CHAPTER 5

ULURU NATIONAL PARK

1.0 Introduction

The mulgara population at Uluru National Park/ Yulara is one of the best documented persistent populations in arid Australia. Mulgaras have been recorded principally in the Yulara lease/ borefield and adjacent areas over the past 30 years. Woolley (1990) captured mulgaras at the Bus Sunset Viewing Area in 1962 and 1966 and in the vicinity of the Sedimentaries in 1975. Mathews and Roff (pers. comm.) reported the presence of mulgaras in the Yulara resort area from 1973 to 1983, and Masters (1993) consistently captured mulgara on the Yulara borefield from 1987 to 1990.

The mulgara population at Uluru National Park is of high conservation value, because of its persistence and because of its location within and adjacent to a World Heritage Area and a UNESCO Biosphere Reserve. It is important that this population be protected not only for its local significance, but also as an important component of the entire arid-zone mulgara population. The persistence of this population, the accumulated prior knowledge and access to resources made Uluru National Park/Yulara an obvious choice for the primary study site for this research.

1.1 Aims of the study

Research during the 1980s by Masters (1993) and Reid *et al.* (1993) focussed attention on the restricted distribution of mulgaras within the Park. Reid *et al.* (1993) identified mulgara as a Level 1 Priority species for the Park and recommended that a research and monitoring program be instigated. These recommendations culminated in a contract being let to Professor Jarman and myself to develop a conservation strategy for mulgaras within the Park and adjacent areas.

The aim of the Mulgara Conservation Strategy was to develop management strategies for the protection of mulgaras within the Park and adjacent areas. The scope of the research project reflected the research objectives of my broader research program and required the researchers to:

- Locate major populations of mulgaras within Uluru National Park and adjacent areas;

- Investigate environmental characteristics that determine the patchy distribution of the species;

- Investigate causes of decline and potential threats.

1.3 The Study Area

1.3.1 Topography and Vegetation

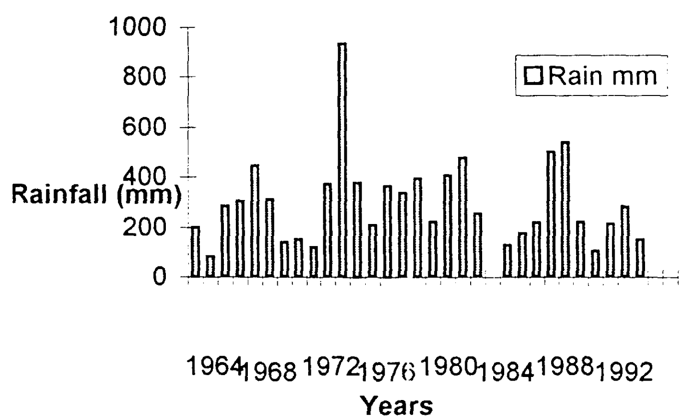
The area is predominately represented by spinifex-covered Quaternary sands overlying Cambrian Mount Currie conglomerate. The conglomerate is exposed as two major rock outcrops, Uluru and Kata Tjuta (Hooper *et al.*, 1973). The major plant formations are spinifex grasslands characterised by *Triodia* spp. and *Plectrachne* spp., and *Acacia* spp. shrublands. The *Acacia* shrublands occur mostly on loams and red earths while the hummock grasslands occupy sandplains or dunefields comprised of red siliceous sands (Buckley 1981a,b; Griffin, 1984).

Allan (1984) mapped 21 land-units in three land-systems for the Park which are reproduced in Figure 11.

1.3.2 Climate

Uluru National Park, like other arid zone areas, experiences extreme temperatures with the short-term mean minima and maxima ranging from 21.9°C to 39.2°C for January and 4.3°C to 20.9°C in July (Reid *et al.*, 1993). It also experiences an unpredictable and low rainfall with an average of 220mm per year. Figure 12 presents the rainfall records over thirty years to June 1994, minus a record for 1984 (Reid *et al.*, 1993).

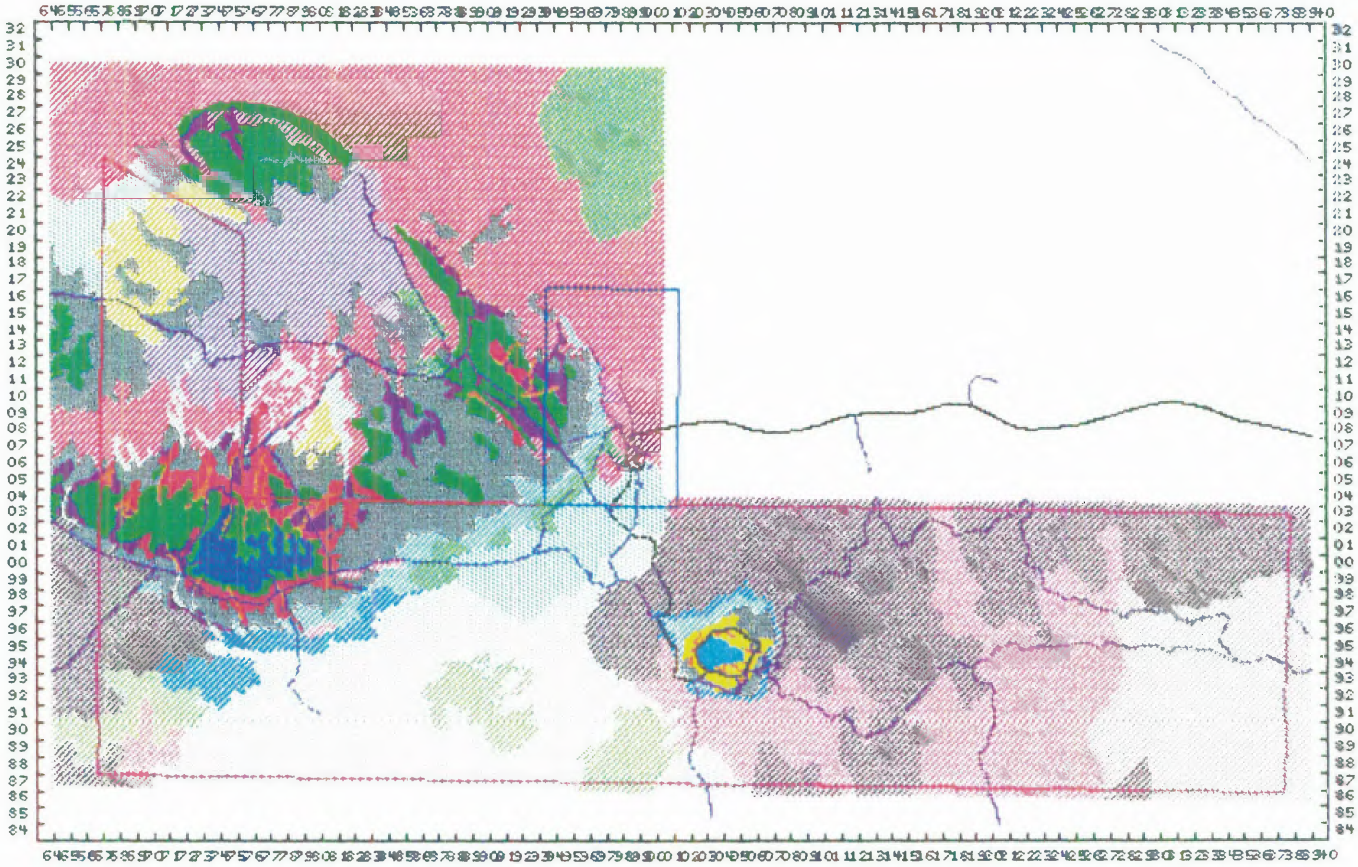
Figure 11: Annual rainfall from 1964- 1994 for Uluru National Park (Reid *et al.*, 1993)



1.3.3 Regional hydrogeology

Uluru National Park and surrounding areas are underlain by Proterozoic and Palaeozoic rocks of the Amadeus Basin (Jacobson *et al.*,1989). The basin supports a paleodrainage line, expressed on the surface by a chain of salt lakes which extend over 500km from Lake Hopkins in western Australia through to the Finke River in the east.

Figure 12: Uluru National Park land units as defined by Allan (1984)



MAP : Uluru National Park landunits
as defined by Allan (1984)

SCALE = 1:
TICKMARK INTERVAL = 1000 metres
— SEALED ROADS
— UNSEALED ROADS
— TRACKS
— ULURU PARK BOUNDARY (dig)
— YULARA TOWN LEASE (DIG)

MONOLITHS	
Uluru	1a
Kata Tjuta	1b
FOOTHILLS	
Foothills	2
FANS & ALLUVIUM	
Uluru Run-on Areas	3a
Drainage Lines	3b
Calcareous Interfluves	3c
Sandy Interfluves	3d
Lower Outwash Fans	3e
PLAINS	
Clayey Loam Soil	4a+4a(1)
Clayey Depressions	4a(2)
Sandy Loam Soil	4b

SANDPLAINS			
Transitional	w/	TRPU	5a1
Transitional	w/	TRBA	5a2
Earthy Sands	w/	TRPU	5b1
Earthy Sands	w/	TRBA	5b2
DUNEFIELDS			
Open System	w/	TRPU	5c1
Open System	w/	TRBA	5c2
Network	w/	TRPU	5d1
Network	w/	TRBA	5d2
Reticulate	w/	TRPU	5e1
Parallel	w/	TRPU	5f1
Parallel	w/	TRBA	5f2

Quaternary sand dunes cover a large portion of the basin and are up to 30 m high. They overlie a Cainozoic sequence, up to 100m thick, of sand, clay, gravel and calcrete and these sediments infill the major paleodrainage system which drains to the southeast (Jacobson *et al.*, 1989).

Jacobson *et al.* (1989) drafted maps of the surficial aquifers associated with this paleodrainage system. The locations of the contours of the isopachs (thickness (m) of the potentially water bearing Cainozoic sediments) were determined by bore data and photointerpretation. A section of the paleodrainage system lies between Kata Tjuta and Yulara and drains into Lake Amadeus to the north. The surficial aquifer associated with the drainage line supplies the township of Yulara and the resort complex with water (Fig. 13).

1.3.4 Surficial aquifer: water supply

Standing water levels in the bores most commonly used to supply water to Yulara are 20 -30 m below the surface. From 1984 to 1989 the standing water level at Bore RN12066 dropped by approximately 3 metres, consistent with its use, and rose again after pumping ceased. Similarly the standing water level at RN10483 dropped by approximately 3 metres in 1991/2, reflecting its use (N.T. Power and Water Authority data). High rainfall events in 1988 and 1989 provided recharge to the aquifer which allowed the rise in water table evidenced by both bores after the cessation of pumping.

The ability of the aquifer to sustain drawdown relies on recharge from rainfall events. In 1989 the aquifer was recharged by 75% due to good rains over a 4-month period and this theoretically makes the aquifer secure for approximately ten years given current water usage. The water usage of Yulara has increased from 300 ML in 1984 to 800 ML in August-September 1994 (Peter McDonald pers. comm.).

1.4 Aṉangu assistance

Edith Richards, a Park senior ranger, played a pivotal role in teaching me to recognise mulgara and predator sign, and participated in a large portion of the field work. A group of senior women, Maureen Natjuna, Marjorie Wilson, Ruth Connelly, Kunmaṉara, Tjukupati, and Mrs Patterson, assisted in field work during 1991 and 1992.

