CHAPTER 3

MULGARA DISTRIBUTION

1.0 Introduction

The allocation of research and management funding to threatened species is being prioritised at a national level. Given the range of taxa in need of research and management, a priority system is required to ensure that funding and management agencies are focussed on a co-ordinated approach. This means that not all threatened taxa will receive the same emphasis and therefore the rationale for funding research and management of a particular species requires justification.

The current approach is to rank species within categories of endangerment and from these rankings identify which should have priority for research and management actions. The approach currently used by the IUCN/SSC Australasian Marsupial and Monotreme Specialist Group to review status of taxa for the Marsupial and Monotreme Action Plan (MMAP) is based on IUCN Red List Categories (1994). These categories are based on whether a species is threatened (i.e. critically endangered, endangered or vulnerable), at lower risk (i.e. conservation dependent or near threatened) or data deficient (MMAP, 1995). The ranking scheme is based on a modified system developed by Millsap *et al.* (1990), and is broadly based on an assessment of the percentage reduction in the distribution and population size of taxa (Maxwell *et al.*, 1996).

Mulgaras have been ranked as Vulnerable (ANZECC, 1991), i.e. they face a high risk of extinction in the wild in the medium-term future (IUCN, 1994). To review whether this ranking is appropriate requires an assessment of changes in the distribution and abundance of mulgaras.

One of the principal aims of my research has been to assess whether there has been a decline in distribution of mulgaras and, if a decline is affirmed, to identify possible causes for the decline. One approach to this question is to collate the available mulgara locality data and compare the assumed original distribution of mulgaras with what is known of the contemporary distribution. This comparison should assist in the assessment of whether mulgaras are accurately ranked as vulnerable or whether they more aptly belong to another category. This is of particular importance with the proposed separation of *Dasycercus hillieri* from *D. cristicauda*. Future research and management options will clearly rely on an accurate assessment of the decline and status of mulgaras overall and particularly with respect to the the taxonomic geographical boundaries and status of the two species. Furthermore identification of threatening processes and potential management strategies will be greatly influenced by our understanding of if, where and when mulgara distribution has retracted or populations declined.

Information provided in Chapter 2 by Aboriginal informants identified a reduction in distribution from the southern part of the mulgara's original range. Other data sources including taxonomic studies and a review of known historic and contemporary locality records form the basis of this Chapter which investigates the distribution and abundance of mulgara.

2.0 Taxonomy

2.1 Introduction

Mulgaras are a member of the Family Dasyuridae. The genus for mulgara has undergone a number of name changes from the original *Chaetocercus* (Krefft, 1867) to *Phascogale* (Woodward, 1902), *Amperta* (Cabrera, 1919) and finally to *Dasycercus* (Peters, 1875).

The Type species for the mulgara (*Dasycercus cristicauda)* was classified by Krefft (1867) as *Chaetocercus cristicauda*. The holotype AM M11342, a mounted skin in the Australian Museum collection, was probably from the vicinity of Lake Alexandrina, S.A. (Walton, 1988). This specimen was apparently in such poor condition that the taxonomist added fur of another animal to the mounted specimen (Spencer, 1896). Spencer amended the original description based on specimens obtained from Charlotte Waters (1896).

Mulgaras from the Pilbara district, W.A., were identified as *Phascogale blighi* by Woodward (1902) based on mounted specimens WAM 578 and 579. These specimens were later re-identified as a new species of *Phascogale*, *P. blythi* by Waite (1904) but are now included in *Dasycercus cristicauda cristicauda* (Woolley, 1983; Walton, 1988). *Phascogale hillieri* was classified by Thomas (1905) based on a holotype specimen, BMNH 5.3.28.1, which was a single mounted skin (without skull) from Killalpaninna, S.A., east of Lake Eyre. *Phascogale hillieri* was renamed to *Chaetocercus hillieri*; however, Wood-Jones (1923) suggested that, unless further specimens could substantiate this species, it should be regarded as a pale variety of *Chaetocercus cristicauda*. This inclusion of *Chaetocercus cristicauda hillieri* was recognised by Finlayson (1935).

Finlayson (1961) referred to two mulgara sub-species: *Dasycercus cristicauda cristicauda* and *D. c. hillieri*. This is the currently accepted position (Woolley, 1983) with *D. c. cristicauda* reportedly occupying the greater part of the range from W.A., N.T. and S.A. and *D. c. hillieri* located within southwestern Qld and northeastern S.A.

One of my research aims was to verify the existence of the two sub-species and their taxonomic boundaries. Given the reported difficulty of separating the sub-species on morphological characteristics (Wood-Jones, 1923; Finlayson 1935), the Evolutionary Biology Unit (EBU) of the South Australian Museum was approached to ascertain the possibility of using molecular genetic techniques to verify the status of the sub-species. Mark Adams (EBU) agreed to a collaborative study which would be conducted utilising funds allocated to genetic analysis through the Mulgara Research Plan.

2.2 Methods

Molecular techniques such as allozyme electrophoresis and DNA analysis provide an independent method for assessing genetic relationships and systematic affinities within animal groups. Baverstock *et al.* (1982) used allozyme electrophoresis to investigate the phylogenetic relationships amongst 31 species of dasyurid. This technique has also been used to analyse sibling species complexes, identifying the specific status of allopatric populations and determining evolutionary relationships amongst species (Richardson *et al.*, 1986; Hills and Moritz, 1990).

The initial aim was to conduct allozyme electrophoresis on as many tissue samples as could be collected or obtained from frozen tissue collections. I undertook to collect or organise the collection of blood and tissue samples from as many populations as possible while Adams organised access to material held by the S.A.Museum.

Live animals were bled by nicking the tip of the tail with a sterilized scapel. Approximately 0.5ml of blood was then 'milked' from the tail into capillary tubes containing heparin (to prevent coagulation) and stored in liquid nitrogen. Blood flow usually ceased as soon as the active process of 'milking' stopped. For the occasional animal which continued to bleed, 'vet bond' bandage was placed over the cut. None of the animals appeared to be adversely affected by the process. Field captured animals were held overnight, fed house mice and released the following evening.

Blood was collected by the Territory and Wildlife Park veterinarian and staff from seven captive Sangster's Bore, N.T. mulgaras and four captive animals from Uluṟu National Park/Yulara, N.T. These animals are held by the Territory Wildlife Park as part of a mulgara stud book and breeding program. Nine mulgaras from Marymia, W.A., were bled in the field and two juvenile mulgaras from Kintore, N.T., were accidentally killed as they were dug up with their mother. The livers and blood were sampled from these animals.

Five mulgara livers were held in the S.A. Museum frozen tissue collection and included material from Uluṟu National Park, N.T., Port Hedland, W.A., and Horse Hill and Purni Bore, S.A. The S.A. samples provided the only available representative material for *D. c. hillieri*. Dr C. Dickman has agreed to procure blood samples from animals at Ethabuka Station in Queensland; however, this population drastically declined at the time of the request and to date he has been unable to obtain samples. While it was considered important to include samples from Queensland, time restraints ultimately required us to continue without these samples. It is hoped that samples will be obtained in the future and provided for follow up DNA analysis.

Due to a surprising result from the allozyme electrophoresis, it was decided that further comfirmation work should be undertaken using DNA techniques and to reassess the morphological characteristics. The EBU has undertaken to continue this work which will enable the use of dried and wet museum specimens as well as the material utilised in the allozyme analysis. This will expand the amount of material available and will enable us to investigate the uniformity of the species across their geographic ranges. DNA from liver and blood samples is currently being prepared from samples collected and from museum specimens.

This work is being undertaken currently and only preliminary results are available for presentation and discussion herein. Mark Adams (EBU) has kindly given his permission for this material to be presented.

2.3 Results

2.3.1 Allozyme results

Allozyme electrophoresis was carried out on tissue samples from 27 animals. Forty-six loci were examined overall, 44 of which were expressed in liver and blood (16 in liver only) and 2 expressed only in the blood. The S.A. (*D. c. hillieri)* sample consisted of 3 livers, and differed from the N.T./ WA *(D. c. cristicauda)* liver samples (N=2) at 8 fixed differences (a "fixed" difference occurs where two populations fail to share any allozymes at a locus, see Richardson *et al.,* 1986). Three of these differences were expressed in blood, with an additional two being weakly expressed by a single blood sample from the N.T. Table 3 presents the allele frequencies (as percentages) for the S.A. vs N.T. vs W.A. regions.

The two taxa were found to differ at 18% of the loci surveyed. This level of genetic divergence is much higher than is normally found between populations and sub-species of a single biological species (Richardson *et al.*, 1986). This is particularly true for dasyurids, which typically display low levels of genetic variability both within species and between congeneric species (Baverstock *et al.*, 1982; Adams pers. comm.). Indeed, the genetic divergence between *D. c. cristicauda* and *D. c. hillieri* approaches that found between *Dasyuroides byrnei* (the kowari) and *D. cristicauda cristicauda* (Baverstock *et al.*, 1982). This latter comparison suggests that the generic distinction may not be appropriate and implies that additional species may be present within the plesiomorphic morphotype (Adams pers. comm.). These results indicate that the sub-species *D. c. hillieri* warrants recognition as a separate species, possibly *D. "hillieri"* (a final name must await a formal re-diagnosis and description). Preliminary analysis indicated that there were some minor differences in allele frequency between the N.T. and W.A. sub-populations, but that these sub-populations clearly fall within the *D. "cristicauda"* species.

