- Investigate potential threats to this population.

1.2 The Study Area

The Tanami Desert, N.T. covers an area of some 160 000 km^2 north-west of Alice Springs. The majority of the area is Aboriginal land, with some areas remaining as pastoral leases. Sangster's Bore is located 30 km south-east of the Granites gold-fields and is within the Warlpiri and Kartangarurru-Kurintji Aboriginal Land Trust (Gibson, 1986). The study area was centred on Sangster's Bore with additional sites sampled along the Granites borefield road (Fig. 25).

1.2.1 Topography and vegetation

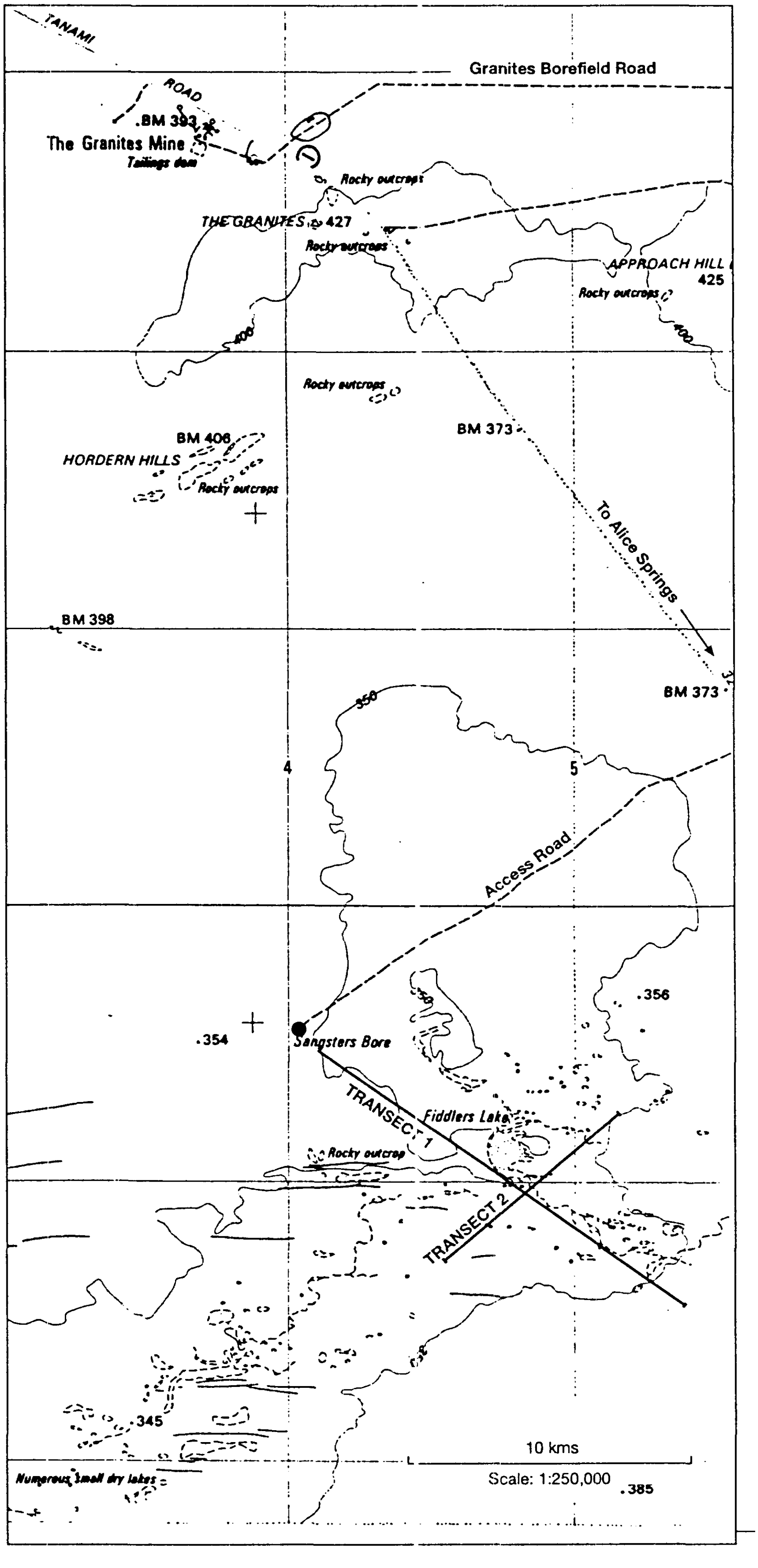
The Tanami Desert is composed of a number of tectonic units overlain by a thin veneer of Cainozoic sediment that reduces any outcropping to small low areas of weathered rock (Gibson,1986). Sandplains are the dominant feature with occasional sand dunes. Salt and freshwater lakes occur mainly in the central and south-western section of Tanami. The salt lakes, which are generally dry, may extend for several hundred hectares, and are often linked by salt channels. One of these saline drainage systems, Salt Beef Lake, occurs in the vicinity of Sangster's Bore. The lake and its associated drainage lines carry water only after exceptional rainfall periods (Gibson and Cole, 1992).