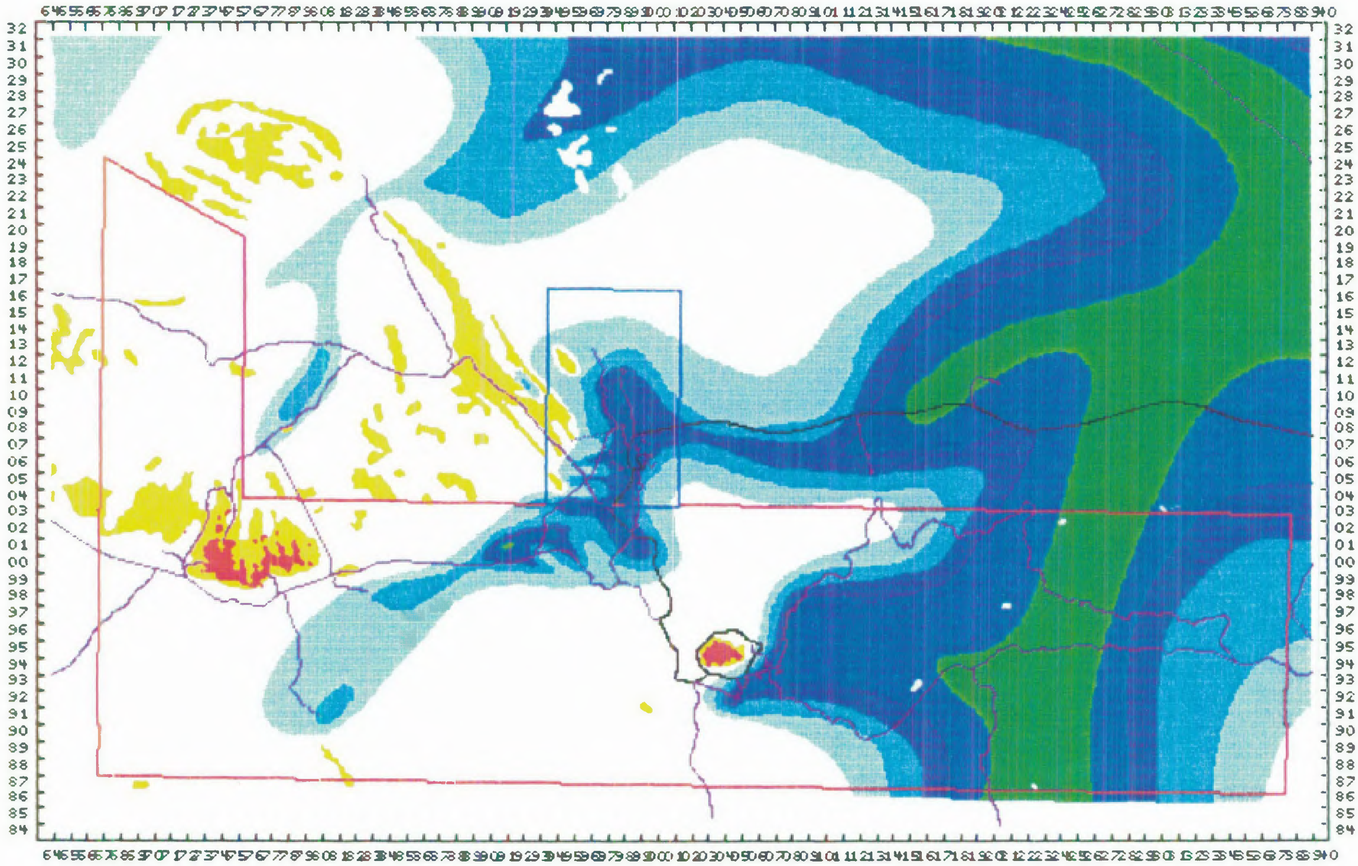
A group of senior men, Norman Tjakilyiri, Kata Kura, Willy Wamantjangu, and Tungku Peapai, and ranger trainees Nyinku, Janice Norman and Joan Nyangkula, accompanied me on a field trip to Pantu (Lake Amadeus).

2.0 Methods

2.1 Introduction

Field work was undertaken over a four-year period, commencing in 1991 with trips from the 23 March to the 19 April and 25 July to the 15 August. I resided at Muṯitjulu Community from June to December 1992 and undertook field work throughout the 6-

Figure 13: Surficial aquifers associated with the paleodrainage system as mapped by Jacobson *et al*. (1989).



MAP : 13: Surficial aquifers
mapped by Jacobsen et al. (1989)

SCALE = 1:

TICKMARK INTERVAL = 1000 metres

— SEALED ROADS

— UNSEALED ROADS

…… TRACKS

— ULURU PARK BOUNDARY (dig)

— YULARA TOWN LEASE (DIG)

- 20 to 40 Isopachs
- 40 to 60
- 60 to 80
- 80 to 100
- 100 plus
- Monoliths: Uluru/K_Tjuta
- Bedrock Outcrop

month period. Two trips from 11th to the 15th March and the 26th to the 30th June, 1994 completed the field work.

The general methods were described in Chapter 4. Additional information specific to UNP is covered in this section.

2.2 Mulgara distribution

2.2.1 Elliott trapping

In 1991 'Elliott' box trapping was focussed within the known distribution of the mulgara population and trap lines were set in an attempt to locate the boundary of the population. Fourteen trap-transects were located radiating out from the Yulara bore field into the Park (Fig. 14). The first two transects, UNP111 and UNP112, were set up over 1.2 km placing one trap every 50 m to maximise the area covered. These transects were found to be too difficult to service and the distance between traps was reduced to 25 m with an overall distance of 600 m for the remaining 12 transects.

2.2.2 Mulgara sign searches

In 1991 sites were randomly sampled within landunit associations as defined by Allan (1984). From 1992 to the completion of the study, sites were selected at 2 km intervals while sign was being detected and thereafter at 5 km intervals along roads and tracks. In 1994 an overland transect was walked with Park staff, from Yulara to the Tuit Track with sites being surveyed at approximately 1km intervals along the transect.

One hundred and ninety individual sites were surveyed for mulgara sign. Fourty four of these sites, based around the trapping grids of Jeff Foulkes and Pip Masters (CCNT) and my invertebrate study sites (described in section 2.5) were repetitively sampled over the four-year period. The combination of repeat searches and single searches resulted in a total of 259 site searches over the study period.

2.3 Introduced predators and herbivores

One hundred and seventy one sites were searched for dingo, fox, cat, rabbit and camel sign. The Park and adjacent areas have never been grazed by domestic stock.

2.4 Habitat assessment

2.4.1 E-RMS: Geographical information system

A geographical information system E-RMS (NSW NPWS) was set up for the Park by the ANCA in 1990/1. Remotely mapped features for the Park included landunit, vegetation and terrain derived from Allan (1984), topographical features and contours, some of the Park's fire history (mapped by G. Allan, CCNT), surficial aquifers (Jacobson *et al.*, 1989), cadastral boundaries and major roads and tracks. There are gaps in the database for the landunits east and north of Yulara and the fire-history maps from 1990 onwards have not been incorporated.

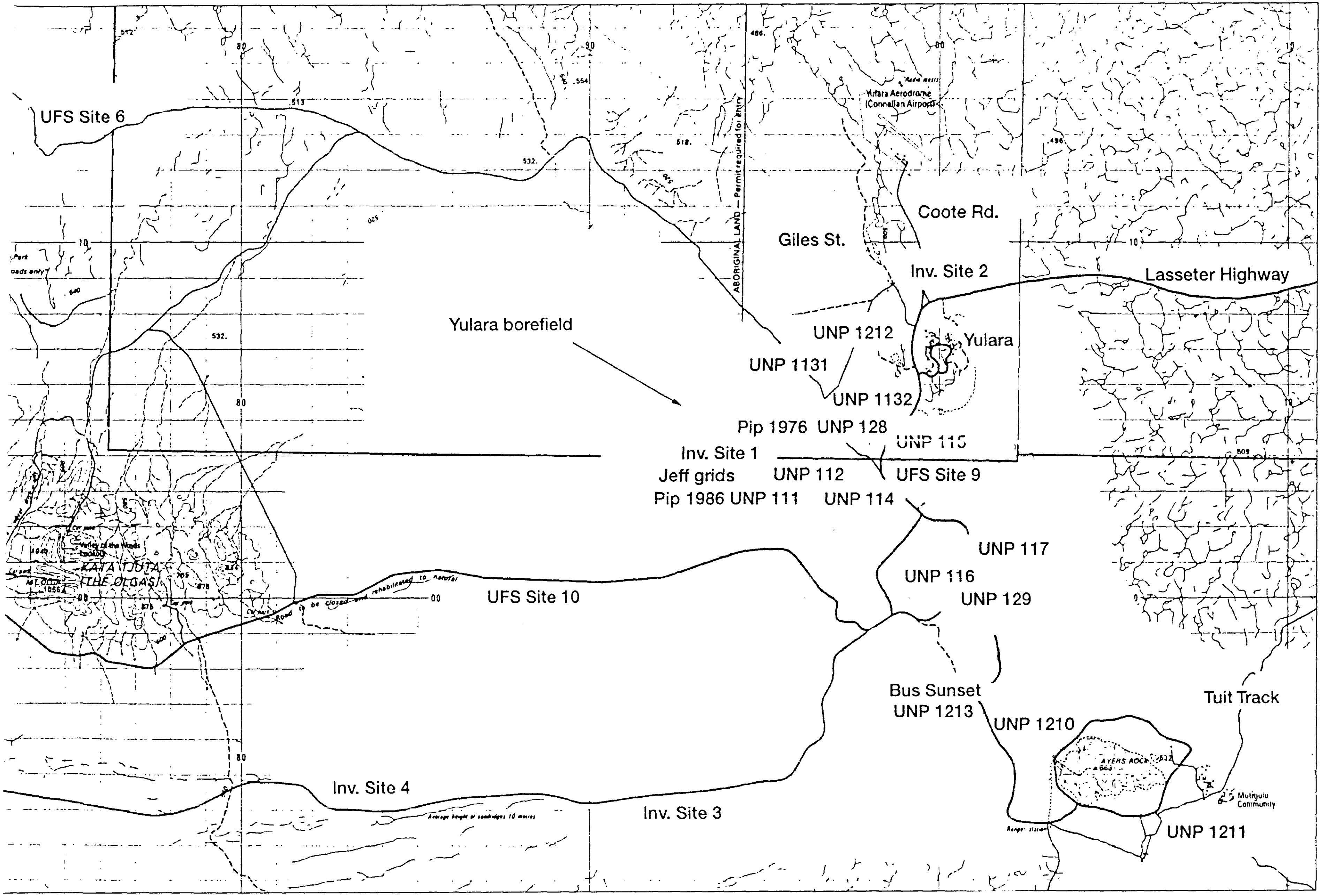


Figure 14: Uluru National Park/ Yulara Elliott trapping and invertebrate study sites.

Frequency of mulgara tracks, scats, burrows (fresh, current and disused), fox, dingo, cat, rabbit and goanna sign detected in this study have been ranked and incorporated into the database. This has allowed the production of distribution maps of sign across the study area and over the study period. The association of mulgara distribution with habitat and predators was investigated through the GIS by mapping distribution of mulgara sign over individual habitat variables or over more complex associations through the use of 'Boolean overlays'. A log-likelihood ratio analysis tested the statistical significance of the association between the abundance of sign and the chosen predictor variables.

E-RMS also contains a predictive modelling module which uses induction (machine learning) to derive a decision-tree model relating ground-surveyed data to one or more remotely mapped variables. This method is particularly useful for predicting the potential distribution of rare species based on habitat variables (NSW NPWS, no date). Predictive models were generated using the mulgara and predator data obtained during this study. The stopping criterion was selected such that there was at least 95% confidence that the branching structure of the model reflected real rather than chance correlations.

2.4.2 Site-based habitat assessment

Habitat parameters as described in Chapter 4 were collected at 190 sites. A subset of 90 sites were sampled for known fire history and spinifex form; and 31 sites were sampled for percentage ground, shrub and tree cover as described in Chapter 4.

2.5 Invertebrates

A program was designed to sample and compare the invertebrate communities from sites recording persistent mulgara sign and sites where mulgara had not been recorded. The aim was to assess whether sites which persistently supported mulgara could be differentiated from sites not supporting persistent mulgara populations through their invertebrate communities.

Four invertebrate sampling sites were established, with Sites 1 and 2 within the area supporting persistent mulgara numbers and Sites 3 and 4 in areas where no mulgara sign had been located (Fig. 14). Both positive sites were dominated by *Triodia basedowii* spinifex regrown since the 1976 fires, while Site 3 was dominated by 1976 *Triodia pungens* spinifex and Site 4 represented a mix of 1976 *Triodia pungens* and *Plectrachne schinzii.*

Two sets of double pitfall lines were established per site, with each line containing 5 pitfalls. The two lines in each subsets were set 40 m apart and subsets were established 300 m apart. Each site had a total of 20 pitfalls. The pits were clear plastic cocktail cups containing a killing/preserving solution made up of 80% water, 20% propylene glycol, 1% glacial acetic acid and 0.01% detergent (Weir pers. comm, James pers. comm.). Each site was sampled continuously for 72 hours, after which the samples were sieved and washed into specimen jars containing 70% alcohol. Each pit sample was kept separate. Pits were fitted with sandfilled inserts between trips to prevent accidental deaths.

Samples were collected in Summer, Autumn and Spring over two years finishing in August 1994. After the initial selection of sites, a local resident Marion Hill became responsible for the sampling program. Ms Hill established the sorting and processing techniques and initiated the reference collection. Jeannette van der Lee (University of New England) processed the samples, finished the reference collection and entered the data to a database.

Samples were sorted by trip and site. Each pit was sorted separately with specimens taken to morphotype for all groups except ants. Reference specimens were removed for each morphotype and an individual number assigned for each morphotype within a taxon. The frequencies of occurence for each morphotype per pit were tabulated. Biomass of morphotypes was determined by oven-dry weights from Trip 3 to Trip 6. Morphotypes were also recorded in size classes. The extremely large numbers of ants precluded sorting to morphotype and they were sorted only into size classes. The frequencies of ants of each size class per pit were recorded. ANOVA was used to test for significant differences between sites (Zar, 1974; Statistix, 1990).The reference collection is currently held at the University of New England.

3.0 Results

3.1 Mulgara distribution

3.1.1 Elliott box trapping

Four sites UNP111, 112, 1131, and 1132 were located on the transitional sandplain where mulgaras were known to reside. The remaining eleven sites were selected at increasing distances away from the known mulgara area (Fig. 14).

