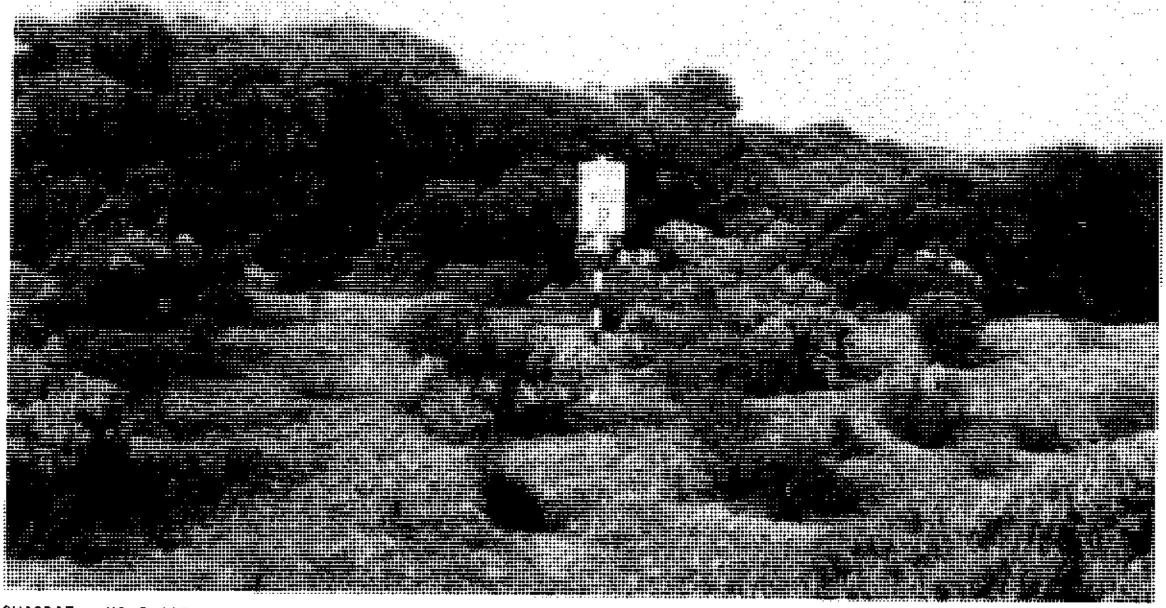
YANGOONABIE 4934
KNARDNA 4935
1: 100,000

SURVEY: T.S.F; D.C.W

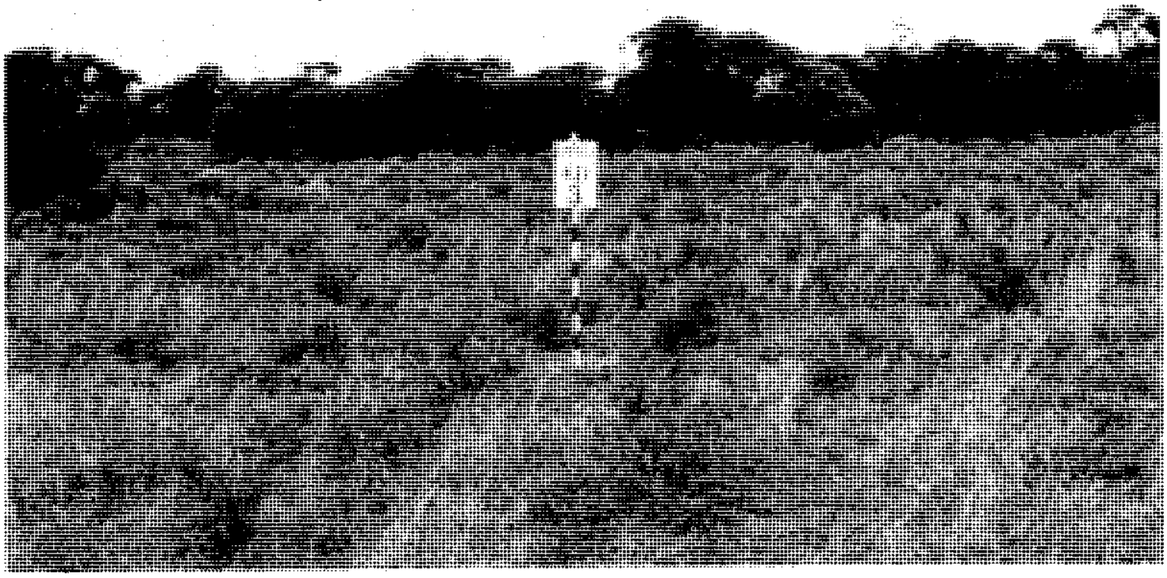
AUST. SURVEY OFFICE S.A. | A4/2559



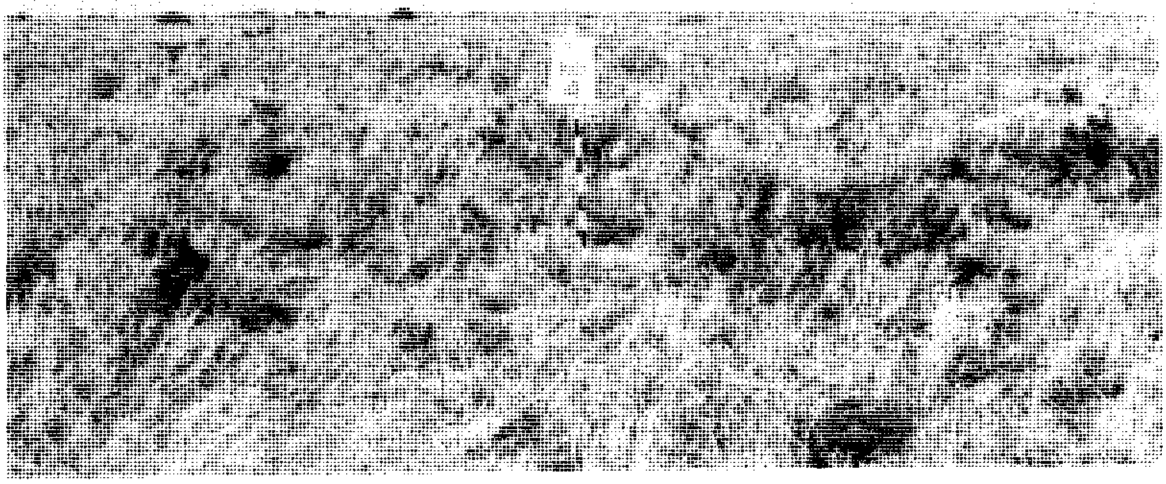
QUADRAT KO 1 II DATE 10/04/84
LATITUDE 31,35,06 LONGITUDE 130,23,19
ALTITUDE 70 metres
LOCATION 52 km SE Koonalda Stn., South Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE conservation



QUADRAT KO 2 III DATE 09/04/84
LATITUDE 31,34,13 LONGITUDE 130,23,02
ALTITUDE 60 metres
LOCATION 51 km SE Koonalda Stn., South Australia
LANDFORM pan SOIL TEXTURE clay
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION hard setting DISTURBANCE none visible
LAND USE conservation

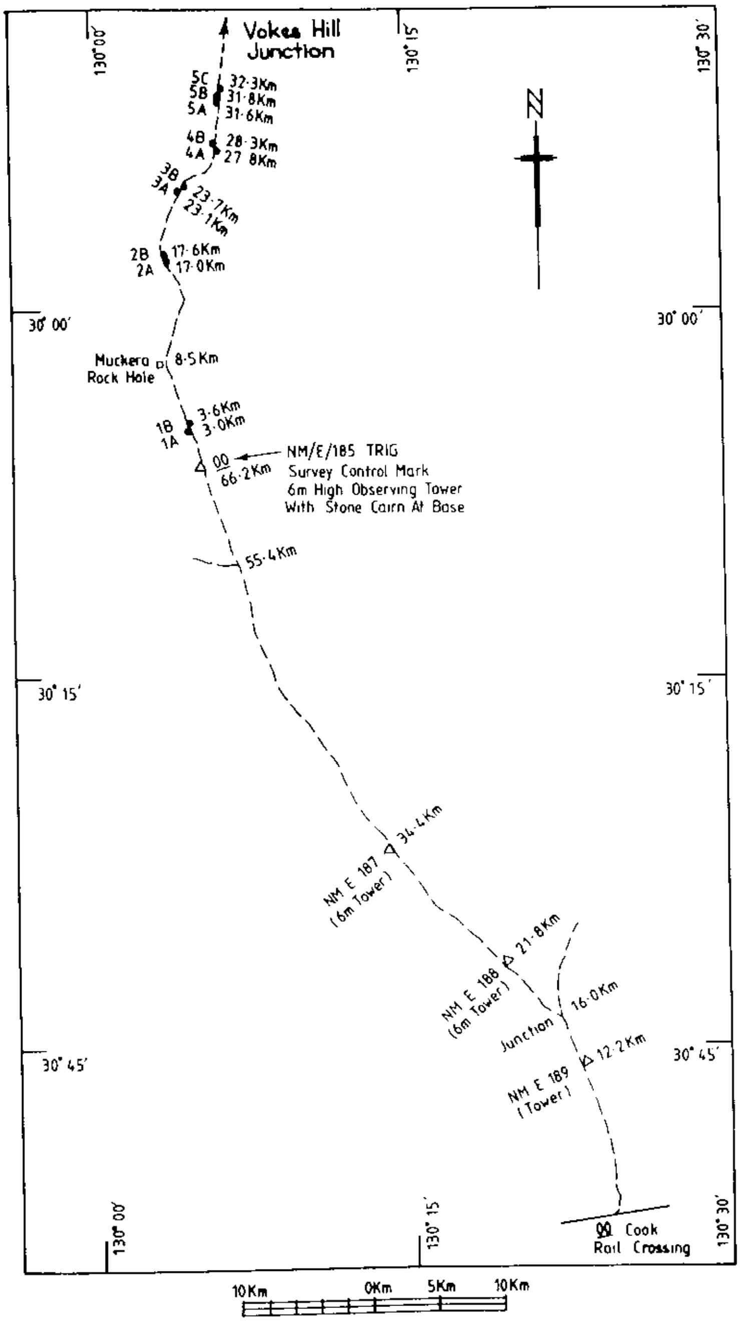


QUADRAT KD 3 II DATE 09/04/84
LATITUDE 31,30,48 LONGITUDE 130,22,01
ALTITUDE 65 metres
LOCATION 48 km SE Koonalda Stn., South Australia
LANDFORM plain SOIL TEXTURE clay
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION hard setting DISTURBANCE none visible
LAND USE conservation



QUADRAT KD 4 II DATE 08/04/84
LATITUDE 31,29,44 LONGITUDE 130,19,00
ALTITUDE 65 metres
LOCATION 43 km SE Koonalda Stn., South Australia
LANDFORM plain SOIL TEXTURE clay
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION hard setting DISTURBANCE none visible
LAND USE conservation

QUADRAT KO 5 II DATE 08/04/84
LATITUDE 31,26,48 LONGITUDE 130,16,48
ALTITUDE 70 metres
LOCATION 40 km E Koonalda Stn., South Australia
LANDFORM plain SOIL TEXTURE clay
SURFACE STREW none apparent
SURFACE CONDITION hard setting DISTURBANCE none visible
LAND USE conservation



MUCKERA (MU)

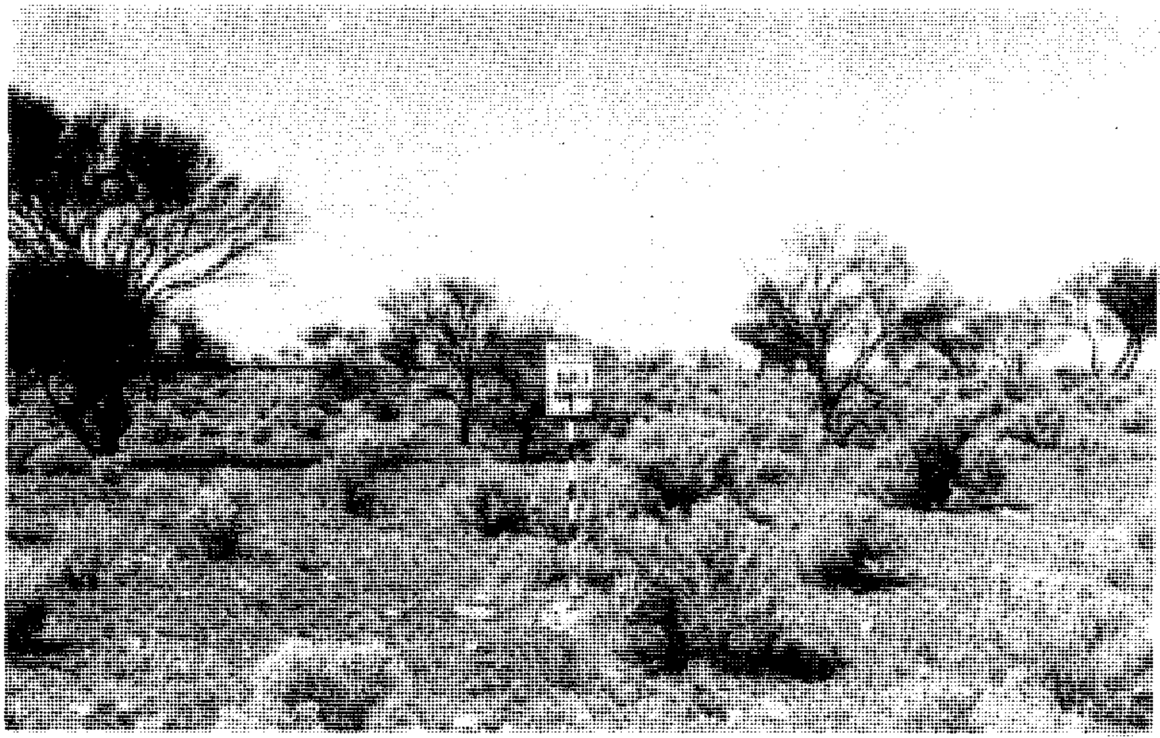
TRAP LINE	GEOGRAPHICAL SOUTH LAT.	GEOGRAPHICAL EAST LONG.	AMG (84) ZONE 52 EAST	AMG (84) ZONE 52 NORTH	SA PSM REF. NO	DESCRIPTION
1 A	30 04 58.70	130 04 30.14	603 602	6 671 522	4937/1031	PM & INDICATOR
1 B	30 04 39.96	130 04 25.26	603 477	6 672 100	4937/1032	"
2 A	29 58 09.22	130 03 24.14	601 952	6 684 143	4938/1056	"
2 B	29 57 52.65	130 03 19.40	601 829	6 684 654	4938/1057	"
3 A	29 55 13.67	130 04 12.88	603 308	6 689 535	4938/1058	"
3 B	29 55 00.33	130 04 26.72	603 683	6 689 942	4938/1059	"
4 A	29 53 35.92	130 05 55.54	606 090	6 692 518	4938/1060	"
4 B	29 53 18.05	130 05 54.99	606 080	6 693 068	4938/1061	"
5 A	29 51 34.80	130 06 08.36	606 469	6 696 243	- / -	"
5 B	29 51 28.33	130 06 08.34	606 471	6 696 442	4938/1063	"
5 C	29 51 12.21	130 06 08.11	606 469	6 696 939	4938/1064	"

HORIZONTAL RELIABILITY ± 5m OR BETTER

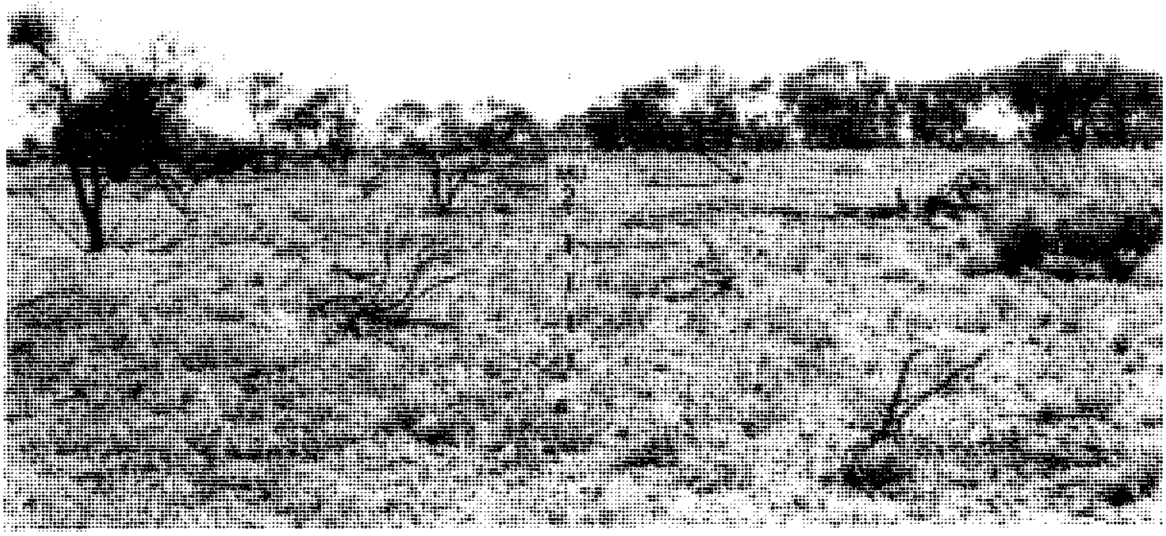
MAP REFERENCE
COOK
WYOLA
1: 250,000

SURVEY: T.S.F, D.C.W

AUST. SURVEY OFFICE S.A. | A4/2561



QUADRAT MU 1 I DATE 08/04/84
LATITUDE 30,04,59 LONGITUDE 130,04,30
ALTITUDE 145 metres
LOCATION 67.5 km NW Cook, South Australia
LANDFORM plain SOIL TEXTURE sand
SURFACE STREW pebble (4-64mm) cobble (64-256mm)
SURFACE CONDITION crusting DISTURBANCE scalded
LAND USE no defined use

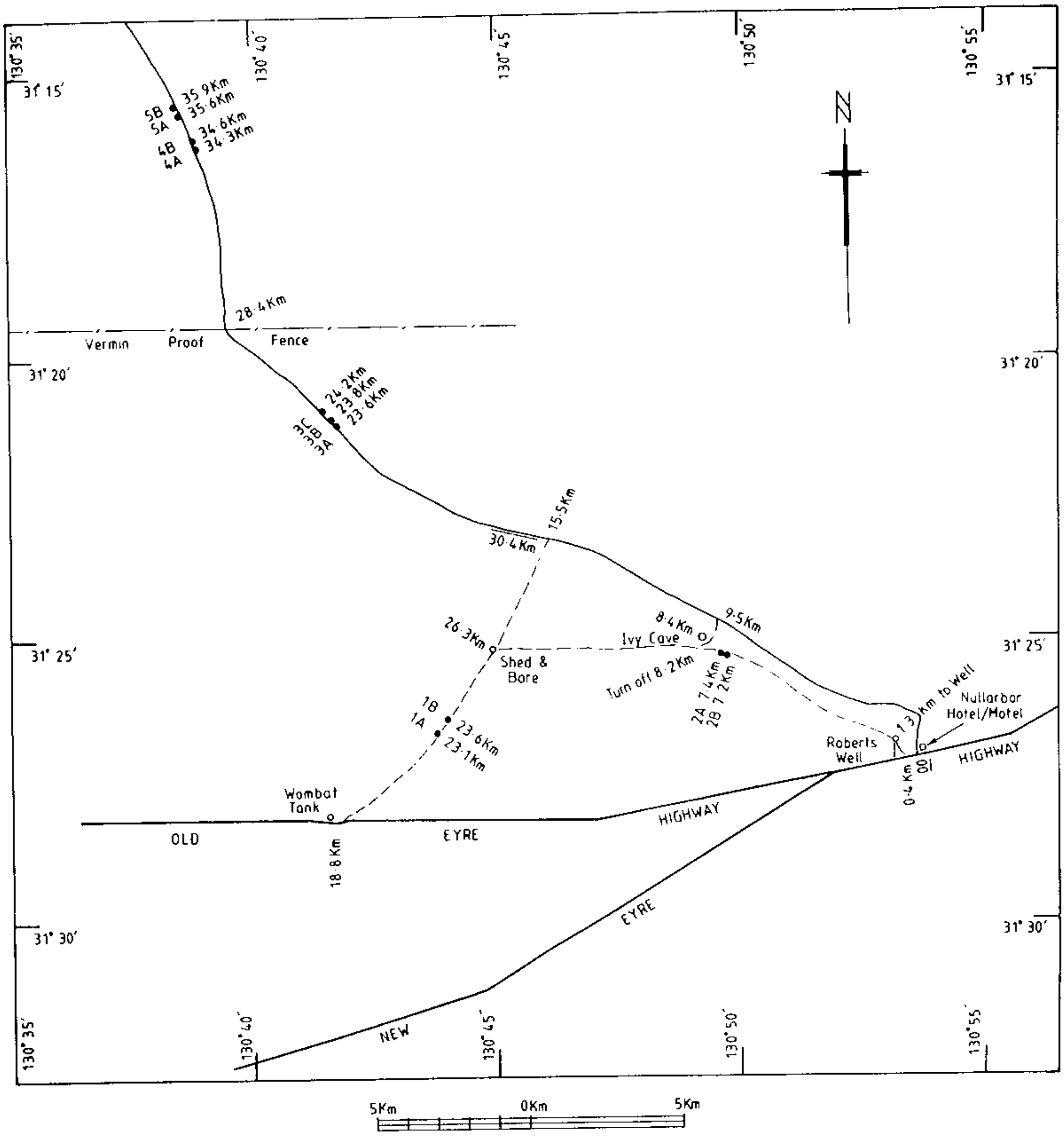


QUADRAT MU 2 I DATE 08/04/84
LATITUDE 29,58,09 LONGITUDE 130,03,24
ALTITUDE 150 metres
LOCATION 80 km NW Cook, South Australia
LANDFORM plain SOIL TEXTURE sand
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE gullied
LAND USE no defined use

QUADRAT MU 3 I DATE 08/04/84
LATITUDE 29,55,14 LONGITUDE 130,04,13
ALTITUDE 155 metres
LOCATION 82.5 km NW Cook, South Australia
LANDFORM plain SOIL TEXTURE sand
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use

QUADRAT MU 4 I DATE 07/04/84
LATITUDE 29,53,36 LONGITUDE 130,05,56
ALTITUDE 160 metres
LOCATION 85 km NW Cook, South Australia
LANDFORM interdune low SOIL TEXTURE
SURFACE STREW pebble (4-64mm) cobble (64-256mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use

QUADRAT MU 5 I DATE 07/04/84
LATITUDE 29,51,35 LONGITUDE 130,06,08
ALTITUDE 165 metres
LOCATION 87.5 km NW Cook, South Australia
LANDFORM dune SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE no defined use



CATACOMBS (CA)

TRAP LINE	GEOGRAPHICAL		AMG (84) ZONE 52		SA PSM REF. NO	DESCRIPTION
	SOUTH LAT.	EAST LONG.	EAST	NORTH		
1 A	31 26 40.01	130 43 48.27	664 405	6 519 833	5035/1025	PM & INDICATOR
1 B	31 26 25.17	130 44 01.01	664 748	6 520 285	5035/1026	"
2 A	31 25 16.23	130 49 36.38	673 638	6 522 264	5035/1027	"
2 B	31 25 18.02	130 49 43.84	673 834	6 522 206	5035/1028	"
3 A	31 21 11.20	130 41 46.04	661 334	6 530 009	5035/1029	"
3 B	31 21 05.32	130 41 37.26	661 105	6 530 193	5035/1030	"
3 C	31 20 55.99	130 41 26.75	660 831	6 530 485	5035/1031	"
4 A	31 16 16.83	130 38 54.40	656 934	6 539 142	5035/1032	"
4 B	31 16 09.24	130 38 49.55	656 809	6 539 377	5035/1033	"
5 A	31 15 38.28	130 38 33.30	656 393	6 540 337	5035/1034	"
5 B	31 15 30.31	130 38 27.69	656 249	6 540 585	5035/1035	"