Table 3: Comparison of allele frequencies between mulgara populations from S.A, N.T and W.A.

LOCUS	ALLELE	SA	NT	WA
Ada	b		100	100
	a	100		
	N	3	14	10
Ak-1	b		25	15
	a	100	75	85
	N	3	14	10
Alb	b	100		
	a		100	100
	N	3	14	10
Dia-2	b			22
	a	-	100	78
	N		13	9
Est-1	b		4	
	a	100	96	100
	N	3	14	10
Est-2*	b	100		
	a		100	100
	N	2	1	1
Gda	b			10
	a	100	100	90
	N	3	14	10
Gdh*	b	100		
	a		100	100
	N	2	2	1
Gpd*	b		100	100
	a	100		
	N	3	1	1
Gpi	b			5
	a	100	100	95
	N	3	14	10
Hb	b	100		
	a		100	100
	N	3	14	10
Mdh	b	100	96	100
	a		4	
	N	3	14	10
Mpi	b	100	100	95
	a			5
	N	3	14	10
Ndpk	b			5
	a	100	100	95
	N	3	14	10
Pep-B	c			10
	b		64	60
	a	100	36	30
	N	3	14	10
Pk*	b	100		
	a		100	100
	N	2	1	1
Sordh*	b	100		
	a		100	100
	N	2	2	1
Trf	b		85	83
	a	-	15	17
	N		13	9

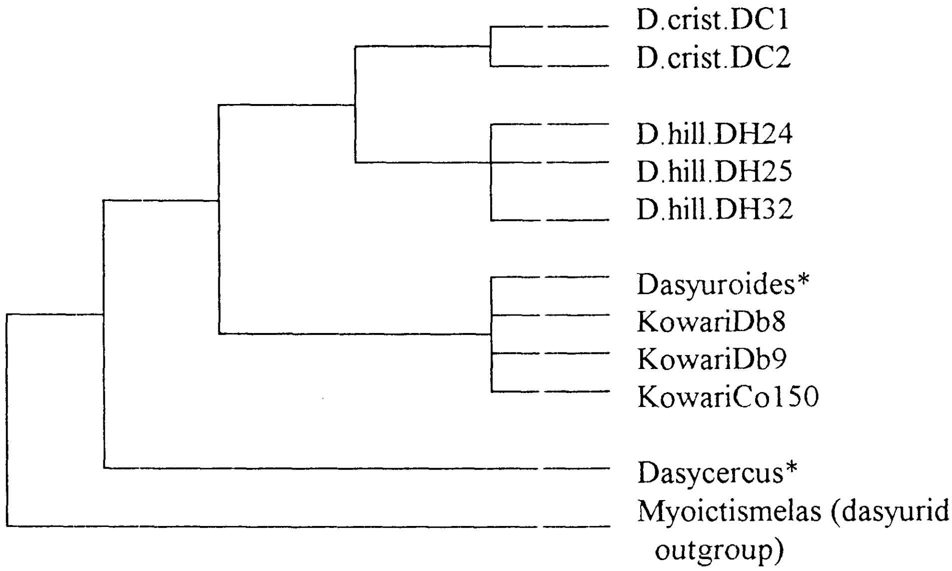
Asterisked loci were only expressed in liver.
Invariants in the analysis were: Acon-1*, Acon-2*, Acp, Ak-2, Ap*, Dia-1*, Enol, Est-3*, Fdp*, Fum, Got, G6pd, Gapd*, Glo, Gpt*, Idh, Ldh, Me*, Np, Pep-C, Pep-D, Pgam*, 6Pgd, Pgk*, Pgm, Sod and Tpi (Adams pers. comm.).

2.3.2 DNA analysis

On the basis of the allozyme results, further work on the DNA is being undertaken by Louise Rodbourne (EBU) under the supervision of Mark Adams (EBU), and the morphology of the two 'species' is being investigated by Meredith Smith (EBU). The two main aims in undertaking the DNA analysis are to further explore population differentiation within *D. cristicauda* and to establish DNA profiles from museum specimens. This would allow access to material from the Queensland populations and to assess whether there are additional species within *D. cristicauda*.

A mitochondrial 'cytochrome-b' gene sequence for *Dasycercus* published in GENEBANK provided the basis for commencing to isolate this sequence from three *D. hillieri* and two *D. cristicauda* liver samples. Approximately 300 base-pair fragments were isolated and compared with the published sequence. There was hardly any match with either of the two taxa. To verify this surprising result, similar runs were undertaken on kowari *(Dasyuroides byrnei)* specimens as an 'outgroup' for analysing the DNA data phylogenetically. Both samples from the kowari sequences matched the GENEBANK published sequence, leading to the conclusion that the published *Dasycercus* sequence is either contaminated or mislabelled (Adams pers. comm.). Figure 2 presents a phylogenetic tree for the mulgara and kowari specimens run to date.

Figure 2: Phylogenetic Tree for ~300 base pair "cytochrome b" gene



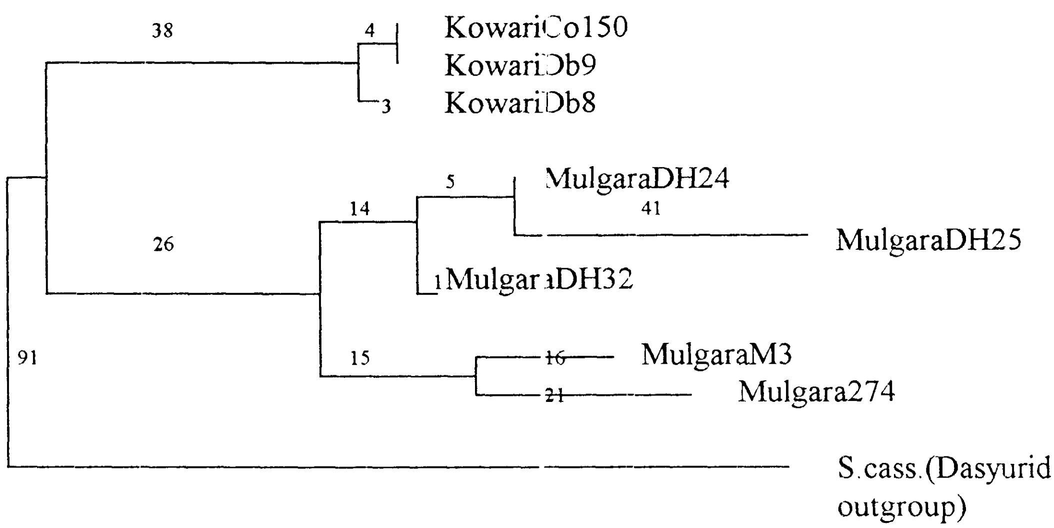
* Sequences in "Genebank"

The sequences of the two mulgara species differed at a number of base positions in the ~300 bases sequenced and this allowed the EBU team to develop new DNA primers to target a smaller region of the gene (around 130 pairs). It is hoped that these primers will permit DNA amplification in the museum specimens.

Blood cytochrome-b sequences are being developed and will be used to clarify whether there are any significant within-species differences between the four animals profiled (two from W.A. and two from the N.T.). These sequences will act as a template for sequencing more animals if results are favourable.

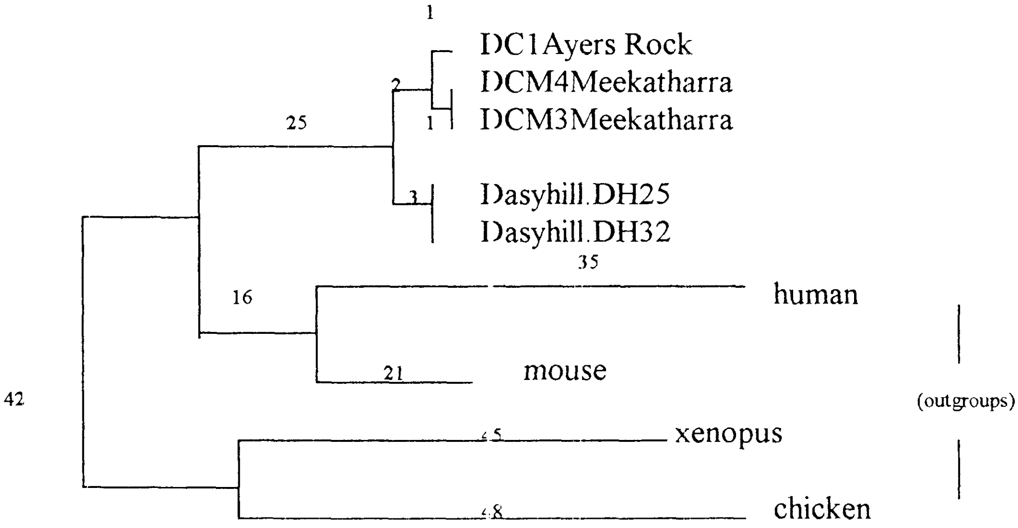
Further work on assessing the within-species differences will be targeted at mitochondrial "D-loop" sequences. This work is still in its development phase; however, preliminary work confirms that *D. cristicauda* and *D. hillieri* cluster into two distinct groups, with the kowari specimens forming a more distantly related taxon. Figure 3 presents a phylogenetic tree overviewing the D-loop sequence data for the mulgara, kowari and *Sminthopsis crassicaudata* specimens. One of the mulgara samples (DH25) had degraded, causing it to appear more divergent than the others. This is because it was only represented by a smaller fragment with more ambiguities in it (Adams pers comm).