The extensive sandplains surrounding the drainage lines and saltlake at Sangster's Bore are dominated by *Plectrachne schinzii* and shrubs. Hummock-forming *Triodia pungens* and *Melaleuca glomerata* occur on the low sandy rises overlying the drainage lines. The shallower soils overlying calcrete at the edge of the sandy rises support a stoloniferous form of *T. pungens* which is a virtually continous tillering form with individual hummocks absent or poorly defined (Mazzer, 1988).

As the soils become shallower and more saline towards to centre of the drainage channels *T. pungens* is replaced by *Plectrachne* sp., *Eragrostis falcata* and *Hemichroa diandra* (Thomas, 1987).

The Granites borefield road traverses *P. schinzii* and stoloniferous *T. pungens* sandplain with a few low laterised outcrops supporting *T. basedowii*. The region is traversed by a paleodrainage system which drains southwards to Lake McKay and supports hummock-forming *T. pungens* within the drainage line (Domahidy, 1990). The borefield road runs approximately 10 km southeast of, but parallel to, the drainage line for most of its length, then finishes at the borefield which is within the paleodrainage system.

Figure 25: Sangster's Bore and Granites Borefield Road study area



1.2.2 Climate

The Tanami Desert is arid with a summer monsoonal influence. The average rainfall at Rabbit Flat (90 km north-west of Sangster's Bore) is 446 +/- 178 mm with the majority falling in the summer. The area experiences high monthly variability in rainfall. Daily temperatures at Rabbit Flat range from a mean minimum of 6°C in the winter through to a mean maximum of 39°C in the summer (Gibson and Cole, 1992).

1.2.3 Regional hydrogeology

A hydrogeological map of the Granites-Tanami mining region has been prepared by the N.T. Power and Water Authority (Domahidy, 1990). The region is traversed by two palaeodrainage systems that now exist as broad topographic depressions containing alluvial deposits and calcrete and drain southwards to Lake McKay. The largest system runs westwards then southerly through the Granites mine region. The largest groundwater resource in the vicinity of the Granites mine is estimated to exceed 1×10^9 cubic metres . The bores in the calcrete aquifers typically yield 10L/s , while bores in the alluvial sand and gravel yield around 5 L/s (Domahidy, 1990). The mapping process did not include Sangster's Bore; however, bore yields compiled by the N.T. Power and Water Authority are presented in Table 12.

Table 12 : Standing water levels in bores (m)

Bore number	location	standing water level (m)
RN 14396	access rd to Sangster's Bore	4
RN 14443	access rd to Sangster's Bore	3.9
RN 14393	access rd to Sangster's Bore	4
RN 14392	access rd to Sangster's Bore	4
Sangster's well	19km S of Granites	5
RN 13622	WNW of Granites	36
RN14277	Granites mine site	33
RN 13047	Granites mine site area	30
RN 13158	between Granites and Sangster's Bore turnoff	dry
RN 13294	between Granites and Sangster's Bore turnoff	dry
RN 13295	between Granites and Sangster's Bore turnoff	dry
RN 14388	between Granites and Sangster's Bore turnoff	dry
RN 14389	between Granites and Sangster's Bore turnoff	dry

1.2.4 Landuse

There are three major Aboriginal settlements at Yuendumu, Lajamanu (Hooker Creek) and Ali-curung (Warrabri) (Gibson, 1986) and a large proportion of the land area is held by Aboriginal land trusts. There has been some pastoral interest in the Tanami with stations being established in the early 1900s, but their use declined in the 1940s-50s. There has been some renewed interest with several pastoral leases being established in the 1980s; however, pastoralism is not a major landuse in the Tanami Desert (Gibson, 1986).

Mining is potentially a major land use with substantial gold mines located at the Granites and Tanami fields and exploration leases covering a great portion of the Tanami Desert.

2.0 Methods

2.1 Introduction

Field work was undertaken in May -June 1991 and July 1993 at Sangster's Bore and July 1993 on the Granites bore field road. The general methods used were as described in Chapter 4. Details specific to Sangster's Bore and the Granites are covered in this section.