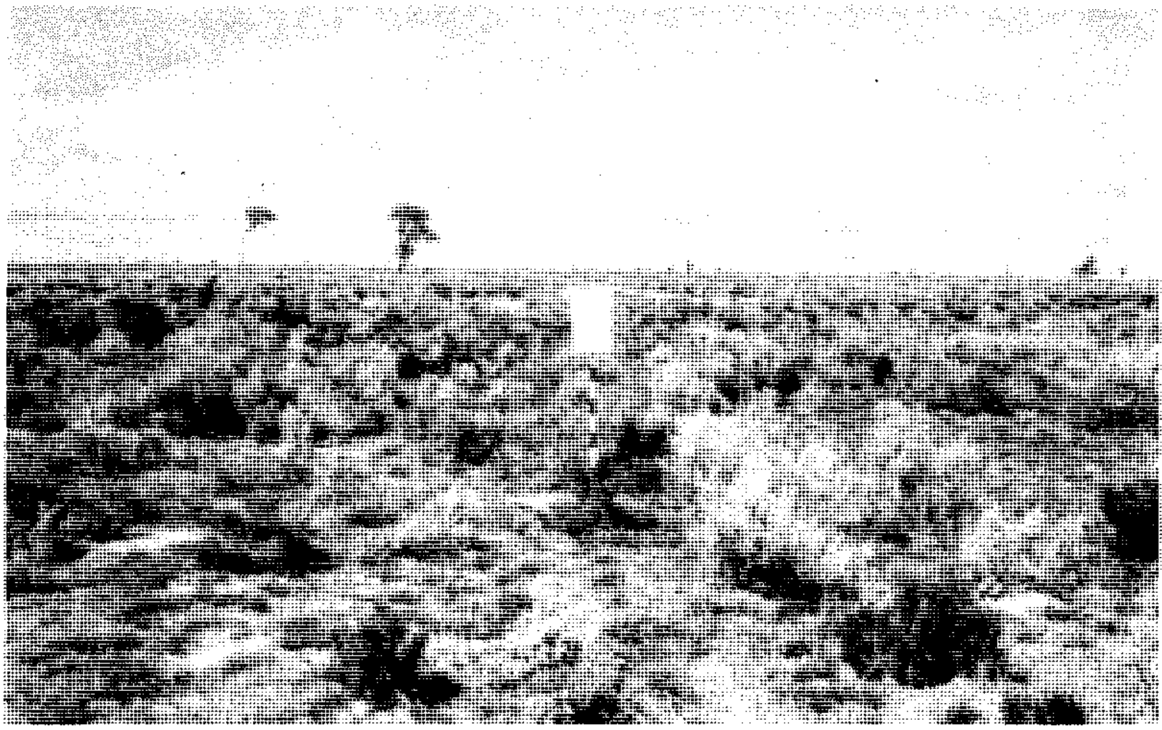
HORIZONTAL RELIABILITY ± 5m OR BETTER

MAP REFERENCE
NULLARBOR 5035
1:100,000

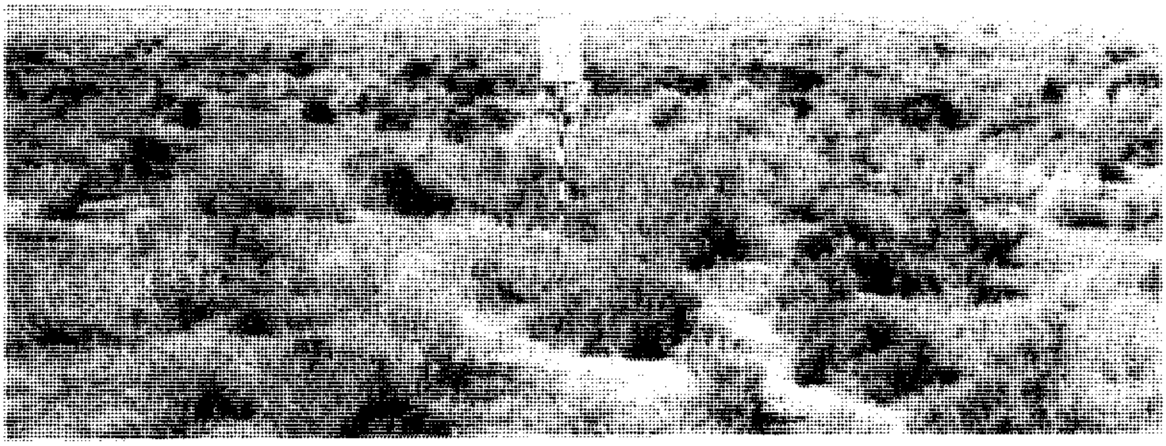
SURVEY: T.S.F, D.C.W

AUST. SURVEY OFFICE S.A. | A4/2558

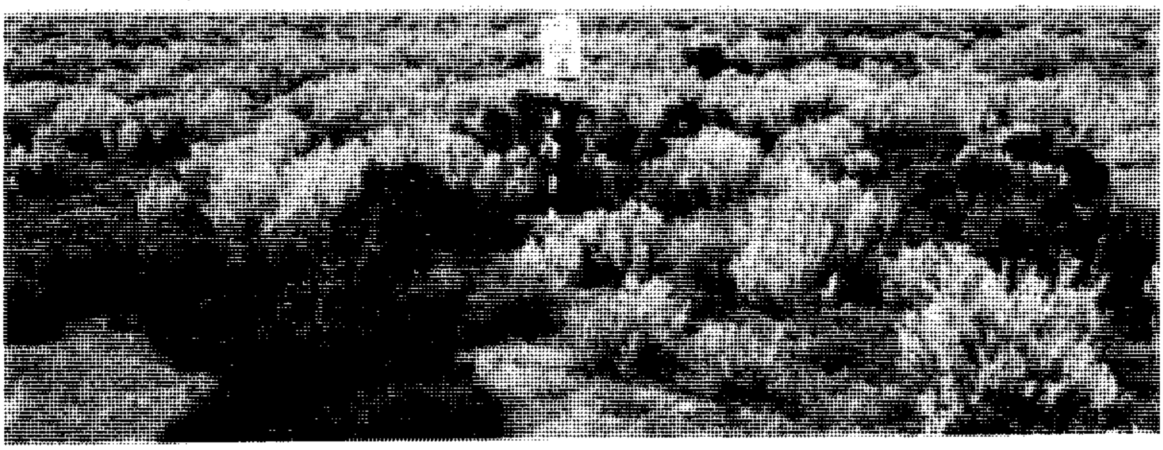
QUADRAT CA 1 I DATE 13/04/84
LATITUDE 31,26,40 LONGITUDE 130,43,48
ALTITUDE 60 metres
LOCATION 15 km W Nullarbor Stn., South Australia
LANDFORM depression SOIL TEXTURE clay
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION hard setting DISTURBANCE none visible
LAND USE conservation



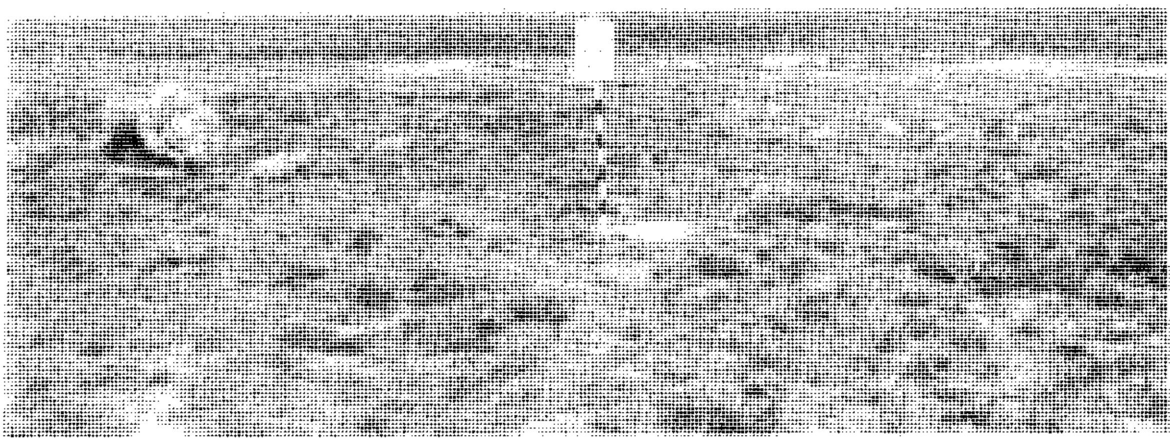
QUADRAT CA 2 I DATE 14/04/84
LATITUDE 31,25,16 LONGITUDE 130,49,36
ALTITUDE 60 metres
LOCATION 7 km NW Nullarbor Stn., South Australia
LANDFORM plain SOIL TEXTURE clay
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION hard setting DISTURBANCE none visible
LAND USE conservation



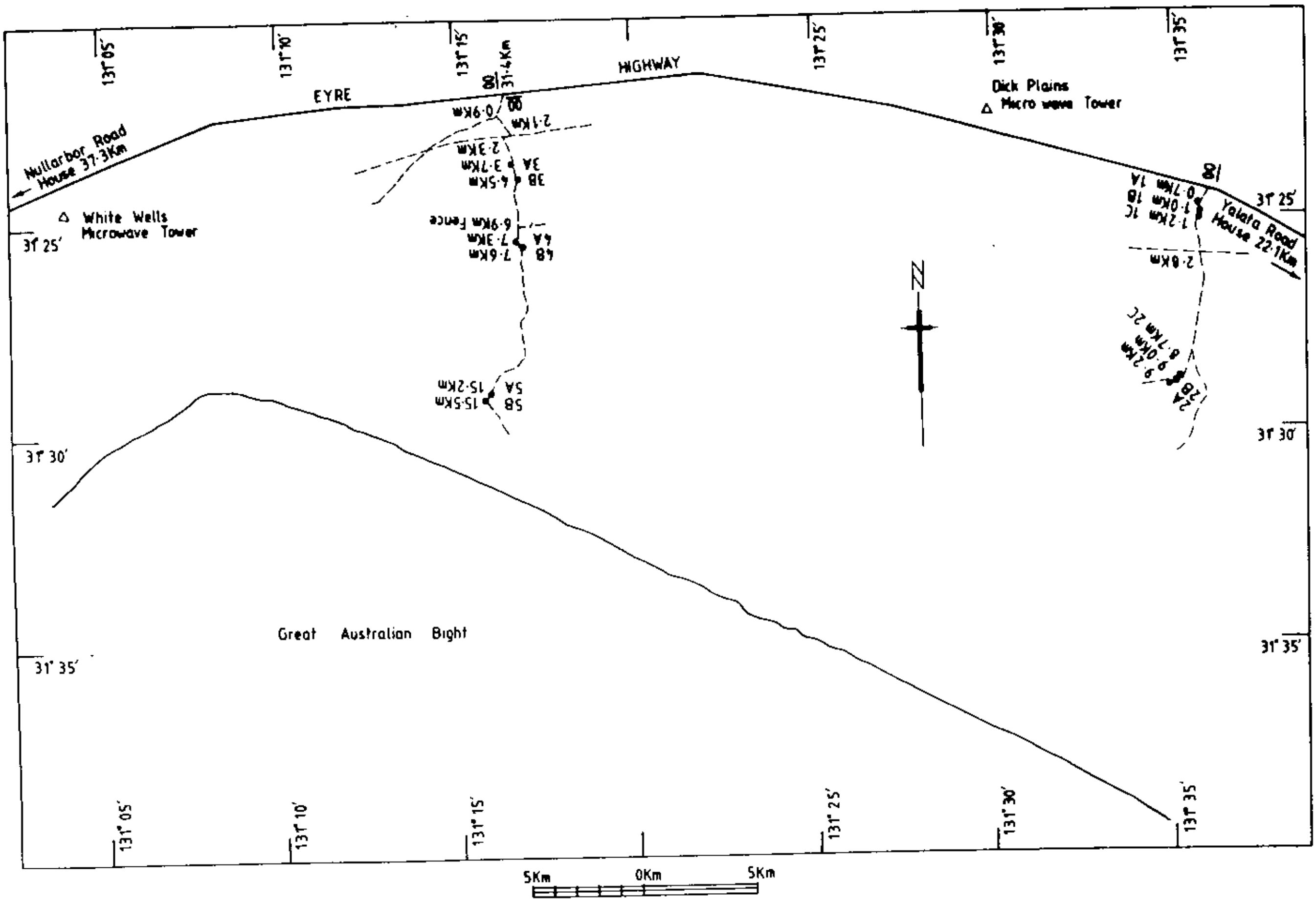
QUADRAT CA 3 I DATE 14/04/84
LATITUDE 31,21,11 LONGITUDE 130,41,46
ALTITUDE 65 metres
LOCATION 21 km NW Nullarbor Stn., South Australia
LANDFORM plain SOIL TEXTURE clay
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION hard setting DISTURBANCE none visible
LAND USE conservation



QUADRAT CA 4 I DATE 14/04/84
LATITUDE 31,16,17 LONGITUDE 130,38,54
ALTITUDE 75 metres
LOCATION 29 km NW Nullarbor Stn., South Australia
LANDFORM rise SOIL TEXTURE clay
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION hard setting DISTURBANCE none visible
LAND USE light grazing



QUADRAT CA 5 II DATE 15/04/84
LATITUDE 31,15,38 LONGITUDE 130,38,33
ALTITUDE 75 metres
LOCATION 31 km NW Nullarbor Stn., South Australia
LANDFORM depression SOIL TEXTURE clay
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION hard setting DISTURBANCE none visible
LAND USE light grazing



YALATA (YA)

TRAP LINE	GEOGRAPHICAL SOUTH LAT.	GEOGRAPHICAL EAST LONG.	AMG (84) ZONE 52 EAST	AMG (84) ZONE 52 NORTH	SA PSM REF. NO	DESCRIPTION
1 A	31 24 47.37	131 35 49.60	746 900	6 521 678	5235/1036	PM & INDICATOR
1 B	31 24 55.96	131 35 48.11	746 855	6 521 415	5235/1037	"
1 C	31 25 04.40	131 35 48.18	746 850	6 521 155	5235/1038	"
2 A	31 28 59.90	131 34 58.34	745 363	6 513 932	5235/1039	"
2 B	31 28 55.75	131 35 07.44	745 606	6 514 054	5235/1040	"
2 C	31 28 51.00	131 35 13.56	745 771	6 514 197	5235/1041	"
3 A	31 23 37.96	131 16 37.41	716 510	6 524 491	5135/1036	"
3 B	31 23 59.73	131 16 46.97	716 749	6 523 815	5135/1037	"
4 A	31 25 26.82	131 16 42.72	716 581	6 521 136	5135/1040	"
4 B	31 25 36.80	131 16 51.53	716 807	6 520 824	5135/1043	"
5 A	31 29 01.61	131 15 55.46	715 196	6 514 546	5135/1041	"
5 B	31 29 09.93	131 15 47.79	714 989	6 514 294	5135/1042	"

HORIZONTAL RELIABILITY ± 5m OR BETTER

MAP REFERENCE

ILLCUMBA 5135 , COYMBRA 5134
PILPUPPIE 5234 , YALATA 5235
1 : 100,000

SURVEY: T.S.F, D.C.W

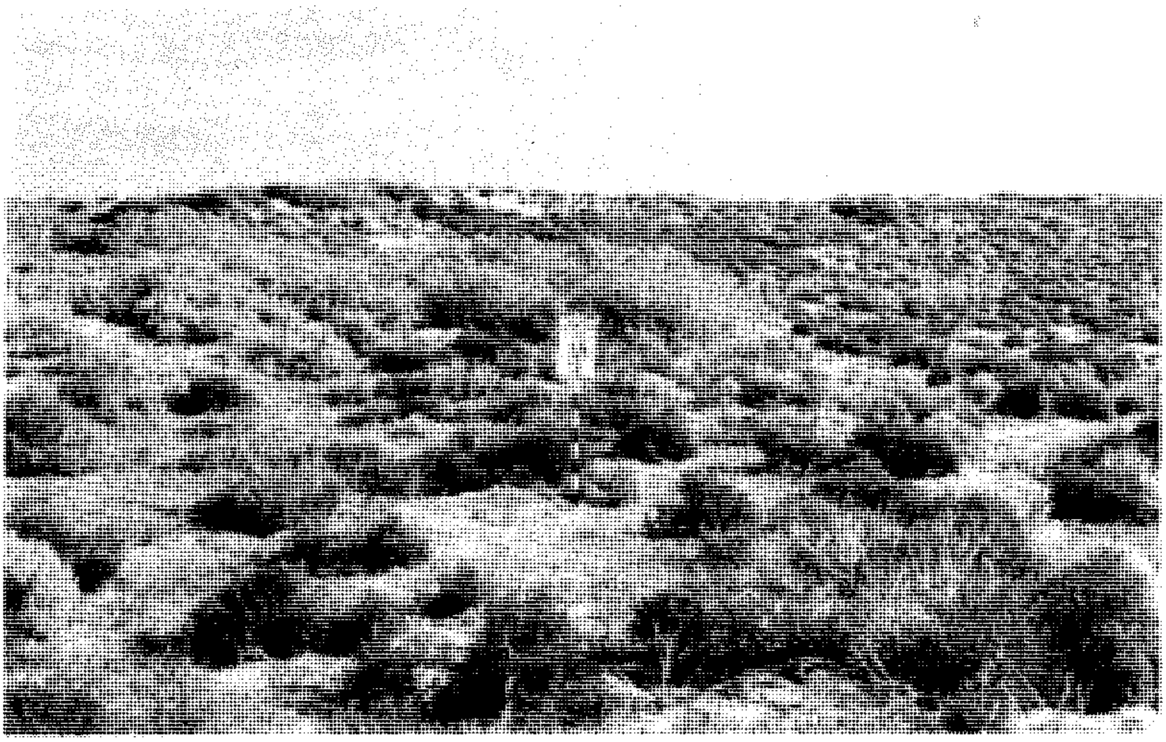
AUST. SURVEY OFFICE S.A.	A4/2564

QUAORAT YA 1 I DATE 18/04/84
LATITUDE 31,24,47 LONGITUDE 131,35,50
ALTITUDE 120 metres
LOCATION 22 km NW Yalata Roadhouse, South Australia
LANOFORM rise SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITIDN loose DISTURBANCE none visible
LAND USE conservation

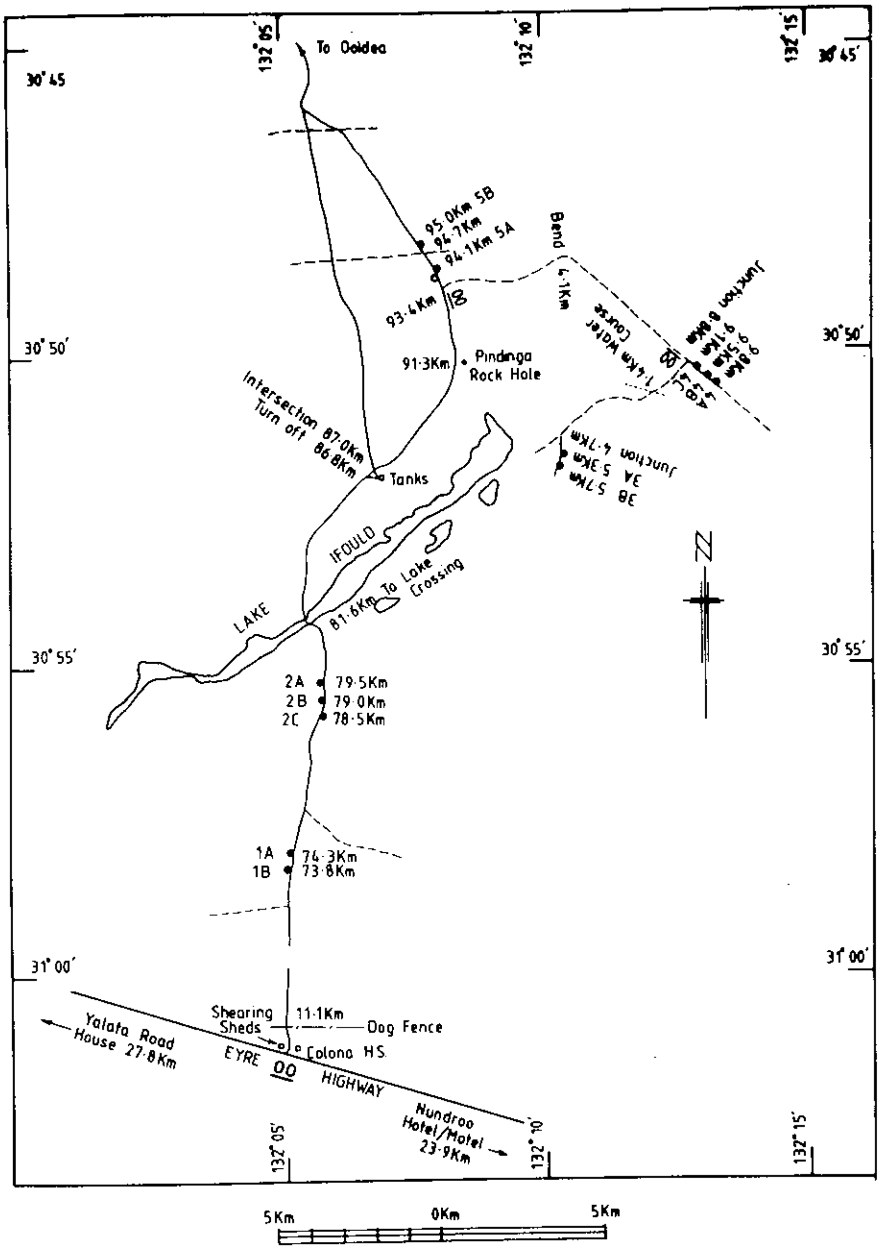
QUADRAT YA 2 I OATE 18/04/84
LATITUDE 31,29,00 LDNGITUDE 131,34,58
ALTITUDE 60 metres
LOCATION 20 km W Yalata Roadhouse, South Australia
LANDFORM ridge SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE conservation

QUADRAT YA 3 III DATE 19/04/84
LATITUDE 31,23,38 LONGITUDE 131,16,37
ALTITUDE 50 metres
LOCATION 51 km NW Yalata Roadhouse, South Australia
LANDFORM rise SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE conservation

QUADRAT YA 4 I DATE 19/04/84
LATITUDE 31,25,27 LONGITUDE 131,16,43
ALTITUDE 50 metres
LOCATION 50 km W Yalata Roadhouse, South Australia
LANDFORM hill SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE conservation



QUADRAT YA 5 V	OATE 20/04/84
LATITUDE 31,29,02	LONGITUDE 131,15,55
ALTITUDE 20 metres
LOCATION 50 km W Yalata Roadhouse, South Australia
LANDFORM dune	SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose	DISTURBANCE sheet eroded
LAND USE conservation



IFOULD (IF)

TRAP LINE	GEOGRAPHICAL		AMG (84) ZONE 53		SA PSM REF. NO	DESCRIPTION
	SOUTH LAT.	EAST LONG.	EAST	NORTH		
1 A	30 58 00.63	132 05 08.43	221 627	6 570 416	5336/1032	PM & INDICATOR
1 B	30 58 16.73	132 05 05.69	221 567	6 569 918	5336/1033	"
2 A	30 55 16.66	132 05 44.66	222 457	6 575 492	5336/1036	"
2 B	30 55 32.81	132 05 46.23	222 511	6 574 996	5336/1035	"
2 C	30 55 47.96	132 05 42.80	222 433	6 574 527	5336/1034	"
3 A	30 51 36.94	132 10 25.55	229 744	6 582 452	5336/1038	"
3 B	30 51 48.37	132 10 18.75	229 573	6 582 095	5336/1039	"
4 A	30 50 30.64	132 13 17.39	234 260	6 584 609	5336/1040	"
4 B	30 50 22.61	132 13 08.27	234 011	6 584 850	5336/1041	"
4 C	30 50 14.89	132 12 57.84	233 728	6 585 081	5336/1042	"
5 A	30 48 37.58	132 07 58.34	225 691	6 587 877	5336/1045	"
5 B	30 48 14.00	132 07 41.06	225 213	6 588 592	5336/1046	"

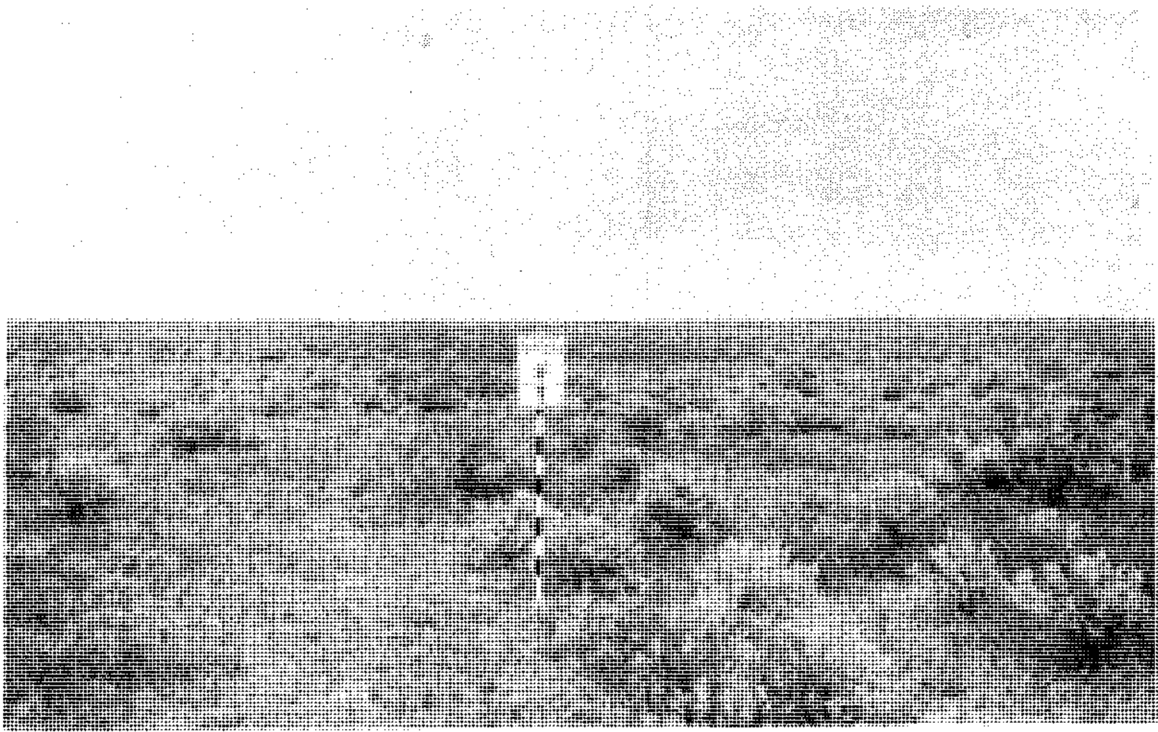
HORIZONTAL RELIABILITY ± 5m OR BETTER

MAP REFERENCE

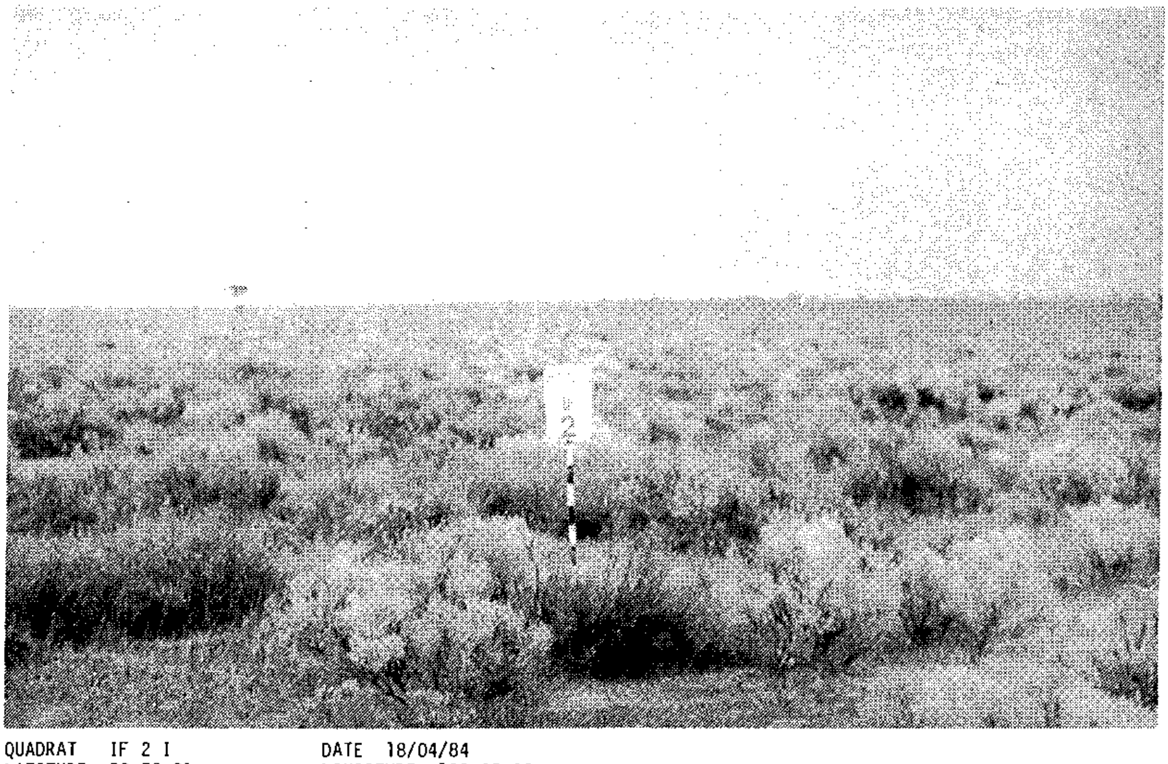
BARTON SH 53 9
1: 250,000

SURVEY: T.S.F; D.C.W

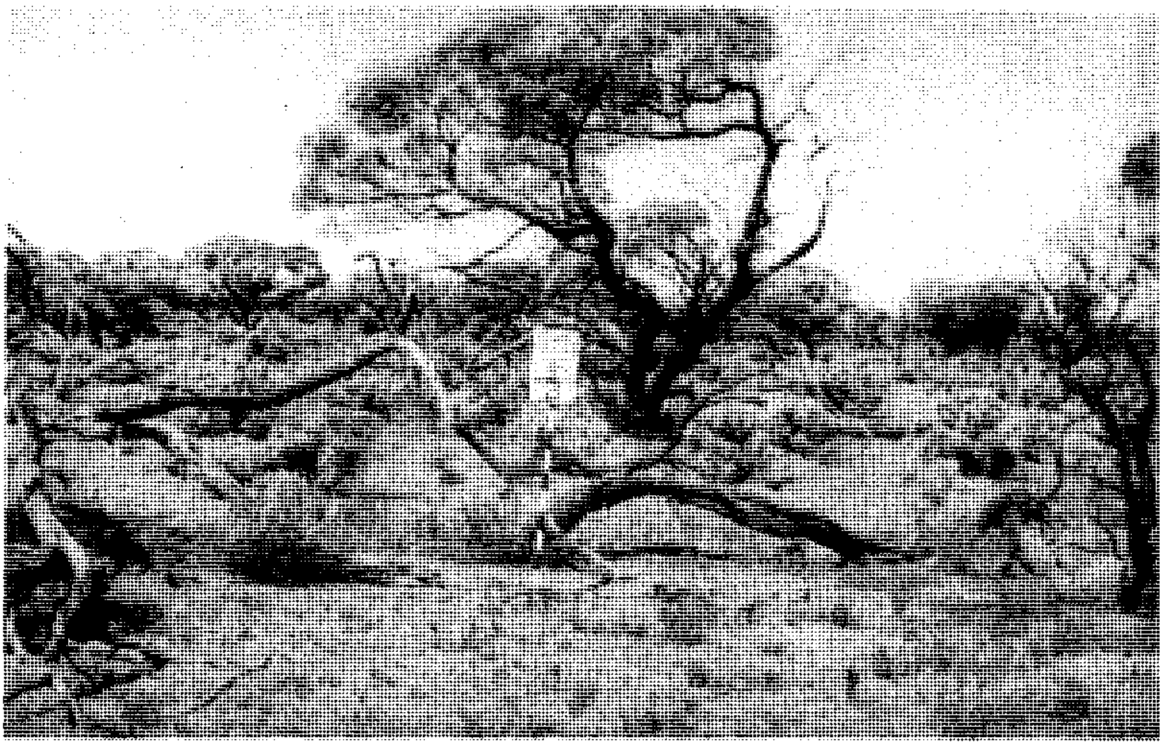
AUST. SURVEY OFFICE S.A. | A4/2560



QUADRAT IF 1 I DATE 18/04/84
LATITUDE 30,59,00 LONGITUOE 132,04,00
ALTITUOE 90 metres
LOCATION 54.5 km N Colona H/S, South Australia
LANOFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use