Table 5 presents the percentage trap success for mulgaras captured during the study and in the pilot program in 1989.

Table 5: Mulgara percent trap success

Site	date	No. trap nights	% trap success
Bus Sunset Viewing Area	May 1989	300	0.3
Bus Sunset Viewing Area	Dec. 1989	300	3.0
Ranger stn	April 1989	450	0.0
UNP111	March 1991	75	1.3
UNP112	March 1991	75	4.0
UNP1131	March 1991	75	0.0
UNP1132	March 1991	75	4.0
UNP114	March 1991	75	5.3
UNP115	March 1991	75	2.6
UNP116	March 1991	75	0.0
UNP117	March 1991	75	0.0
UNP114	July 1991	75	2.6
UNP128	July 1991	75	1.3
UNP129	July 1991	75	1.3
UNP1210	July 1991	75	0.0
UNP1211	August 1991	75	0.0
UNP1212	August 1991	75	0.0
UNP1213	August 1991	75	0.0
UNP1214	August 1991	75	0.0
Total number of mulgaras captured = 27 plus 3 recaptures, (recaptures were not included in calculation of % trap success).			

Mulgaras were captured on all sites on the transistional sandplain except for UNP1131. The next closest sites outside the transitional sandplain, UNP115 and UNP114, also returned captures. On the next furthest sites UNP116, 117 and 129, only one mulgara was captured on (UNP129). Apart from captures of mulgaras at the Bus Sunset Viewing Area, no other traplines placed at distances from the borefield yielded mulgara captures.

Table 6 presents the biological data collected from the captured mulgaras.

Table 6: Weights and breeding condition of captured mulgaras.

Site	date	Wt (gms)	Sex (m/f)	Breeding condition
b/sunset	May 1989	81	F	non-parous adult
b/sunset	Dec. 1989	-	-	escaped
		49	F	sub-adult
		66	M	testes 6.5mm
		75	F	6 nipples lactating
		59	F	sub-adult
		42	F	sub-adult
		49	F	sub-adult
		55	F	sub-adult
		52	M	testes 8.4mm
UNP111	March 1991	-	M	adult,tail incrassated
UNP112	March 1991	-	F	pouch closed, fully furred, tail incrass.
UNP1132	March 1991	-	M	adult, tail incrassated
UNP1132	March 1991	-	F	6 nipples not used,tail incrassated
UNP1132	March 1991	-	F	Adult
UNP114	March 1991	90	F	6 nipples, 4 used,tail incrassated
UNP114	March 1991	110	M	adult,tail incrassated
UNP114	March 1991	60	F	adult non-parous, tail incrassated
UNP114	March 1991	100	M	adult, tail incrassated
UNP115	March 1991	130	M	adult, tail incrassated
UNP115	March 1991	100	M	adult, tail incrassated
UNP114	July 1991	67	F	Ad. non-par. hairy/pouch, tail sl.incrass
UNP114	July 1991	46	F	Ad. non-par.,v. thin; not incrassated
UNP128	July 1991	51	M	Adult very thin, tail not incrassated
UNP129	July 1991	67	M	Adult very thin, tail not incrassated

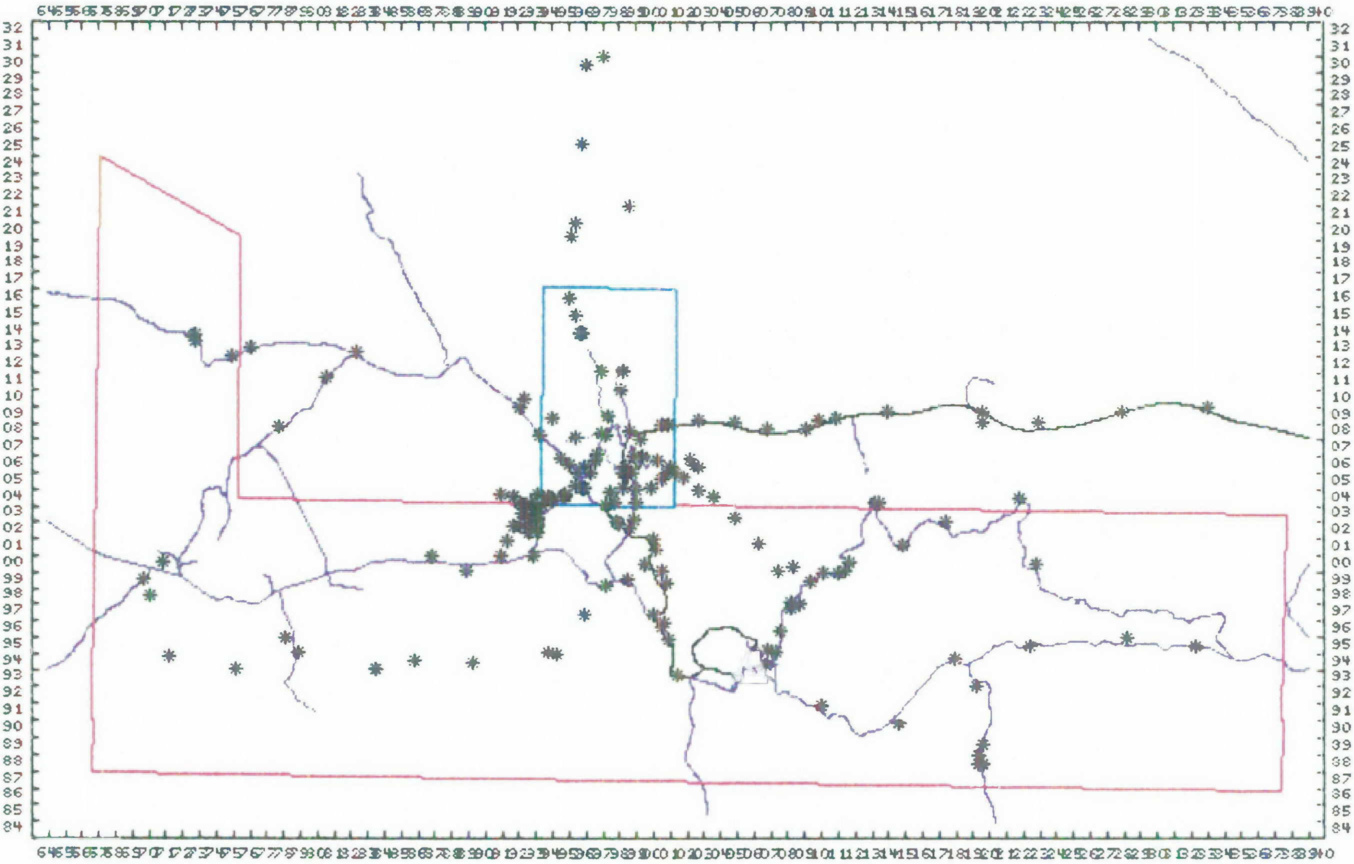
Reported adult weights for mulgaras are between 75and 170 gm for males and 45 and 95 gm for females (Woolley, 1983; Masters, pers. comm.). Table 6 suggests that all of the animals caught at Bus Sunset Viewing Area during December 1989 were sub-adults except for one adult female. These data conform with Masters reporting captures of females with pouch young in August 1989 and females with independent young by September to October (Masters, pers. comm.). Masters noted that 1989 was a good year for breeding for mulgaras due to the previously good rainfall years of 1987 and 1988. The sub-adults may have been dispersing from the main population.

Adult mulgaras caught in July 1991 were in the sub-adult weight range, and were in very poor condition with their tails not incrassated. This could have been a response to 1990 and 1991 being dry years and the consequent lack of food resources.

3.1.2 Searches for mulgara sign

Two hundred and fifty nine sites were surveyed for mulgara sign during the study, with 41 sites surveyed in 1991, 152 sites in 1992, 31 sites in 1993 and 34 sites in 1994. Figure 15 presents the sites searched from 1991 to 1994. Figure 16 shows the total mulgara sign recorded in 1992 after two dry years, while Figure 17 focusses on the distribution of fresh mulgara burrows from 1991 to 1994 (including dry and wet

Figure 15: Sites searched for mulgara sign and predator sign (1991-1994)



MAP : 15:Sites searched for mulgara and predator sign (1991-1994)

SCALE = 1:

TICKMARK INTERVAL = 1000 metres

— SEALED ROADS

— UNSEALED ROADS

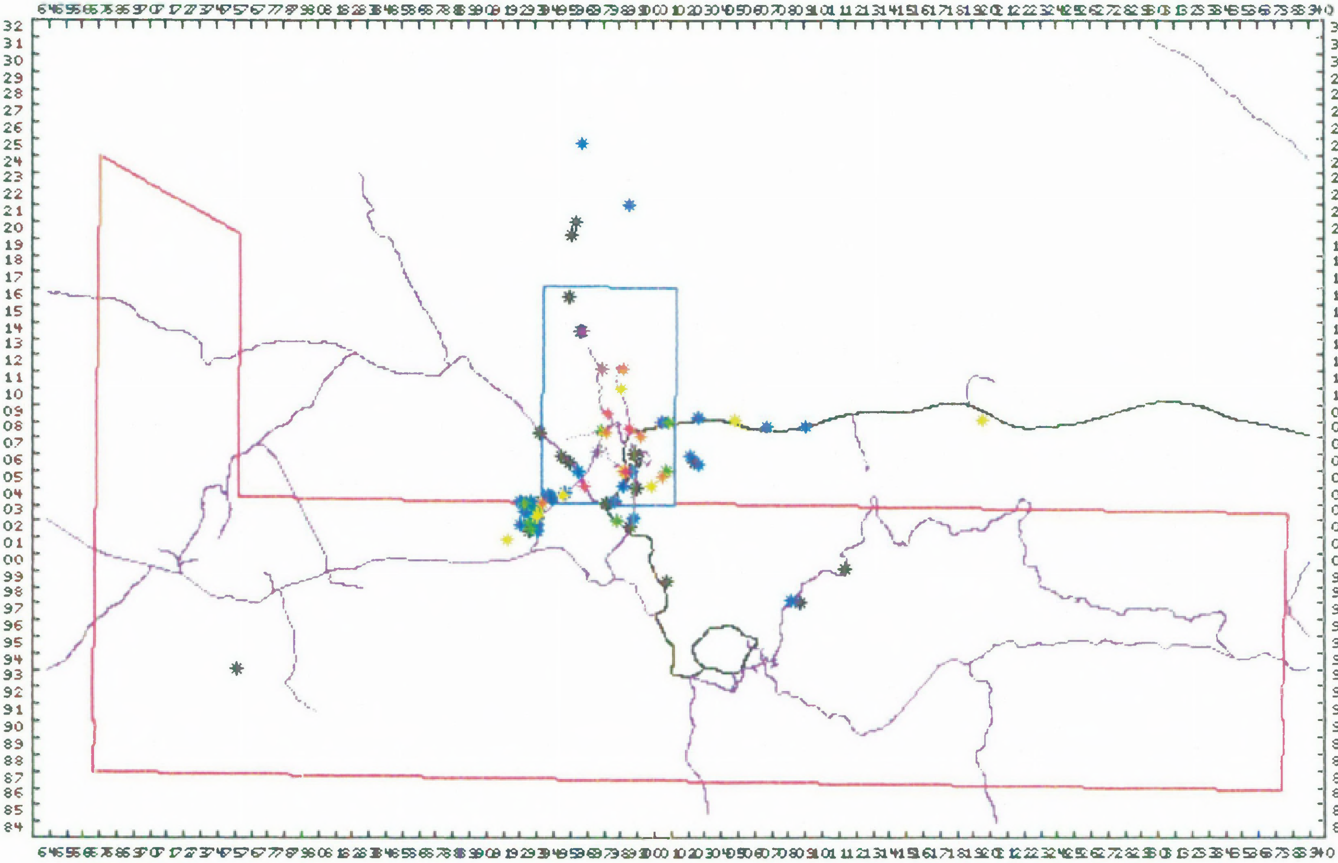
..... TRACKS

— ULURU PARK BOUNDARY (dig)

— YULARA TOWN LEASE (DIG)

* Sites sampled

Figure 16: Total mulgara sign detected on sites sampled in 1992



MAP : 16:Total mulgara sign detected
on sites sampled in 1992

SCALE = 1:

TICKMARK INTERVAL = 1000 metres

— SEALED ROADS

— UNSEALED ROADS

···· TRACKS

— ULURU PARK BOUNDARY (dig)

— YULARA TOWN LEASE (DIG)