2.2 Mulgara distribution

2.2.1 Elliott trapping

In 1991, Elliott traplines were set at 7 sites along transect 1 which traversed the drainage line and covered the major vegetation and topography types (Figure 28) at Sangster's Bore. The aim of the trapping effort was to assess which habitats were supporting mulgaras. Four sites TD111, TD113, TD117 and JLJ were established on the sandy rises with hummock-form *T. pungens*. TD112 was set on a limestone outcrop and saline drainage line with stoloniferous *T. pungens* and *Plectrachne* sp.; TD114 was set on the edge of the drainage line also with stoloniferous *T. pungens* and *Plectrachne* sp., TD 115 was on the sandplain immediately adjacent to the drainage line on the jumpup, vegetated with *P. schinzii* and *Acacia stipuligera;* and TD116 was on the *P. schinzii* sandplain.

2.2.2 Sign searches

Ten sites were searched for sign of mulgaras, bilbies and introduced predators and herbivores in 1991. Seven sites were along the Elliott trap lines using the circle and belt transect techniques outlined in Chapter 4. Additional sign searches were carried out with Darby Tjampitjimpa at 3 sites using random searches as described in Chapter 4.

In 1993, 40 sites were searched using the twenty minute search pattern as outlined in Chapter 4. Twenty seven sites were within the Sangster's Bore area; commencing at known mulgara locations and then at 2 km intervals along tracks and cross country. Seven sites were selected at 2 and 5 km intervals along the Granites borefield road and 6 sites were opportunistically sampled along the Tanami Highway.

2.3 Habitat assessment

Habitat data were collected at all fifty sites as outlined in Chapter 4. Wheel point data for percentage vegetation cover were collected at 20 of the Sangster's Bore sites.

3.0 Results

3.1 Mulgara distribution

3.1.1 Elliott trapping

Table 13 presents the trapping data for 1991. Two mulgaras were captured in 575 trap nights.

Table 13: Trapping data for Sangster's Bore 1991

Site	date	Species	breeding condition
TD111	1/6/91	nil	
TD112	2/6/91	*Pseudantechinus macdonellensis*	
		Pseudomys desertor	
TD113	31/5/91	Mulgara	adult female 66 gm
TD114	30/5/91	nil	
TD115	29/5/91	nil	
TD116	29/5/91	nil	
JLJ	29/5/91	Mulgara	adult male 104 gm

3.1.2 Mulgara sign

Table 14 presents the total mulgara sign recorded at each site in 1991. All sites on the sandy rises over the drainage line recorded mulgara sign, whereas no mulgara sign were recorded in the other habitats.

Table 14: Sangster's Bore 1991 mulgara total sign

LOCATION	HABITAT	METHOD	TOTAL MULGARA SIGN
TD111	*T.pungens*	belt transect	22
TD112	*Plectrachne* sp.	belt transect	0
TD113	*T.pungens*	belt transect	3
TD114	*T.pungens* stol.	belt transect	0
TD114A	*T.pungens* stol.	belt transect	0
TD115	*A. stipuligera*	belt transect	0
TD116	*P. schinzii*	belt transect	0
TD117	*T.pungens*	belt transect	28
TD117A	*T.pungens*	belt transect	13
JLJ	*T.pungens*	belt transect	1

In 1993, sites were searched at 2 km intervals in two transects. The north-south transect intersected the drainage line, covering 20 km and starting and finishing on *P. schinzii* sandplain. The west-east transect was 11 km long and ran along the drainage line. Additional sites were searched on the access track from the highway, 11 km north east of Sangster's Bore and eastwards on the Tanami Highway. Mulgara sign was found on 51% of the sites searched; however, only 13% of sites had greater than five sign and 6 % had 10 or more sign. Figure 26 presents the mulgara sign recorded on transect 1 and Figure 27 the mulgara sign recorded on transect 2. Site numbers and their respective locations on the transects are presented in Appendix 2.