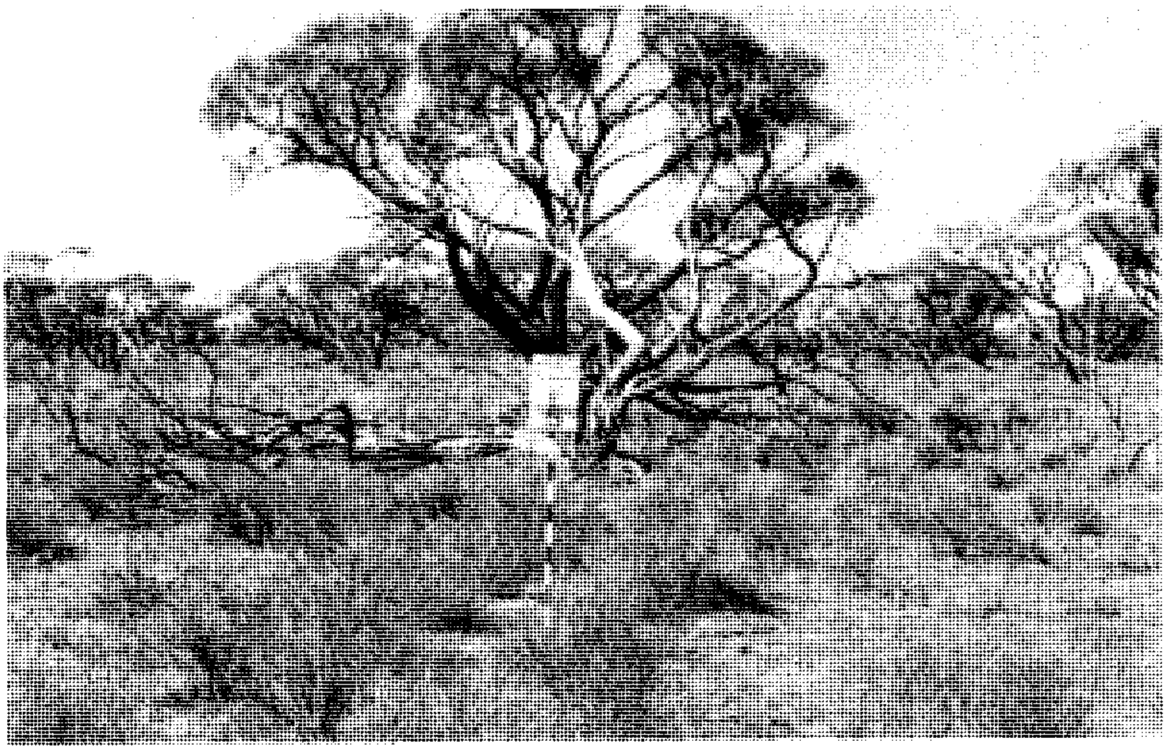


QUADRAT IF 2 I DATE 18/04/84
LATITUDE 30,58,01 LONGITUDE 132,05,08
ALTITUOE 75 metres
LOCATION 62 km N Colona H/S, South Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use

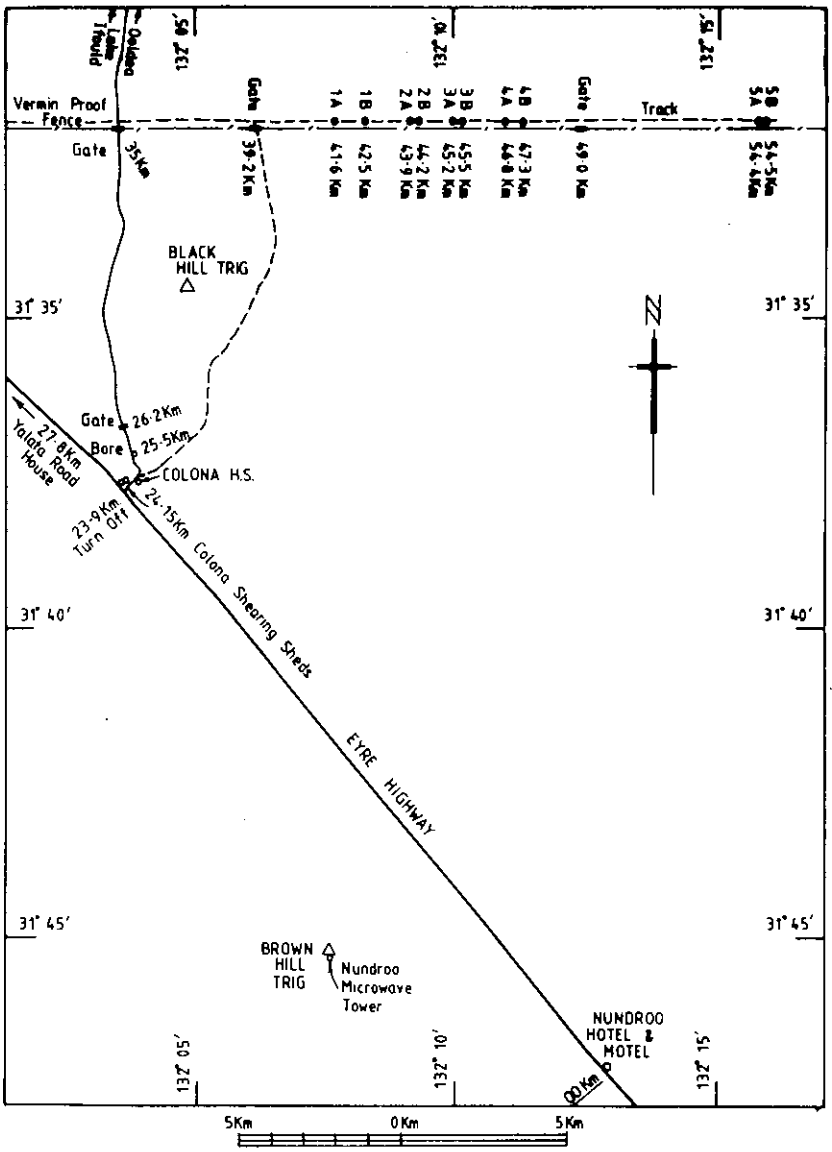


QUADRAT IF 3 I DATE 17/04/84
LATITUOE 30,55,17 LONGITUOE 132,05,45
ALTITUOE 80 metres
LOCATION 68 km N Colona H/S, South Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW
SURFACE CONDITION crusting DISTUR8ANCE none visible
LANO USE no defined use

QUADRAT IF 4 I DATE 17/04/84
LATITUDE 30,50,31 LONGITUDE 132,13,17
ALTITUDE 85 metres
LOCATION 60 km N Colona H/S, South Australia
LANOFORM dune SOIL TEXTURE sand
SURFACE STREW none apparent
SURFACE CONDITION loose DISTURBANCE none visible
LAND USE no defined use



QUADRAT IF 5 I DATE 17/04/84
LATITUDE 30,48,38 LONGITUDE 132,07,58
ALTITUDE 105 metres
LOCATION 63 km N Colona H/S, South Australia
LANDFORM plain SOIL TEXTURE sandy clay loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use



COLONA (KO)

TRAP LINE	GEOGRAPHICAL		AMG (84) ZONE 53		SA PSM	DESCRIPTION
	SOUTH LAT.	EAST LONG.	EAST	NORTH	REF. NO	
1 A	31 31 54.72	132 07 42.71	227 352	6 507 864	5334/1164	PM & INDICATOR
1 B	31 31 53.30	132 08 16.63	228 246	6 507 932	5334/1165	"
2 A	31 31 54.27	132 09 09.80	229 650	6 507 939	5334/1166	"
2 B	31 31 53.44	132 09 20.08	229 920	6 507 971	5334/1167	"
3 A	31 31 54.97	132 09 58.53	230 936	6 507 950	5334/1168	"
3 B	31 31 55.34	132 10 08.64	231 203	6 507 946	5334/1169	"
4 A	31 31 55.11	132 10 57.23	232 485	6 507 986	5334/1171	"
4 B	31 31 54.15	132 11 18.19	233 037	6 508 030	5334/1172	"
5 A	31 31 56.19	132 15 46.47	240 117	6 508 146	5334/1173	"
5 B	31 31 55.78	132 15 52.83	240 285	6 508 163	5334/1174	"

HORIZONTAL RELIABILITY ± 5m OR BETTER

MAP REFERENCE

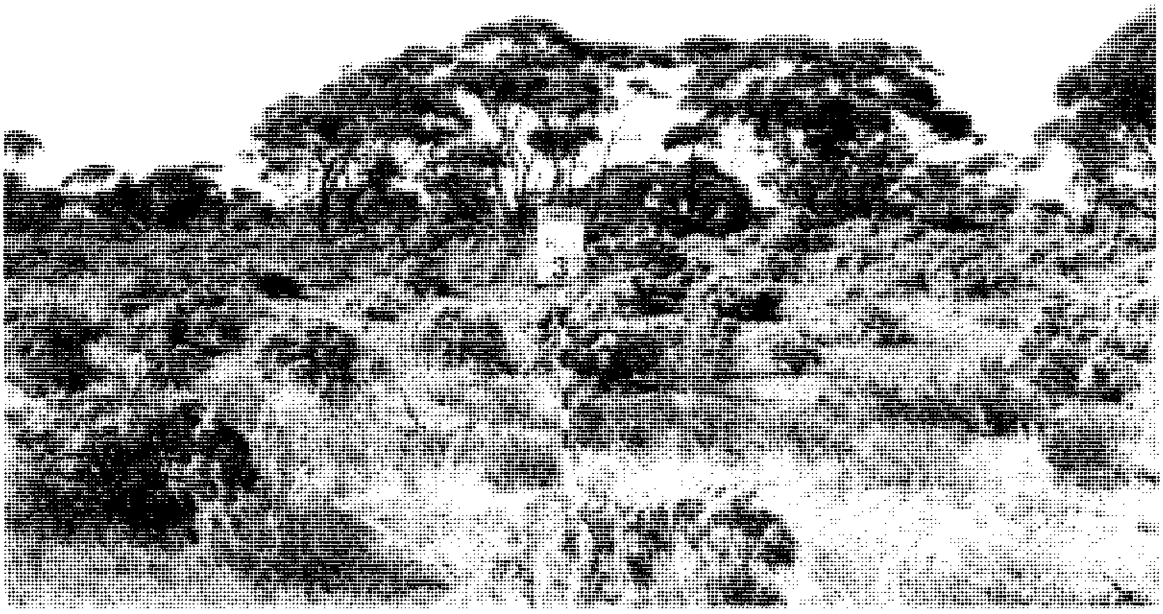
COORABIE 5334
1:100,000

SURVEY: T.S.F; D.C.W

AUST. SURVEY OFFICE S.A. | A4/2557

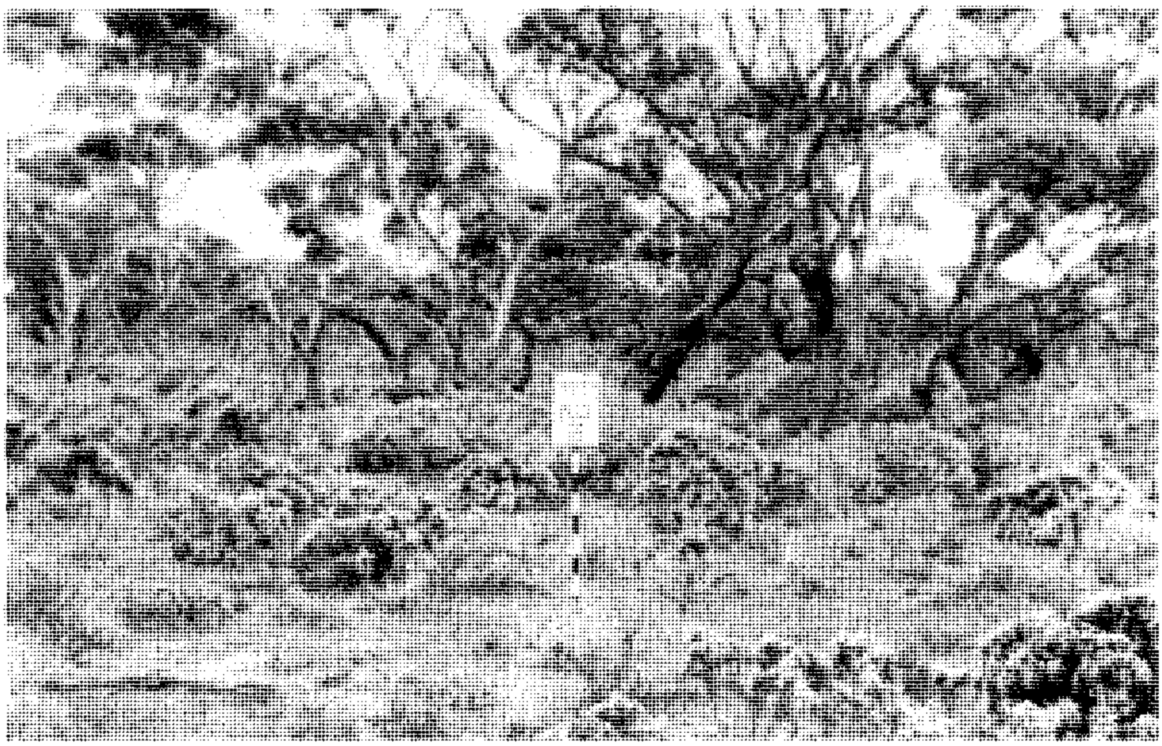
QUADRAT KO 1 I DATE 13/04/84
LATITUDE 31,31,54 LONGITUDE 132,07,43
ALTITUDE 50 metres
LOCATION 12.5 km NE Colona H/S, South Australia
LANDFORM plain SOIL TEXTURE loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use

QUADRAT KO 2 I DATE 13/04/84
LATITUDE 31,31,54 LONGITUDE 132,09,10
ALTITUDE 50 metres
LOCATION 12.6 km NE Colona H/S, South Australia
LANDFORM plain SOIL TEXTURE loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use



QUADRAT KO 3 I DATE 13/04/84
LATITUDE 31,31,55 LONGITUDE 132,09,58
ALTITUDE 50 metres
LOCATION 15 km NE Colona H/S, South Australia
LANDFORM hill SOIL TEXTURE loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use

QUADRAT KO 4 I DATE 14/04/84
LATITUDE 31,31,55 LONGITUDE 132,10,57
ALTITUDE 60 metres
LOCATION 16.2 km NE Colona H/S, South Australia
LANDFORM plain SOIL TEXTURE loam
SURFACE STREW pebble (4-64mm)
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use



QUADRAT KO 5 1 DATE 14/04/84
LATITUDE 31,31,56 LONGITUDE 132,15,46
ALTITUDE 53 metres
LOCATION 14.2 km NE Colona H/S, South Australia
LANDFORM ridge SOIL TEXTURE loam
SURFACE STREW none apparent
SURFACE CONDITION crusting DISTURBANCE none visible
LAND USE no defined use

APPENDIX II

THE PLANTS RECORDED FROM QUADRATS ON THE NULLARBOR STUDY AREA IN APRIL AND SEPTEMBER 1984

APPENDIX II: THE PLANTS RECORDED FROM QUADRATS ON THE NULLARBOR STUDY AREA IN APRIL AND SEPTEMBER 1984

Plant taxonomy used follows Jessop J.P. (1983) ed. A List of the Vascular Plants of South Australia, South Australian Department of Environment and Planning, but includes the 1984 Taxonomic update of this work which, although computerised, has yet to be published. The quadrats from which plants wererecorded are divided into the three major zones of the Nullarbor Study Area as shown below:

Northern Fringe	(NF)	BA1-5, PL1-6, JU1-5, MU2-5, IF3-5
Treeless Plain	(TP)	HA1-5, FO1-5, HU1-5, CA1-5, IF1-2, KD4-5, KU1-2, MU1
Coastal Fringe	(CF)	CO1-5, MA1-6, KU3-5, ME3-5, ME1-5, KD1-3, YA1-5, KO1-5

NULLABOR SURVEY (APRIL, SEPTEMBER 1984)

DISTIBUTION BY QUADRATS OF PLANTS OBSERVED

Microsyphe sp.	CF: KU 4 KU 5
Moss/Lichen	NF: MU 2 MU 3 MU 4 IF 3 IF 4 IF 5
	TP: HU 1 HU 2 HU 4 HU 5 CA 1 CA 2 CA 3 CA 4 CA 5 IF 1 IF 2 KD 4 KD 5 MU 1
	CF: ME 1 ME 2 ME 3 ME 4 ME 5 KD 1 KD 2 KD 3 YA 1 YA 2 YA 3 YA 4 YA 5 KO 1 KO 2 KO 3 KO 4 KO 5
AIZOACEAE	
Carpobrotus modestus	CF: CO 5 MA 4 MA 5 KU 5
Carpobrotus rossii	CF: CO 4 CO 5 MA 4 MA 5 KU 5 ME 1 YA 5
Disphyma crassifolium	CF: KU 4 KU 5 ME 1 KD 1 YA 5 KO 1 KO 2 KO 3
Gunniopsis calcarea	NF: BA 2
	TP: CA 2 CA 3 CA 5
	CF: MA 1 MA 6 ME 1 ME 4
Gunniopsis sp.	TP: FO 5
	CF: MA 1 MA 6 KU 4
Mesembryanthemum crystallinum	TP: KD 4
	CF: MA 5 KU 5 ME 1 YA 3 YA 4 YA 5
Tetragonia sp.	TP: CA 5
	CF: ME 2 ME 4
Tetragonia eremaea	NF: PL 2 PL 5 IF 3 IF 4 IF 5
	TP: FO 2 FO 3 FO 4 FO 5 IF 1 IF 2
	CF: CO 1 ME 5
Tetragonia implexicoma	CF: ME 1 ME 2 KD 2 KD 3 YA 3 YA 4 YA 5
AMARANTHACEAE	
Hemichroa diandra	CF: KD 1 YA 5
Ptilotus exaltatus	NF: PL 3 PL 4
Ptilotus gaudichaudii	NF: PL 2 PL 3 PL 4 PL 5 JU 5
Ptilotus obovatus	NF: PL 1 PL 2 PL 3 PL 4 PL 5 JU 3 JU 4 JU 5 MU 2 MU 3 MU 4 MU 5 IF 4
	TP: HA 5
	CF: CO 1 ME 1 YA 3 YA 4 KO 5
Ptilotus polystachyus var. polystachyus	NF: PL 3 PL 4 JU 5 MU 2 MU 5
Ptilotus symonii	CF: CO 2
Ptilotus sp.	NF: JU 5
	TP: KU 2
APOCYNACEAE	
Alyxia buxifolia	NF: PL 4
ASCLEPIADACEAE	
Marsdenia sp.	NF: PL 1 PL 2
Rhyncharrhena linearis	NF: JU 5
BORAGINACEAE	

Halgania sp.	CF: CO 3
Halgania andromedifolia	CF: ME 2
Halgania viscida	NF: PL 4
Halgania cyanea	NF: MU 5
Heliotropium europaeum	TP: FO 5
Omphalolappula concava	NF: PL 2 PL 5 IF 3 IF 5
	TP: HA 4 CA 3 IF 1 IF 2
	CF: CO 2 MA 1 ME 1 KD 1 KD 3 YA 2 KO 1
Trichodesma zeylanicum	NF: MU 2
CAMPANULACEAE	
Wahlenbergia communis	NF: PL 2
CARYOPHYLLACEAE	
Sagina maritima	TP: CA 2
Spergularia diandra	CF: CO 1
CASUARINACEAE	
Casuarina cristata	NF: BA 1 PL 1 PL 2 PL 3 PL 4 PL 5 JU 5 MU 3 MU 4
	TP: MU 1
	CF: YA 5
Allocasuarina humilis	CF: CO 3
CHENOPODIACEAE	
Atriplex sp.	TP: HU 2
Atriplex acutibractea	NF: BA 3 BA 5 MU 2
	TP: HA 1 HA 2 HA 4 HA 5 HU 1 HU 2 HU 3 HU 4 HU 5 IF 1 IF 2
	CF: CO 1
Atriplex cinerea	CF: MA 5 KU 5 ME 1 YA 5
Atriplex cryptocarpa	TP: HU 3 HU 4 HU 5
Atriplex eardleyae	TP: HU 2 CA 3 CA 5 KD 5
	CF: ME 2 ME 5 KD 3
Atriplex nummularia	NF: BA 2 JU 1 JU 2 JU 4
	TP: HA 1 HA 3 HA 4 HA 5 FO 4 KU 1 KU 2
	CF: CO 1 CO 2 MA 1 MA 2 MA 6 KU 5 ME 1 ME 2 ME 3 ME 4 ME 5 KD 3
Atriplex paludosa	CF: MA 3 KU 5 YA 4
Atriplex stipitata	NF: IF 4 IF 5
Atriplex vesicaria	NF: BA 1 BA 2 BA 3 BA 4 BA 5 PL 1 PL 2 JU 1 JU 2 JU 3 IF 3 IF 4 IF 5
	TP: HA 1 HA 2 HA 3 HA 4 HA 5 HU 5 CA 1 CA 2 CA 3 CA 4 CA 5 IF 1 IF 2 KD 4 KD 5 KU 1 KU 2
	CF: CO 1 CO 2 MA 1 MA 2 MA 3 MA 6 KU 3 KU 4 KU 5 ME 2 ME 3 ME 4 ME 5 KD 1 KD 2 KD 3 YA 1 YA 2 YA 3 YA 4 YA 5 KO 1 KO 2 KO 3 KO 4 KO 5
Chenopodium sp.	NF: MU 4 MU 5
Chenopodium cristatum	NF: PL 5 MU 2
	TP: MU 1
Chenopodium desertorum	CF: CO 5
Chenopodium melanocarpum	NF: PL 2

Dissocarpus paradoxa	TP:	FO 5					
Enchylaena tomentosa	NF:	BA 3	BA 4	BA 5	PL 1	PL 2	PL 5
		JU 5	MU 2	MU 3	MU 4	MU 5	IF 3
		IF 4	IF 5				
	TP:	HA 5	FO 3	FO 5	HU 3	HU 5	CA 1
		CA 5	IF 2	KD 4	KD 5	KU 1	MU 1
	CF:	CO 2	MA 1	MA 5	MA 6	KU 5	ME 1
		ME 2	ME 3	ME 4	ME 5	KD 2	KD 3
		YA 1	YA 2	YA 3	YA 4	YA 5	KO 1
		KO 3	KO 4	KO 5			
Eriochiton sclerolaenoides	NF:	IF 3	IF 4	IF 5	BA 5	PL 1	PL 2
		PL 3	PL 4	PL 5			
	TP:	FO 1	IF 1	IF 2	KD 4	KU 2	HA 5
		FO 5	MU 1				
	CF:	MA 1	MA 2	MA 6	KD 3	KO 1	KO 2
		KO 4	KO 5				
Halosarcia sp.	TP:	CA 2					
	CF:	YA 5					
Halosarcia pterygosperma	CF:	MA 1	KU 3	KU 4	KU 5	YA 5	
Maireana sp.	NF:	BA 3	IF 4				
	TP:	HA 1	HA 2	HA 3	HA 4	HA 5	HU 3
		CA 2	CA 3				
	CF:	ME 3	ME 5	YA 1			
Maireana sp. (probably hybrid)	NF:	IF 5					
Maireana erioclada	NF:	BA 3	BA 4	BA 5	JU 5	MU 2	MU 3
		MU 4	MU 5	IF 3	IF 4	IF 5	
	TP:	CA 1	CA 2	CA 5	IF 1	IF 2	KD 4
		KD 5	KU 2				
	CF:	CO 2	MA 1	MA 2	MA 3	MA 6	KU 3
		KU 4	ME 1	ME 2	ME 3	ME 4	ME 5
		KD 1	KD 2	KD 3	YA 1	YA 2	YA 3
		YA 4	YA 5	KO 1	KO 2	KO 3	KO 4
		KO 5					
Maireana georgei	NF:	JU 3					
Maireana integra	NF:	PL 2					
Maireana oppositifolia	CF:	KU 4	KU 5	KD 1	YA 3	YA 4	YA 5
		KO 3					
Maireana pyramidata	NF:	PL 2					
Maireana radiata	NF:	BA 1	BA 2	BA 3	IF 3	IF 4	
	TP:	KU 2					
	CF:	YA 2					
Maireana sedifolia	NF:	BA 1	BA 2	BA 3	BA 4	BA 5	PL 1
		PL 2	PL 3	PL 5	JU 2	JU 3	JU 4
		JU 5	IF 3	IF 4	IF 5		
	TP:	HA 1	HA 2	HA 4	HA 5	FO 1	FO 2
		HU 1	HU 2	HU 4	CA 1	CA 2	CA 3
		CA 4	CA 5	IF 1	IF 2	KD 4	KD 5
		KU 1	MU 1				
	CF:	CO 1	MA 1	MA 6	ME 4	ME 5	KD 3
Maireana trichophora	NF:	BA 5					
Maireana trichoptera	NF:	PL 1	PL 2	PL 3	PL 4	PL 5	JU 3
		JU 4	IF 3	IF 4	IF 5		
	TP:	CA 2	KU 2				
	CF:	MA 2	MA 6	KO 3	KO 5		
Maireana triptera	NF:	PL 1	PL 2	PL 3	PL 4	PL 5	
Maireana turbinata	NF:	IF 3	IF 4	IF 5			
	TP:	FO 5	HU 2	HU 3	CA 3	CA 4	IF 1