* 1 total sign

* 2-5 total sign

* 6-10 total sign

* 11-15 total sign

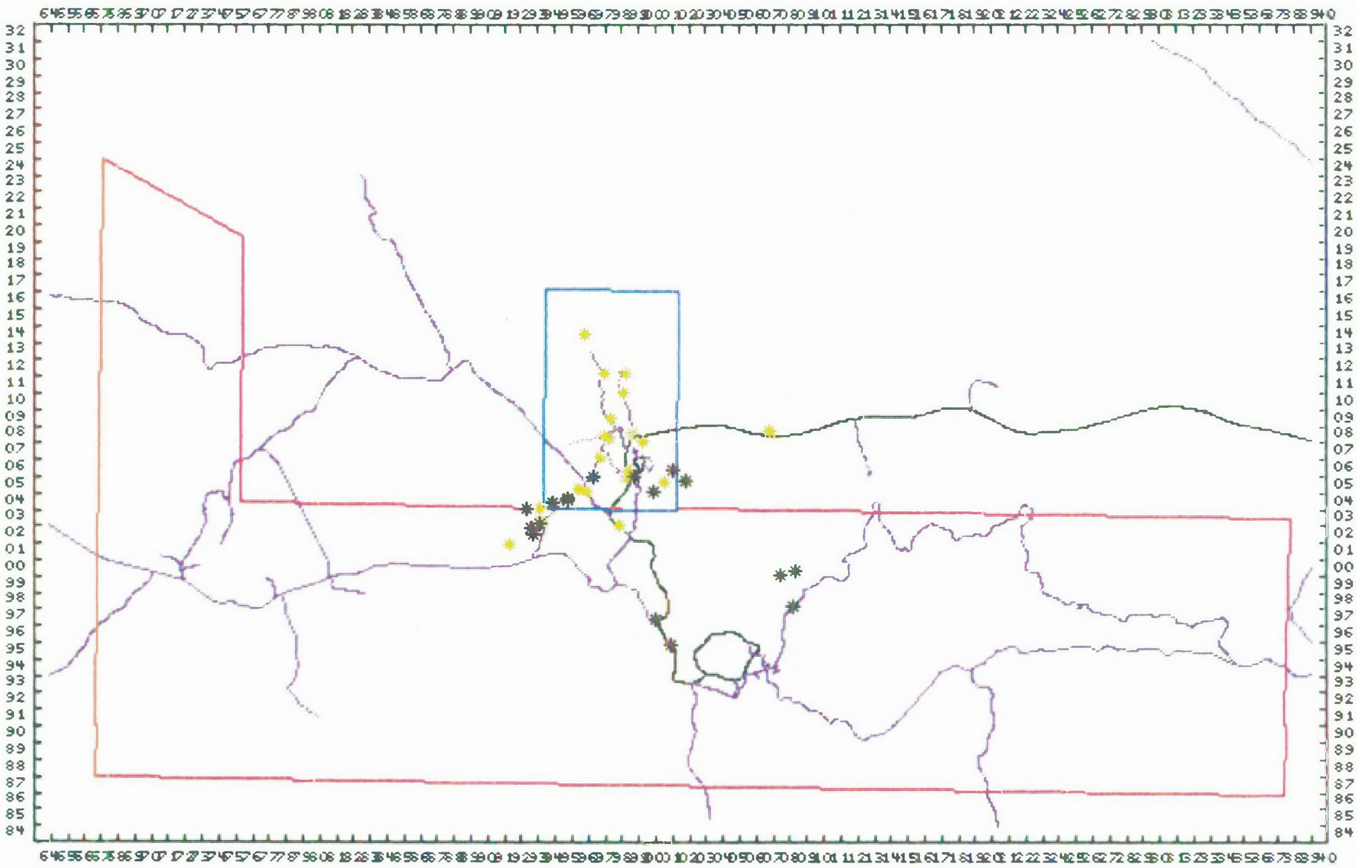
* 16-20 total sign

* 21-25 total sign

* 26-30 total sign

* 31-35 total sign

Figure 17: Fresh mulgara burrows detected on sites sampled over the study period (1991-1994)



MAP : 17:Fresh mulgara burrows
on sites sampled 1991-1994

SCALE = 1:
TICKMARK INTERVAL = 1000 metres
— SEALED ROADS
— UNSEALED ROADS
TRACKS
— ULURU PARK BOUNDARY (dig)
— YULARA TOWN LEASE (DIG)
* 1991-1994 >=2 Fresh burrows
* 1991-1994 1 Fresh Burrow

years). A comparison of Figures 16 and 17 demonstrates an expansion of fresh activity outside the area supporting mulgaras in 1992.

Of the 44 sites sampled more than once during the study, some were sampled twice while others, such as the invertebrate study sites and Foulkes' and Masters' trapping sites, were sampled on three or four occasions. The numbers of sign recorded on different dates for each site were analysed using a one-way analysis of variance. A significant increase in the amount of sign was recorded on Foulkes' G1-G5 grid line ($p<0.005$ for fresh sign, $p<0.05$ for total sign). All other sites showed no statistically significant change in the amount of sign recorded. Most sites were sampled in 1992 and 1993 with some surveyed again in 1994. On the edge of the mulgara population's distribution such as the Bus sunset viewing area and UNP 927, no presence of mulgaras was detected during one survey, while low levels of sign were detected on subsequent surveys and vise versa suggesting that mulgara inhabited these sites intermittently. On twelve sites repetitively surveyed outside the known mulgara distribution no sign of mulgaras was detected over the four year-study period.

3.1.3 Comparison of mulgara sign and Elliott trap captures

To assess whether there was a relationship between trap success and numbers of sign detected, I searched for mulgara sign on sites at the same time that they were being trapped by Masters and Foulkes.

I surveyed Foulkes' grids three times and Masters' sites twice. Masters trapped each site for 600 trap nights and had 8 lines of 25 traps. I recorded sign of mulgara by searching between sets of two lines over a 20 minute period giving a total of 4 searches per site. Foulkes trapped for 150 trap nights per grid and I conducted 20 minute searches within each grid. The results from this study were analysed using Rank Spearman Correlations. A positive relationship was found to exist between the number of mulgaras caught in Elliott traps and the abundance of mulgara sign recorded (r_s 0.2331, $p<0.05$).

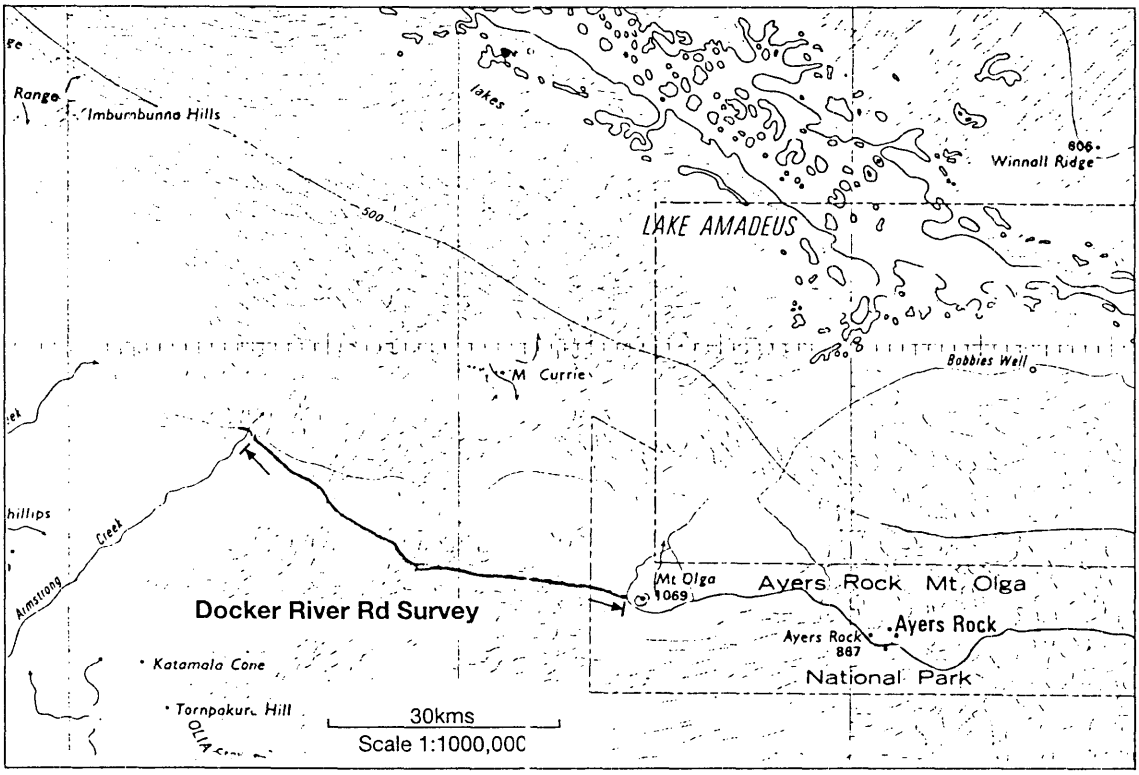
3.1.4 Docker River Road sites

In August 1992, an additional eight sites were surveyed along the Docker River Road west from Kata Tjuṯa to Karu Nyiṯayira (Armstrong Creek) a distance of 63.4 km (Fig. 18). Mulgara sign was recorded over a distance of 43.4 km with freshly dug burrows located within a 38 km section. Table 7 presents a summary of current and fresh sign recorded per site.

Table 7: Mulgara sign on Docker River Road to Armstrong Creek

Dist. fm K.Tjuta (km)	*Current Mulgara Sign*	*Fresh Mulgara Sign*	*Total Mulgara Sign*
77.1	0	0	0
63.4	1	0	1
62	1	0	1
59.4	0	0	0
54.2	1	3	4
24	2	4	6
20	3 disused	0	3
19.1	0	0	0
<19 mulga plains	0	0	0

Figure 18: Docker River road survey area



3.2 Introduced predators and herbivores

Figures 19 to 21 present the distributions of signs of dingo, cat and fox recorded in 1992 after 2 dry years. The potential relationship between mulgaras and predators was assessed by comparing the number of total mulgara sign and the number of signs of each of the predators per site over 174 sites. A positive relationship was identified between the number of total mulgara sign and the number of dingo sign ($p<0.001$), but no relationship was found between mulgaras and cats or mulgaras and foxes. There also appeared to be no association between mulgaras and rabbit numbers. There were however positive correlations between cat and dingo ($p<0.001$), cat and fox ($p<0.001$), and rabbit and fox ($p<0.01$).

To further explore the positive relationship identified between mulgaras and dingoes, and the apparent lack of relationship between mulgaras and cats and foxes, a series of Poisson regressions was tested to determine which predator or rabbit attributes best explained the variation in number of total mulgara sign detected per site. The number of dingo sign was again the only attribute which contributed significantly to the number of mulgara sign detected.

The best-fit Poisson regression model was:

$$\text{Total mulgara sign} = 2.543 - 1.578 \text{ Invdingo}$$

The dingo sign data were inversely transformed to reduce skewness and contributed significantly to the equation ($p<0.001$) with a deviance of 693.59 and 78 degrees of freedom. The Wilk-Shapiro index was 0.837 indicating that assumptions of normality were not violated by the equation.

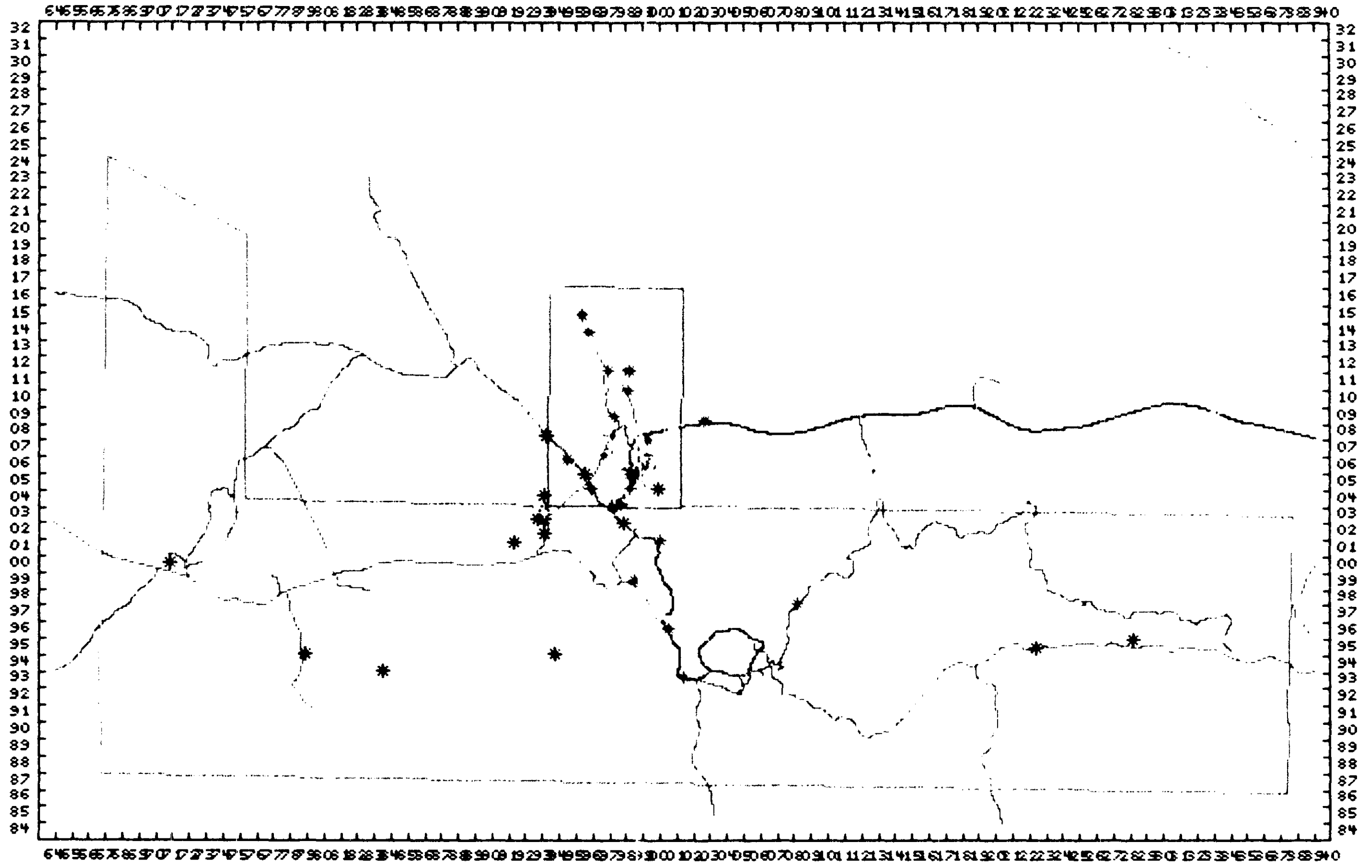
The regression equations and the Spearman Rank Correlations indicated that there is significant positive spatial association between mulgaras and dingoes within the study area. The positive nature of the associations suggest that dingoes are living in association with mulgaras and appear to not be a limiting factor on the mulgara population.