Figure 26: Total mulgara sign per site on Transect 1 in 1993

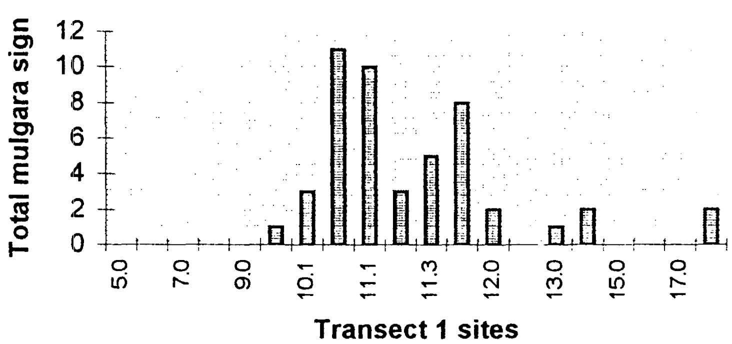
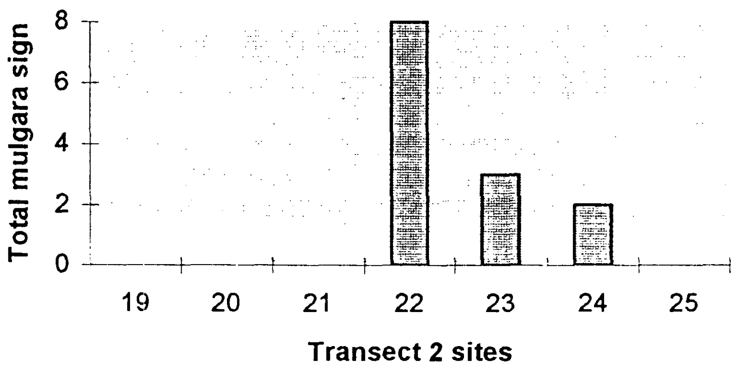


Figure 27: Total mulgara sign detected per site on Transect 2 in 1993.



Seven sites were surveyed for sign in both 1991 and 1993 as presented in Table 15.

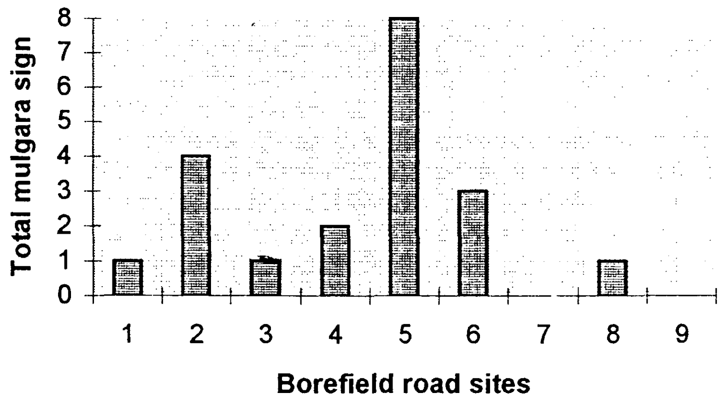
Table 15: Comparison of repeat sign surveys 1991 and 1993

Site	1991 total mulgara sign	1993 total mulgara sign
TD111	22	1
TD112	0	0
TD113	3	2
TD114	0	0
TD115	0	0
TD116	0	2? (possible)
JLJ	1	8

Sites which recorded mulgara sign were all within the *T. pungens* hummocks on sandy rises over the drainage line, except for the unconfirmed sign recorded at TD116, located south of the drainage line on the *P. schinzii* sandplain. The major difference between 1991 and 1993 was the decline from 22 to 1 sign on TD111. In 1993 the highest levels of mulgara sign were clustered around sites 11 and 22 with numbers of sign decreasing within 2 km in each direction. No mulgara sign was recorded west of Site 22. The data suggest that mulgaras are patchily distributed across the sandy rises and that the locations supporting high levels of mulgaras change temporally as well as spatially.

Searches for mulgara sign were conducted at sites along the 32 km distance of the Granites borefield road (Fig.28). Two additional sites were searched at 10 km and 20 km east of the borefield road on the Tanami Highway between the borefield road and Sangster's Bore turnoff.

Figure 28: Granites Borefield Rd: total mulgara sign detected per site in 1993



A list of site locations and numbers is presented in Appendix 2. Seventy seven percent of the sites searched had mulgara sign; however, only 11% had more than 5 sign and no sites had 10 or more sign.

3.2 Bilbies, introduced predators and herbivores

All sites were searched for signs of bilby, dingo, cat, fox, rabbit and cattle. The predator sign and bilby sign recorded in 1991 are presented in Table 16.

Table 16: 1991 numbers of predator and bilby sign per site

Location	Habitat	Fox sign	Cat sign	Dingo sign	Bilby sign
TD111	*T.pungens*	0	0	0	3
TD112	*Plectrachne* sp.	0	0	1	0
TD113	*T.pungens*	0	3	0	1
TD114	*T.pungens* stol.	1	4	3	0
TD115	*A. stipuligera*	0	2	0	0
TD116	*P. schinzii*	0	1	0	0
JLJ	*T.pungens*	0	0	0	2

Sites were compared for mulgara sign, predator sign and bilby sign. A positive correlation was found between the abundance of mulgara sign and bilby sign, ($p<0.01$) but no other significant correlations were found.