Figure 3: Phylogenetic tree for ~ 500 base sequence of "D-loop" region



Further primers based on ~ 400 base pair subset of the original 500 base sequence have also been created to exactly match invariant regions within the mulgara/kowari lineage. These primers are currently being produced. Other developments include looking at 12S, another mitochondrial gene which is responsible for encoding the 12S ribosomal RNA. Figure 4 presents the phylogenetic tree summarising the 12S sequence data for 5 mulgaras. The separation into two species was confirmed by the two clusters of points.

Figure 4: Phylogenetic tree for "12S ribosomal RNA" gene



Work on the morphology of the two species is in its preliminary stages with no reportable results to date (Adams pers. comm.).

2.4 Discussion

The results from the allozyme analysis found that the mulgara specimens from Horse Hill and Purnie Bore, S.A., differed from specimens from Uluru National Park, N.T., and Marymia, W.A., at 18% of the loci surveyed (Adams pers. comm.). This is about the same level of divergence found between South Australian *Dasycercus* and *Dasyuroides byrnei* in an earlier study of 32 loci (Baverstock *et al.*, 1982) and supports the proposition that the sub-species *D. c. hillieri* actually warrants recognition as a separate species. We propose that the sub-species be identified as *D. hillieri* and given the common name of ampurta as discussed in Chapter 2. At this stage we believe that this species occurs in the north-eastern portion of South Australia. I believe that this species will also apply to animals from south-western Queensland, the N.T. Simpson Desert and possibly to the Waekaya Desert, N.T. Samples from these regions will be required to clarify this situation.

Preliminary results from the DNA profiles support the separation of the north-eastern South Australian species from the Northern Territory and Western Australian species, and will hopefully enable museum specimens from Queensland to be investigated. The DNA profiles also indicate that there are some small differences in allele frequency between the Northern Territory and Western Australian sub-populations but that these sub-populations rightfully belong within *D. cristicauda*. I propose that the common name mulgara continue to be applied to this species as discussed previously in Chapter 2. The generic term *Dasycercus* will be used when referring to both species.

3.0 Distribution

3.1 Introduction

Having identified the distinction between *D. cristicauda* and *D. hillieri*, we need to consider what is known of their original and current distribution and abundance. The arid zone has been the focus for surveys and expeditions sporadically since the early 1800s. The first scientific expedition was conducted by the Horn expedition in 1894. This was followed by an expedition in 1930-31 which mapped the Canning Stock Route and was accompanied by Otto Lipfert, who collected for the Western Australian and South Australian museums. Finlayson conducted scientific surveys between 1931 and 1935 through central Australia as far west as the Rawlinson Range and returned to undertake further research in 1950-1956. In 1952 representatives of the Australian Museum also collected specimens in the centre.

These early expeditions contributed much of what we know about the historic distributions of the arid zone mammals, including mulgara and ampurta. Aboriginal knowledge has provided substantial insight (e.g. Burbidge *et al.*, 1988; Tunbridge, 1991; Baker *et al.*, 1993; Nesbitt and Baker, 1993), although the scientific community generally disregarded this information for many years and much of it has now been lost. Another source of information on the composition of the pre-European fauna has been through the analysis of cave surface deposits, particularly from owl pellets. Baynes (1987, 1984), and Baynes and Baird (1992) have undertaken a number of studies using this technique and argue that they are representative of the original (immediately pre-European) fauna.

Baynes (1987) argues that specimens on the surfaces of cave deposits are truly representative of the immediately pre-European fauna because the mammal fauna changes very slowly through time in the Holocene cave deposits which have been excavated and dated. Radiocarbon dates for surface material from caves on the Nullarbor Plain are around 390 +/- 210 years B.P. (Baynes, 1987), which he argues is consistent with the material representing the original (i.e. immediately pre-European) mammal fauna. Further Baynes (1992) states that cave deposit material from south-western Australia shows that most of the species persisted in the area throughout the Holocene and suggested that once the arid-zone climate became re-established after the end of the last glacial the vertebrate fauna would have become relatively stable. He therefore argues that bone material even several hundreds of years old is probably representative of the original fauna and believes that this proposition is supported from remains in surface deposits from small caves all across the western arid zone.

Data from owl pellets combined with Aboriginal and historical data provide a substantial database from which to establish the original range of *Dasycercus* distribution. This database can then be put into a modelling program to predict the original distribution of species. BIOCLIM (The Bioclimate Prediction System) has been developed to map species distribution over a series of climatic factors and elevation. Sixteen parameters are derived for each data point, characterising annual, seasonal and extreme components based on temperature and precipitation. These values are then used to derive a climatic profile for the species. This climatic profile can then be used to assess the apparent climatic suitability of various geographic regions. A number of acceptance criteria are built into the model which separate suitable areas (all climatic values within 90 percentiles), marginal areas where all values are within the total range of the profile, and non-suitable (points failing to match all 16 parameters of the profile) (Busby, 1986).

3.2 Methods

Records of *Dasycercus* were collated from Museum records, literature reviews, Aboriginal information, incidental records, results of contemporary surveys and my data. A database has been established and will be maintained by the Conservation Commission of Northern Territory (CCNT) for the Mulgara Recovery Team.

The locality data were sent to ERIN (Environmental Resources Information Network), where the elevation values for mulgara data were developed by a 1/40th degree digital elevation model (DEM). Some data points could not be assigned elevation values and were removed from the analysis. A total of 348 sites, including sub-fossil sites, was used for the BIOCLIM model. This analysis was run in June 1994 and does therefore not include data from 1995, nor does it separate the two species.

ERIN also mapped the distribution data over vegetation based on a 1988 digital data set which was developed by the Australian Surveying and Information group (AUSLIG, 1990).

3.3 Results

In much of what follows I have used the terms "mulgara" and *"Dasycercus"* to refer to a combination of the two species, as the formal taxonomy has not yet been re-defined and the BIOCLIM analysis was run prior to receiving the outcome of the molecular genetic results. Nevertheless, I propose that all records east of 134° longitude (inclusive) represent locations of ampurta (*D. hillieri*).

Three hundred and seventy four records of mulgara localities including additional records since June, 1994, are presented in Appendix 1. The database contains only museum records which had a site location and a date. The records for some areas are representative and do not include every capture or sighting.

Figure 5 presents the locations of 254 records, including some multiple records per site, for *Dasycercus* recorded prior to 1980 and Figure 6 presents the locations of 172 records of mulgara from 1980 to present. Figure 7 presents the current predicted suitable and marginal geographic regions for *Dasycercus* derived by BIOCLIM based on 1988 vegetation mapping and mulgara records up to June, 1994.

Figure 5: *Dasycercus* historical records including subfossils and records to 1979