		IF 2					
	CF:	KO 1					
Osteocarpum salsuginosum	TP:	CA 1	CA 2				
	CF:	ME 5					
Rhagodia candolleana	NF:	IF 4					
	CF:	CO 4	CO 5	MA 2	MA 4	KU 5	
Rhagodia crassifolia	NF:	BA 3	BA 4	BA 5	PL 1	PL 2	PL 3
	TP:	HU 1	HU 4	KU 2			
	CF:	MA 3	ME 1	ME 2	ME 3	ME 4	KD 2
		YA 1	YA 2	YA 3	YA 4	YA 5	KO 2
		KO 3	KO 4	KO 5			
Rhagodia preissii	NF:	MU 5					
	CF:	MA 4	MA 5				
Rhagodia spinescens	NF:	BA 1	BA 2	BA 3	BA 4	BA 5	PL 1
		PL 2	PL 3	PL 4	PL 5	JU 1	JU 2
		JU 3	JU 4	JU 5	MU 2	MU 3	MU 4
		MU 5	IF 3	IF 4	IF 5		
	TP:	HA 4	HA 5	FO 1	FO 2	FO 3	FO 4
		FO 5	HU 1	HU 2	HU 3	HU 4	HU 5
		CA 5	IF 2	MU 1			
	CF:	KD 3	YA 1	KO 1	KO 2	KO 3	KO 4
		KO 5					
Rhagodia ulicina	TP:	CA 1	CA 3	CA 5			
	CF:	ME 1	ME 4	ME 5			
Salsola kali	NF:	BA 1	BA 2	BA 3	BA 5	PL 1	PL 2
		PL 4	PL 5	JU 2	JU 4	MU 2	MU 3
		MU 4	MU 5	IF 3	IF 4	IF 5	
	TP:	HA 1	HA 2	HA 3	HA 4	HA 5	FO 1
		FO 2	FO 3	FO 4	FO 5	HU 1	HU 2
		HU 3	HU 4	HU 5	CA 3	CA 5	IF 1
		IF 2	KD 4	KD 5	MU 1		
	CF:	ME 1	ME 4	ME 5	KD 2	KD 3	YA 2
		YA 3	YA 5	KO 1	KO 3	KO 5	
Sclerolaena sp.	CF:	ME 1					
Sclerolaena brevifolia	NF:	BA 1	BA 3				
	TP:	CA 2	CA 5				
	CF:	KU 3	KU 4				
Sclerolaena diacantha	NF:	BA 2	BA 3	BA 4	BA 5	PL 1	PL 2
		PL 3	PL 4	PL 5	JU 1	JU 2	JU 3
		JU 4	JU 5	MU 2	MU 3	MU 4	MU 5
		IF 3					
	TP:	HA 1	HA 2	HA 3	HA 4	HA 5	FO 1
		FO 2	FO 3	FO 4	FO 5	KU 1	KU 2
		MU 1					
	CF:	CO 1	CO 2	MA 1	MA 2	MA 3	MA 5
		MA 6	KU 3	ME 1	ME 4	ME 5	KD 1
		YA 1	YA 2	YA 3	YA 4	KO 2	
Sclerolaena obliquicuspis	NF:	BA 4	IF 3	IF 4	IF 5		
	TP:	HA 3	HA 4	HA 5	HU 1	HU 2	HU 3
		HU 4	HU 5	CA 1	CA 2	CA 3	CA 4
		CA 5	IF 1	IF 2			
	CF:	KU 3	ME 5	KD 3	YA 2	YA 3	YA 5
		KO 1	KO 2	KO 3	KO 4	KO 5	
Sclerolaena patenticuspis	NF:	BA 2	BA 5				
	TP:	HA 1	HA 2	HA 3	HA 4	HA 5	KD 4
		KD 5					
	CF:	CO 2	ME 2	ME 5	KD 2	KD 3	YA 5
Sclerolaena uniflora	NF:	IF 3	IF 4				

	TP: MU 1
	CF: ME 5 KD 1 YA 1 YA 4 YA 5 KO 3
	KO 4 KO 5
Sclerostegia disarticulata	TP: CA 1 CA 2 CA 3 CA 4 CA 5 KD 4
	KD 5
	CF: CO 1 ME 5 KD 1 KD 3 KO 1 KO 2
	KO 3 KO 4 KO 5
Threlkeldia sp.	TP: CA 1 CA 2 CA 3 CA 4 CA 5 KD 4
	KD 5
	CF: KD 1 KD 2 KD 3
Threlkeldia diffusa	TP: KD 4 KD 5
	CF: CO 2 KD 1 KD 2 KD 3 YA 1 YA 2
	YA 3 YA 4 YA 5 KO 1 KO 3 KO 4
	KO 5
CHLOANTHACEAE	
Dicrastylis beveridgei	NF: MU 5
COMPOSITAE	
Actinobole sp.	TP: CA 1 CA 4 CA 5
Actinobole uliginosum	NF: PL 2
Angianthus sp.	TP: HA 2
	CF: MA 6
Angianthus conocephalus	TP: HA 1 HA 2 HA 5 HU 1 HU 4 HU 5
	CA 1 CA 2 CA 3 CA 4 CA 5 IF 1
	KD 4 KD 5 MU 1
	CF: CO 1 KD 3
Angianthus disarticulata	TP: CA 3
Angianthus milenei	NF: PL 2
Angianthus tomentosus	CF: YA 2 YA 5
Arctitheca populifolia	CF: YA 5
Arctotheca populifolia	CF: YA 5
Asteridea athrixioides	NF: BA 1
	CF: CO 1
Athrixia athrixoides	CF: MA 1 MA 2 MA 3
Brachycome sp.	NF: PL 3 PL 4
Brachycome cheilocarpa	CF: CO 1 CO 4
Brachycome ciliaris	NF: BA 1 BA 2 BA 3 BA 4 BA 5 PL 1
	PL 2 PL 3 PL 4 MU 2 MU 5 IF 3
	IF 4 IF 5
	TP: IF 1 IF 2 KD 5
	CF: CO 1 CO 2 MA 1 MA 6 KU 3 KU 4
	KD 1 KD 2 KD 3 YA 2 YA 3 YA 4
	YA 5 KO 1 KO 2 KO 3 KO 4 KO 5
Brachycome iberidifolia	TP: CA 1 CA 2 CA 4
Brachycome lineariloba	TP: CA 1 CA 2 CA 4 KD 4 KD 5
	CF: KD 1 KD 3 KO 1 KO 2
Brachycome tatei	CF: KD 1
Calocephalus sp.	NF: BA 2 PL 2 PL 5 JU 1 JU 2 JU 3
	JU 4
	TP: HA 1 HA 2 HA 5
Calocephalus brownii	CF: YA 5
Calocephalus platycephalus	CF: KU 4
Calotis breviradiata	TP: HU 2 HU 3 JU 3
Calotis hispidula	NF: BA 2 BA 3 BA 4 BA 5 PL 2 IF 3
	IF 4 IF 5
	TP: HA 4 HA 5 IF 1 IF 2 MU 1
	CF: CO 1 CO 2 CO 4 KO 1 KO 3 KO 4

Calotis multicaulis	NF:	BA 2 PL 2 PL 5
Centaurea melitensis	NF:	BA 1 BA 2
	TP:	HA 3 CA 3
	CF:	MA 5 YA 3 YA 4 YA 5
Cephalipterum drummondii	NF:	PL 5 JU 3 JU 4 MU 2 IF 3 IF 4
		IF 5
	TP:	HU 4 IF 2 MU 1
Chrysocoryne pusilla	NF:	MU 5
Craspedia pleiocephala	CF:	KO 1 KO 2 KO 4
Cratystylis conocephala	NF:	BA 1 BA 2 BA 3 BA 4 BA 5 PL 1
		PL 2 PL 5 JU 1 IF 4
	CF:	CO 1 CO 2 MA 6 KU 3 ME 1 ME 4
		KD 2 YA 1 YA 2 YA 3 YA 4 YA 5
		KO 3 KO 4 KO 5
Cratystylis subspinescens	NF:	PL 2
Elachanthus pusillus	CF:	CO 1
Gnaphalium luteoalbum	CF:	CO 4
Gnephosis pygmaea	NF:	PL 2
Gnephosis skirrophora	NF:	MU 2 IF 5
	TP:	IF 1 IF 2 KD 5 MU 1
	CF:	KD 1 KD 2 KD 3 KO 1 KO 2 KO 3
		KO 4
Helichrysum aff. propinqua	CF:	MA 6
Helichrysum ayersii	NF:	PL 1 PL 2 PL 3 PL 5 JU 1 JU 2
		JU 3 JU 4
Helichrysum davenportii	NF:	MU 5
Helichrysum floribundum	NF:	BA 2 JU 1 JU 2 JU 4
	TP:	HA 1 HA 2 HA 3 HA 4 HA 5
Helichrysum haigii	TP:	HA 5
	CF:	MA 1 MA 6
Helichrysum leucopsidum	NF:	JU 3
Helipterum adpressum	NF:	JU 5 PL 4
Helipterum chlorocephalum	NF:	BA 1 BA 2
	CF:	CO 1
Helipterum demissum	CF:	CO 4
Helipterum fitzgibbonii	NF:	PL 1 PL 2 PL 3 PL 4 PL 5 MU 2
		MU 3 MU 4 MU 5 IF 3 IF 4 IF 5
	TP:	IF 1 IF 2 MU 1
Helipterum floribundum	NF:	BA 1 BA 2 BA 4 BA 5 PL 1 PL 2
		PL 5
	TP:	HU 5
	CF:	CO 1
Helipterum humboldtianum	NF:	BA 1 BA 2 IF 4
	TP:	IF 2
	CF:	KO 3 KO 4
Helipterum maryonii	NF:	PL 3
Helipterum pygmaeum	TP:	KD 5
	CF:	KD 3
Helipterum splendidum	NF:	PL 2
Helipterum strictum	NF:	PL 2
	CF:	CO 1
Helipterum tenellum	NF:	BA 2 BA 3
	CF:	MA 6
Helipterum tietkensii	CF:	CO 4
Isoetopsis graminifolium	NF:	BA 5 PL 2
	TP:	HA 5 CA 1 CA 3 CA 5 KD 4 KD 5
	CF:	CO 1 MA 6 KU 4 ME 5 KD 1 KD 3
		KO 1 KO 2 KO 3

Ixiolaena leptolepis	TP:	IF 2					
Minuria cunninghamii	NF:	IF 3	IF 5				
	TP:	HU 3	CA 2	KD 4			
Minuria leptophylla	NF:	MU 2					
	TP:	HU 4					
Olearia sp.	NF:	BA 2	BA 4	BA 5			
	TP:	KU 2					
	CF:	CO 1	MA 3				
Olearia axillaris	CF:	MA 4					
Olearia exiguifolia	CF:	ME 1	ME 3	KD 2			
Olearia floribunda	CF:	YA 2					
Olearia magniflora	CF:	YA 1	YA 2	KO 5			
Olearia muelleri	NF:	BA 3	BA 4	PL 3	PL 4		
	CF:	CO 2	CO 4	MA 2	MA 3	ME 3	ME 4
		KD 2	YA 1	YA 2	YA 4	KO 5	
Olearia ramossima	CF:	MA 2	MA 3				
Osteospermum calandulaceum	TP:	HA 1					
Podolepis sp.	TP:	HA 2					
Podolepis canescens	NF:	BA 1	BA 2	BA 3	BA 4	BA 5	PL 1
		PL 2	PL 3	PL 4	PL 5		
	TP:	HA 1	HA 2	HA 3	HA 4	HA 5	
	CF:	CO 1	ME 1	YA 2			
Podolepis capillaris	NF:	MU 2	MU 3	MU 4	MU 5		
	TP:	MU 1					
Podolepis rugata	CF:	YA 2					
Podolepis rugosa	TP:	KU 2					
Scyphocoronis major	CF:	CO 3					
Senecio sp.	TP:	HA 2	HA 4	KU 2			
Senecio glossanthus	TP:	CA 1	CA 2	CA 3	CA 4	KD 4	KD 5
	CF:	CO 2	CO 3	CO 4	CO 5	MA 1	MA 4
		MA 6	KU 3	KU 4	ME 4	ME 5	KD 1
		KD 2	KD 3	YA 1	YA 2	YA 5	
Senecio gregorii	NF:	PL 2					
Senecio lautus	NF:	PL 2	MU 2	IF 3	IF 4	IF 5	
	TP:	HA 1	HA 2	HA 3	HA 4	HA 5	HU 1
		HU 2	HU 3	HU 4	CA 1	CA 2	CA 4
		IF 1	IF 2	KD 4	KD 5		
	CF:	CO 5	MA 6	ME 1	KD 1	KD 3	YA 2
		YA 3	YA 4	YA 5	KO 1	KO 2	KO 3
		KO 4	KO 5				
Senecio lautus ssp. maritimus	TP:	KD 5					
	CF:	MA 5	KU 5	ME 1	YA 2	YA 3	YA 4
		YA 5	CO 1				
Senecio lautus ssp. lautus	NF:	BA 3					
Sonchus asper ssp. asper	NF:	IF 3					
	TP:	IF 1					
	CF:	KO 2					
Sonchus oleraceus	NF:	BA 1	BA 2	BA 4	PL 2	MU 2	IF 3
		IF 4					
	TP:	HA 3	CA 1	CA 2	CA 3	CA 5	IF 2
		KD 4	KD 5				
	CF:	CO 1	CO 2	CO 3	CO 4	CO 5	MA 2
		MA 5	KU 5	ME 1	ME 5	KD 1	YA 1
		YA 2	YA 3	YA 4	YA 5	KO 1	KO 2
		KO 3	KO 4	KO 5			
Vittadinia sp.	NF:	IF 3	IF 4				
	TP:	HA 3					
Vittadinia australasica	CF:	YA 2	YA 5				

Vittadinia eremaea	NF:	MU 2
	TP:	MU 1
Vittadinia nullarborensis	NF:	BA 1 BA 2 BA 3 BA 4 BA 5 PL 2
		PL 3 PL 4 PL 5
	TP:	HA 1 HA 2 HA 3 HA 4 HA 5 HU 2
		HU 3 HU 4 HU 5
	CF:	CO 1
Waitzia sp.	NF:	PL 5
	TP:	HA 1 HA 3 HA 4 HA 5
Waitzia acuminata	NF:	MU 5
	TP:	HA 2
Waitzia aurea	NF:	PL 3 PL 4
CONVOLVULACEAE		
Convolvulus erubescens	NF:	PL 2 MU 2
	TP:	HA 1 HA 2 HA 5 HU 3 HU 4 HU 5
		MU 1
	CF:	CO 1
CRASSULACEAE		
Crassula sp.	TP:	KD 4 KD 5
	CF:	YA 2 YA 3 YA 4 YA 5
Crassula colorata	NF:	IF 5
	CF:	CO 1 CO 3 CO 4 CO 5 KD 2 YA 1
		YA 2 YA 4 KO 1 KO 2 KO 4
Crassula exserta	NF:	PL 2
	CF:	CO 1 CO 3 CO 4 CO 5
Crassula sieberana	NF:	IF 4 IF 5
	CF:	ME 1 YA 2 YA 3 YA 4 YA 5 KO 1
		KO 2 KO 3 KO 4 KO 5
CRUCIFERAE		
Arabidella filifolia	NF:	IF 5
	TP:	HU 1 HU 2 HU 4 IF 2
Arabidella trisecta	NF:	BA 2
	TP:	HA 2 HA 3 HA 4 HA 5
Brassica sp.	TP:	HA 2
Brassica tournefortii	NF:	MU 2 IF 3 IF 5
	TP:	IF 1 IF 2 MU 1
	CF:	CO 1 CO 4 CO 5 MA 1 KU 5 ME 1
		YA 2 YA 3 YA 4 YA 5 KO 1 KO 3
Cakile sp.	CF:	ME 1
Cakile maritima	CF:	MA 5
Carrichtera annua	NF:	BA 1 BA 2 BA 3 BA 4 PL 2 MU 2
		IF 5
	TP:	HA 1 HA 2 HA 3 HA 4 HA 5 FO 5
		HU 1 HU 2 HU 3 HU 4 HU 5 CA 5
		IF 1 IF 2 KD 4 KD 5 KU 2
	CF:	CO 1 MA 1 MA 6 KD 3 YA 3
Cochlearia sp.	CF:	MA 4 MA 5
Hymenolobus procumbens	CF:	ME 5 YA 2
Lepidium sp.	NF:	PL 3 PL 4
	TP:	HA 5
Lepidium africanum	TP:	FO 2
	CF:	CO 4
Lepidium phlebopetalum	NF:	BA 2 PL 2 PL 3 PL 4 PL 5 JU 2
		JU 3 JU 4 MU 2 MU 3 MU 4 IF 3
		IF 5

	TP: HA 1 HA 4 CA 2 IF 1 IF 2 MU 1
	CF: MA 1 MA 3 MA 4 KD 1
Phlegmatospermum cochlearinum	NF: IF 3
	TP: HA 2 HA 3 HA 4 HA 5
	CF: YA 2
Phlegmatospermum eremaeum	TP: HA 5
	CF: CO 2 CO 4
Sisymbrium sp.	TP: CA 1
	CF: KD 3 YA 3 YA 4 YA 5
Sisymbrium erysimoides	TP: HU 1 HU 2 HU 3 HU 4 HU 5 CA 1
Sisymbrium irio	TP: KD 5
	CF: KO 1 KO 2
Stenopetalum sp.	NF: PL 3 PL 5
	TP: HA 2
Stenopetalum lineare	NF: PL 1 PL 2 PL 3 PL 4 PL 5 JU 2
	JU 3 JU 4 MU 2 IF 3 IF 4 IF 5
	TP: IF 1 IF 2 KD 5
	CF: CO 1 CO 3 CO 4 MA 1 MA 6 ME 5
	KO 2 KO 3 KO 4
Stenopetalum sphaerocarpum	NF: PL 2 PL 3 PL 4 PL 5
Stenopetalum velutinum	NF: PL 3 PL 4
	CF: ME 1
CUPRESSACEAE	
Callitris preissii ssp. verrucosa	CF: CO 3 CO 4 CO 5
CYPERACEAE	
Gahnia lanigera	CF: CO 3 CO 4
Lepidosperma viscidum	CF: CO 3 CO 4
Schoenus pleiostomoneus	CF: CO 3
EPACRIDACEAE	
Acrotriche affinis	CF: ME 1 YA 5
Acrotriche cordata	CF: CO 3
Astroloma sp.	CF: CO 4
Conostephium drummondii	CF: CO 3 CO 4
Leucopogon sp.	CF: CO 3 CO 5
Lysinema ciliatum	CF: CO 3 CO 4
Styphelia hainesii	CF: CO 3 CO 4
EUPHORBIACEAE	
Adriana quadripartita	CF: CO 5
Beyeria lechenaultii	CF: CO 3 YA 3 YA 4
Euphorbia sp.	CF: ME 3
Euphorbia boopthana	NF: PL 1 PL 2 PL 3 PL 4 PL 5 JU 5
Euphorbia drummondii	NF: BA 1 BA 2 BA 3 BA 4 BA 5 PL 1
	PL 2 PL 3 PL 4 PL 5 MU 2 IF 3
	IF 5
	TP: HA 1 HA 2 HA 3 HA 4 IF 1 IF 2
	CF: CO 1 MA 1 MA 6 KU 3 ME 2 KO 4
Euphorbia paralias	CF: MA 5 KU 5 YA 5
Euphorbia tannensis	NF: MU 4 IF 3 IF 4
	TP: IF 2
Poranthera microphylla	CF: CO 3
FRANKENIACEAE	
Frankenia sp.	NF: PL 2 IF 3 IF 5
	TP: CA 1 KD 5

Frankenia densa TP: CA 3
CF: CO 1 MA 1 MA 2 MA 3 MA 5 YA 2
YA 3 YA 4 YA 5
Frankenia fecunda NF: PL 2
Frankenia muscorum CF: MA 3 KU 4 KU 5
Frankenia muscosa CF: ME 1 KD 1 KD 2 YA 3 YA 4 YA 5

GERANIACEAE
Erodium sp. NF: MU 4 MU 5 IF 3 IF 4 IF 5
TP: HU 2 HU 4 CA 1 CA 2 CA 3 CA 5
IF 1 IF 2
CF: ME 1 KO 1 KO 2
Erodium cicutarium NF: BA 1 BA 2 JU 2 JU 3
TP: HA 2 CA 1 CA 2 CA 3 CA 4 CA 5
KD 4 KD 5
CF: CO 1 CO 2 MA 1 MA 6 KU 3 KU 4
KD 1 KD 2 KD 3 YA 5 KO 1 KO 2
Erodium cygnorum NF: PL 1 PL 2 PL 3 PL 4 JU 2 JU 4
TP: HA 5
Erodium moschatum NF: IF 3 IF 4
TP: IF 1 IF 2
Geranium sp. TP: CA 1 CA 3
Pelargonium sp. CF: ME 1
Pelargonium littorale CF: CO 5

GOODENIACEAE
Brunonia australis NF: PL 3 PL 4
Goodenia sp. NF: PL 1 MU 2 MU 3 MU 4
TP: MU 1
Goodenia occidentalis NF: PL 2 PL 3 PL 4
Goodenia pinnatifida NF: PL 5 JU 2 JU 3 JU 4
TP: HA 1 HA 3 HA 4
CF: CO 1
Goodenia varia CF: ME 1 KD 1
Scaevola crassifolia CF: MA 5 KU 5
Scaevola myrtifolia CF: CO 3
Scaevola spinescens NF: PL 3 PL 4 JU 2 IF 4
TP: HU 3
CF: ME 3 ME 4 YA 1 YA 2 YA 3 YA 4
KO 3 KO 5
Velleia sp. TP: IF 1 IF 2
CF: YA 5
Velleia arguta CF: CO 1
Velleia rosea NF: PL 3 PL 4

GRAMINEAE
Aristida sp. NF: BA 5 PL 1 PL 2 PL 3 PL 4 PL 5
TP: HA 1 HA 2 HA 3 HA 4 HA 5
CF: CO 1
Aristida anthoxanthoides CF: CO 2
Aristida browniana NF: MU 4 MU 5
Aristida contorta NF: BA 1 BA 2 BA 3 BA 4 BA 5 PL 1
PL 2 PL 3 PL 4 PL 5 JU 4 JU 5
MU 2 MU 3 MU 4 MU 5
TP: HA 1 HA 2 HA 3 HA 4
CF: CO 1 CO 4 CO 5 MA 2
Avellinia michelii CF: CO 3
Avena fatua TP: HA 3

Bromus arenarius	TP:	CA 5					
	CF:	KO 1	KO 2	KO 3			
Bromus rubens	TP:	HA 3	HA 4				
	CF:	YA 2					
Danthonia sp.	NF:	PL 3					
	TP:	HU 1	HU 2	HU 3	HU 4	HU 5	CA 1
		CA 2	CA 3	CA 4	CA 5	KD 4	KD 5
	CF:	ME 1	ME 3	ME 4	ME 5	KD 1	KD 2
		KD 3	YA 2	KO 2			
Danthonia caespitosa	NF:	BA 1	BA 2	BA 3	BA 4	BA 5	PL 4
		IF 5					
	TP:	HA 1	HA 2	HA 3	HA 4	HA 5	IF 1
		IF 2	MU 1				
	CF:	CO 1	CO 2	MA 1	MA 2	MA 6	KU 4
		ME 5	YA 5				
Danthonia setacea	CF:	YA 2	YA 3	YA 5	KO 1	KO 2	KO 3
		KO 4					
Digitaria sp.	NF:	PL 2					
Ehrharta longiflora	CF:	CO 4	CO 5				
Enneapogon sp.	NF:	JU 5					
	CF:	YA 5					
Enneapogon avenaceus	NF:	JU 2	JU 3	JU 5	MU 2		
	TP:	KU 2	MU 1				
	CF:	KU 3					
Enneapogon caerulescens	NF:	PL 1	PL 2	PL 4	PL 5	JU 1	JU 2
		JU 3	JU 5	MU 2			
Enneapogon clelandii	NF:	MU 5					
Enneapogon cylindricus	NF:	MU 3	MU 5				
	TP:	MU 1					
Enneapogon nigricans	NF:	JU 1	JU 2	JU 3	JU 4	JU 5	
	TP:	FO 1	FO 3	FO 4			
	CF:	KU 4					
Enneapogon polyphyllus	NF:	MU 2	MU 3	MU 4			
	TP:	MU 1					
Eragrostis sp.	NF:	MU 3	MU 4				
Eragrostis dielsii	NF:	PL 1	PL 2	MU 4			
Eragrostis eriopoda	NF:	PL 2	PL 3	PL 4	PL 5	JU 4	JU 5
	TP:	FO 5					
Eragrostis lanipes	NF:	MU 5					
Hordeum glaucum	CF:	YA 2					
Lagurus ovatus	TP:	CA 5					
Lophochloa pumila	NF:	IF 3	IF 5				
	TP:	CA 1	IF 1	IF 2	KD 5		
	CF:	MA 1	MA 6	KD 1	KD 3	YA 1	YA 2
		YA 3	YA 4	YA 5	KO 1	KO 2	KO 3
		KO 4	KO 5				
Monachather paradoxa	NF:	JU 5					
Paspalidium sp.	CF:	ME 5					
Paspalidium constrictum	NF:	PL 4	MU 3	MU 4			
Paspalidium jubiflorum	NF:	PL 2	PL 3				
Phleum pratense	CF:	CO 4					
Plagiosetum refractum	NF:	MU 5					
Poa drummondiana	CF:	CO 3	ME 1				
Schismus barbatus	NF:	IF 5					
	TP:	IF 1					
	CF:	KU 5	YA 2	YA 3	YA 4	YA 5	KO 1
Spinifex sericeus	CF:	ME 1					
Stipa sp.	NF:	BA 1	BA 2	BA 3	BA 4	BA 5	PL 3