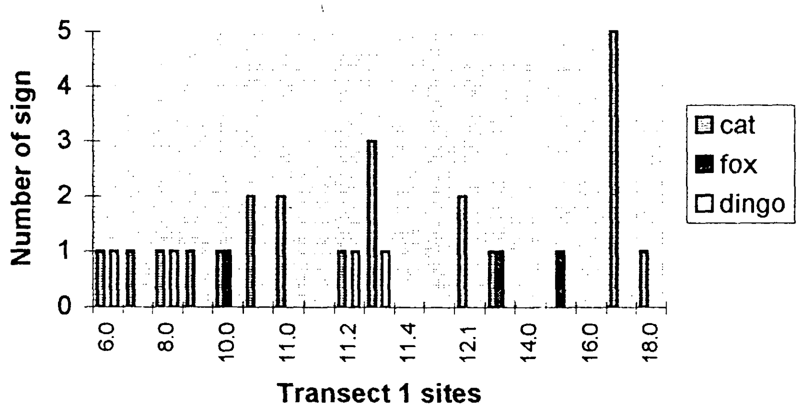
The best-fit Poisson regression was:

Total mulgara sign =1.928 + 0.482 bilby - 0.548 cat - 8.588 dingo

Deviance of 30.12 and 6 degrees of freedom, $p<0.001$. Bilby sign contributed significantly to the equation ($p<0.003$), while cat sign was less significant at $p<0.02$. Dingo sign was not a significant contributor as an individual component ($p>0.05$), but was responsible for a substantial decrease in the deviance from 54.11 to 30.12.

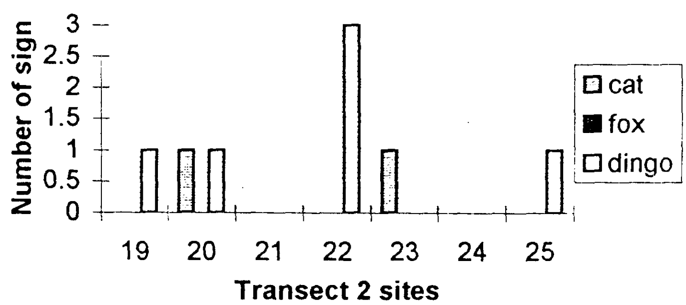
The numbers of combined predator sign recorded on sites along Transect 1 in 1993 are presented in Figure 29 and the signs recorded on sites on Transect 2 are presented in Figure 30. The bilby sign recorded on all sites is presented in Figure 31.

Figure 29: Predator sign detected per site on Transect 1 in 1993



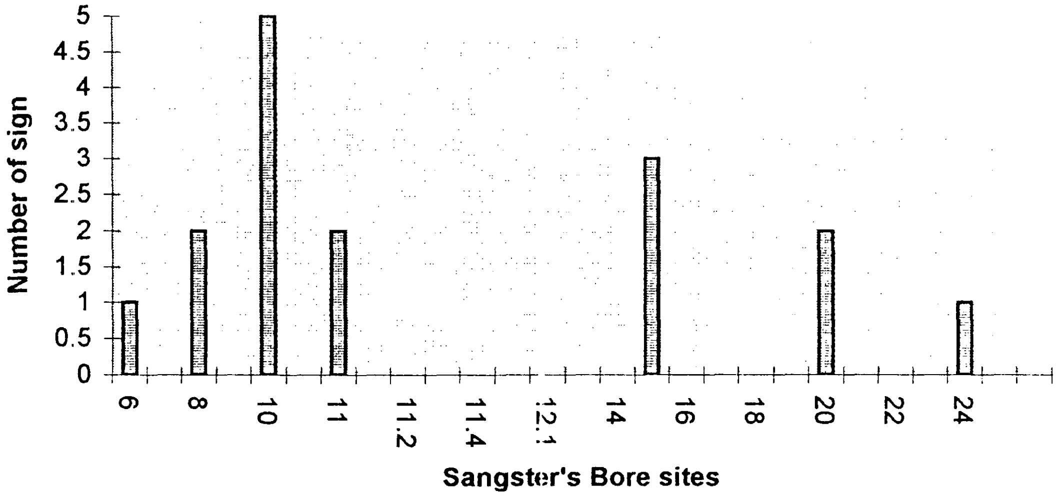
[Site numbers and locations are presented in Appendix 2]

Figure 30: Predator sign detected per site on Transect 2 in 1993



[Site numbers and locations are presented in Appendix 2]