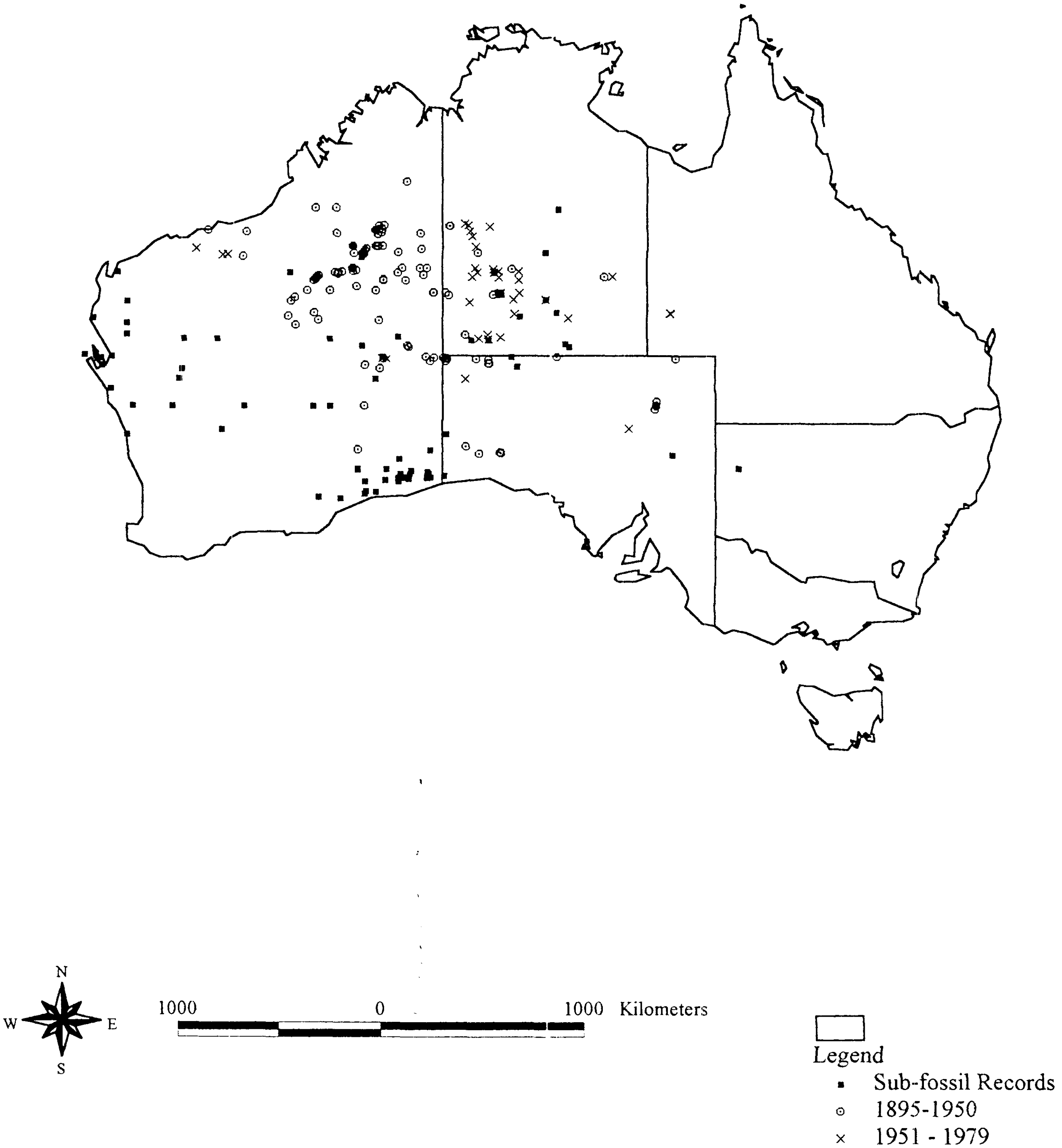


Figure 6: *Dasycercus* current records from 1980 to 1995

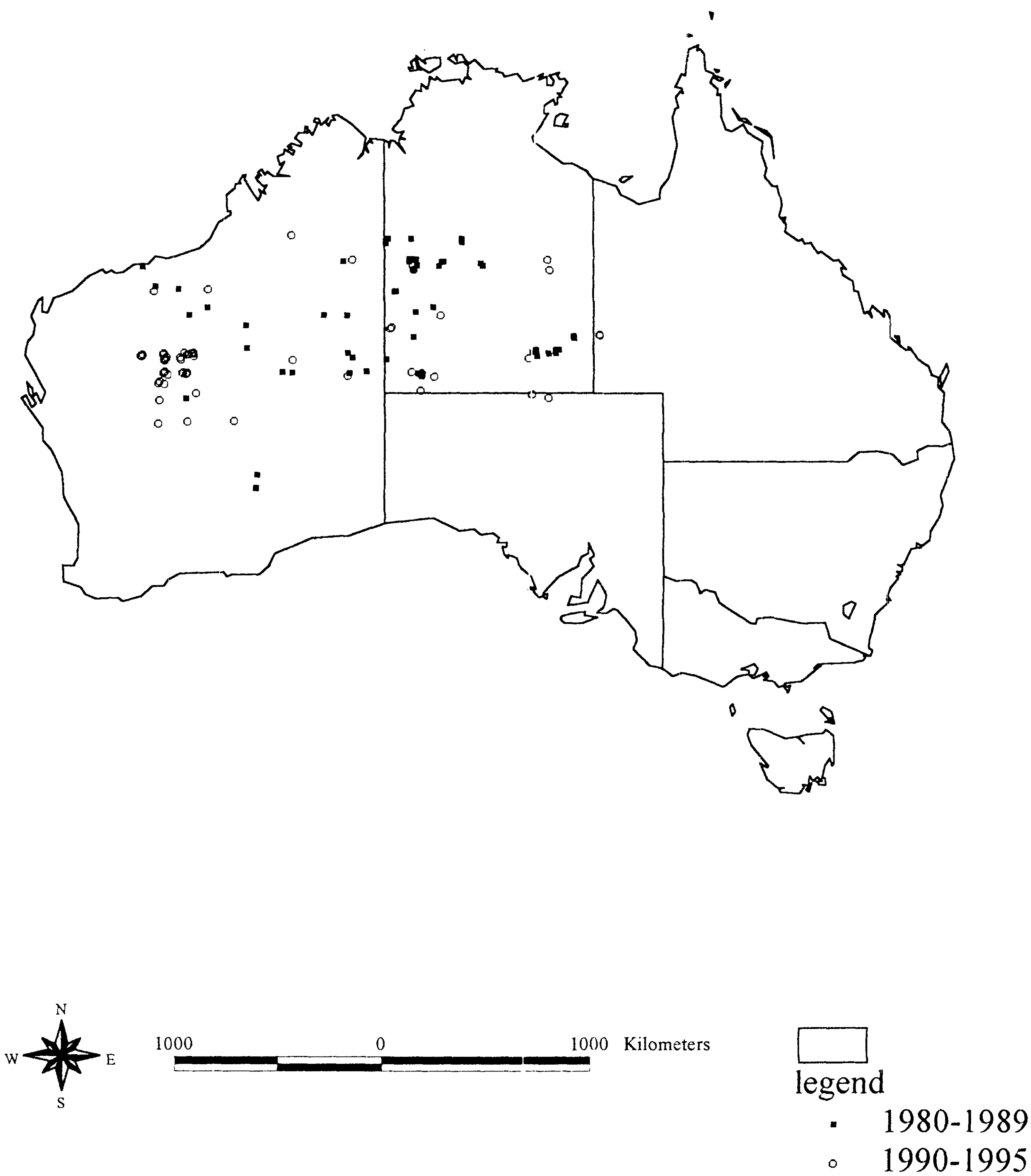
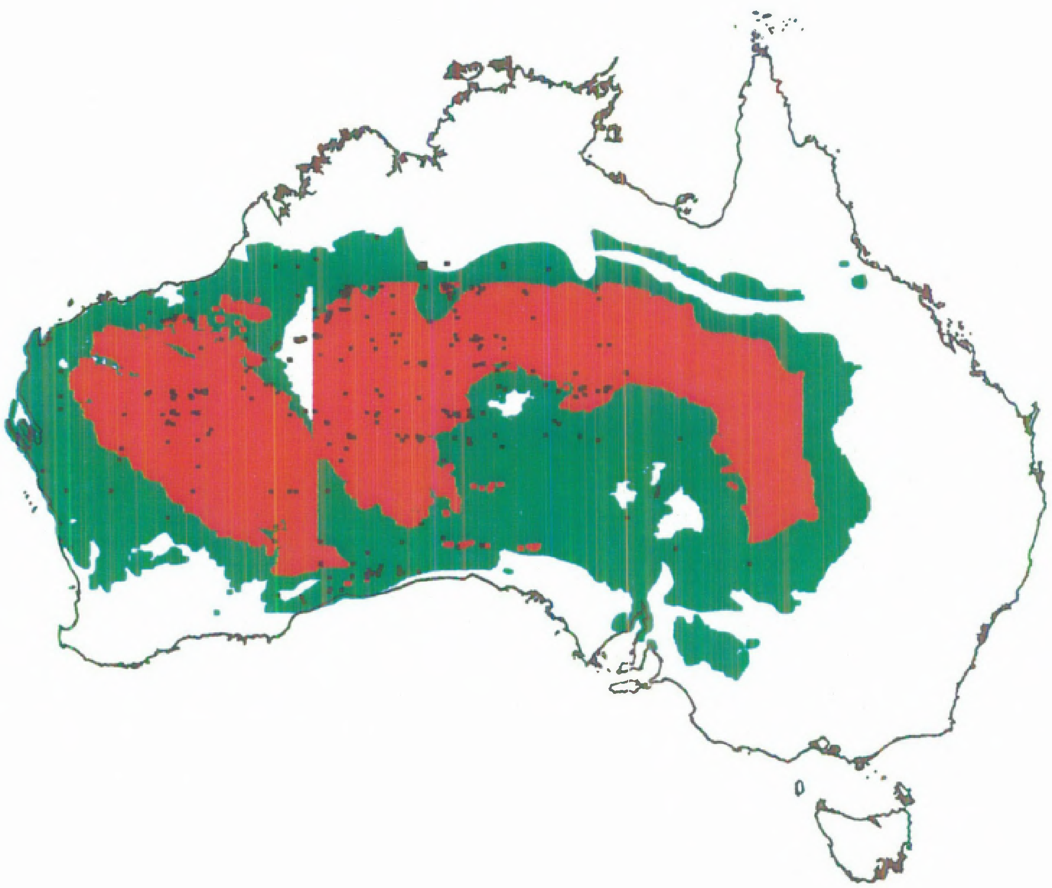


Figure 7: Potential *Dasycercus* distribution predicted by BIOCLIM (ERIN, 1994)



Legend

- Suitable Sites
- Marginal Sites
- Original Sites

Environmental Resources
Information Network (1994)

BACKGROUND:
This map shows the original, marginal and suitable sites for Dasycercus cristicauda (mulgara) based on the BIOCLIM model.