	PL 4 JU 1 JU 2 JU 3 JU 4 JU 5
	MU 5 IF 3 IF 4 IF 5
	TP: HA 1 HA 2 HA 3 HA 4 HA 5 FO 3
	FO 5 HU 1 HU 2 HU 3 HU 4 HU 5
	CA 1 CA 2 CA 3 CA 4 CA 5 KD 4
	KD 5 KU 1 KU 2 MU 1
	CF: CO 1 CO 3 MA 1 MA 2 MA 3 MA 4
	MA 6 KU 3 KU 4 KU 5 ME 1 ME 3
	ME 4 ME 5 KD 1 KD 2 KD 3 YA 1
	YA 2 YA 3 YA 4 YA 5 KO 1 KO 2
	KO 3 KO 4
Stipa acrociliata	TP: CA 1 CA 2 CA 3
	CF: KD 2 KD 3 YA 1 YA 2 YA 3 YA 4
	YA 5 KO 1 KO 3 KO 5
Stipa drummondii	TP: KD 4
	CF: MA 1 KD 1 KD 2 KD 3 YA 2 YA 3
	YA 5 KO 1 KO 2 KO 4
Stipa elegantissima	NF: BA 1 BA 2 BA 3 BA 4 BA 5
	TP: HA 5
	CF: MA 1 MA 6 YA 2
Stipa eremophila	TP: CA 1 CA 2 CA 3 CA 4 CA 5 KD 4
	CF: CO 1 CO 2 CO 3 CO 4 CO 5 KD 3
	YA 5 KO 1 KO 2 KO 3 KO 4
Stipa nitida	NF: MU 2 MU 3 MU 4 MU 5 IF 3 IF 4
	IF 5
	TP: HU 1 HU 2 HU 3 HU 4 HU 5 IF 1
	IF 2 KD 4 KD 5 MU 1
	CF: KD 2 KD 3 YA 1 YA 2 YA 3 YA 4
	YA 5 KO 1 KO 2 KO 3 KO 4 KO 5
Stipa platychaeta	TP: CA 2 CA 5
	CF: MA 4 MA 6 KU 5 ME 4 KO 3
Triodia irritans	CF: YA 2
Triodia scariosa	NF: PL 3 PL 4
	CF: CO 2
Triraphis mollis	NF: PL 1 PL 2
Vulpia bromoides	CF: YA 2
HALORAGACEAE	
Gonocarpus sp.	NF: MU 5
Haloragis trigonocarpa	NF: PL 3 PL 4
JUNCAGINACEAE	
Triglochin calcitrapum	CF: CO 5 MA 4 KO 3
LABIATAE	
Prostanthera baxteri	NF: PL 4
Westringia rigida	NF: IF 4
	TP: KU 2
	CF: CO 2 ME 1 ME 2 ME 3 ME 4 KD 2
	YA 1 YA 2 YA 3 KO 5
LAURACEAE	
Cassytha melantha	CF: CO 5 ME 1 ME 2 ME 3 ME 4 KD 2
	YA 5
LEGUMINOSAE	
Acacia acuminata	TP: FO 3 FO 5
Acacia aff. papyrocarpa	NF: JU 1 JU 3 JU 5

Acacia anceps	CF:	MA 5	KU 5				
Acacia aneura	NF:	PL 1	PL 2	PL 3	PL 4	PL 5	JU 3
		JU 4	JU 5	MU 2	MU 3	MU 4	MU 5
	TP:	FO 5	HU 5	MU 1			
Acacia burkittii	NF:	PL 3	PL 4	MU 3	MU 4		
Acacia cochlearis	CF:	CO 4	CO 5				
Acacia cyclops	CF:	CO 2	MA 5	KU 5	ME 1		
Acacia erinacea	CF:	ME 3					
Acacia hakeoides	CF:	ME 3	YA 2				
Acacia kempeana	NF:	PL 3	MU 3	MU 4			
Acacia ligulata	NF:	MU 2	MU 4	MU 5			
	TP:	MU 1					
	CF:	MA 5					
Acacia nemophylla	NF:	BA 1					
Acacia nitidula	CF:	CO 3	CO 4	CO 5			
Acacia aff. nyssophylla	NF:	JU 5	IF 5				
	TP:	IF 2					
Acacia oswaldii	NF:	BA 4	PL 4	JU 1	JU 2	JU 3	JU 4
		MU 2	MU 3	MU 4	IF 4	IF 5	
	TP:	FO 1	FO 2	FO 3	FO 4	FO 5	HU 4
		HU 5	CA 1	CA 2	CA 5	KD 4	KD 5
		MU 1					
	CF:	MA 6	KU 3	KU 5	ME 1	ME 3	ME 5
		KD 2	KD 3	YA 1	YA 2	YA 3	YA 4
		KO 3	KO 4	KO 5			
Acacia papyrocarpa	NF:	BA 1	BA 2	BA 3	BA 4	BA 5	PL 1
		PL 2	PL 5	JU 1	JU 2	JU 3	JU 4
		JU 5	IF 3	IF 4	IF 5		
	TP:	HA 2	FO 2	FO 3	FO 4	CA 1	IF 2
		KD 4	KD 5	KU 1	KU 2		
	CF:	MA 1	MA 6	KU 3	KU 4	ME 4	ME 5
		YA 3	KO 1	KO 2	KO 3	KO 4	KO 5
Acacia ramulosa	NF:	MU 2	MU 3	MU 4	MU 5		
	TP:	MU 1					
Acacia tetragonophylla	NF:	BA 3	BA 4	BA 5	PL 3	PL 4	PL 5
		JU 3	JU 5	MU 2	MU 3	MU 4	MU 5
	TP:	HA 5	FO 1	FO 3	FO 5	HU 3	HU 5
		MU 1					
Cassia artemisioides var. sturtii	NF:	PL 3	PL 4	JU 3	JU 4	MU 2	MU 3
		MU 4	IF 4	IF 5			
	TP:	HU 4	IF 1				
	CF:	ME 3	YA 2				
Cassia cardiosperma	NF:	BA 4					
Cassia nemophila	NF:	JU 2	JU 3	JU 4	JU 5		
	TP:	FO 3	FO 5				
Cassia nemophila var. zygophylla	NF:	BA 4	BA 5	PL 1	PL 2	PL 3	PL 4
		PL 5	JU 2	JU 3	JU 4	JU 5	
	TP:	CA 5					
	CF:	ME 3	YA 2				
Cassia sturtii	NF:	JU 1	JU 2	JU 3	IF 4	IF 5	
Clianthus formosus	NF:	PL 2	PL 5	JU 3	JU 4	MU 2	MU 3
Eutaxia microphylla	CF:	ME 1	YA 2				
Medicago polymorpha	TP:	HA 3	HA 5				
Psoralea cinerea	TP:	FO 5					
Psoralea patens	TP:	HU 3					
Pultenaea elasticha	CF:	CO 3	ME 1				
Pultenaea obcordatum	CF:	CO 3	CO 5				
Swainsona sp.	TP:	HU 1					

Swainsona campestris	NF: JU 2 JU 3 JU 4
	CF: CO 1
Swainsona kingii	NF: PL 4
Swainsona microphylla	NF: BA 1 BA 2
	CF: CO 1
Swainsona oliveri	NF: IF 3 IF 5
	TP: IF 1 IF 2
Swainsona oroboides	NF: MU 2
	TP: HU 2 HU 4 HU 5
Swainsona tephrotricha	NF: MU 2
Templetonia retusa	CF: CO 3 CO 5 ME 1 ME 3 YA 3
LILIACEAE	
Dianella revoluta	CF: CO 3 MA 4 ME 1 ME 2 ME 3 ME 4
Lomandra effusa	CF: YA 2
Thysanotus patersonii	CF: CO 3 CO 4
Wurmbaea sp.	NF: PL 2
Wurmbea dioica	TP: CA 2
	CF: KO 3 KO 4
LORANTHACEAE	
Amyema sp.	CF: CO 5
Amyema fitzgeraldii	NF: BA 4 BA 5 PL 1
Amyema maidenii	CF: YA 1
Amyema melaleucae	CF: ME 1 ME 2 ME 3
Amyema preissii	TP: CA 5
Amyema quandang	NF: IF 3 IF 4 IF 5
	CF: KO 1 KO 2 KO 3 KO 4 KO 5
Lysiana exocarpi	NF: MU 4
	TP: FO 5 HU 3 HU 5 CA 2 KD 5
	CF: KD 2 KD 3 YA 3 KO 1
Lysiana murrayi	NF: MU 2 MU 3 MU 4 MU 5
	TP: MU 1
MALVACEAE	
Abutilon sp.	NF: MU 2 MU 4 MU 5
Abutilon cryptopetalum	NF: PL 4 MU 5
Abutilon otocarpum	NF: MU 4
Lavatera sp.	TP: HA 5
Lavatera plebeia	TP: HA 5 FO 5 CA 5 MU 1
Malvastrum americanum	TP: CA 5
Selenothamnus squamatus	TP: CA 1 CA 2 KD 4
	CF: KU 4 ME 4 ME 5 KD 1 KD 3 YA 5 KU 4
Sida sp.	NF: JU 2 MU 2 MU 3 MU 4 MU 5
	TP: HA 1 MU 1
Sida calyxhymenia	NF: PL 1 PL 2 PL 3 PL 4 PL 5
	TP: HU 4
Sida corrugata	NF: PL 1 PL 2 PL 3 PL 4 PL 5 JU 4 MU 2 MU 3 MU 4 MU 5
	TP: HA 3 HA 4 HU 4 MU 1
	CF: ME 3
Sida intricata	NF: IF 3 IF 5
Sida platychaeta	CF: ME 4
MYOPORACEAE	
Eremophila sp.	NF: JU 3
	TP: FO 5 KU 2

	CF: CO 2 MA 2 MA 6 KU 5
Eremophila sp. 1	NF: PL 3 PL 4
Eremophila sp. 2	NF: PL 3 PL 4
Eremophila alternifolia	NF: MU 3 MU 4
	CF: KD 3
Eremophila decipiens	NF: BA 1 PL 1 PL 2 PL 3 PL 5
	TP: HA 4 HA 5
	CF: CO 2
Eremophila desertorum	TP: KU 2
Eremophila glabra	CF: CO 5 ME 3 ME 4 YA 1 YA 2 YA 4
Eremophila latrobei	NF: IF 4
	TP: HU 4
Eremophila longifolia	TP: HA 5 FO 5 HU 3 MU 1
Eremophila maculata	TP: HU 2 HU 3 HU 5
Eremophila parvifolia	CF: YA 3 KO 3
Eremophila scoparia	NF: BA 2 BA 3 BA 4 BA 5 PL 1 PL 2
	PL 3 PL 4 JU 1 JU 4 IF 4
	TP: HA 1 HA 3 HA 4
	CF: CO 2 YA 1 KO 5
Eremophila weldii	CF: ME 1 ME 2 ME 3 ME 4
Eremophila willsii	NF: MU 5
Myoporum capparioides	CF: CO 5
Myoporum deserti	CF: MA 3 KU 5 ME 3 YA 1
Myoporum desolata	CF: MA 2 KU 5
Myoporum insulare	CF: CO 5 MA 5 YA 5
Myoporum platycarpum	NF: BA 1 BA 2 BA 3 BA 4 BA 5 PL 5
	JU 2 IF 4 IF 5
	TP: FO 3 FO 5 CA 1 CA 2 KU 2
	CF: CO 1 CO 2 MA 1 MA 6 KD 3 YA 1
	YA 2 YA 3 YA 4 KO 1 KO 2 KO 3
	KO 4 KO 5
MYRTACEAE	
Beaufortia micrantha	CF: CO 3 CO 4
Eucalyptus brachycalyx	CF: MA 1 ME 1 ME 2 ME 4
Eucalyptus calcareana	CF: ME 1 ME 2 ME 4
Eucalyptus diversifolia	CF: CO 3 CO 4 CO 5 ME 1
Eucalyptus foecunda	CF: CO 3 CO 4 CO 5
Eucalyptus gracilis	TP: KU 2
	CF: MA 5 ME 1 ME 2 ME 3 ME 4 KD 2
	YA 1 YA 2 YA 3 YA 4
Eucalyptus incrassata var. angulosa	CF: CO 3 CO 4 CO 5
Eucalyptus oleosa	NF: BA 1 BA 3 PL 4 IF 4
	TP: KD 4 KU 2
	CF: CO 1 CO 2 MA 2 MA 3 ME 1 ME 2
	KD 2 KD 3 YA 1 YA 2 YA 3 YA 4
	KO 3 KO 5
Eucalyptus pyriformis	NF: MU 5
Eucalyptus rugosa	TP: KU 2
	CF: CO 1 CO 2 CO 3 CO 4 CO 5 MA 4
	MA 5 KU 3 KU 5 ME 1
Eucalyptus socialis	NF: PL 3
	CF: ME 1 ME 2 ME 3 ME 4 YA 1 YA 2
	YA 3 YA 4 YA 5
Eucalyptus striaticalyx	CF: ME 2 ME 3 ME 4 YA 1 YA 2 YA 3
	YA 5
Eucalyptus yalatensis	TP: KU 2
	CF: ME 3 ME 4 YA 2

Melaleuca lanceolata	TP:	KU 2					
	CF:	CO 2	CO 3	CO 4	CO 5	MA 2	MA 3
		MA 4	MA 5	KU 3	YA 1	YA 2	YA 3
		YA 4	YA 5				
Melaleuca pauperiflora	TP:	KD 4					
	CF:	ME 1	ME 2	ME 3	ME 4	KD 1	KD 2
		KD 3	KO 5				
Melaleuca quadrifaria	CF:	CO 3	MA 2	MA 3	KU 3	ME 1	
Thryptomene sp.	NF:	MU 5					
ORCHIDACEAE							
Caladenia filamentosa	CF:	CO 3					
Pterostylis biseta	CF:	MA 4					
Pterostylis mutica	CF:	CO 2	CO 3	CO 4			
OXALIDACEAE							
Oxalis corniculata	TP:	HA 5					
	CF:	CO 1					
Oxalis perennans	TP:	CA 5					
	CF:	CO 1	ME 1	KD 3	YA 2		
PITTOSPORACEAE							
Marianthus bicolor	CF:	CO 5					
Pittosporum phylliraeoides	NF:	MU 2	MU 3	MU 4	IF 4		
	TP:	HA 1	HA 3	HA 5	FO 3	FO 5	HU 1
		HU 3	HU 4	HU 5	CA 3	CA 5	KU 1
		KU 2	MU 1				
	CF:	CO 1	ME 3	ME 4	ME 5	KD 3	YA 1
		YA 2	YA 3	YA 4	YA 5	KO 1	KO 2
		KO 3	KO 4	KO 5			
PLANTAGINACEAE							
Plantago sp.	TP:	HA 3	HA 4	HA 5			
Plantago bellardii	TP:	CA 1	CA 2	CA 3	CA 4	CA 5	
	CF:	KO 2					
Plantago debilis	NF:	BA 1	BA 2	PL 2			
	CF:	CO 1	CO 2				
Plantago drummondii	NF:	IF 3					
	TP:	IF 1	IF 2				
Plantago lanceolata	TP:	CA 1	CA 2	CA 3	CA 4	CA 5	
	CF:	YA 5					
POLYGALACEAE							
Comesperma volubile	NF:	MU 2	MU 3				
	CF:	CO 5	MA 4	ME 3			
POLYGONACEAE							
Emex australis	CF:	CO 4					
Muehlenbeckia adpressa	CF:	CO 5	MA 5				
Muehlenbeckia cunninghamii	TP:	FO 5					
PORTULACACEAE							
Calandrinia sp.	NF:	IF 4	IF 5				
	CF:	CO 4	MA 4				
Calandrinia calyptrata	NF:	PL 2	PL 3	PL 4	PL 5		
	CF:	CO 1	CO 3	CO 4	CO 5		
Calandrinia corrigioloides	CF:	CO 3	CO 4	CO 5			
Calandrinia disperma	NF:	MU 5					

Calandrinia eremaea	NF: MU 2 MU 4 MU 5
	CF: YA 2
Calandrinia remota	NF: MU 5
Portulaca sp.	CF: KU 5
Portulaca quadrifaria	CF: MA 1 MA 3 MA 4 MA 5 MA 6
PRIMULACEAE	
Anagallis arvensis	TP: KU 2
	CF: CO 4 MA 5 ME 1 YA 3
PROTEACEAE	
Adenanthos forrestii	CF: CO 3 CO 4
Grevillea sp.	TP: FO 3 FO 5
Grevillea sparsiflora	CF: CO 3
Hakea nitida	CF: CO 3 CO 4 CO 5 MA 4
RESTIONACEAE	
Loxocarya flexuosa	CF: CO 3 CO 4
RHAMNACEAE	
Pomaderris forrestiana	CF: CO 3 ME 1 ME 2 ME 3 ME 4
Pomaderris myrtilloides	CF: CO 3 CO 4
Spyridium oligacephalum	CF: CO 3
Spyridium rotundifolium	CF: CO 3
RUBIACEAE	
Canthium lineare	NF: PL 3
Pomax umbellata	NF: MU 5
RUTACEAE	
Boronia crassifolia	CF: CO 3 CO 4
Geijera linearifolia	TP: CA 5
	CF: ME 1 ME 2 ME 3 ME 4 KD 2 KD 3
	YA 1 YA 2 YA 3 YA 4 YA 5 KO 1
	KO 3 KO 4 KO 5
Geijera parviflora	NF: BA 1 BA 2 BA 3 BA 4 BA 5
	TP: KU 2
	CF: CO 1 CO 2 MA 2 MA 3 MA 5 KU 3
	KU 5
Microcybe pauciflora	CF: CO 3 ME 2
SANTALACEAE	
Exocarpos aphyllus	NF: PL 3 JU 1
	CF: CO 3 CO 5 MA 2 MA 3 MA 4 MA 5
	ME 1 ME 2 ME 3 ME 4 KD 2 YA 1
	YA 2 YA 3 YA 4 YA 5 KO 1 KO 2
	KO 3 KO 4 KO 5
Exocarpos sparteus	NF: PL 4
Exocarpos syrticola	CF: KD 2 KD 3
Santalum acuminatum	NF: BA 3 PL 1 PL 2 PL 5 JU 2 JU 3
	JU 4 JU 5 MU 4 IF 3 IF 4 IF 5
	TP: KD 4
	CF: KU 3 ME 1 ME 2 ME 3 ME 4 ME 5
	KD 2 KD 3 KO 2 KO 3 KO 4 KO 5
Santalum lanceolatum	NF: MU 4
Santalum murrayanum	CF: CO 4 CO 5
Santalum spicatum	NF: PL 1 PL 3 PL 4 JU 1 JU 2 JU 3
	JU 4 MU 3 IF 5

	CF: KU 3 KO 5
SAPINDACEAE	
Dodonaea sp.	TP: KU 2
Dodonaea angustissima	NF: PL 3 PL 4 MU 4 MU 5
Dodonaea filifolia	CF: MA 4
Dodonaea lobulata	NF: MU 4
Dodonaea stenozyga	NF: PL 3
	TP: KU 2
	CF: CO 3 MA 4 ME 1 ME 3 ME 4 KD 2 KD 3 YA 4
Dodonaea viscosa	CF: CO 3 CO 4 CO 5
Heterodendrum oleaefolium	NF: BA 1 BA 3 BA 4 BA 5 PL 1 PL 3 PL 4 PL 5 JU 1 JU 2 JU 3 MU 2 MU 3 MU 4 IF 3 IF 4
	TP: HA 2 HA 3 HA 4 HA 5 FO 1 HU 5
	CF: CO 1
SOLANACEAE	
Lycium australe	NF: BA 1 BA 2 BA 4 BA 5 JU 1 MU 3 MU 4 IF 3 IF 5
	TP: HA 1 HA 2 HA 4 HA 5 FO 2 FO 5 HU 2 HU 3 HU 4 HU 5 CA 1 CA 2 CA 3 CA 4 CA 5 KD 4 KD 5
	CF: CO 1 CO 2 MA 1 MA 6 KU 4 KU 5 ME 5 KD 1 KD 2 KD 3 YA 4 YA 5 KO 5
Lycium ferocissimum	CF: YA 5
Nicotiana sp.	CF: MA 1
Nicotiana goodspeedii	NF: MU 2
	TP: HU 4 CA 2 CA 5 KD 5 MU 1
	CF: ME 1 KD 1 YA 3 YA 5
Nicotiana rosulata ssp. ingulba	NF: PL 2
	TP: HA 4 FO 5
	CF: CO 1 CO 2 MA 1 MA 6 KU 3
Nicotiana velutina	NF: MU 5
	TP: KD 5
	CF: ME 5 KD 1
Solanum sp.	NF: BA 3 BA 5 PL 1 PL 2 PL 3 PL 4 PL 5
Solanum coactiliferum	NF: MU 5
Solanum ellipticum	NF: MU 2 MU 4 MU 5
	TP: MU 1
Solanum lasiophyllum	NF: PL 1 PL 2 PL 3 PL 4 PL 5 JU 4
Solanum nigrum	TP: CA 5
	CF: ME 1
Solanum symonii	CF: MA 5
STACKHOUSIACEAE	
Stackhousia muricata	NF: MU 5
THYMELAEACEAE	
Pimelea phylicoides	CF: ME 3
Pimelea serpyllifolia	CF: YA 2
UMBELLIFERAE	
Daucus glochidiatus	TP: HA 4 HA 5 CA 1 CA 2 CA 3
	CF: CO 1 CO 2 CO 3 CO 4 YA 5 KO 1

		KO 2					
Trachymene pilosa	CF:	CO 4	CO 5				
URTICACEAE							
Parietaria debilis	TP:	HU 5	CA 5				
	CF:	CO 3	CO 4	MA 1	MA 4	ME 1	YA 1
		YA 2	YA 4	KO 3			
ZYGOPHYLLACEAE							
	CF:	ME 2					
Nitraria billardierii	NF:	BA 2	BA 5	IF 5			
	TP:	HA 1	HA 2	CA 2	KD 4	KU 2	
	CF:	MA 1	MA 5	MA 6	KU 4	KU 5	ME 1
		ME 3	KD 1	YA 5			
Zygophyllum sp.	NF:	BA 1	BA 2	BA 4	PL 1	PL 2	PL 3
		PL 4	PL 5	MU 2	MU 3	MU 4	MU 5
		IF 3	IF 4	IF 5			
	TP:	HA 1	HA 2	HA 3	HU 2	HU 4	CA 4
		CA 5	IF 2	KD 4	KD 5	MU 1	
	CF:	CO 1	ME 2	ME 4	ME 5	KD 1	KD 2
		KD 3	YA 1	YA 3	YA 5	KO 1	KO 2
		KO 3	KO 4	KO 5			
Zygophyllum ammophilum	CF:	MA 5					
Zygophyllum apiculatum	TP:	KU 2					
	CF:	ME 1	ME 4				
Zygophyllum aurantiacum	NF:	BA 3	PL 1	PL 3	PL 4	PL 5	JU 1
		JU 2	JU 3	JU 4			
	CF:	CO 1	CO 2	MA 2	MA 4		
Zygophyllum billardierei	CF:	YA 2	YA 3	YA 5			
Zygophyllum compressum	CF:	YA 1					
Zygophyllum eremaeum	NF:	MU 2	MU 3	MU 4	MU 5		
	TP:	MU 1					
Zygophyllum fruticosa	NF:	JU 4					
Zygophyllum glaucum	CF:	CO 2					
Zygophyllum iodocarpum	NF:	BA 1	BA 2	BA 3	BA 4	BA 5	PL 1
		PL 3	PL 4	PL 5	JU 2	JU 4	
	TP:	HA 1	HA 2	HA 3	HA 4	HA 5	HU 4
		KU 2					
	CF:	CO 1	CO 2	CO 4	CO 5	MA 6	KU 3
		KU 4	KU 5				
Zygophyllum ovatum	NF:	BA 2	BA 4				
	TP:	HU 1	HU 3	IF 1	KU 2	MU 1	
	CF:	MA 2					

APPENDIX III

THE MAMMALS RECORDED FROM QUADRATS ON THE NULLARBOR STUDY AREA IN APRIL AND SEPTEMBER 1984

APPENDIX III: THE MAMMALS RECORDED FROM QUADRATS ON THE NULLARBOR STUDY AREA IN APRIL AND SEPTEMBER 1984

Mammal taxonomy follows the Australian Taxonomic listing prepared by the Bureau of Flora and Fauna and held on the SADEP computer.

The quadrats from which mammals were recorded are divided into the three major zones of the Nullarbor Study Area as detailed in Appendix II.