3.3 Habitat assessment

3.3.1 Geographical Information System: E-RMS

Log-likelihood ratio tests were used to investigate the association between the frequency of mulgara sign and individual habitat parameters. Some habitat variables have been incompletely mapped within the GIS, which limits the interpretation of these analyses. However, the models generated by E-RMS still provide valuable insight into the pattern of mulgara distribution within the Park and adjacent areas.

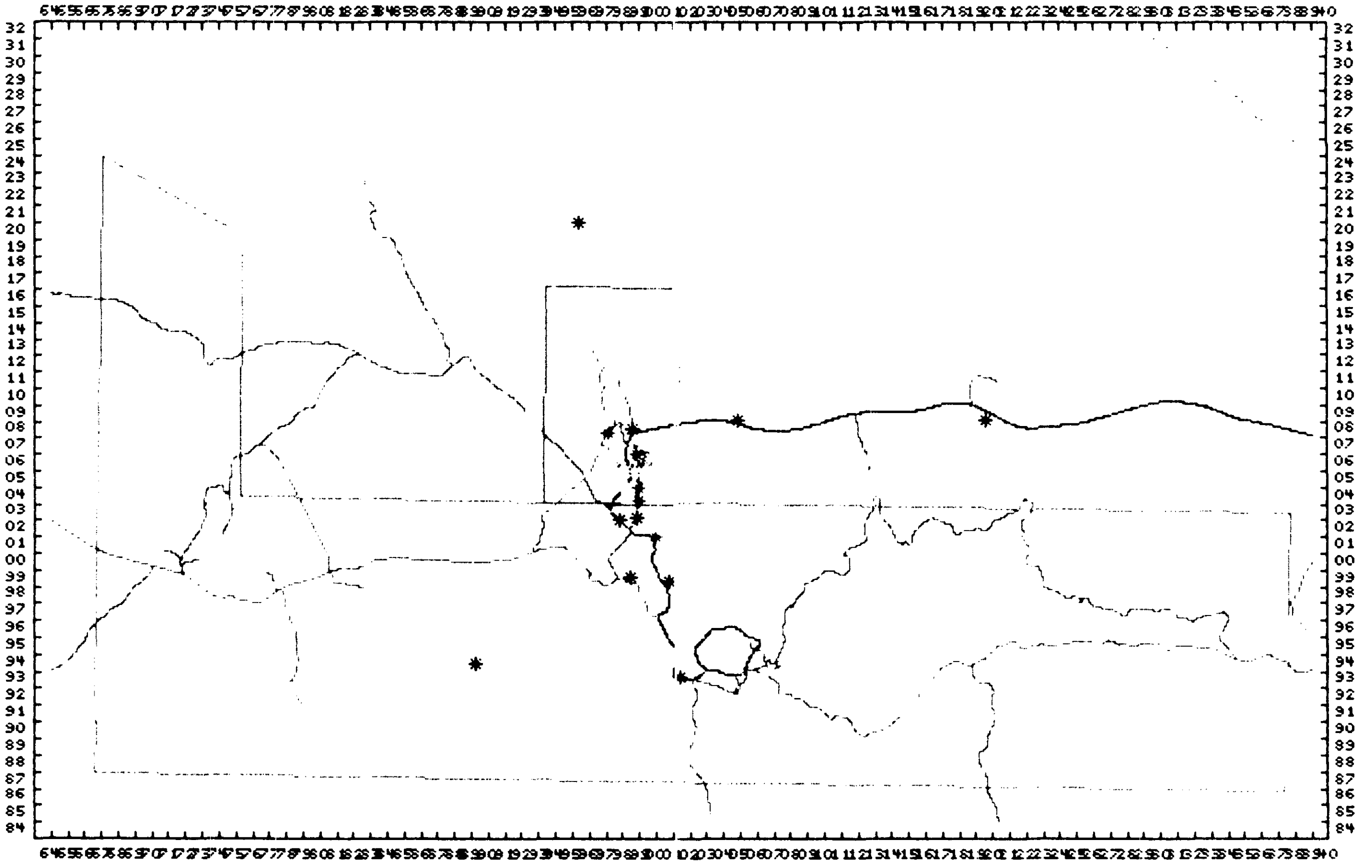
Figure 19: Dingo sign detected on sites sampled in 1992



MAP : 19: Dingo sign detected on
sites sampled in 1992

SCALE = 1:
TICKMARK INTERVAL = 1000 metres
— SEALED ROADS
— UNSEALED ROADS
TRACKS
.. ULURU PARK BOUNDARY (dig)
— YULARA TOWN LEASE (DIG)
* 1 sign
2 sign
+ 3 sign
+ 4 sign
5 sign
6 sign
. 7 sign
* 8 sign
* 9 sign
+ 10 sign

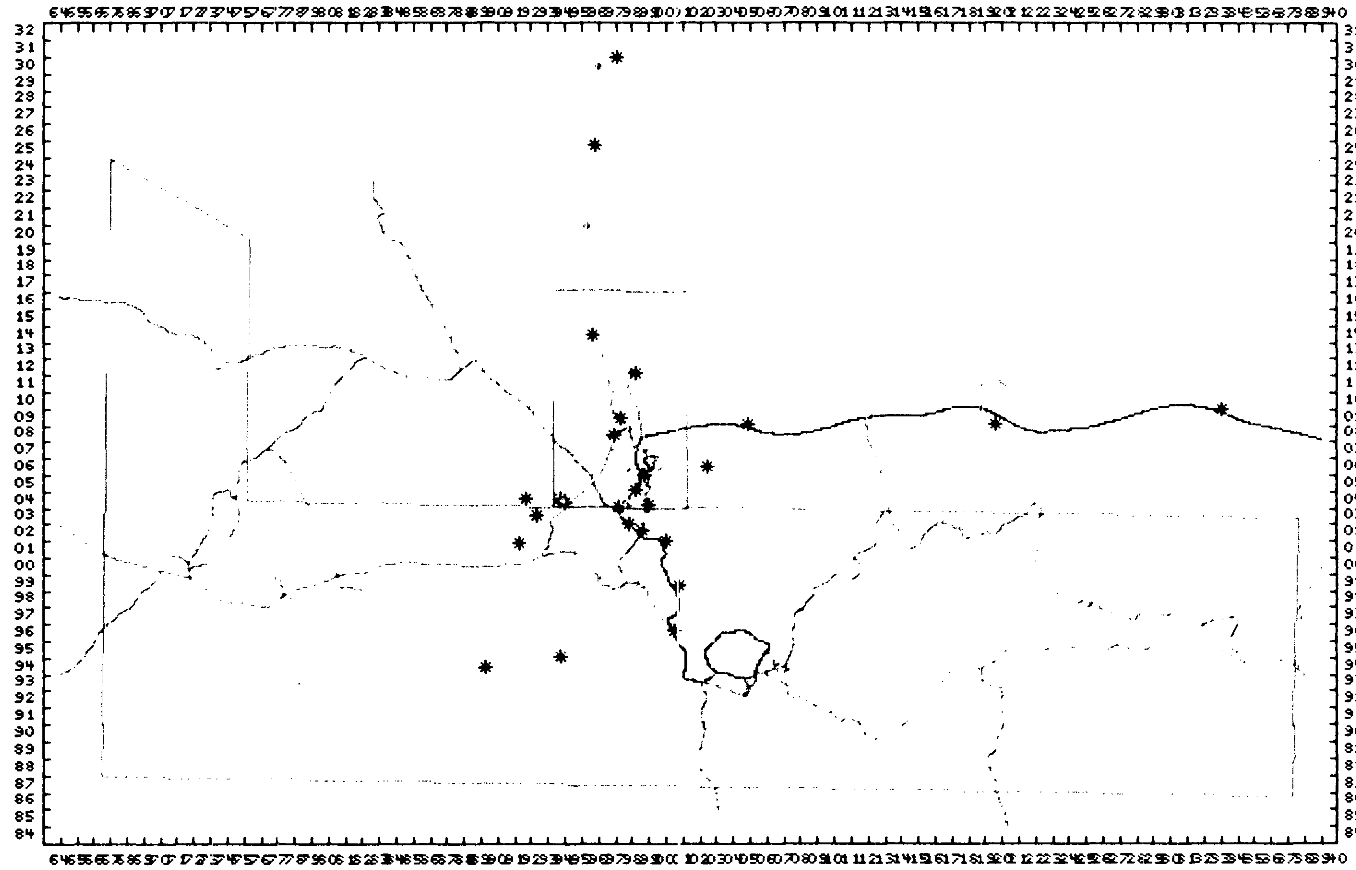
Figure 20: Cat sign detected on sites sampled in 1992



MAP : 20:Cat sign detected on
sites sampled in 1992

SCALE = 1:
TICKMARK INTERVAL = 1000 metres
— SEALED ROADS
— UNSEALED ROADS
TRACKS
... ULURU PARK BOUNDARY (dig)
— YULARA TOWN LEASE (DIG)
* 1 sign
+ 2 sign
3 sign
+ 4 sign
5 sign
• 6 sign
* 7 sign
* 8 sign
+ 9 sign
10 sign

Figure 21: Fox sign detected on sites sampled in 1992



MAP : 21:Fox sign detected on sites sampled in 1992

SCALE = 1:

TICKMARK INTERVAL = 1000 metres

— SEALED ROADS

UNSEALED ROADS

TRACKS

ULURU PARK BOUNDARY (dig)

YULARA TOWN LEASE (DIG)

* 1 sign

2 sign

3 sign

4 sign

5 sign

6 sign

7 sign

8 sign

9 sign

10 sign

Table 8: Log-likelihood association between total mulgara sign and habitat parameters

VARIABLE	1991	1992	1993
landunit	sig.p<0.05	sig.p<0.001	sig.p<0.001
vegetation	not sig.	sig.p<0.001	sig.p<0.001
terrain	sig.p<0.01	sig.p<0.001	sig.p<0.001
fire history	sig.p<0.05	sig.p<0.001	sig.p<0.001
land tenure	sig.p<0.001	sig.p<0.001	not sig.
geology	not sig.	not sig.	not sig.
surf.aquifers	sig.p<0.01	sig.p<0.001	sig.p<0.001
water chemistry	sig.p<0.05	sig.p<0.01	sig.p<0.001
hydrodynamics	sig.p<0.001	sig.p<0.001	sig.p<0.001

Sites surveyed in 1994 have not been included in Tables 8 as many were situated on the Lasseter Highway which had incomplete coverage of habitat variables within E-RMS. Landunit, vegetation, terrain, fire history, ground water chemistry, the hydrodynamic profile and the surficial aquifers are all found to be significantly asssociated with the presence of mulgaras.

Certain categories within each of the habitat parameters contributed more significantly than others to the association with mulgara sign and are presented below:

- Land unit - Mulgara sign was significantly associated with the transitional sandplains, parallel dune systems and the sandy loam plains.
- Vegetation - Mulgara sign was significantly associated with *Triodia basedowii* and mulga woodland. There was a negative association with *Triodia pungens*.
- Terrain - Mulgara sign was significantly associated with sandplains and plains, and negatively association with dunefields.
- Land Tenure - Mulgara sign was significantly associated with Yulara, and after 1991 had a negative association with Uluru National Park due to loss of available habitat through fire.
- Fire History - Mulgara sign was significantly associated with 1976 fires and management burns from 1982, 1986 and 1989. In 1993 there was a strong positive association with 1986 burns. Mulgara sign was negatively associated with pre-1976 aged spinifex.
- Surficial aquifers - Mulgara sign was positively associated with surficial aquifer.
- Ground water chemistry - Mulgara sign was predominantly associated with sections of the aquifer in which the water contained 400-1500 bicarbonate-chloride mg/L

dissolved solids. This is the fresher water which occurs close to the hilly recharge areas and in the calcrete (Jacobson *et al.*, 1989).