SOURCES:
AUSLIG (1993). 'Coastline. 1:100,000 digital dataset'.
Baker (1994). 'Mulgara site locations'.

CAVEATS:
The data used in the analysis have been assumed by ERIN to be correct as received from the data suppliers.
BIOCLIM climate surfaces fitted to data from the Bureau of Meteorology (1901 - 1975).
The digital elevation model from CRES (1992).

Projection: Geographic.
Australian Spheroid.

ERIN

3.4 *Dasycercus* habitats

The *Dasycercus* historical and current locality records were mapped over a 1988 derived continental vegetation map (Figure 8). While some arid plant communities have been substantially affected over the past 100 years, the broad landcover types are sufficiently similar to use the 1988 vegetation map to consider the changes in *Dasycercus* distribution in respect to landcover (Newman and Condon, 1969; Graetz *et al.*, 1995). *Dasycercus* records are located in a range of habitats. In the Nullarbor region and parts of the south-eastern arid zone, historic *Dasycercus* records are located within low open shrubland (bluebush and saltbush) and a large area of hummock grassland in the north-east of South Australia. Further to the north and west the *Dasycercus* records are scattered throughout hummock grasslands, tall shrubland, open shrubland and low open woodland. *Dasycercus* in the Simpson Desert and adjacent desert systems have been primarily recorded from cane grass (*Zygochloa paradoxa*) or spinifex on dune slopes and crests, as opposed to spinifex dominated swales and sandplains further to the west.

3.5 Changes in abundance and stability of Dasycercus *populations*

The locality records and BIOCLIM predictions indicate that *Dasycercus* were and are still distributed across large portions of the arid zone. These maps, however, only provide points of known occurrence and overall range of distribution. They do not give any indication as to how abundant, or persistent individual populations are within this broader distribution.

The concept of persistent populations is based on the premise that these populations are able to exist continuously in an area, as opposed to populations which are dispersing into or temporarily inhabitating areas (den Boer, 1981; Morton, 1990). The ability of populations to persist in certain areas despite droughts or other adverse conditions is an important factor determining the long-term survival of populations in climatically unpredictable regions such as the arid zone. This long-term survival is often keyed into particular habitats, often called refuges, which allow taxa to persist despite unsuitable climatic or ecological conditions occuring over larger parts of their preferred habitats (Morton *et al.*, 1995). It is important assess changes to these persistent populations if a true understanding of change in the status of the *Dasycercus* species is to be obtained.

To consider whether there have been changes in the abundance or persistence of *Dasycercus* populations within their overall range requires a comparison of historical and current knowledge on particular populations. This is difficult as there is limited information available on specific populations with most *Dasycercus* records deriving from regional surveys or opportunistic records. The status of several populations is considered in detail in Part 2; however, an overview of the historical and current *Dasycercus* records can provide some insight into the status of populations in various parts of the arid zone.

Present Vegetation (1988) and Mulgara sites

Environmental Resources Information Network (1994)

BACKGROUND.

This map shows Present Vegetation (1988) classed in upper stratum growth form and density categories with Mulgara sites.

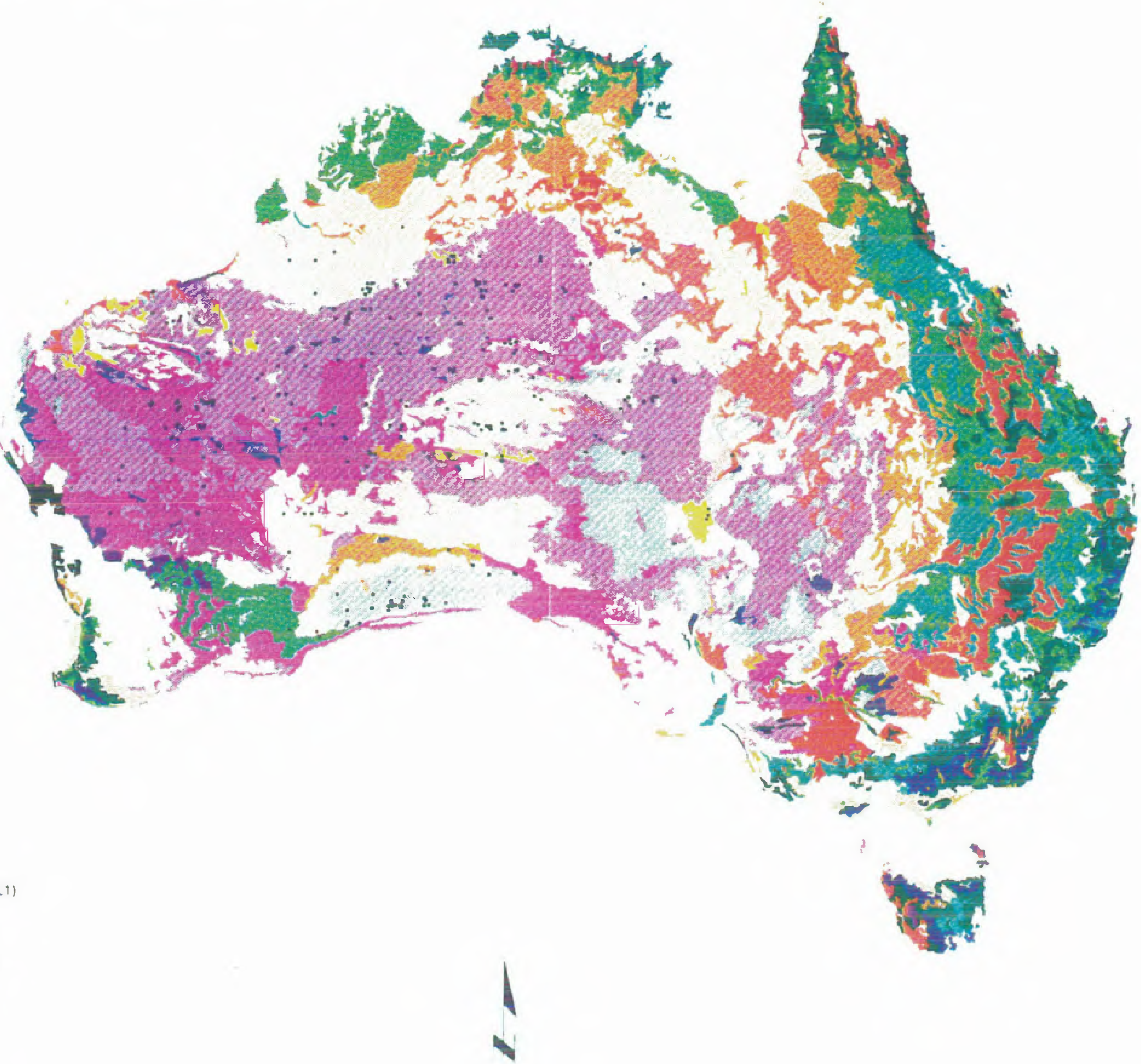
SOURCES.

AUSLIG (1991). 'Present Vegetation (1988) 1:5 million digital dataset'.
AUSLIG (1993). 'Coastline. 1:100,000 digital dataset'.
Baker (1994). 'Mulgara site locations'.

CAVEATS:

The data used in the analysis have been assumed by ERIN to be correct as received from the data suppliers.

Projection: Geographic
Australian Spheroid



Upper Stratum Growth Form and Density

- Sparse open herbfield (F1)
- Sown pasture (F3)
- Dense sown pasture (F4)
- Sparse open tussock grassland (G1)
- Open tussock grassland (G2)
- Tussock grassland or sedgeland (G3)
- Closed tussock grass/sedgeland (G4)
- Hummock grasses (H2)
- Low open shrubland (Z1)
- Low shrubland (Z2)
- Open heath (Z3)
- Tall open shrubland (S1)
- Tall shrubland (S2)
- Open scrub (S3)
- Low open woodland (L1)
- Low woodland (L2)
- Low open forest (L3)
- Low closed forest (L4)
- Open woodland (M1)
- Woodland (M2)
- Open forest (M3)
- Closed forest (M4)
- Tall open forest (T3)

Figure 8: ***Dasycercus*** **distribution records over vegetation mapped in 1988 (ERIN, 1994)**

3.5.1 Dasycercus cristicauda (mulgara)

Western Australia

Mulgaras have been collected intermittently from the majority of the arid regions of Western Australia. Bone material has been recorded from cave deposits on the Hampton Tableland (Nullarbor) and on the west coast north of Latitude 31° S to Shark Bay. These lie in the gap between the modern desert records and the original occurrences along the west coast (Baynes, 1984). The largest collection of mulgaras in Western Australia was a series of 52 specimens taken along the Canning Stock Route in the Great Sandy Desert by Otto Lipfert in 1930-1931.

More recently Burbidge *et al.* (1988) recorded a number of locations from Aboriginal people where mulgara were still current in the Western Desert and fresh tracks were sighted in 1990 between Giles and Warburton (Johnson pers. comm.). Four specimens have been recorded from the Pilbara in the last 10 years with the most recent being a single animal captured at Woodstock Station in February 1990 (Kendrick and How pers. comm.). One mulgara was opportunistically captured at Rudall River in July 1988 (Thieberger pers. comm.).