NULLABOR SURVEY (APRIL, SEPTEMBER 1984)
DISTRIBUTION BY QUADRATS OF MAMMALS OBSERVED

BOVIDAE		
Bos taurus	TP:	HA 2
Ovis aries	NF:	BA 2
BURRAMYIDAE		
Cercartetus concinnus	NF:	BA 4
	CF:	CO 4 CO 5 MA 2 MA 3 MA 4 MA 5 KU 5
CAMELIDAE		
Camelus dromedarius	NF:	PL 2 JU 2 JU 4 JU 5 MU 4 MU 5 IF 5
	TP:	FO 1 FO 3 FO 4 FO 5 CA 2
	CF:	YA 1 YA 2 YA 3 YA 4 YA 5
CANIDAE		
Canis familiaris	NF:	PL 2 PL 4 PL 5 JU 1 JU 2 JU 3 JU 4 JU 5 MU 2 MU 3 MU 4 MU 5 IF 4
	TP:	FO 2 FO 3 FO 4 FO 5 HU 2 HU 4 CA 1 CA 3 CA 4 IF 1 KD 4 KD 5
	CF:	MA 5 KD 2 KD 3 YA 4 YA 5 KO 1 KO 4 KO 5
Vulpes vulpes	NF:	JU 3 JU 5 MU 2 MU 3 MU 5
	TP:	HA 2 HA 3 FO 2 HU 1 HU 2 HU 3 HU 4 HU 5 CA 1 CA 2 CA 4 KD 4 KD 5
	CF:	CO 2 MA 1 MA 4 MA 5 MA 6 KU 4 KU 5 KD 2 KD 3 YA 3 YA 4 YA 5
DASYURIDAE		
Ningaui ridei	NF:	PL 6
Sminthopsis crassicaudata	NF:	BA 3 PL 5 JU 2 JU 3 JU 4 JU 5 MU 2 MU 3 IF 5
	TP:	HA 2 HA 3 HA 4 HA 5 FO 1 FO 2 FO 3 FO 5 HU 3 IF 1 IF 2 KU 2 MU 1
	CF:	CO 1 ME 5 KO 2
Sminthopsis dolichura	NF:	BA 2 BA 4 PL 1 PL 3 PL 5 IF 3 IF 4
	CF:	ME 1 ME 2 ME 4 YA 1 YA 2 KO 1
Sminthopsis gilberti	CF:	CO 5 MA 3
Sminthopsis ooldea	NF:	PL 1 PL 3 JU 5
EQUIDAE		
Equus caballus	TP:	KU 1 KU 2
FELIDAE		
Felis catus	NF:	BA 3 MU 3 MU 4 MU 5
	TP:	HA 1 HA 2 HA 3 FO 1 FO 2 FO 3 HU 2 HU 3 HU 4 CA 2 KD 4 KD 5
	CF:	MA 5 KU 4 KD 2 KD 3 KO 4
LEPORIDAE		
Oryctolagus cuniculus	NF:	BA 1 BA 2 BA 3 BA 4 BA 5 PL 1 PL 2 PL 3 PL 4 PL 5 JU 1 JU 2 JU 3 JU 4 JU 5 MU 2 MU 3 MU 4 MU 5 IF 3 IF 5
	TP:	HA 1 HA 2 HA 3 HA 4 HA 5 FO 1

FO 2 FO 3 FO 4 FO 5 HU 1 HU 2
HU 3 HU 4 HU 5 CA 1 CA 2 CA 3
CA 4 CA 5 IF 1 IF 2 KD 4 KD 5
KU 1 KU 2 MU 1
CF: CO 1 CO 2 MA 1 MA 2 MA 3 MA 5
MA 6 KU 3 KU 4 KU 5 KD 1 KD 2
KD 3 YA 1 YA 2 YA 3 YA 4 YA 5
KO 1 KO 3 KO 4 KO 5

MACROPODIDAE

Macropus fuliginosus
NF: BA 1 BA 2 BA 3 BA 4 BA 5 PL 2
PL 3 JU 1 JU 2 JU 3 JU 4 JU 5
IF 3 IF 4
TP: HA 5 IF 2 KD 4 KD 5 KU 1 KU 2
CF: CO 1 CO 2 CO 4 MA 1 MA 3 MA 5
MA 6 KU 3 ME 5 KD 2 KD 3 YA 2
YA 3 YA 4 YA 5 KO 1 KO 5

Macropus rufus
NF: PL 2 PL 3 PL 4 PL 5 JU 1 JU 2
JU 3 JU 4 JU 5 MU 3 MU 4 MU 5
IF 3 IF 5
TP: HA 2 HA 3 HA 4 HA 5 FO 1 FO 2
FO 3 FO 4 FO 5 HU 1 HU 2 HU 3
HU 4 HU 5 CA 3 IF 1 KD 4 KU 1
KU 2 MU 1
CF: MA 2 KO 2 KO 4 KO 5

MOLOSSIDAE

Tadarida australis
NF: BA 2 BA 3 PL 2 PL 4 PL 5 JU 3
TP: FO 5 CA 3 CA 4 CA 5
CF: CO 2 CO 3 CO 4 MA 2 MA 4 KU 5

MURIDAE

Leporillus sp
TP: HU 4

Mus musculus
NF: BA 2 BA 4 BA 5 PL 2 PL 3 PL 4
PL 5 JU 2 JU 3 JU 4 JU 5 MU 2
MU 3 MU 4 MU 5 IF 3 IF 4 IF 5
TP: HA 2 HA 4 HA 5 FO 1 FO 3 FO 5
HU 1 HU 2 HU 3 HU 4 HU 5 CA 1
CA 4 IF 1 IF 2 KD 4 KD 5 KU 1
MU 1
CF: MA 5 MA 6 KU 5 ME 2 ME 3 ME 5
KD 1 KD 2 KD 3 YA 2 YA 3 YA 4
YA 5 KO 1 KO 2 KO 3 KO 4 KO 5

Notomys alexis
NF: PL 4

Notomys mitchellii
NF: IF 4
CF: CO 3 CO 4 MA 2 MA 3 KU 5 ME 1
ME 2 YA 2

Pseudomys bolami
NF: BA 3 BA 4 PL 1 PL 5

Pseudomys hermannsburgensis
NF: PL 1 PL 3 PL 5 JU 3 JU 4 MU 3
MU 5

TACHYGLOSSIDAE

Tachyglossus aculeatus
NF: BA 3 JU 2 IF 5
CF: CO 3 CO 4 MA 5

VESPERTILIONIDAE

Chalinolobus gouldii
NF: BA 3 PL 2 PL 3
CF: CO 2 YA 1 YA 3

Chalinolobus morio
CF: CO 3 MA 2 MA 3 KD 2 KD 3

Eptesicus regulus
CF: MA 2 MA 3 MA 4 YA 1

Scotorepens balstoni
NF: PL 2 PL 6

Nyctophilus geoffroyi
NF: BA 3 JU 4
TP: FO 5

	CF: KD 2 KO 5
Nyctophilus timoriensis	NF: BA 3
Nyctophilus cf. *gouldii*	CF: MA 2 MA 4 YA 3
	CF: YA 1
VOMBATIDAE	
Lasiorhinus latifrons	TP: CA 1 CA 2 CA 3 CA 4 CA 5 IF 1 IF 2 KD 4 KD 5 KU 2
	CF: KD 1 KD 2 KD 3 KO 1 KO 2 KO 3 KO 4 KO 5

APPENDIX IV

THE BIRDS RECORDED FROM QUADRATS ON THE NULLARBOR STUDY AREA IN APRIL AND SEPTEMBER 1984

APPENDIX IV: THE BIRDS RECORDED FROM QUADRATS ON THE NULLARBOR STUDY AREA IN APRIL AND SEPTEMBER 1984

Bird taxonomy follows the Australian taxonomic listing prepared by the Bureau of Flora and Fauna and held on the SADEP computer.

The quadrats from which birds were recorded are divided into the three major zones of the Nullarbor Study Area as detailed in Appendix II.

NULLABOR SURVEY (APRIL, SEPTEMBER 1984)

DISTRIBUTION BY QUADRATS OF BIRDS OBSERVED

ACANTHIZIDAE							
Acanthiza sp.	TP:	HU 3					
Acanthiza apicalis	NF:	BA 4	BA 5	PL 3	PL 4	JU 4	JU 5
		MU 5					
	TP:	KU 2					
	CF:	CO 2	CO 3	CO 4	CO 5	MA 2	MA 3
		MA 4	KU 5	ME 1	ME 2	ME 3	ME 4
		KD 2	KD 3	YA 1	YA 2	YA 3	YA 4
		KO 3	KO 5				
Acanthiza chrysorrhoa	NF:	BA 4	BA 5	PL 3	PL 4	JU 3	MU 3
		MU 4	MU 5	IF 3	IF 4	IF 5	
	TP:	CA 1	KU 2				
	CF:	CO 1	CO 5	MA 1	MA 4	KU 3	KU 5
		ME 4	KD 2	YA 1	YA 2	YA 4	KO 2
		KO 3	KO 4	KO 5			
Acanthiza iredalei	NF:	BA 2	BA 4	BA 5	IF 4		
	TP:	HA 2	HA 3	HA 4	HA 5	CA 1	CA 2
		CA 3	CA 4	CA 5	IF 2		
	CF:	MA 1	MA 6	KU 4	KO 4		
Acanthiza uropygialis	NF:	BA 3	BA 4	BA 5	PL 3	PL 4	PL 6
		JU 3	JU 4	MU 3	MU 4	MU 5	IF 3
		IF 4					
	TP:	MU 1					
	CF:	KO 2	KO 3	KO 4			
Aphelocephala leucopsis	NF:	BA 1	BA 2	BA 4	BA 5	PL 2	PL 3
		JU 1	JU 2	JU 3	JU 4	JU 5	MU 2
		MU 3	MU 4	MU 5	IF 3	IF 4	IF 5
	TP:	HA 4	HA 5	FO 1	FO 2	FO 3	FO 4
		CA 1	CA 2	CA 4	IF 2	KD 5	KU 1
		KU 2	MU 1				
	CF:	CO 1	MA 1	MA 6	KU 3	KU 4	ME 5
		KO 2	KO 3	KO 4	KO 5		
Gerygone fusca	NF:	PL 4					
Sericornis brunneus	NF:	BA 4	MU 5				
	TP:	HA 2	HA 4	HA 5			
	CF:	KU 3	ME 1	ME 2	ME 3	ME 4	KD 2
Sericornis cautus	CF:	CO 3	CO 4	KU 4	YA 2		
Sericornis frontalis	CF:	CO 3	CO 4	CO 5	MA 3	MA 4	MA 5
		KU 5	ME 1	ME 3	KD 1	KD 2	KD 3
		YA 2	YA 3	YA 4			
Sericornis fuliginosus	TP:	HA 2	HA 4	HA 5	HU 1	HU 2	HU 4
		CA 1	CA 2	CA 3	CA 4	CA 5	IF 1
		IF 2					
	CF:	CO 1	KD 1	YA 5			
Smicrornis brevirostris	NF:	BA 3	PL 4	PL 6	MU 4	MU 5	IF 4
	TP:	KU 2					
	CF:	CO 1	CO 2	CO 3	CO 4	CO 5	MA 2
		MA 3	MA 4	MA 5	ME 2	ME 3	ME 4
		YA 1	YA 2	YA 4	KO 3	KO 5	

ACCIPITRIDAE							
Accipiter cirrhocephalus	NF:	BA 1					
Accipiter fasciatus	TP:	HU 5					
	CF:	MA 2	KU 5	KD 2	YA 2		
Aquila audax	NF:	BA 2	BA 3	BA 4	BA 5	PL 1	PL 2
		PL 3	PL 5	JU 1	JU 2	JU 4	MU 2
		MU 3	MU 4	MU 5	IF 3	IF 5	
	TP:	HA 2	HA 3	HA 4	HA 5	FO 1	FO 2
		FO 3	FO 4	FO 5	HU 1	HU 3	HU 5
		CA 1	CA 3	IF 1	IF 2	KD 4	KU 1
		KU 2	MU 1				
	CF:	CO 3	CO 4	MA 1	MA 5	KU 4	ME 4
		KD 1	KD 2	KD 3	YA 2	YA 5	
Circus assimilis	TP:	FO 2	HU 5				
	CF:	CO 1	MA 1				
Elanus notatus	TP:	HA 3					
Haliastur sphenurus	NF:	MU 2					
Hamirostra melanosternon	NF:	JU 2					
Hieraaetus morphnoides	NF:	PL 6					
	TP:	FO 2	HU 2				
	CF:	YA 1					
Lophoictinia isura	NF:	PL 6					
AEGOTHELIDAE							
Aegotheles cristatus	NF:	BA 3	PL 2	PL 3	MU 3		
	CF:	CO 2	MA 2	YA 3			
ALCEDINIDAE							
Halcyon pyrrhopygia	NF:	BA 3	JU 2	MU 2	MU 3		
	TP:	FO 3					
	CF:	KO 1	KO 4	KO 5			
Halcyon sancta	NF:	BA 3					
	CF:	CO 2					
ARDEIDAE							
Ardea novaehollandiae	CF:	MA 5	KU 5				
Ardea pacifica	CF:	MA 5					
Egretta alba	CF:	MA 5					
ARTAMIDAE							
Artamus sp.	NF:	MU 2					
Artamus cinereus	NF:	BA 1	BA 2	8A 4	BA 5	PL 1	PL 2
		PL 3	PL 4	PL 5	PL 6	JU 1	JU 2
		JU 3	JU 4	JU 5	MU 2	MU 3	MU 4
		MU 5	IF 3	IF 4	IF 5		
	TP:	HA 2	FO 1	FO 2	FO 3	FO 4	FO 5
		HU 5	CA 1	CA 2	IF 2	KD 5	KU 1
		KU 2	MU 1				
	CF:	CO 1	CO 2	MA 1	MA 5	MA 6	KU 4
		ME 4	ME 5	KD 1	KD 2	KO 1	KO 2
		KO 4					
Artamus cyanopterus	CF:	MA 2	YA 1	YA 2	YA 4	KO 3	KO 5
Artamus minor	CF:	KO 4	KO 5				
Artamus personatus	NF:	BA 1	BA 2	BA 3	BA 4	BA 5	PL 1
		PL 3	PL 4	PL 5			
	CF:	MA 1	MA 2	MA 3	MA 4		

CACATUIDAE	
Cacatua galerita	CF: YA 4
Cacatua leadbeateri	CF: CO 3 CO 4 MA 2 MA 5 KU 3 KU 5
	YA 3 KO 2 KO 3 KO 4 KO 5
Cacatua roseicapilla	NF: BA 1 BA 2 BA 3 PL 2 IF 3 IF 4
	IF 5
	TP: MU 1
	CF: KO 1 KO 2 KO 3 KO 4 KO 5
CAMPEPHAGIDAE	
Coracina maxima	NF: BA 3 BA 5 PL 1 PL 2 PL 3 PL 4
	PL 5 JU 1 JU 5 MU 3 IF 3 IF 4
	TP: KU 2 MU 1
	CF: CO 2 KU 4
Coracina novaehollandiae	NF: BA 1 BA 3 BA 4 BA 5 PL 1 PL 2
	PL 3 PL 4 PL 5 PL 6 JU 1 JU 2
	JU 3 JU 5 MU 3 MU 4 IF 4 IF 5
	TP: FO 5 CA 1 CA 2 KD 5 KU 2
	CF: CO 1 CO 2 CO 3 MA 2 MA 3 MA 4
	MA 5 KU 3 KU 4 KU 5 ME 1 ME 4
	YA 1 YA 2 KO 2 KO 3 KO 4
Lalage sueurii	NF: BA 2 BA 5 PL 3 PL 4 JU 3 MU 2
	MU 3 MU 5 IF 5
	TP: HU 5 KU 2
	CF: CO 1 MA 1 MA 2 KU 5 KO 2 KO 5
CAPRIMULGIDAE	
Caprimulgus guttatus	CF: CO 1
CHARADRIIDAE	
Charadrius melanops	NF: PL 2
Charadrius rubricollis	CF: KU 5
Charadrius ruficapillus	TP: FO 3
	CF: MA 5· KU 5 ME 1 YA 5
Peltohyas australis	TP: HA 1 HA 2 FO 1 FO 2 FO 3 FO 4
	HU 1 HU 2 HU 5
	CF: KD 1
Vanellus tricolor	NF: BA 3 JU 2 JU 5 IF 5
	TP: FO 3 FO 4
CLIMACTERIDAE	
Climacteris affinis	NF: PL 3 PL 4 JU 2 JU 3 JU 4 IF 3
Climacteris rufa	CF: YA 1
COLUMBIDAE	
Phaps chalcoptera	CF: CO 3 KO 4
CORCORACIDAE	
Corcorax melanorhamphos	CF: YA 2
CORVIDAE	
Corvus sp.	NF: BA 1 BA 2 BA 4 BA 5 PL 1 PL 2
	PL 4 PL 5 JU 1 JU 2 JU 3 JU 4
	MU 2 MU 3 MU 4 MU 5 IF 3 IF 4
	IF 5
	TP: HA 1 HA 2 HA 3 HA 4 HA 5 FO 1
	FO 3 FO 4 FO 5 HU 1 HU 4 HU 5
	CA 1 IF 1 IF 2 KD 4 KU 1 KU 2

		MU 1					
	CF:	CO 1	CO 2	MA 1	MA 2	MA 4	MA 5
		MA 6	KU 3	KU 4	KU 5	ME 1	KD 2
		KD 3	YA 3	YA 5	KO 1	KO 3	KO 4
		KO 5					
Corvus bennetti	NF:	BA 3	JU 3	MU 3	MU 4	MU 5	IF 3
		IF 4	IF 5				
	TP:	FO 1	FO 5	HU 1	HU 3	HU 5	CA 1
		CA 2	CA 3	CA 5	IF 1	IF 2	MU 1
	CF:	MA 4	ME 4	ME 5	KD 1	KD 2	YA 2
		YA 3	YA 4	YA 5	KO 3	KO 4	KO 5
Corvus coronoides	NF:	MU 4					
	TP:	HU 3	HU 5	CA 1	KD 4	KD 5	
	CF:	MA 1	ME 1	ME 3	ME 4	ME 5	KD 1
		KD 2	KD 3	YA 1	YA 2	YA 3	YA 5
		KO 2					
CRACTICIDAE							
Cracticus nigrogularis	NF:	BA 1	BA 2	BA 3	PL 1	PL 2	PL 3
		PL 5					
Cracticus torquatus	NF:	BA 1	BA 2	BA 3	BA 4	BA 5	PL 1
		PL 2	PL 3	PL 4	PL 5	PL 6	JU 1
		JU 2	JU 3	JU 4	JU 5	MU 3	MU 5
		IF 3	IF 4	IF 5			
	TP:	FO 1	FO 3	FO 5	CA 1	CA 2	IF 2
		KD 4	KD 5	KU 2	MU 1		
	CF:	CO 1	CO 2	CO 3	CO 4	CO 5	MA 1
		MA 2	MA 3	MA 4	MA 5	MA 6	KU 3
		KU 4	KU 5	ME 1	ME 2	ME 3	ME 4
		ME 5	KD 1	KD 2	KD 3	YA 1	YA 2
		YA 3	YA 4	YA 5	KO 1	KO 2	KO 4
		KO 5					
Gymnorhina tibicen	NF:	BA 1	BA 2	BA 3	BA 4	BA 5	PL 1
		PL 2	PL 4	PL 5	JU 2	JU 3	JU 4
		JU 5	MU 3	IF 3	IF 5		
	TP:	FO 1	FO 2	FO 3	FO 4	FO 5	KD 5
		KU 2	MU 1				
	CF:	CO 1	CO 2	KU 3	KU 4	ME 5	KD 3
		YA 2	YA 3	YA 4	KO 5		
Strepera versicolor	NF:	BA 1	BA 3	JU 4			
	CF:	CO 2	CO 3	CO 4	CO 5	MA 2	MA 3
		MA 4	KU 5	ME 2	ME 3	ME 4	YA 1
		YA 2	YA 3	YA 4			
CUCULIDAE							
Chrysococcyx basalis	NF:	BA 1	BA 2	BA 4	BA 5	PL 3	PL 4
		PL 5	PL 6	MU 3	MU 4		
	TP:	HA 3	HA 4	CA 1	CA 2		
	CF:	CO 1	CO 2	CO 4	KU 4	YA 1	KO 2
Chrysococcyx lucidus	CF:	CO 5					
Chrysococcyx osculans	NF:	BA 3					
	CF:	YA 1					
Cuculus pallidus	NF:	BA 3	BA 4	8A 5	PL 2	PL 4	PL 5
		PL 6	JU 1	JU 2	JU 3	JU 4	MU 2
		MU 3	MU 4	MU 5	IF 3	IF 4	IF 5
	TP:	FO 1	FO 3	FO 4	FO 5	IF 2	KU 2
		MU 1					
	CF:	CO 1	CO 2	KU 4	YA 1	YA 3	YA 5

		KO 2	KO 4	KO 5			
Cuculus pyrrhophanus	NF:	MU 5					
DICAEIDAE							
Dicaeum hirundinaceum	NF:	IF 4					
	CF:	KO 2	KO 3	KO 4			
DROMAIIDAE							
Dromaius novaehollandiae	NF:	JU 4	MU 4				
	CF:	CO 1	MA 5	KO 2			
EPHTHIANURIDAE							
Ephthianura albifrons	NF:	BA 2					
	TP:	HA 1	KU 2				
	CF:	CO 1	KO 2				
Ephthianura aurifrons	TP:	HA 5	FO 2	FO 4	HU 1	HU 2	HU 3
		HU 4	HU 5	IF 1	IF 2	KD 5	
Ephthianura tricolor	NF:	BA 1	BA 2	BA 4	BA 5	PL 2	JU 2
		JU 3	JU 4	MU 2	MU 3	IF 5	
	TP:	HA 5	FO 3	FO 5	IF 2	MU 1	
	CF:	CO 1	MA 1	MA 3	MA 6		
FALCONIDAE							
Falco berigora	NF:	BA 1	BA 2	BA 3	BA 4	PL 2	PL 3
		PL 4	JU 1	JU 3	JU 4	MU 2	MU 3
		MU 4	MU 5	IF 4	IF 5		
	TP:	HA 4	HA 5	FO 1	FO 2	FO 3	FO 4
		FO 5	CA 1	CA 2	CA 3	IF 2	KU 2
		MU 1					
	CF:	CO 1	MA 1	MA 2	MA 3	MA 6	KU 4
		ME 5	KD 3	KO 2	KO 3	KO 5	
Falco cenchroides	NF:	BA 1	BA 2	BA 3	BA 4	BA 5	PL 1
		PL 2	JU 1	JU 2	JU 4	MU 3	MU 4
		MU 5	IF 5				
	TP:	HA 1	HA 2	HA 3	HA 4	HA 5	FO 1
		FO 2	FO 4	FO 5	HU 1	HU 2	HU 3
		CA 3	CA 4	IF 1	IF 2	KD 4	KD 5
		KU 2	MU 1				
	CF:	CO 1	CO 2	MA 1	MA 5	MA 6	KU 3
		KU 4	ME 1	ME 3	KD 1	YA 3	YA 5
		KO 1	KO 2	KO 3	KO 4		
Falco longipennis	NF:	BA 1					
	TP:	KU 2					
Falco peregrinus	CF:	KU 4					
GLAREOLIDAE							
Stiltia isabella	TP:	HU 5					
GRALLINIDAE							
Grallina cyanoleuca	NF:	BA 3					
	CF:	KD 3					
HAEMATOPODIDAE							
Haematopus fuliginosus	CF:	MA 5	KU 5				

HIRUNDINIDAE

Cecropis nigricans	NF:	BA 2
	CF:	MA 1 MA 5 KU 5 YA 1 KO 2 KO 3 KO 4 KO 5
Cheramoeca leucosternum	NF:	PL 2 MU 4 MU 5
	TP:	FO 5 IF 2
	CF:	MA 2 MA 5 KD 2
Hirundo neoxena	NF:	IF 5
	TP:	HA 5 CA 1 CA 2 CA 3 CA 4 KD 4 KD 5 KU 1 KU 2
	CF:	CO 2 CO 5 MA 4 MA 5 KU 5 ME 1 ME 3 ME 4 KD 1 KD 2 KD 3 YA 5 KO 4

LARIDAE

Hydroprogne caspia	CF:	MA 5 KU 5
Larus novaehollandiae	CF:	MA 5 KU 5 YA 5
Larus pacificus	CF:	ME 1
Sterna bergii	CF:	KU 5

MALURIDAE

Amytornis textilis	TP:	HA 1 HA 2 HA 3 HA 4 HA 5 CA 4
Malurus sp.	TP:	HU 1 HU 3 HU 4 IF 2
Malurus lamberti	NF:	MU 4 MU 5 IF 3
	CF:	ME 1 ME 2 ME 3
Malurus leucopterus	TP:	HA 1 HA 2 HA 4 HA 5 HU 2 HU 3 HU 4 CA 1 CA 2 CA 3 CA 4 CA 5 IF 2
Malurus pulcherrimus	CF:	CO 3 CO 4 CO 5 KD 1
Malurus splendens	NF:	MU 5

MEGAPODIIDAE

Leipoa ocellata	CF:	CO 5 MA 2 MA 3

MELIPHAGIDAE

Acanthagenys rufogularis	NF:	BA 1 BA 2 BA 3 BA 4 BA 5 PL 2 PL 3 PL 4 PL 5 PL 6 JU 2 JU 3 MU 4 MU 5 IF 3 IF 4
	TP:	FO 3 FO 5 KU 2
	CF:	CO 1 CO 2 MA 1 KU 4 KU 5 ME 1 ME 2 ME 3 ME 4 KD 2 KD 3 YA 1 YA 2 YA 3 YA 4 KO 1 KO 2 KO 3 KO 4 KO 5
Anthochaera carunculata	NF:	BA 1 BA 3 BA 4
	CF:	CO 2 CO 3 CO 4 CO 5 MA 2 MA 3 MA 4 MA 5 KU 5 KD 2 YA 1 YA 2 YA 3 YA 4 KO 1 KO 4
Lichenostomus sp.	NF:	MU 5
Lichenostomus cratitius	CF:	CO 3 CO 4
Lichenostomus leucotis	NF:	BA 4
	CF:	CO 3 CO 4 CO 5 MA 2 MA 3 MA 4 MA 5 YA 2 KO 3
Lichenostomus ornatus	NF:	IF 4
	CF:	CO 4 MA 4 YA 1 YA 2 YA 4 KO 1 KO 2 KO 3 KO 5
Lichenostomus plumulus	NF:	PL 6 MU 3
Lichenostomus virescens	NF:	BA 4 BA 5 PL 2 PL 3 PL 4 JU 1 JU 2 JU 3 JU 4 JU 5 MU 2 MU 3

		MU 4	MU 5	IF 3	IF 4	IF 5	
	TP:	HA 4	FO 1	FO 2	FO 3	FO 4	FO 5
		HU 2	HU 3	HU 5	KU 2	MU 1	
	CF:	CO 1	MA 1	MA 5	MA 6	KU 3	KU 4
		KU 5	ME 1	ME 3	KD 1	KD 2	KD 3
		YA 2	YA 3	YA 4	YA 5	KO 1	KO 2
		KO 3	KO 4	KO 5			
Lichmera indistincta	CF:	MA 5					
Manorina flavigula	NF:	BA 1	BA 3	BA 4	BA 5	PL 1	PL 2
		PL 3	PL 4	PL 5	PL 6	JU 1	JU 2
		JU 3	JU 4	JU 5	MU 2	MU 3	MU 4
		MU 5	IF 3	IF 4	IF 5		
	TP:	FO 1	FO 2	FO 3	FO 4	FO 5	CA 1
		KD 4	KD 5	KU 2	MU 1		
	CF:	CO 1	CO 2	MA 1	MA 2	MA 6	KU 3
		KU 4	KU 5	ME 1	ME 2	ME 3	ME 4
		ME 5	KD 2	KD 3	YA 1	YA 2	YA 3
		YA 4	KO 1	KO 2	KO 3	KO 4	KO 5
Melithreptus brevirostris	CF:	MA 3	MA 4	YA 2			
Phylidonyris albifrons	NF:	BA 4	PL 4	JU 2	MU 4	MU 5	IF 4
	TP:	FO 1	MU 1				
	CF:	CO 2	CO 3	CO 4	CO 5	MA 2	MA 3
		MA 5	KU 5	ME 1	ME 2	ME 3	KD 2
		YA 1	YA 2	YA 3	YA 4	KO 4	
Phylidonyris novaehollandiae	CF:	MA 5					
MOTACILLIDAE							
Anthus novaeseelandiae	NF:	BA 1	BA 2	BA 5	PL 2	JU 1	JU 2
		JU 3	JU 4	JU 5	MU 2	MU 3	IF 3
		IF 4	IF 5				
	TP:	HA 1	HA 2	HA 3	HA 4	HA 5	FO 1
		FO 2	FO 3	FO 4	FO 5	HU 1	HU 2
		HU 3	HU 4	HU 5	CA 1	CA 2	CA 3
		CA 4	CA 5	IF 1	IF 2	KD 4	KD 5
		KU 1	KU 2	MU 1			
	CF:	CO 1	MA 1	MA 6	KU 4	KU 5	ME 1
		ME 3	ME 5	KD 1	KD 2	KD 3	YA 5
		KO 1	KO 2	KO 3	KO 4		
MUSCICAPIDAE							
Colluricincla harmonica	NF:	BA 4	BA 5	PL 2	PL 3	PL 4	PL 5
		JU 1	JU 2	JU 3	JU 5	MU 3	MU 4
		MU 5	IF 3	IF 4	IF 5		
	TP:	FO 3	FO 5	KU 2	MU 1		
	CF:	CO 1	CO 2	CO 3	CO 4	CO 5	MA 2
		MA 3	MA 4	MA 5	KU 3	KU 5	ME 1
		ME 2	ME 3	ME 4	KD 2	KD 3	YA 1
		YA 2	YA 3	YA 4	KO 1	KO 2	KO 3
		KO 4	KO 5				
Drymodes brunneopygia	CF:	CO 5	MA 5				
Eopsaltria griseogularis	CF:	CO 3	CO 4	CO 5	MA 2	MA 3	
Melanodryas cucullata	NF:	BA 2	BA 4	BA 5	PL 2	PL 3	PL 4
		PL 5	JU 1	JU 2	JU 3	JU 4	JU 5
		MU 2	MU 3	MU 4	MU 5	IF 3	
	TP:	CA 2	MU 1				
	CF:	MA 1	MA 6	KO 1	KO 2	KO 3	KO 4
Microeca leucophaea	NF:	BA 4	PL 3	PL 4	PL 6	IF 4	
	CF:	CO 1	CO 2	MA 2	MA 3	MA 4	YA 1

