

09PH
S7279



The suitability of habitat for greater bilby
(*Macrotis lagotis*) in the Tanami Desert
and the relationship with fire

Richard Southgate

School of Earth and Environmental Sciences
University of Adelaide

October 2006

**A thesis submitted for the degree of
Doctor of Philosophy**

Contents

Abstract.....	vii
Declaration.....	x
Acknowledgements	xi
Chapter 1 General Introduction	1
Knowledge of Australian arid-zone fauna.....	2
Pattern and process in the arid zone	3
Habitat suitability modelling	10
Conservation status and management.....	11
The structure of the thesis.....	14
References	18
Chapter 2 The study species	26
Taxonomy, distribution and status	26
Taxonomy.....	26
Distribution and status.....	27
Life history characteristics.....	28
Gestation, fecundity and growth.....	29
Density, home range size and movement	29
Habitat use and diet	30
References	32
Chapter 3 An evaluation of transect, plot and aerial survey techniques to monitor the spatial pattern and status of the bilby (<i>Macrotis lagotis</i>) in the Tanami Desert, Northern Territory	37
Introduction	38
Methods	39
Study area	39
Bilby sign.....	40
Random plots.....	42
Fixed transects	43
Aerial survey.....	44
Analysis	44
Results	47
Random plots.....	47
Fixed transects	47
Aerial survey.....	48
Efficacy.....	50
Discussion.....	50
Factors affecting accuracy	55
Factors affecting precision.....	57
Efficacy.....	57
References	58

Chapter 4 An examination of the Stafford Smith/ Morton ecological model: a case study in the Tanami Desert, Australia	62
Introduction	63
Methods	65
The study area	65
Field data	66
Spatial database	67
Climate	67
Substrate	69
Vegetation and fire	70
Analysis	70
Results	71
Rainfall, elevation and temperature	71
Substrate pattern	74
Vegetation and fire pattern	76
Accuracy of spatial data	79
Discussion	82
Climate	83
Substrate	84
Fire and substrate heterogeneity	85
Accuracy	86
Conclusions	86
References	87
Appendix 4.1	90

Chapter 5 Modelling introduced predator and herbivore distribution in the Tanami Desert, Australia	91
Introduction	92
Methods	94
Study area	94
Random plots	94
Transects	97
Evaluation plots	98
Climatic data	98
Analysis	99
Results	101
Introduced and naturalised predators	101
Introduced herbivores	108
Model reliability and evaluation	108
Discussion	109
Patterns of distribution	109
Substrate effects	112
The effect of episodic rainfall and fire	113
Gradient effects	114
Limitations of the models	116
Conclusions	117
References	118

Appendix 5.1.....	126
Appendix 5.2.....	127
Chapter 6 Age classes of the greater bilby <i>Macrotis lagotis</i> based on track and faecal pellet size.....	131
Introduction	132
Methods	133
Development of the procedures	133
Application of the procedures	134
Results	136
Tracks	136
Faecal pellets	137
Application of the procedures	139
Discussion.....	140
Development of procedures.....	140
Application of the procedures	142
References	143
Chapter 7 Bilby distribution and fire: a test of alternative models of habitat suitability in the Tanami Desert	146
Introduction	147
Introduced herbivore/ substrate model	148
Introduced predator model.....	149
Altered fire regime model	149
Climatic/vegetation gradient model.....	150
Methods	151
Study area, climate and vegetation	151
Animal identification and monitoring techniques	153
Explanatory variables	155
Variable selection and model fitting.....	158
Model evaluation	160
Results	160
Spatial and temporal trends in bilby prevalence.....	160
Bilby–environment relationship	165
Model ranking, prediction and evaluation	168
Discussion.....	170
Extent of occurrence.....	170
Area of occupancy	170
Habitat suitability and refugia characteristics	172
Predictive performance of the global models and limitations	174
Implications for conceptual models for arid Australia	176
Implications of management and assessment of status	177
Appendix 7.1.....	186
Appendix 7.2.....	187

Chapter 8 The diet of the bilby <i>Macrotis lagotis</i> in relation to substrate, fire and rainfall characteristics in the Tanami Desert	189
Introduction	190
Methods	192
Study area	192
Faecal collection and bilby prevalence	193
Faecal analysis	196
Environmental variables	197
Results	199
Faecal analyses and overall dietary composition	199
The relationship of dietary composition with environmental variables	202
Temporal variation in the diet at the two sites with persistent activity	205
Comparison of diet at sites with persistent and transient activity	207
Discussion	209
Dietary composition	209
Prevalence and persistence of the bilby and diet	211
Fire-promoted plant foods and habitat attributes	213
Implication for research and management	214
References	215
Chapter 9 Fire-promoted plant production and spinifex-fueled fires in the Tanami Desert	220
Introduction	221
Methods	222
Study area	222
Random plot monitoring	224
Transect monitoring	224
Experimental fire plots	226
Climatic variables	226
Analysis	227
Results	227
Spinifex species and vegetation pattern	227
Vegetation cover and fire	234
Distribution of food plant species	235
Yakirra occurrence and growth	235
Discussion	237
Determinants of vegetation cover	239
Determinants of fire	241
Spatial and temporal determinants of food plants	242
Decision tree for fire management to promote Yakirra production	243
References	245
Chapter 10 Conclusion	251
Key findings	252
Data models	252
Ecological models	254
A link between bilby prevalence, food production and fire pattern	260