Figure 31: Bilby sign detected per site at Sangster's Bore in 1993



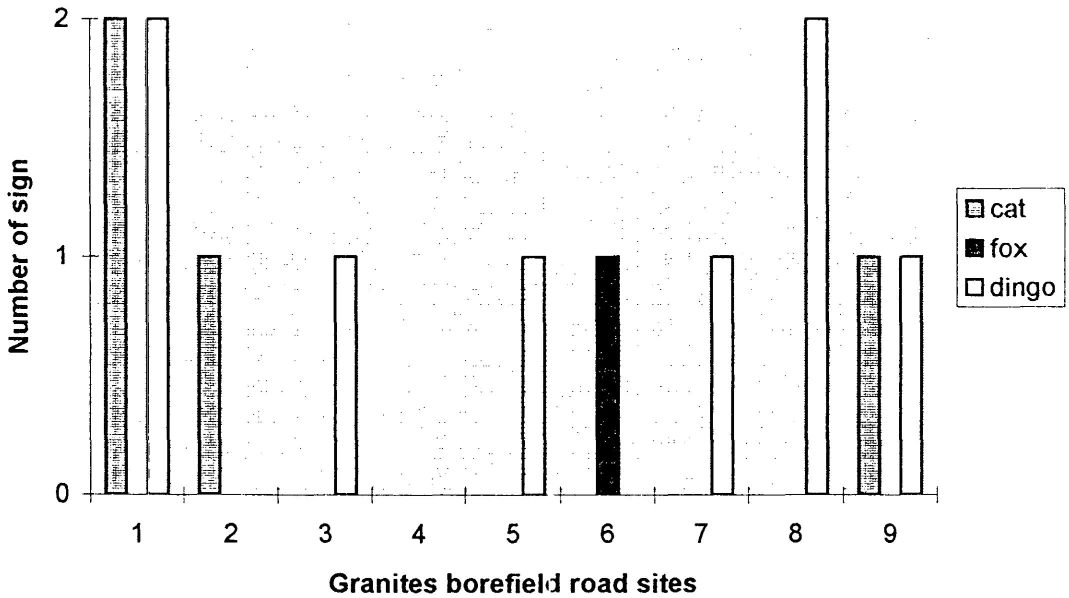
[Site numbers and locations are presented in Appendix 2]

Rabbit sign was found on only one site and was not considered in further analyses. No associations were found between mulgara sign and any of the predators or bilby sign using Spearman Rank Correlations. A positive correlation between fox and bilby ($p< 0.05$) was the only significant correlation found between any of the species.

A series of Poisson regressions confirmed the apparent lack of relationship between mulgaras and predators or bilbies with no individual component contributing significantly to any equations.

Data on the predator sign detected at sites along the Granites borefield road in 1993 are presented in Figure 32.

Figure 32: Granites borefield road: predator sign detected per site in 1993



[Site numbers and locations are presented in Appendix 2]

The abundances of mulgara sign, predator and bilby sign on the Granites Borefield sites were compared using Spearman Rank Correlations, and relationships examined with Poisson regressions. No relationships or correlations were found between the abundance of mulgaras and predators or bilbies.

When all the data sets for 1991 and 1993 at Sangster's Bore and the Granites were combined, no correlations were found between mulgaras and predators, rabbits or bilbies; however, a positive correlation was found between dingo and rabbit ($p<0.01$).

The best-fit Poisson regression was:

Total mulgara sign = 1.076 +0.634 bilby - 2.674 fox - 0.39 cat

The deviance was 228.7 with 43 degrees of freedom at $p<0.001$. Bilby, fox and cat contributed significantly to the equation at $p<0.001$.

A positive association between mulgaras and bilbies appears to occur at Sangster's Bore but not at the Granites borefield road. This implies a positive spatial relationship between mulgaras and bilbies at Sangter's Bore. Bilby numbers were low along the Granites borefield road which may explain the lack of association in this area. A series of 1080 baiting programs to control predators was run at Sangster's Bore in the late 1980s and early 1990s as part of the mala re-introduction program. The baiting had ceased by 1993; however, cats continued to be shot as part of the same re-introduction program. No predator control has been undertaken along the Granites borefield road. These varying predator control regimes would have had a significant impact on the types and numbers of predators in the area. Cat sign appeared to have a negative influence on mulgaras at Sangster's Bore, as did foxes and dingoes to a lesser degree. The apparently variable influence of the three different predators on mulgara sign over the study period maybe potentially be explained by the variable predator control regimes implemented over the study period.