- Hydrodynamics - There was a positive association between mulgara sign and the 480-500m contour of the aquifer.

A baseline model of preferred mulgara habitat can be generated from a combination of the habitat attributes found to be significantly associated with the presence of mulgaras. This model would include:

- Transitional sandplains, sandy loam plains and to a lesser extent parallel dune systems.

- *Triodia basedowii* or mulga over *T. basedowii*.

- A preferred spinifex age of between 7-16 years since burning (depending on cumulative rainfall (Griffin, 1984)).

- The presence of the surficial aquifer, particularly where the water contained 400-1500 mg/L of the bicarbonate-chloride ionic group of dissolved solids.

Due to the loss of habitat within the Park area through the 1991 fires, this preferred habitat currently predominately lies within the boundaries of the Yulara lease area. The model was derived by examining the influence of individual habitat attributes on the number of mulgara sign detected. This provided the baseline from which to consider a model where the effect of the inter-relationships of the habitat attributes on mulgaras was considered. The predictive modelling module within E-RMS (NSW NPWS) was used, as described in the methods, to develop a model of core mulgara habitat based on the cumulative effect of all of the habitat parameters.

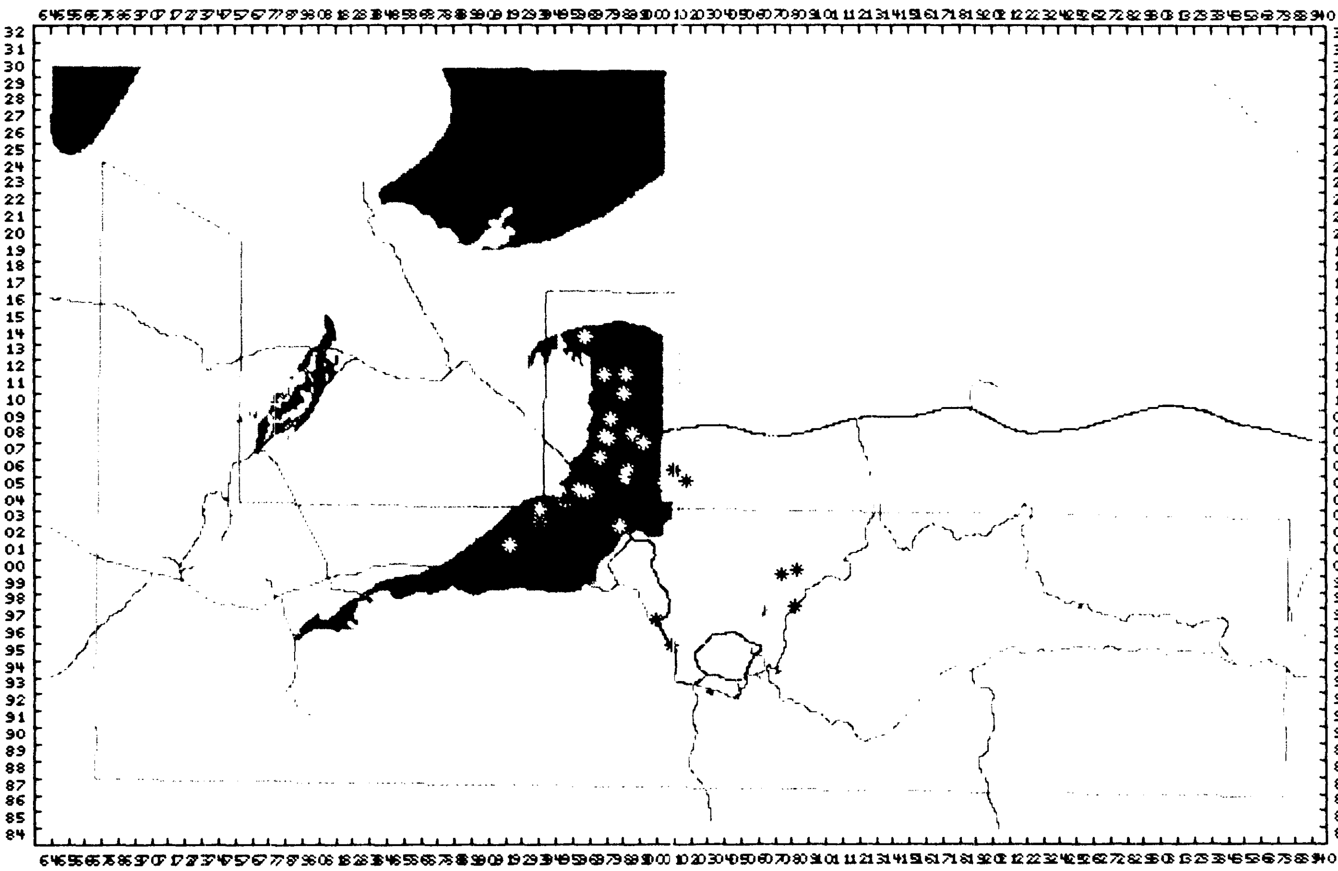
The resulting model for predicted core mulgara habitat combined:

- sandy loam soil;
- transitional sandplain;
- broad swaled dune systems;
- *Triodia basedowii;*
- and presence of the surficial aquifer.

This model presents a tighter subset of the combined habitat attributes as important to mulgaras than presented in the previous model based on assessing the influence of individual habitat attributes. The locations of areas which matched this model of core habitat were mapped using E-RMS and are presented in Figure 22.

The distribution of fresh mulgara burrows recorded during the survey is overlain on the core habitat areas predicted by the model. One of the areas identified as core habitat by the model overlies the area of highest numbers of mulgara sign recorded during the study. Only three records of a single fresh burrow were recorded outside the predicted

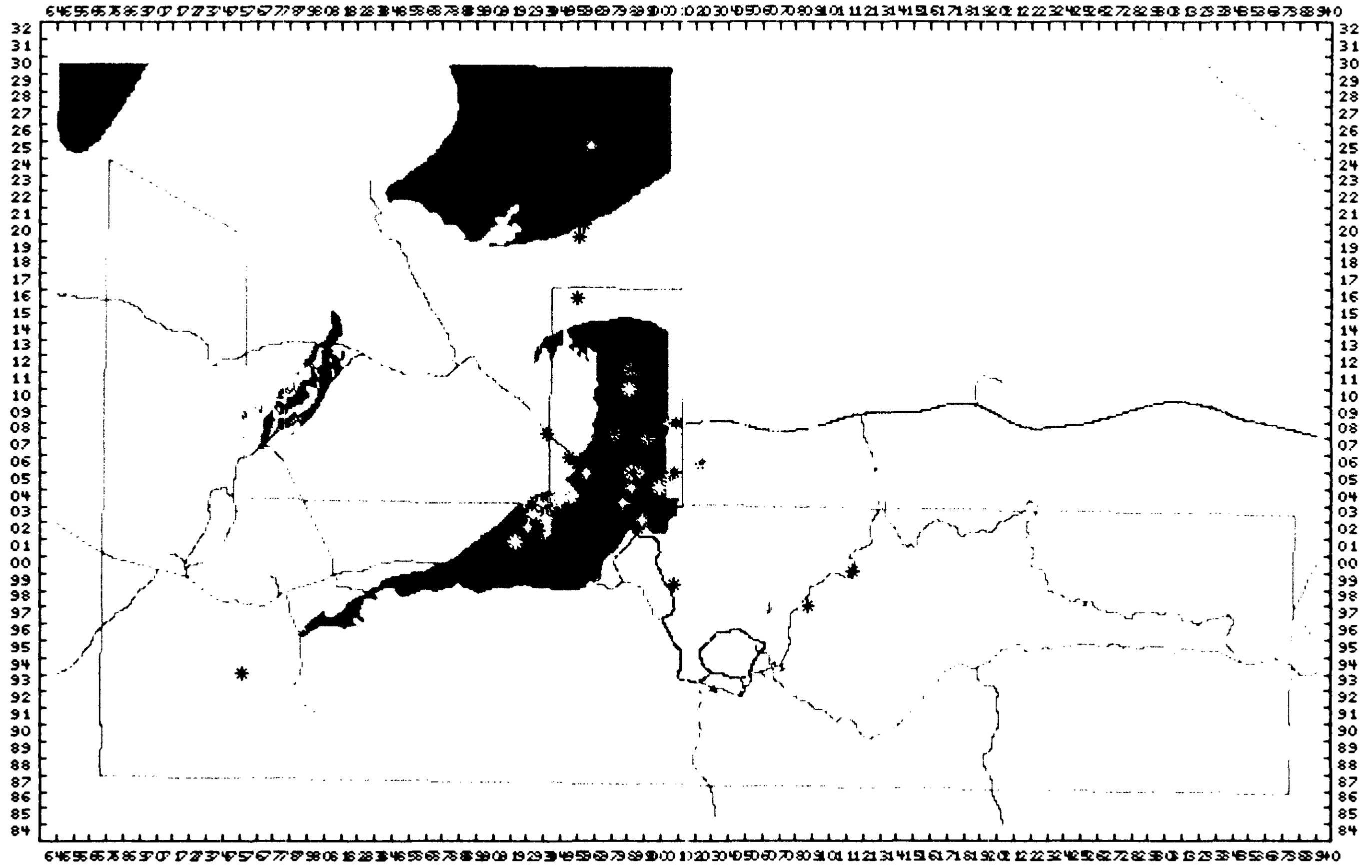
Figure 22: Predictive model of core mulgara habitat (E-RMS derived) with fresh mulgara burrows detected on sites sampled from 1991 to 1994.



MAP : 22:Predicted core mulgara habita
with fresh burrows sampled 1991-

SCALE = 1:
TICKMARK INTERVAL = 1000 metres
— SEALED ROADS
... UNSEALED ROADS
TRACKS
. ULURU PARK BOUNDARY (dig)
-.. YULARA TOWN LEASE (DIG)
1991-1994 >=2 Fresh burrows
* 1991-1994 1 Fresh Burrow
■ Core Mulgara Habitat

Figure 23: Modelled core mulgara habitat with total mulgara sign sampled in 1992



MAP : 23:Predicted core habitat
with 1992 total mulgara sign

SCALE = 1:

TICKMARK INTERVAL = 1000 metres

— SEALED ROADS

UNSEALED ROADS

TRACKS

ULURU PARK BOUNDARY (dig)

YULARA TOWN LEASE (DIG)

* 1 total sign

2-5 total sign

+ 6-10 total sign

11-15 total sign

16-20 total sign

21-25 total sign

+ 26-30 total sign

* 31-35 total sign

Core Mulgara Habitat

core habitat: one at the Bus Sunset Viewing Area in 1993 and two near the Tuit Track in 1994. These sites were only occupied after good rains. Sites to the east of Yulara would be inside the core habitat but, because of the lack of mapped land-units in this area, were not adequately accounted for in the model.

Figure 23 presents the modelled core mulgara habitat overlain by the total mulgara sign recorded in 1992. The main point of contrast with the previous figure is the small amount of non-fresh sign recorded in the predicted habitat to the north of Yulara and one record south of Kata Tju<u>t</u>a. Figure 24 shows the currently available core mulgara habitat, which has been substantially reduced in the short-term due to fires which have occurred since 1988.

Fire history affected whether the habitats identified by the model would be currently supporting mulgara. The only large area of core habitat that has been unaffected by recent fires is the Yulara bore field region. The 1989 wildfire burnt out the area to the north (on the Lake Amadeus track); the area northwest of the Park boundary towards Mt Currie was also burnt in 1989. Neither of these areas had been searched for mulgaras prior to the fires. The unburned area on the Lake Amadeus road has been searched but the spinifex was either very old or the regrowth too young to support mulgaras. The corner of the Valley of the Winds Road and old Docker River road has also been burnt by three fires in 1984 and 1989. This site was searched in 1991 but no mulgara sign was found.

Two small areas around Ulu<u>r</u>u were selected by the model as core mulgara habitat. The predicted core habitat on the Tuit Track is very close to site where mulgara sign was recorded during the study. The other predicted core habitat behind the ranger station used to support mulgara according to A<u>n</u>angu but in 1991 was considered to be unsuitable as the spinifex was too senescent or had been recently burnt. Mulgara sign was sighted by A<u>n</u>angu south of the ranger station in the latter part of 1994 (Hill pers. comm.) in an area of regrown spinifex.