Implications for management	261
Custodial management	262
Manipulative management	263
Implications for future research and monitoring	263
Innovative monitoring techniques	263
Evaluation and reformulation of species occupancy models.....	264
Assessment of status.....	264
Climate change	264
Fox and feral cat control.....	265
Ecological role of the dingo.....	265
References	265
Statement of authorship.....	269

Abstract

The bilby *Macrotis lagotis* is a threatened species of bandicoot and wild populations are now restricted largely to spinifex grasslands in arid Australia. The species is one of the few medium-sized native mammals (35-5500 g) remaining in the arid zone. Most other species in this size range have become extinct or are now restricted to the more temperate parts of their former range.

In this thesis, I examined the distribution and abundance of the bilby in the Tanami Desert in an area covering 230,000 km². This desert is similar to other parts of the arid zone dominated by spinifex grasses. The landscape is mostly flat, soils are generally poor and annual rainfall is exceedingly variable. It is sparsely settled by humans and supports little pastoral production and no agriculture. The challenge to manage these areas for conservation is immense because of the difficulties in controlling populations of introduced predators and herbivores and wildfire.

The bilby can be easily bred in captivity and populations have now been established in several predator-proof exclosures on the Australian mainland. This high-intensity form of custodial management has taken much of the attention away for the wild bilby populations. My work aimed to partially redress this situation. I investigated the potential of fire as a form of low-intensity manipulative management to improve the status of wild bilby populations. The use of fire as a management tool was examined because previous research indicated that fire-promoted foods sometimes formed a large component of the bilby diet.

The scarcity of bilbies in the study area posed a number of methodological problems and a number of techniques to collect information on bilby occurrence were trialed. The use of tracking as the principal means to record bilby occurrence provided the opportunity to collect data on a range of other species that occupied habitat concurrently, including feral cats, foxes, dingoes, rabbits and camels. A combination of an aerial survey using a

helicopter and a ground-truth plot technique proved to be the most rapid and cost effective means to produce repeatable data on bilby occurrence.

A statistical modelling approach was used to make inferences about the processes that shape distribution and the environmental conditions that provide refugia for the species examined. I used this approach to examine a number of ecological models. Three related to the ecological framework for arid Australia proposed by Stafford Smith and Morton (1990) and the remainder related to the hypothesised causes of medium-sized mammal decline. The proposition that introduced herbivores would be more prevalent on fluvial substrates was supported but there was little support for the proposition that introduced predator species would follow a similar pattern. Foxes and feral cats used a wide variety of habitats and were common on the poorer, sandy substrates. The dingo was the only predator species that showed a strong association with drainage lines.

At a landscape scale, a number of variables were found to associate significantly with bilby prevalence. Proximity to recent fire was a significant variable but only in the central part of Tanami Desert. There was a positive association with lateritic and rock feature substrate, the rainfall gradient and dingo prevalence. None of the hypotheses proposed to explain medium-sized mammal decline was overwhelmingly supported. The positive association between bilby and dingo prevalence indicated that the two species favoured similar habitat and that the dingoes may be providing a rescue effect for bilbies. A substantial part of the dingo diet in the study area was feral cat and foxes were absent in the northern quarter of the study area and on drainage substrates when dingoes were prevalent.

Through dietary analysis I was able to link fire pattern and bilby prevalence. Plant material was the predominant component of the diet in the central part of the study area where bilby prevalence was greatest. Seed from a fire-promoted plant *Yakirra australiense* formed most of the plant material consumed particularly, in close proximity to recently burnt habitat. This provided a strong indication that habitat suitability for the bilby could be improved with fire management.

The factors affecting the production of *Yakirra* and fire recurrence were investigated and a simple decision model was developed to assist managers decide where and when to burn, and amount of *Yakirra* to expect. The information required to run the decision model could be derived from current remotely sensed spatial databases that document monthly rainfall and fire history. *Yakirra* abundance was associated positively with summer rainfall and diminished with time since fire. Fire recurrence was associated with vegetation cover that could be best estimated using the variables of antecedent rainfall since fire and rainfall within a three month period. Fire management to enhance habitat suitability for the bilby would be of most benefit in the northern part of the Tanami Desert where growth rate of vegetation is high and there is little existing fire age heterogeneity.

Based on the extent of occurrence, the distribution of the bilby has changed little in the last 20 years. However, much of the area defined by occurrence is evidently acting as a dispersal sink with widely dispersed, extremely low-density bilby sign and no indication of juvenile production. It is suggested that the bilby status is less secure than previously thought and future assessment should be based on the area of occupancy and not extent of occurrence.