Five mulgaras were captured in the Gibson Desert Nature Reserve in 1989 (Pearson, 1990; Christensen pers. comm.) . During a survey in the Reserve in 1991, I found old burrows but no recent sign; however, Woods (pers. comm.) recorded fresh mulgara tracks here in 1995. In 1987, a single mulgara was captured in the Queen Victoria Spring Nature Reserve which was the most southern modern occurrence in Western Australia (Pearson, 1990). I surveyed this area in 1991 but found no sign of mulgara and no captures have been recorded since despite continued trapping effort (Pearson pers. comm.). Two mulgaras were captured at Wanjarri Nature Reserve, south of Wiluna in February 1991 (Connell pers. comm.) and I recorded fresh sign at two sites within the Reserve in September 1991.

A colony of mulgaras was located in the vicinity of a proposed gold mine site at Marymia in early 1993 by Ecologia consultants working for Resolute Resources Ltd. The population was found to contain over 40 individuals in 1993; however, numbers declined in 1994. A regional survey in the Gascoyne region recorded mulgaras from several localities in 1993. Mulgaras were also recorded in 1994-1995 at Jundee Station, Eagle Mining, Nifty mining camp, on the edge of the Great Victoria Desert (50 km from Kalgoolie), Kennedy Range in the Carnarvon Basin, De La Poer Nature Reserve and Barrambie (Pearson pers. comm.; Chapman pers. comm.; Moseby pers. comm.). The survey work I conducted in Western Australia in 1991 and 1993 is described in more detail in Chapter 7.

It is apparent from reviewing the records in Western Australia that mulgaras have been and are continuing to be recorded from a broad area of the arid zone in that state. The majority of these records are single records and a number of sites have had mulgaras appearing intermittently, e.g. Gibson Desert Nature Reserve and Queen Victoria Spring Nature Reserve. Some areas such as Marymia have had temporarily high numbers of mulgaras which have subsequently declined. To date no persistent substantial population of mulgaras has been located in Western Australia. It is clear that for these intermittent detectable populations to appear that there must be persistent populations within Western Australia but their locations are currently unknown.

Northern Territory

Mulgaras have been recorded from a number of locations in the Northern Territory. In the Tanami they were recorded at 24 locations during a regional survey, but have been recorded in good numbers only in the Sangster's Bore region where they have been detectable persistently for eleven years. Over an eight-year study 174 individual mulgaras were captured on sites at Sangster's Bore (Gibson and Cole, 1992). Further to the south mulgaras were sighted and tracked at Central Mt Wedge Station in 1991 and 1992 (Waudby pers. comm.; my data). The station is situated near Papunya where mulgaras were captured in 1966 (Woolley, 1990). Mulgaras were also captured near Yuendumu and Haasts Bluff in 1955 (Finlayson, 1961). Mulgaras are reported by Aboriginal informants to be persistent and common at Kintore (see Chapter 2).

Mulgaras have been reported within the Uluru National Park region by a number of authors including Woolley (1990), Masters (1993), Reid *et al.* (1993) and Baker and Jarman (1995). Masters (1993) reported a total of 123 mulgaras captured over the period 1976-1989. Baker and Jarman (1995) reported the capture of 20 individuals in 1991 and estimated from captures and sign that the core Mulgara population resided within a 55 sqkm area. Masters (pers. comm.) has estimated that the Uluru/Yulara population currently stands at approximately 150 animals.

The locations and data collected on mulgaras in the Northern Territory indicate that they are relatively widespread and that there are at least three persistent and sizable populations at Uluru National Park/Yulara, Sangster's Bore and Kintore. Further discussion of these three populations can be found in Chapters 2, 5, 6 and 7.

South Australia

Finlayson (1961) reported that mulgaras were one of the most abundant small mammals in the Everard, Mann and Musgrave Ranges region of South Australia in the 1930s. Biological surveys which have been conducted bi-annually on the Anangu Pitjantjatjara Lands since 1990, have been focussed on a cross - section of habitats along the southern edge of the Everard, Mann and Musgrave Ranges and the dunefields and sandplains to the south. No sign of mulgara has been located on any of the sites surveyed and Aboriginal traditional owners state that they disappeared many years ago (see Chapter 2). Other surveys conducted throughout South Australia in recent years (e.g. McKenzie and Robinson, 1987; Copley *et al.*, 1989; Woolley, 1990) have failed to locate any ampurta populations. Available information suggests that mulgaras have become extinct in South Australia.

3.3.2 Dasycercus hillieri (ampurta)

South Australia

Ampurtas were historically reported to be widespread and at times very common in the north-eastern part of South Australia by Spencer (1896), Finlayson (1935) and Wood-Jones (1923). However, a number of regional and intensive surveys conducted in the eastern arid zone areas of South Australia over recent years (Reid pers. comm.; Copley pers. comm.) failed to record any sign of ampurtas.

In 1990 an ANZES expedition to the Simpson Desert Nature Reserve and Witjira National Park caught a total of 15 ampurtas. However, a second survey in 1991 captured no ampurta and found sign at only one location, in a drainage valley north of Lake Griselda. This variability was thought to be associated with seasonal conditions (Head pers. comm.). I conducted a brief survey in this region in 1992 and found recent sign of mulgaras at several localities (see Chapter 7).

No persistent ampurta populations have been located, though it is apparent that there must be a least one in the Witjira National Park/ Andado region. A comparison of the historical records and current records suggest that ampurta populations have declined substantially in South Australia.

Queensland

Woolley (1990) captured 7 ampurtas at Sandringham Station in southwestern Queensland in 1968; however, on a return trip in 1971 she was unable to locate any further individuals or sign. Since 1990 surveys for ampurtas near Bedourie, at Kamran and Sandringham Stations and other sites near Birdsville have failed to reveal further populations (Dickman pers. comm.). However, two ampurtas were captured at a new study site east of the Field River, near the N.T. border, in 1995 (Dickman pers. comm.).

In 1990 a single ampurta population was located on Ethabuka Station in the same region as Sandringham Station, and became one of the principal focusses of a study by Dickman and co-workers (Dickman pers. comm.). The population has been regularly studied since 1990 and data collected on diet, habitat use and movement using tracking and observation techniques. Twenty four ampurtas were captured on 12 main trap grids during the March 1990 field trip. Additional individuals were captured on the 9 supplementary grids. Ampurta numbers peaked in June 1992, then crashed and have remained very low (0-2) individuals per trip with a single animal being captured in July 1995 (Dickman pers. comm.).

The two known populations have each crashed within a four-year period of being located and only one other locality has been recorded. The available data would suggest that the population in Queensland is very patchily distributed and potentially in decline.

Northern Territory

Ampurtas have been recorded at fifteen locations during surveys of the Simpson Desert in the Northern Territory (Gibson and Cole, 1988). Masters (pers. comm.) also recorded an ampurta track on the French line in the Simpson Desert in 1995 (Appendix 1). Two *Dasycercus* were captured in the Waekaya desert north of the Simpson Desert during a survey in 1993 (Gibson pers. comm.).

The genetic status of the *Dasycercus* population in the Simpson Desert is at this stage assumed to be *D. hillieri* in association with the Queensland and South Australian counterparts. The status of the Waekaya desert population is unknown. No substantial persistent population has been located within the Simpson Desert or Waekaya Desert to date; however, no specific surveys for ampurta have been undertaken. The available data suggest they are patchily distributed and in low numbers.

4.0 Discussion

The data presented in Figures 5 and 7 indicate the probable outer boundaries of the original *Dasycercus* distribution. From these data it appears that *Dasycercus* were originally located virtually across the entire arid zone. Within this outer boundary the potential distribution based on the climatic predictions of BIOCLIM suggest that there were sections of the arid zone, particularly in the Simpson Desert that were climatically unsuitable for *Dasycercus*. The BIOCLIM prediction also indicates that the suitable habitat was more fragmented and covered a smaller range than that including the marginal areas. Those areas included as marginal were predominantly around the edge of the arid zone and particularly the Nullarbor Plain.

A comparison of the current locality records and the BIOCLIM prediction indicates that the majority of the current known records lie within the suitable habitat rather than the marginal areas. There has been a reduction in overall distribution of *Dasycercus* particularly from the south. The northern boundary is the only area in which the original outer distribution limit has been maintained.

The locality records and BIOCLIM delimit the *Dasycercus*' range, but do not illustrate what has occured within this outer boundary. These data cannot provide us with the detail required to be able to assess whether *Dasycercus* were continuously distributed across their range or whether they were persistently or sporadically widespread. To assess these factors we must rely on the narratives of Aboriginal people and the early researchers and expeditioners for their insight into the dynamics of the *Dasycercus* populations they observed. One of the limitations of the data available is the fragmentary nature of their collection both temporally and spatially.

Wood-Jones recorded the mulgara as a typical desert animal well known to Aboriginal people and believed it to be common in good seasons (1923, p109). He stated that mulgaras appeared to have:

> " a wide distribution in the Centre, and although like most carnivores it is not usually at all abundant it is capable of rapid increase in good seasons."

As mentioned earlier, he noted that the numbers could increase greatly during mouse plagues.