3.3.2 Habitat assessment based on site data

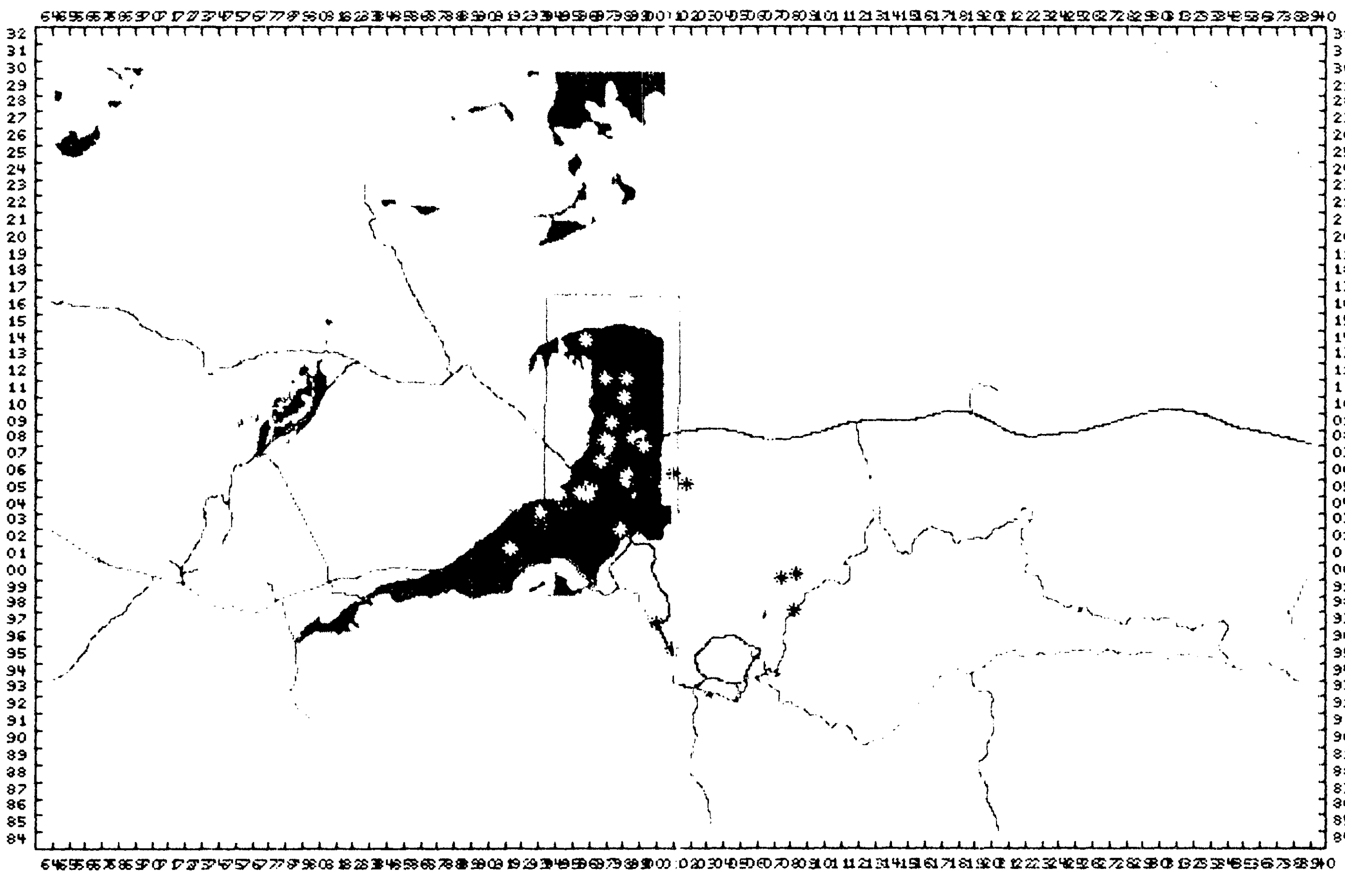
To ground-truth the models generated through E-RMS, 190 sites were sampled for mulgara sign and habitat characteristics. Explanations for the variation in the number of mulgara sign per site were sought by running Poisson regressions with combinations of habitat variables. Sites on which more than 20 mulgara sign were detected were treated as outliers and omitted from the analyses.

The best-fit Poisson regression for total mulgara sign was:

> Total mulgara sign = -1.42 + 1.01 aquifer + 1.49 *T. basedowii* + 0.80 10-20yrs since fire + 1.11 mix of 0-10 yrs and 10-20 years since fire

Deviance of 659.58, with 177 degrees of freedom and $p<0.001$. All variables contributed significantly to the equation at $p<0.001$.

Figure 24: Remnant modelled core habitat from fires burnt since 1988



MAP : 24:Remnant modelled habitat
from fires burnt since 1988

SCALE = 1:

TICKMARK INTERVAL = 1000 metres

— SEALED ROADS

... UNSEALED ROADS

TRACKS

ULURU PARK BOUNDARY (dig)

YULARA TOWN LEASE (DIG)

1991-1994 >=2 Fresh burrows

* 1991-1994 1 Fresh Burrow

█ Core habitat minus recent fires

The best-fit Poisson regression for fresh mulgara sign was:

> Fresh mulgara sign = -2.16 + 1.89 aquifer + 1.31 *T. basedowii* - 2.39 20-30 yrs since fire

Deviance of 437.73, 178 degrees of freedom and $p<0.001$. All variables contributed significantly to the equation at $p<0.001$, except for 20-30 yrs since fire ($p< 0.005$).

Regressions for both total and fresh mulgara sign highlighted the presence of the aquifer, *T. basedowii* and the fire age as being the most influential factors affecting the number of mulgara sign recorded. Both regressions indicated the importance of an appropriate fire regime, with a preference for spinifex that has regrown from fire around 10-20 years previously, or a mixture of this age group and a younger successional stage of between 0-10 years since fire. However, areas with a single age class within the 0-10 years since fire were found not to be suitable, nor were older spinifex communities which remained unburnt for over 20 years. The models generated by these regressions complement those generated through the E-RMS.

3.3.3 Fire history

Ninety spinifex sites with a range of fire histories were assessed for the effect of fire age on mulgara habitat selection. The field work was carried out in 1992. Spinifex that had been burnt in 1976 and between 1982 and 1986 respectively supported the highest percentage of mulgara sign at 69% and 64% respectively. Only 8% of the sites burnt in 1950 had mulgara sign, compared to 22% of sites burnt after 1986. A one-way ANOVA was used to compare the number of mulgaras found in spinifex burnt in 1950, 1976, 1982-1986 and after 1986. There was a significant difference in the number of mulgara sign found on sites with different fire ages ($p<0.001$).

Spinifex hummock growth form is affected by time since burning and rainfall, and was assessed as an indicator of a site's fire history. Seven classes of form were defined in Chapter 4. The forms of ten hummocks at each of 90 sites were recorded. Abundance of mulgara sign was compared to the mean frequency of each of the forms of spinifex using a Spearman Rank Correlation corrected for ties. Negative correlations were found between mulgara sign and seedlings, stoloniferous spinifex and empty-centred rings ($p<0.001$). A positive correlation was found with well-formed hummocks (class 3) and hummocks starting to form rings (class 4) ($p<0.001$). No correlation was found between mulgara sign and young, small hummocks.

Class 3 and 4 growth stages were found in spinifex burnt in 1976, while class 2 was found in spinifex burned between 1982-6. These results are consistent with the data provided in the analysis of fire age in Section 3.2.2.

3.3.4 Percentage vegetation cover

Thirty one of the sites surveyed for mulgara in 1992 were assessed for percentage cover of vegetation. Percent cover values for spinifex, dead spinifex, non-spinifex ground cover and shrubs were calculated along with height classes, classes of continuous spinifex cover and continuous bare ground.

The number of mulgara sign was positively associated with percent spinifex cover ($p<0.05$) and negatively associated with non-spinifex ground cover and shrub cover ($p<0.05$) using Spearman Rank Correlations. Mulgaras also appeared to have a preference for spinifex hummocks that were either less than or equal to 1m in width ($p<0.05$) but were negatively associated with 4m continuous open space ($p<0.05$).

The best regression model to describe abundance of mulgara sign was

Total mulgara sign = -2.944 + 0.464 [6 m bare ground] + 0.060 [<1 m diam hummock]

Deviance for the regression was 132.64 and significance was $p<0.0001$. The individual components contributed significantly to the equation at $p<0.001$. The Wilk-Shapiro index was 0.91.

These analyses indicate a preference by mulgara for spinifex hummocks less than or equal to 1 m in diameter with clear open spaces between each hummock, and confirmed the associations generated by the Spearman Rank Correlations.

3.3.5 Vegetation height classes

Height classes of spinifex hummocks, shrubs and trees were compared with the abundance of mulgara sign to ascertain whether mulgara are showing a preference for particular height classes. A negative correlation between total mulgara sign and low shrubs, i.e. between 0.76 and 1 m in height ($p<0.05$), was the only significant association. Mulgaras habitat selection appeared not to be affected by the height or ground, shrub or tree cover except for the negative association with low shrubs. This association may be related to fire history and reflect the dominance of low shrubs such as *Thryptomene* sp. and subsequent loss of spinifex in very old unburnt communities.

3.4 Invertebrates

Invertebrate samples for each site were sorted to morphotypes as described in section 2.5. The final reference collection was identified to Order based on CSIRO (1991). A total of 23 identifiable Orders and two unknown groups were identified and the numbers of morphotypes within each order or group are presented in Table 9.

Table 9: Numbers of morphotypes collected and separated within each Order/group from the whole invertebrate sample (all sites; all collections).

Collembola (springtails)	3	Embioptera (web spinners)	1
Diptera (flies)	99	Mantodea (praying mantids)	9
Coleoptera (beetles)	74	Araneida (orb-web spiders)	161
Coleoptera larvae	1	Acrididae (grasshoppers)	49
Scorpionida (scorpions)	6	Thysanura (silverfish)	26
Orthoptera (grasshoppers,crickets)	59	Isopoda (isopods)	2
Neuroptera (lacewings)	10	Blattodea (Cockroaches)	21
Isoptera (termites)	4	Hemiptera (bugs etc)	84
Chilopoda (centipedes)	5	Thysanoptera (thrips)	14
Lepidoptera (moths etc)	20	Pseudoscorpionida	9
Lepidoptera larvae	2	Hymenoptera (flying ants, wasps etc.)	147
Unknown larvae	26		
Unknown	20		

The numbers of orders and comparable groups recorded at all sites over the whole sampling period were compared to determine whether differences could be detected between sites with mulgaras (sites 1 and 2) and sites without (sites 3 and 4) (Table 10). The numbers of invertebrate Orders and groups found at each site and over the sampling period did not differ significantly between sites with and without mulgara based on analysis of variance (ANOVA).

Table 10: The number of Orders (and comparable groups) recorded at each site and trip.

Site	Trip1 November 1992	Trip2 March 1993	Trip3 August 1993	Trip4 December 1993	Trip5 April 1994	Trip6 August 1994
1	18	19	13	22	21	23
2	17	24	16	23	18	18
3	14	21	18	18	24	18
4	15	19	17	15	19	15

Mulgara sites (sites 1 and 2) and sites without mulgaras (sites 3 and 4) and trips were compared to determine whether there were significant differences in the number of morphotypes (Table 11) between sites or between seasons. There was a significant difference in the number of morphotypes sampled between seasons ($p<0.001$), but no difference between sites.

Table 11: The numbers of morphotypes collected per site over the sampling period.

Site	Trip1	Trip2	Trip3	Trip4	Trip5	Trip6
1	96	83	52	142	40	42
2	101	77	35	91	37	34
3	115	67	42	69	39	43
4	86	58	38	48	29	32

Changes in abundances of some individual Orders were also investigated by analysis of variance. Because the data set was large (over 1500 individual invertebrates), only a selection of the more common taxa [Coleoptera (beetles), Orthoptera (grasshoppers), Isoptera (termites), Pseudoscorpionida, Blattodea (cockroaches) and Hemiptera (bugs)] was considered in the analyses. No statistically significant differences were detected for any group between sites. Abundances of Coleoptera, Orthoptera, Blattodea and Hemiptera varied significantly between seasons ($p<0.005$); however, abundances of Isoptera and Pseudoscorpionida did not differ significantly.

Patterns in the size classes of invertebrates found at the four sites over time were investigated.There was a trend for larger (greater then 20 mm) invertebrates and invertebrates in the 10-15 mm size range to be collected more abundantly during the Summer of 1993, and a slight trend for invertebrates in the 15-20 mm size range to be collected more abundantly during the Summer of 1992 and Autumn of 1993. However, one-way analysis of variance tests found no significant differences in abundances for any classes either between sites or over the 6 trips.

The terrestrial ants (Hymenoptera) were too large a group to treat in the same fashion as the other taxa. The ants were therefore grouped into size classes and the abundance of individuals in each size class recorded. Analysis of variance on each size class found there was a significant difference in the abundance of ants less than 2 mm in size ($p<0.001$) and ants between 10 and 15mm ($p<0.05$) between sampling times. There were no other significant differences between sites or sampling times.