	YA 2 KO 5
Myiagra inquieta	CF: YA 1 KO 3 KO 4 KO 5
Oreoica gutturalis	NF: BA 1 BA 2 BA 4 BA 5 PL 2 PL 3
	PL 4 PL 5 PL 6 JU 1 JU 2 JU 3
	JU 4 JU 5 MU 2 MU 3 MU 4 MU 5
	IF 3 IF 4 IF 5
	TP: FO 2 FO 5 KU 2 MU 1
	CF: CO 1 CO 2 MA 1 MA 2 MA 6 KU 3
	KD 1 KD 2 KD 3 YA 1 KO 1 KO 2
	KO 3 KO 4 KO 5
Pachycephala inornata	NF: MU 5
	CF: KO 2 KO 3 KO 4 KO 5
Pachycephala pectoralis	NF: BA 3
	CF: CO 3 CO 4 CO 5 MA 2 MA 3 MA 5
	YA 2 YA 3 YA 4
Pachycephala rufiventris	NF: BA 5 PL 3 PL 4 PL 5 PL 6 JU 3
	MU 3 MU 4 MU 5
Petroica goodenovii	NF: BA 2 BA 4 BA 5 PL 2 PL 3 PL 4
	PL 5 JU 1 JU 3 JU 4 JU 5 MU 3
	MU 4 MU 5 IF 3 IF 4
	TP: FO 1 FO 2 FO 3 FO 4 HU 2 HU 3
	CA 1
	CF: ME 4 YA 1 YA 4 KO 1 KO 2 KO 3
	KO 4
Rhipidura fuliginosa	CF: KD 3 YA 4
Rhipidura leucophrys	NF: BA 1 BA 2 BA 4 BA 5 PL 2 PL 3
	PL 4 PL 5 PL 6 JU 1 JU 2 JU 3
	JU 4 JU 5 MU 2 MU 3 MU 4 MU 5
	IF 3 IF 4 IF 5
	TP: FO 1 FO 2 FO 3 FO 4 FO 5 HU 3
	CA 1 KU 1 KU 2 MU 1
	CF: CO 1 MA 1 KU 3 KU 4 ME 4 ME 5
	KD 2 KD 3 YA 1 YA 2 KO 3 KO 4
	KO 5
NEOSITTIDAE	
Daphoenositta chrysoptera	NF: PL 3 PL 4 PL 5 JU 1 MU 3 IF 3
	IF 4 IF 5
	CF: CO 1 YA 1 KO 2 KO 4
ORTHONYCHIDAE	
Cinclosoma alisteri	TP: HU 1 HU 3 CA 3 CA 4
Cinclosoma castanotum	NF: MU 3 MU 4
	CF: CO 3 CO 4 CO 5 MA 2 MA 3 MA 4
	ME 2 YA 1 YA 2
OTIDIDAE	
Ardeotis australis	NF: BA 1 JU 1
	TP: HA 2 HA 3 HA 4
	CF: MA 1
PARDALOTIDAE	
Pardalotus striatus	NF: BA 3 BA 4 PL 1 PL 4 PL 6 MU 5
	IF 4
	CF: CO 2 CO 3 CO 5 MA 2 MA 3 MA 4
	YA 1 YA 2 YA 4 KO 3 KO 5
Pardalotus xanthopygus	NF: BA 3
	CF: CO 3 CO 4 CO 5 MA 3 MA 4 MA 5

		ME 3 KD 2 YA 1 YA 2 YA 3 YA 4
PHALACROCORACIDAE		
Phalacrocorax carbo	CF:	KU 5
PHASIANIDAE		
Coturnix novaezelandiae	TP:	IF 1
	CF:	YA 4
PLATYCERCIDAE		
Barnardius zonarius	NF:	BA 3 BA 4 BA 5 PL 3 PL 4 PL 5 PL 6 IF 3 IF 4
	CF:	CO 1 CO 4 MA 2 MA 3 MA 5 ME 4 YA 1 YA 2 YA 3 KO 1 KO 2 KO 3 KO 4 KO 5
Melopsittacus undulatus	NF:	BA 2 BA 4 BA 5 PL 1 PL 3 JU 3 JU 4 JU 5 MU 2 MU 3 MU 4 MU 5
	TP:	FO 5 IF 2
	CF:	MA 1 MA 5 MA 6
Neophema bourkii	TP:	FO 2
Northiella haematogaster	NF:	PL 2 PL 5 JU 1 JU 2 JU 3 JU 4 JU 5
	TP:	FO 1 FO 3 FO 4 FO 5 KU 1
	CF:	KO 2
Psephotus varius	NF:	PL 2 PL 3 PL 4 PL 5 JU 1 JU 3 JU 4 JU 5 MU 2 MU 3 MU 4 MU 5 IF 3 IF 4 IF 5
	TP:	KU 2 MU 1
	CF:	KU 3 KU 4 KU 5 ME 1 ME 4 YA 2 YA 4 KO 1 KO 2 KO 3 KO 4 KO 5
PLOCEIDAE		
Poephila guttata	CF:	ME 5 YA 4
PODARGIDAE		
Podargus strigoides	NF:	BA 3 JU 1
	TP:	FO 5 IF 2 KU 2
	CF:	MA 2 KD 3 YA 1 YA 3 YA 4 KO 3 KO 4
POLYTELITIDAE		
Nymphicus hollandicus	CF:	KO 2
Polytelis anthopeplus	NF:	BA 5
PROCELLARIIDAE		
Puffinus tenuirostris	CF:	YA 5
SCOLOPACIDAE		
Calidris alba	CF:	MA 5
Calidris ferruginea	CF:	KU 5
Calidris ruficollis	CF:	MA 5 KU 5
Limosa lapponica	CF:	KU 5
Tringa hypoleucos	CF:	MA 5

STRIGIDAE		
Ninox novaeseelandiae	NF:	BA 3
	CF:	CO 2 MA 2 MA 3 YA 1 YA 2
STURNIDAE		
Sturnus vulgaris	CF:	KD 3 KO 1 KO 3 KO 5
SULIDAE		
Morus serrator	CF:	KD 1
SYLVIIDAE		
Cinclorhamphus cruralis	NF:	BA 2 BA 5 PL 2 PL 4 JU 2 JU 3
		MU 2
	TP:	HA 1 HA 2 HA 3 HA 4 HA 5 FO 2
		FO 3 HU 3 HU 4 CA 2 IF 1 IF 2
		KD 4 KU 1 KU 2 MU 1
	CF:	CO 1 MA 1 MA 6 KU 4 KD 1 KD 3
Cinclorhamphus mathewsi	CF:	MA 1
TIMALIIDAE		
Pomatostomus superciliosus	NF:	BA 4 BA 5 PL 2 PL 3 PL 4 PL 5
		JU 2 JU 3 JU 4 JU 5 MU 2 MU 3
		MU 4 MU 5 IF 3 IF 4 IF 5
	TP:	FO 1 FO 3 FO 4 FO 5 CA 1 KU 2
		MU 1
	CF:	CO 1 CO 3 CO 4 MA 2 MA 3 MA 4
		MA 5 MA 6 KU 3 ME 1 ME 2 ME 3
		ME 4 ME 5 KD 1 KD 2 KD 3 YA 1
		YA 2 KO 1 KO 2 KO 3 KO 4 KO 5
TURNICIDAE		
Turnix velox	NF:	BA 2 BA 5 PL 2 JU 5 MU 2 MU 3
		MU 5 IF 3 IF 5
	TP:	IF 1 IF 2 KD 4 KU 2
	CF:	CO 1 MA 1 MA 6 YA 3 KO 1
ZOSTEROPIDAE		
Zosterops lateralis	CF:	CO 3 CO 4 CO 5 MA 3 MA 5 KU 5
		ME 1 ME 3 KD 2 YA 4

APPENDIX V

THE AMPHIBIANS AND REPTILES RECORDED FROM QUADRATS ON THE NULLARBOR STUDY AREA IN APRIL AND SEPTEMBER 1984

APPENDIX V: THE AMPHIBIANS AND REPTILES RECORDED FROM QUADRATS ON THE NULLARBOR STUDY AREA IN APRIL AND SEPTEMBER 1984

Reptile taxonomy follows the Australian Taxonomic listing prepared by the Bureau of Flora and Fauna and held on the SADEP computer. This taxonomy has been published as: Cogger, H.G., Cameron, E.E. and Cogger, H.M. (1983), Zoological Catalogue of Australia. Vol. 1. Amphibia and Reptilia. Australian Government Publishing Service, Canberra. The quadrats from which reptiles were recorded are divided into the three major zones of the Nullarbor Study Area as defined in Appendix II.

NULLABOR SURVEY (APRIL, SEPTEMBER 1984)

DISTRIBUTION BY QUADRATS OF AMPHIBIANS AND REPTILES OBSERVED

LEPTODACTYLIDAE		
Neobatrachus sp	NF:	BA 1
AGAMIDAE		
Amphibolurus adelaidensis	CF:	CO 2 CO 3 CO 4 CO 5 MA 2 MA 3 MA 4 MA 6 ME 1 ME 2 YA 4 YA 5 KO 5
Amphibolurus cristatus	NF:	BA 3
	CF:	ME 3 YA 1 YA 2
Amphibolurus fordi	NF:	MU 5
Amphibolurus maculatus	CF:	CO 3 CO 4 CO 5 MA 4 ME 1
Amphibolurus mckenziei	NF:	BA 5
	CF:	KO 2 KO 4
Amphibolurus minor	NF:	BA 3 BA 4 JU 3 JU 5 MU 3 MU 5
	CF:	MA 2 YA 3 YA 4 KO 3
Amphibolurus muricatus	CF:	CO 3 CO 4 MA 2 MA 3 KU 5 ME 3
Amphibolurus nullarbor	TP:	HA 2 HA 3 HA 5 HU 1 HU 3 KU 1
	CF:	MA 1 MA 6 KU 5 ME 3 ME 4
Amphibolurus pictus	NF:	BA 1 BA 2 BA 4 BA 5 PL 2 JU 1 IF 5
	TP:	CA 1 CA 2 IF 1 KD 4 KD 5
	CF:	MA 1 MA 6 KU 5 KD 1 YA 2 YA 5 KO 1 KO 2 KO 3 KO 4 KO 5
Amphibolurus reticulatus	NF:	PL 1 PL 2 PL 3 PL 4 PL 5 JU 2 JU 3 JU 5 MU 3 MU 4
Moloch horridus	NF:	MU 5
Tympanocryptis lineata	NF:	BA 1 BA 2 BA 4 BA 5
	TP:	HA 2 HA 3 HA 4 HA 5 FO 1 FO 2 FO 3 FO 4 CA 2 CA 3 CA 4 KD 4 KU 2
	CF:	ME 5 KD 3 KO 2
ELAPIDAE		
Drysdalia mastersi	CF:	MA 3 MA 5 KU 5 ME 1 ME 4 YA 1 YA 3 YA 5
Pseudechis australis	TP:	FO 1 FO 2
Pseudonaja sp.	TP:	CA 3 KD 5
	CF:	ME 4 KD 3
Pseudonaja sp. (Prob. affinis)	CF:	MA 6
Pseudonaja affinis	NF:	BA 3
	TP:	KD 5
	CF:	MA 2 MA 4 MA 6 KU 3 ME 3
Pseudonaja modesta	NF:	PL 5
	TP:	HA 5
Pseudonaja nuchalis	TP:	CA 1 CA 3
	CF:	ME 3 YA 4 YA 5 KO 4
Pseudonaja textilis	TP:	HU 5 CA 2
Simoselaps bertholdi	NF:	BA 4 PL 1 JU 3
	CF:	KO 1
Simoselaps semifasciata	NF:	PL 4
Unechis spectabilis	TP:	KU 1
	CF:	MA 1 MA 6 KO 1

GEKKONIDAE		
Diplodactylus granariensis	NF:	BA 1 BA 2 BA 3 BA 4
	TP:	HA 5 IF 2 KU 1 KU 2
	CF:	CO 1 CO 2 CO 3 CO 4 CO 5 MA 2
		MA 3 KU 5 ME 2 ME 3 ME 5 KD 2
		KD 3 YA 2 KO 1 KO 4 KO 5
Diplodactylus intermedius	NF:	BA 1 BA 5
	TP:	MU 1
Diplodactylus maini	NF:	BA 1 BA 2 BA 3 BA 4 BA 5 PL 1
		PL 2
Diplodactylus pulcher	NF:	PL 4 PL 5 MU 3
	TP:	FO 5
Diplodactylus stenodactylus	TP:	FO 3
	CF:	KO 2 KO 4 KO 5
Gehyra variegata	NF:	BA 1 BA 3 BA 4 PL 1 PL 2 PL 3
		PL 4 PL 5 JU 1 JU 2 JU 3 JU 4
		JU 5 MU 2 MU 3 MU 4 MU 5 IF 3
		IF 5
	TP:	FO 1 FO 2 FO 3 FO 4 FO 5 IF 2
		MU 1
	CF:	MA 2 MA 3 YA 2 YA 3 KO 1 KO 3
		KO 4 KO 5
Heteronotia binoei	NF:	BA 3 PL 1 PL 2 PL 3 PL 4 PL 5
		JU 1 JU 2 JU 3 JU 4 JU 5 MU 5
	CF:	CO 3 YA 3 YA 4 KO 3
Lucasium damaeum	NF:	MU 5 IF 3 IF 4 JU 1
Nephrurus laevissimus	NF:	MU 5
Nephrurus levis	NF:	PL 2 MU 5
Nephrurus stellatus	NF:	IF 4
	CF:	YA 3 YA 5
Phyllodactylus marmoratus	NF:	BA 3
	TP:	CA 2
	CF:	CO 2 CO 3 CO 4 CO 5 MA 2 KU 3
		KU 5 ME 1 ME 3
Rhynchoedura ornata	NF:	PL 1 PL 3 JU 3 MU 3 MU 4
Underwoodisaurus milii	NF:	JU 1 MU 3 MU 4 MU 5 IF 3
	TP:	HA 1 HA 2 HA 3 HA 4 FO 1 FO 2
		FO 3 FO 4 FO 5 HU 1 HU 4 HU 5
		CA 2 CA 3 IF 2 KD 4 KU 2 MU 1
	CF:	CO 3 KU 5 ME 5 KD 3 YA 3 YA 5
		KO 1 KO 2 KO 4 ME 3
PYGOPODIDAE		
Aprasia inaurita	CF:	MA 4
Delma australis	CF:	CO 2 YA 1 YA 2 YA 4
Pygopus lepidopodus	CF:	ME 1 YA 5
Pygopus nigriceps	NF:	MU 3
SCINCIDAE		
Cryptoblepharus carnabyi	NF:	PL 3 PL 5
Cryptoblepharus plagiocephalus	NF:	BA 3 PL 3 IF 4
	CF:	YA 1 KO 3
Cryptoblepharus virgatus	CF:	CO 2 CO 3 CO 4 CO 5 MA 2 ME 1
	CF:	YA 3
Ctenotus brooksi	TP:	KD 5
	CF:	CO 3 CO 4 MA 5 ME 5 YA 1 YA 4
		YA 5
Ctenotus regius	NF:	PL 1 JU 2 JU 5 MU 2 MU 3 MU 4

		MU 5	IF 3	IF 4	IF 5		
Ctenotus schomburgkii	NF:	BA 1	BA 2	BA 3	BA 4	BA 5	PL 2
		PL 4	JU 1	JU 2	JU 3	JU 4	JU 5
		IF 5					
	TP:	MU 1					
	CF:	CO 2	MA 6	ME 3	KO 1	KO 2	KO 3
		KO 4	KO 5				
Ctenotus uber	NF:	BA 1	BA 2	BA 5			
	TP:	HA 1	HA 2	HA 3	HA 4	HA 5	
Egernia carinata	CF:	MA 3					
Egernia formosa	CF:	KD 1					
Egernia inornata	NF:	PL 4	MU 3				
Egernia multiscutata	CF:	CO 3	CO 4				
Eremiascincus richardsonii	NF:	MU 5					
Hemiergis initialis	NF:	BA 3					
	TP:	KU 2					
	CF:	CO 1	CO 2	CO 5	MA 2	MA 3	MA 4
		MA 5	KU 3	KU 5	ME 2	KD 3	
Leiolopisma baudini	CF:	MA 5					
Lerista bipes	NF:	PL 1	PL 2	PL 5	MU 4	MU 5	
Lerista desertorum	NF:	PL 1	PL 2	PL 3	JU 1	JU 2	JU 4
		JU 5					
	TP:	FO 3	FO 5				
Lerista distinguenda	CF:	CO 3	CO 4	CO 5	MA 4		
Lerista frosti	NF:	BA 1	BA 3	BA 4	BA 5		
	TP:	CA 3	KD 4	KD 5	KU 2		
	CF:	CO 1	MA 1	MA 2	MA 3	MA 4	MA 5
		MA 6	KU 3	KU 4	KU 5	ME 2	ME 3
		KD 3					
Lerista labialis	NF:	JU 2	JU 3	JU 4	MU 2	MU 3	
Lerista microtis	CF:	KD 1					
Lerista muelleri	NF:	PL 1	PL 3	PL 4	PL 5	JU 3	
Lerista picturata	NF:	BA 3					
	CF:	CO 4	CO 5	MA 1	MA 2	KU 3	KU 5
		ME 1	YA 1	YA 3	YA 5		
Menetia greyi	NF:	BA 3	PL 1	PL 2	PL 5	JU 1	JU 2
		JU 3	JU 4	JU 5	MU 2	MU 4	MU 5
		IF 3					
	TP:	FO 1	FO 2	FO 3	FO 4	FO 5	HU 3
		CA 1	CA 4	KU 2			
	CF:	CO 1	CO 2	CO 4	CO 5	MA 1	MA 2
		MA 3	MA 5	KU 5	ME 5	KD 1	KD 3
		YA 1	YA 5	KO 3	KO 4	MU 1	
Morethia adelaidensis	NF:	BA 1	BA 2	BA 4	BA 5		
	TP:	HA 1	HA 4	FO 1	FO 2	FO 3	FO 4
		CA 1	CA 3	CA 4	IF 2	KD 4	KD 5
		KU 1					
	CF:	MA 1	MA 6	YA 3	YA 5	KO 3	KO 4
		KO 5					
Morethia boulengeri	NF:	PL 4	JU 1				
Morethia butleri	NF:	BA 3					
Morethia obscura	NF:	BA 3	MU 5				
	CF:	CO 1	CO 2	CO 3	CO 4	CO 5	MA 1
		MA 2	MA 3	MA 4	MA 5	MA 6	KU 5
		ME 1	ME 2	ME 3	KD 1	KD 2	YA 2
		YA 4	YA 5				
Tiliqua branchialis	CF:	ME 1					
Tiliqua occipitalis	NF:	MU 5					

	TP: HA 2 FO 5 CA 5 IF 1 IF 2
Trachydosaurus rugosus	NF: BA 3 BA 5 IF 4
	TP: HA 1 HA 3 HA 4 HA 5 HU 1 HU 2
	HU 4 CA 1 CA 2 CA 3 CA 4 CA 5
	IF 2 KD 4 KD 5 KU 1
	CF: CO 1 CO 2 MA 4 MA 6 KU 5 ME 1
	ME 3 ME 5 KD 1 KD 2 KD 3 YA 3
	YA 4 YA 5 KO 1 KO 2 KO 3 KO 4
	KO 5
VARANIDAE	
Varanus sp.	NF: JU 4
Varanus gilleni	NF: MU 2
Varanus gouldii	NF: IF 3 IF 4 IF 5
	TP: HU 4 HU 5 MU 1
	CF: YA 2

APPENDIX VI

DETAILS OF SITES ON NULLARBOR AND ADJACENT AREAS WHERE BONE MATERIAL HAS BEEN COLLECTED

APPENDIX VI: DETAILS OF SITES LISTED BY BAYNES IN THE PAPER ON THE ORIGINAL MAMMAL FAUNA

For each site the following details are given: the site number used in Baynes' paper; the karst feature number of the C.E.G.S.A. Nullarbor Caving Atlas (Mott and Pilkington 1982), e.g. N84, if the site has one; the formal name of the site, if it has one; and co-ordinates describing its position. These are followed by a brief description if one has not already been published in the Nullarbor Caving Atlas, and if the details are available. The names of collectors of the mammal remains from the sites used in this study are given next, with the dates on which the material was collected; finally the accession numbers of the specimens in the vertebrate palaeontological collection of the Western Australian Museum or the sample field number are provided.

1. Unnamed. Approx. 29°45'S, 129°15'E. A group of seven caves "100 miles north-east Forrest (approx.)", of which four yielded material. A.J. Carlisle Nov. 1975. Unaccessed.

2. N84, Decoration Cave. 30°17'S, 128°40'E. J.W.J. Lowry Aug. 1966. 68.3.93-106.

3. Unnamed. Approx. 30°45'S, 128°25'E. Two small caves "north of Reid". A.J. Carlisle 1977. 77.11.1-9.

4. N60, Lynch Cave. 30°58'S, 127°04'E. J.W.J. Lowry Aug. 1966; W.H. Butler Jul. 1967. 67.10.245-46; unaccessed 83228-30.

5. Unnamed. 31°02'S, 126°48'E. Cave "15 miles S. of W. of Loongana". W.H. Butler Jul. 1967. Unaccessed 83234.

6. Unnamed. 31°02'S, 126°55'E. Cave 7.5 miles SW of Loongana. W.H. Butler Jul. 1967. Unaccessed 83232.

7. Unnamed. Approx. 31°04'S, 125°20'E. Cave "5 miles S. of Rawlinna". K.J. Marshall 1968. 68.5.55-57, 70.6.3.

8. N83, Old Homestead Cave. 31°10'S, 127°57'E. J.W.J. Lowry Sept./Nov. 1966. 67.4.78-189, 67.10.282-311, 70.6.12-19.

9. N140, unnamed. 31°15'S, 128°29'E. J.W.J. Lowry Sept. 1966. 67.10.251-280, 68.3.85-86, 70.4.226-28.

10. N139, unnamed. 31°24'S, 128°35'S. J.W.J. Lowry Oct. 1966. 67.10.459-67, 73.7.113.

11. N82, Skinkhole. 31°26'S, 127°52'E. J.W.J. Lowry Sept. 1966. 67.10.468-516, 68.3.70-75, 70.4.221-22, 71.5.65-66, 68-69.

12. N149, unnamed. 31°26'S, 127°11'E. J.W.J. Lowry Sept. 1966. 67.10.184-222, 67.10.523-35, 68.3.124-47, 73.7.15-17.

13. Unnamed. 31°32'S, 125°12'E. Sinkhole "4 km N. of Rawlinna shearing shed". Donated by L. Johnson Mar. 1975. 75.12.21.

14. N58, Roaches Rest Cave. 31°34'S, 127°14'E. J.W.J. Lowry Aug. 1966; K.A. Lance Jan. 1976. 67.3.21-54, 67.10.247-50, 78.12.1-2.

15. N59, Horseshoe Cave. 31°39'S, 127°26'E. M. Archer, B.G. Muir & K. Akerman Nov. 1969 to Feb. 1970. 72.1.1-27, 72.1.1055-1127.

16. N3, Abrakurrie Cave. 31°40'S, 128°28'E. J.W.J. Lowry Sept.-Oct. 1966, J. Bywater Dec. 1969 and A.D. Jones Jan. 1976. 67.3.109-53, 68.3.92, 71.3.143, 76.4.19-39.

17. N8, Cocklebiddy Cave. 31°58'S, 125°55'E. D.C. Lowry Dec. 1965, D.C. & J.W.J. Lowry Jan. 1966. 67.10.244, 68.2.71-308, 68.3.1-6, 68.3.46-51, 70.4.214-216, 70.4.279-80, 70.6.13-14, 73.7.3-12, 73.7.18-19.

18. Unnamed. 32°28'42"S, 123°50'22"E. Sinkhole 3.3 km SW of Balladonia Station homestead. Small figure-of-eight shaped entrance. Vertical solution pipe about 7 m to small circular chamber with small southern extension. Murray Thomas et al., Dec. 1971; A. Baynes and R.P. Hart Apr. 1984. Unaccessed, ABRS 29.

19. N1, Warbla Cave. 31°32'S, 129°06'E. J.W.J. Lowry Oct. 1966. 67.4.328-333, 67.5.1-143, 67.10.224-26.

20. N40, Kestrel Cavern No. 1. 31°40'S, 127°14'E. J.W.J. Lowry Nov. 1968, J. Bywater Dec. 1969. 68.11.32-72, 71.3.138-141, 74.5.25.

21. N63, Thylacine Hole. 31°41'S, 127°43'E. J.W.J. Lowry Oct. 1966, J.W.J. Lowry Oct. 1968. 67.4.313-323, 67.10.227, 67.10.371-458, 68.3.110-117, 68.11.117, 70.4.239-242, 70.11.20-32, 71.1.293, 71.10-208, 73.6.252-78.

22. N37, Mullamullang Cave, 31°43'S, 127°14'E. J.W.J. Lowry Aug. 1966, P.J. Bridge 1966. 67.4.334-37, 67.4.388-426, 68.3.91, 68.7.45-51.

23. N70, Firestick Cave. 31°45'S, 127°01'E. P. Cawthorn Jan. 1961, D.L. Cook Jan. 1962, J.W.J. Lowry Oct. 1966. 65.9.69-74, 66.3.1-19, 67. 4.324-27, 67.10.11-182, 70.4.4-6, 73.6.224-232, 73.6.287-95.