3.3 Habitat assessment

Habitat attributes were tested for correlations with fresh and total mulgara sign at all 50 sites (Sangster's Bore and Granites). Soil texture and fire history were not included in the data set. Positive correlations were found between mulgara sign (both fresh and total) and sandy rises over drainage lines, soft sand and hummock-form *T. pungens* ($p<0.001$). Of these habitat attributes, sandy rise over drainage line was selected as the most significant variable accounting for 27% of the variance in mulgara sign using a stepwise regression with logarithmically transformed total mulgara sign. These relationships were examined further with the presence of a shrub layer, sandy rise over drainage line, spinifex hummock form and lack of non-spinifex ground cover selected as the most influential habitat attributes.

The Poisson regression which best explained the variation in abundance of mulgara sign was:

> Total mulgara sign = 0.56 + 0.05 shrubs - 0.14 ground veg. + 14.25 sandy rise/drl + 1.61 class 3 hummock + 0.799 ring hummock

with a deviance of 47.87, and 25 degrees of freedom, $p < 0.005$. Of the contributing variables, only the presence of a shrub layer and class 3 spinifex hummocks contributed significantly to the equation ($p<0.05$), however removal of the other variables resulted in a substantial gain in the deviance. The Wilk-Shapiro index was 0.86.

3.3.1 Percentage vegetation cover

Mulgara sign was found on *T. pungens* sites with a range of cover from 25-45%. A positive correlation was found between the number of mulgara sign and the presence of hummock-form *T. pungens* cover ($p<0.01$). The height of the *T. pungens* was also an influencing factor with mulgara sign being positively associated with the taller spinifex hummocks (0.26-0.75m) at $p<0.005$ and to a lesser extent with class 1 (0.06-0.25m) at $p<0.05$. This preference for the taller spinifex conforms with the preference for the hummock-form *T. pungens* which is the tallest spinifex form in the area. A negative correlation was found between mulgara sign and spinifex other than hummock-form *T. pungens* ($p<0.05$).

The presence of hummock-form *T. pungens*, the presence of a shrub layer and the absence of dead spinifex were the habitat variables identified through regression analyses as best explaining the variation in numbers of mulgara sign. The unconfirmed mulgara signs on site TD116 were identified by the analyses as outliers and were omitted from further analyses.

The Poisson regression which best accounted for the variation in mulgara sign was:

Total mulgara sign= -2.622 + 0.0888 hummock-form *T. pungens* -0.147 dead spinifex + 0.209 shrub layer

with a deviance of 24.74, 16 degrees of freedom and significant at $p<0.05$. All of the components contributed significantly to the equation ($p<0.001$). The Wilk-Shapiro index was 0.90.

Continuous spinifex cover and continuous bare ground were also found to affect mulgaras habitat preferences, with positive correlations between mulgara sign and 4 m continuous bare ground around hummocks ($p<0.005$). One metre, 2 m and 5 m continuous bare ground were slightly correlated at $p<0.05$ and there were negative correlations between the number of mulgara sign and less than 1 m bare ground and 1 m continuous cover ($p<0.05$). These correlations indicated that mulgaras prefer large continuous open space, and avoid closely spaced spinifex hummocks.

4.0 Discussion

4.1 Mulgara distribution

Data from the field trip in 1991 indicated that mulgaras were restricted principally to the sandy rises over the drainage line. No mulgara sign was located in other habitat types. These initial findings were corroborated in 1993, when a more extensive search was undertaken for mulgara sign within the Sangster's Bore region. Two possible but unconfirmed mulgara tracks were noted on the *P. schinzii* sandplain south of the drainage line; however, these were the only potential mulgara sign located outside of the sandy rises on drainage line within the Sangster's area. These data agree with the findings of Gibson and Cole (1992) who found that 98% of mulgaras were located within the *T. pungens* sandy rises on the drainage line.

Within the preferred habitat at Sangster's Bore, the distribution of mulgaras was patchy, with high levels of activity in certain areas and low levels or nil sign found in areas of similar habitat close by. Some sites also changed markedly in the frequency of sign recorded on them between 1991 and 1993. These data suggest that mulgaras are moving from one locality to another over time, and are not evenly distributed across the habitat.

The mulgara signs recorded at the Granites borefield road sites were located in a variety of habitats, all of them different from the Sangster's Bore sites. The borefield road runs parallel to and approximately 10 km from the paleodrainage system as described by Domahidy (1990). The borefield lies over and draws from one of the major aquifers associated with the paleodrainage system. Without more detailed research, I can only suggest that it is likely that the mulgara intermittently recorded on the road represent an extension of a population concentrating on a core habitat similar to that described at Sangster's Bore. The records here, in particular the high level of activity recorded on the laterite site, point to the fact that mulgaras are able to inhabit a

Plate 5: Mulgara habitat at Sangster's Bore

variety of habitat types, as noted by earlier reports. The persistence of mulgaras in these habitats is untested.