Finlayson (1935) reported *D. cristicauda hillieri* to be widely distributed in the extreme northeast corner of S.A. between the Barcoo and Diamantina and capable of greatly increasing numbers over several months. He stated that from 1932-1935 *D.c. cristicauda* were one of the most plentiful small mammals in the Lake Amadeus region (south of the Mann and Musgrave Ranges, S.A.). By the early 1960s, however, he recorded that mulgaras were almost unknown in the Amadeus region and were much reduced elsewhere (Finlayson, 1961). Aboriginal informants (see Chapter 2) also state that mulgaras have not been seen south of the Mann and Musgrave Ranges in S.A. since around the 1950s.

Bolam (1930, p25) reported on the activities of mulgaras in the Ooldea area:

> "In periods of drought the Phascogales (mulgaras and kowaris) and foxes create havoc among the timid animals."

From these early descriptions an impression is gained of *Dasycercus* distribution as being widespread but not necessarily continuous and that their abundance fluctuated substantially depending on the seasons.

One of the questions which is raised is whether there has been a change from persistent presence of *Dasycercus* to a fluctuation between presence and absence in parts of its range. People from Kintore were explicit in naming the locality of persistent mulgara populations and the outer limits to those populations. At Mu<u>t</u>itjulu, A<u>n</u>angu stated that mulgaras used to be very common around the area but were not any more. Again, however, they noted that there were habitat boundaries which restricted the overall distribution of mulgaras. It appears that *Dasycercus* were more widespread and abundant than currently occur in some areas, particularly in the south-east and the western semi-arid areas, and that regional populations are reliant on persistent core populations. The concept of persistent versus ephemeral populations will be further addressed in Part 2 of this thesis.

4.1 Timing of the decline

Ride (1970) and Parker (1973) reported the mulgara distribution to be widespread and common following good seasons. However, by the late 1970s, there was growing concern regarding the mulgara's status. Laut *et al.* (1977) listed their status in South Australia as indeterminate (i.e. suspected as being vulnerable, rare or endangered) and Archer (1979) wrote that there had been some restriction in distribution since settlement. By the early 1980s mulgaras were classified as rare (Aslin, 1983) and are currently classified as vulnerable (ANZECC, 1991).

4.2 What caused the decline in distribution ?

Having ascertained that there has been in decline in the distribution of *Dasycercus*, the second question posed by this research was 'what has caused the decline in distribution? Is it due to the restriction to limited habitats or some other cause?'

Early records of habitat use indicate that mulgaras utilised a range of habitat types, including bluebush and saltbush steppes, stony plains, spinifex sandplains and canegrass covered dune crests. There have been no records of mulgara from the blue bush or salt bush steppes since the 1930s nor on the gibber flats of the Simpson Desert since Spencer's records in the late 1800s. The overall impression is that mulgara/ampurta are now constrained to spinifex sandplains or canegrass/spinifex dunes.

There are a number of possible causes for this reduction in range and habitat usage, which have all been identified by previous authors as having a role to play in the decline and extinction of a number of the arid zone fauna (e.g Morton, 1990; Burbidge and McKenzie, 1989; Johnson and Roff, 1982). Those most likely to have affected *Dasycercus* are reviewed in the following sections.

4.3 Loss of suitable habitat

4.3.1 Introduced herbivores

Dramatic changes to vegetation, particularly in the southern parts of the arid zone, have occurred due to grazing pressure from rabbits, cattle and sheep (Wood, 1984). Newman and Condon (1969) stated that the bluebush-saltbush steppes are the most degraded rangeland type. Sheep were grazing the bluebush steppe in South Australia for around ten years prior to the arrival of rabbit in the 1870s. Pastoral development of central Australia commenced around 1870s when grazing was established on the non-spinifex grasslands and bluebush/saltbush steppes. Cattle numbers fluctuated in response to seasons, with peaks in 1928 and 1958 just prior to major droughts. The exceptional rains in 1973-78 resulted in a massive increase in cattle numbers to higher than previously experienced (Griffin and Friedel,1985).

The spread of the rabbit invasion through the arid zone was extremely rapid. From the time of release in Victoria in 1859, the rabbits had arrived in central Australia via the Lake Eyre Basin by the 1890s. By 1901 they were being recorded as plentiful in the Musgrave Ranges and by 1902 they were seen around Lake Amadeus. Rabbit tracks were recorded in the Davenport Range area by 1905 which is near the present northern limit of the main population (Finlayson, 1961). Rabbits are not common (i.e. they are found, but patchily) north of the Tropic of Capricorn (Cooke, 1977) with the climate and habitat posing a northern barrier. At their peak, rabbits covered around 60% of the N.T. (Strong, 1983).

Plagues of rabbits were common in good seasons, with records of millions being seen in the Simpson Desert (Clune,1944). One of their most damaging attributes is their ability to progressively denude the landscape of vegetation as droughts progress. Terry (1937) recorded that during a drought in 1931 near Warburton, rabbits were being caught up in shrubs at the head height of a rider on camel back. These plagues were often followed by massive die-off during subsequent droughts, for example during the 1925-1938 drought (Clune, 1944).

As indicated in Figure 8, *Dasycercus* have been recorded from a range of habitat types including open bluebush and saltbush steppe of the Nullarbor (Wood-Jones, 1949; McKenzie and Robinson, 1987), stony tablelands (Spencer, 1896), mulga sand dune country (Wood-Jones, 1949) and spinifex sand plains and dune ridges (Finlayson, 1935; 1961). Spencer (1896) recorded: "Specimens were found frequently burrowing in the stony plains around Charlotte Waters, but (the species) does not seem to occur further north". Toby Ginger (Finke Community) stated that historically the gibber flats around Charlotte Waters were well covered in bluebush, prior to the arrival of rabbits and sheep.

Mulgara specimens were collected in the vicinity of Rawlinna by Wills around 1927. These specimens came from one area of the Nullarbor Plain which is an open bluebush steppe (*Maireana sedifolia*) mixed with saltbush. The other locality was a lightly wooded steppe of myall (*Acacia papyrocarpa*) and bluebush. This latter vegetation type is typical fringe vegetation along the edge of the Nullarbor (McKenzie and Robinson, 1987). Troughton also caught mulgara specimens near Fisher (close to Ooldea) on the limestone plains covered with knee-high bushes (Troughton, 1967). McKenzie and Robinson believe that mulgaras were extant on the Nullarbor at least prior to 1929.

These bluebush and saltbush steppes are one of the habitats in which mulgaras are no longer found. It is possible that a combination of grazing pressure and marginal climatic conditions (Figure 6) contributed to the demise of mulgara populations from these areas. Within the central arid zone, most of the *Dasycercus* records are located in hummock grasslands, low open woodland and tall open shrubland communities. Further to the north and west there is a dominance of tall open shrubland and tall shrubland, and open woodlands in the far north-west. These habitats and locations are less affected by the effects of grazing pressure, due principally to their aridity and spinifex ground cover.

The impact of grazing on *Dasycercus* would most likely be through the loss of vegetation structure and cover, subsequent loss of invertebrate and vertebrate prey items and the compaction of the ground making it harder to dig burrows. The increased numbers of predators such as cats, foxes and dingoes that utilise the rabbits and some domestic stock for prey would also have impacted on *Dasycercus* numbers.

4.3.2 Fire

The increase in wildfires as a result of the interference with Aboriginal burning practices would have an impact upon *Dasycercus* populations by removing cover and prey items over large areas and could have been responsible for at least local disappearances. Griffin and Friedel (1985) cite the large scale fires in 1920 to 1923, 1960s and the fires of 1973 to 1978 where over 33% (~ 240 000 km^2) of the Alice Springs Pastoral district burnt in over 600 separate fires. Large areas of arid South Australia, Queensland and Western Australia were also burnt during this period. At Uluru National Park 46% of the Park was burnt in 1950 and 76% was burnt in 1976, with both of these fires being part of much larger wildfires (Saxon, 1984).

Large hot burns are likely to remove all available cover and leave mulgaras and their prey with nowhere to live. Gibson and Cole (1992) stated that the mulgara's persistence together with most smaller mammals suggested that fire is not as important to its survival as for other CWR species. However, the size of their survey plots was relatively small and they were patchy and may not have keyed in on the major fire impacts likely to affect mulgaras (Johnson pers. comm.). The research of Masters (1993) and that presented herein (Chapters 5-7) suggest that fire is an important factor in determining habitat suitability for mulgaras.

4.4 Predation

Foxes have a similar distribution to rabbits and have been established in South Australia since 1925 and the 1930s for the remainder of the arid zone (Wood-Jones, 1923; King and Smith, 1985; Griffin and Friedel, 1985).

Foxes were noted at Anna Creek by 1910 and for 20 years made slow progress in their northerly advance. Finlayson found in 1932 that they had become well known to Aboriginal people and doggers in the Everard and Musgrave Ranges. By 1956 the fox outnumbered the dingo in the Musgrave, Mann and Tomkinson Ranges, S.A. This was partly due to the doggers taking dingo scalps in the eight years prior. The annual scalp take was estimated to be between 500 and 3 000 per year with the maximum number being taken in 1956 (Finlayson, 1961). Foxes were recorded in WA in 1911-12 and had reached the Kimberleys by the 1930s. They are generally considered as common in the southern areas and rare in the western deserts and northern deserts (King and Smith, 1985).