There was an overall trend for invertebrate composition and abundance to vary seasonally across all sites; however, no significant differences were identified between sites supporting and not supporting mulgaras.

4.0 Discussion

4.1 Mulgara distribution

One of the primary aims of the project was to locate major populations of mulgaras within Uluru National Park and adjacent areas. Mulgara sign recorded from 1991 to 1994 indicated that there was only one mulgara population located within the Park. This population is primarily located on the transitional sandplain and dunefields in the vicinity of Yulara and the adjacent borefield. The area occupied by this population is covered by three land tenures: Uluru National Park, Yulara lease and Aboriginal Land.

Research by Masters (pers. comm.) has indicated that this population is comprised of approximately 150 individuals.

The impact of fire on mulgara distribution was demonstrated by a patch burn within the Park in 1991 which burnt a substantial area including site UNP114 (opposite the Park entrance station). Prior to the fire 15 mulgara sign were recorded on this site but subsequently no further sign was recorded during the study. As a result of this patch burn a large portion of the core mulgara habitat within the Park has been temporarily removed, and the majority of mulgara are currently residing on the Yulara lease area and Aboriginal land. Fires to the north and east of Yulara over the past four years have further temporarily restricted the mulgara's distribution.

The core mulgara population was found to be persistent over the four-year study, and in this sense confirmed Aṉangu and historical information. However, the extent of its distribution appeared to fluctuate over time, possibly reflecting changes in seasonal response in addition to responses to fire regimes. Below average rainfall was recorded from 1990 to 1992 and coincided with a contraction in mulgara distribution, demonstrated by the disappearance of mulgaras from the Bus Sunset Viewing Area and Uluṟu Fauna Survey Sites. During this period no fresh mulgara sign was recorded outside the core habitat area, with the exception of a small section of the Tuit Track. Fresh mulgara sign reappeared at the Bus Sunset Viewing Area, the invertebrate study sites along the Kata Tjuṯa Road and south of the Ranger Station during 1993-1994, suggesting a re-expansion of the population into these areas.

Elliott box trapping at the Bus Sunset Viewing Area indicated that mulgaras caught in December 1989 were subadults, possibly dispersing from the core population and in response to good seasonal rains. Animals caught in winter of 1991 were very thin, with little fat reserves in their tails which possibly reflected reduced food availability in winter coupled with the higher energy requirements of breeding. The lower-than-average rainfall in 1991 could also have influenced the availability of food resources. The winter breeding of mulgara was evidenced by a lot of digging activity to establish new burrows and this makes winter a good time to search for mulgara sign.

Mulgara sign recorded along the Docker River Road in 1992 suggested the presence of a second mulgara population west of the Park boundary. A core habitat area to the north of Armstrong Creek in the Mt Currie region was identified by the E-RMS habitat models could be associated with this population but was not surveyed by searching or trapping. Further survey work would be required to map the extent of this population to the north and south. The lack of sign recorded between the Docker River Road population and the Yulara borefield population during 1991 and 1992 implied that the two populations were separate. The appearance of low numbers of fresh mulgara sign along the Kata Tjuṯa road in 1994 and the presence and later disappearance of mulgaras at Site 6 of the Uluṟu Fauna Survey (northwest of Kata Tjuṯa) lend support to a hypothesis that these two populations might merge during good seasons.

4.2 Mulgara habitat preferences

The second aim of the study was to determine the influence of environmental characteristics upon mulgara distribution.

Core habitat requirements, identified through comparing ground-based data with remotely derived habitat variables and through site-based habitat analysis, incorporated:

- Transitional sandplains (between mulga and dunefields) , sandy loam plains and to a lesser extent parallel and open dune systems.
- *Triodia basedowii* (hard spinifex) and mulga over *T.basedowii*.
- Presence of the surficial aquifer particularly where the ground water was fresher.
- Spinifex aged between 7-16 years since burning (dependent on cumulative rainfall).

The predictive model of probable mulgara distribution, generated by E-RMS, identified areas within the region that conform to this prescription. Four areas were identified as potential mulgara habitat, including the Yulara region, Mt Currie area, north of Yulara towards Lake Amadeus and along the old Valley of the Winds road north of Kata Tjuta. Two small localities near the Ranger Station and the Tuit Track were also identified as suitable. Mulgara sign has indeed been located in the vicinity of the Tuit Track, and historically and in 1994 (Hill pers. comm.) near the ranger station. The area east of Yulara along the Lasseter Highway was not included in the model because of the lack of remotely derived data for the area. Site-based observations, however, indicate that the preferred habitat would continue approximately 20 km east of Yulara, after which there is a change from *T. basedowii* to *T. pungens* and *P. schinzii*.

Substantial portions of potential mulgara habitat have been burnt over the past five years, which reduces the available habitat in the short term. Sites specifically analysed for the impact of fire confirmed that mulgaras preferred rounded mature spinifex hummocks aged between 7 and 16 years. The analyses highlighted a negative association between mulgara and recently burnt or old, senescent spinifex. Mulgaras were found to be tolerant of a wide range of percentage ground cover (from 20 to 60%) provided the hummocks were discrete and surrounded by open spaces. It is possible that this formation facilitates the rapid movement of the mulgaras while hunting and escaping from predators.

The surficial aquifer identified in the model represents a portion of the paleodrainage system associated with Lake Amadeus (Jacobson *et al.*, 1989) and appears to play an important role in providing core habitat for mulgaras. The causal relationship between the surficial aquifer and mulgara has not yet been determined but I suggest that the spinifex communities associated with the aquifer can somehow access moisture from the aquifer, thereby providing a relatively drought-resistent core or refuge habitat. One possible process by which spinifex communities may access this ground water could be by a phenomenon termed "hydraulic lift" (Caldwell and Richards, 1989). This process allows water from an aquifer to be pumped from depths of at least 40m to the surface by plant roots. Deep-rooted plants such as jarrah (Bell, 1988) and potentially desert oaks (Griffin pers. comm.) pump water at night through their tap roots and efflux the

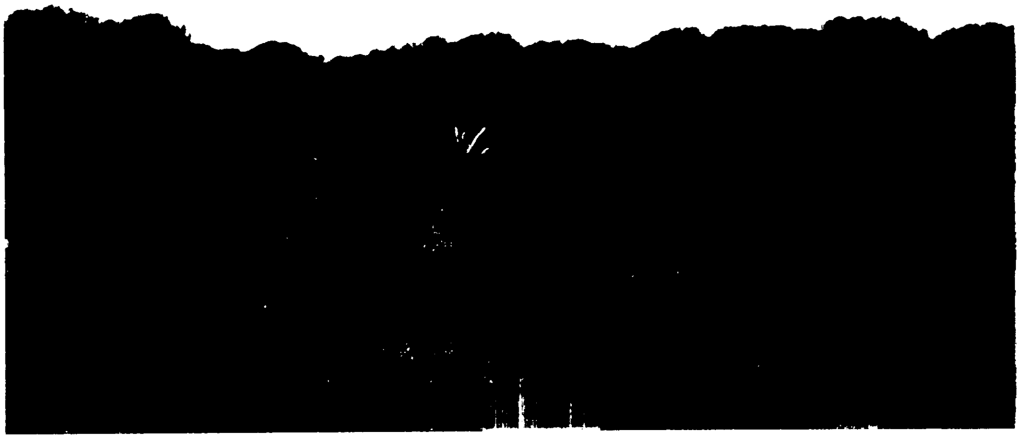


Plate 4: Mulgara habitat on the Yulara borefield, adjacent to a grove of mulga (*Acacia aneura*).

water into the soil where the water is resorbed by the shallow roots of these plants during the following day. Caldwell and Richards (1989) have found that neighbouring plant roots belong to species other than those doing the pumping can parasitise some of the water stored in the upper soil layers. It is possible that trees such as the desert oaks are pumping water up from the aquifer and making it accessible to the spinifex hummocks. It is also possible that the spinifex hummocks, which are very deep rooted (Griffin pers. comm.), could be accessing the aquifer directly. Either situation would enable the spinifex community to remain more productive during dry periods than surrounding areas.

4.3 Invertebrate communities

Invertebrate populations were also investigated as a means of assessing mulgara habitat, but no significant differences were found between sites within and outside the core mulgara distribution. Morphospecies composition, diversity, abundance and biomass of invertebrates collected were similar at all sites during any sampling period. There were, however, substantial seasonal shifts in species composition and abundance recorded on all sites. Morphospecies composition increased during the Summer and the larger sized (10-20 mm) invertebrates were more abundant particularly during the Summer of 1993. In general the Summer periods recorded an overall increase in the abundance of invertebrates, again particularly during 1993, with the least productive time being Spring. Some Orders such as the Pseudoscorpionida and Isoptera were most abundant in Autumn. Masters (pers. comm.) also found that invertebrate abundance dropped in Winter and Spring and rose over Summer and Autumn. She noted that there appeared to be a correlation between the decline in invertebrate abundance during Winter and mulgara abundance as indicated by trapping on her study sites, and suggested that these findings supported the hypothesis that a decline in food resources during Winter limits the mulgara population.

Overall, the invertebrates collected in pitfalls during this study did not appear to reflect or predict the presence or absence of mulgara. This may be a reflection of the limitations of using pitfalls to sample invertebrates. A variety of different techniques to sample the invertebrates, trialled during 1991, had to be abandoned as they were time-consuming and difficult to quantify.

4.4 Introduced predators and herbivores

The final aim of the study was address the issue of potential threats and causes of decline of the Park's mulgara population. One area considered was the likely impact of mammalian predators and rabbits. The presence of predators and rabbits was recorded on all survey sites, and there appeared to be an association between the numbers of mulgara sign and dingo sign. These results reflect the relative numbers of the three predator types in the area, with dingoes being more prevalent than cats and foxes. Rabbits prefer calcrete outcrops and alluvial plains which were outside the preferred mulgara habitat. Dingo, cat and fox signs were recorded throughout the study area; however, there appeared to be a concentration of dingoes and cats in the Yulara area which could be at least partly in response to access to permanent water and scavenging potential around the garbage tip and resort complex.

Attempts to model the association between mulgara sign and predators through the predictive modelling package on E-RMS failed to find a strong enough association to run a model, suggesting that the numbers of predators were not a factor determining the presence or absence of mulgara. It appears that, while predators would have an influence on the abundance of mulgaras, they were not a factor limiting the distribution of mulgara during the study period.

4.4 Potential threats and causes of decline

Having determined that the mulgara population at Uluru National Park, Yulara and adjacent areas is restricted in distribution, the implications in terms of conservation and management require consideration.

The mulgara population at Uluru National Park, Yulara and adjacent areas has contracted and expanded over the four years of the study, while the core population of approximately 150 animals (Masters pers. comm.) has remained relatively stable in the Yulara area. It is therefore probable that survival of mulgara in the Park is dependent on the survival of the core population at Yulara and potentially on the two other identified locations. During good seasons the mulgara population appears to expand its distribution into surrounding areas including the Bus Sunset Viewing Area, and it seems that these areas are also important to the long term viability of the Mulgara population.

There are a number of factors which could threaten the survival of this population. Firstly, fire regimes play an important role in modifying the suitability of core habitats for mulgaras either by temporarily removing suitable habitat, or, if sites are not burnt, by the spinifex becoming old and senescent. Areas recently burnt remain unsuitable for approximately seven years after fire, depending on the cumulative rainfall (Saxon, 1984). This means that recently burnt areas in the Park and north and east of Yulara will not be available to the mulgara population for some time. The remaining mature spinifex in the Yulara area was last burnt in 1976 and is becoming senescent and very flammable. Either planned or accidental fires could place the mulgara population at risk if a substantial portion of the remaining available habitat were burnt before the regenerating areas can again support mulgaras.

A fire management plan is required which takes into consideration the entire mulgara habitat irrespective of land tenure. The strategy needs to leave enough mature spinifex areas for mulgara to survive in, and at the same time to ensure that new suitable areas are regenerating to replace sites where the spinifex is becoming senescent. This needs to be done in small patches so as not to threaten the mulgara population in residence and also such that patches of mature spinifex are left to provide corridors to those areas currently regenerating after fire.

The focus of introduced species and predators on refuge areas is also of concern. At present the influence of cats, foxes and dingoes appears to be non-limiting on the mulgara population. However, this pressure could rise dramatically if, for example, substantial areas of refuge habitat were lost through fire or some other action and the mulgara population were critically reduced. Not only would predation become an increasingly important factor, but so would competition between mulgara and these species for limited food resources.

The future of the mulgara population is also linked with the management of potential future developments in Yulara. The importance of the surficial aquifer to the mulgaras' core habitat has been identified, although the causal relationship is not currently understood. Clearly further research is required to identify this relationship and to ensure that the long-term use of water from the aquifer will not alter attributes of the core habitat. In addition, mulgaras inhabit the majority of spinifex areas within the Yulara lease area, which has implications if future development expands into these habitats.

The protection and maintenance of the core habitat and adjacent secondary habitat is critical to the persistence of mulgara within Uluṟu National Park and adjacent areas.