The incidental sighting of mulgara sign within the hummock grasslands along the Tanami highway in 1993 agrees with Gibson's (1986) records of mulgaras elsewhere within the Tanami Desert. The status of these other areas in terms of persistence of abundance is untested.

4.2 Mulgara core habitat model

The model of habitat preferred by mulgara at Sangster's Bore included:

- soft sandy rises over the drainage line
- presence of robust hummock-forming *Triodia pungens*
- absence of dead spinifex
- presence of shrub layer
- clear open spaces between hummocks (at least 2 m between hummocks)

The lack of data on soil texture and fire history affects the habitat model derived. Soil type is reflected in the landform and spinifex type. However, analyses of the Uluru National Park data (chapter 5) and other site data (chapter 6) suggest that soil texture is an important feature in identifying core mulgara habitat.

Fire history can be extrapolated from the growth form of the spinifex. A clear preference for spinifex which had not senesced was identified. Studies into the effects of fire at Sangster's Bore by Mazzer (1988) indicated that *T. pungens* takes approximately 7 years to completely recover from fire though it becomes the dominant cover after three years. Senescence, i.e. ring formation, is common after 10years (Mazzer, 1988). This indicates that mulgaras at Sangster's Bore are selecting hummock-forming *T. pungens* spinifex areas that are between 3 and 10 years since fire.

The fire regime introduced to protect the mala (Latz pers. comm.) has probably also protected and enhanced the habitats for mulgaras. Elsewhere in the Tanami Desert mosaic patchburning has not been undertaken to any great degree for many years (Lightbody pers. comm.). Although Aboriginal people have recommenced burning since regaining control of their country, there are large areas of single-aged spinifex which could carry large scale wildfires (Lightbody pers. comm.).

Large hot burns are likely to remove all available cover and leave mulgara and their prey with nowhere to live. Gibson and Cole (1992) suggested that fire was not as important to the survival of mulgaras as for other CWR species. However, the size of their study plots was relatively small and may not have incorporated the major fire impacts likely to affect mulgara (Johnson pers comm). Masters (1993) and my research suggest that fire is an important factor in determining habitat suitablility for Mulgara.

4.3 Bilbies, introduced predators and herbivores

Mulgara signs were found to be positively associated with bilbies sign and negatively associated with cat and fox sign. The Poisson regression model for the 1991 Sangster's Bore suggested that cat and dingo were affecting mulgaras. Foxes are itinerant visitors to the Sangster's Bore area but have played a vital role in the destruction of mala colonies (G. Lundie-Jenkins, Johnson pers. comm.). During 1991, there was a 1080 baiting and shooting regime to protect the mala which coincidentally covered the areas supporting mulgaras, and it is probable that the effect of introduced predators on mulgaras at this time was reduced by the impact of the baiting program.

At the time of the 1993 survey, 1080 baiting had been discontinued. However, a cat shooting program was still in place. This change in focus of predator removal is possibly reflected in the change in parameters contributing to the regression model for the 1993 Sangster's mulgara data in which dingoes and foxes but not cats are featured.

There are no baiting or shooting programs undertaken on the Granites lease and in this area mulgaras were negatively associated with bilbies and dingoes. A regression model, generated on all three data sets, suggested a positive association with bilbies and a negative association with foxes and cats.

These regression models suggest that introduced predators have a negative impact on the level of mulgara activity and are therefore potentially impacting on mulgara numbers in particular instances. The data also suggest that 1080 baiting programs and shooting shift the primary predator interaction from one species to another depending on the target group. Mulgaras were positively associated with bilbies at Sangster's Bore, but not at the Granites. The negative association with the Granites sites may be explained by the very low numbers of bilby sign recorded on these sites.

4.4 Potential threats and causes of decline

The mulgara population at Sangter's Bore appears to be centred on a core habitat area based on the hummock-form *T. pungens* on sandy rises over the saline drainage lines. Data from Gibson and Cole (1992) and Morton (pers. comm.) suggest that during good rainfall seasons mulgaras are able to disperse into the surrounding *P. schinzii* sandplain. This core habitat is confined to the drainage lines associated with the paleodrainage systems of which there are several within the Tanami Desert. During droughts these drainage lines may offer discrete refuge areas for mulgara populations which may then be able to disperse and merge after good rainfall seasons.

The suitability of this habitat is dependent on appropriate fire regimes, and so large scale wildfires or lack of fire pose the greatest threats to mulgaras in these areas. Predators do appear to have some impact on mulgara numbers, but the influence appears small and not likely to be threatening to the status of mulgara. This situation could change if some catastrophic event occured, such as a major drought or wildfire destroying a large portion of the habitat.