24. N160, Dingo Cave. 31°51'S, 126°44'E. R.C. Hyslop and D.F. Petchell Aug. 1967, J.W.J. Lowry Oct. 1968, M. Thomas et al. Jan 1972. 67.9.132-138, 68.11.75-81, 70.4.223-25, 74.5.44.

25. N50, Capstan Cave. 32°01'S, 125°58'E. P.J. Bridge 1967. 67.11.26-43, 70.4.213.

26. N.49, Pannikin Plain Cave. 32°02'S, 126°11'E. G. Zeck Dec. 1960, D.C. & J.W.J. Lowry Dec. 1965, D.L. Cook date unknown. 65.9.75-78, 67.10.242-43, 68.3.52-53, 69.7.751-53.

27. N47, Murra-el-elevyn Cave. 32°04'S, 126°02'E. E.L. Lundelius and G.W. Kendrick, 1954-55, J.H. Partridge Jan. 1964, J.W.J. Lowry Dec. 1966, P.J. Bridge 1967, A. Baynes and P.J. Bridge Mar. 1967. 63.6.5-10, 64.8.1, 66.1.54-56, 67.10.238-39, 68.3.54-67, 69.5.13-18, 73.1.80-95.

28. Unnamed. 32°29'50"S, 124° 38'05"E. Sinkhole on northern side of track across Hampton Tableland at M.R. 552033 Price 1:100,000 sheet. Vertical solution pipe about 7 m to small round chamber. R.P. Hart and A. Baynes Apr. 1984. Unaccessed ABRS 32B.

29. N157, Twin Level Cave. 32°34'09"S, 124°47'34"E. A. Baynes and R.P. Hart Apr. 1984. Unaccessed ABRS 32C.

30. Unnamed. 32°28'04"S, 123°23'56"E. Very small breakaway on north shore of salt lake S. of old Telegraph line in Dundas Nature Reserve. A. Baynes and R.P. Hart Apr. 1984. Unaccessed ABRS 28.

31. Booanya Rock. 32°45'44"S, 123°36'45"E. Overhang on south side of upper rock. A. Baynes and R.P. Hart Apr. 1984. Unaccessed ABRS 25.

32. N2, Weebubbie Cave. 31°40'S, 128°45'E. J.W.J. Lowry Oct. 1966 and Nov. 1968. 67.3.55-104, 68.11.87-90, 70.6.160, 70.6.1476.

33. Unnamed. 31°41'S, 129°02'E. "Overhang in cliffs 1.2 miles E. of Wilsons Bluff cairn". J.W.J. Lowry Sept. and Nov. 1966. 67.10.314-330, 68.3.90, 70.6.9-11, .17, .22, 72.4.3-9.

34. N45, Winbirra Cave. 31°42'S, 128°29'E. J.W.J. Lowry Oct. 1966. 67.4.338-82, 70.6.150, .152.

35. N44, Kutowalla Ooline. 31°43'S, 128°29'E. J.W.J. Lowry Oct. 1966. 67.10.332-70, 70.6.148, .151.

36. N165, Kelly Cave. 31°46'S, 127°45'E. R. Shoosmith Jan. 1974, R.P. Hart Jan. 1976. 74.2.26, 76.4.40 and unaccessed.

37. N132, Webbs Cave. 31°46'S, 127°48'E. D.L. Cook Jan. 1962, A. Baynes, P.J. Bridge and M. Gregson Mar. 1967, M. Thomas et al. Jan 1972. 64.2.16, 73.1.96-112, 74.5.34.

38. N193, Witches Cave. 31°50'S, 127°43'E. K.A. Lance Jan. 1976. 78.12.3 and unaccessed.

39. N53, Moonera Tank Cave. 31°59'S, 126°30'E. D.C. & J.W.J. Lowry Dec. 1965 and Jan. 1966. 68.3.7-10, 68.3.40-45.

40. N56, Tommy Grahams Cave. 32°06'S, 126°11'E. G.W. Kendrick and G. Hitchin May 1966, A.J. Carlisle 1966 and 1967. 66.4.45-62, 70.4.229-30, 70.5.6-25.

41. N159, Telegraph Cave. 32°13'S, 125°53'E. A.J. Carlisle 1966. 66.12.2-4, 66.12.6-21.

42. Unnamed. 32°33'S, 125°32'E. Small doline 200 m inland from Point Dover. D.C. Lowry July 1967. 67.8.63-69.

43. N62, Madura Six Mile South Cave. 31°58'S, 127°02'E. D.L. Cook Dec. 1961, D.C. & J.W.J. Lowry Jan. 1966. 62.8.10, 68.3.18-31, 69.7.643-669, 71.6.160-198, 73.6.235-7.

44. N46, Nurina Cave. 32°02'S, 127°01'E. P. Cook Dec. 1965, D.C. & J.W.J. Lowry Jan. 1966. 66.1.18-20, 67.10.240, 67.10.241, 68.3.11-14.

45. Unnamed. 32°35'30"S. 122°55'02"E. Granite rock 8 km N. of Mount Andrew. Large crescentic open cave on northern flank of rock. A. Baynes and R.P. Hart Apr. 1984. Unaccessed ABRS 39.

46. Unnamed. 32°10'S, 126°18'E. Small overhang in Hampton Escarpment. A. Baynes and W.K. Youngson Sept. 199. 73.1.123.

47. No cave; surface pick up. 32°17'S, 126°03'E. Twilight Cove. J.W.J. Lowry Nov. 1966, P. Reilly and M. Brooker Oct. 1973. 67.10.228, 74.5.28-31.

48. Unnamed. 32°55'43"S, 124°31'58"E. Small cave near top of cliff face at extreme east end of Wylie Scarp (where it swings seaward to become Baxter Cliffs). A. Baynes and R.P. Hart Apr. 1984. Unaccessed ABRS 33/2.

49. Peak Charles. 32°52'S, 121°09'E. Combined sample from three caves: large open cave on E. slope of N. spur; high open cave near top W. slope N. spur; and small sheet erosion cave on S.W. slope S. spur. A. Baynes and R.P. Hart Apr. 1984. Unaccessed ABRS 60.

50. Mount Arid. 33°58'30"S, 123°12'23"E. Large cave 30 m x 30 m on north slope with open roof. A. Baynes, R.P. & R.M. Hart and C. Hart Mar. 1984. Unaccessed ABRS 7.

51. "Fox Cave". 33°53'02"S, 122°06'04"E. Granite Hill NW of Marbellup Hill. Large cave 22 m wide and 27 m deep facing SE. M. Smith, A. Baynes, R.P. & R.M. Hart Mar. 1984. Unaccessed ABRS 5B.

52. Darke Peak, Eyre Peninsula, S.A. 33°26'S, 136°10'E. G.C. Medlin et al. Apr. 1984. In collection of G.C. Medlin.

53. South Block Range, Eyre Peninsula, S.A. 34°24'S, 135°34'E. A.J. Watts Jan. 1984. South Australian Museum collection.

APPENDIX VII

ELECTROPHORETIC EXAMINATION OF MAMMAL AND REPTILE SPECIMENS

APPENDIX VII: ELECTROPHORETIC EXAMINATION OF MAMMAL AND REPTILE SPECIMENS COLLECTED FROM THE NULLARBOR BY T. REARDON EVOLUTIONARY BIOLOGY UNIT, SOUTH AUSTRALIAN MUSEUM, JANUARY 1985

A. Mammals

All of the species of mammals examined have previously been electrophoretically characterised by the E.B.U. As a consequence the diagnostic genetic markers which delineate these species from other morphologically similar taxa are already known. The results are (controls were used but are not listed):

1. Sminthopsis (5 diagnostic genetic differences from 24 loci)
S. ooldea
FW2220, FW2083, FW2081, FW5538, FW5545
S. dolichura
FW2253, FW2052
(plus South Australian specimens: Field numbers 1474, 1495, 1602, 1607, 1619, 1622, 1632, 1633, 1846, 1864)

2. Pseudomys (7 diagnostic genetic differences from 24 loci)
P. hermansburgensis
FW2254, FW2255, FW5448, FW2080, FW5547, FW5540, FW2251
P. bolami
FW2250, FW2282, FW2276

3. Notomys (6 diagnostic genetic markers from 24 loci)
The following specimens are all N. mitchellii
FW2065, FW5521, FW5514, FW5535, FW2273, FW2274
(plus South Australian specimens: Field numbers 2203, 2204, 2225, 1516, 1517, 1564, 1603)

4. Nyctophilus (2 diagnostic genetic markers from 24 loci)
The following specimens are ascribable to N. timoriensis/major
FW2062, FW5505, FW5506
(plus South Australian specimens: Field numbers 2328, 2344)

Note: N. gouldi and N. timoriensis are very close genetically. The level of intraspecies genetic variation for the diagnostic markers has not yet been fully documented and hence we cannot as yet unequivocally classify all new specimens.

5. Eptesicus (10 diagnostic genetic markers from 24 loci)
The following specimens are all E. regulus
FW5510
(plus South Australian specimens: Field numbers 1865, 1866)
Two specimens, FW5509 and FW5511, did not exhibit any enzyme activity at the 24 loci examined.

B. Reptiles

Unlike the mammals, there are no background electrophoretic results available for the genera of reptiles examined here. This makes it considerably more difficult to "type" specimens as belonging to particular species. There are two further complications. Firstly, in contrast with the mammals, many of the reptile tissue samples exhibited very poor electrophoretic activity; indeed some were virtually inactive. Such poor sample condition results in non-genetic electrophoretic variation, and this can be difficult to distinguish from genetic variation in taxa that have not been electrophoretically characterised. Secondly, the low sample sizes involved for all comparisons do not allow the unequivocal use of any existing electrophoretic differences as diagnostic characters, since the presence of intra-specific variation in these characters cannot be ruled out.

The results are:

1. Lerista bipes
JU21 - no enzyme activity
PL18 - no enzyme activity
PL16, PL17 - identical at 26 loci
S.A. specimens
1.16 - poor enzyme activity - identical to PL16 at 12 loci
1.12 - poor enzyme activity - identical to PL16 at 15 loci
1537 - attributable to L. frosti (tissue labelled Lerista sp.)

2. Lerista frosti
C028 - no enzyme activity
HA5, HA6 - identical at 22 loci
S.A. specimens
1508, 1512, 1519, 1531 identical to HA5 (based on 16-22 loci)

3. Lerista picturata
C035 - no enzyme activity
C036 vs 8A38 - 2 electrophoretic differences at 18 loci
S.A. specimens
1565, 1624 identical to each other at 24 loci: 2 electrophoretic differences between both C036 and 8A38.

4. Gehyra variegata
PL28 vs PL35 - identical at 14 loci. PL35 exhibited poor enzyme activity.

PL33 vs PL29 - 5 electrophoretic differences at 24 loci
S.A. specimens
1476 - identical to PL29 at 22 loci
1477 vs PL29 - 12 electrophoretic differences at 17 loci

5. Ctenotus uber
HA10, HA12, BA5 identical at 25 loci

6. Diplodactylus maini
PL13 - no enzyme activity
8A12 - unique electrophoretic profile from other Diplodactylus

7. Diplodactylus intermedius
HA7 vs BA3 - 1 electrophoretic difference at 17 loci

8. Diplodactylus graniarensis
HA14, CO3, CO12 identical at 21 loci
S.A. specimens
1480 - ascribable to D. intermedius
1873, 1506, 1520, 1526, 1522 identical to HA14 at 20 loci
1511 - no enzyme activity

Conclusions

1. There is considerable variability in the enzyme activity found resident in the reptile tissues. Unfortunately in most instances the specimens of interest involves tissues with little or no enzyme activity. It is not clear whether this is a chance correlation or a more direct relationship. The mammal tissues, with two exceptions, exhibited typical levels of enzyme activity.

2. There is strong evidence of sibling species in two cases. These are:

    1. Gehyra variegata
    PL 33 vs PL29 and PL35 (and the S.A. specimens)

    2. Diplodactylus graniarensis
    BA1 vs HA14, CO3 and CO12 (and 4 S.A. specimens)

    3. The electrophoretic variation found in L. picturata and D. intermedius may or may not reflect the presence of sibling species. Further electrophoretic work on these groups would be desirable.

    4. There was one case of field mis-identification involving a D. graniarensis/D. intermedius mix up.

    5. The G. variegata sample 1477 (S.A.) is probably a result of an inter-species mis-labelling occurrence, either in the field or in the laboratory.

In summary, two recommendations stem from this study.

A. The significance of the variation in enzyme activity for the reptile tissues should be investigated.

B. A comprehensive electrophoretic survey of problem groups within the reptiles should be undertaken.

This is currently one of the research aims of the E.B.U. (funded by A.R.G.S.)

APPENDIX VIII

VEGETATION DESCRIPTION OF PLUMRIDGE 6 QUADRAT

APPENDIX VIII: VEGETATION DESCRIPTION OF THE PLUMRIDGE 6 QUADRAT, CONSIDERED TO BE TYPICAL OF THE GREAT VICTORIA DESERT AND HENCE OUTSIDE THE NULLARBOR STUDY AREA

Low open woodland of mallee trees of
Eucalyptus transcontinentalis and
Eucalyptus oleosa

over Triodia scariosa

with scattered shrubs of
Halgania viscida
Cassia nemophila
Solanum lasiophyllum
Eremophila latrobei
Kennedia ?prorepens
Acacia sp.

Eremophila miniata

herbs
Ptilotus exaltatus
Ptilotus alopecuroides
Waitzia acuminata
Helipterum fitzgibonii
Podolepis eriopoda

bunchgrasses
Eragrositis eriopoda
Enneapogon caerulescens

APPENDIX IX

SOILS

APPENDIX IX

NULLARBOR SOILS

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Introduction

Field samples from the intensive study areas of the Nullarbor Region of Western Australia and South Australia were analysed in the Department of Botany of the University of Western Australia under the direction of Dr David T. Bell.

Methods

Field samples were collected in two major lots; the first during March-April 1984 and the second during September-October 1984. Most samples represent a composite of material through one depth profile. Certain samples were divided to determine variation between surface conditions and those of the subsurface. Separate collections have been analysed in some instances.

(a) Texture
Each field collection sample was air dried, weighed and passed through a 2mm sieve and then reweighed to determine the proportion of the whole sample in the general gravel class (¿2.00m). On the remaining fraction (¡2.00m), the proportions of sand (2.00-0.02mm), silt (0.02-0.002) and clay (0.002mm) were determined by the hydrometer method (Bouyoucos 1936). The soils were classified for texture from these values (Soil Survey Staff 1951). All remaining analysis were carried out using the 2.00mm sample.

(b) Soil pH and Conductivity
Dried soil samples were prepared in 1:5 soil to distilled-deionized water pastes and allowed to stand for 48 hours before measurement by glass electrodes and appropriate meters.

(c) Total N (Nitrogen)
Replicate samples of each soil type were digested by a micro-Kjeldahl method. This digestion involved 0.5g of soil, 5ml of concentrated $H2SO4$ (sulphuric acid), two 1g mercury catalyst tablets, and boiling chips. The samples were digested on a block digester (Prototype Equipment) and made up to 20ml with deionized distilled water when the digestion was complete. The digested samples were then analysed on a Technicon Autoanalyser II using the dialyzer module and absorbance mode .

(d) Total P (Phosphorus)
Boiling chips and 0.5ml HNO3 (nitric acid) were added to replicate samples of 0.5g of each soil sample. After the brown fumes had stopped 1ml of HClO4 (perchloric acid) was added and digestion continued on a block digester (Diotype Equipment). At the completion of digestion samples were made up to 10mls with deionized distilled water. The orthophosphate formed during this digestion was then determined by a modified single solution method of Murphy and Riley (1962), using a spectrophotometer.

(e) Cations
Concentrations of K (potassium), Ca (calcium), and Mg (magnesium) were determined from the perchloric acid digest samples of total P using a Varian Techtron AA-6 atomic absorption spectrophotometer. Duplicate samples were analysed.

Results

Edaphic conditions from all sampling areas except Kuthala 2 and 5 have been presented in Table ... Upper profile samples in some instances show higher values of nitrogen and potassium, probably due to the greater quantities of soil organic matter in these upper edaphic regions. Most sites, however, had similar levels of most of the parameters between the upper and lower subsamples, thus allowing a mean value to be determined and compared with the other site values. In general therefore nutrient conditions for germinating seeds can be represented by these bulk sampling values.

Without participating in the collection phase of the sampling it is difficult to provide more than a few brief impressions. Of major initial impact is the magnitude of the Ca and Mg values which is to be expected for soils developed from the Nullarbor limestones. The total N and total P readings, however, are also rather high when compared to other soils in Western Australia. Total P values for site C03-C05 would be similar to the leached acid sands of the northern sandplain area near Badgingarra. Jarrah forest soil total P values are an order of magnitude higher. High cation values tend to occur in the soils with appreciable levels of clay and silt as do the soils with high conductivity values. Soils of the Nullarbor are expected to have high pH values but values of 9 are very rare.

TABLE 43: NULLARBOR SOIL ANALYSES, AN ASTERISK INDICATES A SAMPLE COLLECTED IN SEPTEMBER RATHER THAN APRIL WHEN THE BULK OF THE SOIL SAMPLING WAS CARRIED OUT. A - IN THE TABLE INDICATES VALUES OF BETWEEN 0 AND 1 PER CENT AND THEREFORE NOT MEASURABLE

Sample Site Code	Nutrients (parts per million)					Texture					pH	Conductivity $^{-1}cm^{-1}$ x10^{-6}
	Total N	Total P	K	Ca	Mg	¿2mm% Gravel	% Sand	¿2mm % Silt	% Clay	Classif-ication		
BA1	610	224	9232	92045	6090	27	68	20	12	Sandy loam	8.03	540
BA2	590	152	8580	129026	7102	32	36	28	36	Clay loam	8.27	1445
BA3	610	134	6175	85316	4897	12	74	18	8	Sandy loam	8.19	460
BA4	560	130	7461	80348	4042	6	66	24	10	Sandy loam	8.28	112
BA5	560	178	12630	75492	6118	6	61	27	12	Sandy loam	8.06	150
CO1	1030	206	15187	76410	7654	1	55	33	12	Sandy loam	7.93	310
CO2	570	104	7924	89399	5769	2	52	33	15	Loam	7.88	2210
CO3	310	5	446	7857	251	1	96	2	2	Sand	8.20	54
CO4	230	6	197	2596	203	22	98	1	1	Sand	7.85	69
CO5	490	6	116	5615	163	1	99	-	1	Sand	7.80	42
FO1	670	322	4553	77283	3433	28	65	24	11	Loamy sand	8.12	900
FO2	620	236	4831	42155	3254	24	82	12	6	Loamy sand	8.38	130
FO3	850	317	9477	17602	3994	3	69	20	11	Sandy loam	8.73	164
FO4	500	134	6769	11785	3881	8	71	20	10	Sandy loam	8.5	220
FO5	730	271	11842	16437	4557	5	57	27	16	Sandy loam	8.56	116
HA1	560	120	5593	118660	4988	18	46	41	13	Loam	7.87	2560
HA2	460	140	4087	168500	7040	40	54	27	19	Sandy loam	8.07	1700
HA3	440	146	5983	152034	4265	6	26	34	40	Clay loam	8.43	586
HA4	510	136	6699	174354	4855	35	60	24	16	Sandy loam	8.1	1160
HA5	440	122	12188	83973	5447	4	40	36	24	Loam	8.30	1020
JU1	400	145	6659	84695	4104	6	67	23	10	Sandy loam	8.17	234
JU2	360	80	3780	35635	2291	5	83	12	5	Loamy sand	8.08	353
JU3	420	96	4185	10592	1178	1	86	8	7	Loamy sand	8.28	141
JU4	350	108	5170	44052	1821	1	83	9	8	Loamy sand	8.29	118
JU5	300	76	5374	36236	2387	5	79	11	10	Sandy loam	8.34	126
MA1	1040	192	8006	123667	9058	4	63	26	11	Sandy loam	8.73	1970
MA2	990	142	5602	156969	12507	10	72	21	8	Sandy loam	7.96	1855
MA3	1450	175	8554	138525	9701	21	83	11	7	Loamy sand	7.86	1255
MA4	570	48	938	10504	928	0	98	1	1	Sand	7.74	63
MA5	100	167	84	195871	8587	0	100	0	0	Sand	8.55	57
MA6	2000	220	8301	107664	8274	18	75	20	5	Loamy sand	7.74	373
KU1	540	33	11470	82422	7243	16	36	40	24	Loam	7.75	805
KU3	940	175	5426	183227	8330	6	68	22	10	Sandy loam	7.73	2430
KU4	650	176	6035	178564	10843	42	63	24	13	Sandy loam	8.07	1430
PL1	260	100	2912	5280	1778	-	83	11	6	Loamy sand	7.43	45
PL2	350	186	3184	45238	2495	12	85	10	5	Loamy sand	8.22	510
PL3	340	80	4628	35438	2329	2	80	14	6	Loamy sand	8.06	564
PL4	290	88	2188	36743	1166	15	86	9	5	Loamy sand	8.14	123
PL5	390	78	2619	31347	1411	8	87	8	5	Loamy sand	8.13	132
ME2	420	135	3121	160467	4538	26	50	25	25	Sandy clay loam	8.05	486
ME3	540	149	6846	77246	4425	16	48	28	24	Loam	8.07	532
ME4	570	185	11947	50647	5597	2	34	44	22	Loam	8.14	1240
ME5	610	122	5006	106095	3536	25	46	38	16	Loam	8.09	785
CA1	1100	224	8746	157122	7207	10	74	18	8	Sandy loam	7.76	1850
CA2	1030	308	8733	118693	7272	21	74	20	6	Sandy loam	7.92	680
CA3	950	303	9538	94189	6780	24	76	17	7	Sandy loam	7.61	680
CA4	350	325	8063	97470	7542	16	61	26	13	Sandy loam	9.17	231

CA5	860	118	10338	68912	7340	31	64	26	10	Sandy loam	8.59	204
HU1	1100	244	11827	31521	4811	11	58	27	15	Sandy loam	7.38	234
HU3	560	320	9612	23581	6101	1	51	35	14	Loam	7.71	144
HU4	340	246	8674	43224	4606	14	67	23	10	Sandy loam	7.71	129
HU5	180	175	8715	28592	4676	20	69	21	10	Sandy loam	8.05	108
IF1	680	154	4504	146303	4297	3	87	6	7	Loamy sand	7.72	140
IF2	820	146	5034	60176	3614	8	86	8	6	Loamy sand	7.55	142
IF3	410	105	5161	51376	2547	1	82	11	7	Loamy sand	7.79	105
IF4	330	55	1987	-	982	1	94	1	5	Sand	7.44	72
IF5	390	100	5321	7757	1863	1	86	7	7	Loamy sand	7.25	96
KO1	1280	154	4130	101800	4456	4	85	10	5	Loamy sand	7.85	1450
KO2	390	216	7019	101464	5153	22	80	10	10	Loamy sand	7.64	124
KO3	690	216	2539	151300	5258	6	86	10	4	Loamy sand	7.38	400
KO4	330	172	4213	133386	4410	14	86	10	4	Loamy sand	7.51	755
KO5	670	172	2459	142080	4349	3	88	8	4	Loamy sand	7.72	176
KD1	1630	156	2270	141661	7919	15	84	11	5	Loamy sand	7.18	168
KD2	1110	211	3794	161549	6832	22	80	12	8	Loamy sand	7.44	450
KD3	520	226	7418	116325	6319	11	79	14	7	Loamy sand	7.36	140
KD4	1090	188	8272	110145	7142	17	77	15	8	Sandy loam	7.82	400
KD5	520	207	6356	106428	5527	24	79	16	5	Loamy sand	7.80	195
MU1	680	131	6306	13136	1681	31	89	3	8	Loamy sand	8.00	98
MU2	360	64	2428	359	646	1	92	3	5	Sand	7.68	80
MU3	460	62	1600	3314	437	4	92	4	4	Sand	7.75	38
MU4	490	88	3011	3625	783	37	86	8	6	Loamy sand	7.75	149
MU5	290	20	416	342	156	0	98	1	1	Sand	8.09	22
YA1	620	192	1472	-	5848	1	89	7	4	Sand	7.84	710
YA2	470	10	568	175659	6604	1	94	2	4	Sand	7.63	820
YA3	580	18	920	148014	5055	1	92	3	5	Sand	7.73	630
YA4	540	98	1043	160547	4906	1	91	4	5	Sand	7.81	450
YA5	680	20	543	198689	7098	1	96	2	4	Sand	8.13	112
FO1 (lower profile)	870	204	4560	63379	3677	42	79	14	7	Loamy sand	7.78	1780
FO2 (top 5cm)	820	232	5081	40390	3517	20	79	14	7	Loamy sand	8.71	187
FO2 (lower profile)	570	232	4956	54136	3620	27	82	12	6	Loamy sand	8.47	132
FO2 (top 5cm)	670	240	4706	30174	2888	21	82	12	6	Loamy sand	8.29	129
FO3 (lower profile)	650	271	9222	17328	3952	2	66	22	12	Sandy loam	8.41	153
FO3 (top 5cm)	1040	362	9732	17876	4036	5	72	18	10	Sandy loam	9.04	174
FO4 (lower profile)	480	142	7008	23640	4026	2	74	18	8	Sandy loam	8.70	107
FO4 (top 5cm)	680	190	6874	15912	3911	2	74	17	9	Sandy loam	8.67	92
FO5 (lower profile)	490	271	11557	19989	4608	8	56	30	14	Sandy loam	8.52	134
FO5 (top 5cm)	960	271	12126	12885	4506	2	59	24	17	Sandy loam	8.60	98
MA1 (lower profile)	720	187	7061	143344	9115	5	72	20	8	Sandy loam	8.42	3120
MA1 (top 5cm)	1360	198	8952	103990	9000	3	54	31	15	Sandy loam	9.04	810
MA2 (lower profile)	810	155	4362	184862	11842	12	77	18	5	Loamy sand	8.12	2810
MA2 (top 5cm)	1850	209	4614	160298	9086	3	85	11	4	Loamy sand	8.48	140
MA3	1110	204	6538	139319	11444	20	76	20	4	Loamy sand	7.94	1160

(lower profile)												
MA3 (top 5cm)	2730	235	6816	106104	8027	9	78	18	4	Loamy sand	8.22	152
MA4 (lower profile)	340	12	989	11815	897	0	98	1	1	Sand	7.78	86
MA4 (top 5cm)	790	84	886	9194	958	0	98	1	1	Sand	7.69	40
MA5 (lower profile)	80	194	86	202633	8771	0	100	0	0	Sand	8.58	61
MA5 (top 5cm)	120	140	83	189109	8403	0	100	0	0	Sand	8.52	54
MA6 (lower profile)	1880	201	8131	114267	8381	25	78	18	4	Loamy sand	7.99	189
MA6 (top 5cm)	2120	239	8471	101062	8168	12	72	21	7	Sandy loam	7.48	557
PL1 (sub-surface)	280	68	2900	9906	1842	0	84	10	6	Loamy sand	7.57	66
PL2 (surface)	240	132	2924	654	1714	0	83	12	5	Loamy sand	7.29	23