Burbidge *et al.* (1988) stated that feral cats and foxes are widespread and abundant in the deserts. It is not known when cats first became established; however, they were recorded there by European explorers since the early 1890s. Many Aborigines residing in the central deserts regard cats as always having been present and some indicated that they moved into central Australia from the west.

Kerle (1993) recorded that Uluru National Park has historically supported high levels of feral animals. A "plague" of cats was recorded in 1970 and cat and fox numbers reportedly increased after the extremely good rainfall in 1973 until the 1976 fires. An increase in the numbers of cats and foxes was also recorded from 1987 to 1990 (Reid *et al.*, 1993).

Morton (1990) suggests that the impact of predation is an important but subsidiary role to the impact of introduced herbivores on refuge habitats, particularly during droughts. Other researchers have recently alerted us to the potential impact of foxes (e.g. Kinnear, 1991) and cats, and suggest that the impact of introduced predators may be greater than suggested by Morton.

Introduced predators are likely to impact on mulgaras by preying upon them and by competing for similar resources. This impact may be substantial, particularly during droughts. Dickman (pers. comm.) noted that foxes first arrived at Ethabuka, Qld, in mid 1991 following a population explosion of long-haired rats, *Rattus villosissimus*. The station owners stated that there had been no foxes on the Station for the previous

10-12 years. The foxes focussed their hunting on the rats until mid-late 1992 after which scat analysis indicated a dietary switch to smaller mammals. Ampurta were first recorded in the scats in June 1992. Dickman (pers. comm.) reports that the fox numbers peaked in the latter part of 1992 and that feral cats were present since his study commenced in 1990. Dickman stated that due to unusually good seasons it was unlikely that the ampurta population decline was due to resource shortages and that he believes that the foxes are depressing the ampurta population.

4.5 Refugia

Morton (1990) developed a conceptual model to account for the disappearance of the medium sized, CWR mammals. This was based on the proposition that certain mammals were or are dependent on small fertile areas as drought refuges, and that these areas were targeted also by introduced herbivores which altered the vegetation composition of these habitats. This degradation together with pressure of introduced predators and in some places altered patterns of fire caused increased probabilities of local disappearance during droughts.

In support of this proposition Morton points to the usually infertile nature of the majority of the spinifex sandplains and the more fertile or moisture retaining areas associated with topographic diversity which receive additional run-on of water and nutrients during rain events, e.g. floodouts or paleodrainage systems. Morton proposed that the arid landscape comprises a series of patches of fertile and dependable production scattered throughout a vast infertile landscape that in the occasional wet years tend to expand and coalesce. Conversely during the long dry times which intervene, these patches shrink and break up into smaller units and, as the drought stretches out, more and more of the patches disappear altogether.

The locations of the currently known persistent mulgara populations appear to be associated with either surface or sub-surface drainage systems, e.g. the Fiddlers (Salt Beef) Lake drainage line at Sangster's Bore in the Tanami, the sub-surface drainage line at Uluru National Park/Yulara Lease, run-on areas associated with the ranges at Kintore, edge of the salt lake at Central Mt Wedge, and the paleodrainage system at Wantjira Nature Reserve (see Chapters 5-7). At Sangster's Bore and Uluru National Park small numbers of mulgaras have been located away from these areas but only during or after good rainfall seasons (Gibson, 1986; Morton and Latz pers. comm.; Reid *et al.*, 1993; Baker and Jarman, 1995).

Spinifex grasslands occupy at least 22% of the continent (Griffin,1990). The spinifex grasslands which fulfil the criteria of refuge habitats by way of association with more reliable moisture and nutrient regimes would be small and patchy and perhaps provide an explanation for the apparently widespread but patchy distribution of the mulgara.

The role of refugia in maintaining mulgara populations in some areas appears to be important and will be investigated in more detail in subsequent chapters. If in fact, mulgaras do depend on these drought refugia, then the impact of introduced herbivores and predators is likely to be intensified during droughts when the populations are limited to small isolated areas of suitable habitat.

Johnson and Roff (1982) argued that remnant populations of rabbits survive during droughts in favourable areas (e.g. saltlakes and water courses) which most probably formed drought refuges for many native species including the western quoll (*Dasyurus geoffroii*), as well as foxes and cats. They believed that it is conceivable that rabbits indirectly caused the extinction of the quolls in these favourable areas during dry times by reducing the invertebrate and native vertebrate prey items through habitat destruction. By simplifying the prey supply to few species, often in low numbers, rabbits amplified the normal feast-or-famine situation. This situation probably also applies to *Dasycercus*.

5.1 Assessment of status of Dasycercus cristicauda *and* D. hillieri

5.1.1 Mulgara (*D. cristicauda*) Distribution

Genetic analysis to date suggests that the taxonomic boundary for mulgara is west of 134° E. Based on available data it appears that animals at Uluru National Park/Yulara north to Kintore and Sangster's Bore belong to *D. cristicauda,* as do all the animals west into and including Western Australia to the Pilbara. The extent to which there are discrete genetic subdivisions within this distribution is unresolved at this point in time.

The current range of mulgaras has remained relatively similar to their historic distribution in the central and northern parts of their range. However, to the south there appears to have been a substantial reduction, particularly in the Nullarbor and north-western South Australia. The demise on the Nullarbor in both South Australia and Western Australia appears to have happened historically, i.e. in the early phases of European settlement. However the disappearance in north-western South Australia has been relatively more recent i.e. post 1930s. Pearson has only captured one mulgara at the Queen Victoria Spring Nature Reserve, which represents the most southerly record in recent years. It may be that this animal was part of a seasonal expansion of a population, or that there are low numbers of mulgaras residing in remnant populations in the area.

Within the rest of the distribution, while the overall spread is similar to its historical range, the actual records of persistent populations are patchy. Most recent records are of single or low numbers of captures, and are usually based on a single survey. The only known long-term persistent populations to date are at Uluru National Park/Yulara, Sangster's Bore and Kintore, all in the Northern Territory. While there are bound to be others, some that were thought to be persistent have tended to drop out over time, e.g. Marymia, and Gibson Desert Nature Reserve. It is probable that in all these areas and other such as Woodstock in the Pilbara where only intermittent captures have occured, there are refuge/ core populations which have not been located yet, and that areas that have been surveyed have opportunistically captured animals from expanded populations.

Assessment of the status of *D. cristicauda* based on the MMAP system estimates the range reduction as 25-74% and a current distribution area of 80 001-1 000 000 km^2.

The recommendation to the MMAP review is to retain *D. cristicauda* conservation status as Vulnerable.

5.1.2 Ampurta (*D. hillieri*) Distribution

The genetic analysis has identified the animals from the north-eastern section of S.A. to be *D. hillieri*. It is believed that the Queensland population will also be *D. hillieri* (Archer, 1979) and potentially also animals from the rest of the Simpson Desert and potentially the Waekaya Desert to the north. It is proposed for the moment, until further data collection can verify or deny, that the distribution for the taxon *D. hillieri* is east of 134° E.

Including the Sandringham Station population which disappeared after 1967, only three populations presumed to be ampurtas have been located by survey and research teams. One, the population at Ethabuka Station in the vicinity of Sandringham Station, Qld crashed in 1992 with only one animal being captured in 18 months. The status of this population is now very uncertain (Dickman pers. comm). The population at Witjira National Park, upon which the genetic work has been done, was recorded in good numbers in 1990 and then disappeared in 1991. Since then low levels of sign have been recorded but no other animals captured. Other biological surveys in the north-east of S.A. have found no sign of ampurtas (Copley pers. comm.). One of the questions which will require further investigation, is the genetic status of animals which have been captured in the Waekaya Desert, N.T., and also animals that have been previously recoded by Gibson in the northern Simpson Desert. I suggest that these animals and the records from N.S.W. and Flinders Ranges are *D. hillieri*.

It is clear that there has been a dramatic reduction in range for this species. Assessment of the status of *D. hillieri* based on the MMAP system is that the population size is unknown but suspected to be small, the population trend is known to be decreasing, the range is estimated to have declined by 75-89%, and the current distribution area to be around 1 001-80 000km^2. The recommendation of the MMAP review is to classify *D. hillieri* conservation status as Endangered.

Further work will be required to determine the geographic range of *D. hillieri* and to locate persistent populations.

6.0 Conclusion

Two of the principal questions which I identified as pertinent to the aims of my research have been addressed in this chapter The taxonomic question raised in Question 2 has been clarified with the proposal of two species rather than sub-species. This finding affects the consideration of distribution and abundance of the two species as they have previously been considered together as a single species.

With respect to question 1, *Dasycercus* have declined in distribution since the arrival of Europeans and in some areas have become locally extinct. A decline in abundance is more difficult to assess and is complicated by seasonal and temporal fluctuations. The information within this chapter suggests that there has been an overall decline in the abundance of *Dasycercus* and a decline in abundance has been observed within individual colonies, particularly of ampurta.

Question 3 identified the need to examine factors causing declines in distribution and abundance. A number of possible factors have been proposed to account for the decline of the group of medium-sized arid-zone mammals. These aspects will be investigated through case studies presented in Part 2 of this thesis.